ICES WGEF REPORT 2014

ICES ADVISORY COMMITTEE

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Report of the Working Group on Elasmobranch Fishes (WGEF)

17–26 June 2014

Lisbon, Portugal

ICES CIEM

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Executive Summary

The ICES Working Group on Elasmobranch Fishes, 2014 (Chairs, Ivone Figueiredo, Portugal and Jim Ellis, United Kingdom) was held at IPMA, Lisbon, Portugal from the 17–26 June 2014. Twenty-two Expert Group members attended, with nine other members contributing via correspondence. One representative of the ICES Secretariat also attended the meeting. Nine ICES member states were represented. See Annex 1 of this report for a full list of participants.

ICES WGEF meets annually, with advice for a subset of stocks drafted in alternating years. No special requests were received this year.

Twenty-six Working Documents were presented to the Group, mainly relating to survey results, biological sampling and exploratory methods. Several working documents presented results from national projects to better understand the spatial and temporal dynamics of demersal elasmobranchs, including some species currently listed as 'prohibited species'. See Annex 3 for a list of working documents presented to WGEF in 2014.

Work focused on those stocks for which it was an advisory year, namely spurdog and skates (Rajidae) in the Celtic Seas and the Bay of Biscay and Iberia Coast ecoregions. Exploratory analyses for those stocks that will be addressed in detail next year were also undertaken.

In order to better align the WGEF report with ICES advice sheets, separate chapters were written this year for angel shark *Squatina squatina,* white skate *Rostroarja alba* and catsharks (Scyliorhinidae). Information for these species and stocks previously straddled various ecoregion chapters. A new chapter for Greenland shark *Somniosus microcephalus* was also drafted.

The following stocks chapters were addressed at the 2014 WGEF meeting:

Section	Species/Assemblage	Area	Assessment type
2	Spurdog	Northeast Atlantic	Updated information and assessment
3	Leafscale gulper shark and Portuguese dogfish	Northeast Atlantic (IV–XIV)	Updated information
4	Kitefin shark	Northeast Atlantic (entire ICES area)	Updated information
5	Other Deepwater sharks	Northeast Atlantic (ICES Subareas IV–XIV)	Updated information
6	Porbeagle	Northeast Atlantic (ICES Subareas I–XIV)	Updated information
7	Basking shark	Northeast Atlantic (ICES Subareas I–XIV)	Updated information
8	Blue shark	North Atlantic (North of 5ºN)	Updated information
9	Shortfin mako	North Atlantic (North of 5ºN)	Updated information
10	Tope	Northeast Atlantic and Mediterranean	Updated information
11	Thresher sharks	Northeast Atlantic and Mediterranean	Updated information
12	Other Pelagic sharks	Northeast Atlantic	Updated information
13	Skates and rays	Barents Sea	Updated information
14	Skates and rays	Norwegian Sea	Updated information
15	Skates and rays	North Sea, Skagerrak, Kattegat and eastern Channel	Updated information
16	Skates and rays	Iceland and East Greenland	Updated information
17	Skates and rays	Faroes Islands	Updated information
18	Skates and rays	Celtic Seas (ICES Subareas VI and VII except Division VIId)	Updated information and assessment
19	Skates and rays	Bay of Biscay and Iberian waters (ICES Subarea VIII and Division IXa)	Updated information and assessment
20	Skates and rays	Azores and Mid-Atlantic Ridge	Updated information
21	Smooth-hounds	Northeast Atlantic	Updated information
22	Angel shark	Northeast Atlantic	Updated information
23	White skate	Northeast Atlantic	Updated information
24	Greenland shark	Northeast Atlantic	Updated information
25	Catsharks	Northeast Atlantic	Updated information

1 Introduction

1.1 Terms of Reference

2013/2/ACOM19 The **Working Group on Elasmobranch Fishes** (WGEF), chaired by Ivone Figueirdo, Portugal, and Jim Ellis, UK, will meet in Lisbon, Portugal, from 17–26 June 2014 to:

a) Address generic ToRs for Regional and Species Working Groups (see table below);

b) Update the description of elasmobranch fisheries for deep-water, pelagic and demersal species in the ICES area and compile landings, effort and discard statistics by ICES Subarea and Division, and catch data by NEAFC area;

c) Continue to work towards the F_{MSY} Framework for the stocks listed in the table below;

d) Evaluate the stock status of skates (Rajidae) in Biscay, Iberia and Celtic Seas for the provision of biennial advice in 2014.

e) Prepare for an evaluation of the stock status of skates (Rajidae) in the North Sea and sharks for the provision of biennial advice in 2015, quadrennial advice for sharks with 0-catch advice.

f) Develop stock annexes for skates (Rajidae) in the Celtic Seas, in the Biscay and Iberian ecoregion and in the North Sea;

g) Finalise stock annexes for demersal elasmobranchs in the Celtic Seas, and demersal elasmobranchs in the North Sea; and blue shark in the Northeast Atlantic;

h) Make a first draft of the advice using the updated template for rays, developed by WKUPDATE and WGEF, in 2012 and 2013.

i) Continue the necessary planning for a future PSA for elasmobranchs in the ICES area by:

- i) Reviewing existing approaches; and
- ii) Intersessionally, compiling the input of parameters required for a regional PSA.

Material and data relevant for the meeting must be available to the group no later than 14 days prior to the starting date.

WGEF will report by 1 August 2014 for the attention of ACOM.

1.2 Participants

The following WGEF members attended the meeting:

Gerard Bias	France
Tom Blasdale	UK (Scotland)
José De Oliveira	UK (England and Wales)
Guzman Diez	Spain (Basque Country)
Jim Ellis (chair)	UK (England and Wales)
Ivone Figueiredo (chair)	Portugal
Samuel Iglesias	France
Graham Johnston	Ireland
Klara Jakobsdottir	Iceland

Pascal Lorance	France
Arve Lynghammar	Norway
Catarina Maia	Portugal
Inigo Martinez	ICES Secretariat
Sophy McCully	UK (England and Wales)
Teresa Moura	Portugal
Mario Rui Pinho	Portugal (Azores)
Jan-Jaap Poos	The Netherlands
Cristina Rodriguez Cabello	Spain
Matthias Schaber	Germany
Bernard Seret	France
Sam Shepherd	Ireland
Alain Tetard	France
Paddy Walker	The Netherlands

The following WGEF members assisted by correspondence:

Massimiliano Cardinale	Sweden
Helen Dobby	UK (Scotland)
Armelle Jung	France
Kelle Moreau	Belgium
Francis Neat	UK (Scotland)
Barbara Serra-Pereira	Portugal
Harriet van Overzee	Netherlands
Francisco Velasco	Spain
Tone Vollen	Norway
Carlos Farias	Spain
Ignacio Sobrino	Spain
Juan Gil Herrera	Spain

1.3 Background and history

The Study Group on Elasmobranch Fishes (SGEF), having been first established in 1989 (ICES, 1989), was re-established in 1995 and had meetings or met by correspondence in subsequent years (ICES, 1995–2001). Assessments for elasmobranch species had proven very difficult because of the lack of data. The 1999 meeting was held concurrently with an EC-funded Concerted Action Project meeting (FAIR CT98–4156) allowing for a greater participation from various European institutes. Exploratory assessments were carried out for the first time at the 2002 SGEF meeting, covering eight of the nine case study species considered by the EC-funded DELASS project (CT99–055). The success of this meeting was as a consequence of the DELASS project, a three-year collaborative effort involving fifteen fisheries research institutes and two subcontractors. Though much progress was made on methodology, there was still much work to be done, with the paucity of species-specific landings data a major data issue.

In 2002, SGEF recommended the group be continued as a working group (ICES, 2002). The medium-term remit of this WG being to adopt and extend the methodologies and assessments for elasmobranchs prepared by the EC-funded DELASS project; to review and define data requirements (fishery, survey and biological parameters) for stock identification, analytical models and to carry out such assessments as are required by ICES customers.

In 2003, WGEF met in Vigo, Spain and worked to further the stock assessment work carried out under DELASS. In 2003, landings data were collated for the first time. This exercise was based on data from ICES landings data, the FAO FISHSTAT database, and data from national scientists (ICES, 2003). In 2004, WGEF worked by correspondence to collate and refine catch statistics for all elasmobranchs in the ICES area. This task was complicated by the use (by many countries) of generic reporting categories for sharks, rays and dogfish. WGEF evaluated sampling plans and their usefulness for providing assessment data. (ICES, 2004)

In 2005, WGEF came under ACFM and was given the task of supporting the advisory process. This was because ICES has been asked by the European Commission to provide advice on certain species. This task was partly achieved by WGEF in that preliminary assessments were provided for spurdog, kitefin shark, thornback ray (North Sea) and deep-water sharks (combined). ACFM produced advice on these species, as well as for basking shark and porbeagle, based on the WGEF Report. A standard reporting and presentation format was adopted for catch data and best estimates of catch by species were provided for the first time (ICES, 2005).

In 2006, work continued on refining catch estimates and compiling available biological data (ICES, 2006), with good progress made in some ecoregions. Work was begun on developing standard reporting formats for length–frequency, maturity and cpue data.

In 2007, WGEF met in Galway, with the demersal elasmobranchs of three ecoregions (North Sea, Celtic Seas and Bay of Biscay/Iberian waters) subject to more detailed study and assessment (ICES, 2007), with special emphasis on skates (Rajidae), given that these are some of the more commercially valuable demersal elasmobranchs in these shelf seas. It should be noted, however, that though there have been some historical tagging studies (and indeed there are also ongoing tagging and genetic studies), current knowledge of the stock structure and identity for many of these species is poor, and in most instances the assumed stock area equates with management areas.

WGEF met twice in 2008. The first meeting was in March (in parallel with WGDEEP) in order to update assessments and advice for deep-water sharks and demersal elasmobranchs. A second WGEF subgroup met with the ICCAT shark subgroup in Madrid in September 2008 to address the North Atlantic stocks of shortfin mako and blue shark, and to further refine data available for the NE Atlantic stock of porbeagle (ICES, 2008a).

In June 2009 WGEF held a joint meeting with the ICCAT SCRS Shark subgroup at ICES headquarters in Copenhagen. This was a highly successful meeting and for the first time pooled all available data on North Atlantic porbeagle stocks (ICES, 2009). In addition, updated assessments were carried out for North Sea, Celtic Seas, and Biscay and Iberian demersal elasmobranchs and for the deep-water sharks *Centrophorus squamosus* and *Centroscymnus coelolepis*. A three year assessment schedule was also agreed.

In June 2010 WGEF met in Horta, Portugal. This meeting was a full assessment meeting and stock updates were carried out for 19 species or species groups (ICES, 2010), with draft advice provided for eight species. In addition three special requests from the EC, relating to new advice on five elasmobranch species, were answered.

In June 2011 WGEF met at ICES Headquarters Copenhagen. Although this was not an advice year, advice was provided for *Squalus acanthias*. This was the result of a benchmark assessment of this species carried out via correspondence during spring 2011. The updated model was used to provide F_{MSY}-based advice for the first time. A special request from NEAFC, on sharks and their categorisation by habitat was also addressed (ICES, 2011).

In June 2012 WGEF met at IPMA in Lisbon (ICES, 2012b). This meeting was a full assessment meeting during which both stock updates and draft advice were provided. Two special requests, one from NEAFC and the other from the NWWRAC (via the EC), were also answered. WGEF also met in Lisbon the following year (ICES, 2013) with preparatory work and exploratory analyses conducted, in addition to addressing some special advice requests from the EU.

Overall the working group has been very successful in maintaining participation from a wide range of countries. Attendance has increased and reached a stable level in recent years, with participation from quantitative assessment scientists, fishery managers, survey scientists and elasmobranch biologists.

Interest in the work of WGEF from other RFMOs has increased, with regular contact and cooperation between WGEF and ICCAT and the GFCM. Since WGEF 2011, ICES WGEF members have been invited to stock assessments carried out by the International Commission for the Conservation of Atlantic Tunas (ICCAT), and by the General Fisheries Commission for the Mediterranean (GFCM). As many elasmobranch species and stocks range outside the ICES area, WGEF encourages co-operation between ICES and other RFMOs, both in providing information, and in sharing resources for stock assessment.

Stock assessments for many elasmobranchs are particularly difficult owing to incomplete (or lack of) species-specific catch data, the straddling and/or highly migratory nature of some of these stocks (especially with regards deep-water and pelagic sharks), and that internationally-coordinated fishery-independent surveys only sample a small number of demersal elasmobranchs with any degree of effectiveness.

1.4 Planning of the work of the group

Given the large number of stocks that WGEF had to address, WGEF and the ICES Secretariat have developed the following time frame for advice (Table 1.1).

In 2014, the following species and stocks were scheduled for advice, and advice will be updated every two years:

- Spurdog in the Northeast Atlantic;
- Skates and rays (Rajidae) in the Celtic Seas (ICES Subareas VI and VII except Division VIId);[1]
- Skates and rays (Rajidae) in the Bay of Biscay and Iberian Coast (ICES Subarea VIII and Division IXa)

In 2015, the following species and stocks are scheduled for advice, and advice will also be updated every two years:

- Skates and rays (Rajidae) in the Greater North Sea, (including Skagerrak, Kattegat and eastern Channel);
- Skates and rays (Rajidae) in the Azores and Mid-Atlantic Ridge;

[1] Note: Skate species that have a stock unit of VIId–e are included within the Celtic Seas chapter and advice. Skate species that have a stock unit of IVc,VIId are included within the North Sea chapter and advice will be provided next year.

- Smooth-hounds in the Northeast Atlantic;
- Catshark stocks in the Northeast Atlantic;
- Tope in the Northeast Atlantic;
- Leafscale gulper shark and Portuguese dogfish Northeast Atlantic (IV–XIV);
- Kitefin shark in the Northeast Atlantic (ICES Subareas I–XIV).

Species for which ICES has advised that the species should be maintained on the Prohibited Species List and some of the species subject to zero TAC will be provided with updated advice every four years. The next scheduled advice for these stocks is 2015, and the species/stocks include:

- Angel shark in the Northeast Atlantic;
- White skate in the Northeast Atlantic;
- Porbeagle in the Northeast Atlantic (ICES Subareas I–XIV);
- Basking shark in the Northeast Atlantic (ICES Subareas I–XIV);
- Portuguese dogfish in the Northeast Atlantic (ICES Subareas I–XIV);
- Kitefin shark in the Northeast Atlantic (ICES Subareas I–XIV).

Table 1.1 Stocks with updated advice in 2014.

ICES Stock code	Stock name	EcoRegion	Advice updated	Advice
dgs-nea	Spurdog (*Squalus acanthias*) in the Northeast Atlantic	Widely distributed and migratory stocks	2014	Quadrennial/Biennial
rjb-89a	Common skate (*Dipturus batis*-complex) in Subarea VIII and Division IXa (Bay of Biscay and Atlantic Iberian waters)	Bay of Biscay and Iberian coast	2014	Biennial
rjn-bisc	Cuckoo ray (*Leucoraja naevus*) in Subarea VIII (Bay of Biscay and Cantabrian Sea)	Bay of Biscay and Iberian coast	2014	Biennial
rjn-pore	Cuckoo ray (*Leucoraja naevus*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz)	Bay of Biscay and Iberian coast	2014	Biennial
rjh-pore	Blonde ray (*Raja brachyura*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz)	Bay of Biscay and Iberian coast	2014	Biennial
rjc-bisc	Thornback ray (*Raja clavata*) in Subarea VIII (Bay of Biscay and Cantabrian Sea)	Bay of Biscay and Iberian coast	2014	Biennial
rjc-pore	Thornback ray (*Raja clavata*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz)	Bay of Biscay and Iberian coast	2014	Biennial
rjm-bisc	Spotted ray (*Raja montagui*) in Subarea VIII (Bay of Biscay and Cantabrian Sea)	Bay of Biscay and Iberian coast	2014	Biennial
rjm-pore	Spotted ray (*Raja montagui*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz)	Bay of Biscay and Iberian coast	2014	Biennial
rju-8ab	Undulate ray (*Raja undulata*) in Divisions VIIIa,b (Bay of Biscay)	Bay of Biscay and Iberian coast	2014	Biennial
rju-8c	Undulate ray (*Raja undulata*) in Divisions VIIIc (Cantabrian Sea)	Bay of Biscay and Iberian coast	2014	Biennial
rju-9a	Undulate ray (*Raja undulata*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz)	Bay of Biscay and Iberian coast	2014	Biennial

ICES Stock code	Stock name	EcoRegion	Advice updated	Advice
raj-89a	Other skates and rays in Subarea VIII and Division IXa (Bay of Biscay and Atlantic Iberian waters)	Bay of Biscay and Iberian coast	2014	Biennial
rjb-celt	Common skate (*Dipturus batis*) complex (flapper skate (*Dipturus* cf. *flossada*) and blue skate (*Dipturus* cf. *intermedia*)) in Subareas VI and VII (excluding VIId)	Celtic Seas	2014	Biennial
rji-celt	Sandy ray (*Leucoraja circularis*) in Subareas VI and VII (Celtic Sea and West of Scotland)	Celtic Seas	2014	Biennial
rjf-celt	Shagreen ray (*Leucoraja fullonica*) in Subareas VI and VII (Celtic Sea and West of Scotland)	Celtic Seas	2014	Biennial
rjn-celt	Cuckoo ray (*Leucoraja naevus*) in Subareas VI and VII (Celtic Sea and West of Scotland)	Celtic Seas	2014	Biennial
rjh-7afg	Blonde ray (*Raja brachyura*) in Divisions VIIa, f, g (Irish and Celtic Sea)	Celtic Seas	2014	Biennial
rjh-7e	Blonde ray (*Raja brachyura*) in Division VIIe (western English Channel)	Celtic Seas	2014	Biennial
rjc-7afg	Thornback ray (*Raja clavata*) in Divisions VIIa, f, g (Irish and Celtic Sea)	Celtic Seas	2014	Biennial
rjc-echw	Thornback ray (*Raja clavata*) in Division VIIe (Western English Channel)	Celtic Seas	2014	Biennial
rjc-VI	Thornback ray (*Raja clavata*) west of Scotland (Subarea VI)	Celtic Seas	2014	Biennial
rje-7ech	Small-eyed ray (*Raja microocellata*) in the English Channel (Divisions VIId,e)	Celtic Seas	2014	Biennial
rje-7fg	Small-eyed ray (*Raja microocellata*) in Divisions VIIf, g (Bristol Channel)	Celtic Seas	2014	Biennial
rjm-67bj	Spotted ray (*Raja montagui*) in Subarea VI and Divisions VIIb,j (west of Scotland and Ireland)	Celtic Seas	2014	Biennial
rjm-7aeh	Spotted ray (*Raja montagui*) in Divisions VIIa and VII e-h (southern Celtic seas)	Celtic Seas	2014	Biennial
rju-7bj	Undulate ray (*Raja undulata*) in Divisions VIIb,j (Southwest of Ireland)	Celtic Seas	2014	Biennial
rju-ech	Undulate ray (*Raja undulata*) in Divisions VIId, e (English Channel)	Celtic Seas	2014	Biennial
raj-celt	Other skates and rays in Subareas VI and VII (excluding VIId)	Celtic Seas	2014	Biennial

Table 1.2. Elasmobranch stocks with advice update expected in 2015.

ICES Stock code	Stock name	EcoRegion	Advice updated	Advice
sho-89a	Black-mouth dogfish (*Galeus melastomus*) in in Subarea VIII and Division IXa (Bay of Biscay and Atlantic Iberian waters)	Bay of Biscay and Iberian seas	2015	Biennial
syc-8c9a	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Divisions VIIIc and IXa (Atlantic Iberian waters)	Bay of Biscay and Iberian seas	2015	Biennial
syc-bisc	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Divisions VIIIa,b,d (Bay of Biscay)	Bay of Biscay and Iberian seas	2015	Biennial
sho-celt	Black-mouth dogfish (*Galeus melastomus*) in Subareas VI and VII (Celtic Sea and West of Scotland)	Celtic Seas	2015	Biennial
syc-celt	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea VI and Divisions VIIa–c, e–j (Celtic Seas and west of Scotland)	Celtic Seas	2015	Biennial
syt-celt	Greater-spotted dogfish (*Scyliorhinus stellaris*) in Subareas VI and VII (Celtic Sea and West of Scotland)	Celtic Seas	2015	Biennial
rjb-34	Common skate (*Dipturus batis*-complex) in Subarea IV and Division IIIa (North Sea and Skagerrak)	North Sea	2015	Biennial
rjn-34	Cuckoo ray (*Leucoraja naevus*) in Subarea IV and Division IIIa (North Sea and Skagerrak and Kattegat)	North Sea	2015	Biennial
rjh-4aVI	Blonde ray (*Raja brachyura*) in Division IVa and subarea VI (Northern North Sea and west of Scotland)	North Sea	2015	Biennial
rjh-4c7d	Blonde ray (*Raja brachyura*) in Divisions IVc and VIId (Southern North Sea and eastern English Channel)	North Sea	2015	Biennial
rjc-347d	Thornback ray (*Raja clavata*) in Subarea IV, and Divisions IIIa and VIId (North Sea, Skagerrak, Kattegat and eastern English Channel)	North Sea	2015	Biennial
rjm-347d	Spotted ray (*Raja montagui*) in Subarea IV, and Divisions IIIa and VIId (North Sea, Skagerrak, Kattegat, and Eastern English Channel)	North Sea	2015	Biennial
rjr-234	Starry ray (*Amblyraja radiata*) in Subareas II, IIIa and IV (Norwegian Sea, Skagerrak, Kattegat and North Sea)	North Sea	2015	Biennial
raj-347d	Other skates and rays in the North Sea ecoregion (Subarea IV, and Divisions IIIa and VIId)	North Sea	2015	Biennial
syc-347d	Lesser-spotted dogfish (*Scyliorhinus canicula*) in Subarea IV, and Divisions IIIa and VIId (North Sea, Skagerrak, Kattegat, and Eastern English Channel)	North Sea	2015	Biennial

ICES Stock code	Stock name	EcoRegion	Advice updated	Advice
agn-nea	Angel shark (*Squatina squatina*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial
rja-nea	White skate (*Rostroraja alba*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial / bienial
bsk-nea	Basking shark (*Cetorhinus maximus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial
cyo-nea	Portuguese dogfish (*Centroscymnus coelolepis*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial
gag-nea	Tope (*Galeorhinus galeus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Biennial
guq-nea	Leafscale gulper shark (*Centrophorus squamosus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Biennial
por-nea	Porbeagle (*Lamna nasus*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial
raj-mar	Rays and skates (mainly thornback ray) in the Azores and Mid-Atlantic Ridge	Widely distributed and migratory stocks	2015	Biennial
sck-nea	Kitefin shark (*Dalatias licha*) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Quadrennial
trk-nea	Starry smooth-hound (*Mustelus* spp.) in the Northeast Atlantic	Widely distributed and migratory stocks	2015	Biennial

1.5 ICES approach to F_{MSY}

Most elasmobranch species are slow growing, with low production. Some species, such as basking shark, are on several lists of 'threatened' or 'endangered' species. They may also be listed under international trade agreements such as the Convention on the International Trade on Endangered Species (CITES), which may place limitations on fishing for or trade in these species.

Because of this, it is not believed that F_{MSY} is an appropriate or achievable target in all cases, particularly in the short-term. However the ICES F_{MSY} methodology has evolved in recent years. For example, new methods that are more appropriate for data-deficient stocks have been developed, and there is a greater interest in considering generation time into such methods and for the provision of advice. The generation time of elasmobranchs is often much longer than most teleosts. For each assessed stock the ICES F_{MSY} approach is considered, the group's approach and considerations outlined in the stock summary sheets.

1.6 Community plan of action for sharks

An Action Plan for the Conservation and Management of Sharks (EU, 2009) was adopted by the European Commission in 2009. Further detail on this plan and its relevance to this WG can be found in the 2009 WG Report.

1.7 Conservation advice

Several terms are used to define stock status, particularly at low levels. Some of these terms mean different things to different people. Therefore WGEF takes this opportunity to define how terms are used within this report, and also how we believe these terms should be used when providing advice.

In addition, several elasmobranch species are currently on the Prohibited Species List in European Council Regulations fixing Fishing Opportunities each year. Although this may be appropriate, WGEF believes that this status should only be used for long-term conservation, whilst a (near) zero TAC may be more appropriate for short-term management.

These ideas are discussed in detail below.

Extinction vs. extirpation

Extinction is defined as "*The total elimination or dying out of any plant or animal species, or a whole group of species, worldwide*" (Chambers Dictionary of Science and Technology), yet increasingly the term 'extinct' is used in conservation and scientific literature to highlight the disappearance of a species from a particular location or region, even if the area is at the periphery of the main geographical range.

Additionally, some of the studies that have reported a species to be (locally or regionally) 'extinct' can be based on limited data, with supporting data often neither spatially nor temporally comprehensive enough to confirm the loss, especially with regards to species that are wide-ranging, small-bodied and/or cryptic, or distributed in habitats that are difficult to survey.

In terms of a standardized approach to the terminology of lost species, we would propose the following:

Extinct: When an animal or plant species has died out over its entire geographical range.

Extirpated: When an animal or plant species has died out over a defined part of its range, from where it was formerly a commonly occurring species. This loss should be due, whether directly or indirectly, to anthropogenic activities.

If anthropogenic activities are not considered to have affected the loss of the species, then the species should be considered to have 'disappeared' or been lost from the area in question. The term 'extirpated' should also be used to identify the loss of the species from part of the main geographical range or habitat, and therefore be distinguished from a contraction in the range of a species, where it has been lost from the fringes of its distribution or suboptimal habitat.

Additionally, the terms 'extinct' and 'extirpated' should be used when there have been sufficient appropriate surveys (i.e. operating at the relevant temporal and spatial scale and with an appropriate survey or census method) to declare the species extinct/extirpated. Prior to this time, these terms could be prefixed near- or presumed.

Presumed extinct/extirpated should be used when the species has not been recorded in available survey data (which should operate at an appropriate temporal and spatial scale), but when dedicated species-specific surveys have not been undertaken.

Near extinct/extirpated should be used when there are isolated reports of the species existing in the geographical area of interest.

In terms of ICES advice, the term 'extinct' was used in both 2005 and 2006 to describe the status of angel shark in the North Sea; although since 2008 the term 'extirpated' has been used.

The utility of the 'Prohibited species' on the TACs and quotas regulations

The list of prohibited species on the TACs and quotas regulations is an appropriate measure for trying to protect the marine fish of highest conservation importance, particularly those species that are also listed on CITES and various other conservation conventions. Additionally, there should be sufficient concern over the population status and/or impacts of exploitation that warrants such a long-term conservation strategy over the whole management area.

There are some species that would fall into this category. For example, white shark and basking shark are both listed on CITES and some European nations have given legal protection to these species. Angel shark has also been given legal protection in UK.

It should also be recognized that some species that are considered depleted in parts of their range may remain locally abundant in some areas, and such species might be able to support low levels of exploitation. From a fisheries management viewpoint, advice for a zero or near zero TAC, or for no target fisheries, is very different from a requirement for 'prohibited species' status, especially as a period of conservative management may benefit the species and facilitate a return to commercial exploitation in the short term.

Additionally, there is a rationale that a list of prohibited species should not be changing regularly, as this could lead to confusion for both the fishing and enforcement communities.

In 2009 and 2010 undulate ray, *Raja undulata* was moved on to the prohibited species list. This had not been recommended by ICES. Following a request from commercial fishers, the European Commission asked ICES to give advice on this listing. ICES reiterated that undulate ray would be better managed under local management measures and that there was no justification for placing undulate ray on the prohibited species list. To-date, there has been limited change in the listing of this species, though it was removed from the Prohibited Species List for sub-area VII in 2014 (where it remained as a species that cannot be retained or landed).

1.8 Sentinel fisheries

ICES advice for several elasmobranch stocks suggests that their fisheries should, for example "*consist of an initial low* (level) *scientific fishery*". In discussions of such fisheries, WGEF would suggest that a 'sentinel fishery' is a science-based data collection fishery conducted by commercial fishing vessel(s) to gather information on a specific fishery over time using a commercial gear but with standardized survey protocols. Sentinel fisheries would:

- Operate with a standardized gear, defined survey area, and standardized index of effort;
- Aim to provide standardized information on those stocks that may not be optimally sampled by existing fishery-independent surveys;
- Include a limited number of vessels;
- Be subject to trip limits and other technical measures from the outset, in order to regulate fishing effort/mortality in the fishery;
- Carry scientific observers on a regular basis (e.g. for training purposes) and be collaborative programmes with scientific institutes;
- Assist in biological sampling programmes (including self-sampling and tagging schemes);
- Sampling designs, effort levels and catch retention policy should be agreed between stakeholders, national scientists and the relevant ICES assessment expert group.

1.9 Mixed fisheries regulations

Apart from TAC regulations, several ICES divisions have fish stocks subject to recovery plans, including the cod recovery plan, hake recovery plan, etc.

As several elasmobranch stocks, particularly skates and rays, are caught in mixed fisheries within these areas catches of elasmobranchs may be limited by restrictive effort limitations because of these plans. In general, these are not referred to within the text, but must be taken into consideration when looking at landings trends from within these areas.

1.10 Current ICES expert groups of relevance to the WGEF

Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)

Several elasmobranchs are taken in North Sea demersal fisheries, including spurdog (see Section 2), tope (Section 10), various skates (Section 15) and starry smooth-hound (Section 21). WGNSSK should note that the Greater Thames Estuary is the main part of the North Sea distribution of thornback ray *Raja clavata* and may also be an important nursery ground for some small shark species, such as tope and starry smooth-hound. Thornback ray is an important species in ICES Division IVc, and is taken in fisheries targeting sole (e.g. trawl and gillnet), cod (e.g. trawl, gillnet and longline), as well as in targeted fisheries.

Working Group for the Celtic Seas Ecoregion (WGCSE)

Several elasmobranchs are taken in the waters covered by WGCSE, including spurdog (see Section 2), tope (Section 10), various skates and rays (Section 18) and starry smooth-hound (Section 21).

WGCSE should note that common skate *Dipturus batis*-complex, which has declined in many inshore areas of northern Europe, may be locally abundant in parts of ICES Division VIa and the deeper waters of the Celtic Sea (VIIh–j). Thornback ray is abundant in parts of the Irish Sea, especially Solway Firth, Liverpool Bay and Cardigan Bay. The Lleyn Peninsula is an important ground for greater-spotted dogfish *Scyliorhinus stellaris*. WGSCE should also note that the Bristol Channel is of high local importance for small-eyed ray *Raja microocellata*, as well as being an important nursery ground for some small sharks (e.g. starry smooth-hound and tope) and various skates.

In 2009, the EC prohibited landings/retention of angel shark, white skate, common skate and undulate ray from this ecoregion (CEC, 2009). Angel shark was formerly abundant in parts of Cardigan Bay, the Bristol Channel and Start Bay, and is now rarely observed. Similarly, white skate may also be extirpated from most parts of the region. Common skate may be locally abundant on some offshore fishing grounds, and undulate ray are locally abundant in parts of the (western) English Channel, and so these measures may have caused controversy with some sections of the fishing industry.

Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP)

In 2008, WGEF met in parallel with WGDEEP in order to assess and provide advice on deep-water sharks (see Sections 3–5). In February 2010 WGDEEP held a benchmark assessment of deep-water stocks (WKDEEP; ICES 2010a). Two WGEF members attended in order to carry out an assessment of the deep-water shark species *Centrophorus squamosus* and *Centroscymnus coelolepis*. Considerable progress during the meeting in terms of the robust construction of a plausible catch and effort history for both species. A novel approach to assessing such species as deep-water sharks was presented at the meeting using a subset of the data on Portuguese dogfish and was agreed by WKDEEP to be a highly promising approach, pending the acceptable reconstruction of the aforementioned catch and effort data, and its further development and possible future application is to be strongly encouraged.

International Bottom-trawl Survey Working Group (IBTSWG)

IBTSWG continue to provide maps of the distribution of a variety of demersal elasmobranchs from the IBTS surveys in the North Sea and western areas. WGEF consider that these plots provide useful information and hope that IBTSWG will continue such work in the future.

Working Group on Beam Trawl Surveys (WGBEAM)

WGBEAM carries out some analysis of catch rates and distribution of certain skate species from beam trawl surveys in the North Sea and Celtic Seas ecoregions. This sort of analysis is very useful for WGEF.

Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS)

There have been improvements in the collection of biological information for skates in fishery-independent trawl surveys and in the provision of species composition for commercial skate catches. There are, however, some issues that need to be resolved, for example (i) ensuring accurate species identification when reporting species composition from market sampling, and (ii) developing standardized and appropriate methods for raising species composition data.

One of the skate species for which ICES has been unable to provide advice based on survey data is blonde ray *Raja brachyura*. This large bodied species has a patchy distribution and so is not sampled effectively in existing groundfish surveys. Given that this species is often landed with spotted ray *Raja montagui*, it is considered important that better differentiation between these species is required. Given the difficulties in separating these species, market sampling may still be required to get a more accurate species composition for these sister taxa.

Working Group on Fish Technology and Fish Behaviour (WGFTFB)

Annex 8 of ICES (2008b) provided a useful overview of technical issues relating to fisheries in the North Sea and Celtic Seas ecoregions, etc. It was noted that were "Problems with the introduction of the 5% bycatch limits for dogfish (*Squalus acathias*) on west coast and North Sea grounds. They can be encountered in large congregations but it is almost impossible for vessels to identify them using sonar, etc. so they are difficult to avoid".

WGFTFB also noted that "Regulations introduced at the start of 2008 preventing the targeting of spurdog have created problems, particularly for inshore gillnetters off the North Galway and Mayo coasts". Several of these vessels now spent more time potting for crab and lobster. The regulation also affected vessels operating in the southwest of the British Isles, including for trawlers which can sometimes catch large quantities of spurdog. Hence, this regulation will have led to some discarding (ICES, 2008b).

A maximum landing length (100 cm) was introduced for 2009. Since then there has been a complete ban on landing spurdog, so this measure is not currently relevant.

Other elasmobranch issues discussed by WGFTFB include the switch from beam trawls to outrigger trawls (see Section 3.1.1. of ICES, 2008b). This change of gear, driven by the reduction in fuel consumption, may lead to increased catches of skates and rays, and WGFTFB noted that "*In terms of overall catch composition ray represented between 32.35%–45.07% (average 36.65%) of the total catch by weight for the four vessels*". It is thought that fishers may target skates with such gears in order to compensate for the reduction in catches of sole *Solea solea.* The move away from beam trawls may also allow vessels to fish inside 12 nm, where there can be large concentrations of skates.

ICES 2008b also provided some information on the use of electropositive alloys (mischmetals) as a shark bycatch reduction method for longline fisheries (See various projects summarized in Section 19.13 of ICES, 2008b). Although some (but not all) of these studies demonstrated reduced hooking rates of elasmobranchs, the use of mischmetals in commercial operations may be limited by expense, hazardous nature, and its rapid dissolution in seawater.

A theme session entitled "Elasmobranch Fisheries: Developments in stock assessment, technical mitigation and management measures" was held at the 2010 ICES Annual Science Conference in Nantes, France. This was co-convened by members of WGEF and WGFTFB. Forty-two papers were submitted, on subjects ranging from biochemistry to the results of satellite tagging surveys, and included aspects of the stock assessment of several species. Papers were submitted on elasmobranch studies from throughout the ICES area, as well as on stocks in the Mediterranean Sea and the South Atlantic and Pacific oceans.

Given the potential landing obligation, further collaborative work between WGEF and FTFB on discard survival and bycatch mitigation is to be encouraged.

Working Group on the Bycatch of Endangered Species (WGBYC)

After three years as a study group, SGBYC became a full Working Group in 2011. The Group has expanded from its initial remit of examining cetacean bycatch, and its particular role in monitoring how EC Regulation 812/2004 is implemented at a national level, into examining the bycatch of other endangered species, including sea birds, marine reptiles and elasmobranchs. Having first sent a representative to this group in January 2010, WGEF should maintain close contact with this group and continue to provide expertise to the group with regards elasmobranch issues.

Working Group on the Northeast Atlantic Continental Slope Surveys (WGNEACS)

WGNEACS has expanded from a planning group. Its role is to coordinate deep-water surveys in the ICES area. There are three survey regions; Northern, Central and Southern. Results and analysis from some surveys is used in the assessment of deep-water shark species.

Working Group on Deep-water Ecology (WGDEC)

WGDEC formed in 2007 and has met annually since then. The main role of the group is to map vulnerable marine ecosystems in the deep-sea and to advise on spatial conservation measures. Through their association with various deep-water habitats and their need for conservation action, deep-sea sharks are relevant to work undertaken by WGDEC.

Workshop on Sexual Maturity Staging of Elasmobranchs (WKMSEL)

The first workshop met in October 2010, following a recommendation from PGCCDBS. Its objectives were to agree on a common maturity scale for elasmobranchs, both oviparous and viviparous species, across laboratories and compare existing scales and standardize maturity determination criteria. Although WGEF agrees that standardization across laboratories is important, there are concerns over some of the new scales proposed. In particular, the increase in the number of stages compared with other scales used will lead to some problems if introduced. These include:

- Comparison of new records with older samples;
- Training requirements for all staff who stage elasmobranchs;
- Adoption of new systems and/or software adjustments for survey/other databases, such as IBTS, DATRAS, etc.

A second workshop was held in December 2012, following a recommendation by ICES, to revise and update the maturity scales proposed by WKMSEL. The new macroscopic scales for males and females of oviparous and viviparous species have simple descriptions that facilitate the assignment of maturity stages, as it was recommended by WGEF in 2012. The adoption of substages (e.g. 3a and 3b) allow for an optional simplified version of the scale, useful for quick uses or when the capacity and experience are a constraint.

Following WGEF recommendations, previous scales were reanalysed to make a correspondence between them and the new. The correspondence was adequate for most of the stages proposed except for the later ones, e.g. post-laying for oviparous females and regenerating for both oviparous and viviparous. These new stages were considered essential to fully understand the reproductive strategies of the species and get better estimates for life-history parameters, needed in demographic and other assessment models.

1.11 Other meetings of relevance to WGEF

ICCAT

WGEF has conducted joint assessments with ICCAT in 2008 and 2009. These were useful in pooling information on highly migratory pelagic shark species, including porbeagle, blue shark and shortfin mako. It is intended that these collaborations continue to usefully assess and update knowledge of pelagic shark species. ICCAT shark specialist subgroup also recommends maintaining links and sharing data with WGEF. In 2012 a representative of WGEF attended the ICCAT Ecological Risk Assessment and shortfin mako stock assessment in Faro, Portugal. Data from this meeting were used in the WGEF account of shortfin mako (Chapter 9). Opportunities for further collaborative meetings with the ICCAT shark sub-group will be investigated intersessionally and the ICES Secretariat should make efforts to establish such collaboration.

General Fisheries Commission for the Mediterranean (GFCM)

From 2010 to 2013, the GFCM carried out a programme to improve the knowledge and assess the status of elasmobranchs in the Mediterranean and the Black Sea. The main outcomes of this four year programme were three meetings and two publications:

1) Expert Meeting on the status of Elasmobranchs in the Mediterranean and Black Sea (Sfax, Tunisia, 20–22 September 2010);
2) Workshop on Stock Assessment of Selected Species of Elasmobranchs (Brussels, Belgium, 12–16 December 2011);
3) Workshop on Age Determination (Antalya, Turkey, 8–12 October 2012);
4) Bibliographic review to sum up the information gathered during the above mentioned meetings, published in 2012 within the GFCM Series Studies and Reviews; and
5) Publication of a technical manual on age determination of elasmobranchs.

The Chair of WGEF was invited to attend and Chair the 2nd elasmobranch stock assessment of the GFCM. It was felt that both ICES and the GFCM would benefit from this interaction due to the overlap in the distribution of certain stocks, and also in comparing stock assessment methods for data-poor stocks. This was a highly successful meeting, with several elasmobranch stocks assessed for the first time. WGEF encourages co-operation and sharing of data, information and expertise with the GFCM and other RFMOs.

In 2013, the GFCM decided to develop a three-year extension of this programme including the:

1) Preparation of a draft proposal on practical options for mitigating bycatch for the most impacting gears in the Mediterranean and Black Sea;
2) Production and dissemination of guidelines on good practices to reduce the mortality of sharks and rays caught incidentally by artisanal fisheries;

3) Development of studies on growth, reproduction, population genetic structure and post-released mortality and identification of critical areas (nurseries) at national or regional level;
4) Preparation of factsheets and executive summaries for some commercial species presenting identification problems;
5) Assessment of the impact of anthropogenic activities other than fisheries on the observed decline of certain sharks and rays populations;
6) Implementation of a pilot tagging programme for pelagic sharks.

1.12 Relevant biodiversity conservation issues

ICES work on elasmobranch fish is becoming increasingly important as a source of information to various multilateral environmental agreements concerned about the conservation status of some species. Table 1.3 lists species occurring in the ICES area that are being considered within these fora.

Table 1.3. Species listed by Multilateral Environmental Agreements.

Species	Multinational Environmental Agreement			
	OSPAR	CMS	CITES	Bern
Spurdog *Squalus acanthias*	✓	App II	Proposed, Rejected 2010	
Gulper shark *Centrophorus granulosus*	✓			
Leafscale gulper shark *Centrophorus squamosus*	✓			
Portuguese dogfish *Centroscymnus coelolepis*	✓			
Angel shark *Squatina squatina*	✓			App III (Med)
Sawfish *Pristis pristis* and *P. pectinata*			App I	
Common skate *Dipturus batis*	✓			
White skate *Rostroraja alba*	✓			App III (Med)
Thornback ray *Raja clavata*	✓(North Sea)			
Spotted ray *Raja montagui*	✓ (North Sea)			
Giant devil ray *Mobula mobular*				App II (Med)
Basking shark *Cetorhinus maximus*	✓	App I and II	App II	App II (Med)
White shark *Carcharodon carcharias*		App I and II	App II	App II (Med)
Shortfin mako shark *Isurus oxyrinchus*		App II		App III (Med)
Longfin mako shark *Isurus paucus*		App II		
Porbeagle shark *Lamna nasus*	✓	App II	Accepted 2013	App III (Med)
Blue shark *Prionace glauca*				App III (Med)

OSPAR Convention

The OSPAR Convention (www.ospar.org) guides international cooperation on the protection of the marine environment of the Northeast Atlantic. It has 15 Contracting Parties and the European Commission, representing the European Community. The OSPAR list of threatened and/or declining species and habitats, developed under the OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area, provides guidance on the future conservation priorities and research needs of marine biodiversity (species and habitats) at risk in this region. To date, eleven elasmobranch species are listed (Table 1.3), either across the entire OSPAR region or in areas where they are declining. Background Documents that summarize the status of each of these species and propose actions and measures to be taken, including through ICES, are currently under development.

Convention on the Conservation of Migratory Species (CMS)

CMS recognizes the need for countries to cooperate in the conservation of animals that migrate across national boundaries, if an effective response to threats operating throughout a species' range is to be made. The Convention actively promotes concerted action by the range states of species listed on its Appendices. The CMS Scientific Council has determined that in all 35 shark and ray species, globally, meet the criteria for listing in the CMS Appendices (Convention on Migratory Species, 2007). Table 1.3 lists Northeast Atlantic elasmobranch species that are currently included in the Appendices. CMS Parties should strive towards strictly protecting the endangered species on Appendix I, conserving or restoring their habitat, mitigating obstacles to migration and controlling other factors that might endanger them. The range states of Appendix II species (migratory species with an unfavourable conservation status that need or would significantly benefit from international cooperation) are encouraged to conclude global or regional agreements for their conservation and management (www.cms.int).

Convention on International Trade in Endangered Species (CITES)

CITES was established in recognition that international cooperation is essential to the protection of certain species from overexploitation through international trade. It creates the international legal framework for the prevention of trade in endangered species of wild fauna and flora and for the effective regulation of international trade in other species which may become threatened in the absence of such regulation. Species threatened with extinction may be listed in Appendix I, essentially banning commercial international trade in their products. Appendix II of CITES includes "*species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival*". Trade in these species is closely monitored and allowed only after exporting countries provide evidence that such trade is not detrimental to populations of the species in the wild (e.g. where fisheries are regulated). Table 1.3 lists elasmobranch species occurring in the Northeast Atlantic that are listed in the Appendices or currently known to be proposed for listing. Resolution Conf. 12.6 encourages parties to identify endangered shark species that require consideration for inclusion in the Appendices if their management and conservation status does not improve; several other ICES species are included in these lists. Decision 13.42 encourages parties to improve their data collection and reporting of catches, landings and trade in sharks (at species level where possible), to build capacity to manage their shark fisheries, and to take action on several species-specific recommendations from the Animals Committee (CITES 2009).

1.13 ICES fisheries advice

ICES advice is now provided under the Maximum Sustainable Yield framework (MSY).

Maximum sustainable yield is a broad conceptual objective aimed at achieving the highest possible yield over the long term (an infinitely long period of time). It is non-specific with respect to: (a) the biological unit to which it is applied; (b) the models used to provide scientific advice; and (c) the management methods used to achieve MSY. The MSY concept can be applied to an entire ecosystem, an entire fish community, or a single fish stock. The choice of the biological unit to which the MSY concept is applied influences both the sustainable yield that can be achieved and the associated management options. Implementation of the MSY concept by ICES will first be applied to individual fish stocks. Further information on the background to MSY and how it is applied to fish stocks by ICES can be found in the General Context to ICES Advice.

1.14 Data availability

Provision of data prior to working group

WGEF members agree that future meetings of WGEF should continue to meet in June, as opposed to earlier meetings, as (a) more landings data are available; (b) meeting outside the main spring assessment period should provide national laboratories with more time to prepare for WGEF, (c) it will minimize potential clashes with other assessment groups (which could result in WGEF losing the expertise of stock assessment scientists) and (d) given that there are not major year-to-year changes in elasmobranch populations (cf. many teleost stocks), the advice provided would be valid for the following year.

In almost all cases, members provided national catch data to the group before the new data deadlines proposed by ICES.

The group agreed that cpue from surveys should be provided as disaggregated raw data, and not as compiled data. The group agreed that those survey abundance estimates that are not currently in the DATRAS database are also provided as raw data by individual countries.

WGEF recommends that MS provide better explanations of how national data for species and length compositions are raised to total catch, especially when there may be various product weights reported (e.g. gutted or dressed carcasses and livers and/or fins).

Landings data

Since 2005, WGEF has collated landings data for all elasmobranchs in the ICES area, although this task has been hampered by the use by so many countries of "nei" (not elsewhere identified) categories. Landings data (as extracted from ICES FishStat Database) have been collated in species-specific landings tables and stored in a WG archive. These data have been corrected as follows:

- Replacement with more accurate data provided by national scientists;
- Expert judgements of WG members to reallocate data to less generic categories (usually from a "nei" category to a specific one).

The data in these archives are considered to be the most complete data and are presented in tabular and graphical form in the relevant chapters of this Report and on the WG ICES SharePoint.

WGEF aims to allocate progressively more of the "nei" landings data over time, and some statistical approaches have been presented to WGEF (see Johnston *et al.*, 2005; ICES, 2006). However the Working Group's best estimates are still considered inaccurate for a number of reasons:

i) Quota species may be reported as elasmobranchs to avoid exceeding quota, which would lead to overreporting;

ii) Fishers may not take care when completing landings data records, for a variety of reasons;

iii) Administrations may not consider that it is important to collect accurate data for these species;

iv) Some species could be underreported to avoid highlighting that bycatch is a significant problem in some fisheries;

v) Some small inshore vessels may target (or have a bycatch of) certain species and the landings of such inshore vessels may not always be included in official statistics.

The data may also be imprecise as a result of revisions by reporting parties. WGEF aims to arrive at an agreed set of data for each species and will document any changes to these datasets in the relevant working group report.

Discards

Discards data are available to WGEF but more detailed studies of such datasets are required. Other issues that need to be considered for more detailed studies of discard data are species identification problems, and the problems of raising such data for those species that are only occasionally recorded, or can be found in large numbers occasionally.

Stock structure

This report presents the status and advice of various demersal, pelagic and deep-water elasmobranchs by individual stock component. The identification of stock structure has been based upon the best available knowledge to date (see the stock-specific chapters for more details). However, it has to be emphasized that overall, the scientific basis underlying the identity of many of these demersal and deep-water stocks is currently weak. In most of the cases, the identification of stock is based on the distribution and relative abundance of the species, limited knowledge of movements and migrations, reproductive mode, and consistency with management units.

The WG considers that the stock definitions proposed in the report are limited for many species, and in some circumstances advice may refer to 'management units'.

The WG recommends that increased research effort be devoted to clarifying the stock structure of the different demersal and deep-water elasmobranchs being investigated by ICES.

Length measurements

Further information on the issues of different types of length measurement can be found in Section 1.15 of the 2010 WGEF report.

WGEF recommends that length–frequency information both commercial and survey be made available to the group to enable length-based assessments to take place.

Differences in the methods of measuring fish were outlined in ICES (2010b).

Other issues–*Dipturus* complex

Two papers (Iglesias *et al*., 2010; Griffiths *et al*., 2010), demonstrated that *Dipturus batis*, frequently referred to as common skate, is in fact a complex of two species, that were erroneously synonymised in the 1920s. Hence, much of the data for *Dipturus batis* is a confusion of blue skate *D. batis (*c.f. *flossada)* and flapper skate *D. intermedia*.

In 2012 a special request was received from the European Commission to determine whether these species could be reliable identified and whether they have different distributions, with regard to the possible setting of separate TACs for the two species. This special request is dealt with in Annex IV of 2012 WGEF report. Where possible, this report refers to the species separately, with the confounded data referred to as the *Dipturus batis* complex.

Currently labs can only upload data to DATRAS for *D. batis*, as TSN codes are not available for provisionally-titled species. The Secretariat and IBTSWG are attempting to enable species-specific data to be input. In 2012, the case was submitted to the International Commission on Zoological Nomenclature (ICZN) with *Dipturus batis* proposed for the smaller species (ex. *Dipturus batis cf. flossada*) and *Dipturus intermedia* for the larger one. Pending on the decision of this commission, ICES is unable to progress this issue further.

This issue is further discussed in Section 21.1 of the 2010 WGEF report.

1.15 Methods and software

Many elasmobranchs are data-limited, and the paucity of data can extend to:

- Landings data, which are often incomplete or aggregated;
- Life-history data, as most species are poorly known with respect to age, growth and reproduction;
- Commercial and scientific datasets that are compromised by inaccurate species identification (with some morphologically similar species having very different life-history parameters);
- Lack of fishery-independent surveys for some species (e.g. pelagic species) and the low and variable catch rates of demersal species in existing bottom-trawl surveys.

Hence, the work undertaken by WGEF often precludes the formal stock assessment process that is used for many commercial teleosts stocks, and the analyses of survey, biological and landings data are used more to evaluate the status of the species/stocks.

Analytical assessment models are only used in the stock assessments of two species; porbeagle and spurdog. In 2011 WGEF updated and refined the model last used for the spurdog assessment in 2008 and 2010. A benchmark assessment of spurdog was carried out prior to, and during WGEF 2011. Further information can be found in Section 2 of 2011 WGEF report.

For other species WGEF followed the latest ICES guidelines on the assessment of data-limited stocks (ICES, 2012a). For most species survey data was available. For certain low-abundance species, only landings information is available. For demersal elasmobranchs in the Celtic and North Sea, a 'survey status' is provided for each species. For Bay of Biscay and Iberia Coast besides survey data for more frequently caught species there is also fishery-dependent information. Survey data quickly illustrate the relative abundance of each species in each survey, as well as a visual indication of trends in abundance and mean length. Further details are outlined in each chapter.

1.16 InterCatch

WGEF has not used InterCatch for its landings figures. Landings figures are supplied by individual members. These are considered to be superior to official statistics as regional laboratories can better provide information on local fisheries. In addition, the problems of the use of generic categories and species misidentification can be better evaluated in advance by WGEF members.

1.17 References

CEC. 2009. Council Regulation (EC) No 43/2009 of 16 January 2009 fixing for 2009 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required. Official Journal of the European Union L 22; 205 pp.

CITES. 2009. Conservation and management of sharks and stingrays. AC24 WG5 Doc. 1. http://www.cites.org/common/com/AC/24/wg/E–AC24–WG05.pdf.

Convention on Migratory Species. 2007. Report of the Fourteenth Meeting of the Scientific Council of the Convention on the Conservation of Migratory Species of Wild Animals. http://www.cms.int/bodies/ScC/Reports/Eng/ScC_report_14.pdf.

EU. 2009. Communication from the Commission to the European parliament and the council on a European Community action plan for the conservation and management of sharks. COM (2009) 40.

GFCM. 2013. Report of the thirteenth session of the sub-committee on marine environment and ecosystems (SCMEE). FAO HQs, Rome, Italy, 18–20 February 2013. 55 p.

Griffiths, A.M., Sims, D.W., Cotterell, S.P., El Nagar, A., Ellis, J.R., Lynghammar, A., McHugh, M., Neat, F.C., Pade, N.G., Queiroz, N., Serra-Pereira, B., Rapp, T., Wearmouth, V.J. and Genner, M.J. 2010. Molecular markers reveal spatially segregated cryptic species in a critically endangered fish, the common skate (*Dipturus batis*). Proceedings of the Royal Society B, 277: 1497–1503.

ICES. 1989. Report of the Study Group on Elasmobranch Fisheries, 26–28 April 1989, Dublin, Ireland. ICES Document CM 1989/G: 54, 37 pp.

ICES. 1995. Report of the Study Group on Elasmobranch Fishes, 15–18 August 1995, Copenhagen, Denmark. ICES Document CM 1995/G: 03, 88 pp.

ICES. 1996. Report by Correspondence of the Study Group on Elasmobranch Fishes. ICES Document CM 1996/G: 04, 49 pp.

ICES. 1997. Report of the Study Group on Elasmobranch Fishes, 26–30 May 1997, Copenhagen, Denmark. ICES Document CM 1997/G: 02, 123 pp.

ICES. 1998. Report of the Study Group on Elasmobranch Fishes. ICES Document CM 1998/G: 12, 29 pp.

ICES. 1999. Report of the Study Group on Elasmobranch Fishes, 23–27 March 1999, Santander, Spain. ICES Document CM 1999/G: 11, 18 pp.

ICES. 2000. Report of the Study Group on Elasmobranch Fishes. ICES Document CM 2000/G: 09, 9 pp.

ICES. 2001. Report of the Study Group on Elasmobranch Fishes. ICES Document CM 2001/G: 07, 6 pp.

ICES. 2002. Report of the Study Group on Elasmobranch Fishes, 6–10 May 2002, Copenhagen, Denmark. ICES Document CM 2002/G: 08, 119 pp.

ICES. 2003. Report of the Working Group on Elasmobranch Fishes, 28 April–2 May 2003, Vigo, Spain. ICES Document CM 2003/G: 09, 151 pp.

ICES. 2004. Report of the Working Group on Elasmobranch Fishes (WGEF). ICES Document CM 2004/G: 11, 110 pp.

ICES. 2005. Report of the Working Group on Elasmobranch Fishes (WGEF). 14–21 June 2005, Lisbon, Portugal. ICES CM 2006/ACFM:03, 229 pp.

ICES. 2006. Report of the Working Group on Elasmobranch Fishes (WGEF). 14–21 June 2006, ICES Headquarters. ICES CM 2006/ACFM:31, 291 pp.

ICES. 2007. Report of the Working Group on Elasmobranch Fishes (WGEF), 22–28 June 2007, Galway, Ireland. ICES CM 2007/ACFM:27, 318 pp.

ICES. 2008a. Report of the Working Group Elasmobranch Fishes (WGEF), 3–6 March 2008, Copenhagen, Denmark. ICES CM 2008/ACOM:16, 332 pp.

ICES. 2008b. Report of the ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB), 21–25 April 2008, Tórshavn, Faroe Islands. ICES CM 2008/FTC:02, 265 pp.

ICES. 2010a. Report of the Benchmark Workshop on Deep-water Species (WKDEEP). 17–24 February, Copenhagen, Denmark. ICES CM 2010/ACOM:38, 247 pp.

ICES. 2010b. Report of the Working Group on Elasmobranch Fishes (WGEF). 22–29 June 2010, Horta, Portugal. ICES CM 2010/ACOM 19, 560 pp.

ICES. 2011. Report of the Working Group on Elasmobranch Fishes (WGEF), 20–24 June 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:19, 492 pp.

ICES. 2012a. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68. 42 pp.

ICES. 2012b. Report of the Working Group on Elasmobranch Fishes (WGEF), 19–26 June 2012, Lisbon, Portugal. ICES CM 2012/ACOM:19, 547 pp.

ICES. 2013. Report of the Working Group on Elasmobranch Fishes (WGEF), 17–21 June 2013, Lisbon, Portugal. ICES CM 2013/ACOM:19, 649 pp.

Iglesias, S.P., Toulhaut, L. and Sellos, D.Y. 2010. Taxonomic confusion and market mislabelling of threatened skates: important consequences for their conservation status. Aquatic Conserv: Mar. Freshw. Ecosyst. 15pp DOI: 10.1002/aqc.1083.

Johnston, G., Clarke, M., Blasdale, T., Ellis, J., Figueiredo, I., Hareide, N. R., and Machado, P. 2005. Separation of Species Data from National Landings Figures. ICES CM 2005/N:22, 16 pp.

2 Spurdog in the Northeast Atlantic

2.1 Stock distribution

Spurdog, *Squalus acanthias*, has a worldwide distribution in temperate and boreal waters, and occurs mainly in depths of 10–200 m. In the NE Atlantic this species is found from Iceland and the Barents Sea southwards to the coast of Northwest Africa (McEachran and Branstetter, 1984).

WGEF considers that there is a single NE Atlantic stock ranging from the Barents Sea (Subarea I) to the Bay of Biscay (Subarea VIII), and that this is the most appropriate unit for assessment and management within ICES. Spurdog in Subarea IX may be part of the NE Atlantic stock, but catches from this area are likely to consist of a mixture of *Squalus* species, with increasing numbers of *Squalus blainville* further south.

Analyses of microsatellite data conducted by Verissimo *et al.* (2010) found genetic homogeneity between east and west Atlantic spurdog, but the authors suggested this could be accomplished by transatlantic migrations of a very limited number of individuals. Further information on the stock structure and migratory pattern of Northeast Atlantic spurdog can be found in the Stock Annex.

2.2 The fishery

2.2.1 History of the fishery

Spurdog has a long history of exploitation in the Northeast Atlantic (Pawson *et al.*, 2009) and WG estimates of total landings are shown in Figure 2.1a and Table 2.1. The main exploiters of spurdog have historically been France, Ireland, Norway and the UK (Figure 2.1b and Table 2.2). The main fishing grounds for the NE Atlantic stock of spurdog are the North Sea (IV), West of Scotland (VIa) and the Celtic Seas (VII) and, during the decade spanning the late 1980s to 1990s, the Norwegian Sea (II) (Table 2.3). Outside these areas, landings have generally been low. The fishery has changed significantly in recent years in line with restrictive management measures, which have included more restrictive quota, a maximum landing length and bycatch regulations. Further details of the historical development of the fishery are provided in the Stock Annex.

2.2.2 The fishery in 2013

The zero TAC for spurdog for EU vessels has resulted in a major change in the magnitude and spatial distribution of reported landings. Landings have declined across all ICES subareas in recent years, although there are some landings in the northern parts of the ICES area.

The Norwegian directed fishery with small costal vessels was prohibited from 2011, but Norwegian landings decreased by 50% from 2010 to 2011. For first half of 2012 bycach up to 20% were allowed and was calculated as percentage of all landings during a week. This was modified for second half of the year allowing 20% bycatch calculated for the whole half-year period. For 2013 the bycatch allowance was reduced to 15% calculated for each half-year period. In 2012, 64% of the total reported landings were by Norwegian vessels. These landings were bycatch in gillnet fisheries operating in Divisions IIa, IIIa and IVa. In Subarea IIIa, a significant component of the landings was taken as bycatch by shrimp trawlers. The remainder of the landings were taken as bycatch in line fisheries and, to a lesser extent, other trawl fisheries. Preliminary reported landings of spurdog from Norwegian fisheries were 251 t in 2013.

No other countries reported significant landings of spurdog in 2013. Landings reported by Denmark, France, Iceland, Netherlands and UK (Scotland) accounted for 6–27 t each, while no other nations reported more than 2 t. Notably, with the zero TAC from 2011, the reported landings from UK (England and Wales), traditionally one of the major exploiters of the spurdog stock, are now reduced to about one tonne.

Commercial fishermen in various areas, including the southern North Sea and Celtic Sea, continue to report that spurdog can be seasonally abundant on their fishing grounds.

Further general information on the mixed fisheries exploiting this stock and changes in effort can be found in ICES (2009 a, b) and STECF (2009).

2.2.3 ICES advice applicable

In 2012, ICES advised that "on the basis of the precautionary approach that there should be no targeted fishery and that catches in mixed fisheries be reduced to the lowest possible level. A rebuilding plan should be developed for this stock".

2.2.4 Management applicable

The following table summarizes ICES advice and actual management applicable for NE Atlantic spurdog during 2001–2013:

Year	Single-stock exploitation boundary (tonnes)	Basis	TAC (IIa(EC) and IV) (tonnes)	TAC IIIa, I, V, VI, VII, VIII, XII and XIV (EU and international waters) (tonnes)	TAC IIIa(EC) (tonnes)	TAC I, V, VI, VII, VIII, XII and XIV (EU and international waters) (tonnes)	WG landings (NE Atlantic stock) (tonnes)
2000	No advice	-	9 470				15 890
2001	No advice	-	8 870	-	-	-	16 693[1]
2002	No advice	-	7 100	-	-	-	11 020
2003	No advice	-	5 640	-	-	-	12 246
2004	No advice	-	4 472	-	-	-	9365
2005	No advice	-	1 136	-	-	-	8356
2006	F=0	Stock depleted and in danger of collapse	1 051	-	-	-	4054
2007	F=0	Stock depleted and in danger of collapse	841 [2]	2 828	-	-	2853
2008	No new advice	No new advice	631 [2,3]	-	-	2004 [2]	1759
2009	F=0	Stock depleted and in danger of collapse	316 [3,4]	-	104 [4]	1002 [4]	2563
2010	F=0	Stock depleted and in danger of collapse	0 [5]		0 [5]	0 [5]	1248
2011	F=0	Stock depleted and in danger of collapse	0 [6]		0	0 [6]	580
2012	F=0	Stock below possible reference points	0 [6]		0	0 [6]	443
2013	F=0	Stock below possible reference points	0		0	0	332

([1]) The WG estimate of landings in 2001 may include some misreported deep-sea sharks or other species.

([2]) Bycatch quota. These species shall not comprise more than 5% by live weight of the catch retained on board..

([3]) For Norway: including catches taken with longlines of tope shark (*Galeorhinus galeus*), kitefin shark (*Dalatias licha*), bird beak dogfish (*Deania calcea*), leafscale gulper shark (*Centrophorus squamosus*), greater lantern shark (*Etmopterus princeps*), smooth lantern shark (*Etmopterus spinax*) and Portuguese dogfish (*Centroscymnus coelolepis*). This quota may only be taken in zones IV, VI and VII.

([4]) A maximum landing size of 100 cm (total length) shall be respected.

([5])Bycatches are permitted up to 10% of the 2009 quotas established in Annex Ia to Regulation (EC) No. 43/2009 under the following conditions:catches taken with longlines of tope shark (*Galeorhinus galeus*), kitefin shark (*Dalatias licha*), bird beak dogfish (*Deania calceus*), leafscale gulper shark (*Centrophorus squamosus*), greater lantern shark (*Etmopterus princeps*), smooth lantern shark (*Etmopterus pusillus*) and Portuguese dogfish (*Centroscymnus coelolepis*) and spurdog (*Squalus acanthias*) are included (Does not apply to IIIa); a maximum landing size of 100 cm (total length) is respected;the bycatches comprise less than 10% of the total weight of marine organisms on board the fishing vesselCatches not complying with these conditions or exceeding these quantities shall be promptly released to the extent practicable.

([6]) Catches taken with longlines of tope shark (*Galeorhinus galeus*), kitefin shark (*Dalatias licha*), bird beak dogfish (*Deania calcea*), leafscale gulper shark (*Centrophorus squamosus*), greater lanternshark (*Etmopterus princeps*), smooth lanternshark (*Etmopterus pusillus*), Portuguese dogfish (*Centroscymnus coelolepis*) and spurdog (*Squalus acanthias*) are included. Catches of these species shall be promptly released unharmed to the extent practicable.

In all EU regulated areas, a zero TAC for spurdog was retained for 2013. No landings were permitted, in contrast to 2010 when some landings were allowed under a bycatch TAC (equal to 10% of the 2009 quotas), provided certain conditions were met, including a maximum landing length and bycatch ratio limits.

In 2007 Norway introduced a general ban on target fisheries for spurdog in the Norwegian economic zone and in international waters of ICES Subareas I–XIV, with the exception of a limited fishery for small coastal vessels. Bycatch could be landed and sold as before. From 2011, all directed fisheries have been banned, although there is still a bycatch allowance. Since October 2011, the bycatch must not exceed 20% of total landings on a weekly basis. Since 4 June 2012 bycatch must not exceed 20% of total landings over the period 4 June–31 December 2012. From 1 January 2013 bycatch must not exceed 15% of total landings on a half calendar year basis. Live specimens can be released, whereas dead specimens must be landed. From 2011, the regulations also include recreational fisheries. Norway has a 70 cm minimum landing size (first introduced in 1964).

Since 1st January 2008, fishing for spurdog with nets and longlines in Swedish waters has been forbidden. In trawl fisheries there is a minimum mesh size of 120 mm and the species may only be taken as a bycatch. In fisheries with hand-held gear only one spurdog was allowed to be caught and kept by the fisher during a 24-hour period.

Many of the mixed fisheries which caught spurdog in the North Sea, West of Scotland and Irish Sea are subject to effort restrictions under the cod long-term plan (EC 1342/2008).

2.3 Catch data

2.3.1 Landings

Total annual landings (over a 60 year time period), as estimated by the WG for the NE Atlantic stock of spurdog are given in Table 2.1 and illustrated in Figure 2.1a. Preliminary estimates of landings for 2013 were 332 t.

2.3.2 Discards

Estimates of total amount of spurdog discarded are not routinely provided although some discard sampling does take place.

Data from Scottish observer trips in 2010 were made available to the WG. Over 1200 spurdog (raised to trip level and then summed across trips) were caught over 29 trips (across Division IVa and VIa), but on no occasion were any retained.

At the 2010 WG, a working document was presented on the composition of Norwegian elasmobranch catches, which suggested significant numbers of spurdog were discarded.

Preliminary observations on the discard-retention patterns of spurdog as observed on UK (English) vessels were presented by Silva *et al*. (2013 WD; Figure 2.2).

No attempts to raise observed discard rates to fleet level have been undertaken, and given the aggregating nature of spurdog, such analyses would need to be undertaken with care.

Further information on discards can be found in the Stock Annex.

2.3.3 Discard survival

Low mortality has been reported for trawl caught spurdog when tow duration was <1 h, with overall mortality of about 6% (Mandelman and Farrington, 2007; Rulifson, 2007), with higher levels of mortality (ca. 55%) reported for gillnet-caught spurdog (Rulifson, 2007).

2.3.4 Quality of the catch data

In addition to the problems associated with obtaining estimates of the historical total landings of spurdog due to the use of generic dogfish landings categories, anecdotal information suggests that widespread misreporting by species may have contributed significantly to the uncertainties in the overall level of spurdog landings.

Underreporting may have occurred in certain ICES areas when vessels were trying to build up a track record of other species, for example deep-water species. It has also been suggested that over-reporting may have occurred where stocks with highly restrictive quotas have been recorded as spurdog. However, it is not possible to quantify the amount of under and over-reporting that may have occurred. The introduction of UK and Irish legislation requiring registration of all fish buyers and sellers may mean that these misreporting problems have declined since 2006.

It is not known whether the 5% bycatch ratio (implemented in 2008) or the maximum landing length (in 2009) led to misreporting (although the buyers and sellers legislation should deter this) or increased discarding.

Recent catch data are highly uncertain, given the zero TAC in place. Whilst data from discard observer programmes may allow catches to be estimated, the estimation of dead discards will be more problematic.

Some nations may now be reporting landings of spurdog under more generic codes (e.g. *Squalus* sp., Squalidae and Squaliformes) as well as for *Squalus acanthias*.

2.4 Commercial catch composition

2.4.1 Length composition of landings

Sex disaggregated length–frequency samples are available from UK(E&W) for the years 1983–2001 and UK(Scotland) for 1991–2004 for all gears combined. The Scottish length–frequency distributions appear to be quite different from the length–frequency distributions obtained from the UK(E&W) landings, with a much larger proportion of small females being landed by the Scottish fleets. Figure 2.3 shows landings length–frequency distributions averaged over five year intervals. The Scottish data have been raised to total Scottish reported landings of spurdog while the UK(E&W) data have only been raised to the landings from the sampled boats, a procedure which is likely to mean that the latter length frequencies are not representative of total removals by the UK(E&W) fleet. For this reason, the UK(E&W) length frequencies are assumed to be representative only of the landings by the target fleet from this country.

Raw market sampling data were also provided by Scotland for the years 2005–2010. However, sampled numbers have been low in recent years (due to low landings) and use of these data was not pursued.

2.4.2 Length composition of discards

There are no international estimates of discard length frequencies.

Discard length–frequency data were provided by UK(Scotland) for 2010. Length frequencies raised to trip level and pooled over all trips and areas by gear type are shown in Figure 2.4. These have not been raised to fleet level.

Discard length–frequency data were provided by UK(England) for four broad gear types (Figure 2.2). In general beam trawlers caught relatively few spurdog, and these were comprised mostly of juveniles, gillnets catches were dominated by fish 60–90 cm TL and otter trawlers captured a broad length range. Data for larger fish sampled across the whole time-series were most extensive for gillnetters operating in the Celtic Seas (Silva *et al*, 2013 WD). The discarding rates of commercial sized fish (80–100 cm LT) from these vessels increased from 7.5% (2002–2008) to 18.7% (2009–2010), whereas the proportion of fish >100 cm LT discarded increased from 6.2% (2002–2008) to 34.1% (2009–2010), indicating an increased proportion of larger fish were discarded in line with the maximum landing length regulations that were in force during 2009–2010. The zero TAC with no bycatch allowance resulted in the discarding of all observed spurdog in 2011.

2.4.3 Sex ratio

No recent data.

2.4.4 Quality of data

Length–frequency samples are only available for UK landings and these are aggregated into broader length categories for the purpose of assessment. No data were available from Norway, France or Ireland, which are the other main nations exploiting this stock. For the 20 years prior to restrictive measures, UK landings accounted for approximately 45% of the total. However, there has been a systematic decline in this proportion since 2005 and the UK landings in 2008 represented 15% of the total. In 2010 UK landings were just above 5% of the total, and <1% in 2011. It is not known to what extent the available commercial length–frequency samples are representative of the catches by these other nations. In addition, there are only limited length–frequency data from recent years.

2.5 Commercial catch-effort data

No commercial cpue data were available to the WG.

The outline of a Norwegian sentinel fishery on spurdog was presented to the 2012 WG (Albert and Vollen, 2012 WD). This potential provider of an abundance index series has not been initiated yet.

A UK Fishery Science Partnership (FSP) study carried out by CEFAS examined spurdog in the Irish Sea (Ellis *et al.*, 2010), primarily to (a) evaluate the role of spurdog in longline fisheries and examine the catch rates and sizes of fish taken in a longline fishery; (b) provide biological samples so that more recent data on the length-at-maturity and fecundity can be calculated; and (c) tag and release a number of individuals to inform on the potential discard survivorship from longline fisheries. Survey stations were chosen by the fishermen participating in the survey.

This survey undertook studies on a commercial, inshore vessel that had traditionally longlined for spurdog during parts of the year. Four trips (nominally one in each quarter), each of four days, were undertaken over the course of the year. The spurdog caught were generally in good condition, although the bait stripper can damage the jaws, and those fish tagged and released were considered to be in a good state of health.

Large numbers of spurdog were caught during the first sampling trip, of which 217 were tagged with Petersen discs and released. The second sampling trip yielded few spurdog, although catches at that time of year are considered by fishermen to be sporadic. Spurdog were not observed on the first three days of the third trip, but reasonable numbers were captured on the last day, just off the Mull of Galloway. The fourth trip (spread over late October to early December, due to poor weather) yielded some reasonably large catches of spurdog from the grounds just off Anglesey.

2.6 Fishery-independent information

2.6.1 Availability of survey data

Fishery-independent survey data are available for most regions within the stock area. Beam trawl surveys are not considered appropriate for this species, due to the low catchability of spurdog in this gear type. However, the surveys coordinated by IBTS have higher catchability and the gears are considered suitable for this species. Spatial coverage of the North and Celtic Seas represents a large part of the stock range (Figure 2.5). For further details of these surveys and gears used see ICES (2010, 2012). The following survey data have been used in earlier analyses by WGEF:

- UK(England & Wales) Q1 Celtic Sea groundfish survey: years 1982–2002.
- UK(England & Wales) Q4 Celtic Sea groundfish survey: years 1983–1988.
- UK(England & Wales) Q3 North Sea groundfish survey 1977–present.
- UK(England & Wales) Q4 SWIBTS survey 2004–2009 in the Irish and Celtic Seas.
- UK(NI) Q1 Irish Sea groundfish survey 1992–2008.
- UK(NI) Q4 Irish Sea groundfish survey 1992–2008.
- Scottish Q1 west coast groundfish survey: years 1990–2010.
- Scottish Q4 west coast groundfish survey: years 1990–2009.

- Scottish Q1 North Sea groundfish survey: years 1990–2010.
- Scottish Q3 North Sea groundfish survey: years 1990–2009.
- Scottish Rockall haddock survey: years 1990–2009.
- Irish Q3 Celtic Seas groundfish survey: years 2003–2009.
- North Sea IBTS (NS-IBTS) survey: years 1977–2010.

A full description of the current groundfish surveys can be found in the Stock Annex.

Norwegian data on spurdog from the Shrimp survey (NO-shrimp-Q1) and the Coastal survey (NOcoast-Aco-Q4) were presented to the WGEF in 2014 (Vollen, 2014 WD). The survey coverage is shown in Figure 2.6, and general information on the surveys can be found in Table 2.4.

The annual shrimp survey (1998–2013) covers the Skagerrak and the northern parts of the North Sea north to 60°N. The timing of the survey changed from quarter 4 (1984–2003), via quarter 3 (2002–2004), to quarter 1 from 2005. Mesh size was not specified for the first years, 35 mm from 1989–1997, and 20 mm from 1998. Trawl time was one hour from 1984–1989, then 30 minutes for later years.

The coastal survey (1996–2012) yearly covers the areas from 62°N to the Russian border in the north in October–November. Only data south of 66°N were used, as very few spurdog were caught north of this latitude. Length data were available from 1999 onwards. A Campelen Shrimp trawl with mesh size 40 mm was used from 1995–1998, whereas mesh size was 20 mm for later years. Trawl time was 20–30 minutes.

Spurdog catches in these surveys are not numerous. Number of stations with spurdog catches ranged from one to 35 per year in the shrimp survey; and from 0 to 8 per year in the coastal survey. The total number of spurdog caught ranged from one to 341 individuals per year in the shrimp survey, and from 0 to 106 individuals per year in the coastal survey (Table 2.4).

2.6.2 Length-frequency distributions

Length distributions (aggregated overall years) from the UK(E&W), Scottish and Irish groundfish surveys are shown in Figures 2.7–2.8.

The UK(E&W) groundfish survey length–frequency (Figure 2.7a) consists of a high proportion of large females, although this is influenced by a single large catch of these individuals. Mature males are also taken regularly and juveniles often caught on the grounds in the northwestern Irish Sea.

The Irish Q3 GFS also catches some large females (Figure 2.7b), but the majority of individuals (both males and females) are of intermediate size, in the range 50–80 cm.

The Scottish West coast groundfish surveys demonstrate an almost complete absence of large females in their catches (Figure 2.8). These surveys show a high proportion of large males and also a much higher proportion of small individuals, particularly in the Q1 survey. However, it should be noted that these length frequencies exhibit high variability from year to year (not shown) with a small number of extremely large hauls dominating the length–frequency data.

In the UK FSP survey the length range of spurdog caught was 49–116 cm (Figure 2.9), with catches in Q1 and Q3 being mainly large (>90 cm) females. Catches in Q4 yielded a greater proportion of smaller fish. The sex ratio of fish caught was heavily skewed towards females, with more than 99% of the spurdog caught in Q1 female. Although more males were found in Q3 and Q4, females were still dominant, accounting for 87% and 79% of the spurdog catch, respectively. Numerically, between 16.5 and 41.9% of spurdog captured were >100 cm, the Maximum Landing Length in force at the time.

In the Norwegian Shrimp and Coastal surveys the length–frequency distribution was rather uniform overall years, with the length groups 60–85 cm being the most abundant (Figure 2.10). Increased occurrence of smaller individuals (<40 cm) could be seen in later years, primarily in the shrimp survey (Figure 2.11).

Previously presented length frequencies which have not been updated this year are displayed in the Stock Annex.

2.6.3 Cpue

Spurdog survey data are typically characterised by highly variable catch rates due to occasional large hauls and a significant proportion of zero catches. Average catch rates (in numbers per hour) from the NS-IBTS are shown in Figure 2.12. Although the time-series is noisy, it appears that spurdog are now being seen in a greater proportion of hauls in the Q3 survey, with average catch rates also increasing in Q3.

Time-series plots of frequency of occurrence (proportion of non-zero hauls) and catch rates (confidence intervals not shown) for the Irish surveys are shown in Figure 2.13. This short time-series show apparently stable frequency of occurrence and catch rates.

Frequency of occurrence (five year running mean) and average catch rate (in numbers per hour zero hauls not included, with five year running mean,) from the Norwegian Survey trends from the Norwegian Shrimp and Coastal surveys are shown in Figures 2.14–2.15. The frequency of occurrence declined for the Shrimp survey from late 1980s and reached a low in late 1990s. Since then, the Shrimp survey shows an increasing trend, whereas the Coastal survey shows a decreasing trend. With regards to average catch range, numbers are variable but a decrease can be seen from the 1980s to the late 1990s for the Shrimp survey. For the Coastal survey, a peak could be seen around 2004, but it should be noted that results are generally based on very few stations.

Previously presented data (either discontinued or not updated this year) have indicated a trend of decreasing occurrence and decreasing frequency of large catches with catch rates also decreasing (although highly variable) (Figures 2.16–2.17).

Future studies of survey data could usefully examine surveys from other parts of the stock area, as well as sex-specific and juvenile abundance trends. In the absence of accurate catch data, fishery-independent trawl surveys will be increasingly important to monitor stock recovery.

2.6.4 Statistical modelling

At the 2006 WG meeting, an analysis of Scottish survey data was presented, which investigated methods of standardizing the survey catch rate to obtain an appropriate index of abundance. Following on from this, and the subsequent comments of the Review Group, further analysis was conducted in 2009 to provide an index of biomass catch rates rather than abundance in $N.hr^{-1}$.

Data from four Scottish surveys listed above (1990–2013) were considered in the analysis (Rockall was not included due to the very low numbers of individuals caught in this survey). The dataset consists of length–frequency distributions at each trawl station (over 6000 in total), together with the associated information on gear type, haul time, depth, duration and location. For each haul station, catch-rate was calculated:

total weight caught divided by the haul duration to obtain a measure of catch-per-unit of effort in terms of g/30 min.

The objective of the analysis was to obtain standardized annual indices of cpue (on which an index of relative abundance can be based) by identifying explanatory variables which help explain the variation in catch rate which is not a consequence of changes in population size. Due to the highly skewed distribution of catch rates and the presence of the large number of zeros, a 'delta' distribution approach was taken to the statistical modelling. Lo *et al.,* 1992 and Stefansson, 1996 describe this method which combines two generalized linear models (GLM): one which models the probability of a positive observation (binomial model) and the second which models the catch rate conditioned on it being positive assuming a lognormal distribution. The overall year effect (annual index) can then be calculated by multiplying the year effects estimated by the two models.

The aim of the analysis was to obtain an index of temporal changes in the cpue and therefore year was always included as a covariate (factor) in the model. Other explanatory variables included were area (Scottish demersal sampling area, see Dobby *et al.*, 2005 for further details) and month or quarter. Variables which explained greater than 5% of the deviance in previous analysis were retained in the model. All variables were included as categorical variables.

The model results, in terms of retained terms and deviance values are demonstrated in Table 2.5. Estimated effects are shown in Figure 2.18. The diagnostic plot for the final lognormal model fit is shown in Figure 2.19, indicating that the distributional assumptions are adequate: the residuals show a relatively symmetrical distribution, with no obvious departures from normality, and the residual variance shows no significant changes through the range of fitted values.

The estimated year effects for the binomial component of the model demonstrate a significant decline over the time period while the year effects for the catch rate given that it is positive do not indicate any systematic trend. It was considered that this is a potentially useful approach for obtaining an appropriate index of abundance for NE Atlantic spurdog. However, there are a number of issues associated with the analysis which should be highlighted:

- the survey data analysed only covers a proportion of the stock distribution;
- the two Scottish west coast surveys underwent a redesign in 2011, including the use of new ground-gear. No consideration has been given to potential changes in catchability due to the new ground-gear in this analysis.
- further attempts should be made to obtain sex-specific abundance indices.

2.7 Life-history information

Maturity and fecundity data were collected on the UK FSP survey. The largest immature female spurdog was 84 cm, with the smallest mature female 78 cm. The smallest mature and active female observed was 82 cm. All females ≥90 cm were mature and active. The observed uterine fecundity was 2–16 pups, and larger females produced more pups. In Q1, the embryos were either in the length range 11–12 cm or 14–18 cm, and no females exhibited signs of recently having given birth. In Q3, near-term pups were observed at lengths of 16–21 cm. During Q4, near-term and term pups of 19–24 cm were observed, and several females showed signs of recently having pupped. This further suggests that the Irish Sea may be an important region in which spurdog give birth during late autumn and early winter, although it is unclear if there are particular sites in the area that are important for pupping.

The biological parameters used in the assessment can be found in the Stock Annex.

2.8 Exploratory assessments and previous analyses

2.8.1 Previous assessments

Exploratory assessments undertaken in 2006 included the use of a delta-lognormal GLM-standardized index of abundance and a population dynamic model. This has been updated at subsequent meetings. The results from these assessments indicate that spurdog abundance has declined, and that the decline is driven by high exploitation levels in the past, coupled with biological characteristics that make this species particularly vulnerable to such intense exploitation (ICES, 2006).

2.8.2 Simulation of effects of maximum landing length regulations

Earlier demographic studies on elasmobranchs indicate that low fishing mortality on mature females may be beneficial to population growth rates (Cortés, 1999; Simpfendorfer, 1999). Hence, measures that afford protection to mature females may be an important element of a management plan for the species. As with many elasmobranchs, female spurdog attain a larger size than males, and larger females are more fecund.

Preliminary simulation studies of various Maximum Landing Length (MLL) scenarios were undertaken by ICES (2006) and suggested that there are strong potential benefits to the stock by protecting mature females. However, improved estimates of discard survivorship from various commercial gears are required to better examine the efficacy of such measures.

2.9 Stock assessment

2.9.1 Introduction

The assessment for spurdog, presented as exploratory in 2006 (ICES, 2006), was extended in 2010 to account for further years of landings data, updated statistical analyses of survey data, a split of the largest length category into two to avoid too many animals being recorded in this category, and fecundity datasets from two periods (1960 and 2005). This model was not used to provide advice as it had not been through the benchmark process. A benchmark assessment of the model was carried out in 2011 by two external reviewers (via correspondence). A summary of review comments and response to it were provided in Appendix 2a of the 2011 WGEF report (ICES, 2011).

In 2011 WGEF updated the model based on the benchmark assessment. The results of this are presented here for data up to 2013.

The statistical analysis of survey data provides a delta-lognormal GLM-standardised index of abundance (with associated CVs), based on Scottish groundfish surveys. The assessment assumes two “fleets”, with landings data split to reflect a fleet with Scottish selectivity (“non-target fleet”), and one with England & Wales selectivity (“target fleet”). The non-target and target selectivities were estimated by fitting to proportions-by-length-category data derived from Scottish and England & Wales commercial landings databases.

The assessment is based on an approach developed by Punt and Walker (1998) for school shark (*Galeorhinus galeus*) off southern Australia (De Oliveira *et al.*, 2013). The approach is essentially age- and sex-structured, but is based on processes that are length-based, such as maturity, pup-production, growth (in terms of weight) and gear selectivity, with a length–age relationship to define the conversion from length to age. Pup-production (recruitment) is closely linked to the numbers of mature females, but the model allows deviations from this relationship to be estimated (subject to a constraint on the amount of deviation).

The implementation for spurdog was coded in AD Model Builder (Otter Research). The approach is presented in De Oliveira *et al*. (2013) and is similar to Punt and Walker (1998), but uses fecundity data from two periods (1960 and 2005) in an attempt to estimate the extent of density-dependence in pup-production and fits to the Scottish groundfish surveys index of abundance, and proportion-by-length-category data from both the survey and commercial catches (aggregated across gears). Five categories were considered for the survey proportion-by-length-category data, namely length groups 16–31 cm (pups); 32–54 cm (juveniles); 55–69 cm (sub-adults); and 70–84 cm (maturing fish) and 85+ cm (mature fish). The first two categories were combined for the commercial catch data to avoid zero values.

A closer inspection of the survey proportions-by-length-category data showed a greater proportion of males than females in the largest two length categories. This could indicate a lower degree of overlap between the distribution of females and the survey area compared to males, and requires both a separate selectivity parameter to be fitted for the largest two length categories, and the survey proportion-by-length-category data to be fitted separately for females and males. However, the low numbers of animals in the largest length category (85+) resulted in the occurrence of zeros in this length category, so the approach has been to combine the two largest length categories (resulting in a total of four length categories: 16–31 cm, 32–54 cm, 55–69 cm, and ≥70 cm) when fitting to survey proportions-by-length-category data for females and males separately.

The only estimable parameters considered are the total number of pregnant females in the virgin population ($N_0^{f,preg}$), Scottish survey selectivity-by-length-category (four parameters), commercial selectivity-by-length-category for the two fleets (six parameters, three reflecting non-target selectivity, and three target selectivity), extent of density-dependence in pup production (Q_{fec}), and constrained recruitment deviations (1960–2013). Although two fecundity parameters could in principle be estimated from the fit to the fecundity data, these were found to be confounded with Q_{fec}, making estimation difficult, so instead of estimating them, values were selected on the basis of a scan over the likelihood surface. The model also assumes two commercial catch exploitation patterns that have remained constant since 1905, which is an oversimplification given the number of gears taking spurdog, and the change in the relative contribution of these gears in directed and mixed fisheries over time, but sensitivity tests are included to show the sensitivity to this assumption. Growth is considered invariant, as in the Punt and Walker (1998) approach, but growth variation could be included given appropriate data (Punt *et al*., 2001). The population dynamics model is described in more detail in the Stock Annex.

Changes in the assessment in 2011 compared to 2010 are an attempt to address some of the concerns of the reviewers following the benchmark review of spurdog in early 2011 (see Appendix to Chapter 02, ICES, 2011). These changes are summarised as follows:

- To address the concern about appropriate raising procedures for the England and Wales length–frequency data, and the concern that these data are likely heavily biased towards targeted fisheries, the estimated Scottish selectivity is treated as "non-target", and England and Wales selectivity as "target", and alternative scenarios for allocating landings data to non-target and target fisheries are explored. Further details are provided in the Appendix to Chapter 02, ICES (2011) (response R1.2).

- To address the concern that Scottish survey proportions-by-length-category data are dominated by the occasional large tow of spurdog when these occur, these data were recalculated by using the same spatial stratification that forms the basis of the delta-lognormal GLM standardisation of the survey abundance indices. Further details are provided in the Appendix to Chapter 02, ICES (2011) (response R1.5).
- To account for the lack of large females in the Scottish surveys, likely resulting from lack of availability to the survey, the two largest length categories have been combined to form a 70+ category, and separate selectivity parameters defined for males and females in this length category. Furthermore, the survey proportion-by-length-category data are fitted separately for females and males.
- To account for the presumed lack of targeting as a result of management restrictions throughout the distribution area from 2008 onwards, landings data are assumed to come entirely from non-target fisheries from 2008 onwards.

The assessment presented here is an update of the 2011 assessment (presented in ICES, 2011) that includes data up to 2013.

Life-history parameters and input data

Calculation of the life-history parameters M_a (instantaneous natural mortality rate), l_a^s (mean length-at-age for animals of sex s), w_a^s (mean weight-at-age for animals of sex s), and P_a'' (proportion females of age a that become pregnant each year) are summarised in Table 2.6, and described visually in Figure 2.20.

Landings data used in the assessment are given in Table 2.7. The assessment requires the definition of fleets with corresponding exploitation patterns, and the only information currently available to provide this comes from Scottish and England & Wales databases. Two fleets, a "non-target" fleet (Scottish data) and a "target" fleet (England & Wales data), were therefore defined and allocated to landings data. Several targeting scenarios were explored in order to show the sensitivity of model results to these allocations (ICES, 2011), and these results are included here. In order to take the model back to a virgin state, the average proportion of these fleets for 1980–1984 were used to split landings data prior to 1980, but two of the targeting scenarios assume historic landings were only from "non-target" or "target" fleets.

The Scottish survey abundance index (biomass catch rate) was derived on the basis of applying a delta-lognormal GLM model to four Scottish surveys over the period 1990–2013, and is given in Table 2.8 along with the corresponding CVs. The proportions-by-length category data derived from these surveys, along with the actual sample sizes these data are based on, is given in Table 2.9 separately for females and males.

Table 2.10 lists the proportion-by-length-category data for the two commercial fleets considered in the assessment, along with the raised sample sizes. Because these raised sample sizes do not necessarily reflect the actual sample sizes the data are based on (as they have been raised to landings), these sample sizes have been ignored in the assessment (by setting $n_{pcom,j,y} = \overline{n}_{pcom,j}$ in equation 10b of the Stock Annex); a sensitivity test conducted in ICES (2010) showed a lack of sensitivity to this assumption.

The fecundity data (see Ellis and Keable, 2008 for sampling details) are given as pairs of values reflecting length of pregnant female and corresponding number of pups, and are listed in Tables 2.11a and b for the two periods (1960 and 2005).

2.9.2 Summary of model runs

Category	Description	Figures	Tables
•Base case run		2.21–27, 2.31–33	2.12–15
•Retrospective	A 6-year retrospective analysis, using the base case run and omitting one year of data each time	2.28	
•Sensitivity			
Q_{fec}	A comparison with an alternative Q_{fec} values that fall within the 95% probability interval of Figure 2.21, with a demonstration of the deterioration in model fit to the survey abundance index for higher Q_{fec} values	2.22, 2.29	
Targeting scenarios	A comparison of alternative assumptions about targeting (taken from ICES, 2011): Tar 1: the base case (each nation is defined “non-target”, “target” or a mixture of these, with pre-1980s allocated the average for 1980–1984) Tar 2: as for WGEF in 2010 (Scottish landings are “non-target”, E&W “target”, and the remainder raised in proportion to the Scottish/E&W landings, with pre-1980s allocated the average for 1980–1984) Tar 3: as for Tar 2 but with E&W split 50% “non-target” and 50% “target” Tar 4: as for Tar 1, but with pre-1980 selection entirely non-target Tar 5: as for Tar 1, but with pre-1980 selection entirely target	2.30	2.12

2.9.3 Results for base case run

Model fits

Fecundity data available for two periods presents an opportunity to estimate the extent of density-dependence in pup-production (Q_{fec}). However, estimating this parameter along with the fecundity parameters a_{fec} and b_{fec} for the two time periods was not possible because these parameters are confounded. The approach therefore was to plot the likelihood surface for a range of fixed a_{fec} and b_{fec} input values, while estimating Q_{fec}, and the results are shown in Figure 2.21. The two periods of fecundity data are essential for the estimation of Q_{fec}, and further information that would help with the estimation of this parameter would be useful. Figure 2.21d indicates a near-linear relationship between Q_{fec} and MSYR (defined in terms of the biomass of all animals $\geq l^{f}_{mat00}$), so additional information about MSYR levels typical for this species could be used for this purpose (but has not yet been attempted).

The value of Q_{fec} chosen for the base case run (1.98) corresponded to the lower bound of the 95% probability interval shown in Figure 2.21. Lower Q_{fec} values correspond to lower productivity, so this lower bound is more conservative than other values in the probability interval. Furthermore, sensitivity tests presented below show that higher Q_{fec} values are associated with a deterioration in the model fit to the Scottish survey abundance index.

Figure 2.22 shows the model fit to the Scottish surveys abundance index for the base case value of Q_{fec} and for alternative values that still fall within the 95% confidence interval of Figure 2.21c; it is clear from Figure 2.22 that the model fit to the Scottish surveys abundance index deteriorates as Q_{fec} increases. Figure 2.23a shows the model fit to the Scottish and England & Wales commercial proportion-by-length-category data, and Figure 2.23b to the Scottish survey proportion-by-length-category data, the latter fitted separately for females and males. Model fits to the survey index and commercial proportion data appear to be reasonably good with no obvious residual patterns, and a close fit to the average proportion-by-length-category for the commercial fleets. Figure 2.23b indicates a poorer fit to the survey proportions compared to the commercial proportions, and given the residual patterns (a dominance of positive residuals for females, and, more weakly, the opposite for males) that it may be possible to estimated sex ratio (not attempted).

Figure 2.24a compares the deterministic and stochastic versions of recruitment, and plots the estimated recruitment residuals normalised by σ_r. The fits to the two periods of fecundity data are shown in Figure 2.25, highlighting the difference in the fecundity relationship with female length for the two periods, this difference being due to Q_{fec}.

Estimated parameters

Model estimates of the total number of pregnant females in the virgin population $(N_0^{f,preg})$, the extent of density-dependence in pup production (Q_{fec}), survey catchability (q_{sur}), and current (2014) total biomass levels relative to 1905 and 1955 (B_{depl05} and B_{depl55}), are shown in Table 2.12a ("Base case") together with estimates of precision. Estimates of the natural mortality parameter M_{pup}, the fecundity parameters a_{fec} and b_{fec}, and MSY parameters ($F_{prop,MSY}$, MSY, B_{MSY} and MSYR) are given in Table 2.12b. Table 2.13 provides a correlation matrix for some of the key estimable parameters (only the last five years of recruitment deviations are shown). Correlations between estimable parameters are generally low, apart from the commercial selectivity parameters associated with length categories 55–69 cm and 70–84 cm, and Q_{fec} vs. q_{sur}.

Estimated commercial- and selectivity-at-age patterns are shown in Figure 2.26, and reflect the relatively lower proportion of large animals in the survey data when compared to the commercial catch data, and the higher proportion of smaller animals in the Scottish commercial catch data compared to England & Wales (see also Figure 2.23). It should be noted that females grow to larger lengths than males, so that females are able to grow out of the second highest length category, whereas males, with an L_∞ of <85 cm (Table 2.6) are not able to do so (hence the commercial selectivity remains unchanged for the two largest length categories for males). The divergence of survey selectivity for females compared to males is a reflection of the separate selectivity parameters for females/males in the largest length category (70+ for surveys).

A plot of recruitment vs. the number of pregnant females in the population, effectively a stock–recruit plot, is given in Figure 2.24b together with the replacement line (the number of recruiting pups needed to replace the pregnant female population under no harvesting). This plot illustrates the importance of the Q_{fec} parameter in the model: a

Q_{fec} parameter equal to 1 would imply the expected value of the stock–recruit points lies on the replacement line, which implies that the population is incapable of replacing itself. A further exploration of the behaviour of Q_y and $N_{pup,y}$ (equations 2a and b in the Stock Annex) is shown in Figure 2.27.

Time-series trends

Model estimates of total biomass (B_y) and mean fishing proportion ($F_{prop5\text{-}30,y}$) are shown in Figure 2.32 together with observed annual catch ($C_y = \sum_j C_{j,y}$). They indicate a strong decline in spurdog total biomass, particularly since the 1940s (to around 15% of pre-exploitation levels, Table 2.12a), which appears to be driven by relatively high exploitation levels, given the biological characteristics of spurdog. $F_{prop5\text{-}30,y}$ appears to have declined in recent years with B_y levelling off. Figure 2.32 also shows total biomass (B_y), recruitment (R_y) and mean fishing proportion ($F_{prop5\text{-}30,y}$) together with approximate 95% probability intervals. The fluctuations in recruitment towards the end of the time-series are driven by information in the proportion-by-length-category data. Table 2.14 provides a stock summary (recruitment, total biomass, landings and $F_{prop5\text{-}30,y}$).

2.9.4 Retrospective analysis

A six year retrospective analysis (the base case model was re-run, each time omitting a further year in the data) was performed, and is shown in Figure 2.28 for the total biomass (B_y), mean fishing proportion ($F_{prop5\text{-}30,y}$) and recruitment (R_y). There are almost no signs of retrospective bias given the current model configuration.

2.9.5 Sensitivity analyses

Two sets of sensitivity analyses were carried out, as listed in the text table above.

a) Q_{fec}

The a_{fec} and b_{fec} values that provided the lower bound of the 95% probability interval (Q_{fec}=1.98; Figure 2.21a-c) was selected for the base case run. This sensitivity test compares it to the runs for which the a_{fec} and b_{fec} input values provide the optimum (Q_{fec}=2.32) and upper bound (Q_{fec}=2.92). Model result are fairly sensitive to these options (Figure 2.29, Table 2.12a and b), but higher Q_{fec} values, although still within the 95% probability interval, lead to a deterioration in the fit the Scottish survey abundance index, as demonstrated in Figure 2.22b. This is part justification for selecting the lower bound as the base case value.

b) Alternative targeting scenarios

Alternatives targeting scenarios for both the post-1980s landings data (for which data are available by nation) and the pre-1980s landings data (not available by nation) were explored in this set of sensitivity analyses presented in ICES (2011) and shown again here. The alternative scenarios are listed in Section 2.9.3, and results shown in Figure 2.30. These results indicate a general lack of sensitivity to alternative assumptions about targeting.

2.9.6 MSY $B_{trigger}$

The current estimates of B_{MSY} for spurdog is 963 741 t ("Base case" in Table 2.12b). Given the long catch history for spurdog, and the fact that this is accounted for in the assessment (in contrast to other ICES assessments), it is recommended that this estimate (rounded off to 963 700 t) be used as the value for MSY $B_{trigger}$ to be used in the ICES MSY rule for spurdog.

2.9.7 Projections

The base case assessment is used as a basis for future projections under a variety of catch options. These are based on:

- the ICES MSY rule, which assumes that $F_{prop,MSY}$=0.029 and *MSY* $B_{trigger}$=B_{MSY}=963 700 t (Table 2.12b; this rule fishes at $F_{prop,MSY}$=0.029 for total biomass values at or above *MSY* $B_{trigger}$, but reduces fishing linearly when total biomass is below *MSY* $B_{trigger}$ by the extent to which total biomass is below *MSY* $B_{trigger}$), and could accommodate bycatch in mixed fisheres (since it produces catches similar to average landings for 2007–2009);
- zero catch (for comparison purposes);
- TAC_{2009}=1422 t, the last non-zero TAC set for spurdog in 2009;
- average landings for 2007–2009=2384 t, an amount that could accommodate bycatch in mixed fisheries;
- fishing at $F_{prop,MSY}$=0.029.

Results are given in Table 2.15, expressed as total biomass in future relative to the total biomass in 2014, and are illustrated in Figure 2.31.

2.9.8 Conclusion

Since this is an updated assessment, results for the base case model is presented as the final assessment. The base case model shows almost no retrospective bias and provides reasonable fits to most of the available data. Sensitivity tests show the model to be sensitive to the range of Q_{fec} values that fall within the 95% probability interval for corresponding fecundity parameters. However, results show a marked deterioration of the model fit to the Scottish survey abundance index as Q_{fec} increases, thereby justifying the selection of the more conservative lower bound as the base case value (Q_{fec}=1.98). The model is relatively insensitivity to alternative targeting scenarios, including assumptions about selection patterns prior to 1980. A summary plot of the final assessment (the base case run), showing landings and estimates of recruitment, mean fishing proportion (with $F_{prop,MSY}$=0.029) and total biomass, together with estimates of precision, is given in Figure 2.32 and Table 2.14.

Results from the current model confirm that spurdog abundance has declined, and that the decline is driven by high exploitation levels in the past, coupled with biological characteristics that make this species particularly vulnerable to such intense exploitation.

A comparison with the 2011 assessment is provided in Figure 2.33 and shows very little difference.

2.10 Quality of assessments

WGEF has attempted various analytic assessments of NE Atlantic spurdog using a number of different approaches (see Stock Annex (2011) and ICES, 2006). Although these models have not proved entirely satisfactory (as a consequence of the quality of the assessment input data), these exploratory assessments and survey data all indicate a decline in spurdog.

2.10.1 Catch data

The WG has provided estimates of total landings of NE Atlantic spurdog and has used these, together with UK length–frequency distributions in the assessment of this stock. However, there are still concerns over the quality of these data as a consequence of:

- uncertainty in the historical level of catches because of landings being reported by generic dogfish categories;
- uncertainty over the accuracy of the landings data because of species misreporting;
- lack of commercial length–frequency information for countries other than the UK (UK landings are a decreasing proportion of the total and therefore the length frequencies may not be representative of those from the fishery as a whole);
- low levels of sampling of UK landings and lack of length–frequency data in recent years when the selection pattern may have changed due to the implementation of a maximum landing length (100 cm);
- lack of discard information.

2.10.2 Survey data

Survey data are particularly important indicators of abundance trends in stocks such as this where an analytical assessment is not available. However, it should be highlighted that:

- the survey data examined by WGEF cover only part of the stock distribution and analyses should be extended to other parts of the stock distribution;
- spurdog survey data are difficult to interpret because of the typically highly skewed distribution of catch-per-unit of effort;
- annual survey length–frequency distribution data (aggregated over all hauls) may be dominated by data from single large haul.

2.10.3 Biological information

As well as good commercial and survey data, the analytical assessments require good information on the biology of NE Atlantic spurdog. In particular, the WG would like to highlight the need for:

- updated and validated growth parameters, in particular for larger individuals;
- better estimates of natural mortality.

2.10.4 Assessment

As with any stock assessment model, the assessment relies heavily on the underlying assumptions; particularly with regard to life-history parameters (e.g. natural mortality and growth), and on the quality and appropriateness of input data. The inclusion of two periods of fecundity data has provided valuable information that allows estimation of Q_{fec}, and projecting the model back in time is needed to allow the 1960 fecundity dataset to be fitted. Nevertheless, the model has difficulty estimating both Q_{fec} and the fecundity parameters simultaneously, and additional information, such as on appropriate values of MSYR for a species such as spurdog, and possibly also additional fecundity data (which are now available but have not been included), would help with this problem. Further refinements of the model are possible, such as including variation in growth. Selectivity curves also cover a range of gears over the entire catch history, and more appropriate assumptions (depending on available data) could be considered.

In summary, the model is considered appropriate for providing an assessment of spurdog, though it could be further developed in future if the following data were available:

- Selectivity parameters disaggregated by gear for the main fisheries (i.e. for various trawl, longline and gillnets);
- Appropriate indices of relative abundance from fishery-independent surveys, with corresponding estimates of variance;
- Improved estimates for biological data (e.g. growth parameters, reproductive biology and natural mortality);
- Inclusion of additional fecundity data;
- Information on likely values of MSYR for a species such as spurdog.

2.11 Reference points

MSY considerations: Exploitation status is below $F_{prop,\mathrm{MSY}}$, as estimated from the results of the assessment. However, biomass has declined to record low levels in recent years and therefore to allow the stock to rebuild, catches should be reduced to the lowest possible level in 2015 and 2016. Current projections assuming application of the ICES MSY rule (which would accommodate bycatch in mixed fisheries) suggest that the stock will rebuild by 5–9% of its 2014 level by 2017 (Table 2.15).

$F_{prop,\mathrm{MSY}}$=0.029, as estimated by the current assessment, assuming a non-target selection pattern.

2.12 Conservation considerations

In 2006, the IUCN categorised Northeast Atlantic spurdog as 'Critically Endangered'. This categorisation was based on an exploratory assessment which gave a more pessimist view of the stock status than the assessment method that has been benchmarked by ICES. The results from the assessment presented in De Oliveira *et al.* (2013) would support an IUCN listing of 'Endangered' A Red List Workshop for European chondricthyans was held in May 2014, but the outcome of this has not been formally agreed as yet.

2.13 Management considerations

Perception of state of stock

All analyses presented in this and previous reports of WGEF have indicated that the NE Atlantic stock of spurdog has been declining rapidly and is around its lowest ever level. Preliminary assessments making use of the long time-series of commercial landings data suggest that this decline has been going on over a long period of time and that the current stock size may only be a fraction of its virgin biomass (<20%).

Although spurdog are less frequently caught in groundfish surveys than they were 20 years ago, there is some suggestion that spurdog are now being more frequently seen in survey hauls and survey catch rates starting to increase (Figure 2.12).

Stock distribution

Spurdog in the ICES area are considered to be a single stock, ranging from Subarea I to Subarea IX, although landings from the southern end of its range are likely also to include other *Squalus* species.

There should be a single TAC area. Although all areas of the stock distribution are covered by zero TACs, the establishment of bycatch TACs (10% of 2009 values) could result in area misreporting should the TAC for one area be more restrictive than the other.

Biological considerations

Spurdogs are long-lived, slow growing, have a high age-at-maturity, and are particularly vulnerable to high levels of fishing mortality. Population productivity is low, with low fecundity and a protracted gestation period. In addition, they form size- and sex-specific shoals and therefore aggregations of large fish (i.e. mature females) are easily exploited by target longline and gillnet fisheries.

Fishery and technical considerations

Those fixed gear fisheries that capture spurdog should be reviewed to examine the catch composition, and those taking a large proportion of mature females should be strictly regulated.

During 2009 and 2010, a maximum landing length (MLL) was established in EC waters to deter targeting of mature females (see Section 2.10 of ICES, 2006 for simulations on MLL). Those fisheries taking spurdog that are lively may have problems measuring fish accurately, and investigations to determine an alternative measurement (e.g. pre-oral length) that has a high correlation with total length and is more easily measured on live fish are required. Dead dogfish may also be more easily stretched on measuring, and understanding such post-mortem changes is required to inform on any levels of tolerance, in terms of enforcement.

North Sea fisheries were regulated by a bycatch quota (2007–2008), whereby spurdog should not have comprised more than 5% by live weight of the catch retained on board. This was extended to western areas in 2008. The bycatch quota was removed in 2009, when the maximum landing length was brought in.

Spurdog were historically subject to large targeted fisheries, but are increasingly now taken as a bycatch in mixed trawl fisheries. In these fisheries, measures to reduce overall demersal fishing effort should also benefit spurdog. However, a restrictive TAC in this case would likely result in increased discards of spurdog and so may not have the desired effect on fishing mortality if discard survivorship is low.

There is limited information on the distribution of spurdog pups, though they have been reported to occur in Scottish waters, in the Celtic Sea and off Ireland. The lack of accurate data on the location of pupping and nursery grounds, and their importance to the stock precludes spatial management for this species at the present time.

The survivorship of discarded juvenile spurdog is not known.

2.14 References

Albert, O.T. and Vollen, T. 2012. Plan for a Norwegian sentinel fishery for spurdog. Working document for the ICES Elasmobranch Working Group (WGEF) 2012.

Bedford, B.C., Woolner, L.E, and Jones, B.W. 1986. Length–weight relationships for commercial fish species and conversion factors for various presentations. Data Report, MAFF Directorate of Fisheries Research Lowestoft, 10: 41pp.

Cortés, E. 1999. A stochastic stage-based population model of the sandbar shark in the Western North Atlantic. *In* Life in the slow lane: Ecology and conservation of long-lived marine animals. Ed. by J.A. Musick. American Fisheries Society Symposium, 22: 115–136.

Coull, K. A., Jermyn, A. S., Newton, A. W., Henderson, G. I and W. B. Hall. 1989. Length–weight relationships for 88 species of fish encountered in the North East Atlantic. Scottish Fisheries Research Report Number 43.

De Oliveira, J. A. A., Ellis, J. R., and Dobby, H. 2013. Incorporating density dependence in pup production in a stock assessment of NE Atlantic spurdog *Squalus acanthias*. ICES Journal of Marine Science, 70: 1341–1353.

Dobby, H., Beare, D, Jones, E.and MacKenzie, K. 2005. Comparison of trends in long-term survey data for *Squalus acanthias* with a preliminary stock assessment for this species. ICES CM 2005/N:01.

Ellis, J.R. and Keable, J. 2008. The fecundity of Northeast Atlantic spurdog (*Squalus acanthias* L., 1758). ICES Journal of Marine Science, 65: 979–981.

Ellis, J.R., Doran, S., Dunlin, G., Hetherington, S., Keable, J., and Skea, N. 2010. Spurdog in the Irish Sea. Cefas, Lowestoft, Fisheries Science Partnership; 2009; Programme 9, Final Report, 28 pp. (available electronically at http://www.cefas.co.uk/data/fisheries-science-partnership-(fsp)/2008–2009-programme.aspx).

ICES. 2006. Report of the Working Group on Elasmobranch Fishes (WGEF), 14–21 June 2006, ICES Headquarters. ICES CM 2006/ACFM:31. 291 pp.

ICES. 2009a. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak - Combined Spring and Autumn (WGNSSK), 6–12 May 2009, ICES Headquarters, Copenhagen. ICES CM 2009/ACOM:10. 1028 pp.

ICES. 2009b. Report of the Working Group on the Celtic Seas Ecoregion (WGCSE), 13–19 May 2009, ICES Headquarters, Copenhagen.

ICES. 2010. Report of the Working Group on Elasmobranch Fishes (WGEF), 22–29 June 2010, Horta, Portugal. ICES CM 2010/ACOM:19. 558 pp.

ICES. 2011. Report of the Working Group on Elasmobranch Fishes (WGEF), 20–24 June 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:19. 492 pp.

ICES. 2014. 2nd Interim Report of the International Bottom Trawl Survey Working Group (IBTSWG), 31 March–4 April 2014, Hamburg, Germany. ICES CM 2014/SSGESST:11. 177 pp.

Lo, N. C., Jacobson, L. D. and Squire, J. L. 1992. Indices of relative abundance for fish spotter data based on delta-lognormal models. Canadian Journal of Fisheries and Aquatic Sciences, 49: 2515–2526.

McEachran, J. D., and Branstetter, S. 1984. *Squalidae*. In Fishes of the Northeastern Atlantic and the Mediterranean Vol. 1, pp 128–147. Ed. by P. J. P.Whitehead, M.-L.Bauchot, J.-C.Hureau, J. Nielsen, and E. Tortonese. UNESCO, Paris.

Pawson, M. J., Ellis, J. and Dobby, H. 2009. The evolution and management of spiny dogfish (spurdog) fisheries in the Northeast Atlantic. In V. F. Gallucci, G. A. McFarlane & G. C. Bargamann (eds), Biology and Management of Spiny Dogfish Sharks, American Fisheries Society, Bethesda, MD.

Punt, A. E. and Walker, T. I. 1998. Stock assessment and risk analysis for the school shark (*Galeorhinus galeus*) off southern Australia. Marine and Freshwater Research 48, 719–31.

Punt, A. E., Pribac, F., Walker T. I. and B.L. Taylor. 2001. Population modelling and harvest strategy evaluation for school and gummy shark, Report of FRDC 99/102. CSIRO Marine Research, Hobart.

Silva, J. F., Ellis, J. R., Catchpole, T. L. and Righton, D. 2013. Bycatch and discarding patterns of dogfish and sharks taken in commercial fisheries around the British Isles. Working Document to the Working Group on Elasmobranch Fishes, Lisbon, Portugal. 17–21 June 2013. 31pp.

Simpfendorfer, C. A. 1999. Demographic analysis of the dusky shark fishery in Southwestern Australia. *In* Life in the slow lane: Ecology and conservation of long-lived marine animals, pp 149–160. Ed. by J. A.Musick. American Fisheries Society Symposium, 22.

STECF. 2009. STECF Report of the SGMOS-09-05 Working Group on Fishing Effort Regimes Regarding Annex IIA of TAC & Quota Regulations and Celtic Sea.

Stefansson, G. 1996. Analysis of groundfish survey abundance data: combining the GLM and delta approaches. ICES Journal of Marine Science, 53: 577–588.

Veríssimo, A., McDowell, J. R., and Graves, J. E. 2010. Global population structure of the spiny dogfish *Squalus acanthias*, a temperate shark with an antitropical distribution. Molecular Ecology, 19: 1651–1662.

Vollen, T. 2012. Date on spurdog from two Norweigan surveys; the Shrimp survey (1984–2012) and the Coastal survey (1996–2011). Working document for the ICES Elasmobranch Working Group (WGEF) 2012.

Vollen, T. 2014. Data on spurdog from two Norwegian surveys; the Shrimp survey and the Coastal survey - updated with new data in 2014. Working document for the ICES Working Group on Elasmobranch Fishes (WGEF), 17–26 June 2014, 13 pp.

Table 2.1. Northeast Atlantic spurdog. WG estimates of total landings of NE Atlantic spurdog (1947–2013).

Year	Landings (tonnes)	Year	Landings (tonnes)	Year	Landings (tonnes)
1947	16 893	1969	52 074	1991	29 562
1948	19 491	1970	47 557	1992	29 046
1949	23 010	1971	45 653	1993	25 636
1950	24 750	1972	50 416	1994	20 851
1951	35 301	1973	49 412	1995	21 318
1952	40 550	1974	45 684	1996	17 294
1953	38 206	1975	44 119	1997	15 347
1954	40 570	1976	44 064	1998	13 919
1955	43 127	1977	42 252	1999	12 384
1956	46 951	1978	47 235	2000	15 890
1957	45 570	1979	38 201	2001	16 693
1958	50 394	1980	40 968	2002	11 020
1959	47 394	1981	39 961	2003	12 246
1960	53 997	1982	32 402	2004	9365
1961	57 721	1983	37 046	2005	8356
1962	57 256	1984	35 193	2006	4054
1963	62 288	1985	38 674	2007	2853
1964	60 146	1986	30 910	2008	1759
1965	49 336	1987	42 355	2009	2557
1966	42 713	1988	35 569	2010	1248
1967	44 116	1989	30 278	2011	580
1968	56 043	1990	29 906	2012	261
				2013	332

Table 2.2. Spurdog in the NE Atlantic. WG estimates of total landings by nation (1980–2013).

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Belgium	1097	1085	1110	1072	1139	920	1048	979	657	750	582	393	447	335	396	391
Denmark	1404	1418	1282	1533	1217	1628	1008	1395	1495	1086	1364	1246	799	486	212	146
Faroe Islands	0	22	0	0	0	0	0	0	0	6	2	3	25	137	203	310
France	17 514	19 067	12 430	12 641	8356	8867	7022	11 174	7872	5993	4570	4370	4908	4831	3329	1978
Germany	43	42	39	25	8	22	41	48	27	24	26	6	55	8	21	100
Iceland	36	22	14	25	5	9	7	5	4	17	15	53	185	108	97	166
Ireland	108	476	1268	4658	6930	8791	5012	8706	5612	3063	1543	1036	1150	2167	3624	3056
Netherlands	217	268	183	315	0	0	0	0	0	0	0	0	0	0	0	0
Norway	5925	3941	3992	4659	4279	3487	2986	3614	4139	5329	8104	9633	7113	6945	4546	3940
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portugal	2	0	0	0	0	0	1	5	3	2	128	188	250	323	190	256
Russia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	8	653	0	0	0	0	0	0	0	0	0	0	0	0
Sweden	399	308	398	300	256	360	471	702	733	613	390	333	230	188	95	104
UK (E&W)	9229	9342	8024	6794	8046	7841	7047	7684	6952	5371	5414	3770	4207	3494	3462	2354
UK (Sc)	4994	3970	3654	4371	4957	6749	6267	8043	8075	8024	7768	8531	9677	6614	4676	8517
Total	40 968	39 961	32 402	37 046	35 193	38 674	30 910	42 355	35 569	30 278	29 906	29 562	29 046	25 636	20 851	21 318

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	430	443	382	354	400	410	23	11	13	20	17	0	0	7	1	0	0	0
Denmark	142	196	126	131	146	156	107	232	219	82	68	0	0	0	11	26	31	20
Faroe Islands	51	218	362	486	368	613	340	224	295	225	271	241	144	462	179	104	0	0
France	1607	1555	1286	998	4342	4304	2569	1705	1062	2426	715	453	366	577	348	131	42	13
Germany	38	21	31	54	194	304	121	98	138	144	6	0	0	1	1	1	1	0
Iceland	156	106	80	57	107	199	276	200	142	71	75	36	52	95	58	51	44	6
Ireland	2305	2214	1164	904	905	1227	1214	1416	1076	940	614	558	163	214	26	11	2	27
Netherlands	0	0	0	0	28	39	27	10	25	41	34	28	26	5	7	2	28	3
Norway	2748	1567	1293	1461	1643	1424	1091	1119	1054	1010	790	616	711	543	541	246	108	251
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portugal	120	100	46	21	2	3	4	4	9	6	10	9	4	2	2	3	2	2
Russia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	28	95	372	363	306	135	17	71	106	16	15	32	6	4	0	4
Sweden	154	196	140	114	123	238	0	275	244	170	148	95	9	80	5	0	0	0
UK (E&W)	2670	3066	4480	4461	3654	4516	2823	3109	1729	1887	434	386	91	194	8	0	2	1
UK (Sc)	6873	5665	4501	3248	3606	2897	2120	3708	3342	1263	766	415	178	345	56	1	1	6
Total	17 294	15 347	13 919	12 384	15 890	16 693	11 020	12 246	9365	8356	4054	2853	1759	2557	1248	580	261	332

Table 2.3. Spurdog in the NE Atlantic. WG estimates of landings by ICES subarea (1980–2012).

Area	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Baltic	0	0	0	0	0	0	0	1	0	0	0	1	3	0	0	0
I and II	138	20	28	760	40	120	137	417	1559	2808	4296	6614	5063	5102	3124	2725
III and IV	20 544	16 181	11 965	11 572	10 557	11 136	8986	11 653	10 800	10 423	11 497	9264	10 505	6591	4360	7347
V	45	27	18	27	5	22	9	41	6	73	182	133	336	335	364	484
VI	4590	4011	5052	7007	8491	12422	8107	9038	7517	6406	5407	6741	6268	5927	5622	5164
VIIA	2722	4013	4566	4001	6336	6774	6458	7305	5569	3389	2801	2527	2669	2700	2313	1185
VIIB,C	704	925	424	1777	2178	1699	1197	2401	1579	893	369	293	316	2009	1175	1004
VIID,E, F	6693	8210	5989	4664	2450	1280	1644	2892	2120	1634	1339	1122	852	785	800	760
VIIG–K	4793	5479	3881	6924	4902	4965	3864	8106	6175	4477	3736	2495	2622	1745	2680	2034
VIII	739	1095	479	312	234	257	507	497	242	174	273	367	406	435	406	602
IX	0	0	0	0	0	0	1	4	1	2	4	4	2	5	7	5
X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
XII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
XIV	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0
Other or unspecified	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Total	40 968	39 961	32 402	37 046	35 193	38 674	30 910	42 355	35 569	30 278	29 906	29 562	29 046	25 636	20 851	21 318

Area	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Baltic	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
I and II	1853	582	607	779	894	462	357	440	423	685	498	312	337	230	190	92	50	74
III and IV	5299	4977	3895	2705	2475	2516	1904	2395	2163	1019	742	550	490	554	407	185	92	200
V	217	320	442	545	879	1406	808	583	677	473	457	352	211	565	240	155	44	6
VI	4168	3412	2831	2715	5977	5624	3169	3398	2630	2841	851	502	165	265	75	0	1	0
VIIA	1650	1534	1771	2153	1599	1878	1529	2021	938	605	411	280	74	114	3	1	0	3
VIIB,C	603	450	854	1037	1028	816	527	588	432	358	270	262	56	95	7	0	1	0
VIID,E, F	852	646	443	411	438	555	295	268	278	290	174	197	162	314	166	109	43	17
VIIG–K	2229	2984	2656	1822	2161	2846	2130	2339	1739	1973	531	338	196	340	112	14	1	24
VIII	408	418	308	171	405	469	269	134	56	97	85	50	64	80	38	17	26	4
IX	2	2	2	3	19	8	11	5	14	7	35	9	4	5	4	7	2	4
X	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
XII	0	12	104	22	14	41	22	74	12	9	0	0	0	0	0	0	0	0
XIV	0	0	0	0	0	63	0	0	0	0	0	0	0	0	0	0	0	0
Other or unspecified	12	10	6	4	1	2	0	0	0	0	1	0	0	2	5	0	0	0
Total	17 294	15 347	13 919	12 384	15 890	16 693	11 020	12 246	9365	8356	4054	2853	1759	2557	1248	580	261	332

Table 2.4. Spurdog in the NE Atlantic. Norwegian Shrimp and Coastal survey, 1984–2014. Month of survey, mean duration of tows, total number of stations, number of stations with spurdog, total number of spurdog caught, and mesh size used. Source: Vollen (2014 WD).

Year	Survey	Month of survey	Mean duration (h)	# of stations	# of stations with spurdog	# spurdogs caught	Mesh size	Survey	Month of survey	Mean duration (h)	# of stations	# of stations with spurdog	# spurdogs caught	Mesh shze
1984	S	10–11	0.96	59	10	67								
1985	S	10–11	1.00	86	29	303								
1986	S	10–11	0.96	57	26	341								
1987	S	10–11	0.99	93	29	90								
1988	S	10–11	0.97	102	29	87								
1989	S	10–11	0.50	89	11	18	35							
1990	S	10–11	0.49	77	19	130	35							
1991	S	10–11	0.52	101	11	38	35							
1992	S	10–11	0.50	99	12	22	35							
1993	S	10–11	0.50	106	10	14	35							
1994	S	10–11	0.47	101	10	18	35							
1995	S	10–11	0.48	102	8	15	35	C	9–10	0.43	29	6	22	40
1996	S	10–11	0.50	103	4	15	35	C	9–10	0.45	22	5	9	40
1997	S	10–11	0.49	93	10	18	35	C	8–9	0.42	44	1	2	20
1998	S	10–11	0.49	95	9	14	20	C	10–11	0.47	33	8	106	20
1999	S	10–11	0.50	97	4	7	20	C	10–11	0.44	34	2	4	20
2000	S	10–11	0.50	98	5	18	20	C	10–11	0.47	28	6	12	20
2001	S	10–11	0.50	70	2	3	20	C	10–11	0.42	17	5	64	20
2002	S	10–11	0.50	77	1	1	20	C	10–11	0.46	37	4	43	20
2003	S	10–11	0.53	68	12	34	20	C	10–11	0.44	23	4	21	20

Year	Survey	Month of survey	Mean duration (h)	# of stations	# of stations with spurdog	# spurdogs caught	Mesh size	Survey	Month of survey	Mean duration (h)	# of stations	# of stations with spurdog	# spurdogs caught	Mesh shze
2004	S	5–6	0.50	60	7	48	20	C	10–11	0.37	33	5	104	20
2005	S	5–6	0.51	86	7	12	20	C	10–11	0.46	18	2	17	20
2006	S	1–2	0.49	43	9	33	20	C	10–11	0.30	34	8	52	20
2007	S	1–2	0.50	64	14	27	20	C	10–11	0.35	36	7	35	20
2008	S	1–2	0.51	73	13	52	20	C	10–11	0.56	7	0	0	20
2009	S	1–2	0.47	92	16	39	20	C	10–11	0.39	19	0	0	20
2010	S	1–2	0.47	95	20	34	20	C	10–11	0.36	26	3	25	20
2011	S	1–2	0.49	97	18	43	20	C	10–11	0.33	20	5	6	20
2012	S	1–2	0.47	63	14	71	20	C	10–11	0.36	31	5	9	20
2013	S	1–2	0.38	100	35	177	20	C	10	0.42	19	1	1	20
2014	S	1	0.47	68	18	99	20							

Table 2.5. Spurdog in the NE Atlantic. Analysis of Scottish survey data. Summary of significance of terms in final delta-lognormal cpue model.

Binomial model	Df	Deviance	Resid df	Resid dev	%	P(>|Chi|)
			6212	6897.7		
as.factor(year)	23	82.49	6189	6815.3	5%	1.25e-08
as.factor(month)	11	1061.37	6178	5753.9	68%	< 2.20E-16
as.factor(roundarea)	19	421.41	6159	5332.5	27%	< 2.20E-16

Lognormal model	Df	Deviance	Resid df	Resid dev	%	Pr(>F)
			1512	4146.5		
as.factor(year)	23	222.81	1489	3923.6	30%	1.45E-10
as.factor(Q)	3	338.04	1486	3585.6	45%	<2.20E-16
as.factor(roundarea)	17	192.25	1469	3393.4	26%	2.19E-10

Table 2.6. Northeast Atlantic spurdog. Description of life-history equations and parameters.

Parameters	Description/values	Sources
M_a	Instantaneous natural mortality at age *a*: $$M_a = \begin{cases} M_{pup} e^{-a \ln(M_{pup}/M_{adult})/a_{M1}} & a < a_{M1} \\ M_{adult} & a_{M1} \le a \le a_{M2} \\ M_{til} / [1 + e^{-M_{gam}(a-(A+a_{M2})/2)}] & a > a_{M2} \end{cases}$$	
a_{M1}, a_{M2}	4, 30	expert opinion
M_{adult}, M_{til}, M_{gam}	0.1, 0.3, 0.04621	expert opinion
M_{pup}	Calculated to satisfy balance equation 2.7	
l_a^s	Mean length-at-age a for animals of sex *s* $$l_a^s = L_\infty^s (1 - e^{-\kappa^s (a - t_0^s)})$$	
L_∞^f, L_∞^m	110.66, 81.36	average from literature
κ^f, κ^m	0.086, 0.17	average from literature
t_0^f, t_0^m	-3.306, -2.166	average from literature
w_a^s	Mean weight at age *a* for animals of sex *s* $$w_a^s = a^s (l_a^s)^{b^s}$$	
a^f, b^f	0.00108, 3.301	Bedford *et al.*, 1986
a^m, b^m	0.00576, 2.89	Coull *et al.*, 1989
l_{mat00}^f	Female length at first maturity 70 cm	average from literature
P_a''	Proportion females of age a that become pregnant each year $$P_a'' = \frac{P_{\max}''}{1 + \exp\left[-\ln(19) \frac{l_a^f - l_{mat50}^f}{l_{mat95}^f - l_{mat50}^f} \right]}$$ where $P_{\max}''$ is the proportion very large females pregnant each year, and l_{matx}^f the length at which *x*% of the maximum proportion of females are pregnant each year	
$P_{\max}''$	0.5	average from literature
l_{mat50}^f, l_{mat95}^f	80 cm, 87 cm	average from literature

Table 2.7. Northeast Atlantic spurdog. Landings used in the assessment, with the allocation to "Non-target" and "Target" as assumed for the base case run. Estimated Scottish selectivity (based on fits to proportions by length category data for the period 1991–2004) is assumed to represent "non-target" fisheries, and estimated England and Wales selectivity (based on fits to proportions by length category data for the period 1983–2001) "target" fisheries. The allocation to "Non-target" and "Target" shown below is based on categorising each nation as having fisheries that are "non-target", "target" or a mixture of these from 1980 onwards. An average for the period 1980–1984 is assumed for the "non-target"/"target" split prior to 1980, while all landings from 2008 onwards are assumed to come from "non-target" fisheries. Landings from 2010 onwards are assumed to be the average for 2007–2009.

	Non-target	Target	Total		Non-target	Target	Total		Non-target	Target	Total
1905	3503	3745	7248	1942	5135	5490	10625	1979	18462	19739	38201
1906	1063	1137	2200	1943	3954	4227	8181	1980	20770	20198	40968
1907	690	738	1428	1944	3939	4212	8151	1981	20953	19009	39962
1908	681	728	1409	1945	3275	3501	6776	1982	16075	16327	32402
1909	977	1045	2022	1946	5265	5630	10895	1983	17095	19951	37046
1910	755	808	1563	1947	8164	8729	16893	1984	15047	20147	35194
1911	946	1011	1957	1948	9420	10071	19491	1985	17048	21626	38674
1912	1546	1653	3199	1949	11120	11890	23010	1986	15138	15772	30910
1913	1957	2093	4050	1950	11961	12789	24750	1987	19557	22797	42354
1914	1276	1365	2641	1951	17060	18241	35301	1988	17292	18277	35569
1915	1258	1344	2602	1952	19597	20953	40550	1989	15354	14923	30277
1916	258	276	534	1953	18464	19742	38206	1990	14390	15516	29906
1917	164	175	339	1954	19607	20963	40570	1991	14034	15529	29563
1918	218	233	451	1955	20843	22284	43127	1992	15711	13335	29046
1919	1285	1374	2659	1956	22691	24260	46951	1993	12268	13369	25637
1920	2125	2271	4396	1957	22023	23547	45570	1994	9238	11613	20851
1921	2572	2749	5321	1958	24355	26039	50394	1995	12104	9214	21318
1922	2610	2791	5401	1959	22905	24489	47394	1996	10026	7269	17295
1923	2733	2922	5655	1960	26096	27901	53997	1997	9157	6190	15347
1924	3071	3284	6355	1961	27896	29825	57721	1998	8509	5410	13919
1925	3247	3472	6719	1962	27671	29585	57256	1999	7233	5152	12385
1926	3517	3760	7277	1963	30103	32185	62288	2000	9282	6607	15889
1927	4057	4338	8395	1964	29068	31078	60146	2001	9513	7180	16693
1928	4602	4920	9522	1965	23843	25493	49336	2002	6019	5001	11020
1929	4504	4816	9320	1966	20642	22071	42713	2003	7167	5080	12247
1930	5758	6156	11914	1967	21320	22796	44116	2004	5717	3647	9364
1931	5721	6117	11838	1968	27085	28958	56043	2005	4165	4192	8357
1932	8083	8643	16726	1969	25166	26908	52074	2006	2616	1439	4055
1933	9784	10460	20244	1970	22983	24574	47557	2007	1770	1083	2853
1934	9848	10530	20378	1971	22063	23590	45653	2008	1737	0	1737
1935	10761	11505	22266	1972	24365	26051	50416	2009	2561	0	2561
1936	10113	10812	20925	1973	23880	25532	49412	2010	2384	0	2384
1937	11565	12365	23930	1974	22078	23606	45684	2011	2384	0	2384
1938	8794	9402	18196	1975	21322	22797	44119	2012	2384	0	2384
1939	9723	10396	20119	1976	21295	22769	44064	2013	2384	0	2384
1940	4556	4872	9428	1977	20420	21832	42252				
1941	4224	4516	8740	1978	22828	24407	47235				

Table 2.8. Northeast Atlantic spurdog. Delta-lognormal GLM-standardised index of abundance (with associated CVs), based on Scottish groundfish surveys.

YEAR	INDEX	CV
1990	153.3	0.32
1991	90.8	0.32
1992	76.9	0.31
1993	143.2	0.31
1994	125.6	0.35
1995	48.3	0.45
1996	80.2	0.35
1997	52.2	0.35
1998	78.7	0.34
1999	166.6	0.33
2000	69.0	0.36
2001	89.7	0.33
2002	89.5	0.33
2003	83.9	0.34
2004	59.8	0.36
2005	75.4	0.35
2006	60.7	0.34
2007	83.0	0.31
2008	72.3	0.35
2009	58.9	0.36
2010	88.6	0.46
2011	83.8	0.38
2012	72.5	0.38
2013	70.8	0.38

Table 2.9. Northeast Atlantic spurdog. Scottish survey proportions-by-length category for females (top) and males (bottom), with the actual sample sizes given in the second column.

	$n_{psur,y}$	16-31	32-54	55-69	70+
Females					
1990	539	0.0112	0.2685	0.1265	0.1272
1991	962	0.0636	0.1218	0.1092	0.1123
1992	145	0.1430	0.1514	0.2055	0.0424
1993	398	0.1259	0.1635	0.0788	0.1296
1994	1656	0.0744	0.2426	0.0519	0.0352
1995	2278	0.0572	0.3087	0.0779	0.1520
1996	230	0.0722	0.2381	0.0831	0.0684
1997	167	0.0438	0.2011	0.0955	0.0815
1998	446	0.0361	0.2404	0.1201	0.1731
1999	186	0.0316	0.0787	0.0331	0.1079
2000	1994	0.0962	0.2136	0.0456	0.1149
2001	118	0.0132	0.2060	0.0735	0.1363
2002	148	0.0428	0.0789	0.1773	0.1879
2003	224	0.0123	0.1578	0.0788	0.1898
2004	63	0.0412	0.0834	0.1240	0.0597
2005	121	0.0243	0.1434	0.1568	0.0756
2006	92	0.0360	0.1130	0.1727	0.0413
2007	152	0.0287	0.1773	0.1075	0.1657
2008	232	0.0708	0.1590	0.0127	0.1047
2009	233	0.0427	0.1175	0.2547	0.1167
2010	3495	0.1787	0.2687	0.1127	0.0002
2011	130	0.0183	0.1565	0.0684	0.1812
2012	808	0.0364	0.2320	0.0855	0.1316
2013	65	0.1713	0.2228	0.0146	0.1513
Males					
1990	1044	0.0204	0.1300	0.0575	0.2587
1991	1452	0.0711	0.1273	0.0824	0.3123
1992	154	0.2324	0.0534	0.0504	0.1215
1993	644	0.0503	0.1202	0.1555	0.1762
1994	2467	0.0832	0.1809	0.1472	0.1847
1995	1905	0.0566	0.1259	0.0478	0.1738
1996	453	0.0597	0.1480	0.1237	0.2068
1997	270	0.0228	0.1033	0.0803	0.3716
1998	436	0.0207	0.0974	0.0969	0.2155
1999	503	0.0269	0.2437	0.1136	0.3646
2000	2045	0.0100	0.1144	0.0799	0.3255
2001	221	0.0141	0.1045	0.0753	0.3771
2002	264	0.0252	0.0654	0.1209	0.3016
2003	392	0.0209	0.0818	0.1257	0.3328
2004	190	0.0045	0.1397	0.1250	0.4225
2005	225	0.0297	0.0572	0.1506	0.3622
2006	180	0.0846	0.0992	0.1027	0.3505
2007	264	0.0044	0.1786	0.1423	0.1954
2008	395	0.0699	0.1482	0.0669	0.3678
2009	417	0.0252	0.1247	0.0719	0.2466
2010	2478	0.0028	0.1863	0.0644	0.1861
2011	567	0.0170	0.0896	0.0836	0.3853
2012	1278	0.0434	0.1249	0.0495	0.2968
2013	59	0.0242	0.1673	0.0639	0.1847

Table 2.10. Northeast Atlantic spurdog. Commercial proportions-by-length category (males and females combined), for each of the two fleets (Scottish, England & Wales), with raised sample sizes given in the second column.

	$n_{pcom,j,y}$	16-54	55-69	70-84	85+
Scottish commercial proportions					
1991	6167824	0.0186	0.4014	0.5397	0.0404
1992	6104263	0.0172	0.1844	0.7713	0.0272
1993	4295057	0.0020	0.2637	0.7106	0.0236
1994	3257630	0.0301	0.3322	0.5857	0.0520
1995	5710863	0.0112	0.2700	0.6878	0.0309
1996	2372069	0.0069	0.4373	0.5416	0.0142
1997	3769327	0.0091	0.3297	0.5909	0.0702
1998	3021371	0.0330	0.4059	0.5286	0.0325
1999	1869109	0.0145	0.3508	0.5792	0.0556
2000	1856169	0.00001	0.1351	0.7683	0.0967
2001	1580296	0.0021	0.2426	0.7022	0.0531
2002	1264383	0.0529	0.3106	0.5180	0.1186
2003	1695860	0.0011	0.2673	0.5729	0.1587
2004	1688197	0.0106	0.2292	0.6893	0.0708
England & Wales commercial proportion					
1983	243794	0.0181	0.4010	0.4778	0.1030
1984	147964	0.0071	0.2940	0.4631	0.2359
1985	97418	0.0015	0.1679	0.6238	0.2068
1986	63890	0.0004	0.1110	0.6410	0.2476
1987	116136	0.0027	0.1729	0.5881	0.2362
1988	168995	0.0085	0.0973	0.5611	0.3332
1989	109139	0.0011	0.0817	0.5416	0.3757
1990	39426	0.0168	0.1349	0.5369	0.3115
1991	42902	0.0013	0.1039	0.5312	0.3637
1992	23024	0.0003	0.1136	0.4847	0.4013
1993	15855	0.0012	0.1741	0.4917	0.3331
1994	14279	0.0026	0.2547	0.3813	0.3614
1995	48515	0.0007	0.1939	0.4676	0.3378
1996	16254	0.0082	0.3258	0.4258	0.2402
1997	22149	0.0032	0.1323	0.4082	0.4563
1998	21026	0.0007	0.1075	0.4682	0.4236
1999	9596	0.0037	0.1521	0.5591	0.2851
2000	10185	0.0001	0.0729	0.4791	0.4480
2001	17404	0.0024	0.1112	0.4735	0.4128

Table 2.11a. Northeast Atlantic spurdog. Fecundity data for 1960, given as length of pregnant female (l^f) and number of pups (P'). Total number of samples is 783.

l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'
73	3	84	4	86	3	87	7	88	3	89	4	90	1	91	7	93	3	94	5	96	10	101	11
73	3	84	6	86	3	87	8	88	5	89	4	90	3	91	8	93	4	94	5	96	10	101	7
75	3	84	6	86	3	87	9	88	5	89	5	90	3	91	8	93	5	94	6	96	7	102	5
77	3	84	3	86	4	87	2	88	6	89	7	90	5	91	3	93	5	94	6	96	7	102	10
78	3	84	3	86	4	87	5	88	6	89	8	90	6	91	4	93	5	94	7	96	8	102	3
79	2	84	4	86	4	87	5	88	6	89	8	90	8	91	4	93	5	94	8	97	4	103	14
79	3	84	4	86	4	87	5	88	7	89	5	90	5	91	7	93	5	94	8	97	4	103	9
79	4	84	4	86	5	87	5	88	8	89	6	90	6	91	4	93	6	94	8	97	7	103	15
79	4	84	5	86	5	87	6	88	6	89	6	90	6	91	5	93	8	94	9	97	2	103	9
79	3	84	6	86	5	87	5	88	6	89	8	90	7	91	7	93	9	94	9	97	3	103	15
80	4	84	6	86	5	87	5	88	8	90	1	90	7	91	7	93	5	94	9	97	3	105	11
80	3	84	4	86	6	87	6	88	9	90	2	90	9	91	8	93	5	94	11	97	3	110	8
80	4	84	4	86	2	87	7	89	3	90	3	90	10	92	2	93	5	94	3	97	4	117	9
80	5	84	6	86	3	87	7	89	3	90	3	91	2	92	4	93	6	94	3	97	4		
80	2	84	6	86	4	87	7	89	4	90	3	91	3	92	5	93	6	94	8	97	4		
80	3	84	6	86	4	87	8	89	4	90	3	91	4	92	7	93	6	94	9	97	5		
80	3	84	6	86	5	87	9	89	4	90	5	91	5	92	2	93	8	94	9	97	6		
80	5	84	3	86	5	88	2	89	6	90	5	91	5	92	2	93	9	94	9	97	6		
81	1	84	4	86	5	88	2	89	2	90	5	91	6	92	2	93	9	94	11	97	7		
81	3	84	4	86	5	88	2	89	2	90	6	91	6	92	2	93	4	95	3	97	3		
81	3	84	4	86	6	88	4	89	3	90	7	91	7	92	2	93	6	95	6	97	5		
81	3	84	6	86	6	88	4	89	3	90	1	91	2	92	2	93	6	95	6	97	6		
81	6	84	6	86	7	88	5	89	3	90	2	91	2	92	3	93	6	95	8	97	7		
81	3	84	6	86	5	88	5	89	3	90	2	91	2	92	3	93	7	95	3	97	4		
81	3	84	6	86	6	88	5	89	3	90	3	91	2	92	3	93	9	95	4	97	6		
82	3	85	3	86	7	88	5	89	3	90	3	91	2	92	3	93	9	95	4	97	8		
82	4	85	3	86	7	88	6	89	4	90	3	91	3	92	3	93	9	95	4	97	9		
82	4	85	4	86	7	88	1	89	4	90	3	91	3	92	4	93	9	95	5	97	9		
82	4	85	5	86	8	88	2	89	4	90	4	91	4	92	4	93	9	95	7	97	4		
82	5	85	5	86	1	88	3	89	4	90	4	91	4	92	5	93	10	95	7	97	6		
82	6	85	5	86	2	88	3	89	4	90	4	91	4	92	5	93	11	95	7	97	7		
82	1	85	5	86	2	88	3	89	4	90	4	91	4	92	6	93	1	95	9	97	7		
82	4	85	5	86	3	88	3	89	4	90	4	91	4	92	6	93	4	95	6	97	9		
82	4	85	7	86	4	88	3	89	4	90	4	91	4	92	6	93	7	95	9	97	6		
82	6	85	1	86	5	88	3	89	4	90	5	91	4	92	6	93	4	95	7	97	8		
82	6	85	3	86	6	88	4	89	4	90	5	91	5	92	7	93	6	95	8	97	9		
82	5	85	3	86	7	88	4	89	5	90	5	91	5	92	7	93	6	95	10	98	1		
82	6	85	3	86	7	88	4	89	5	90	5	91	5	92	8	93	6	95	11	98	5		
82	5	85	4	86	7	88	4	89	5	90	5	91	5	92	9	93	7	95	11	98	6		
82	6	85	4	86	8	88	5	89	5	90	6	91	6	92	4	93	9	95	11	98	9		
82	5	85	4	87	2	88	5	89	5	90	6	91	6	92	5	93	9	95	4	98	9		
83	3	85	5	87	3	88	5	89	5	90	6	91	6	92	6	93	9	95	7	98	8		
83	2	85	5	87	4	88	5	89	6	90	8	91	6	92	6	93	9	95	8	98	8		
83	2	85	3	87	5	88	5	89	6	90	9	91	6	92	6	93	10	95	11	98	9		
83	3	85	4	87	6	88	5	89	6	90	4	91	7	92	7	93	11	95	11	98	12		
83	4	85	4	87	3	88	5	89	6	90	4	91	7	92	8	94	5	95	11	98	8		
83	5	85	5	87	4	88	5	89	6	90	4	91	7	92	6	94	6	96	4	98	8		
83	4	85	5	87	4	88	6	89	6	90	5	91	7	92	6	94	6	96	4	98	9		
83	4	85	5	87	4	88	6	89	7	90	5	91	4	92	7	94	6	96	9	99	6		
83	5	85	6	87	5	88	6	89	4	90	5	91	4	92	10	94	7	96	4	99	6		
83	5	85	6	87	5	88	6	89	4	90	6	91	4	92	3	94	9	96	5	99	8		
83	5	85	6	87	5	88	6	89	4	90	6	91	4	92	3	94	3	96	5	99	4		
83	6	85	7	87	7	88	6	89	4	90	6	91	4	92	4	94	3	96	5	99	8		
83	4	85	4	87	3	88	4	89	4	90	6	91	5	92	5	94	3	96	5	99	15		
83	4	85	5	87	4	88	5	89	4	90	7	91	6	92	6	94	4	96	6	99	8		
83	4	85	7	87	5	88	5	89	5	90	7	91	6	92	6	94	4	96	6	100	6		
83	6	85	8	87	5	88	5	89	5	90	7	91	6	92	7	94	4	96	6	100	9		
83	4	85	3	87	5	88	6	89	6	90	7	91	6	92	7	94	5	96	6	100	10		
83	4	85	4	87	6	88	6	89	6	90	9	91	6	92	7	94	5	96	8	100	14		
83	4	85	5	87	6	88	6	89	6	90	9	91	7	92	10	94	5	96	5	100	7		
83	6	85	6	87	7	88	5	89	6	90	5	91	7	92	6	94	6	96	5	100	10		
84	3	85	7	87	7	88	5	89	7	90	6	91	7	93	1	94	6	96	6	100	14		
84	3	85	4	87	7	88	6	89	3	90	6	91	8	93	4	94	6	96	6	101	4		
84	3	86	2	87	5	88	6	89	5	90	6	91	8	93	5	94	7	96	8	101	6		
84	4	86	3	87	5	88	6	89	6	90	7	91	8	93	6	94	7	96	8	101	6		
84	6	86	3	87	5	88	6	89	6	90	7	91	8	93	7	94	7	96	7	101	10		
84	3	86	4	87	6	88	7	89	8	90	8	91	4	93	8	94	7	96	7	101	7		
84	3	86	5	87	6	88	8	89	8	90	9	91	5	93	1	94	7	96	8	101	9		
84	3	86	2	87	7	88	8	89	3	90	10	91	7	93	2	94	8	96	10	101	11		
84	4	86	2	87	7	88	9	89	3	90	1	91	7	93	2	94	4	96	10	101	9		

Table 2.11b. Northeast Atlantic spurdog. Fecundity data for 2005, given as length of pregnant female (l^f) and number of pups (P'). Total number of samples is 179.

l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'	l^f	P'
84	6	92	9	94	11	97	5	98	12	100	7	101	14	102	13	103	11	105	16	107	11	109	18
87	8	92	5	95	7	97	12	98	7	100	12	101	9	102	12	103	11	105	15	107	12	109	13
89	6	92	8	95	9	97	7	98	13	100	11	101	14	102	13	103	11	105	15	107	15	109	16
89	6	92	9	95	10	97	12	98	13	100	12	101	10	102	5	103	16	105	5	107	16	110	15
89	5	92	3	95	11	97	14	98	10	100	8	101	10	102	13	104	14	105	16	107	17	110	10
89	3	93	5	96	11	97	14	98	7	100	9	101	10	102	12	104	11	105	19	107	12	110	13
89	8	93	3	96	10	97	7	98	12	100	10	101	12	102	17	104	12	105	11	108	16	111	19
89	5	93	9	96	7	97	7	98	12	100	9	102	17	102	13	104	14	105	8	108	13	112	17
90	9	93	4	96	7	98	12	98	10	100	9	102	3	103	14	104	14	105	17	108	16	112	12
90	7	93	11	96	11	98	12	99	10	100	12	102	15	103	11	104	15	105	13	108	14	112	16
90	9	94	8	96	10	98	7	99	11	100	14	102	16	103	14	104	13	106	16	108	14	113	15
90	4	94	6	97	12	98	16	99	8	101	17	102	13	103	14	104	14	106	16	108	12	113	21
91	6	94	9	97	6	98	8	99	11	101	13	102	10	103	13	104	17	106	14	109	15	114	14
91	6	94	5	97	8	98	11	99	12	101	13	102	12	103	16	105	15	106	7	109	13	116	16
92	8	94	9	97	8	98	5	99	11	101	6	102	13	103	15	105	12	107	12	109	10		

Table 2.12a. Northeast Atlantic spurdog. Estimates of key model parameters, with associated Hessian-based estimates of precision (CV expressed as a percentage and given in square parentheses) for the base-case run, and two sensitivity tests for assuming alternative selectivity-at-age prior to 1980.

	Base case (Q_{FEC}=1.98)		Q_{FEC}=2.32		Q_{FEC}=2.92	
$N_0^{f,preg}$	96 851	[2.1%]	86 577	[2.0%]	73 502	[2.1%]
Q_{fec}	1.978	[1.8%]	2.321	[2.1%]	2.919	[3.2%]
q_{sur}	0.00061694	[22%]	0.00061065	[22%]	0.0005358	[23%]
B_{depl05}	0.150	[27%]	0.180	[29%]	0.280	[32%]
B_{depl55}	0.185	[27%]	0.218	[28%]	0.324	[32%]

Table 2.12b. Northeast Atlantic spurdog. Estimates of other estimates of interest for the base case run, and two sensitivity tests for assuming alternative selectivity-at-age prior to 1980.

	Base case (Q_{FEC}=1.98)	Q_{FEC}=2.32	Q_{FEC}=2.92
M_{pup}	0.758	0.683	0.581
a_{fec}	-12.598	-10.445	-8.358
b_{fec}	0.184	0.155	0.126
$F_{prop,MSY}$	0.0289	0.0352	0.0447
MSY	20 321	23 975	28 742
B_{MSY}	963 741	898 658	818 748
M_{SYR}	0.0293	0.0382	0.0525

Table 2.13. Northeast Atlantic spurdog. Correlation matrix for some key estimable parameters for the base-case.

	$N_0^{f,preg}$	$S_{C2,NON-TGT}$	$S_{C2,TGT}$	$S_{C3,NON-TGT}$	$S_{C3,TGT}$	$S_{C4,NON-TGT}$	$S_{C4,TGT}$	S_{S1}	S_{S2}	S_{S3}	S_{S4}	Q_{FEC}	$\varepsilon_{R,09}$	$\varepsilon_{R,010}$	$\varepsilon_{R,11}$	$\varepsilon_{R,12}$	$\varepsilon_{R,13}$	q_{SUR}
$N_0^{f,preg}$	1																	
$S_{c2,non-tgt}$	-0.12	1																
$S_{c2,tgt}$	-0.01	0.00	1															
$S_{c3,non-tgt}$	-0.24	0.41	0.01	1														
$S_{c3,tgt}$	-0.05	0.01	0.08	0.07	1													
$S_{c4,non-tgt}$	-0.32	0.42	0.01	0.88	0.09	1												
$S_{c4,tgt}$	-0.21	0.07	0.10	0.20	0.55	0.24	1											
S_{s1}	0.04	-0.05	-0.01	-0.13	-0.09	-0.14	-0.15	1										
S_{s2}	0.07	-0.06	-0.01	-0.16	-0.11	-0.17	-0.17	0.47	1									
S_{s3}	0.09	-0.05	-0.01	-0.11	-0.06	-0.13	-0.11	0.37	0.50	1								
S_{s4}	0.03	-0.04	-0.01	-0.09	-0.07	-0.10	-0.10	0.30	0.40	0.33	1							
Q_{fec}	-0.06	0.05	0.01	0.18	0.17	0.18	0.22	-0.12	-0.11	-0.01	-0.05	1						
$\varepsilon_{r,09}$	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.11	0.00	0.00	-0.02	1					
$\varepsilon_{r,10}$	0.00	0.00	0.00	0.00	0.01	0.01	0.01	-0.18	-0.04	-0.01	0.00	0.00	0.03	1				
$\varepsilon_{r,11}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.03	0.00	0.00	0.00	0.00	-0.01	1			
$\varepsilon_{r,12}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.01	1		
$\varepsilon_{r,13}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	
q_{sur}	-0.29	0.03	0.00	-0.03	-0.14	-0.02	-0.13	-0.11	-0.23	-0.35	-0.34	-0.58	0.02	0.00	0.01	0.00	0.00	1

Table 2.14. Northeast Atlantic spurdog. Summary table of estimates from the base case assessment: recruitment (number of pups), total biomass (t) and fishing proportion (averaged over ages 5–30); and WG estimates of landings (t) used in the assessment.

	R (pups)	B_{tot} (t)	Catch (t)	F_{prop} (5-30)
1980	194517	586414	40968	0.099
1981	178369	563219	39962	0.101
1982	167952	540433	32402	0.085
1983	165597	524746	37046	0.100
1984	154639	503214	35194	0.099
1985	144153	482359	38674	0.113
1986	141588	457365	30910	0.094
1987	137549	439403	42354	0.134
1988	130157	409212	35569	0.121
1989	130698	385706	30277	0.110
1990	121928	366801	29906	0.114
1991	127916	348548	29563	0.120
1992	117597	330032	29046	0.124
1993	103180	311231	25637	0.117
1994	99145	295683	20851	0.101
1995	87977	284231	21318	0.106
1996	87367	272148	17295	0.089
1997	86327	263736	15347	0.081
1998	84650	256762	13919	0.075
1999	82211	250646	12385	0.068
2000	82122	245646	15889	0.089
2001	80504	236746	16693	0.097
2002	80137	226875	11020	0.067
2003	82465	222723	12247	0.076
2004	82188	217241	9364	0.060
2005	82345	214615	8357	0.054
2006	81662	212924	4055	0.026
2007	83513	215591	2853	0.018
2008	86982	219551	1737	0.011
2009	91749	224770	2561	0.016
2010	101399	229615	2384	0.014
2011	91208	233931	2384	0.014
2012	93457	238353	2384	0.014
2013	99445	243135	2384	0.014

Table 2.15. Northeast Atlantic spurdog. Assessment projections under different future catch options. Estimates of begin-year total biomass relative to the total biomass in 2014 are shown, assuming that the catch in 2014 is 2 384 tons (average landings for 2007-9). Point estimates are given in the upper third of the table with corresponding lower and upper values (reflecting ±2 standard deviations) given in the middle and bottom third of the table. All landings from 2008 onwards are assumed to be taken by non-target fisheries only. The "+x yrs" in the first column is relative to 2014 (so "+3 yrs" indicates 2017).

	Medium-term projections				
	MSY rule	zero	TAC 2009	Ave land 2007-9	$F_{prop,MSY}$
ave Catch	2746	0	1422	2384	6125
Point estimates					
+ 3 yrs	1.07	1.08	1.07	1.06	1.04
+ 5 yrs	1.12	1.15	1.12	1.11	1.06
+ 10 yrs	1.25	1.32	1.27	1.23	1.11
+ 30 yrs	1.85	2.21	2.02	1.88	1.35
Point estimates - 2 standard deviations					
+ 3 yrs	1.05	1.06	1.05	1.04	1.01
+ 5 yrs	1.08	1.11	1.08	1.07	1.02
+ 10 yrs	1.18	1.25	1.19	1.15	1.04
+ 30 yrs	1.57	1.97	1.81	1.65	1.18
Point estimates + 2 standard deviations					
+ 3 yrs	1.09	1.11	1.10	1.09	1.06
+ 5 yrs	1.16	1.18	1.16	1.15	1.10
+ 10 yrs	1.33	1.39	1.34	1.31	1.18
+ 30 yrs	2.13	2.44	2.22	2.12	1.53

"ave Catch" is the average for the period 2015-2043

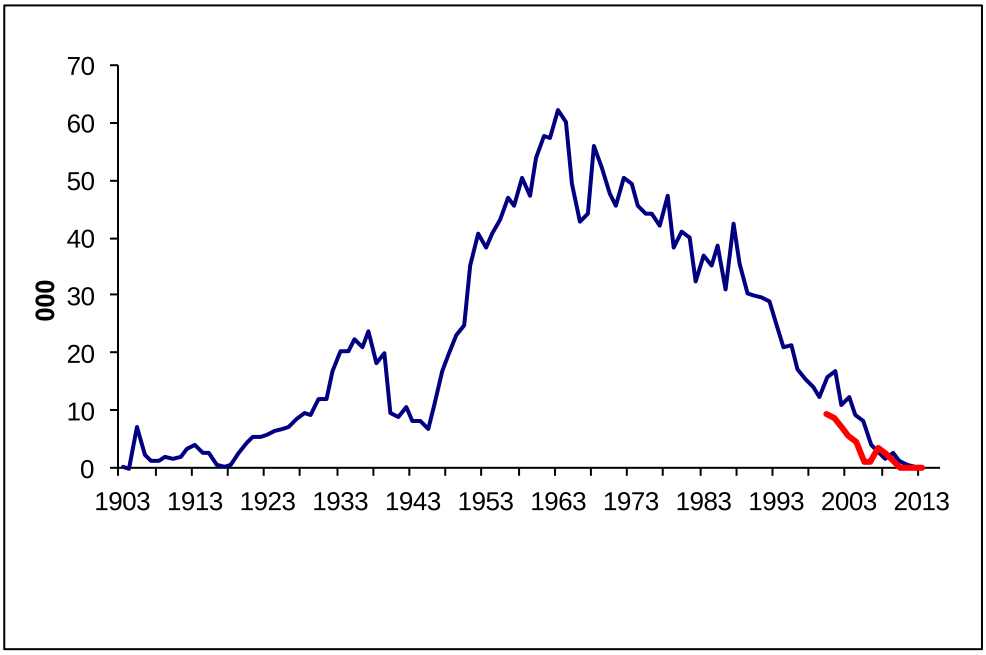


Figure 2.1a. Spurdog in the NE Atlantic. WG estimates of total international landings of NE Atlantic spurdog (1903–2013, blue line) and TAC (red line). Restrictive management (e.g. through quotas and other measures) is only thought to have occurred since 2007.

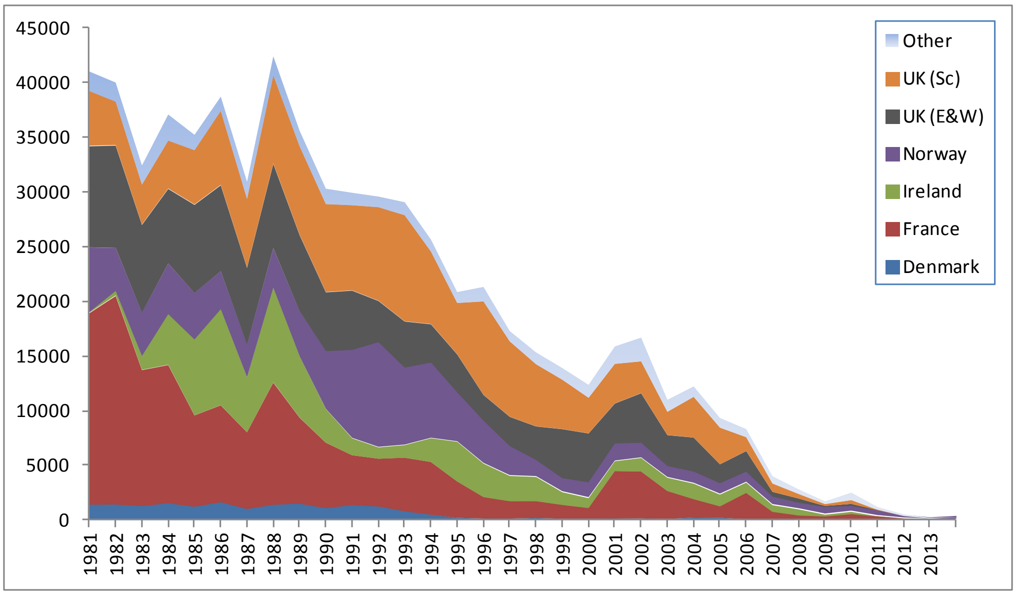


Figure 2.1b. Spurdog in the NE Atlantic. WG estimates of landings by nation (1980–2012).

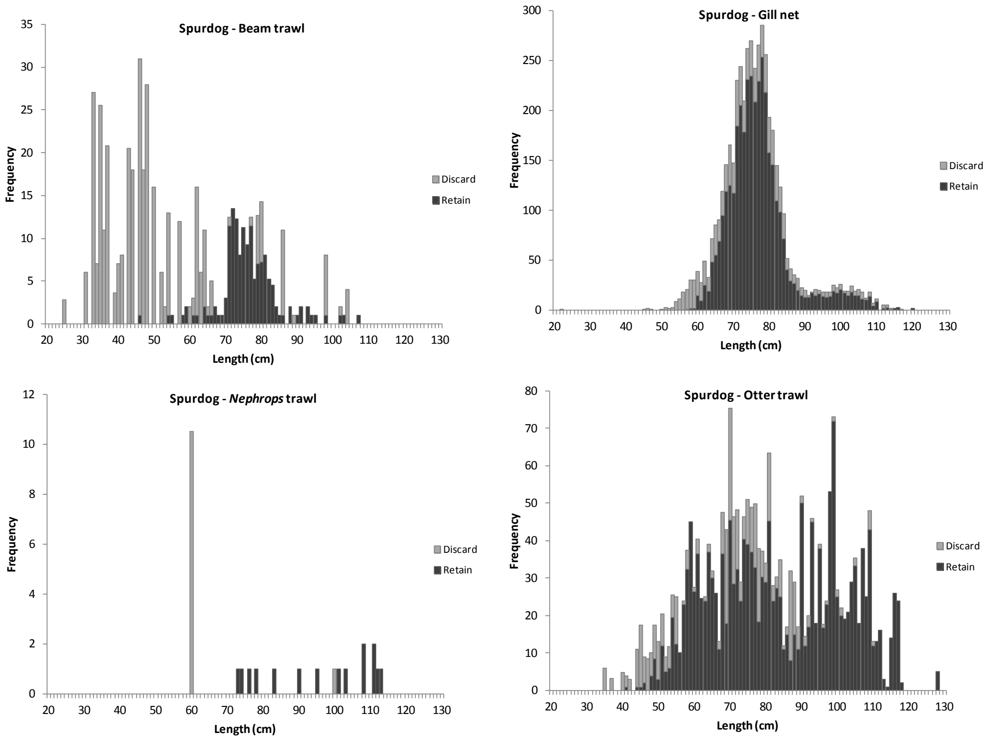


Figure 2.2. Spurdog in the NE Atlantic. Discard-retention patterns of spurdog taken in UK (English) vessels using beam trawl, gillnet, *Nephrops* trawl and otter trawl.

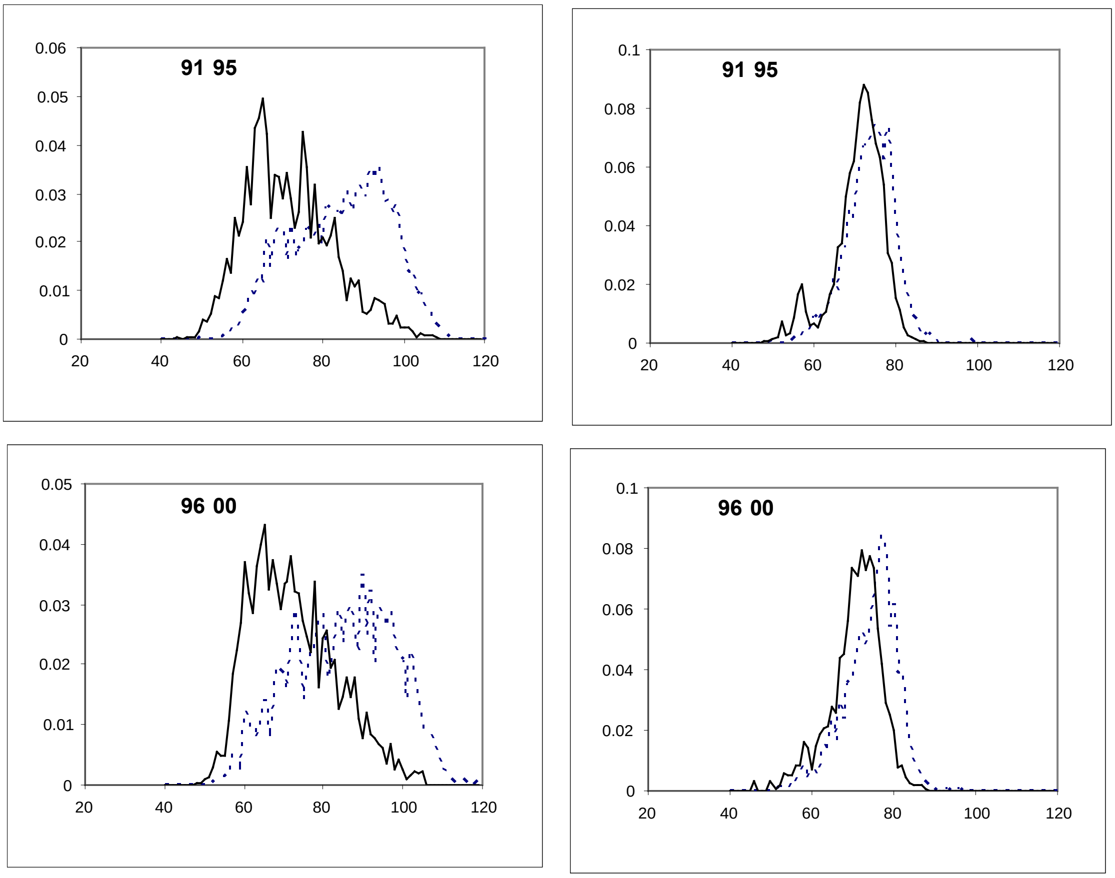


Figure 2.3. Spurdog in the NE Atlantic. Comparison of length–frequency distributions (proportions) obtained from market sampling of Scottish (solid line) and UK(E&W) (dashed line) landings data. Data are sex-disaggregated, but averaged over five year intervals.

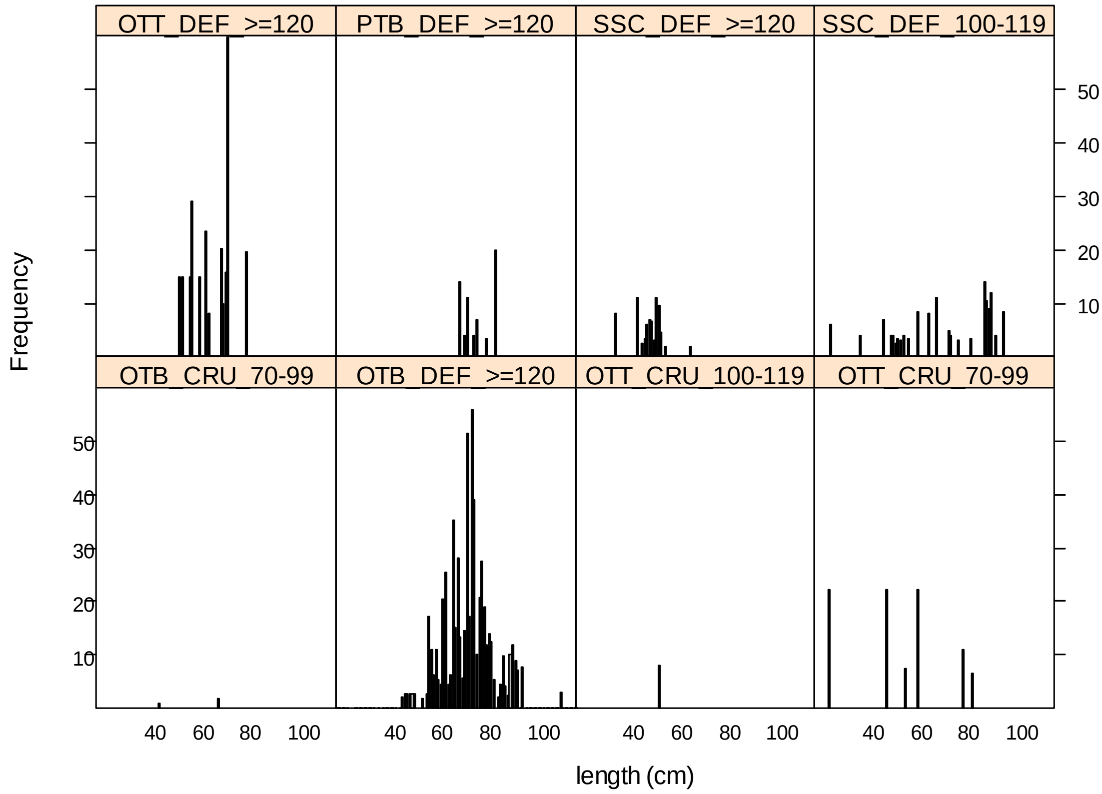


Figure 2.4. Spurdog in the NE Atlantic. Length distributions of spurdog caught on Scottish observer trips in 2010. Data are aggregated across trips for each gear category. Gear codes relate to gear type, target species and mesh size. OTT – Otter trawl twin; PTB – Pair trawl bottom; SSC – Scottish Seine; OTB – Otter trawl bottom; DEF – demersal fish; CRU – crustacean.

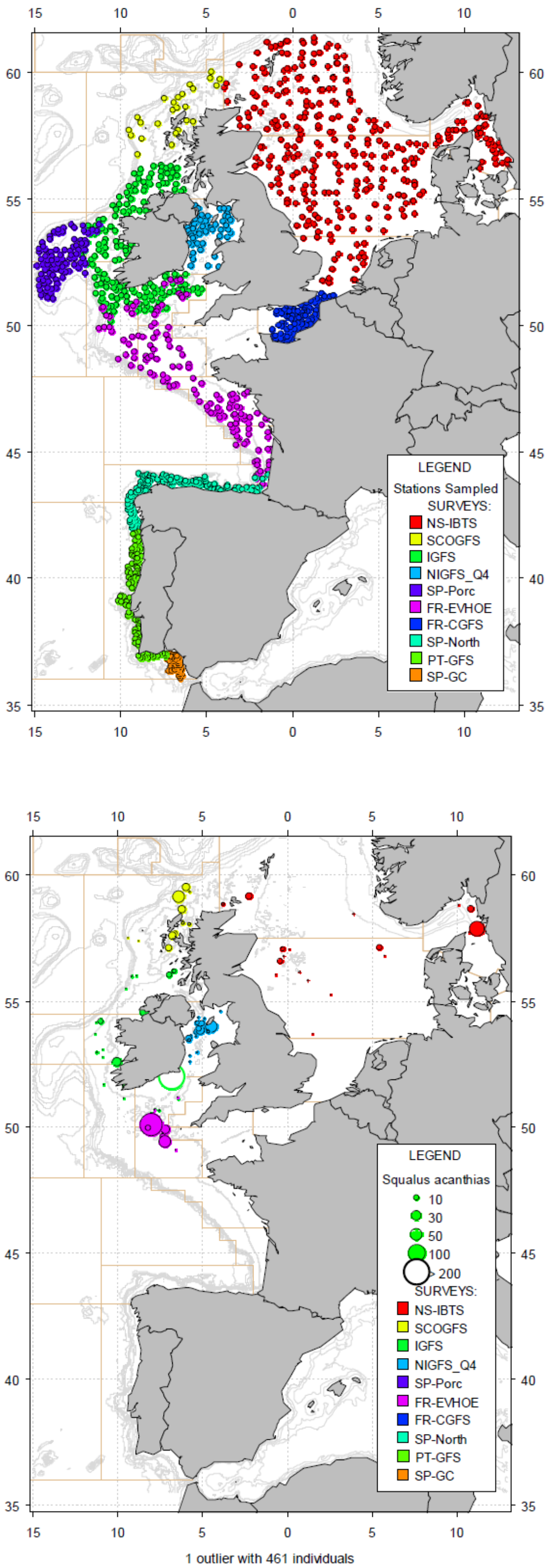


Figure 2.5. Spurdog in the NE Atlantic. Overall spatial coverage of the IBTS (top, all surveys combined) and captures of spurdog (number per hour, bottom) as reported in the 2013 summer/autumn IBTS. The catchability of the different gears used in the NE Atlantic surveys is not constant; therefore the map does not reflect proportional abundance in all the areas but within each survey (From ICES, 2014).

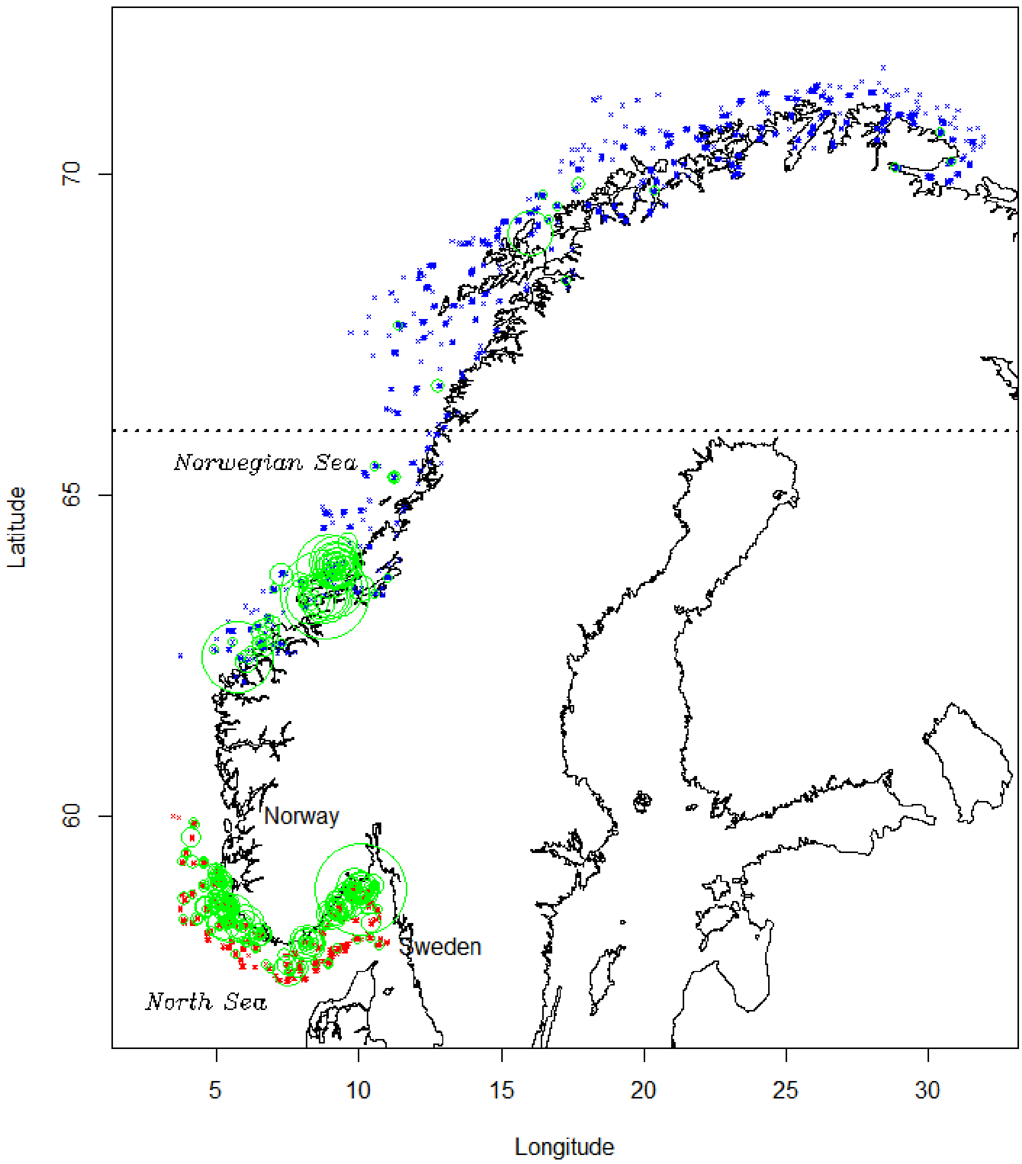


Figure 2.6. Spurdog in the NE Atlantic. Map of survey areas with all stations 1996–2013 for Coastal survey (blue) and Shrimp survey (red). Green circles indicate catches of spurdog, circle area is proportional to catch in number of individuals. Dotted line indicate northern limit of data selection. Source: Vollen (2014 WD).

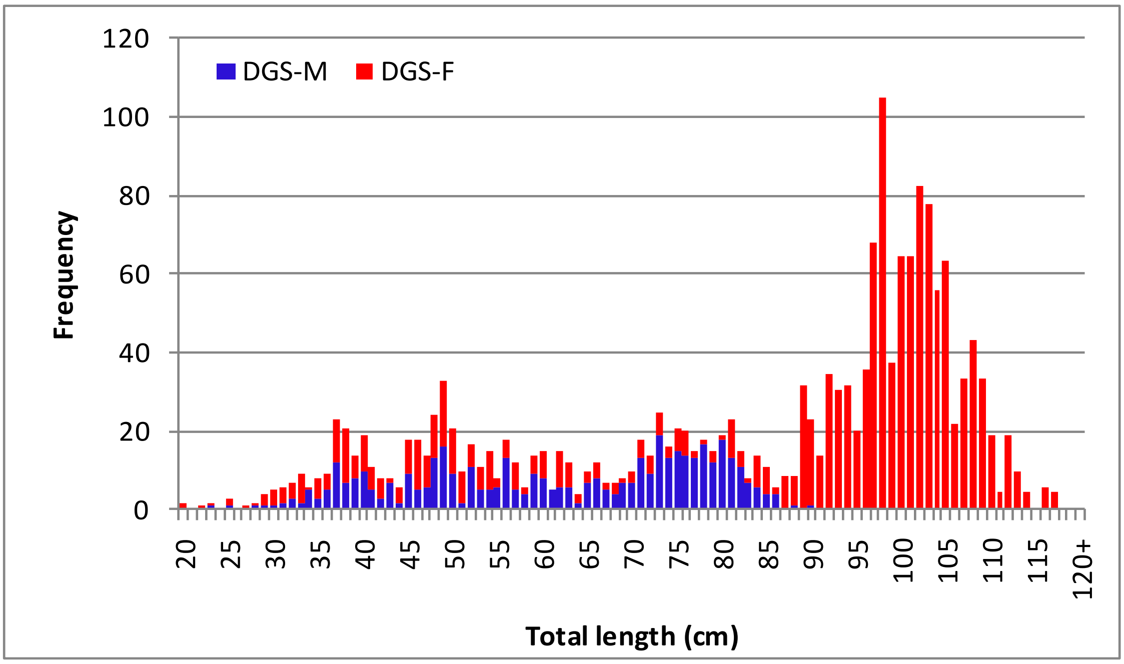


Figure 2.7a. Spurdog in the NE Atlantic. Length distribution of spurdog captured in the UK (England and Wales) westerly IBTS in Q4 (2004–2009, all valid and additional tows). Length distribution highly influenced by a single haul of large females.

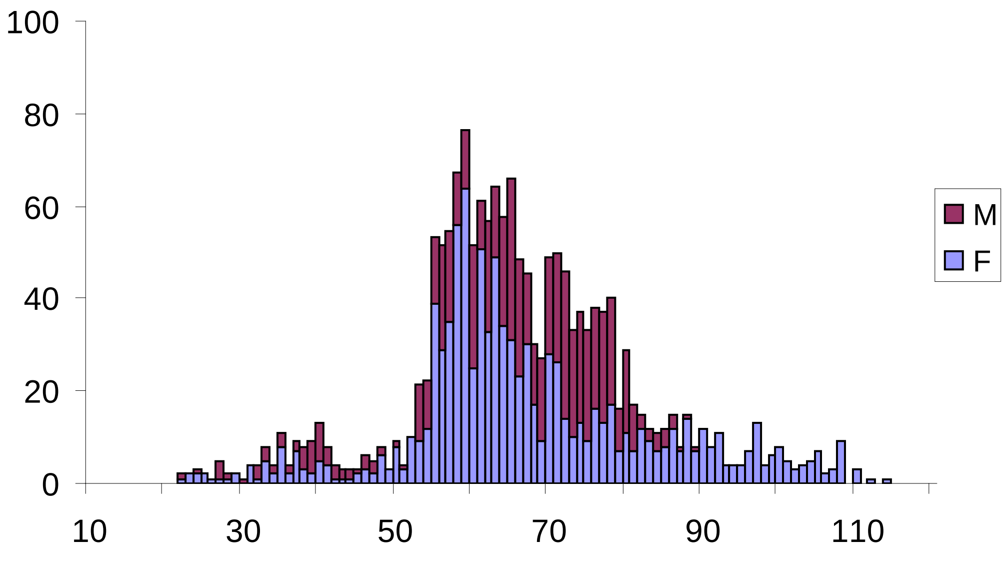


Figure 2.7b. Spurdog in the NE Atlantic. Length distribution of spurdog captured in the Irish Q3 Celtic Seas groundfish survey (2003–2009).

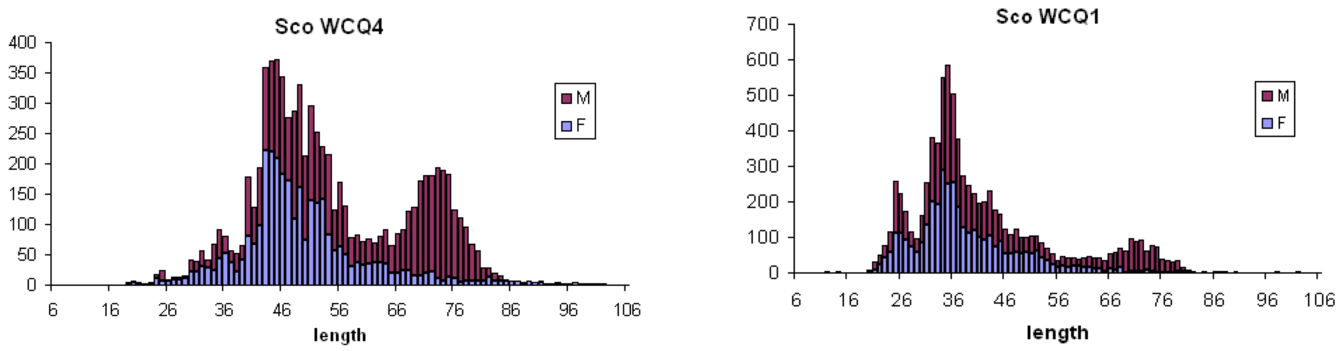


Figure 2.8. Spurdog in the NE Atlantic. Length distribution of spurdog captured in the Scottish Q1 and Q4 groundfish surveys (1990–2010). Length–frequency distributions highly influenced by a small number of hauls containing many small individuals.

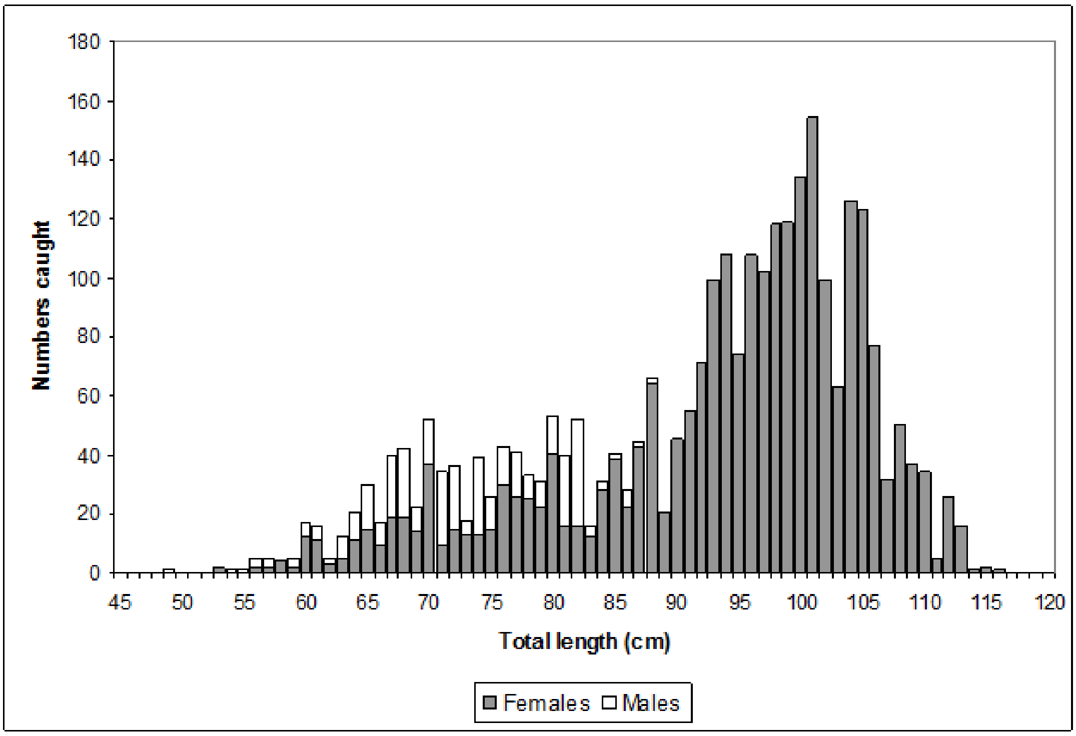


Figure 2.9. Spurdog in the NE Atlantic. Total length–frequency of male and female spurdog taken during the UK(E&W) FSP survey, raised for those catches that were sub-sampled (n = 2517 females and 356 males).

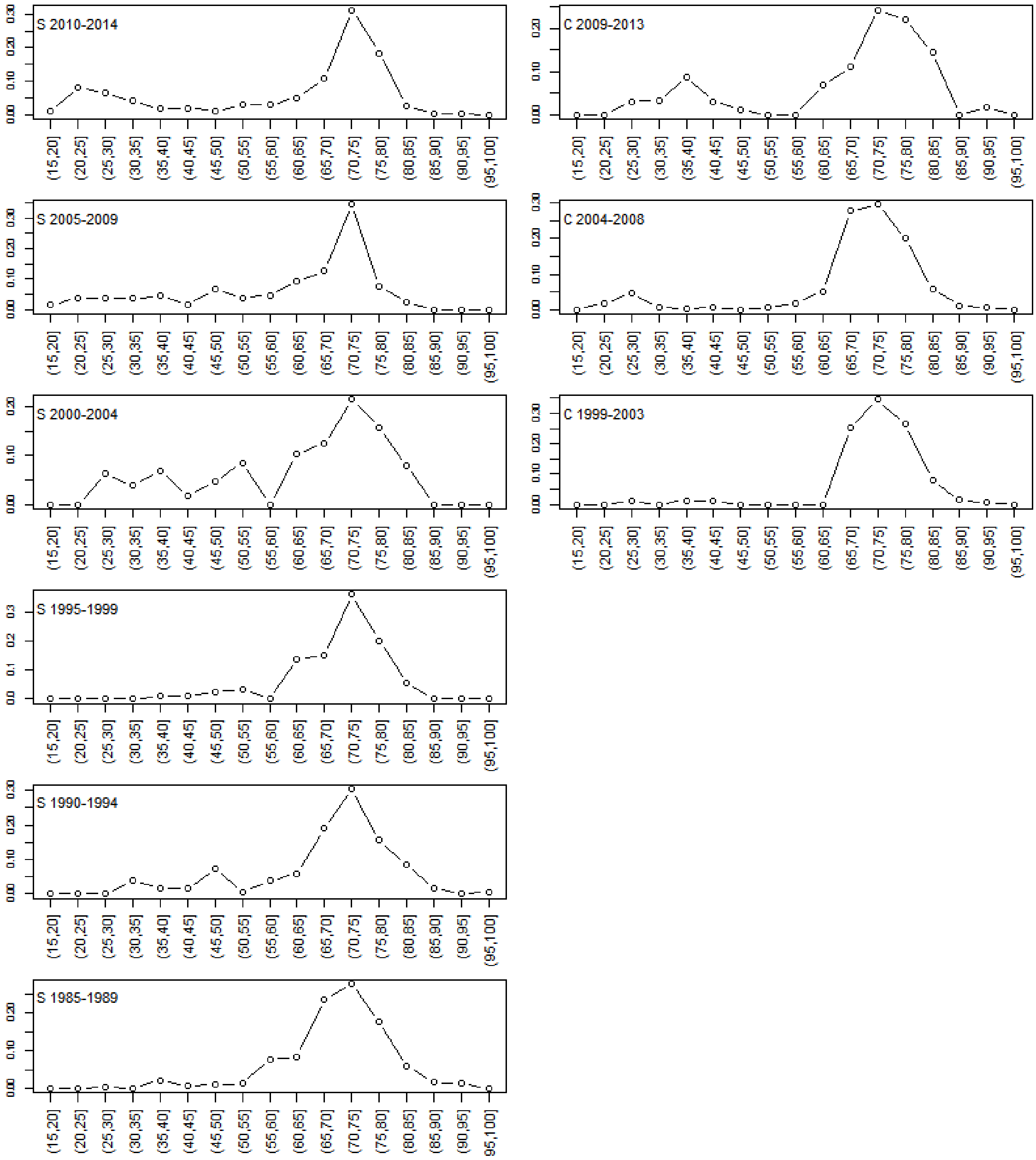


Figure 2.10. Spurdog in the NE Atlantic. Relative length–frequency distributions (5 cm length groups and five year periods) for the Shrimp survey (left) and Coastal survey (right).

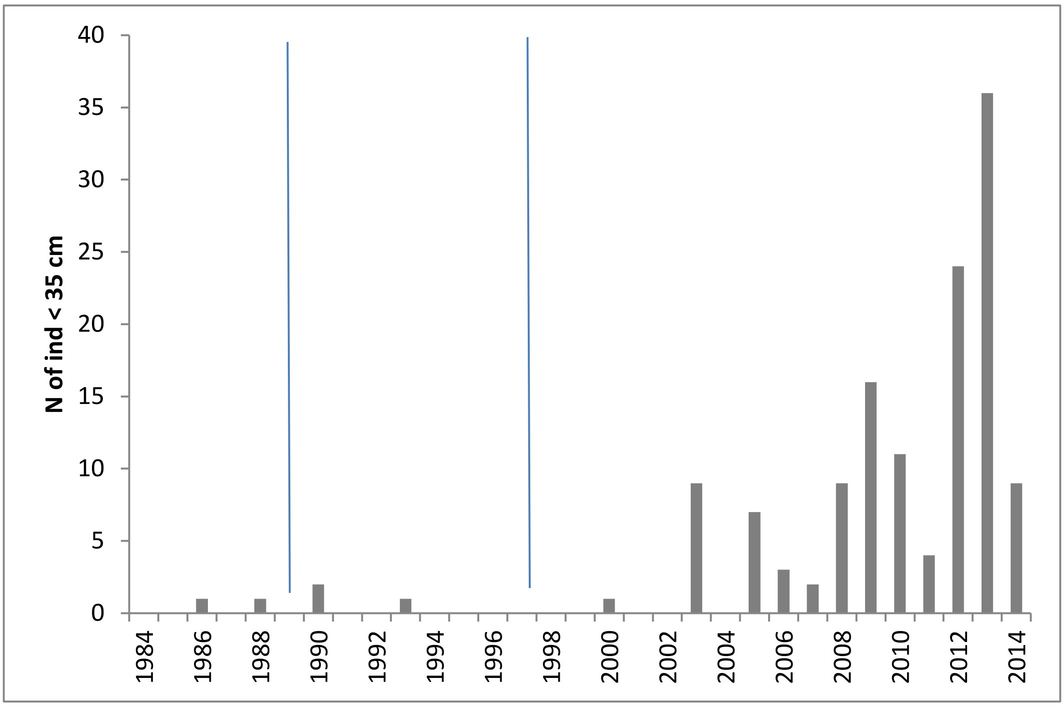


Figure 2.11. Spurdog in the NE Atlantic. Frequency of individuals <35 cm length, both Norwegian surveys combined. Mesh size used within each time period is given.

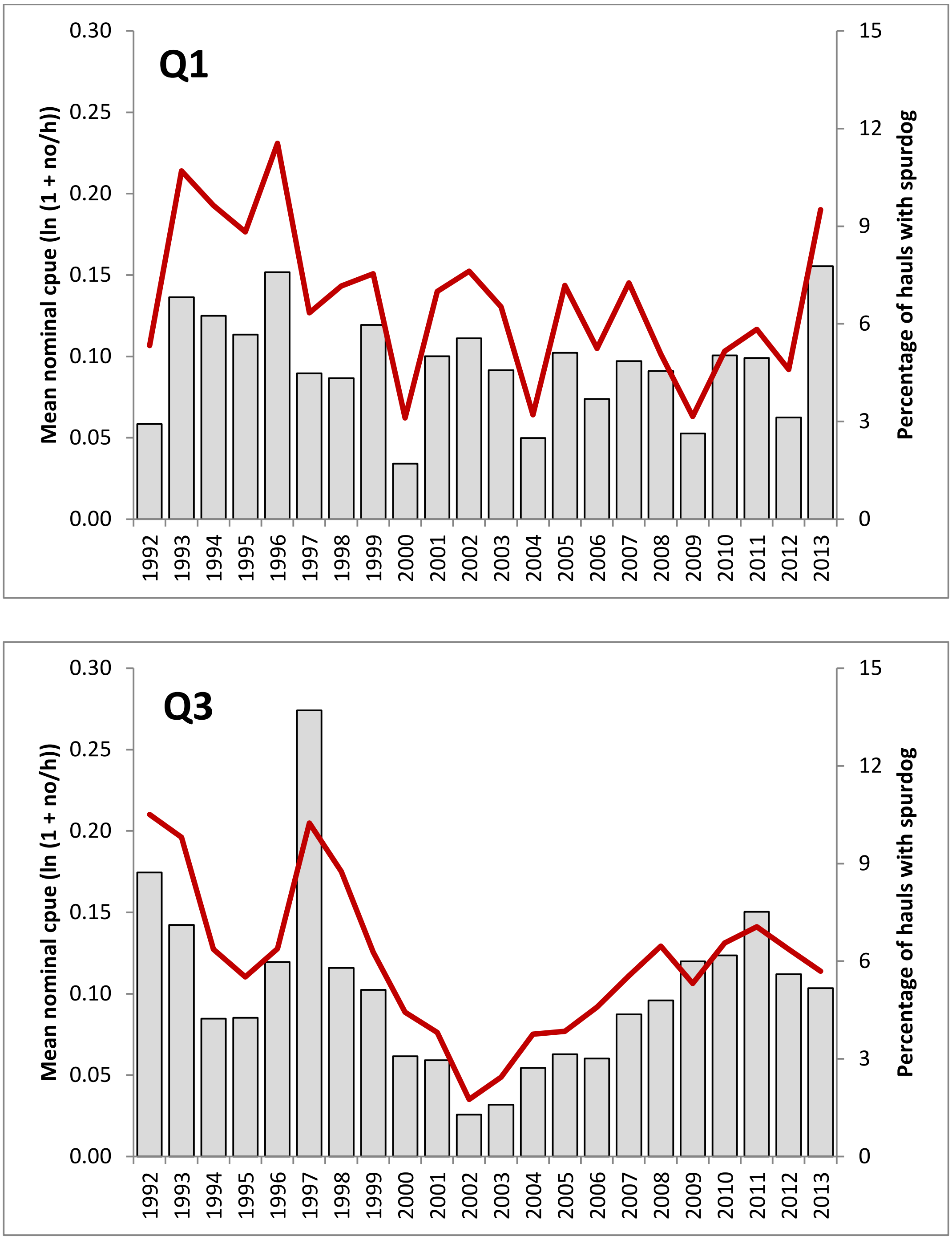


Figure 2.12. Spurdog in the NE Atlantic. Nominal catch per unit of effort (grey bars) and frequency of occurrence (red line) of spurdog in the Q1 and Q3 North Sea IBTS (1992–2013). Catch per unit of effort is mean ln(1+n/h) for all stations in roundfish areas 1–9. Data accessed from DATRAS (19 June 2014).

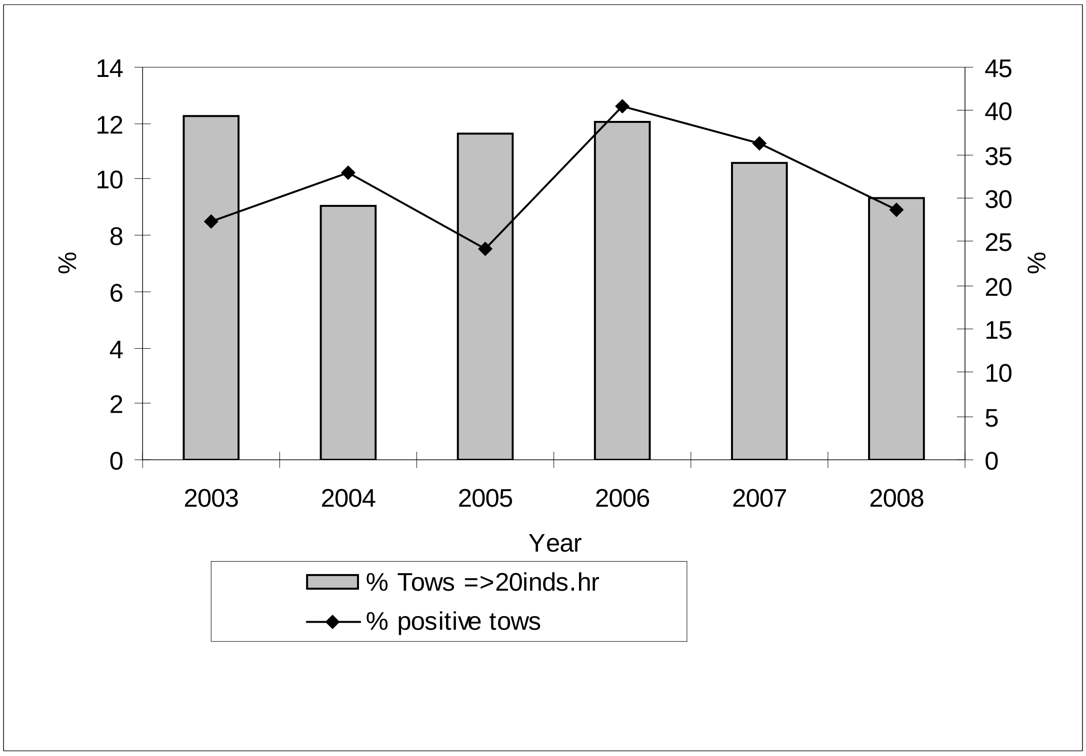


Figure 2.13. Northeast Atlantic spurdog. Proportion of survey hauls in Irish Q3 groundfish survey 2003–2008, ICES Area VII, in which nominal cpue was ≥20 per one hour tow, and percentage of tows in which spurdog occurred.

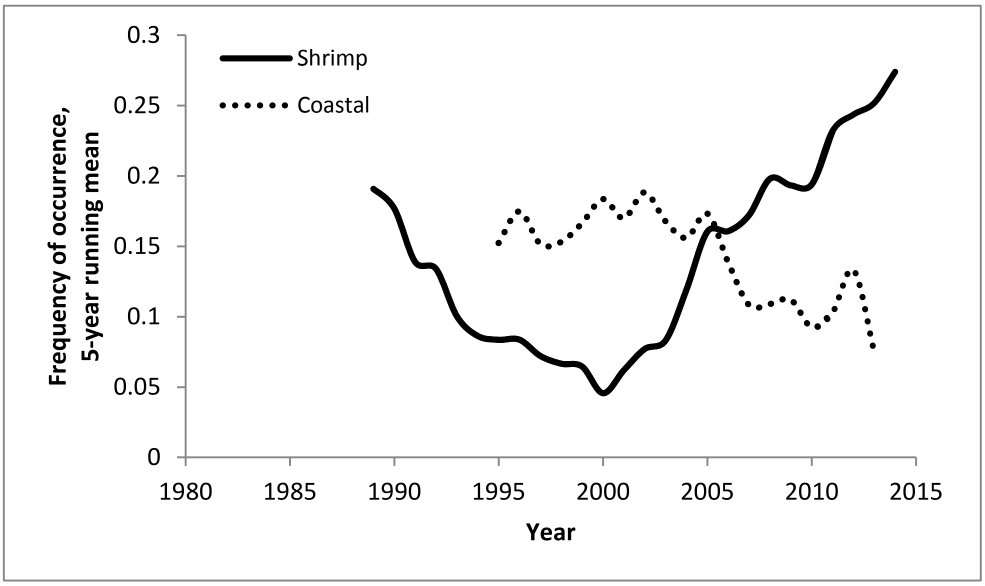


Figure 2.14. Spurdog in the NE Atlantic. Frequency of occurrence of spurdog in the Norwegian Coastal survey and Shrimp survey. A five year running mean is used. Source: Vollen (2014 WD).

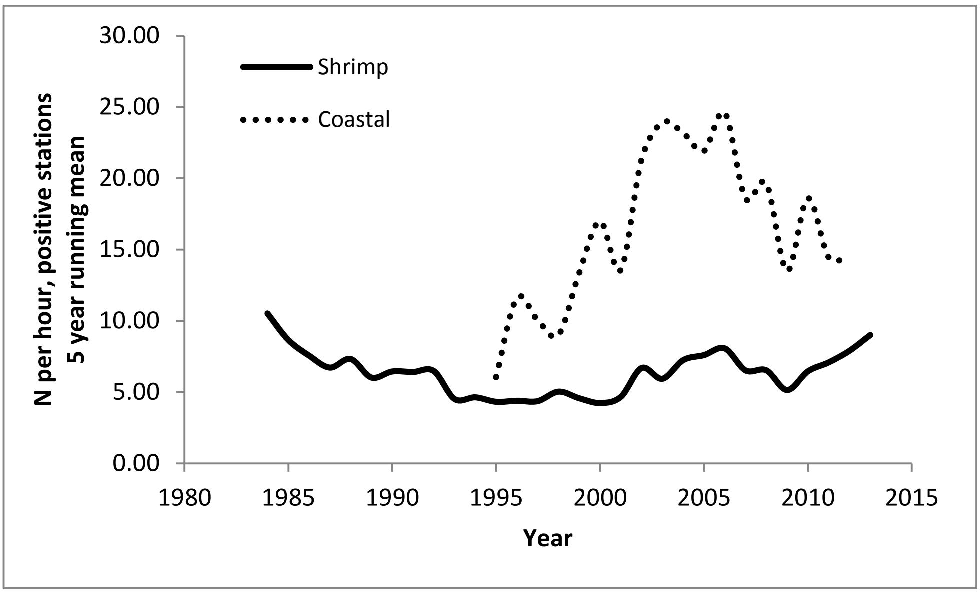
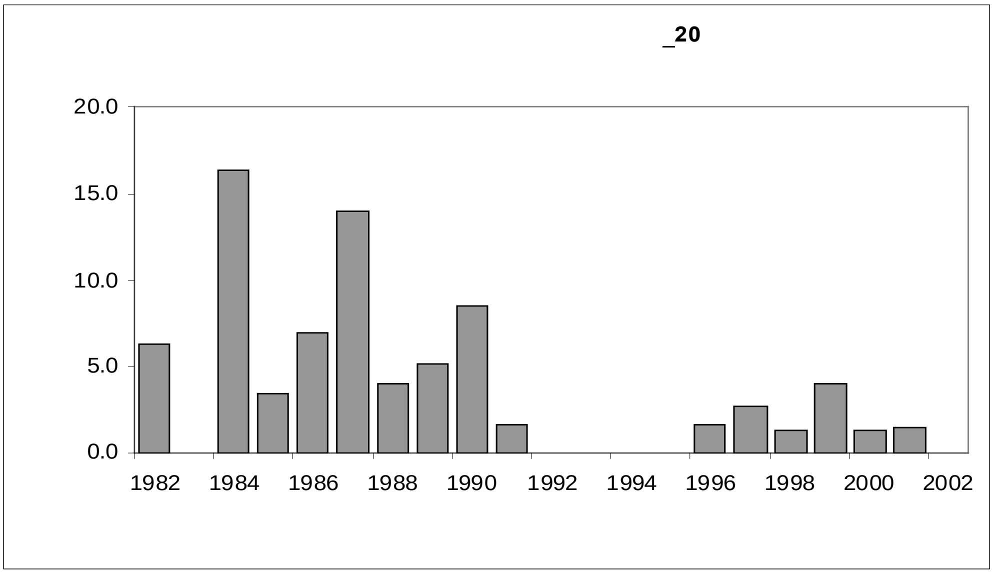


Figure 2.15. Spurdog in the NE Atlantic. Mean number of spurdog caught per hour in the Norwegian Coastal survey and Shrimp survey. A five year running mean is used. Source: Vollen (2014 WD).



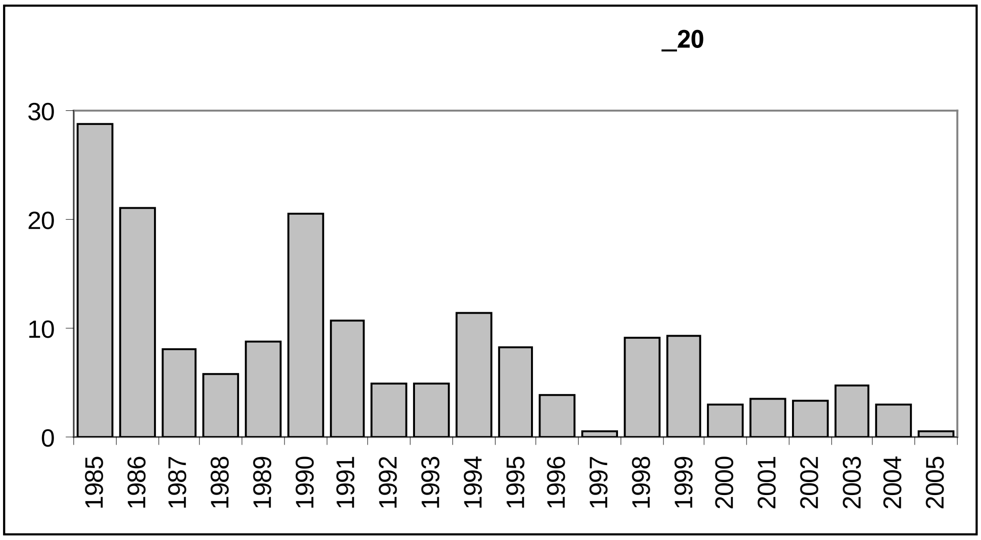
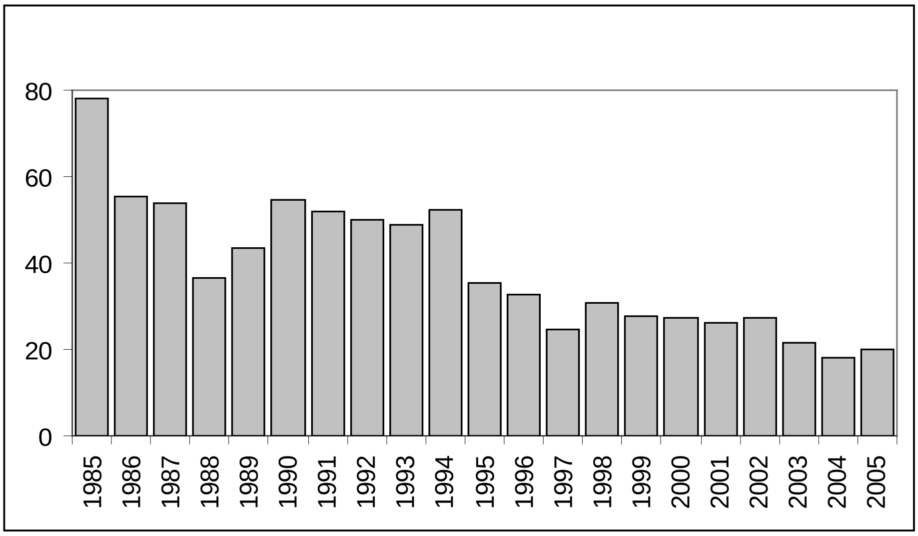


Figure 2.16. Spurdog in the NE Atlantic. Proportion of survey hauls in the English Celtic Sea groundfish survey (1982–2002, top) and Scottish west coast (VIa) survey (Q1, 1985–2005, bottom) in which cpue was ≥20 ind.h–1. (Source: ICES, 2006).

a)



b)

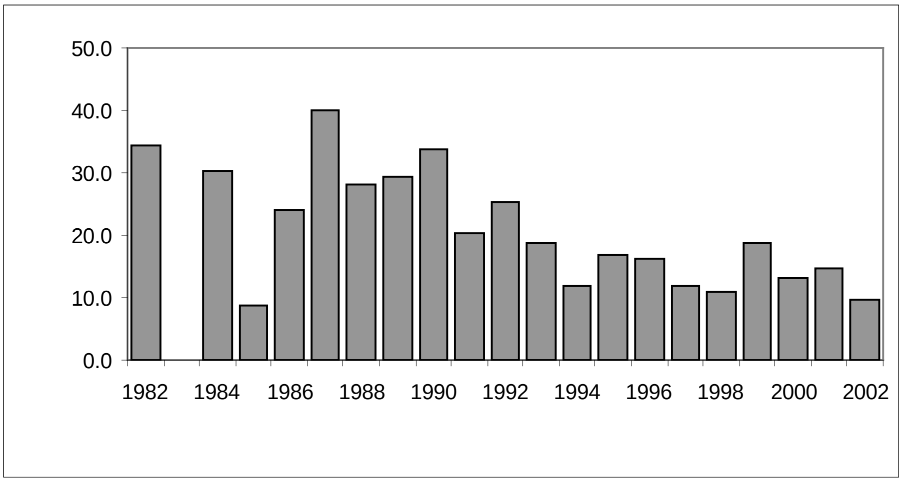


Figure 2.17. Spurdog in the NE Atlantic. Frequency of occurrence in survey hauls in a) the English Q1 Celtic Sea groundfish survey (1982–2002), and b) the Scottish west coast (VIa) survey (Q1, 1985–2005).

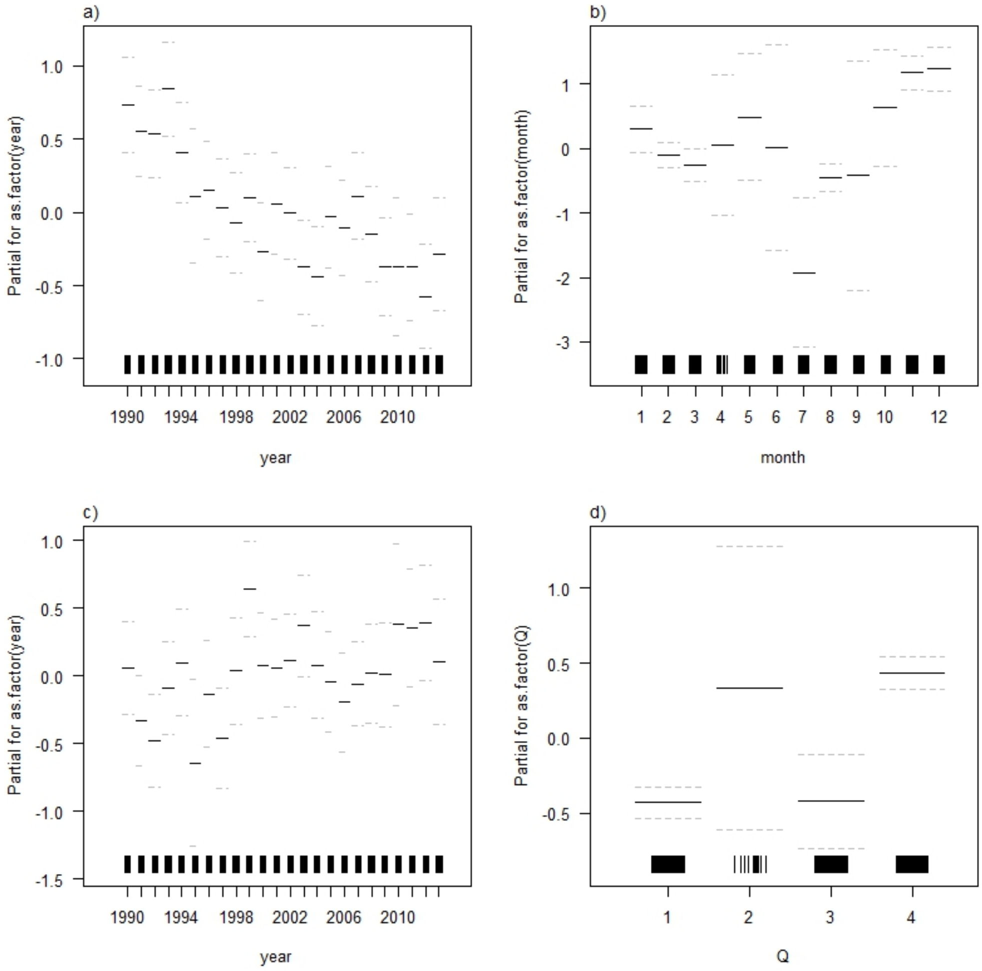


Figure 2.18. Northeast Atlantic spurdog. Estimated year and quarter effects (± 1 s.e.) from the delta-lognormal GLM: binomial model shown in a) and b), and lognormal results in c) and d) (log scale).

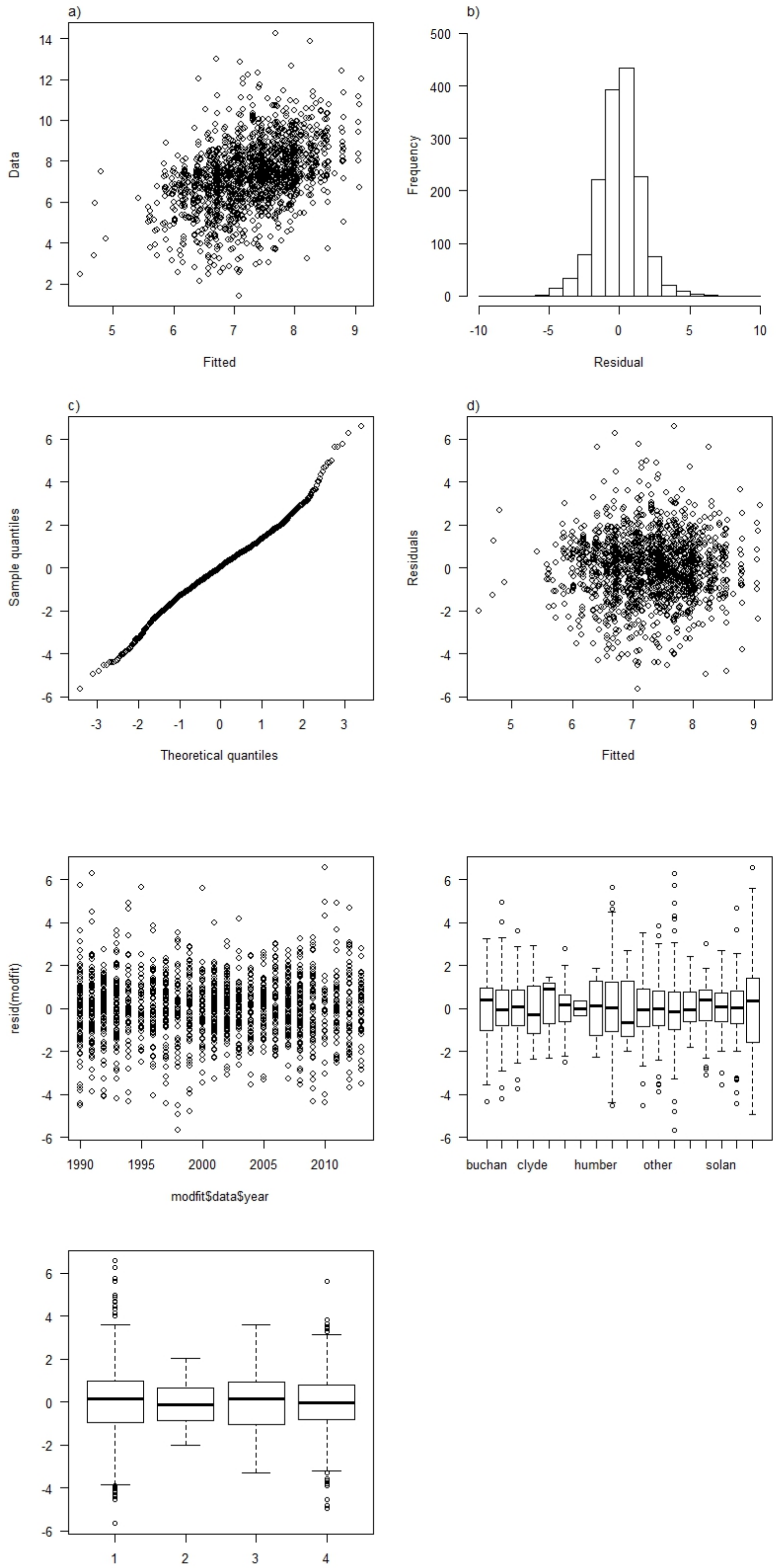


Figure 2.19. Northeast Atlantic spurdog. Analysis of Scottish survey data. Residual plot of final lognormal model fit: a) observed vs. fitted values, b) histogram of residuals, c) normal Q-Q plot, d) residuals vs. fitted values and e), f) and g) residuals vs. year, area and quarter.

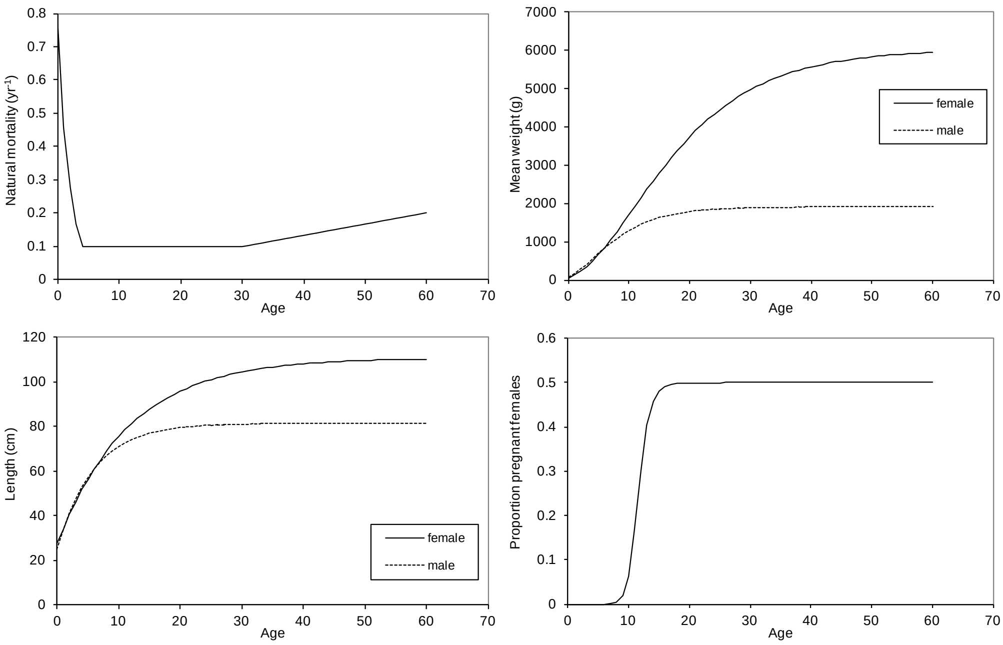


Figure 2.20. Northeast Atlantic spurdog. A visual representation of the life-history parameters described in Table 2.5. [Note, the value of natural mortality-at-age 0 is a parameter derived from the assessment.]

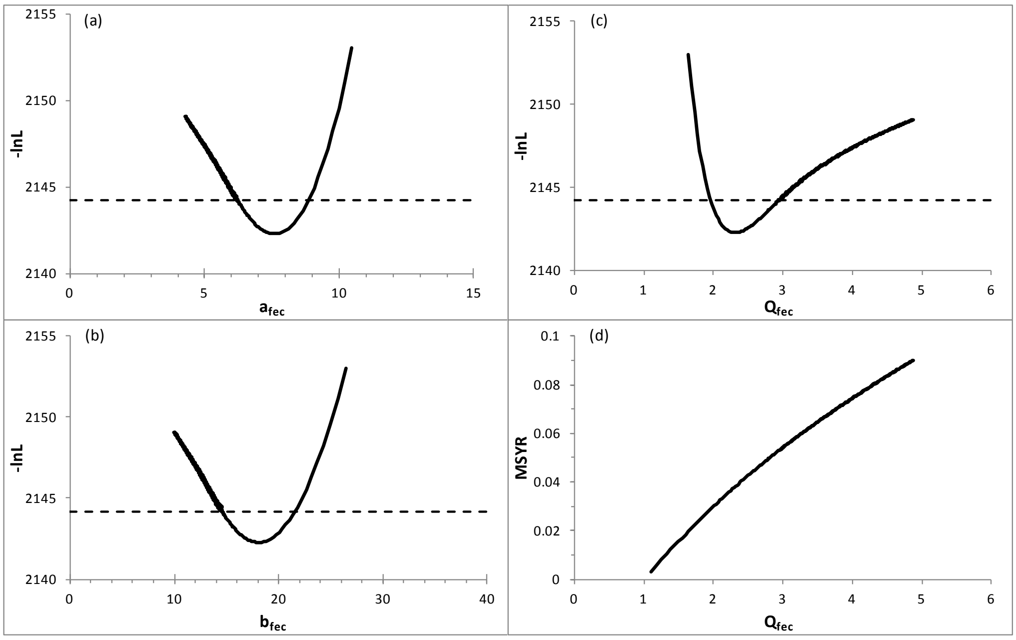


Figure 2.21. Northeast Atlantic spurdog. Negative log-likelihood (-ln*L*) for a range of (a) a_{fec} and (b) b_{fec} values, with (c) corresponding Q_{fec}. Plot (d) shows MSYR (MSY/B_{MSY}) vs. Q_{fec}. Using the likelihood ratio criterion, the hashed line in plots (a)–(c) indicate the minimum –ln*L* value + 1.92, corresponding to 95% probability intervals for the corresponding parameters for values below the line.

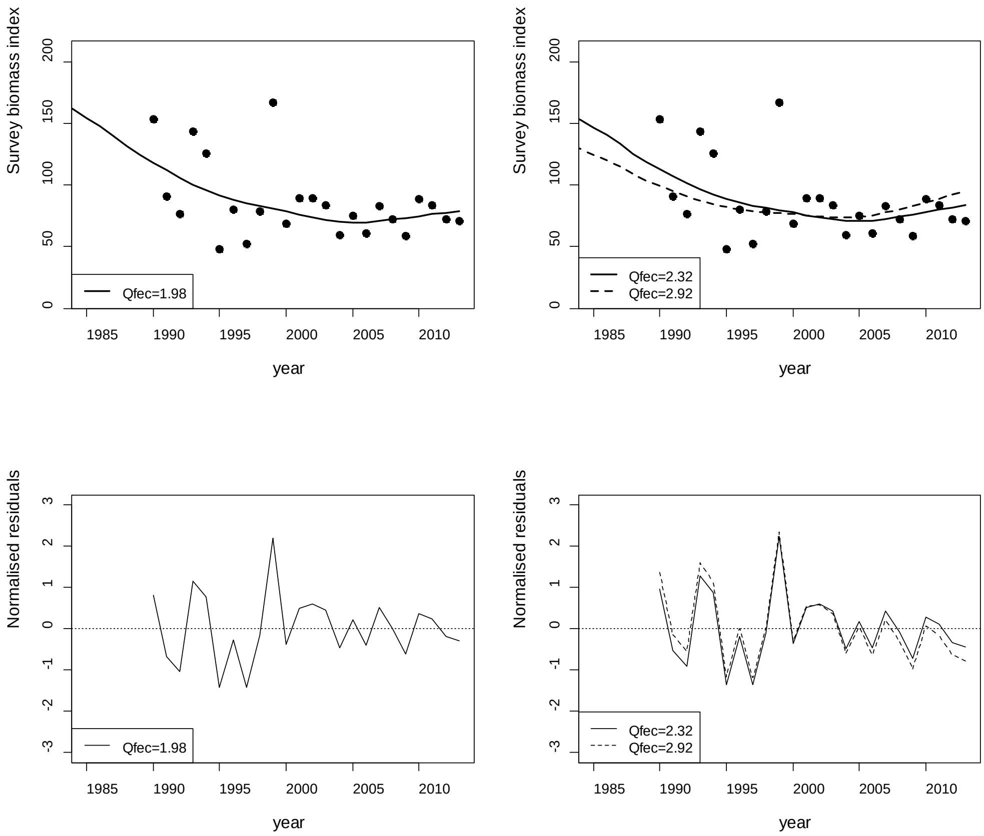


Figure 2.22. Northeast Atlantic spurdog. Model fits to the Scottish surveys abundance index (top panel), with normalised residuals ($\varepsilon_{sur,y}$ in Stock Annex equation 9b) (bottom) for (a) the base-case Qfec=1.98 (the more conservative lower bound in Figure 2.21c) and (b) for two alternatives (the optimum and upper bounds in Figure 2.21c) that fall within the 95% confidence bounds.

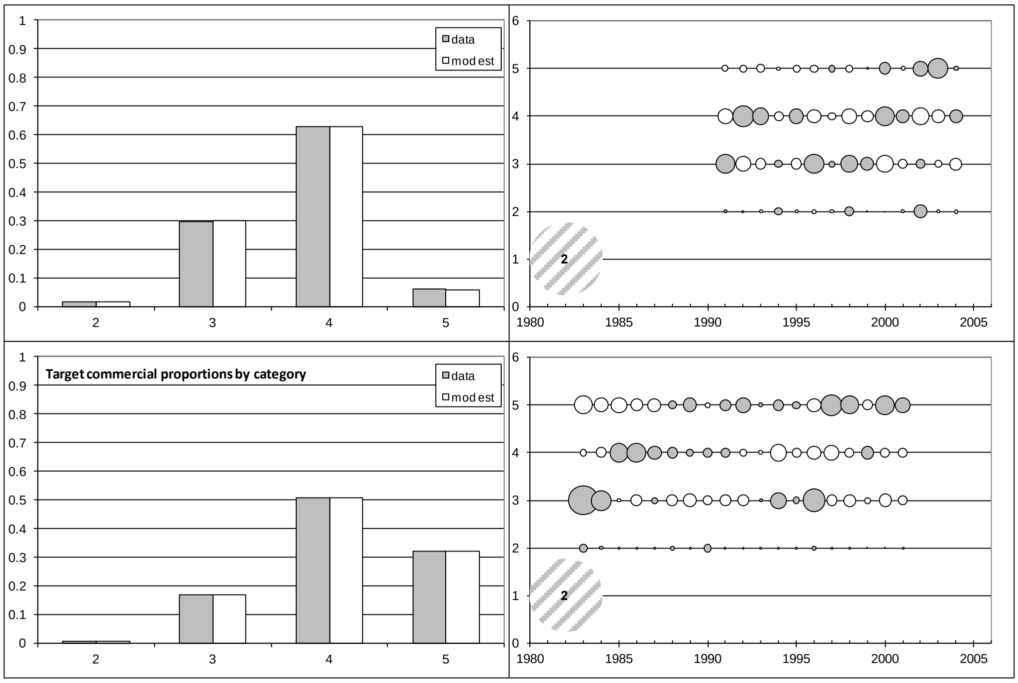


Figure 2.23a. Northeast Atlantic spurdog. Model fits to the non-taraget (Scottish; top row) and target (England & Wales; bottom row) commercial proportions-by-length category data for the base case run. The left-hand side plots show proportions by length category averaged over the time period for which data are available, with the length category given along the horizontal axis. The right-hand side plots show multinomial residuals ($\varepsilon_{pcom,j,y,L}$ in Stock Annex equation 10b), with grey bubbles indicating positive residuals, bubble area being proportional to the size of the residual (the light-grey hashed bubble indicates a residual size of 2, and is shown for reference), and length category indicated on the vertical axis. The length categories considered are 2: 16–54 cm; 3: 55–69 cm; 4: 70–84 cm; 5: 85+ cm.

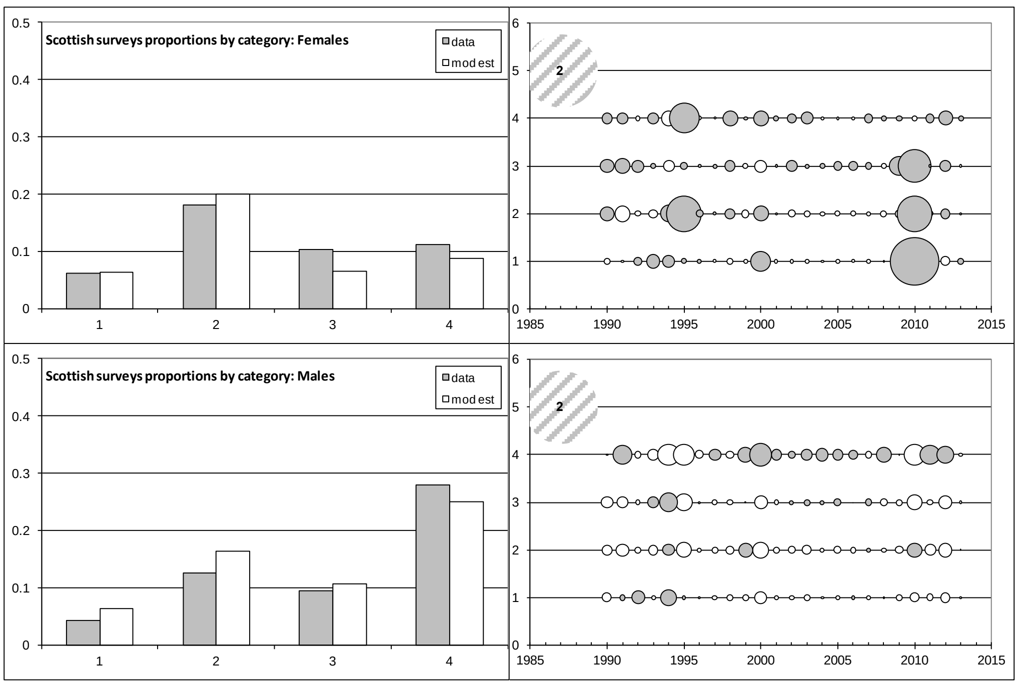


Figure 2.23b. Northeast Atlantic spurdog. Model fits to the Scottish survey proportions-by-length category data for the base-case run for females (top row) and males (bottom row). A further description of these plots can be found in the caption to Figure 2.23a. Length categories considered are 1: 16–31 cm; 2: 32–54 cm; 3: 55–69 cm; 4: 70+ cm.

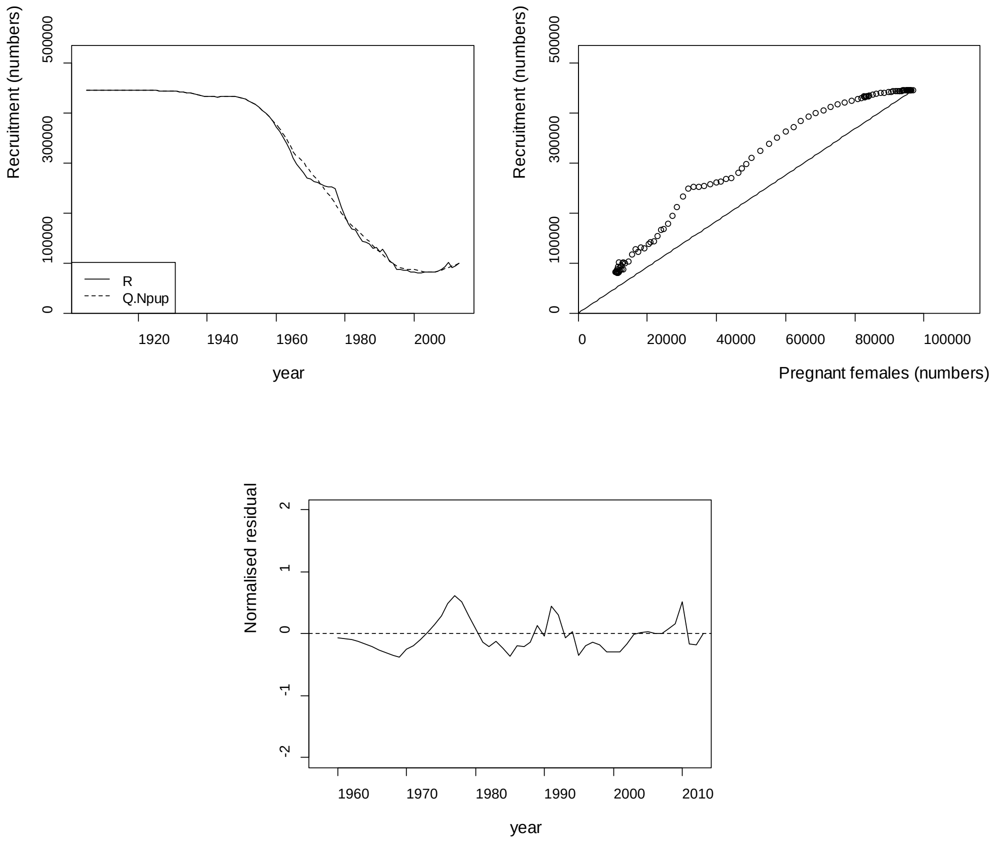


Figure 2.24. Northeast Atlantic spurdog. (a) A comparison of the deterministic (N_{pup}) and stochastic (*R*) versions of recruitment (Stock Annex equations 2a–c) (top-left panel) with normalised residuals ($\varepsilon_{r,y}/\sigma_r$, where $\varepsilon_{r,y}$ are estimable parameters of the model) (bottom); and (b) a plot of recruitment (R) vs. number of pregnant females (open circles), together with the replacement line (number of recruiting pups needed to replace the pregnant female population under no harvesting).

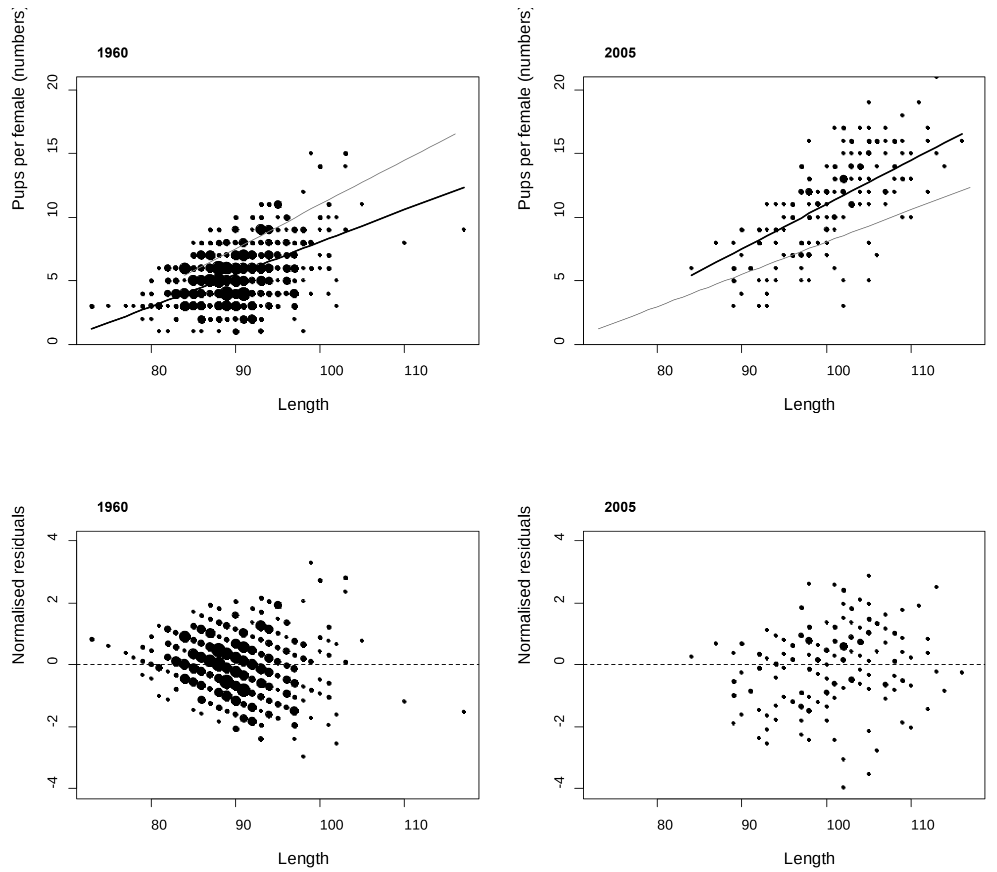


Figure 2.25. Northeast Atlantic spurdog. Fit to fecundity data from two periods (top row) for (a) 1960 and (b) 2005, with associated normalised residuals ($\varepsilon_{fec,k,y}$ in Stock Annex equation 11b) (bottom row). For the top plots, the heavy black lines reflect the model estimates for the given points, while the light grey ones, reflecting the model estimates for the points in the adjacent plot, are given for comparison. For all plots, the diameter of each point is proportional to $\sqrt{n}$, where n is the number of samples with the same number of pups for a given length.

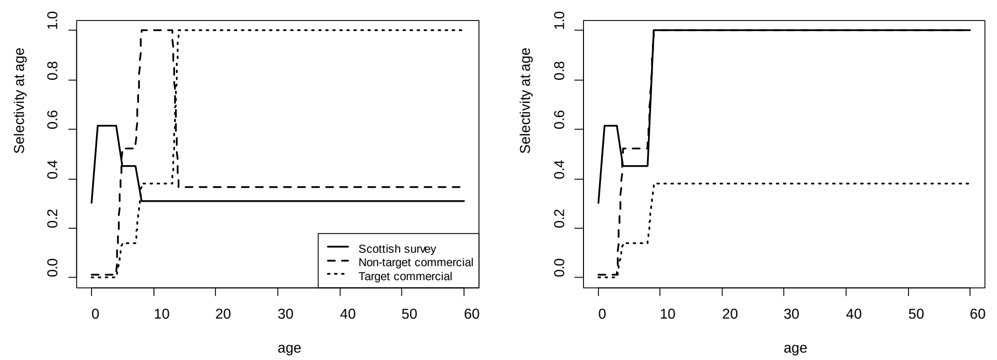


Figure 2.26. Northeast Atlantic spurdog. Estimated selectivity-at-age curves for the base case run for (a) females and (b) males. The two commercial fleets considered have non-target (Scottish) and target (England & Wales) selectivity, which differ by sex because of the life-history parameters for males and females (Table 2.6). The survey selectivity relies on Scottish survey data.

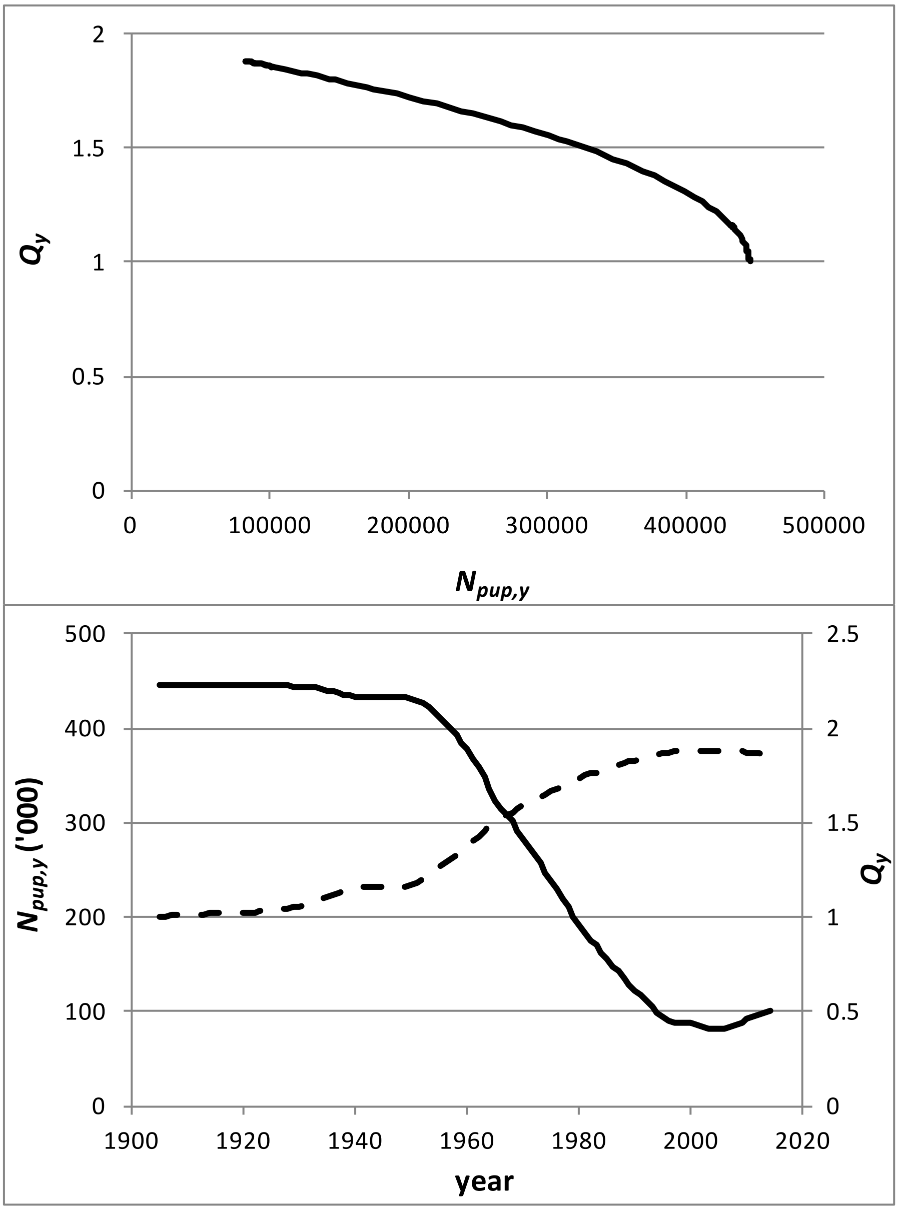


Figure 2.27. Northeast Atlantic spurdog. A plot of the density-dependent factor Q_y (Stock Annex equation 2b) against the number of pups $N_{pup,y}$ (top), and both plotted against time (bottom; solid line for $N_{pup,y}$, and hashed line for Q_y).

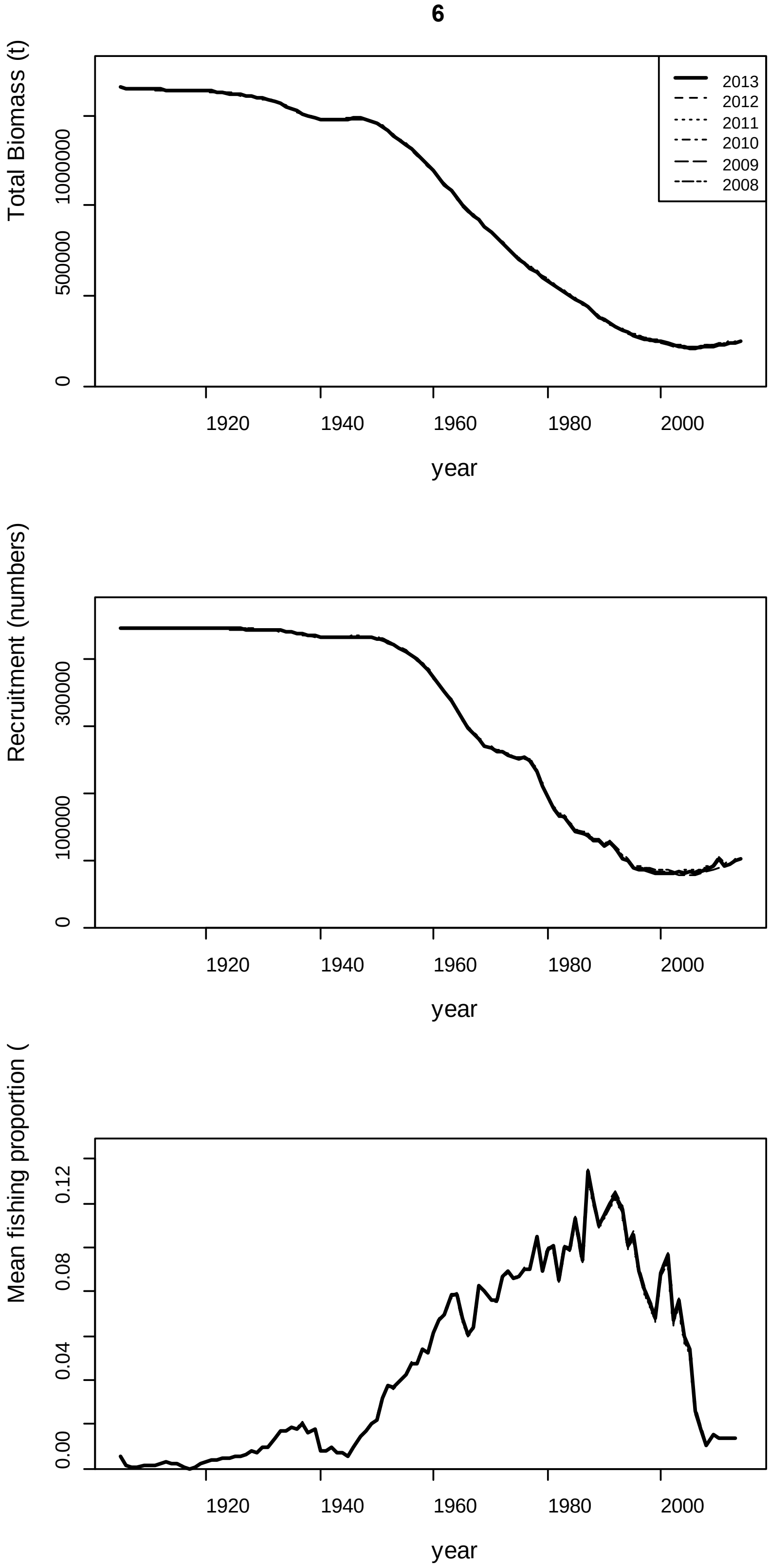


Figure 2.28. Northeast Atlantic spurdog. Six-year retrospective plots (omitting probability intervals for clarity; the model was re-run, each time omitting a further year in the data).

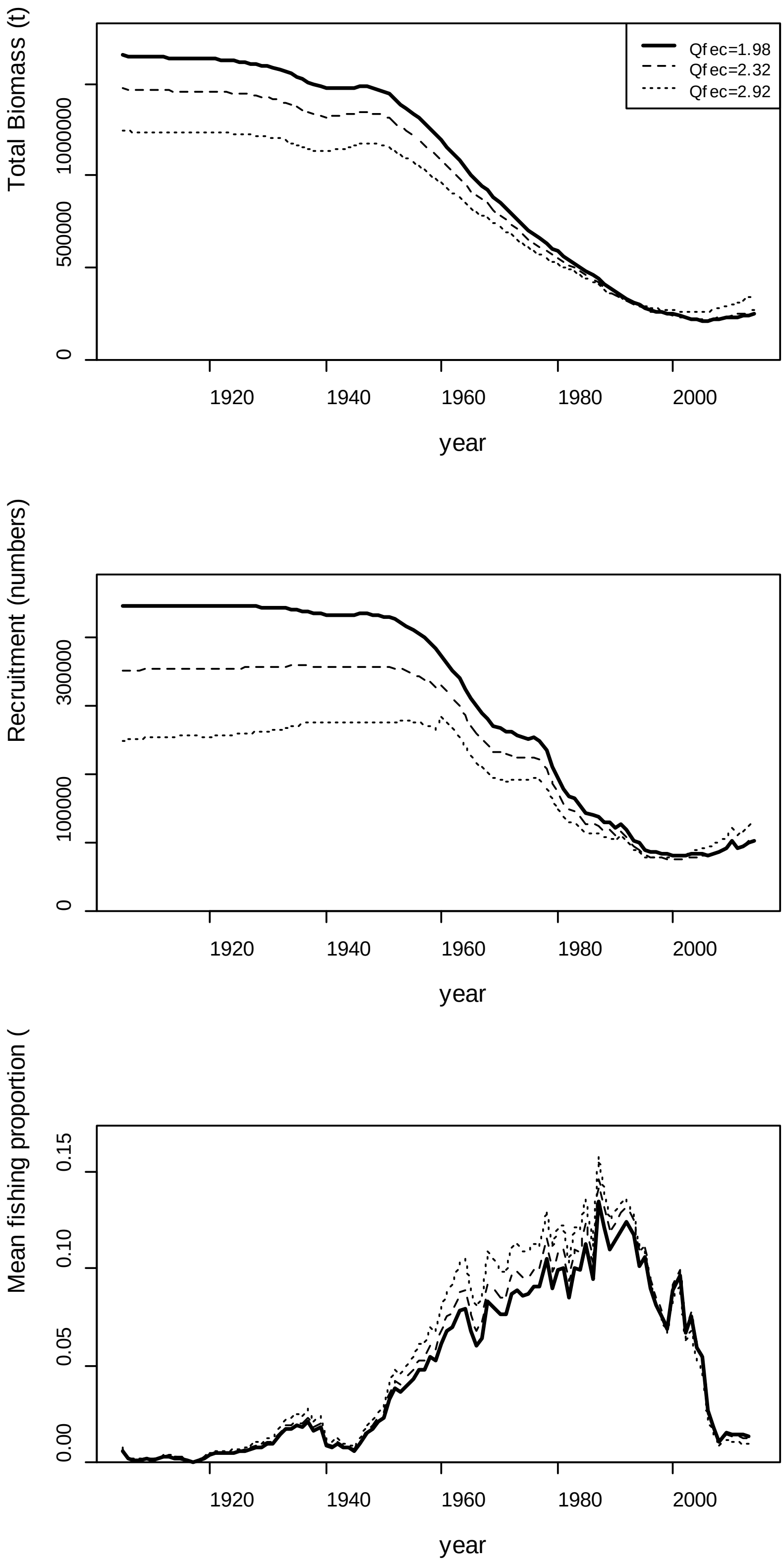


Figure 2.29. Northeast Atlantic spurdog. A sensitivity analysis of the parameter that determines the extent of density-dependence in pup production (Q_{fec}). Three alternative values are considered, related to the smallest, optimum (in terms of lowest –ln*L*) and largest value of Q_{fec} below the hashed line in Figure 2.21c (respectively 1.98 [base case], 2.32 and 2.92).

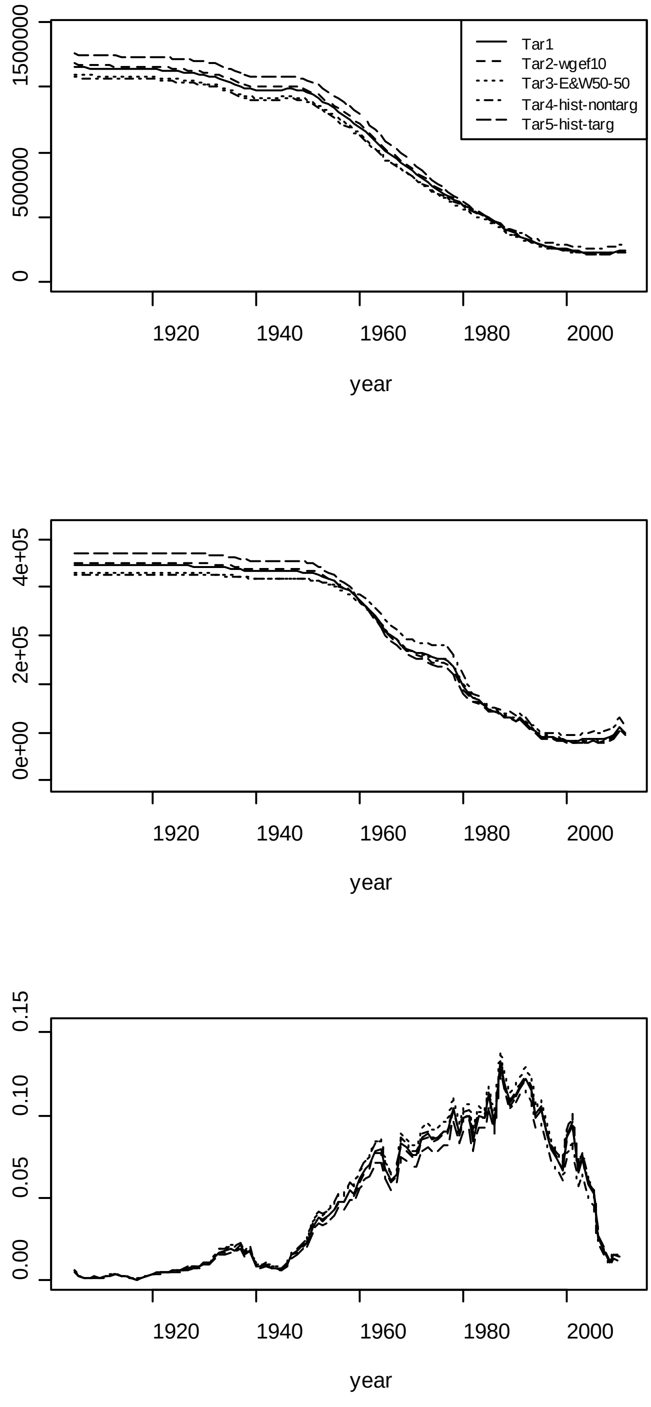


Figure 2.30. Northeast Atlantic spurdog. A comparison of the alternative targeting scenarios, where fishing is defined as either "non-target" (Scottish selectivity) or "target" (England & Wales selectivity). Tar 1 is the base case (each nation is defined "non-target", "target" or a mixture of these, with pre-1980s allocated the average for 1980–1984), Tar 2 is as for WGEF in 2010 (Scottish landings are "non-target", E&W "target", and the remainder raised in proportion to the Scottish/E&W landings, with pre-1980s allocated the average for 1980–1984), Tar 3 as for Tar 2 but with E&W split 50% "non-target" and 50% "target", and Tar 4 and 5 as for Tar 1, but with pre-1980 selectivity entirely non-target (former) or target (latter). This Figure is taken from WGEF (2011; i.e. not update with 2013 data) to illustrate sensitivity to assumptions about historic selection.

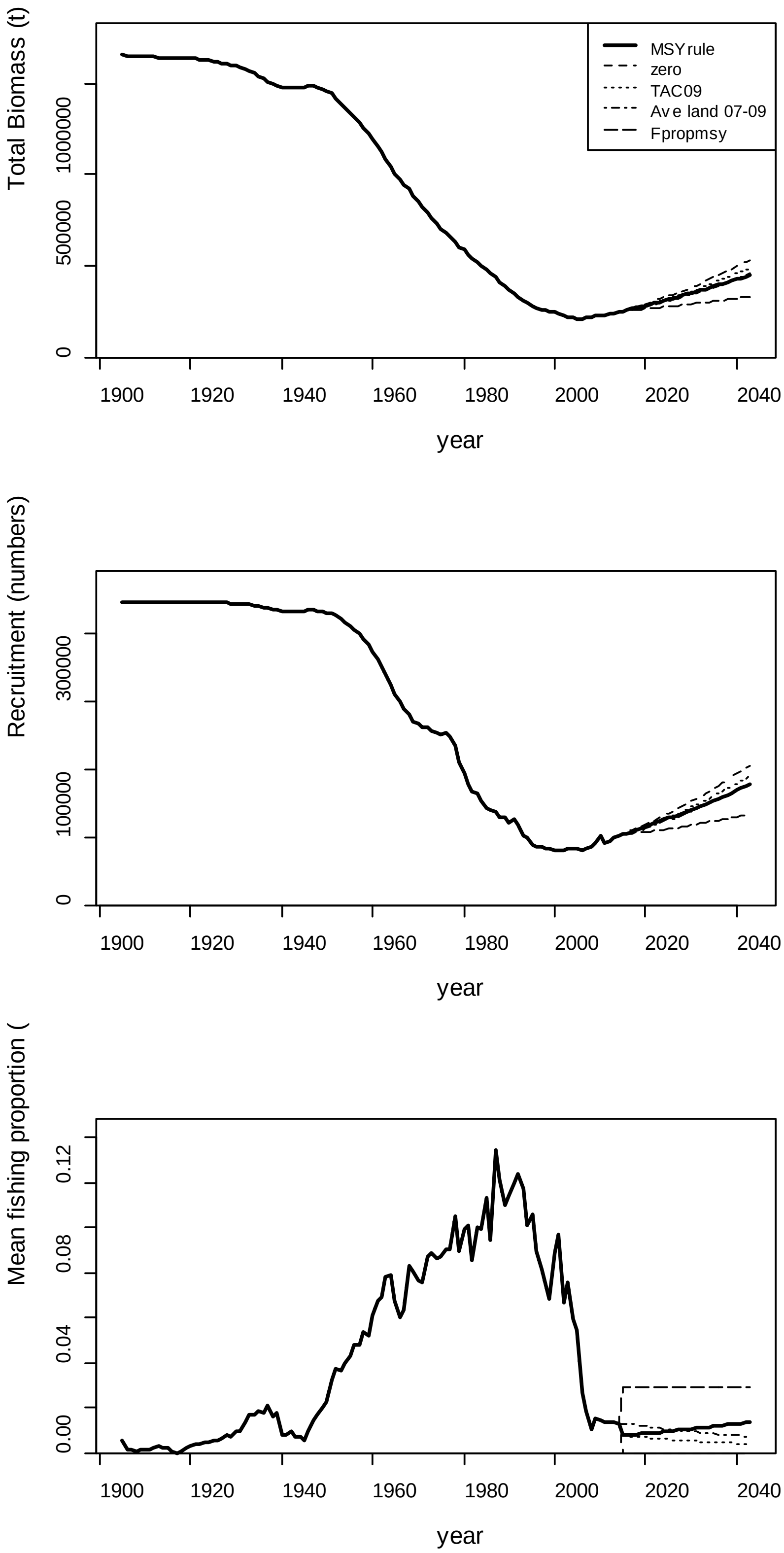


Figure 2.31. Northeast Atlantic spurdog. Northeast Atlantic spurdog. 30-year projections for different levels of future catch, including zero catch for reference.

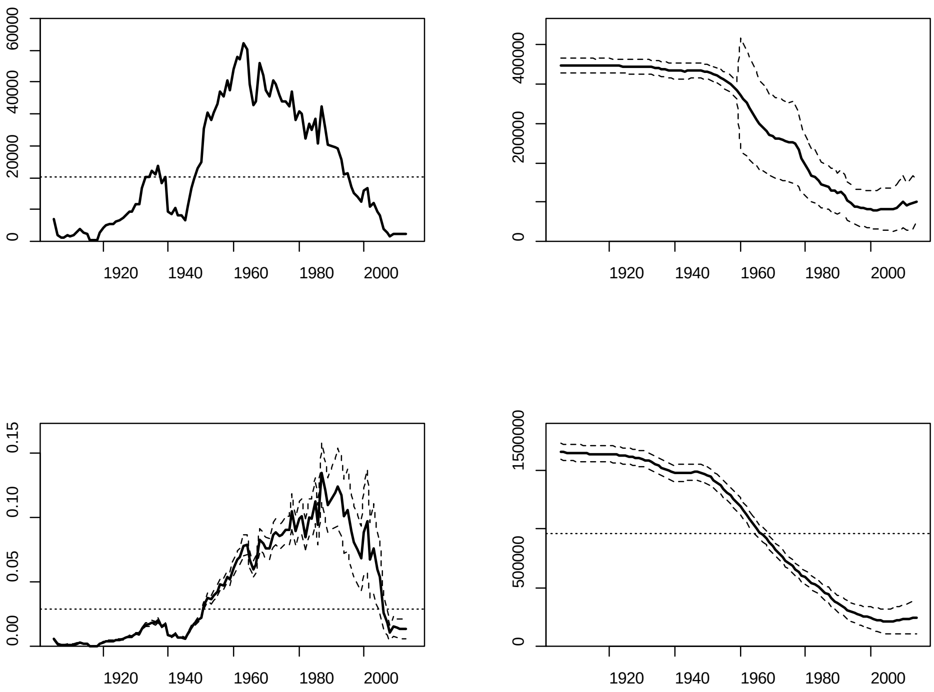


Figure 2.32. Northeast Atlantic spurdog. Summary four-plot for the base-case, showing long-term trends in landings (tons; dotted horizontal line=MSY=20 321t), recruitment (number of pups), mean fishing proportion (average ages 5–30; dotted horizontal line=$F_{prop,MSY}$=0.029) and total biomass (tons; dotted horizontal line=associated *MSY* level=963 741t). Hashed lines reflect estimates of precision (±2 standard deviations).

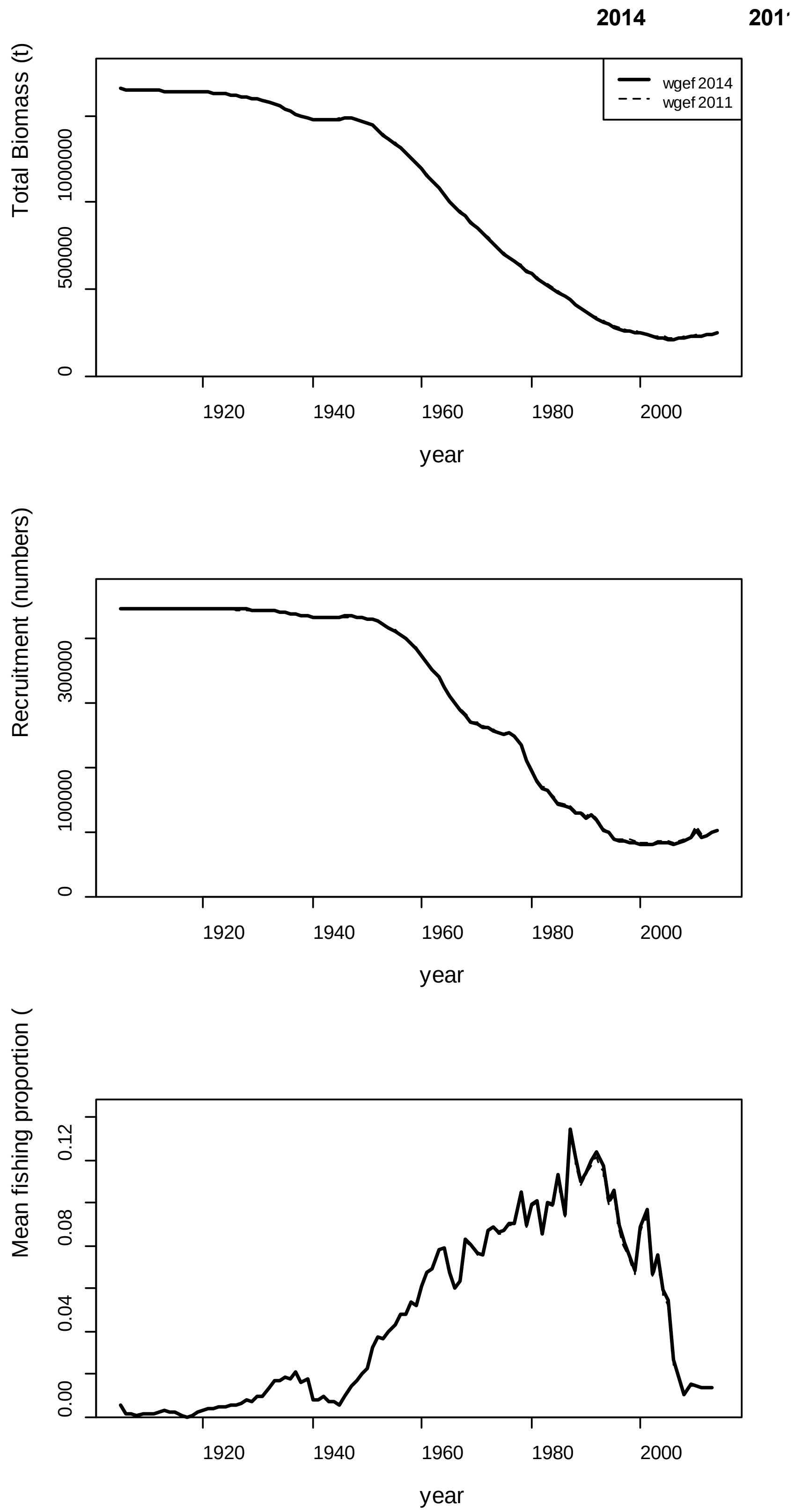


Figure 2.33. Northeast Atlantic spurdog. Comparison with the assessment from WGEF (2011). [Note, there is almost no change.]

3 Deep-water sharks; Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV)

3.1 Stock distribution

A number of species of deep-water sharks are exploited in the ICES area. This section deals with *Centrophorus squamosus* and *Centroscymnus coelolepis*, which have been the two species of greatest importance to commercial fisheries.

In some of European fisheries landings data for both species were combined for most of the time since the beginning of the fishery. In the past these two species have been assigned to a generic term "siki".

3.1.1 Leafscale gulper shark

Leafscale gulper shark (*Centrophorus squamosus*) has a wide distribution in the NE Atlantic from Iceland and Atlantic slopes south to Senegal, Madeira and the Canary Islands. On the Mid-Atlantic Ridge it is distributed from Iceland to the Azores (Hareide and Garnes, 2001) The species can live as a demersal shark on the continental slopes (at depths of 230–2400 m) or have a more pelagic behaviour, occurring in the upper 1250 m of oceanic areas with bottoms around 4000 m (Compagno and Niem, 1998).

Available information suggests that this species is highly migratory (Clarke *et al.*, 2001; 2002; Moura *et al.*, 2014). In the NE Atlantic the distribution pattern formerly assumed for this species considered the existence of a large scale migration, where females would give birth off the Madeira Archipelago, from which there were reports of pregnant females (Severino *et al.*, 2009). New data shows that pregnant females were also found off Iceland, indicating another potentially important reproductive area in the northern part of the NE Atlantic (Moura *et al.*, 2014). Juveniles are rarely caught. Segregation by sex, size and maturity seems to occur, likely linked by factors such as depth and temperature: post-natal and mature females tended to occur in relatively shallower sites whereas pregnant females were distributed preferentially at warmer stations compared to the remaining maturity stages, particularly immature females, which were usually found at greater depths and lower temperatures (Moura *et al.*, 2014). Although based on a small sample size, recent tagging studies have observed movements from the Cantabrian Sea to the Porcupine Bank (Rodríguez-Cabello and Sánchez, 2014).

A molecular study did not reject the null hypothesis of genetic homogeneity among NE Atlantic collections using six nuclear loci (Verissimo *et al.*, 2012). The same study however showed that females of this species are less dispersive than males and possibly philopatric. In the absence of more clear information on stock identity, a single assessment unit of the Northeast Atlantic has been adopted.

3.1.2 Portuguese dogfish

Portuguese dogfish (*Centroscymnus coelolepis*) is widely distributed in the NE Atlantic. Stock structure and dynamics are poorly understood. Specimens below 70 cm have been recorded very rarely. The absence of these small fish in the NE Atlantic may be a consequence of their concentration in nurseries outside the sampling areas, movement to pelagic or deeper waters, gear selectivity or to different habitat and/or prey choices, with juveniles being more benthic (Moura *et al.*, 2014). Consistent results among studies show that females move to shallower waters for parturition (Girard and Du Buit, 1999; Clarke *et al.*, 2001; Moura and Figueiredo, 2012 WD; Moura *et al.*, 2014). The similar size ranges and different maturity stages exist in both the northern and southern

European continental slopes. The occurrence of all adult reproductive stages within the same geographical area and, in many cases in similar proportions, suggests that this species is able to complete its life cycle within these areas (Moura *et al.*, 2014).

Population structure studies developed so far were inconclusive (Moura *et al.*, 2008 WD; Verissimo *et al.*, 2011). In the absence of more clear information on stock identity, a single assessment unit of the Northeast Atlantic has been adopted.

3.2 The fishery

3.2.1 History of the fishery

Fisheries taking these species are described in stock annexes for Leafscale gulper shark and Portuguese dogfish.

3.2.2 The fishery in 2013

Since 2010, EU TACs for deep-water sharks have been set at zero. Consequently, reported landings of most of the species covered in this chapter in 2013 were very low or zero. As most of these species are taken as bycatch in mixed fisheries, it is likely that discarding has increased.

3.2.3 ICES advice applicable

In 2012 ICES advised: on the basis of the precautionary approach that there should be no catches of Portuguese dogfish and leafscale gulper shark. This advice is valid for 2013, 2014 and 2015.

3.2.4 Management applicable

The EU TACs that have been adopted for deep-sea sharks in European Community waters and international waters at different ICES subareas are summarized in the table below. The deep-sea shark category includes the following species (Council regulation (EC) No 1182/2013): Deep-water catsharks (*Apristurus* spp.); frilled shark (*Chlamydoselachus anguineus*), gulper sharks (*Centrophorus* spp.), Portuguese dogfish (*Centroscymnus coelolepis*), longnose velvet dogfish (*Centroscymnus crepidater*), black dogfish (*Centroscyllium fabricii*); birdbeak dogfish (*Deania calcea*); kitefin shark (*Dalatias licha*); greater lantern shark (*Etmopterus princeps*); velvet belly (*Etmopterus spinax*); mouse catshark (*Galeus murinus*); six-gilled shark (*Hexanchus griseus*); sailfin roughshark (sharpback shark) (*Oxynotus paradoxus*); knifetooth dogfish (*Scymnodon ringens*) and Greenland shark (*Somniosus microcephalus*).

FISHING OPPORTUNITIES	V, VI, VII, VIII, IX	X	XII (INCLUDES ALSO *DEANIA HISTRICOSA* AND *DEANIA PROFONDORUM*
2005 and 2006	6763	14	243
2007	2472(1)	20	99
2008	1646(1)	20	49
2009	824(1)	10(1)	25(1)
2010	0(2)	0(2)	0(2)
2011	0(3)	0(3)	0(3)
2012	0	0	0
2013	0	0	0
2014	0	0	0
2015	0	0	0

(1) Bycatches only. No directed fisheries for deep-sea sharks are permitted.

(2) Bycatches of up to 10% of 2009 quotas are permitted.

(3) Bycatches of up to 3% of 2009 quotas are permitted.

Council Regulation (EC) No 1568/2005 bans the use of trawls and gillnets in waters deeper than 200 m in the Azores, Madeira and Canary Island areas.

Council Regulation (EC) No 41/2007 banned the use of gillnets by Community vessels at depths greater than 600 m in ICES Divisions VIa, b, VII b, c, j, k and Subarea XII. A maximum bycatch of deep-water shark of 5% is allowed in hake and monkfish gillnet catches.

A gillnet ban in waters deeper than 200 m is also in operation in the NEAFC regulatory Area (all international waters of the ICES Area). NEAFC also ordered the removal of all such nets from these waters by the 1st February 2006.

NEAFC Recommendation 7: 2013 requires Contracting parties to prohibit vessels flying their flag in the Regulatory Area from directed fishing for deep-sea sharks on the following list: *Centrophorus granulosus, Centrophorus squamosus, Centroscyllium fabricii, Centroscymnus coelolepis, Centroscymnus crepidater, Dalatias licha, Etmopterus princeps, Apristurus spp, Chlamydoselachus anguineus, Deania calcea, Galeus melastomus, Galeus murinus, Hexanchus griseus, Etmopterus spinax, Oxynotus paradoxus, Scymnodon ringens* and *Somniosus microcephalus*.

3.3 Catch data

During 2011–2012 the project "*Reduction of deep-sea sharks bycatches in the Portuguese longline black scabbard fishery*" (Ref. MARE C3/IG/re ARES (2011) 1021013) was carried out to study the bycatch of deep-water sharks, mainly leafscale gulper shark and Portuguese dogfish, from the Portuguese longline fisheries targeting black scabbardfish (mainland Portugal, Azores and Madeira) with the following objectives: i) evaluate the species distributions; ii) evaluate the overlap between deep-sea sharks and black scabbardfish; and iii) evaluate the testing modification of the fishing gear. WGEF considers that this study project does not provide relevant information on the species distribution and on their stocks, as it was restricted to the exploited areas of the deep-water longline fisheries targeting black scabbardfish. Sampling levels were low and did not provide sufficient spatial coverage to allow evaluation of the spatial overlap between deep-sea sharks and black scabbardfish. The trends in estimated biomass indices presented combined quite distinct data sources, logbooks and onboard observations conducted during the project, both with great caveats. No relevant technical modifications on the fishing gear were essayed that could contribute to minimize the deep-sea sharks bycatch levels.

A recent study (Veiga *et al*., 2013) used fishery-dependent data (vessel monitoring systems, logbooks and official daily landings) to evaluate the spatial distribution and overlap between black scabbardfish and leafscale gulper shark taken by the longline fishery operating off mainland Portugal (ICES Division IXa) using the geostatistical method kriging. Results indicated that in fishing grounds where black scabbardfish is more abundant, the relative occurrence of this deep-water shark is reduced. These findings have implications for alternative management measures to be adopted in this particular fishery, particularly where it concerns the minimization of deep-water shark bycatch.

3.3.1 Landings

Landings of leafscale gulper shark and Portuguese dogfish have historically been included by many countries in mixed landings categories such as sharks NEI, dogfish NEI, etc. Where possible, WGEF has used the experience of WG participants to assign mixed landings by species. The assumptions that have been made are described in the Stock Annex. For a significant proportion of landings, it was not possible to determine identity to species level and hence the landings presented here are of "siki" sharks are a mixed category comprising mainly *C. squamosus* and *C. coelolepis* but also including unknown quantities of other species.

Figure 3.1 shows landings trends by country and Figure 3.2 shows trends by area. The Working Group estimates of total landings of mixed deep-water sharks, believed to be mainly Portuguese dogfish and leafscale gulper shark but possibly also containing a small component of other species, are presented in Tables 3.1–3.2.

Landings have declined from around 10 000 t from 2001 to 2004, 1 t in 2012 (Figures 3.1 and 3.2). The recent decrease in landings is mostly related to the imposition of the TAC, which has been set at zero catch since 2010.

3.3.2 Discarding

Since 2010 the EU TACs in for deep-water sharks has been set at zero, and consequently it is believed that the discarding in mixed deep-water fisheries has increased. New discard data were provided by Portugal (IXa), Spain (VI–VII and VIIIc–IXa) and France (VI and VII).

Portugal. The on-board sampling programme of Portuguese commercial vessels that operate deep-water longlines to target black scabbardfish (métier LLD_DWS_0_0_0), carried out by IPMA/INRB, started in mid-2005. Nine and two longline fishing trips were sampled in 2012 and 2013 respectively (Prista *et al.*, 2014 WD). Sampling effort was fixed at three trips per quarter and sampled trips and vessels were selected in a quasi-random way (Fernandes *et al*., 2001 WD). Reasons for lower coverage are mostly related to vessels not having space on board to accommodate observers and/or being unable to guarantee their safety under bad weather conditions, logistic constraints in accessing ports of departure and, after 2009, an increasing need to allocate observers to other fisheries, namely set gill/trammelnets that also target demersal stocks.

Table 3.3 presents haul information of sampled trips and sets and the frequency of occurrence (%) of Portuguese dogfish and leafscale gulper sharks in the discards of the sets sampled. It was not possible to raise discards sampled in the longline fishery to fleet level due to suspected bias in sampled trips with respect to vessel size and fishing ground. Specifically, larger vessels and vessels that operate in the northern reaches of the Portuguese coast appear to have been sampled more in recent years than in the early stages of the sampling programme. Summary data of length–frequency and sex-ratio of elasmobranchs discarded by the Portuguese longline fishery targeting black scabbardfish are presented in Table 3.4.

Under the same sampling program a small number of Portuguese dogfish specimens (n= 7) were discarded from bottom otter trawl fishery that targets deep-water rose shrimp and Norway lobster (OTB__>=55_0_0) in 2013 (Prista *et al.*, 2014WD).

Spain. The Spanish Discards Sampling Programme for Otter and Pair Bottom Trawl (OTB and PTB) fleets, covering ICES Subareas VI, VII, VIIIc and North IX, was started in 1988; however, it did not have yearly continuity until 2003. The sampling strategy and the estimation methodology used follows the "Workshop on Discard Sampling Methodology and Raising Procedures" guidelines (ICES, 2003) and more detail of this applied to this area is explained in Santos *et al*. (WD 2010).

Discards of *Centrophorus* spp. are presented in Table 3.5. It is not known whether these are *C. squamosus* or another species of this genus. It is also unknown whether observers have the necessary identification skills and experience to reliably identify the various deep-water sharks. It should also be noted that observer coverage in this fishery is very low and thus a very large raising factor has been applied. The mix of other species discarded suggest that the majority of the fishery occurs at depths shallower than the usual depth range for *Centrophorus* spp. and hence it is likely that they are only encountered in the small percentage of trips carried out in at the shallower end of the depth distribution. It does not appear that the sampling has been stratified to account for this and this probably explains the high inter-annual variation. The results presented in Table 3.5 can therefore not be considered reliable estimates of the quantity discarded. They are included in this report as indicative that some discarding of this genus does occur and may be of relatively large magnitude.

France. A summary of French on-board observation data for the deep-sea licensed fishing fleet is presented in Table 3.6. Note that this table includes raw observation data without any raising to the total fleet activity data. The level of discards raised to the total fleet activity with proper sampling stratification was estimated to 20% in 2011 (Dubé *et al.*, 2012). Although 2013 data were not available at the time of the WGEF meeting, these data will be available for next year.

WGEF 2013 applied an exploratory technique for estimating total catch of Portuguese dogfish and leafscale gulper shark (equivalent to discards since the introduction of the 0 TAC in 2010) using cpue from observed sampling raised to fleet level with VMS data. The analysis covered only the period 2003 to 2007 due to limitations on VMS data availability. It was not possible to further extend this analysis in 2014, however it is expected that improved data availability in the future will allow this method to be used to produce estimates of discards from the French fleet to be estimated in future years.

At present this approach is applied to *Centrophorus squamosus* and *Centroscymnus coelolepis* combined, i.e."siki sharks". Results by species are not yet fully available, although species were reliably identified at least from 2009. Cpue was estimated from observer data and these were aggregated spatially through the use of a "nested grid" following the approach used for VMS point data presented by Gerritsen *et al*. (2013).

Effort data derived from VMS were then used to raise the gridded cpue data to total catch estimates. The resulting estimates are shown in Table 3.7 together with reported landings in those years. A full description of the method used can be found in the report of WGEF 2013.

3.3.3 Quality of the catch data

Historically, very few countries have presented landing data disaggregated by species. Portugal has supplied species-specific data for many years. Since 2003 onwards other countries have increased species-specific reporting of landings but some of these data may contain misidentifications.

Furthermore it is believed that immediately prior to the introduction of quotas for deep-water species in 2001, some vessels may have logged deep-water sharks as other species (and *vice versa*) in an effort to build up track record for other deep-water species (or deep-water sharks). It was also likely that, before the introduction of quotas for deep-water sharks, some gillnetters may have logged monkfish as sharks.

In the past misreporting was considered a minor problem but this are likely to have changed recently as a reaction to the EU restrictive measures adopted for deep-water sharks. Data provided as a result of the DCF landing sampling programme at Sesimbra landing port in 2009 and 2010 revealed the existence of misidentification problems (Lagarto *et al.*, 2012 WD). Samples collected covered around 1% of the total landed weight (Serra-Pereira *et al.*, 2011WD). Further information is provided in Chapter 5, Other Deep-water Sharks.

IUU fishing is known to take place, especially in international waters.

3.3.4 Discard survival

No information available for commercial fishing operations. Scientific studies have recently tagged leafscale gulper sharks caught by longline at depths of 900–1100 m, indicating that they are capable of surviving capture by such gears (Rodríguez-Cabello and Sánchez, 2014). However, soak times in this study were restricted to 2–3 hours and the lines were hauled back at a slower speed of 0.4–0.5 $m.s^{-1}$.

3.4 Commercial catch composition

3.4.1 Species composition

Between 2006 and 2011, WGEF made a number of attempts to split mixed landings data by species using catch ratios from various historical sources. The benchmarked procedure agreed by WKDEEP 2010 is described in the Stock Annex. This methodology was further explored by a dedicated workshop on splitting of deep-water shark historical catch data in 2011 (ICES, 2011). Initial analysis of new data presented at this meeting indicated that the proportion of *C. squamosus* to *C. coelolepis* varied considerably on both a temporal and spatial level and that further work would be required to reliably split the data.

However, in the absence of reliable spatial data at a higher resolution than is currently available to national institutes, no further work has been carried out and no species level landings estimates are presented in 2014.

3.4.2 Length composition

No new information was available.

3.4.3 Quality of catch and biological data

Despite the past efforts to improve the quality of data, particularly on species composition, considerable uncertainties persist on historical data.

Since the reduction of EU TACs to zero, it is expected that significant quantities of both these species are discarded by deep-water fisheries for other species. Although some sampling of discarding has been done, the data are not adequate to estimate the quantities caught.

3.5 Commercial catch-effort data

No new data.

3.6 Fishery-independent surveys

Marine Scotland Science has conducted deep-water surveys in Subarea VI at depths ranging from 300–2040 m since 1996. The survey can be considered to be standardised in terms of depth coverage since 1998.

Ireland carried out a deep-water survey each year in Area VI and VII, concentrating on NW Ireland–west of Scotland, and the Porcupine area to the west of Ireland. Fishing took place at 500 m, 1000 m, 1500 m and 1800 m. The survey took place in September from 2006–2008 and in December 2009. No further surveys have since taken place.

These and other surveys are part of a planned coordinated survey in the ICES area, through the Planning Group on North East Atlantic Continental Slope Surveys (WGNEACS). WGNEACS 2012 was mainly dedicated to the design of a longline survey in Bay of Biscay and Iberian waters. One of its main objectives would be to clarify the distribution of all the deep-water sharks and to provide data to monitor their stock status, in the absence of commercial fisheries data.

3.7 Life-history information

No new information.

3.8 Assessments

3.8.1 Exploratory assessment

A Generalized Additive Model (GAM) with a Tweedie distribution (to account for occasional large catches and frequent zero values) was applied to catch rates (number per hour) of Portuguese dogfish and leafscale gulper shark in the Scottish deep-water surveys (1998–2013). Data used in this report differ slightly from those used in 2013 in that they are now exclusively derived from hauls on the continental slope. Data used in 2013 included approximately 20 hauls from Rockall and Rosemary Bank which have only been surveyed in recent years and therefore could potentially bias the trend. The survey covered depths of 300–2040 m and gave representative coverage of the continental slope between approximately 55–59°N. The majority of hauls were made at 500, 1000, 1500 m and 1800 m. In any one year there were usually around 5–6 hauls for each of these depth strata.

Data used in the model were restricted to the "core" depth range for each species, established through visual inspection of the data. Core depth ranges for *C. coelolepis* and *C. squamosus* were considered to be 700–1900 m and 500–1800 m, respectively. Since the survey in 1998 did not go deeper than 1000 m, data from that year was excluded from the analysis for these species. The factors considered were Latitude, Depth, and Year. The model formula was: cpue (N/hour) ~ s(year) + s(depth) + s(latitude).

Model fits are shown in Figures 3.3 and 3.4. Year effect was significant for *C. squamosus*, showing a negative trend, but not significant for *C. coelolepis*. Depth effect was significant for both species with a humped trend. Latitude was significant only for *C. coelolepis*.

The results of this analysis should be considered as preliminary and indicative only of general trends. An arbitrary Tweedie coefficient of 1.5 was used and further work will be required to determine appropriate values. The model will be developed further in 2015, including treatment of year as a factor, rather than as a smoothed variable as in the present model.

A statistical approach to evaluate the temporal trends in the abundance of female Portuguese dogfish in the Portuguese waters of ICES Division IXa was presented by Figueiredo *et al.*, 2013. It is a state space model, which integrates all the available information of the species' life history and knowledge of its biological dynamics. The model involves two processes that run in parallel: i) a non-observed process (the state process) that describes the annual female population abundance; ii) and an observational process of annual fisheries catches in numbers, assumed to be measured with error. Estimation is done within the Bayesian paradigm using sequential importance sampling with resampling. To evaluate the sensitivity of the model to the prior distributions chosen for the parameters, three scenarios with different levels of prior information were considered. Trends in population abundance level and the abundance levels themselves are quite similar in the two scenarios using biological information, but the model that incorporated all the available biological information in the priors provided the best fit to the observed data. The results indicate that taking into account the main biological drivers and the fishing information in the same state space model provides a coherent picture of the population abundance trends, further suggesting that the fishing impact on the population inhabiting Portuguese mainland waters was low (Figueiredo *et al.*, 2013: abstract).

3.9 Reference points

WGEF was not able to propose appropriate reference points for advice under the MSY framework. Methodologies for establishing MSY reference points and/or proxies for similar data-poor stocks are continuing and WGEF will use this work as a basis to develop reference points for deep-water sharks.

3.10 Management considerations

No management advice is given in 2014.

3.11 References

Dubé, B., Dimeet, J., Rochet, M.-J., Tétard, A., Gaudou, O., Messannot, C., Fauconnet, L., Morizur, Y., Biseau, A., Salaun, M. 2012. Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2011. http://archimer.ifremer.fr/doc/00109/21976/, 298 pp.

Clarke, M.W., Connolly, P.L. and Bracken, J.J. 2001. Aspects of reproduction of deep-water sharks *Centroscymnus coelolepis* and *Centrophorus squamosus* from west of Ireland and Scotland. *Journal of the Marine Biological Association of the United Kingdom*, 81: 1019–1029.

Clarke, M.W., Connolly, P.L. and Bracken, J.J. 2002. Age estimation of the exploited deep-water shark *Centrophorus squamosus* from the continental slopes of the Rockall Trough and Porcupine Bank. *Journal of Fish Biology*, 60: 501–514.

Compagno, L. J. V. and Niem, V. H. 1998. Squalidae. In FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 2. Cephalopods, crustaceans, holothurians and sharks, pp 1213–1232. Ed. by K.E. Carpenter and V.H. Niem. FAO, Rome.

Fernandes, A. C., Prista, N., Jardim, E., Silva, D. and Ferreira, A., P. 2011. Results from the 2010 Portuguese onboard sampling programme of the deepwater longline fleet with an emphasis on elasmobranch species. Working Document presented in the ICES Working Group on Elasmobranch Fishes (WGEF), Copenhagen, June 2011.

Figueiredo, I., Natário, I., Moura, T., Carvalho, L. 2013. The dynamics of *Centroscymnus coelolepis* females in the Portuguese continental waters. *Aquatic Living Resources*, 26: 355–364.

Gerritsen, H. D., Minto, C., Lordan, C. 2013. How much of the seabed is impacted by mobile fishing gear? Absolute estimates from Vessel Monitoring System (VMS) point data. *ICES Journal of Marine Science*, 70: 523–531.

Girard M., DuBuit M. H. 1999 Reproductive biology of two deep-water sharks from the British Isles, *Centroscymnus coelolepis* and *Centrophorus squamosus* (Chondrichthyes: Squalidae). *Journal of the Marine Biological Association of the UK*, 79: 923–931.

Hareide, N. R. and Garnes, G. 2001. The distribution and catch rates of deep-water fish along the Mid-Atlantic Ridge from 43 to 61 N. *Fisheries Research*, 519: 297–310.

ICES. 2003. Report of ICES Workshop on Discard Sampling Methodology and Raising Procedures. Charlottenlund, Denmark, 2–4 September 2003.

ICES. 2011. Report of the Workshop on splitting of deep-water shark historical catch data 2011 (WKSHARK). 17th June 2011, Copenhagen, Denmark. ICES 2010/2/ACOM36; 25 pp.

Lagarto, N., Moura, T., Farias, I., and Figueiredo, I. 2012. Sampling information from deep-water sharks caught in the black scabbardfish fishery from mainland Portugal. Working Documento to ICES WGEF; 5 pp.

Moura, T., Figueiredo, I. 2012. Reproductive strategy and population structure of *Centroscymnus coelolepis*. Working document to ICES WGEF; 6 pp.

Moura, T., Figueiredo, I. and Gordo, L. 2008. WD. Analysis of genetic structure of the Portuguese dogfish *Centroscymnus coelolepis* caught in the Northeast Atlantic using mitochondrial DNA (Control Region)-Preliminary results. WD to WGEF.

Moura, T., Jones, E., Clarke, M.W., Cotton, C.F., Crozier, P., Daley, R.K., Diez, G., Dobby, H., Dyb, J.E., Fossen, I., Irvine, S.B., Jakobsdottir, K., López-Abellán, L.J., Lorance, P., Pascual-Alayón, P., Severino, R.B., and Figueiredo, I. 2014. Large- scale distribution of three deep-water squaloid sharks: integrating data on sex, maturity and environment. *Fisheries Research*, 157: 47–61.

Prista, N., Fernandes, A.C., Maia, C., Moura, T., Figueiredo, I. 2013. WD. Discards of elasmobranchs in the Portuguese fisheries operating in ICES Division XIa: Bottom otter trawl, deep-water set longlines, set gillnet and trammel net fisheries (2004–2013). Working Document ICES WGEF. 18 pp.

Rodríguez-Cabello, C., and Sánchez, F. 2014. Is *Centrophorus squamosus* a highly migratory deep-water shark? *Deep Sea Research Part I*, 92: 1–10.

Santos J., H. Araújo, I. Salinas and N. Pérez. 2010. Elasmobranches Results from Spanish Discard Sampling Programme. Working Document presented to WGEF 2010.

Serra-Pereira, B., Moura, T., Farias, I., Maia,C., Lagarto, N., Veiga, N. and Figueiredo, I. 2011. Information on sharks, rays and skates landings from mainland Portugal. Working Document.

Severino, R., Afonso-Dias, I., Delgado, J., Afonso-Dias, M. 2009. Aspects of the biology of the leaf-scale gulper shark *Centrophorus squamosus* (Bonnaterre, 1788) off Madeira archipelago. *Arquipélago – Life and Marine Sciences*, 26: 57–61.

Veiga, N., Moura, T., Figueiredo, I. 2013. Spatial overlap between the leafscale gulper shark and the black scabbardfish off Portugal. *Aquatic Living Resources*, 26: 343–353.

Veríssimo, A., McDowell, J.R., and Graves, J.E. 2011. Population structure of a deep-water squaloid shark, the Portuguese dogfish (*Centroscymnus coelolepis*). *ICES Journal of Marine Science*, 68: 555–563.

Veríssimo, A., McDowell, J.R., and Graves, J.E. 2012. Genetic population structure and connectivity in a commercially exploited and wide-ranging deepwater shark, the leafscale gulper (*Centrophorus squamosus*). *Marine and Freshwater Research,* 63: 505–512.

Table 3.1. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Working Group estimate of combined landings of Portuguese dogfish and leafscale gulper shark (t) by ICES area.

	IV A	VA	VB	VI	VII	VIII	IX	X	XII	XIV	UNKNOWN AREA	
1988	0	0	0	0	0	0	560	0	0	0	0	560
1989	12	0	0	8	0	0	507	0	0	0	0	527
1990	8	0	140	6	0	6	475	0	0	0	0	635
1991	10	0	75	1013	265	70	1075	0	1	0	0	2509
1992	140	1	123	2013	1171	62	1114	0	2	0	0	4626
1993	63	1	97	2781	1232	25	946	0	7	0	0	5152
1994	98	0	198	2872	2087	36	1155	0	9	0	0	6455
1995	78	0	272	2824	1800	45	1354	0	139	0	0	6512
1996	298	0	391	3639	1168	336	1189	0	147	0	0	7168
1997	227	0	328	4135	1637	503	1311	0	32	9	0	8182
1998	81	5	552	4133	1038	605	1220	0	56	15	0	7705
1999	55	0	469	3471	895	531	972	0	91	0	0	6484
2000	1	1	410	3455	892	361	1049	0	890	0	0	7059
2001	3	0	475	4459	2685	634	1130	0	719	0	0	10105
2002	10	0	215	3086	1487	669	1198	0	1416	12	0	8093
2003	16	0	300	3855	3926	746	1180	0	849	4	0	10876
2004	5	0	229	2754	3477	674	1125	0	767	0	0	9031
2005	4	0	239	1102	842	376	1033	1	134	0	1323	5054
2006	4	0	195	638	323	208	1325	0	0	0	34	2727
2007	3	0	590	737	94	23	517	0	1	61	0	2025
2008	1	0	171	621	111	27	463	0	0	0	0	1393
2009	1	0	24	54	4	105	33	0	0	0	0	220
2010	1	0	46	43	4	5	5	0	0	0	0	104
2011	0	0	0	0	0	1	1	0	0	0	0	2
2012	0	0	51	0	0	0	1	0	0	0	0	52
2013	0	0	80	0	0	0	0	0	0	0	0	80

Table 3.2. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Working Group estimate of combined landings of Portuguese dogfish and leafscale gulper shark (t) in the Northeast Atlantic by country.

	France	UK (Scot)	UK (E&W)	Ireland	Iceland	Spain (Basque)	Portugal	Germany	Estonia	Latvia	Lithuania	Poland	Russia	Spain (Galicia)	Faeroe Island	Norway	Total
1988	0	0	0	0	0	0	560	0	0	0	0	0	0	0	0	0	560
1989	0	20	0	0	0	0	507	0	0	0	0	0	0	0	0	0	527
1990	140	14	0	0	0	0	481	0	0	0	0	0	0	0	0	0	635
1991	1288	24	104	0	0	0	1093	0	0	0	0	0	0	0	0	0	2509
1992	3104	165	80	0	1	0	1128	148	0	0	0	0	0	0	0	0	4626
1993	3468	469	174	0	1	0	946	91	0	0	0	0	0	0	3	0	5152
1994	3812	743	387	0	0	0	1155	358	0	0	0	0	0	0	0	0	6455
1995	3186	801	986	33	0	0	1354	92	0	0	0	0	0	0	60	0	6512
1996	3630	576	1036	5	0	286	1189	164	0	0	0	0	0	0	282	0	7168
1997	3095	766	2202	0	0	473	1314	106	0	0	0	0	0	0	226	0	8182
1998	3177	1007	1494	3	5	561	1260	40	0	0	0	0	0	0	158	0	7705
1999	3079	625	1019	2	0	450	1036	214	0	0	0	0	0	0	54	5	6484
2000	3519	623	413	138	0	280	1108	265	0	0	0	0	0	572	23	118	7059
2001	3684	2429	320	454	0	608	1151	431	0	0	14	0	0	615	0	399	10105
2002	2103	1184	335	577	0	621	1198	518	53	0	40	8	0	1381	0	75	8093
2003	1454	1594	4027	493	0	719	1180	640	4	0	28	0	0	737	0	0	10876
2004	1189	1135	3610	764	0	563	1125	0	0	0	0	0	0	626	0	19	9031
2005	866	802	1533	381	0	359	1033	79	0	0	0	0	0	0	0	0	5053
2006	744	184	537	113	0	78	1072	0	0	0	0	0	0	0	0	0	2727
2007	855	86	23	36	0	0	522	0	0	0	1	0	500	0	0	0	2023
2008	802	49	7	8	0	0	463	0	0	0	62	0	0	0	3	0	1393
2009	52	30	0	0	0	84	54	0	0	0	0	0	0	0	0	0	220
2010	73	21	0	0	0	0	9	0	0	0	0	0	0	0	0	0	104
2011	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
2012	0	0	0	0	0	0	1	0	0	0	0	0	0	0	51	0	52
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	0	80

Table 3.3. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Frequency of occurrence (%) of Portuguese dogfish and leafscale gulper sharks in the discards of the sets sampled in the Portuguese longline fishery for black scabbardfish (2005–2013).

YEAR	NUMBER OF TRIPS SAMPLED	NUMBER OF SETS	HOURS FISHED	*CENTROSCYMNUS COELOLEPIS* (%)	*CENTROPHORUS SQUAMOSUS* (%)
2005	3	3	115	33	0
2006	6	5	197	20	0
2007	3	3	110	33	0
2008	4	4	157	0	0
2009	6	6	247	17	0
2010	9	9	373	11	11
2011	6	6	169	0	0
2012	9	9	380	0	0
2013	2	2	NA	0	0

Table 3.4. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Length (in cm) and sex-ratio of discards of Portuguese dogfish and leafscale gulper shark sampled onboard the Portuguese deep-water set longline fishery that targets black scabbardfish (2005–2012).

TAXA	N	MEAN	SD	RANGE	% SEXED	SEX RATIO F:M
C. coelolepis	5	61.4	8.2	52–71	100	4:1
C. squamosus	1	65		65–65	0	-

Table 3.5. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Spanish discard data for *Centrophorus* sp. Numbers of sampled trips and total trips are not yet available for the years 2010 onward.

YEAR	CELTIC SEA (SUBAREAS (VI–VII))			IBERIAN WATERS (DIVISIONS (VIIIC–IXA))		
	Sampled trips	Total trips	Raised discards (tonnes)	Sampled trips	Total trips	Raised discards (tonnes)
2003	9	1172	0	51	18 036	0
2004	11	1222	0	53	20 819	0
2005	10	1194	0	97	11 693	4.5
2006	13	1152	3.2	75	18 352	4.1
2007	12	1233	0	95	17 750	0
2008	11	1206	67.3	103	15 114	0
2009	15	1304	61.1	116	14 486	85.9
2010			0			29.2
2011			0			0.9
2012			173.4			0.7
2013			0			0

Table 3.6. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Summary of French on-board observation data for the deep-sea licensed fishing fleet. Number of fishing vessels, trips, haul and days-at-sea observed per year. Accumulated total landings, total discards, proportion landed, proportion discarded, and landings and discards of deep-water species during observed trips.

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Number of vessels observed	22	13	6	1	10	15	17	11	10
Number of fishing trip	29	15	9	1	11	32	36	27	24
Number of hauls	280	152	118	11	222	586	561	414	352
Number of days at sea	333	172	119	14	141	343	455	321	269
Total observed catch (t)	660	341	189	4	378	1438	1300	1162	939
Total landings (t)	401	213	108	4	318	1120	1180	990	808
Total discards (t)	258	129	81	1	61	318	119	171	130
Proportion landed	0.61	0.63	0.52		0.84	0.77	0.90	0.85	0.86
Proportion discarded	0.39	0.37	0.48		0.16	0.23	0.10	0.15	0.14
Catch of deep-water species (t)	378	298	161	1	298	1213	1057	983	776
Landings of deep-water species (t)	201	180	88	>1	254	926	968	827	667
Discards of deep-water species (t)	178	117	72	>1	45	287	89	156	108

Table 3.7. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Catch of siki sharks per year estimated from onboard observation cpue (average 2004–2012) multiplied by VMS effort in 2003–2007 compared to logbook landings (all French landings) in the same years.

Year	Nested grid estimate	Logbook landings
2003	1492.8	1454
2004	1543.2	1189
2005	1321.4	866
2006	926.0	744
2007	866.8	855

Table 3.8. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Data included in the GLM analysis of Scottish deep-water survey data: numbers of hauls within the specified depth range, numbers of individuals caught and numbers caught per hour.

	C. COELOLEPIS			C. SQUAMOSUS		
Year	N hauls	N fish	Mean NpH	N hauls	N fish	Mean Nph
1998				18	57	1.54
2000	22	103	2.34	28	70	1.25
2002	19	63	1.78	27	66	1.45
2004	15	27	0.90	22	18	0.41
2005	14	39	1.39	19	46	1.21
2006	22	35	0.84	33	37	0.64
2007	15	35	1.16	22	19	0.65
2008	22	40	1.09	31	14	0.39
2009	30	31	0.99	38	20	0.79
2011	22	33	1.35	28	1	0.04
2012	27	33	1.52	34	14	0.47

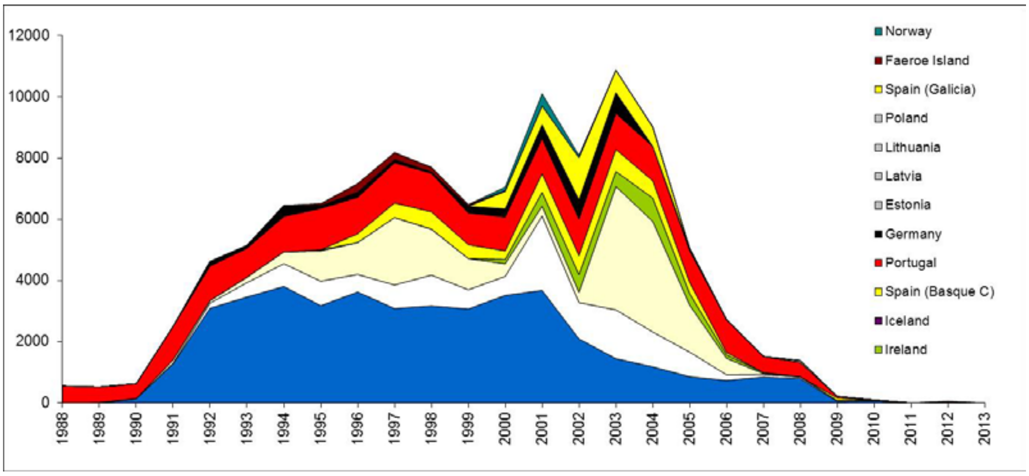


Figure 3.1. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Working Group estimates of combined landings of the two species, by country.

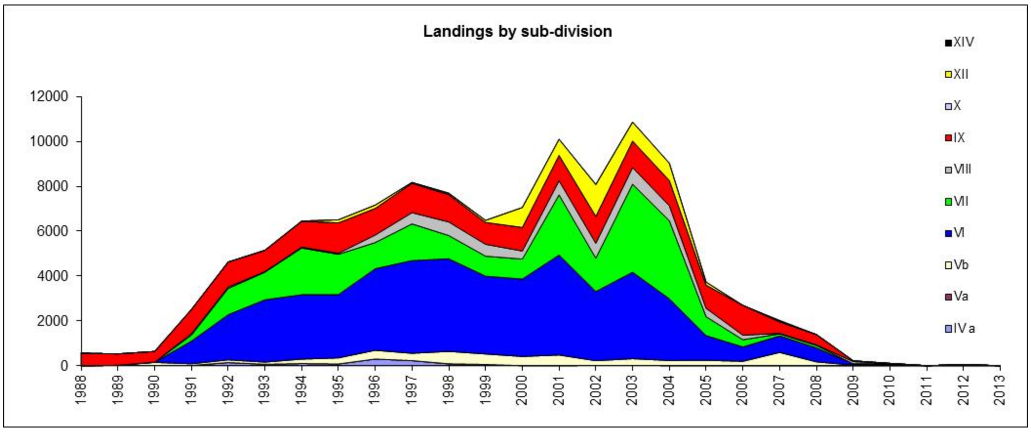


Figure 3.2. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Working Group estimates of combined landings of the two species, by ICES Subarea.

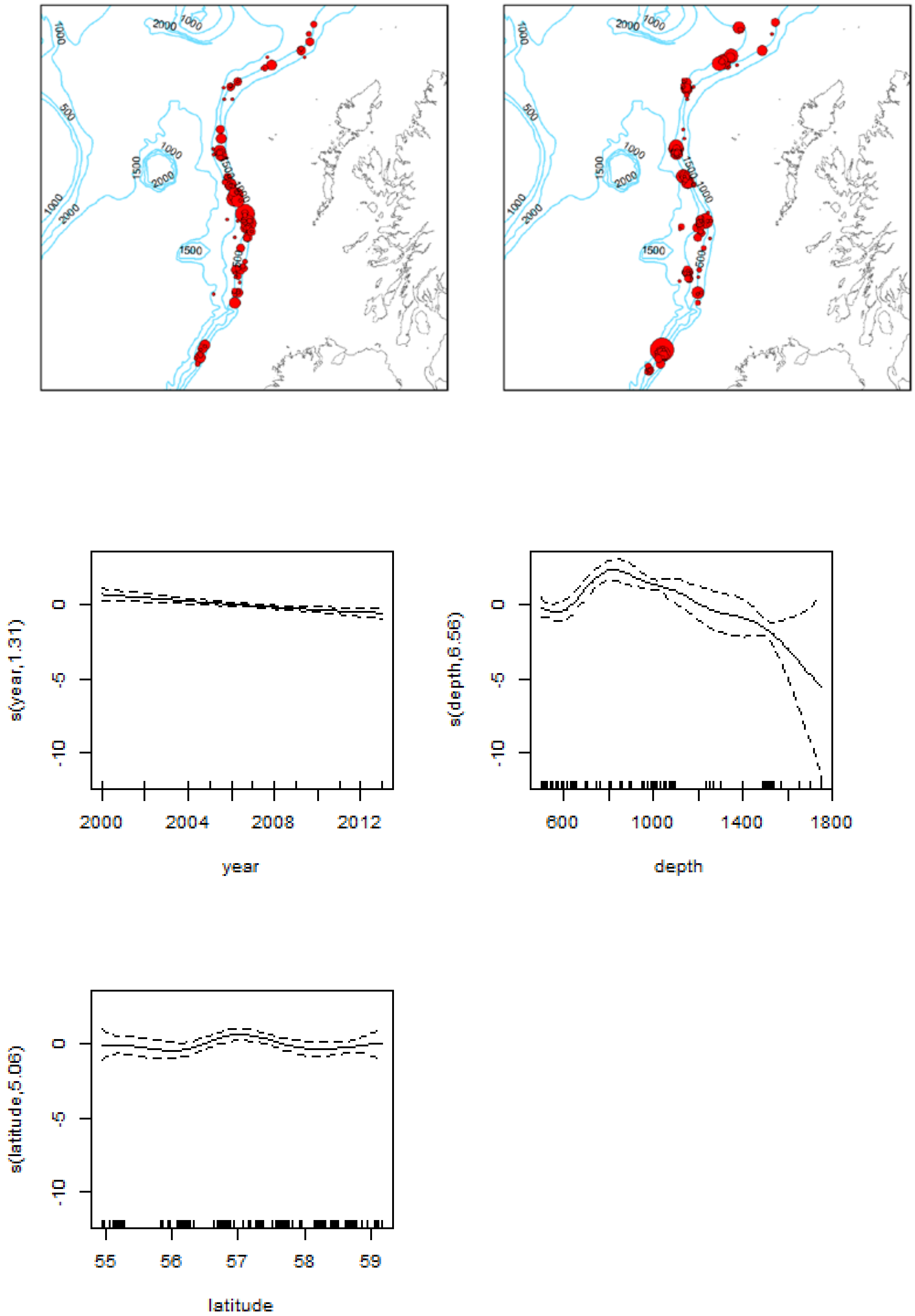


Figure 3.3. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Results of General Additive Model (GAM) applied to *C. Coelolepis* in Scottish deepwater surveys 2000 to 2013. Approximate significance of smooth terms:

	edf	Ref.df	F	p-value
s(year)	1.307	1.545	6.758	0.00404
s(depth)	6.564	7.584	15.469	<2e-16
s(latitude)	5.056	6.100	2.085	0.05451

R-sq.(adj) = 0.395 Deviance explained = 39.8%

GCV score = 0.034503 Scale est. = 0.032662 n = 261

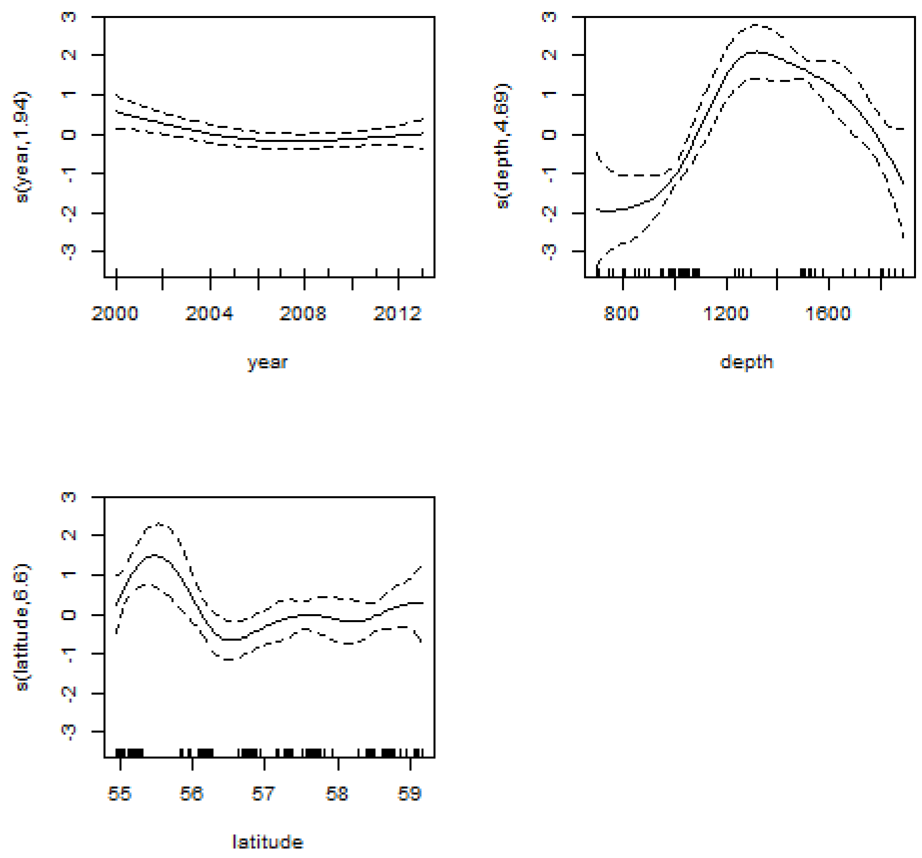


Figure 3.4. Deep-water sharks - Leafscale gulper shark and Portuguese dogfish in the Northeast Atlantic (IV–XIV). Results of General Additive Model (GAM) applied to *C. Coelolepis* in Scottish deep-water surveys 2000 to 2013. Approximate significance of smooth terms:

	edf	Ref.df	F	p-value
s(year)	1.941	2.387	2.836	0.05173
s(depth)	4.688	5.604	28.974	<2e-16
s(latitude)	6.599	7.653	3.440	0.00123

R-sq.(adj) = 0.312 Deviance explained = 52.6%
GCV score = 0.034598 Scale est. = 0.032287 n = 213

4 Kitefin shark in the Northeast Atlantic (entire ICES Area)

4.1 Stock distribution

Kitefin shark *Dalatias licha* is widely distributed in the deeper waters of the North Atlantic, from Norway to northwestern Africa and the Gulf of Guinea, including the Mediterranean Sea and NW Atlantic.

The stock identity of kitefin shark in the NE Atlantic is unknown. However the resource seems to be more abundant in the southern area of the Mid-Atlantic Ridge (ICES Area X). Elsewhere in the NE Atlantic, kitefin shark is recorded infrequently. Kitefin shark is caught as bycatch in mixed deep-water fisheries in Subareas V–VII, although at much lesser abundance than the main deep-water sharks (see Section 3), and the species composition of the landings is not accurately known.

For assessment purposes, the Azorean stock (ICES Subarea X) is considered as a management unit.

4.2 The fishery

4.2.1 History of the fishery

The directed fishery on the Azores stopped at the end of the 1990s because it was not profitable. Kitefin shark in the North Atlantic is currently a bycatch in other fisheries. A detailed description of the fishery can be found in Heessen (2003) and ICES (2003).

Historically, landings from the Azores began in the early 1970s and increased rapidly to over 947 t in 1981 (Figure 4.1). From 1981–1991 landings fluctuated considerably, following market fluctuations, peaking at 937 t in 1984 and 896 t in 1991. Since 1991 the reported landings have declined, possibly as a result of economic problems related to markets. Since 1988, a bycatch has been reported from mainland Portugal with 282 t in 2000 and 119 t in 2003.

4.2.2 The fishery in 2012 and 2013

Kitefin shark from the Azores is now a bycatch from different demersal/deep-water mixed hook and line fisheries, with landings in the period 2004–2009 usually 10 t or less, less than 2 t during 2010 and 2011 and zero during the last two years (WD Pinho, 2014a). Landings of kitefin shark in other areas continue to remain at low levels (Table 4.1).

4.2.3 ICES advice applicable

For 2013 and 2014 ICES advises on the basis of the precautionary approach that no targeted fisheries should be permitted unless there are reliable estimates of current exploitation rates and sufficient data to assess productivity. There should be no fisheries unless there is evidence that this will be sustainable.

This is similar to the advice since 2006 where ICES has advised: "*This stock is managed as part of the deep-sea shark fisheries. No targeted fisheries should be permitted unless there are reliable estimates of current exploitation rates and sufficient data to assess productivity. It is recommended that exploitation of this species should only be allowed when indicators and reference points for future harvest have been identified and a management strategy, including appropriate monitoring requirements has been decided upon and is implemented*".

4.2.4 Management applicable

Deep-water sharks are subject to management in Community waters and in certain non-Community waters for stocks of deep-sea species (EC no 2270/2004 article 1). Fishing opportunities (TAC) for stocks of deep-sea shark species for Community vessels were presented in an Annex (EC no 2270/2004 and EC no 2015/2006 annex part 2). A list of species was given to be considered in the Group of 'deep-sea sharks'.

The 2007–2008 TAC for V, VI, VII, VIII and IX for these species was 2472 t. In Subarea X the TAC was 20 t and in Subarea XII 99 t. The 2009 TAC for V, VI, VII, VIII and IX was 824 t, for XII 25 t and 10 t for Area X. A zero TAC was set for all areas since 2010 (EC Reg. no 1359/2008, EC Reg no 1262/2012).

There is a network of closed areas in Azorean waters (summarized in Section 20).

For 2009 the Regional Government introduced new technical measures for the demersal/deep-water fisheries (Portaria n.º 43/2009 de 27 de Maio de 2009) including area restrictions by vessel size and gear, and gear restrictions (hook size and maximum number of hooks on the longline gear). During 2010 a seamount (Condor seamount) was closed to demersal/deep-water fisheries under a multidisciplinary project to study its dynamic.

4.3 Catch data

4.3.1 Landings

The landings reported from each country, for the period 1988–2012, are given in Table 4.1 and the total historical landings 1972–2013 in Figure 4.1.

4.3.2 Discards

No new data were presented this year. Discard rates between 15% and 85% of the kitefin shark caught by set were reported from the sampled Azorean longliners during 2004–2010 (ICES, 2012). During 2011–2013 the discards may have increased due to management restrictions, or landed as unspecified elasmobranchs.

Sporadic and low levels of kitefin shark discards were reported from the Spanish trawl fleets operating in Iberian waters (Divisions VIIIc, IXa) in 2010–2012.

4.3.3 Quality of catch data

Deep-water sharks taken in the Azores are usually gutted, finned, beheaded and also skinned. Only the trunks and, in some cases, the livers are used. Species misidentification is a problem with deep-water sharks. The Azorean landings data reported to ICES come exclusively from the commercial first sale of fresh fish on the auctions. Therefore, data in Table 4.1 may be an underestimate of total landings.

4.4 Commercial catch composition

No new information.

4.5 Commercial catch-effort data

No new information.

4.6 Fishery-independent surveys

Existing surveys rarely catch kitefin shark, as the surveys are not designed for the species, and will not provide relevant information for the assessment.

Relative abundance of kitefin shark (number per hour trawling) from the Scottish deep-water trawl survey (depth range 500–1000 m) was submitted to the group and presented in Table 4.2. These data confirm that only low numbers (less than ten individuals per year) are caught in this survey. The total sample (n = 34) comprised eight males (60–110 cm) and 26 females (40–140 cm).

Relative abundance data of kitefin shark (Kg per haul) from the Spanish ground fish survey on the Porcupine bank were presented to the group (Ruiz-Pico *et al*., 2014 WD; Figures 4.2–4.4). A total of 177 individuals were caught over the twelve year survey period.

From the Azorean longline survey (ARQDACO(P)-Q1), which fishes 495 stations per survey on average, covering the depth range 50–1200 m, only 59 individuals were caught during the period 1996–2013 (WD Pinho, 2014b). These specimens were caught over the entire time period (four individuals per year on average) at depths of 300–800 m and over a length range of 43–150cm TL.

4.7 Life-history information

There is no new information available.

Individuals less than 98 cm are scarce in the region suggesting that spawning and juveniles probably occurs in deep-water or non-exploited areas. Male kitefin shark are more available to the fishery at 100 cm (age 5) and females at 120 cm (age 6).

4.8 Exploratory assessment models

4.8.1 Previous assessments of stock status

Stock assessments of kitefin shark were made during the 1980s, using an equilibrium Fox production model (Silva, 1987). The stock was considered intensively exploited with the average observed total catches (809 t) near the estimated maximum sustainable yield (MSY = 933 t). An optimum fishing effort of 281 days fishing bottom nets and 359 man trips fishing with handlines were suggested, corresponding approximately to the observed effort.

During the DELASS project (Heessen, 2003) a Bayesian stock assessment approach using three cases of the Pella-Tomlinson biomass dynamic model with two fisheries (handline and bottom gillnets) was performed (ICES, 2003; 2005). The stock was considered depleted based on the probability of the Biomass 2001 being less than B_{MSY}.

4.9 Stock assessment

No new assessment of the species status was undertaken, because no new data were available.

4.10 Quality of assessments

No new assessments were undertaken.

4.11 Reference points

No reference points have been proposed for this stock.

4.12 Conservation considerations

Kitefin shark is listed as 'Near threatened' on the IUCN Red List (Blasdale *et al.*, 2009)

4.13 Management considerations

Preliminary assessment results suggest that the stock may be depleted to about 50% of virgin biomass. However, further analysis is required to better understand the status of the stock. Fisheries for kitefin shark have been affected by fluctuations in the price of shark liver oil. An analysis of liver oil prices may provide some information on historical exploitation levels of this species.

There are no fishery-independent surveys to monitor the stock. The working group considers that the development of a fishery should not be permitted unless data on the level of sustainable catches will be available. If an artisanal, sentinel fishery will be established it should be accompanied by a data collection program.

A seamount (i.e. Condor) has been closed to fisheries up to 2014, accompanied by a multidisciplinary research (ecological, oceanography and geological) project for the characterization of the dynamics of the stock in the area (Portaria n.º 48/2010 de 14 de Maio de 2010).

4.14 References

Blasdale, T., Serena, F., Mancusi, C., Guallart, J. and Ungaro, N. 2009. *Dalatias licha*. The IUCN Red List of Threatened Species. Version 2014.1. <www.iucnredlist.org>. Downloaded on 23 July 2014.

Heessen, H. J. L. 2003. Report of the DELASS Project.

ICES. 2003. Report of the Working Group on Elasmobranch Fishes. ICES CM 2003/G:09, 155 pp.

ICES. 2005. Report of the Working Group on Elasmobranch Fishes. ICES CM 2006/ACFM:03, 224 pp.

ICES. 2012. Report of the Working Group on Elasmobranch Fishes. ICES CM 2012/ACOM:19, 532 pp.

Pinho, M. R. 2014a. Elasmobranchs from the Azorean fisheries (ICES AREA X). ICES Working Document WGEF 2014.

Pinho, M. R. 2014b. Resuming elasmobranchs survey data from the Azores (ICES X). ICES Working Document WGEF 2014.

Ruiz-Pico, S., Velasco, F., Baldó, F., Rodríguez-Cabello, C., and Fernández-Zapico, O. 2014. Results on main elasmobranch species captured during the 2001–2013 Porcupine Bank (NE Atlantic) bottom trawl surveys. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014, 26 pp.

Silva, H. M. Da. 1987. An assessment of the Azorean stock of kitefin shark, *Dalatias licha*. ICES Copenhagen, ICES CM 1987/G:66, 10 pp.

Table 4.1. Kitefin shark in the Northeast Atlantic. Working Group estimates of landings (t) of kitefin shark *Dalatias licha*.

Country	Subarea	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
France	VII, VIII	.	.	.	.	.	.	.	.	.	.	.
UK Scotland	Vb, VI	.	.	.	.	.	.	.	.	.	.	.
UK (E&W)	VI, VII,VIII	.	.	.	.	.	.	.	.	.	.	.
Germany	VII	.	.	.	.	.	.	.	.	.	.	.
Portugal	VI, IXa	149	57	7	12	11	11	11	7	4	4	6
Portugal (Azores)	X	549	560	602	896	761	591	309	321	216	152	40
Total		698	617	609	908	772	602	320	328	220	156	46

Country	Subarea	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
France	VII, VIII	.	.	.	.		+	+	3	1	.
UK Scotland	Vb, VI	.	.	.	.	+	+	8	0	+	.
UK (E&W)	VI, VII,VIII	.	.	.	.	+	+	+	2	5	.
Ireland	X	.	.	.	.	.	.	0	.	.	.
Germany	VII	.	.	.	.	.	.	21	.	.	.
Portugal	VI, IXa	14	282	176	5	119	2	3	6	3	1
Portugal (Azores)	X	31	31	13	35	25	6	14	10	7	10
Total		45	313	189	40	144	9	47	21	14	11

Country	Subarea	2009	2010	2011	2012	2013
France	VII, VIII	.	0	9	0	0
UK Scotland	Vb, VI	.	0	0	.	.
UK (E&W)	VI, VII,VIII	.	0	0	.	.
Ireland	X	.	0	0	.	.
Germany	VII	.	0	0	.	.
Portugal	VI, IXa	1	0	0	0	0
Portugal (Azores)	X	6	2	1	0	0
Total		7	2	11	1	1

Table 4.2. Kitefin shark in the Northeast Atlantic. Relative abundance of kitefin shark (number per hour trawling) from Scottish deep-water survey (depth range 500–1000 m: Only one fish has been caught outside this core depth range), ICES Area VI.

Year	N° hauls	N° positive hauls	N° fish	Mean Nph
1998	17	2	2	0.05
2000	13	0	0	0.00
2002	16	2	4	0.13
2004	14	2	2	0.07
2005	13	1	4	0.15
2006	20	3	8	0.20
2007	15	2	7	0.23
2008	20	3	5	0.13
2009	27	1	1	0.06
2011	15	1	1	0.07
2012	18	0	0	0.00
2013	11	1	1	0.09

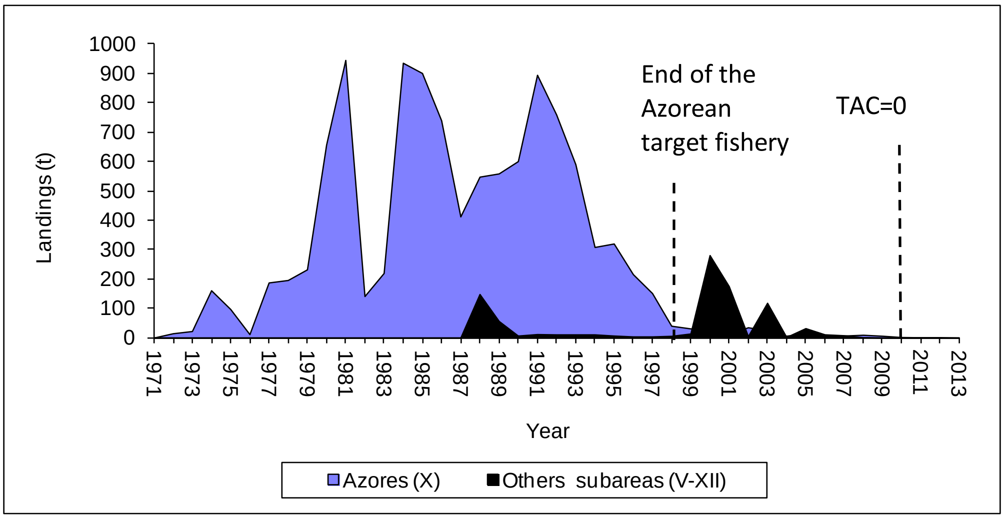


Figure 4.1. Kitefin shark in the Northeast Atlantic. Total landings of kitefin shark by ICES division. Management information is given on the graph.

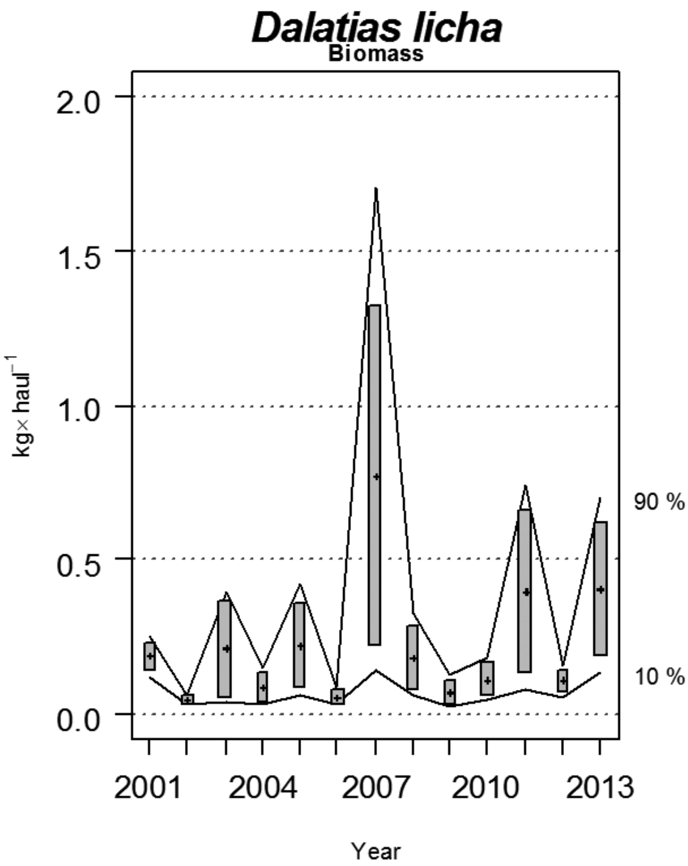


Figure 4.2. Kitefin shark in the Northeast Atlantic. Relative abundance of kitefin shark, in weight (Kg/haul), from the Spanish groundfish survey on the Porcupine bank. Source: Ruiz-Pico *et al.* (2014 WD).

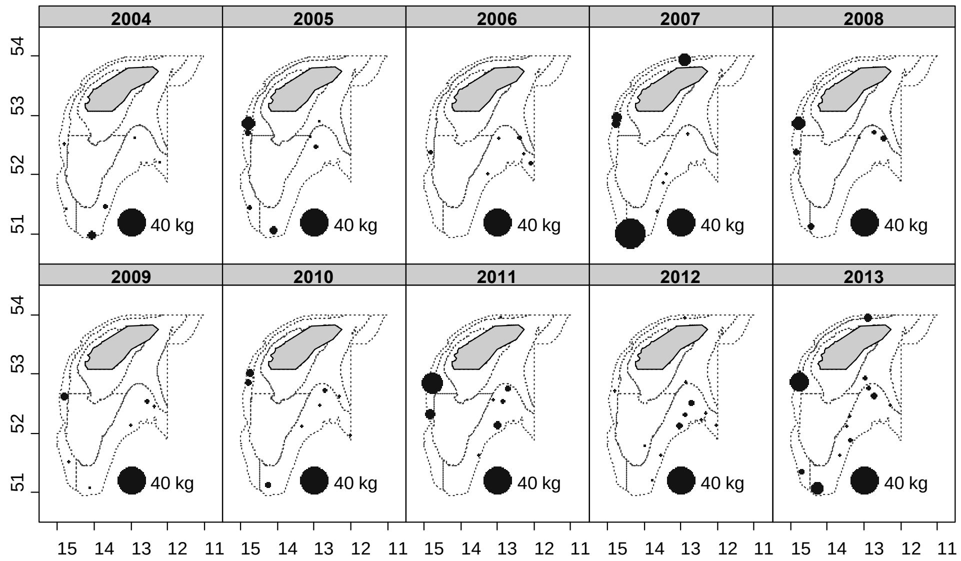


Figure 4.3. Kitefin shark in the Northeast Atlantic. Annual (2004–2013) spatial distribution of kitefin shark (Kg/haul) on the Porcupine bank survey. Source: Ruiz-Pico *et al.* (2014 WD).

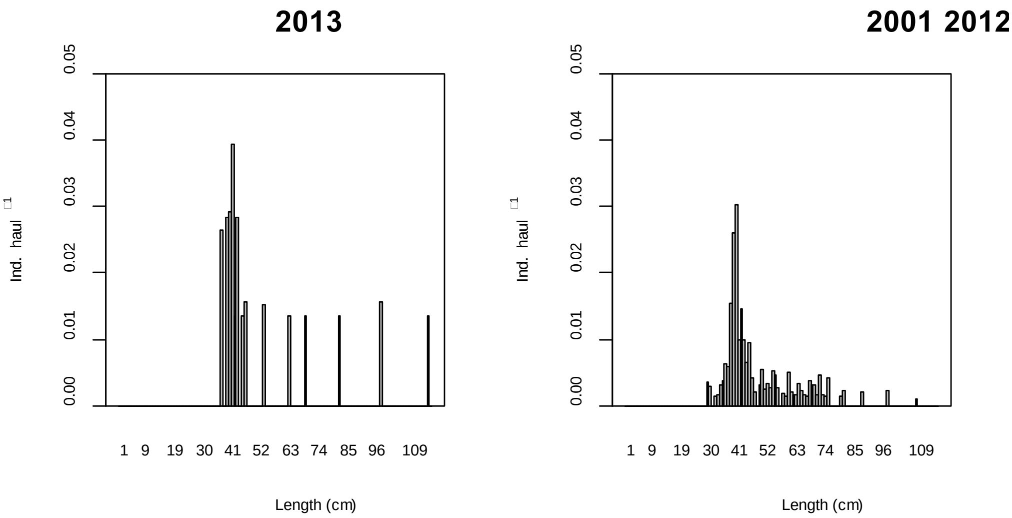


Figure 4.4. Kitefin shark in the Northeast Atlantic. Annual length composition of kitefin shark from the Spanish groundfish survey on the Porcupine Bank. Source: Ruiz-Pico *et al.* (2014 WD).

5 Other deep-water sharks and skates from the Northeast Atlantic (ICES Subareas IV–XIV)

5.1 Stock distributions

This section includes information about deep-water elasmobranch species other than Portuguese dogfish and leafscale gulper shark (see Section 3), kitefin shark (see Section 4) and Greenland shark (see Section 24). Limited information exists on the majority of the species presented here other than annual landings data for some species, which were very low in 2013 due to the zero TAC in force for deep-water sharks. In addition, it is likely that the available landings data for some species may be unreliable due to problems with species identification. For example gulper shark *Centrophorus granulosus* may be sometimes confused with morphologically similar species such as *C. lusitanicus* and *C. harrissoni* (Compagno *et al.*, 2005). Also White *et al.* (2013) demonstrated that *C. niaukang* is an ontogenic stage of *C. granulosus*.

The species and generic landings categories for which landings data are presented are: gulper shark (*Centrophorus granulosus*), birdbeak dogfish (*Deania calcea*), longnose velvet dogfish (*Centroselachus crepidater*), black dogfish (*Centroscyllium fabricii*), velvet belly (*Etmopterus spinax*), lantern sharks *nei* (*Etmopterus* spp.), and 'aiguillat noir' (may include *C. fabricii, C. crepidater* and *Etmopterus* spp.).

Fourteen species of skate (Rajidae) are known from deep water in this area: Arctic skate (*Amblyraja hyperborea*), Jensen's skate (*Amblyraja jenseni*), Krefft's skate (*Malacoraja krefft*i), roughskin skate (*Malacoraja spinacidermis*), deep-water skate (*Rajella bathyphila*), pallid skate (*Bathyraja pallida*), Richardson's skate (*Bathyraja richardsoni*), Bigelow's skate (*Rajella bigelowi*), round skate (*Rajella fyllae*), Mid-Atlantic skate (*Rajella kukujevi*), spinytail skate (*Bathyraja spinicauda*), sailray (*Rajella lintea*), Norwegian skate (*Dipturus nidarosiensis*) blue pygmy skate (*Neoraja caerulea*) and Iberian pygmy skate (*Neoraja iberica)*. Species such as *Dipturus batis*-complex and *Leucoraja fullonica* may occur in deep water, but their main areas of distribution are in shallower waters and they are not considered in this section. One species of electric ray (*Torpedo nobiliana*) may also occur in the deep water of this area.

The stock units for the deep-sea elasmobranchs considered here are unknown.

Eight species of rabbitfish (Chondichthyes; Holocephali), including members of the genera *Chimaera, Hariotta* and *Rhinochimaera* are a by-catch of some deep-water fisheries and are sometimes marketed. The current zero-TACs for deep-water sharks, whose livers were used to extract squalene, may have led to the development of catches on the common chimaera (*C. monstrosa*) in Norway (114 t in 2012, 177 t in 2013) to produce "ratfish oil". Catches of Chimaeridae are included in the report of the ICES Working Group on Deep-water Fisheries Resources (WGDEEP).

5.2 The fishery

5.2.1 History of the fishery

Most catches of other deep-water shark and skate species are taken in mixed trawl, longline and gillnet fisheries together with Portuguese dogfish, leafscale gulper shark and deep-water teleosts.

5.2.2 The fishery in 2013

Since 2010, EU TACs for deep-water sharks have been set at zero (see Section 5.2.4 below). Consequently, reported landings of most of the species covered in this chapter in 2013 were very low or zero. As most of these species are taken as bycatch in mixed fisheries, it is likely that discarding has increased.

5.2.3 ICES advice applicable

No species-specific advice is given for the shark and skate species considered here.

5.2.4 Management applicable

Prior to 2010 in EC waters, a combined TAC was set for a group of deep-water sharks. These include Portuguese dogfish (*Centroscymnus coelolepis*), leafscale gulper shark (*Centrophorus squamosus*), birdbeak dogfish (*Deania calcea*), kitefin shark(*Dalatias licha*), greater lanternshark (*Etmopterus princeps*), velvet belly (*Etmopterus spinax*), black dogfish (*Centroscyllium fabricii*), gulper shark (*Centrophorus granulosus*), blackmouth catshark (*Galeus melastomus*), mouse catshark (*Galeus murinus*), longnose velvet dogfish (*Centroselachus crepidater*), frilled shark (*Chlamydoselachus anguineus*), bluntnose sixgill shark (*Hexanchus griseus*), sailfin roughshark (*Oxynotus paradoxus*), Greenland shark (*Somniosus microcephalus*), knifetooth dogfish (*Scymnodon ringens*) and Iceland catshark (*Apristurus* spp.). In Subarea XII, rough longnose dogfish (*Deania histricosa*) and arrowhead dogfish (*Deania profundorum*) are also included on the list.

In 2010, TACs in all areas were reduced to zero with an allowance for bycatch of 10% of 2009 TACs. For 2011, the bycatch allowance was reduced to 3% of 2009 TACs and in 2012 no allowance for bycatch was permitted. This remains the *status quo* in 2013 and 2014. In 2014 the list of sharks was updated to include all *Centrophorus* species and remove the blackmouth catshark which was considered a demersal species.

Deep-water skates are included in EU TACs for "Skates and Rays Rajidae". In EU waters of VIa, VIb, VIIa–c and VIIe–k, Norwegian skate *Dipturus nidarosiensis* is one of a group of species which may not be retained on board and must be promptly released unharmed to the extent practicable.

5.3 Catch data

5.3.1 Landings

Gulper shark *Centrophorus granulosus*

Reported landings of gulper shark are presented in Tables 5.1 and 5.9.

Almost all landings have been from the Portuguese longline fishery in Subarea IX. Until 2008, annual landings from this fishery were around 100 t however, in 2009, Portuguese landings reduced to 2 t. Other countries reported very small landings from Subareas VI and VII since 2002. Reported landings of this species by UK vessels in Subareas VI and VII are considered to be misidentified. These data have been included in Working Group estimates of "siki sharks".

Birdbeak dogfish *Deania calcea*

Reported landings of birdbeak dogfish are presented in Tables 5.2 and 5.9. It is likely that landings reported as this species include other species in the same genus, particularly in Portuguese landings from Subareas X (Pinho, 2010 WD). Misidentification problems were detected in mainland Portuguese landing ports with two differently species of *Deania* being observed in catches: *D. calcea* and *D. profundorum*.

Five European countries have reported landings from Subareas VII and IX of birdbeak dogfish: Ireland, UK (England and Wales), UK(Scotland), Spain and Portugal. In 2005, the total reported landings for all subareas reached 194 t; however this declined to 66 t in 2008 and zero by 2009.

Catches of this species by Russian deep-water longline fisheries in the Faroese Fishing Zone and other Northeastern Atlantic areas were reported in working documents to WGEF (Vinnichenko and Fomin, 2009 WD; Vinnichenko *et al*., 2010 WD). However landings data from this fishery were not made available to the working group since.

Longnose velvet dogfish *Centroscymnus crepidater*

Reported landings of longnose velvet dogfish are presented in Tables 5.3 and 5.9. It is likely that some landings of this species are also included in data for "siki sharks" (see Section 3) and in other mixed categories.

Five European countries have reported landings from Subareas VI, VII, VIII and IX: UK(England and Wales), UK(Scotland), France, Spain and Portugal. Highest landings (400 t) were recorded in 2005 and were principally derived from the UK registered deep-water gillnet fleet. Reported landings have since declined to zero, probably as a result of the ban on deep-water gillnet fishing and reduced EU TACs for deep-water sharks.

Black dogfish Centroscyllium fabricii

Reported landings of black dogfish are presented in Tables 5.4 and 5.9. Landings of this species may also be included in the grouped category "*Aiguillat noir*" and other mixed categories, including siki sharks.

Four European countries have reported landings, from Subareas IVa, Vb, VII and XII: UK(England and Wales), Iceland, France and Spain.

France reported the majority of the landings of black dogfish in the ICES area, starting to report landings in 1999. French annual landings peaked at about 400 t in 2001 and have since declined. These landings are mainly from Division Vb and Subarea VI. Iceland reported few landings, all from Division Va. The largest annual landings reported by Spain came from Subarea XII in 2000 (85 t) and 2001 (91 t), but recent data are lacking.

Since 2009, only Iceland reported catches of black dogfish, mainly from Subarea V, but always in small amounts (1 ton in 2013).

Velvet belly *Etmopterus spinax*

Reported landings of velvet belly are presented in Tables 5.5 and 5.9. Five countries have reported landings of velvet belly, from Subareas II, III, IV, VI, VII, VIII and X: Denmark, Norway, UK (England and Wales), UK (Scotland) and Spain. Greatest landings are from Denmark. Landings began in 1993, peaked in 1998 at 359 t and have since declined. In recent years catches have mostly been reported by Norway, with a maximum of 19 t in 2013.

Catches of this species by Russian deep-water longline fisheries in the Faroese Fishing Zone and other Northeastern Atlantic areas were reported in working documents to

WGEF (Vinnichenko and Fomin, 2009 WD; Vinnichenko *et al*., 2010 WD). However landings data from this fishery were not made available to the working group since.

Lantern sharks nei *Etmopterus* spp.

Reported landings of lantern sharks nei are presented in Tables 5.6 and 5.9. Four European countries have reported landings from Subareas IV, Vb, VI, VII and IX: France, UK (Scotland), Spain and Portugal.

Portuguese landings mainly referred to *Etmopterus spinax* and *Etmopterus pusillus*, however only a very small proportion of the catches of these species is retained.

Reported French landings began in 1994, peaked at nearly 3000 t in 1996 then declined by 1999. There is doubt as to whether these landings are actually of this genus and further investigations are required. In recent years, French landings of *Etmopterus princeps* have been included in siki sharks.

Spanish landings began in 2000, peaked at over 300 t in 2001. Spanish landings data have not been available since 2003.

Few landings data have been reported since 2003.

"*Aiguillat noir*"

This is a generic category only used by France to record landings on small, deep-water squaliform sharks mainly of black dogfish (*Centroscyllium fabricii*) with lesser quantities of longnose velvet dogfish and lantern sharks nei. Reported landings started in 2000 (249 t) then declined from 266 t in 2001 to 1 t in 2007, since when there have been no reported landings. Landings data are presented in Tables 5.7 and 5.9.

Lowfin gulper shark *Centrophorus lusitanicus*

Reported landings of this species in Portuguese landings in 2009–2013 (Tables 5.8. and 5.9) data are believed to refer to misidentified *C. squamosus, C. coelolepis, S. ringens, D. calcea* and *D. profundorum* (Serra-Pereira *et al*., WD 2011; Lagarto *et al*., 2013 WD).

Norwegian skate *Dipturus nidarosiensis*

The species is occasionally landed in three French ports mostly under the landing name "*D. oxyrinchus*" with the code RJO. The length–frequency distribution of *Dipturus nidarosiensis* observed in the 2012–2014 French landing are presented in Figure 5.1, individuals landed mostly come from the ICES Subarea VIa.

Other skates

Surveys of French fish markets reveals that *Rajella lintea*, *Rajella kukujevi*, *Rajella fyllae*, *Bathyraja spinicauda* and *Dipturus nidarosiensis* are occasionally landed from ICES Division VIa, but without specific landing names.

5.3.2 Discards

Azores, Portugal. Discards information from the Azorean observer programme was provided in Pinho and Canha (2011 WD) (Table 5.10). This information was not updated in 2014.

Portugal (mainland). Discards data from the Portuguese longline fishery were presented. *Etmopterus* spp. and *C. crepidater* are the species with higher percentages of discards along the time-series (although *C. crepidater* was not sampled in 2013). Other elasmobranchs were rarely discarded (Prista *et al.*, 2014 WD). Estimates of percentage discarded by species from deep-water longlines and demersal bottom trawls are given in Table 5.11.

To evaluate the level of bycatch and discards of deep-water sharks in the Portuguese trammelnet fishery a pilot study was made in ICES Division IXa (Moura *et al.*, 2014 WD). Results collected to-date show that the fishery targeting anglerfish between 200 and 600 m has a low frequency of occurrence of deep-water sharks. Preliminary results suggest that higher frequencies are likely to be observed deeper than 600 m, according to the depth ranges reported for most of these species. Results are presented in Table 5.12.

Spain. The Spanish Discards Sampling Programme for Otter and Pair Bottom Trawl (OTB and PTB) fleets, covering ICES Subareas VI, VII, VIIIc and IX (North), started in 1988; however, it did not have yearly continuity until 2003. The sampling strategy and the estimation methodology used follows the "Workshop on Discard Sampling Methodology and Raising Procedures" guidelines (ICES, 2003) and more detail of this applied to this area was explained in Santos *et al*. (2010). An estimate of Spanish deep-water elasmobranch discards for 2012 in Celtic Sea Subareas (VI and VII) and since 2003 is presented in Table 5.13, but updated information was not available to WGEF this year.

5.3.3 Quality of the catch data

Unknown quantities of deep-water species are landed in grouped categories such as "sharks nei", "Dogfish nei" and "Raja rays nei", so catches presented here are probably underestimated. Landings reported by UK vessels for 2003/2004 were considered to be unreliably identified and were therefore amalgamated into a mixed deep-water shark (siki) category together with Portuguese dogfish and leafscale gulper shark. Since 2005/2006, UK landings for most species were considered to be more reliably identified; however, reported landings of gulper shark are still considered to be unreliable and have been added to landings of siki sharks.

As result of restrictive quotas for deep-water shark, landings these species from the Portuguese longline fishery in Division IXa may have been misidentified.

5.3.4 Discard survival

No data available to the Working Group.

5.4 Commercial catch composition

No new information is available.

5.5 Commercial catch and effort data

No new information is available.

5.6 Fishery-independent surveys

5.6.1 ICES Subarea VI

Data from the Scottish deep-water trawl survey were made available. This survey samples at depths of 300–2000 m along the continental slope between approximately 55°N and 59°N (see Neat *et al.*, 2010 for details). An index of relative abundance was generated for the following species: birdbeak dogfish, greater lanternshark (*Etmopterus princeps*), velvet belly, black dogfish, blackmouth catshark, longnose velvet dogfish, bluntnose sixgill shark, mouse catshark (*Galeus murinus*), and pale catshark (*Apristurus aphyodes*.). A subset of hauls was selected for the depth range of each species (defined as the maximum and minimum depth of occurrence). Abundance indexes are presented giving number of hauls, fish caught and mean numbers per hour.

5.6.2 ICES Subarea VII

The Spanish survey on the Porcupine Bank (SpPGFS-WIBTS-Q4) in ICES Subarea VII (VIIc and VIIk) covers an area from longitude 12°W to 15°W and from latitude 51°N to 54°N following the standard IBTS methodology for the western and southern areas (ICES, 2010). The sampling design is random stratified (Velasco and Serrano, 2003) with two geographical sectors (North and South) and three depth strata (< 300 m, 300–450 m and 450–800 m). Haul allocation is proportional to the strata area following a buffered random sampling procedure (as proposed by Kingsley *et al*., 2004) to avoid the selection of adjacent 5×5 nm rectangles. More details on the survey design and methodology are presented in Ruiz-Pico *et al*. (2014 WD).

5.6.3 ICES Divisions VIIIc and IXa

The Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters has covered this area annually since 1983 (except in 1987), obtaining abundance indices and length distributions for the main commercial species and elasmobranchs. In 2013 elasmobranchs made up ca. 26% of the total fish catch. However, this survey was carried out in a new vessel (R/V Miguel Oliver), and results have to be considered with caution (Fernández-Zapico *et al.,* 2014 WD).

In the Portuguese survey (PtGFS-WIBTS-Q4) taking place in the southern occidental and southern coast the deep-water shark with higher catches is *D. profundorum*. This survey is designed for crustacean species and operates to depths of 700 m.

5.6.4 ICES Subarea X

Data from the Azorean bottom longline survey (ARQDACO(P)-Q1) in ICES Division Xa2 was presented (Pinho, 2014 WD). *Deania* spp. were the most representative (abundant) species in the survey. *C. crepidater* was common but much less abundant. Other species occurred in very low numbers (on average between one and four individuals per year). Depth range and length composition are available. However, it should be remarked that the gear configuration used is not adequate for sampling all the species (Pinho, 2014 WD).

5.7 Life-history information

Moore *et al.* (2013) provide length of first maturity of *Centroselachus crepidater* (57.2 cm TL for males and 75.4 cm TL for females) and of *Apristurus aphyodes* (49.0 cm TL for males and 56.9 cm TL for females) from the Rockall Trough.

Rodriguez-Cabello *et al*. (2013) showed that the distribution of *Galeus murinus* extended southward, to Cantabrian Sea, and *Neoraja caerulea* and northwards the distribution of *Neoraja iberica.*

Coelho *et al.* (2014) conducted demographic analyses of *E. spinax* using an age-based model. They found that the population should be stable if there is a two year reproductive cycle, but would be declining if there is a three year cycle, highlighting why an accurate knowledge of reproductive periodicity is important.

Moura *et al.* (2014) found that *Deania calcea* was spatially segregated by size, sex and maturity. Pregnant females inhabit shallower and warmer waters; large immature specimens were deeper, and mature males were more broadly distributed than mature females, supporting the possibility of sex-biased dispersal.

5.8 Exploratory analyses of relative abundance indices

Abundance indices for some deep-water elasmobranchs caught in the Spanish survey on the Porcupine Bank (SpPGFS-WIBTS-Q4) are presented below. More details on the survey design, methodology and results can be found in Ruiz-Pico *et al*., 2014 WD. The most abundant deep-water shark species in biomass in these surveys were *Deania calcea* (birdbeak dogfish), *Deania profundorum* (arrowhead dogfish), *Scymnodon ringens* (Knifetooth dogfish), *Etmopterus spinax* (velvet belly lantern shark), *Dalatias licha* (Kitefin shark), and *Hexanchus griseus* (bluntnose sixgill shark).

Abundance indices series for some deep-water elasmobranchs caught in the Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters are presented below. More details on the survey design, methodology and results can be found in in (Fernández-Zapico *et al.*, 2014 WD). Information for *E. spinax*, *H. griseus*, *S. ringens*, *D. calcea* and *D. profundorum* is presented however the majority of these species are usually found at deeper waters than those covered by this survey (additional hauls) and thus the abundance indices must be treated with caution.

A Generalized Additive Model (GAM) with a Tweedie distribution (to account for occasional large catches and frequent zero values) was applied to catch rates (number per hour) of other deep-water sharks in the Scottish deep-water survey spanning the period 1998–2013. Data used in this report differ slightly from those used in 2013 in that they are now exclusively derived from hauls on the continental slope. Data used in 2013 included approximately 20 hauls from Rockall and Rosemary bank which have only been surveyed in recent years and therefore could potentially bias the trend. The survey covered depths between 300 m and 2040 m and gave representative coverage of the continental slope between approximately 55°N and 59°N. The majority of hauls were made at 500, 1000, 1500 m and 1800 m. In any one year there were usually around 5–6 hauls for each of these depth strata.

Data used in the model were restricted to the "core" depth range for each species, established through visual inspection of the data. Since the survey in 1998 did not go deeper than 1000 m, data from that year were excluded from the analysis for those species with core depth ranges extending beyond 1000 m. The factors considered were Latitude, Depth, and Year. The model used was: cpue (number/hour) ~ s(year) + s(depth) + s(latitude).

The results obtained should be considered as preliminary and indicative only of general trends. An arbitrary Tweedie coefficient of 1.5 was used and further work will be required to determine appropriate values. The model will be developed further in 2015, including treatment of year as a factor, rather than as a smoothed variable as in the present model.

Birdbeak dogfish (*Deania calcea*)

Catch by weight and number in the Spanish survey on Porcupine Bank (Subarea VII) display no overall trend since 2006 (Figure 5.2). This species represented a small percentage of the elasmobranchs mean biomass estimate (13% in 2013, ~9 Kg/h), mean abundance (~2.9 individuals per haul) and is only caught in the deepest hauls of the survey. Before 2012, it is likely that *D. profundorum* was recorded with this species.

In the Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters, *D. calcea* was recorded together with *D. profundorum* until 2009. *D. profundorum* was first separately recorded in 2009 (Sanjuan *et al.*, 2012), but it is likely that it was confounded with *D. calcea* in previous years. Therefore the results previous to 2009 and recorded as *D. calcea* were merged into *Deania* spp. The results of the comparative analysis between *D. calcea* and *D. profundorum* in the last five years showed an increase in the catches of *D. calcea* in 2013 (Figure 5.3), whereas *D. profundorum* increased its catch in VIIIc but decreased in Division IXa.

The abundance of this species in hauls within the core depth range of 400–1500 m on the Scottish slope has fluctuated generally between 0.7 and 2.2 individuals per hour with no evident trend (since 1998; Table 5.14). The catch rate in 2013 was anomalously high at five individuals per hour, the highest in the series. Preliminary analyses using GAM with Tweedie distribution showed a significant positive trend (p=0.04) over time (Figure 5.4). The results of this analysis should be considered as preliminary and indicative only of general trends.

Knifetooth dogfish (*Scymnodon ringens*)

In the Spanish Porcupine survey (SpPGFS-WIBTS-Q4) a slight decrease in biomass and abundance of *S. ringens* was found, but the levels of both variables were similar to those from the 2009–2012 period (Figure 5.5).The average catch of this species was of ~1.2 individuals and around 4 kg per haul, and thus *S. ringens* represented only a small percentage of the mean stratified elasmobranch biomass caught (5%).

Catches in the Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters have fluctuated since 2004 with no overall trend (Figure 5.6). However, the catch rate values increased in relation to previous years in 2013, reaching the maximum value of the series.

Velvet belly lantern shark (*Etmopterus spinax*)

Since 2001 the stratified biomass and abundance indices in the Spanish Porcupine survey have greatly fluctuated. No clear long term trend can be observed in these indices (Figure 5.7). In the Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters, the biomass index shows an increasing trend since 1996 with the strongest increase in recent years (2006–2013) and the highest value in 2013 (Figure 5.8).

The relative abundance of this species derived from Scottish deep-water survey at depths from 300 to 1100 m has varied with no overall trend (between three and ten individuals per hour) since 1998 (Table 5.15 and Figure 5.9). Preliminary analyses using GAM with Tweedie distribution suggest a significant negative trend over time.

Greater lantern shark (*Etmopterus princeps*)

The relative abundance of this species between depths of 800–1800 m from Scottish deep-water survey has been variable (averaging three individuals per hour), for the past 14 years (Table 5.16; Figure 5.10). Preliminary analyses using GAM with Tweedie distribution suggest no trend over time.

Bluntnose sixgill shark (*Hexanchus griseus*)

Stratified biomass and abundance indices of *H. griseus* in the Spanish Porcupine survey have fluctuated since 2001. Despite the high values of biomass and abundance reported in 2013 no clear long-term trend can be observed in these indices (Figure 5.11). This species represents 2% of the total of the elasmobranchs stratified catch.

In the Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters, the catch rate of *Hexanchus griseus* increased in relation to previous years, reaching the highest values of the historical series in 2013 (Figure 5.12).

The relative abundance of this species between depths of 300–800 m from Scottish deep-water survey was averaging less than one individual per hour, for the past 14 years (Table 5.17). There was an anomalously high catch of 15 individuals in 2008.

Black dogfish (Centroscylium fabricii)

The relative abundance of this species between depths of 800–1800 m from Scottish deep-water survey has fluctuated with no overall trend (around five individuals per hour) since 1998 (Table 5.18; Figure 5.13). Variability of the catch rates are high, occasionally large catches are registered. Preliminary analyses using GAM with Tweedie distribution suggest no significant trend over time.

Longnose velvet dogfish (*Centroselachus crepidater*)

The relative abundance of this species between depths of 500–1800 m from Scottish deep-water survey has been variable (averaging five individuals per hour, but with occasional very high catches) for the past 14 years (Table 5.19; Figure 5.14). Preliminary analyses using GAM with Tweedie distribution suggest no significant trend over time.

Mouse catshark (*Galeus murinus*)

The relative abundance of this species between depths of 500–1500 m from Scottish deep-water survey was, in average one individual per hour, for the past 14 years (Table 5.20; Figure 5.15). Preliminary analyses using GAM with Tweedie distribution suggest no significant trend over time.

Pale catshark (*Apristurus aphyodes*)

The relative abundance of this species between depths of 800–2030 m from Scottish deep-water survey was in average four individual per hour, for the past 14 years (Table 5.21; Figure 5.16). Preliminary analyses using GAM with Tweedie distribution suggest an increasing trend over time.

Deep–water skates and rays

Most species of skates and rays in the Scottish deep-water survey occur at such low frequency that times-series analyses are inappropriate. Total number of each of the species, blue pygmy skate (*Neoraja caerulea*), Mid-Atlantic skate (*Rajella kukujevi*), round skate (*Rajella fyllae*), deep-water skate (*Rajella bathyphila*), Bigelow's skate (*Rajella bigelowi*), Richardson's skate (*Bathyraja richardsoni*), Jensen's skate (*Amblyraja jenseni*), Krefft's skate (*Malacoraja kreffti*), per year across all depths is presented (Table 5.22).

5.9 Quality of assessments

No assessments undertaken.

5.10 Reference points

No reference points have been proposed for any of these species.

5.11 Management considerations

No management advice is given in 2013.

5.12 References

Coelho, R., Alpizar-Jara, R., and Erzini, K. 2014. Demography of a deep-sea lantern shark (*Etmopterus spinax*) caught in trawl fisheries of the northeastern Atlantic: Application of Leslie matrices with incorporated uncertainties. *Deep Sea Research Part II: Topical Studies in Oceanography*. DOI: 10.1016/j.drs2.2014.01.012.

Compagno, L., Dando, M. and Fowler, S. 2005. Sharks of the World. Collins Field Guide. Harper Collins Publishers, London, 368 p.

Fernández-Zapico O., Velasco F., Rodríguez-Cabello C., Punzón, A., Serrano, A., Ruiz-Pico, S., and Blanco, M. 2014. Results on main elasmobranch species captured in the bottom trawl surveys on the Northern Spanish Shelf. Working document ICES WGEF. 20 p.

ICES. 2003. Report of ICES Workshop on Discard Sampling Methodology and Raising Procedures. Charlottenlund, Denmark, 2–4 September 2003.

Kingsley, M.C.S., Kanneworff, P., and Carlsson, D.M. 2004. Buffered random sampling: a sequential inhibited spatial point process applied to sampling in a trawl survey for northern shrimp *Pandalus borealis* in West Greenland waters. *ICES Journal of Marine Science*, 61: 12–24.

Lagarto, N., Moura, T., Farias, I. and Figueiredo, I. 2012. Sampling information from deep-water sharks caught in the black scabbardfish fishery from mainland Portugal. Working Document ICES WGEF 2012; 5 pp.

Lagarto, N., Moura, T., Farias, I. and Figueiredo, I. 2013. Sampling information from deep-water sharks caught in the black scabbardfish fishery from mainland Portugal. Working Document ICES WGEF 2013; 3 pp.

Moore, D., Neat, F., and McCarthy I. 2013. Population biology and ageing of the deep water sharks *Galeus melastomus*, *Centroselachus crepidater* and *Apristurus aphyodes* from the Rockall Trough, north-east Atlantic. *Journal of the Marine Biological Association of the UK*, 93: 1941–1950.

Moura, T, Fernandes, A., and Alpoim, R. 2014. Results from the pilot study on the Portuguese trammel nets fishery targeting anglerfish in ICES Division IXa. Working Document for the ICES Working Group on Elasmobranch Fishes, Lisbon, 17–26 June 2014; 5pp.

Moura, T., Jones, E., Clarke, M., Cotton, C., Crozier, P., Daley, R., Diez, G., Dobby, H., Dyb, J., Fossen, I., Irvine, S., Jakobsdottir, K., López-Abellán, L., Lorance, P., Pascual-Alayón, P., Severino, R., and Figueiredo, I. 2014. Large-scale distribution of three deep-water squaloid sharks: Integrating data on sex, maturity and environment. *Fisheries Research*, 157: 47–61.

Neat, F.C., Kynoch, R.J., Drewery, J. and Burns, F. 2010. Deepwater survey manual. Marine Scotland Science: http://www.scotland.gov.uk/Resource/Doc/295194/0103756.pdf

Pinho, M. R. 2010. Update landings of elasmobranches from the Azores (ICES Area X). Working Document ICES WGEF, 2010-19; 10 pp.

Pinho, M. R. and Canha, A. 2011. Elasmobranchs discards from the Azores longline fishery (ICES Subdivision Xa2). ICES Working Document WGEF.

Pinho, M.R. 2014. Resuming elasmobranchs survey data from the Azores (ICES X). Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 17–26 2014; 18 pp.

Prista, N., Fernades, A., Maia, C., Moura, T., and Figueiredo I. 2014. Discards of elasmobranchs in the Portuguese fisheries operating in ICES Division XIa: Bottom otter trawl, deepwater set longlines, set gillnet and trammel net fisheries (2004–2013). WD WGEF 2014, Lisbon, 17–26 June 2014; 20 pp.

Rodriguez-Cabello, C., Pérez, M., and Sanchez, F. 2013. New records of chondrichthyans species in the Cantabrian Sea (southern Bay of Biscay). *Journal of the Marine Biological Association of the UK*, 93: 1929–1939.

Ruiz-Pico, S., Velasco, F., Baldó, F., Rodríguez-Cabello, C., Fernández-Zapico, O. 2014. Results on main elasmobranch species captured during the 2001–2013 Porcupine Bank (NE Atlantic) bottom trawl surveys. Working Document ICES WGEF; 26 pp.

Sanjuán, A., De Carlos, A., Rodríguez-Cabello, C., Bañón, R., Sánchez, F. and Serrano, A. 2012. Molecular identification of the arrowhead dogfish *Deania profundorum* (Centrophoridae) from the northern waters of the Iberian peninsula, *Marine Biology Research*, 8: 901–905.

Santos J., H. Araújo, I. Salinas and N. Pérez. 2010. Elasmobranches Results from Spanish Discard Sampling Programme. ICES WGEF.2010; 6 pp.

Serra-Pereira, B., Moura, T., Farias, I., Maia, C., Lagarto, N., Veiga, N., and Figueiredo, I. 2011. Information on sharks, rays and skates landings from mainland Portugal. Working Document ICES WGEF; 13 pp.

Velasco, F., and Serrano, A., 2003. Distribution patterns of bottom trawl faunal assemblages in Porcupine bank: Implications for Porcupine surveys stratification design. Working Document presented to IBTSWG 2003; 19 pp.

Vinnichenko, V.I. and Fomin K. Yu. 2009. Russian research and fisheries of sharks and skates in the Northeast Atlantic in 2008. Working document presented to ICES WGEF 2009; 12 pp.

Vinnichenko, V.I., Dolgov, A.V. and A.S.Yurko. 2010. Russian Research and Fisheries of Sharks and Skates in the Northeast Atlantic in 2009. Working Document to WGEF WD2010-14.

White, W., Ebert, D., Naylor, G., Ho, H-C., Clerkin, P., Verissimo, A., and Cotton, C. 2014. Revision of the genus *Centrophorus* (Squaliformes: Centrophoridae): Part 1- Redescription of *Centrophorus granulosus* Bloch & Schneider), a senior synonym of *C. acus* garman and *C. niaukang* Teng. *Zootaxa,* 3752 (1): 035-072.

Table 5.1. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of gulper shark.

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
France												
Portugal	1056	801	958	886	344	423	242	291	187	95	54	96
Spain												
Total	1056	801	958	886	344	423	242	291	187	95	54	96

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
France										+	1	
Portugal	159	203	89	62	104	132	93	13	6	3		
Spain	8		n.a.	n.a.						+		
Total	167	203	89	62	104	132	93	13	6	3	0	0

Table 5.2. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of birdbeak dogfish.

COUNTRY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Ireland													1	1
Spain			5	n.a.	n.a.	n.a								
UK(England and Wales)				+	+	47	19							
UK(Scotland)		1	+	3	38	2								
France									5			+	+	+
Portugal	13	37	67	72	157	145	74	43	66	22	5	1	1	0
Total	13	38	72	75	195	194	94	43	71	22	5	1	2	1

Table 5.3. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of longnose velvet dogfish.

COUNTRY	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
France	+	+	+	13	10	8	6	0	0	5					
UK (Scotland)	+	+	+	+	21	7	97	128	19	0					
UK (England and Wales)					+	+	113	281	0	0					
Portugal		1	3	4	2	1	.	0	1	0	27	+	0	0	0
Spain		85	68	n.a.	n.a.	n.a.	n.a.	0							
Total	+	86	71	17	33	16	216	409	20	5	27	0	0	0	0

Table 5.4. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of black dogfish.

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
France	**382**	**395**	**47**	**90**	**49**	**.**	**35**		**137**			**+**	**+**	
Iceland	**.**	**.**	**+**	**+**	**n.a.**	**.**				**1**	**10**	**1**	**3**	**1**
UK (England and Wales)	**.**	**.**	**.**	**+**	**+**	**5**								
Spain	**85**	**91**	**n.a.**	**n.a.**	**n.a.**	**.**								
Total	**467**	**486**	**47**	**90**	**49**	**5**	**35**		**137**	**1**	**10**	**1**	**3**	**1**

Table 5.5. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of velvet belly.

Country	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Norway											
Denmark	27	+	10	8	32	359	128	25	52		
UK (Scotland)											
UK (England and Wales)											
Spain										85	
Total	27	+	10	8	32	359	128	25	52	85	

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Norway								4	11	19
Denmark										
UK (Scotland)				8						
UK (England and Wales)		8						2		
Spain								1		+
Total		8		8				7	11	19

Table 5.6. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of lantern sharks NEI.

Country	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
France	846	2388	2888	2150	2043	+	+	+	+	+	+	.
Spain	.	.	.	.	.	.	38	338	99			.
Portugal	+	+	+	+	.	.	+	.	.	.	+	+
UK Scotland												
Total	846	2388	2888	2150	2043	+	38	338	99	+	+	+

Country	2006	2007	2008	2009	2010	2011	2012	2013
France		+	+			+	+	+
Spain								
Portugal	+	+	+	+	+	+	+	
UK Scotland			20					
Total	+	+	20	+	+	+	+	+

Table 5.7. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of "*aiguillat noir*".

Country	2000	2001	2002	2003	2004	2005
France	123	165	11	37	21	5
Total	123	165	11	37	21	5

Table 5.8. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings of *Centrophorus lusitanicus*.

Country	2007	2008	2009	2010	2011	2012	2013
Portugal	n.a.	n.a.	423	271	584	689	613
Total			423	271	584	689	613

Table 5.9. Other deep-water sharks and skates from the Northeast Atlantic. Working Group estimates of landings by species.

Species	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Gulper shark	1056	801	958	886	344	423	242	291	187	95	54	96
Birdbeak dogfish											13	38
Black dogfish											467	486
Longnose velvet dogfish											86	71
Velvet belly				27	+	10	8	32	359	128	25	52
Lantern shark NEI					846	2388	2888	2150	2043	+	38	338
Aiguillat noir											123	165
Angular roughshark												
Lowfin gulper shark												
Knifetooth dogfish												
Arrowhead dogfish												
TOTAL	1127	876	1042	974	1269	2893	3238	2588	2708	303	894	1340

Species	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Gulper shark	167	203	89	62	104	132	93	20	7	3	1	1
Birdbeak dogfish	72	75	195	194	94	43	72	22	5	1	2	1
Black dogfish	47	90	49	5	35	1	137	1	10	1	3	1
Longnose velvet dogfish	17	33	16	216	409	23	2	27	0	0	1	1
Velvet belly	85			8		8	0	0	0	23	11	19
Lantern shark nei	99					0	20	0	0	0	0	0
Aiguillat noir	11	37	21	5		0	0	0	0	0	0	0
Angular Roughshark			75	99	52	0	0	54	46	17	0	0
Lowfin gulper shark						0	0	311	271	584	689	613
Knifetooth dogfish						196	0	83	115	4	5	1
Arrowhead dogfish						n.a.	n.a.	n.a.	n.a.	5	1	0
TOTAL	641	523	562	684	750	432	404	561	505	675	757	657

Table 5.10. Other deep-water sharks and skates from the Northeast Atlantic. Discards of deep-water shark species (numbers) recorded by Azores observers 2005–2010.

Species	Damaged	Non commercial	Undersized	Not identified	Total
Centrophorus granulosus		2			2
Dalatias licha		41	3		44
Deania calceus	6	254	1		261
Etmopterus spinax	8	6302	8	1	6319
Hexanchus griseus		2	1	2	5

Table 5.11. Other deep-water sharks and skates from the Northeast Atlantic. Frequency of occurrence (%) of deep-water sharks in the discards of the hauls sampled on board the Portuguese fisheries by gear type: crustacean bottom otter trawl - OTB_CRU; demersal fish bottom otter trawl - OTB_DEF; deep-water set longline fishery that targets black scabbardfish LLS_DWS (2004–2012). "---" indicates no occurrence; NA, information not available by species.

Fishery	Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
OTB_CRU	*Deania calcea*	5	5	3	4	9	2	2	2	4	NA
	Centrophorus granulosus	---	---	---	---	---	---	1	---	1	NA
	Deania profundorum	---	---	---	---	---	---	---	2	---	NA
	Etmopterus spp.	36	24	50	22	17	8	11	23	29	7
OTB_DEF	*Deania calcea*	1	---	---	---	---	---	---	---	---	NA
	Etmopterus spp.	4	3	1	---	---	2	---	---	---	---
LLS_DWS	*Centroscymnus coelolepis*	---	33	20	33	---	17	11	---	---	---
	Centroscymnus crepidater	---	---	80	67	25	17	22	17	11	---
	Centroscymnus cryptacanthus	---	---	---	---	25	---	---	---	---	NA
	Deania calcea	---	---	---	---	25	17	11	---	22	NA
	Squalus spp.	---	---	---	---	---	---	---	---	11	NA
	Deep-water sharks nei	---	---	---	---	---	---	22	---	---	NA
	Centrophorus squamosus	---	---	---	---	---	---	11	---	---	---
	Deania profundorum	---	---	---	---	---	---	---	---	11	NA
	Etmopterus spp.	---	100	100	100	100	100	100	100	100	100
	Scymnodon ringens	---	67	---	67	---	17	---	---	---	NA

Table 5.12. Other deep-water sharks and skates from the Northeast Atlantic. Number and catch weight of anglerfish (*Lophius* spp.) and number of sharks by 100 m depth strata. *Lophius* spp. combines *Lophius piscatorius* and *Lophius budegassa*. N = number of sampled specimens; W_{est}, estimated weight (based on length–weight relationships). From Moura *et al*. (2014).

	TOTAL	NUMBER (N) BY DEPTH STRATA					
Species	**Number (n)**	100–200	200–300	300–400	400–500	500–600	>600
*Centroscymnus coelolepis**	**3**		1			2	
*Centroscymnus crepidater**	**2**					1	1
*Chlamydoselachus anguineus**	**5**						5
*Dalatias licha**	**5**					1	4
*Deania calcea**	**11**					2	9
*Scymnodon ringens**	**3**					1	2
Etmopterus pusillus	**1**					1	
Squaliformes NI	**1**					1	
Mitsukurina owstoni	**2**				2		
Galeus atlanticus	**1**			1			
Galeus melastomus	**23**	1	1	1		8	12
Scyliorhinus canicula	**138**	30	75	31	1	1	
Mustelus spp	**1**					1	
Galeorhinus galeus	**2**		2				
Lophius spp. (N)	**2104**	216	1230	520	3	44	91
Lophius spp. (W_{est})	**6965.0**	683.4	3544.0	1316.1	20.0	263.6	1137.8
No hauls	**50**	9	25	7	1	2	6

*** sharks included in the EU deep-water shark list.**

Table 5.13. Other deep-water sharks and skates from the Northeast Atlantic. Spanish discard data of deep-water shark species. In bold weight discarded (tons.) of demersal elasmobranches and below in italics. CV of estimations by fishing ground. For detailed information see (Santos *et al.*, 2010).

Fishing Ground	Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Celtic Sea (Subareas VI–VII)											
	Dalatias licha	0	90.9	13.9	1.3	0	0	2.9	0.5	47.7	0.4
		-	99.7	99.7	98.8	-	-	99.3	99.5	99.7	99.6
	Deania calcea	0	9.8	87.3	17.3	22.2	6.1	2.6	3.6	0	6.2
		-	99.7	76	49.5	99.7	62.1	99.3	99.5	-	72
	Etmopterus spinax	16.2	296.1	117.7	2.8	6.6	653.6	60.1	206.1	167.2	16.9
		63.5	94.4	59.5	84.7	99.7	92.9	39.1	76.3	80.5	96.8
	Galeus melastomus	90.1	504.4	169.5	12.8	220.7	456.6	984.6	1045.7	737.1	395.1
		95.1	64.3	57.1	36.6	47.8	73.5	81.3	77	44.6	89.7
Iberian Waters (Divisions VIIIc–IXa)											
	Dalatias licha	0	0	1.3	2.6	0	0	0	3.8	0	0.1
		-	-	102.6	100.2	-	-	-	99.7	-	99.7
	Deania calcea	10.8	51.4	5.5	22.8	1.8	17.9	27.6	157.4	32.4	39.5
		54.9	81.3	61.4	84.5	69.9	96.6	53.9	62.1	43.4	49.9
	Etmopterus spinax	0.5	332.1	5.6	1.8	1.7	19.5	37.9	28.8	23.3	78.5
		90.5	90.8	49.5	68.5	59.4	58.9	75.6	58.6	79.5	72.7
	Galeus melastomus	588.8	243.5	527.3	553.2	1063.4	225.8	903.7	1271.9	730.7	1433
		31.4	54.8	36	60.7	36.7	28.5	62.8	51.1	34.8	40.5

Table 5.14. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for Birdbeak dogfish *D. calcea* from Scottish deep-water survey.

Year	N hauls	N fish	Mean NpH	Proportion of positive hauls
1998	19	28	0.7	0.63
2000	31	134	2.2	0.9
2002	27	79	1.6	0.84
2004	24	73	1.7	0.63
2005	18	35	1.0	0.47
2006	28	109	2.1	0.68
2007	18	59	1.7	0.47
2008	25	41	1.0	0.26
2009	31	19	0.7	0.42
2011	21	14	0.6	0.37
2012	21	34	1.8	0.58
2013	23	109	5.0	0.63

Table 5.15. Other deep-water sharks and skates from the Northeast Atlantic Summary data for *E. spinax* from Scottish deep-water survey.

YEAR	N HAULS	N FISH	MEAN NPH	PROPORTION OF POSITIVE HAULS
1998	18	319	8.5	0.39
2000	22	360	8.4	0.36
2002	20	137	3.8	0.55
2004	19	137	4.1	0.32
2005	13	98	3.8	0.31
2006	21	201	5	0.33
2007	12	221	9.4	0.42
2008	17	257	8.7	0.53
2009	24	91	4.6	0.13
2011	13	66	5	0.38
2012	27	176	7.6	0.52
2013	37	367	10.5	0.46

Table 5.16. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for *Etmpterus princeps* from Scottish deep-water survey.

YEAR	N HAULS	N FISH	MEAN NPH	PROPORTION OF POSITIVE HAULS
2000	20	148	3.70	0.63
2002	16	247	8.33	0.81
2004	14	123	4.48	0.54
2005	14	77	2.75	0.58
2006	19	102	3.97	0.56
2007	15	163	5.62	0.69
2008	22	57	1.74	0.55
2009	29	149	5.62	0.48
2011	21	68	2.96	0.61
2012	22	74	3.46	0.36
2013	23	118	5.2	0.52

Table 5.17. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for bluntnose sixgill shark (*Hexanchus griseus*) from Scottish deep-water survey.

Year	N hauls	N fish	Mean NpH	proportion of positive hauls
1998	18	1	0.03	0.06
2000	16	0	0	0
2002	13	3	0.13	0.15
2004	14	0	0	0
2005	7	2	0.14	0.14
2006	11	1	0.05	0.09
2007	6	8	0.68	0.33
2008	8	15	1.09	0.25
2009	8	1	0.14	0.13
2011	8	0	0	0
2012	8	1	0.14	0.13
2013	11	3	0.31	0.18

Table 5.18. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for *Centroscymnus fabricii* from Scottish deep-water survey.

Year	N hauls	N fish	Mean NpH	proportion of positive hauls
2000	20	372	9.3	0.75
2002	15	107	3.8	0.53
2004	13	104	4.0	0.46
2005	12	158	6.6	0.58
2006	17	180	5.6	0.53
2007	12	109	4.6	0.5
2008	19	175	5.7	0.58
2009	25	138	6.4	0.56
2011	14	214	14.1	0.64
2012	14	119	9.9	0.64
2013	13	71	5.4	0.62

Table 5.19. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for long nosed velvet dogfish, *Centroselachus crepidater* from Scottish deep-water survey.

YEAR	N HAULS	N FISH	MEAN NPH	PROPORTION OF POSITIVE HAULS
1998	18	1054	27.2	0.78
2000	28	524	9.6	0.75
2002	23	276	6.6	0.74
2004	20	341	9.3	0.7
2005	17	248	7.3	0.71
2006	25	271	5.8	0.72
2007	15	213	7.1	0.67
2008	18	499	16.2	0.72
2009	25	192	9.1	0.64
2011	17	183	10.1	0.47
2012	16	103	7.3	0.56
2013	21	223	11.0	0.48

Table 5.20. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for mouse catshark (*Galeus murinus*) from Scottish deep-water survey.

YEAR	N HAULS	N FISH	MEAN NPH	PROPORTION OF POSITIVE HAULS
1998	7	16	0.984615	0.57
2000	15	38	1.271612	0.6
2002	10	56	3.146067	0.6
2004	8	18	1.142857	0.5
2005	8	2	0.125	0.12
2006	10	30	1.578947	0.6
2007	6	33	2.8125	0.83
2008	9	12	0.75	0.56
2009	16	38	3.064516	0.75
2011	7	4	0.541761	0.43
2012	8	12	1.773399	0.75
2013	9	10	1.149425	0.22

Table 5.21. Other deep-water sharks and skates from the Northeast Atlantic. Summary data for pale catshark, *Apristurs aphyodes* from Scottish deep-water survey.

Year	N hauls	N fish	Mean NpH	proportion of positive hauls
2000	20	43	1.08	0.2
2002	16	49	1.55	0.44
2004	14	81	2.89	0.57
2005	14	96	3.43	0.54
2006	19	174	5.03	0.61
2007	15	89	2.94	0.46
2008	22	100	3.16	0.6
2009	29	64	2.22	0.3
2011	21	178	7.80	0.56
2012	26	105	4.32	0.58
2013	18	88	5.0	0.39

Table 5.22. Other deep-water sharks and skates from the Northeast Atlantic. Total number of deep-water skates and rays from Scottish deep-water survey across all depths and all years of time-series: blue pygmy skate (*Neoraja caerulea*), Mid-Atlantic skate (*Rajella kukujevi*), round skate (*Rajella fyllae*), deep-water skate (*Rajella bathyphila*), Bigelow's skate (*Rajella bigelowi*), Richardson's skate (*Bathyraja richardsoni*), Jensen's skate (*Amblyraja jenseni*), Krefft's skate (*Malacoraja kreffti*).

Year	N. caerulea	R. kukukujevi	R. fyllae	R. bathyphila	R. bigelowi	B. richardsoni	A. jenseni	M. krefti
1998	1	0	11	0	0	0	0	0
2000	1	0	6	2	2	0	0	0
2002	4	1	9	4	0	0	1	1
2004	0	1	7	1	0	0	0	0
2005	0	0	2	0	1	0	0	0
2006	0	0	7	2	1	0	0	0
2007	1	0	4	1	1	0	6	2
2008	0	0	6	0	0	0	3	0
2009	0	0	8	0	2	2	1	1
2011	0	4	4	0	1	0	1	0
2012	5	0	6	0	1	2	6	0
2013	0	0	1	0	3	10	6	2
Total	12	6	71	10	12	14	24	6

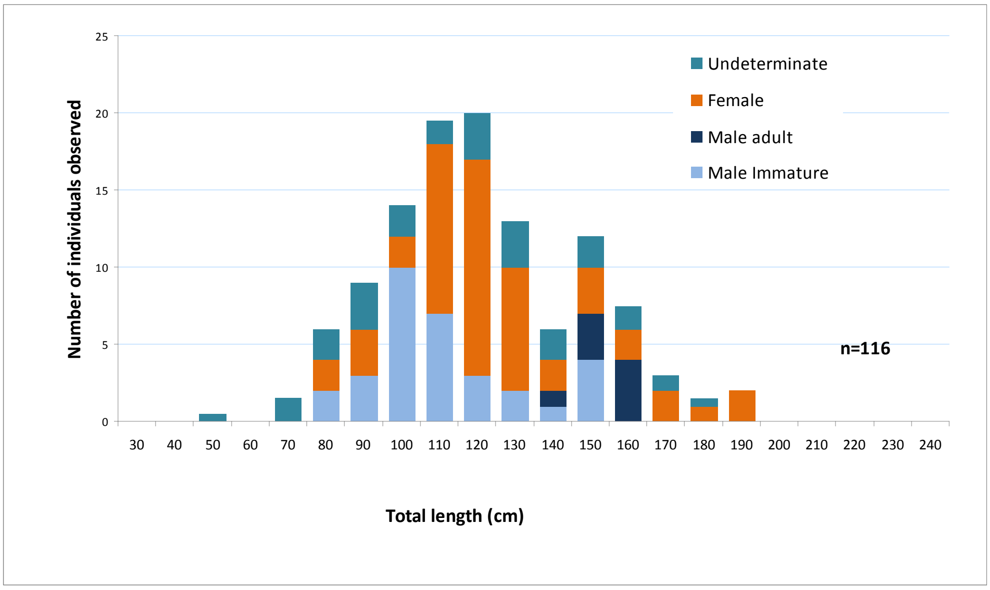


Figure 5.1. Other deep-water sharks and skates from the Northeast Atlantic. Length–frequency distribution of *Dipturus nidarosiensis* observed in the 2012–2014 French landing and coming from ICES Areas VI and VII.

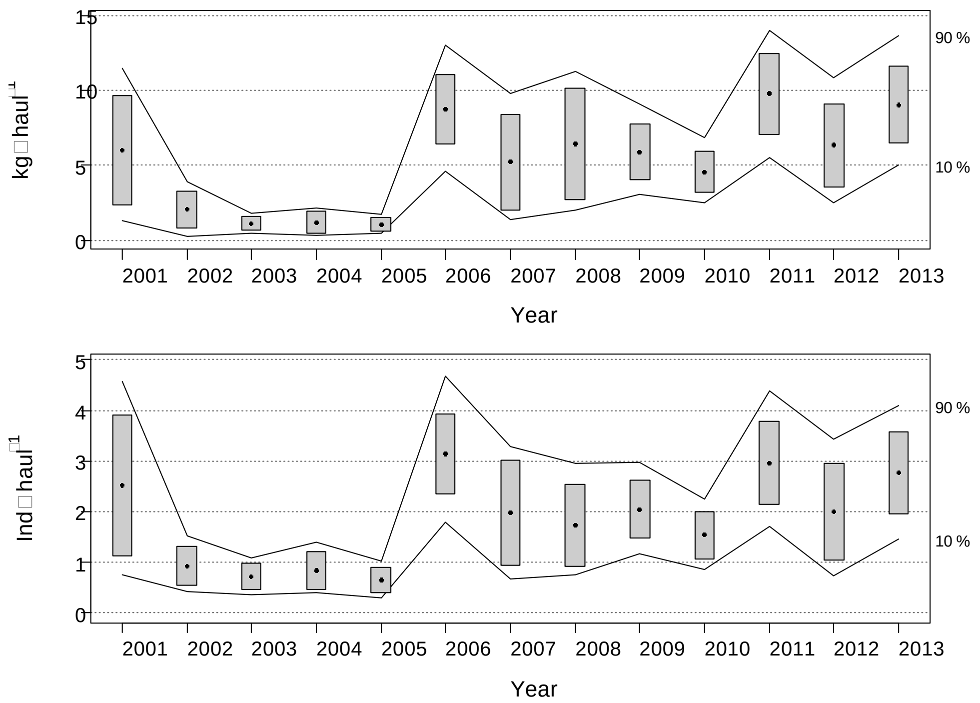


Figure 5.2. Other deep-water sharks and skates from the Northeast Atlantic. Birdbeak dogfish (*Deania calcea*) biomass index (Kg haul^{-1}) from the Spannish Porcupine survey (SpPGFS-WIBTS-Q4) time-series (2001–2013). Boxes show parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Fernández-Zapico *et al.*, (2014, WD).

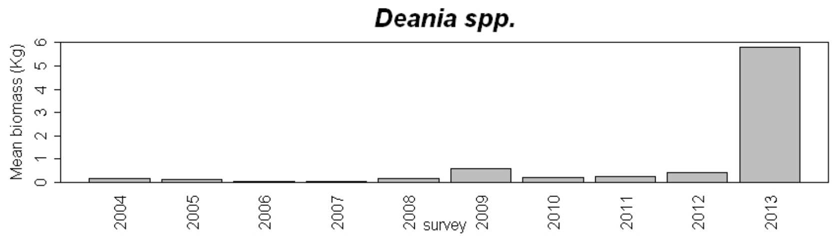


Figure 5.3. Other deep-water sharks and skates from the Northeast Atlantic. Catches by weight of *Deania* spp. In north Spanish shelf bottom trawl surveys (2004–2013) including all additional hauls out of the standard stratification (>500 m) during the last decade.

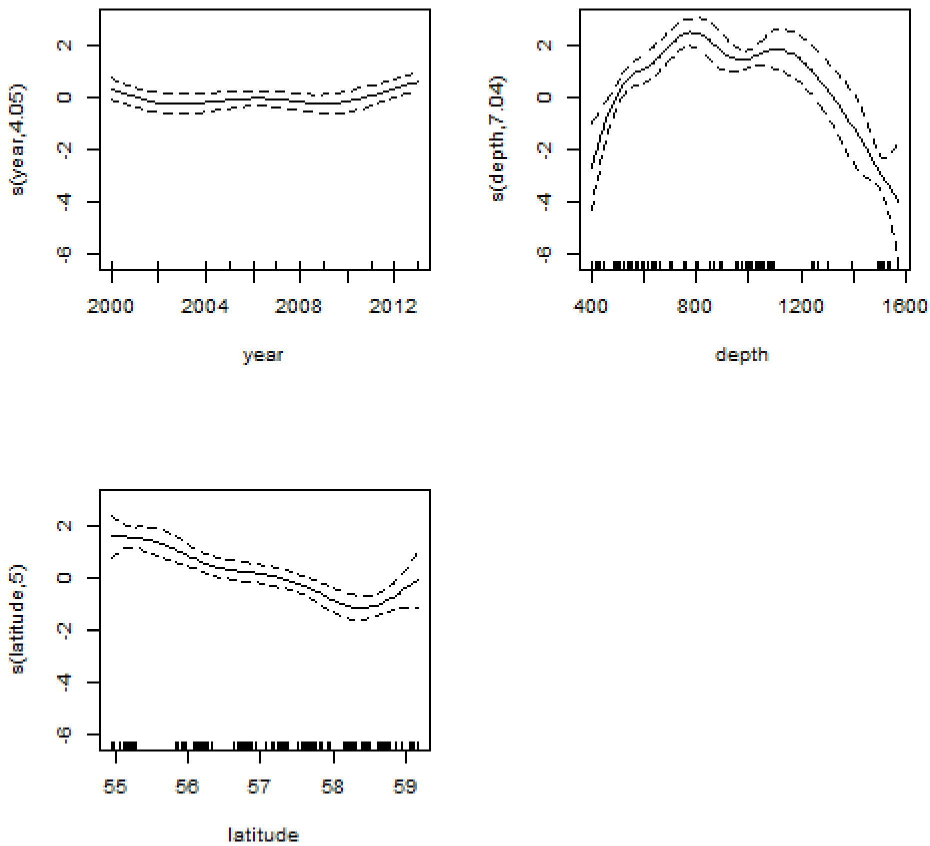


Figure 5.4. Other deep-water sharks and skates from the Northeast Atlantic. Results of General Additive Model (GAM) applied to Birdbeak dogfish *Deania calcea* in Scottish deep-water surveys 2000 to 2013. Approximate significance of smooth terms: s(year) p = 0.0434, s(depth) p < 2e-16, s(latitude) p= 2.65e-13. Deviance explained = 39.8%.

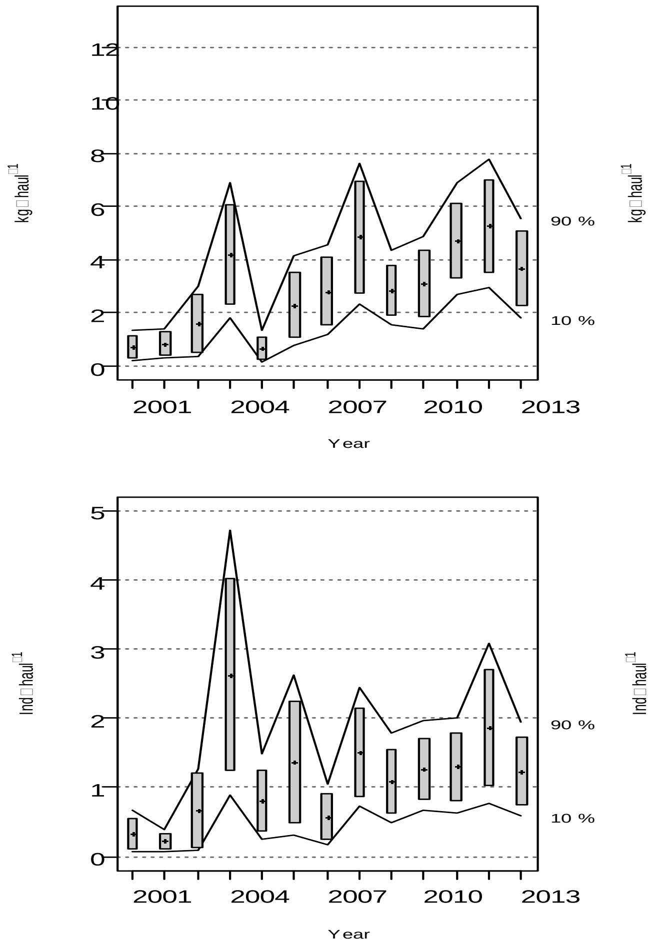


Figure 5.5. Other deep-water sharks and skates from the Northeast Atlantic. Knifetooth dogfish (*Scymnodon ringens*) biomass index (top, kg·haul^{-1}) and abundance index (bottom, numbers. Haul in the Spanish Porcupine survey (SpPGFS-WIBTS-Q4) time-series (2001–2013). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Fernández-Zapico *et al.*, (2013, WD).

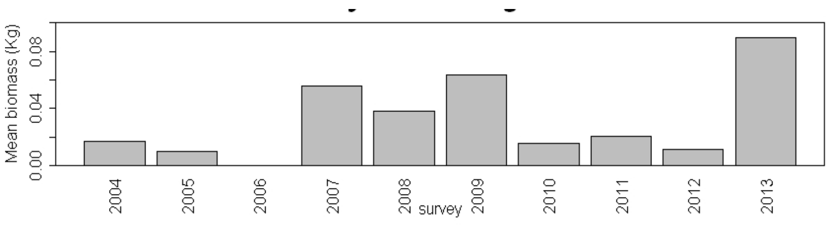


Figure 5.6. Other deep-water sharks and skates from the Northeast Atlantic. Catches by weight of Knifetooth dogfish (*Scymnodon ringens*) in north Spanish shelf bottom trawl surveys (2004–2013) including all additional hauls out of the standard stratification (>500 m) during the last decade.

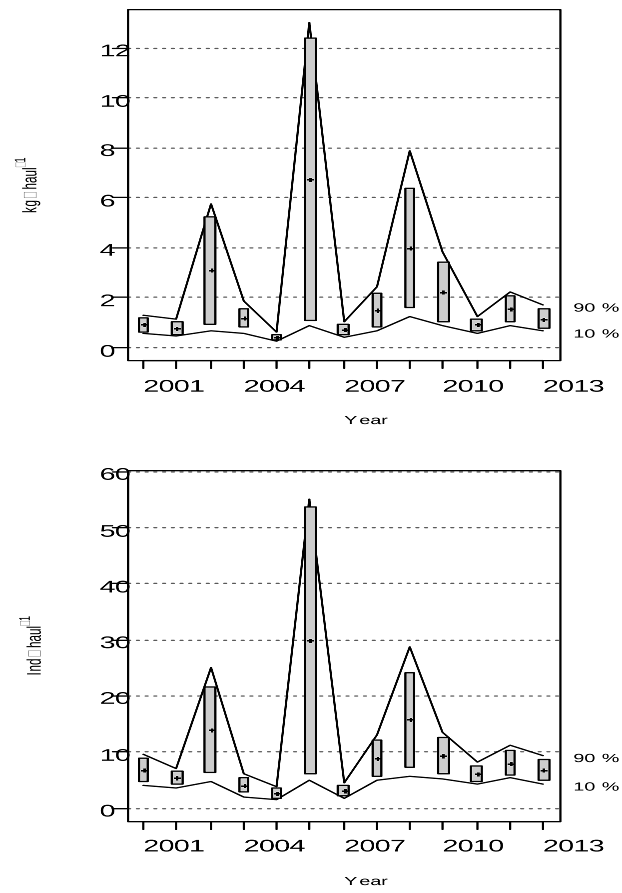


Figure 5.7. Other deep-water sharks and skates from the Northeast Atlantic. *Etmopterus spinax* biomass index (top, kg·haul–1) and abundance index (bottom, numbers. haul–1) during Porcupine survey time-series (2001–2013). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Fernández-Zapico *et al.*, (2014, WD).

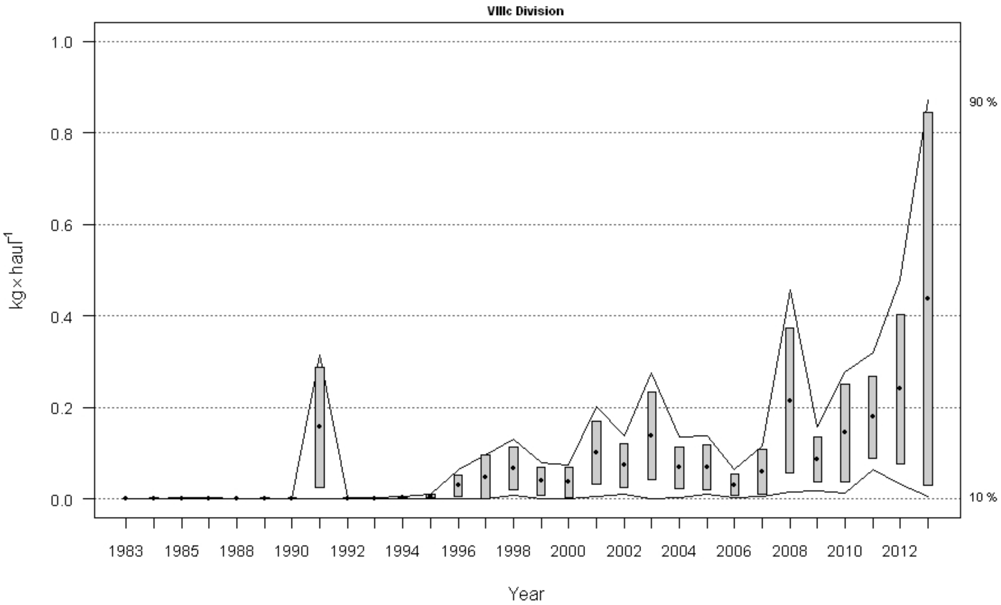


Figure 5.8. Other deep-water sharks and skates from the Northeast Atlantic. Catches by weight of velvet belly shark (*Etmopterus spinax*) in north Spanish shelf bottom trawl surveys (1983–2013) in the VIIIc Division covered by the survey.

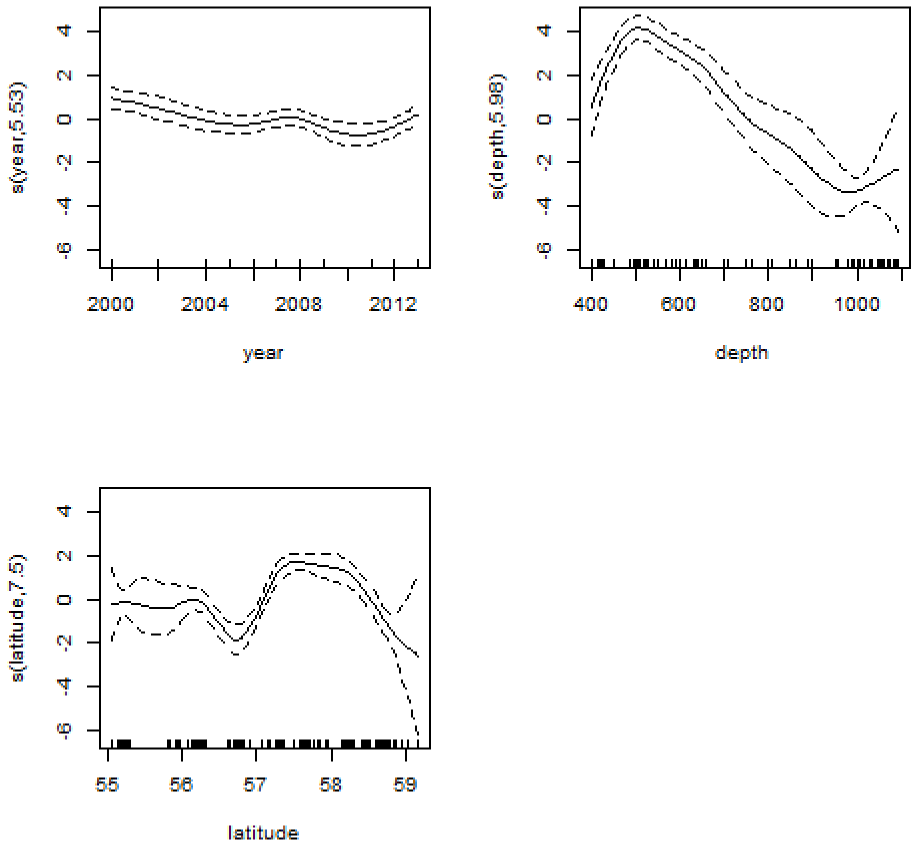


Figure 5.9. Other deep-water sharks and skates from the Northeast Atlantic. Results of General Additive Model (GAM) applied to Velvet belly shark (*Etmopterus spinax*) in Scottish deep-water surveys 2000 to 2013. Approximate significance of smooth terms: s(year) p = 0.00284, s(depth), p< 2e-16, s(latitude) p<2e-16. Deviance explained = 79%.

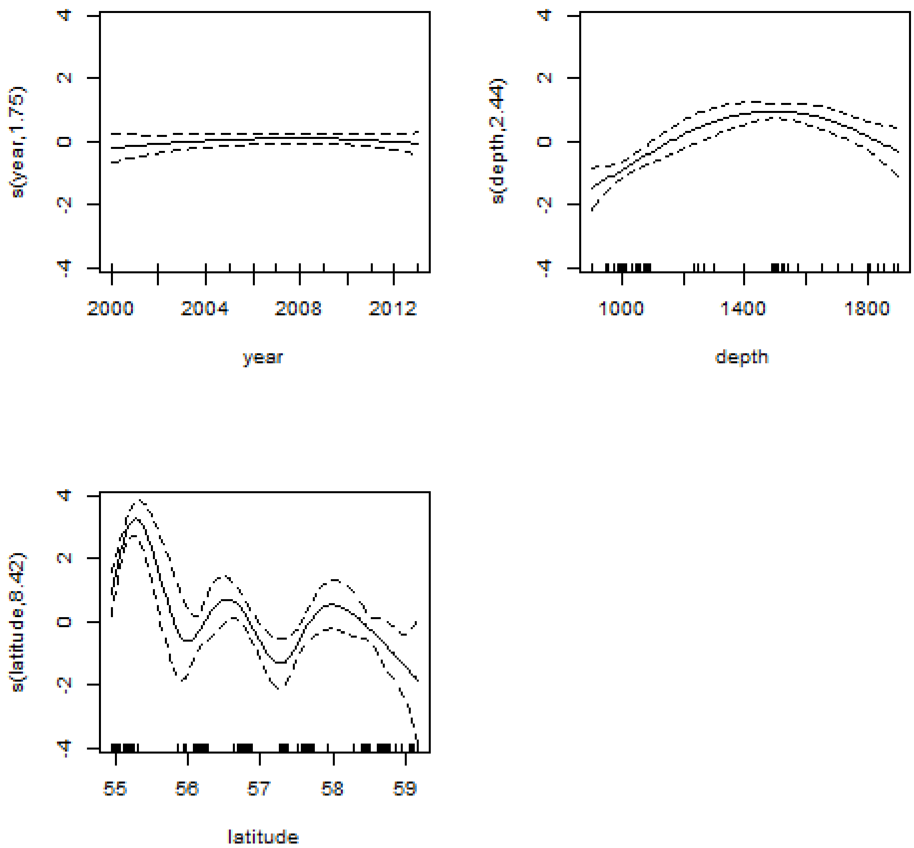


Figure 5.10. Other deep-water sharks and skates from the Northeast Atlantic. Results of General Additive Model (GAM) applied to *Etmopterus princeps* in Scottish deep-water surveys 2000 to 2013. Approximate significance of smooth terms: s(year) p = 0.512, s(depth), p= 1.76e-12, s(latitude) p<2e-16. Deviance explained = 59.2%.

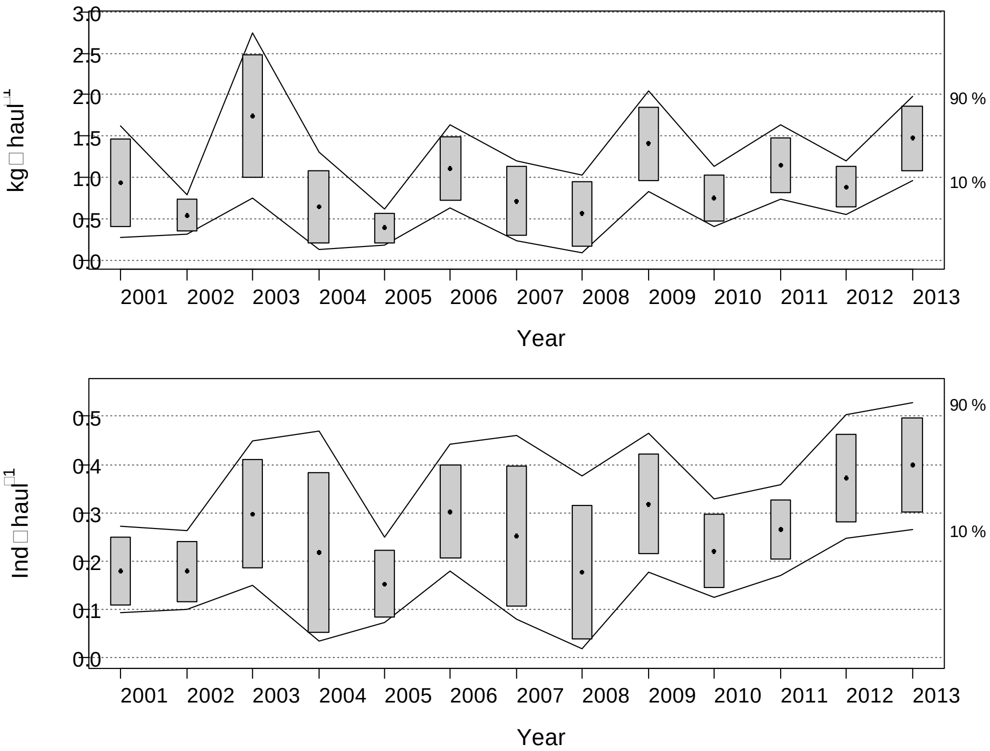


Figure 5.11. Other deep-water sharks and skates from the Northeast Atlantic. Changes in bluntnose sixgill shark (*Hexanchus griseus*) biomass index (Kg haul^{-1}) during Porcupine survey (SpPGFS-WI-BTS-Q4) time-series (2001–2012). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000). From Fernández-Zapico *et al.*, (2014, WD).

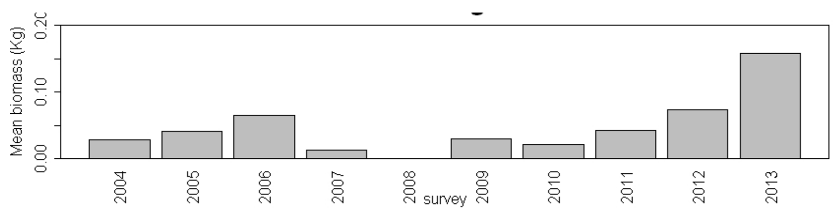


Figure 5.12. Other deep-water sharks and skates from the Northeast Atlantic. Catches by weight of bluntnose six-gilled shark (*Hexanchus griseus*) in north Spanish shelf bottom trawl surveys (2004–2013) including all additional hauls out of the standard stratification (>500 m) during the last decade.

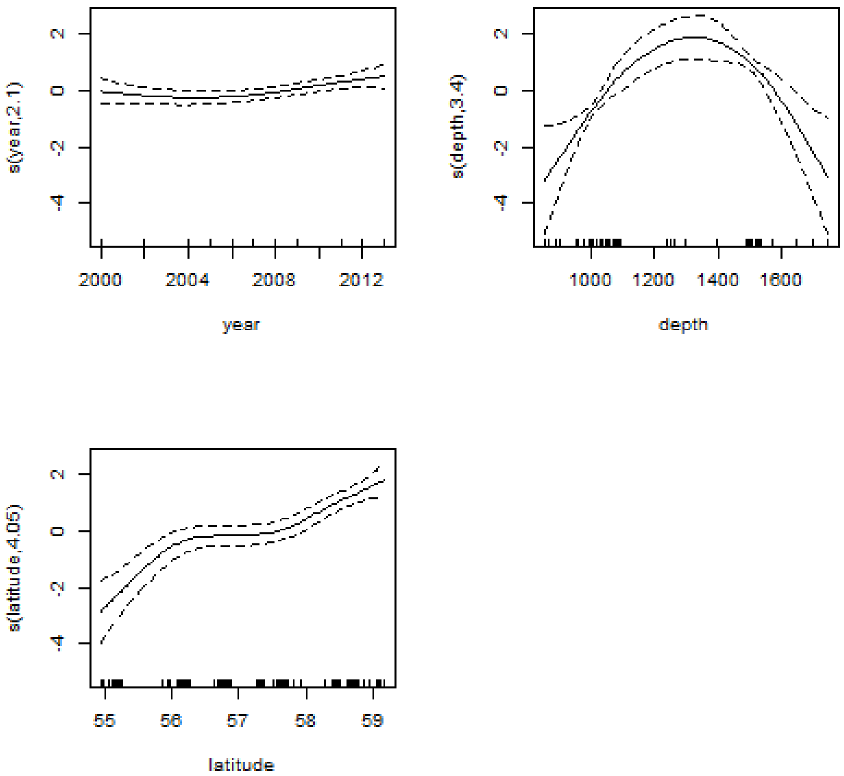


Figure 5.13. Other deep-water sharks and skates from the Northeast Atlantic. Results of General Additive Model (GAM) applied to *Centroscymnus fabricii* in Scottish deep-water surveys 2000 to 2013. Approximate significance of smooth terms: s(year) p= 0.0624, s(depth), p= 1.03e-13, s(latitude) p= 1.57e-13. Deviance explained = 51%.

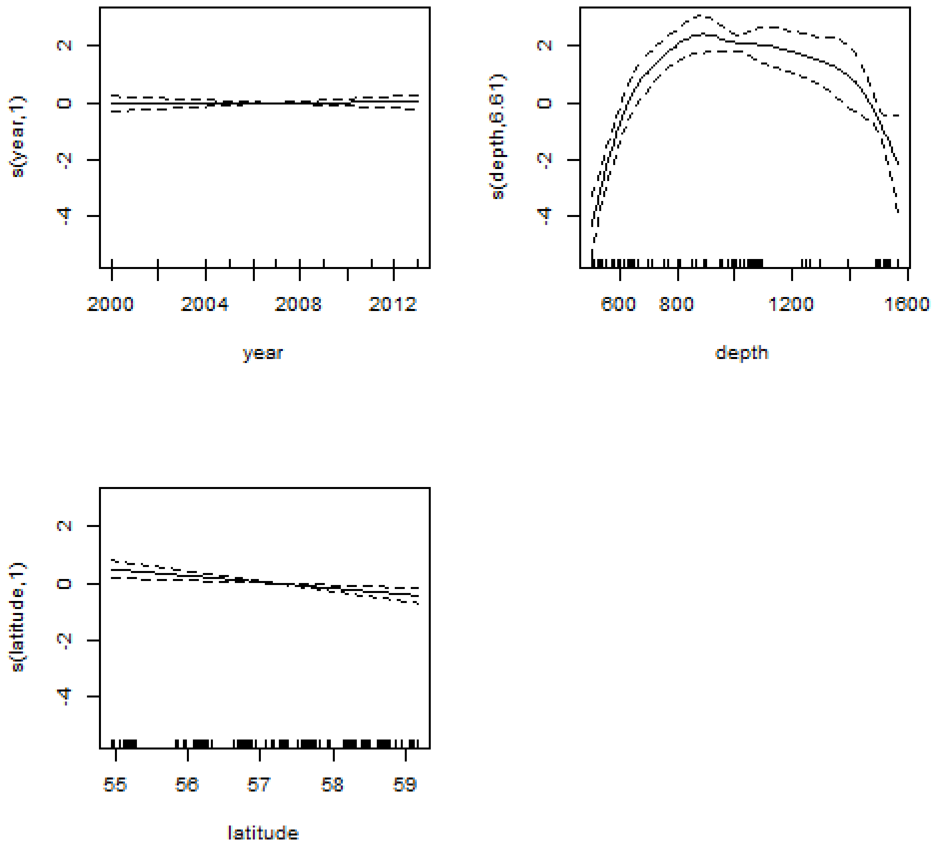


Figure 5.14. Other deep-water sharks and skates from the Northeast Atlantic. Results of General Additive Model (GAM) applied to longnose velvet dogfish *Centroselachus crepidater* in Scottish deep-water surveys 2000 to 2013. Approximate significance of smooth terms: s(year) p= 0.81, s(depth), p<2e-16, s(latitude) p= 0.00151. Deviance explained = 56.9%.

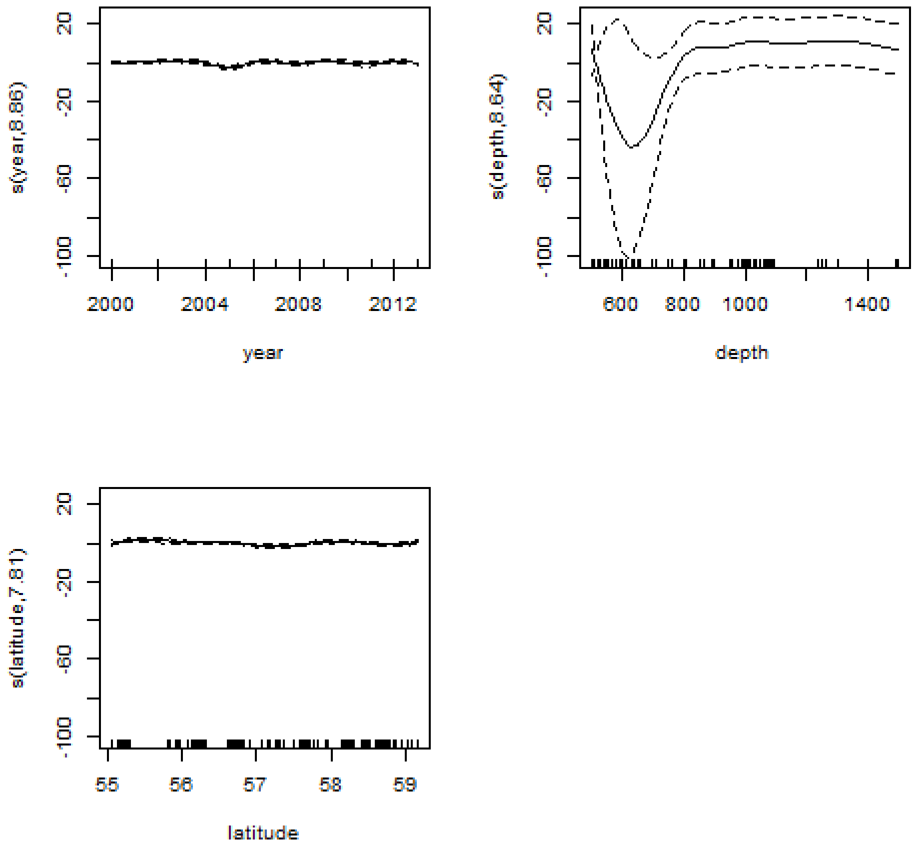


Figure 5.15. Other deep-water sharks and skates from the Northeast Atlantic. Results of General Additive Model (GAM) applied to longnose velvet dogfish mouse catshark (*Galeus murinus*) in Scottish deep-water surveys 2000 to 2013. Approximate significance of smooth terms: s(year) p= 0.0005, s(depth), 4.59e-11, s(latitude) p= 0.00076. Deviance explained =66.3%.

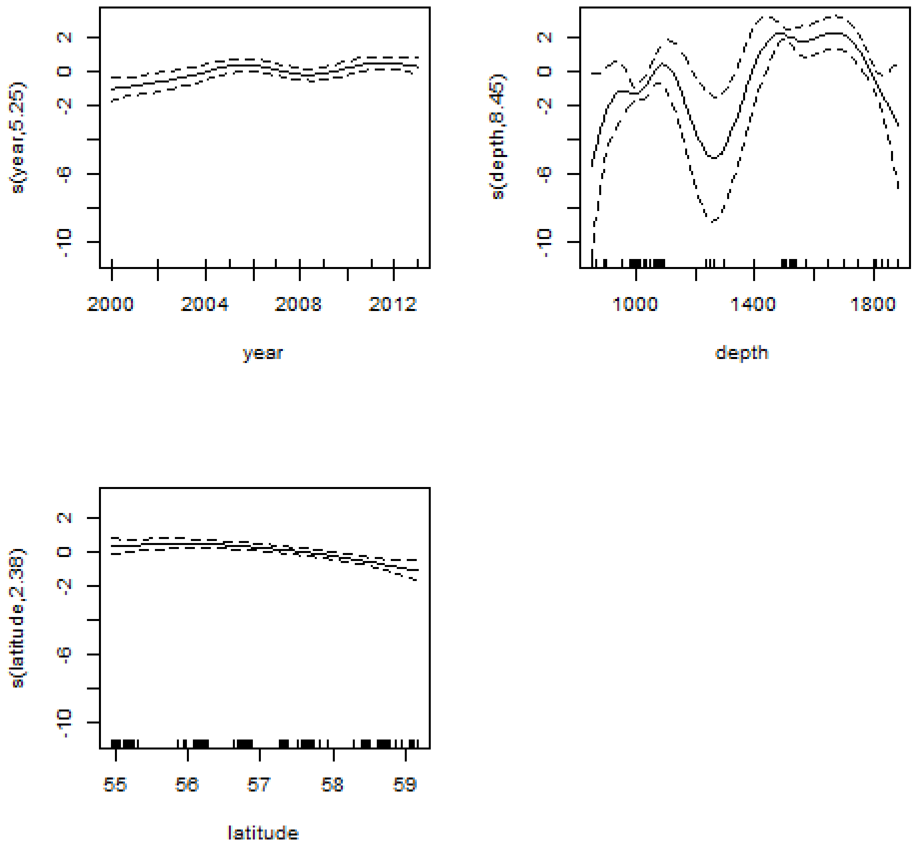


Figure 5.16. Other deep-water sharks and skates from the Northeast Atlantic. Results of General Additive Model (GAM) applied to pale catshark *Apristurus aphyodes* in Scottish deep-water surveys 2000 to 2013. Approximate significance of smooth terms: s(year) p= 0.004196 , s(depth) p<2e-16 , s(latitude) p= 0.000123 . Deviance explained =64.5%.

6 Porbeagle in the Northeast Atlantic (Subareas I–XIV)

6.1 Stock distribution

WGEF has traditionally considered that there is a single-stock of porbeagle *Lamna nasus* in the NE Atlantic that occupies the entire ICES area (Subareas I–XIV). This stock extends from Norway, Iceland and the Barents Sea to Northwest Africa. For management purposes the southern boundary of the stock is 36°N and the western boundary at 42°W. The information to identify the stock unit is in the Stock Annex (ICES, 2011).

New evidence available from archival tagging studies around the British Isles and on the Bay of Biscay shelf edge, however, indicates that porbeagle can cross the North Atlantic to at least the Mid-Atlantic Ridge and thus may making trans-Atlantic migrations. Figure 6.1 shows the movements of one porbeagle tagged in Ireland that spent a considerable time just west of the Mid-Atlantic Ridge. In addition, there is one record from the Inland Fisheries Ireland Agency of one specimen that was tagged off Ireland and recaptured in American waters (IFI, unpublished data). Genetic studies have also indicated that gene flow occurs across the North Atlantic (Pade, 2009).

WGEF considers that further studies are warranted to re-evaluate the stock structure.

6.2 The fishery

6.2.1 History of the fishery

The main country catching porbeagle in the last decade was France and, to a lesser extent, Spain, UK and Norway. The only regular target fishery that has existed recently was the French fishery (although there have been occasional targeted fisheries in the UK). However, historically there were important Norwegian, Danish and Faroese target fisheries. The species is also taken as a bycatch in mixed fisheries, mainly in UK, Ireland, France and Spain.

A detailed history of the fishery is in the Stock Annex (ICES, 2010).

6.2.2 The fishery in 2013

No fishery has been allowed since the implementation of a zero TAC in 2010. However, some limited landings are reported in 2013 as in the previous three years (Table 6.1). The 2012 working group estimate (45 t) remains the highest figure since the zero TAC was implemented. However, it is thought that the previous two years data are underestimates, due to misreporting. Furthermore, all data since 2010 must be considered as unrepresentative of removals, as dead discards are not quantified. The landings in 2013 were reported mainly by France (13 t), with smaller contributions from Norway (8 t) and Iceland (1 t).

Porbeagle is also present in recent import/export trade data into and within the EU, but it is unclear as to whether these data are confounded with shortfin mako. Further examination of such data is required.

6.2.3 ICES advice applicable

The advice is biennial and consequently the 2012 advice remains valid for 2013 and 2014, although the next advice will only be provided in 2015:

In 2012, ICES advised that "on the basis of the precautionary approach that no fishing for porbeagle should be permitted. Landings of porbeagle should not be allowed. A rebuilding plan should be developed for this stock".

Prior to this advice, in 2008 and 2010, ICES reiterated the precautionary advice of:

"Given the state of the stock, no targeted fishing for porbeagle should be permitted and bycatch should be limited and landings of porbeagle should not be allowed".

In 2010, ICES also advised that there was no catch option that would be compatible with the ICES MSY framework. In 2012, stock status was unknown, with a qualitative evaluation indicating that the stock is depleted. No reliable quantitative assessment (or reference points) could be presented for this stock; therefore, fishing possibilities could not be projected.

6.2.4 Management applicable

Since 2010, EC Regulations (23/2010, 57/2011, 44/2012, 39/2013 and 43/2014) have established a zero TAC for porbeagle in EU waters and prohibited EU vessels to fish for, to retain on board, to tranship and to land porbeagle in international waters.

EC Regulation 40/2008 first established a TAC for porbeagle taken in EC and international waters from ICES Subareas I–XII and XIV of 581 t. In 2009, the TAC was reduced to 436 t (a decrease of 25%) and it was adopted a technical measurement stating that "*A maximum landing size of 210 cm (fork length) shall be respected*" (EC Regulation No 43/2009).

EC Regulation 1185/2003 prohibits the removal of shark fins and subsequent discarding of the body of this species. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

In 2007 Norway banned all direct fisheries for porbeagle, based on ICES advice. However during the period 2007–2011, specimens taken as bycatch could be landed and sold. Since 2011, live specimens must be released, whereas dead specimens can be landed, but this was not mandatory. The number of specimens landed must be reported in addition to weight. From 2011, regulations also include recreational fishing. However, since 2012, porbeagle landings are not remunerated.

It has been forbidden to catch and land porbeagle in Sweden since 2004.

6.3 Catch data

6.3.1 Landings

Tables 6.1a, b and Figures 6.2–6.3 show the historical landings of porbeagle in the Northeast Atlantic. From 1971 onwards, France remained the major contributor.

It should be noted that these data need to be treated as underestimates and with some caution (see Section 6.3.3). More detailed information on landings is presented in the Stock Annex.

6.3.2 Discards

No information is available on the discards from non-target fisheries, although as a high value species, it is likely that specimens caught incidentally were landed, at least prior to quota becoming restrictive. Discards are generally thought to be low, but might be seasonally important in some métiers (e.g. gillnet fisheries in the Celtic Sea).

The EU adoption in 2009 of a maximum landing size for this species likely lead to an increase of discarding of large fishes by vessels from the directed fishery but there is no account of the numbers discarded.

6.3.3 Quality of catch data

Landing data are incomplete and need to be further scrutinized to better collate or estimate historical catch data (more information is available in the stock annex). Recent catch data are lacking as dead bycatch is also discarded.

6.3.4 Discard survival

Data on discard survival are limited. Preliminary studies of at-vessel mortality in gillnet fisheries indicate about 80% of porbeagle were dead (Bendall *et al.,* 2012a). However it is important to note that this study was based on a small sample size (n = 20) and the soak time was shorter than that adopted by normal fishing operations. Survival on longlines is likely to be much higher, but would depend on soak time.

6.4 Commercial catch composition

Only limited length frequency data are available. However, length distributions by sex are available for 2008 and 2009 for the French target fishery (Hennache and Jung, 2010; Figure 6.4). These distributions are considered representative of the international catches because during that period France was the major contributor for catch figures.

The composition by weight class (<50 kg and ≥50 kg) of the French fishery catches reveals that the proportion of large porbeagle in the landings decreased after 1993 (Table 6.2).

Catch data derive from the target French fishery highlighted the dominance of porbeagle (89%) on the total catch. Other species including blue shark (10%), common thresher (0.6%) and tope (0.3%) were also caught.

6.4.1 Conversion factors

Length–weight relationships are available for different areas and for different time periods (Table 6.3). The conversion factors collected from the French targeted fishery have been updated using data from the 2009 sampling.

6.5 Commercial catch and effort data

In 2009 a standardized cpue series was presented based on data collected from 17 boats belonging to the French targeted fishery (Biais and Vollette, 2009). These boats landed more than 500 kg of porbeagle per year during more than six years after 1972 and more than four years from 1999 onwards (to include a boat which has entered recently in the fishery, given the limited number of boats in recent years). This series is longer than the one included in the Stock Annex and it provides catch and effort (days at sea) by vessel and month.

At the 2009 ICCAT-ICES meeting standardized catch rates were also presented for North Atlantic porbeagle during the period 1986–2007, caught as low prevalent bycatch in the Spanish surface longline fishery targeting swordfish in the Atlantic Ocean (Mejuto *et al.*, 2009). The analysis was performed using a GLM approach that considered several factors such as longline style, quarter, bait and also spatial effects by including seven zones.

The nominal and the standardized catch rate series of the French fleet show that higher values occurred by the late 1970s (Figure 6.5). Since then, cpue has varied between 400–900 kg per day and trend was evident.

This absence of trend in the last part of the time-series has been confirmed by an analysis of the effect of porbeagle aggregating behaviour, as well as an effect of cooperation between skippers. The analysis was carried out for years 2001–2008 for which detailed data were available (Biais and Vollette, 2010). The analysis showed high inter-annual variation in local abundance in the French fishing area, and short-term changes in porbeagle catch rates must be considered with caution.

Spanish data showed a higher variability than the French one (Figure 6.6), possibly as it was based on bycatch data and derived from fishing fleet that operate in areas with low abundance of porbeagle.

6.6 Fishery-independent surveys

No fishery-independent survey data are available for the NE Atlantic, although records from recreational fisheries may be available. Tagging studies from surveys are currently available (see Section 6).

6.7 Life-history information

The life-history information (including habitat description) is presented in Stock Annex.

6.7.1 Movements and migrations

Migrations of three porbeagle tagged off Ireland with archival pop-up tags (PAT) in 2008 and 2009 are described by Saunders *et al.* (2011). One specimen migrated 2400 km to the northwest off Morocco, residing around the Bay of Biscay for about 30 days. The other two remained in off-shelf regions around the Celtic Sea/Bay of Biscay and off western Ireland. They occupied a vertical water column ranging from 0 to 700 m with temperatures varying from 9° to 17°C, but during the night they preferentially stayed at upper layers. The Irish tagging programme is continuing.

The UK (Cefas) launched a tagging program in 2010 to address the issue of porbeagle bycatch and to further promote the understanding of porbeagle movement patterns in UK marine waters. Altogether, 21 satellite tags were deployed between July 2010 and September 2011, and 15 tags popped off after two to six months. However, four tags failed to communicate. The tags attached to sharks in the Celtic Sea generally popped off to the south of the release positions while those to sharks off the northwest coast of Ireland popped off in diverse positions. One of them popped off in the western part of the North Atlantic, one close to the Gibraltar Straits and another in the North Sea. Several tags popped off close to the point of release (Bendall *et al*., 2012b).

In June–July 2011, France (Ifremer and IRD) joined the international tagging effort in cooperation with Cefas by a survey on the shelf edge in the West of Brittany. Three PATs were deployed by Ifremer-IRD and three by Cefas (results in Bendall *et al*., 2012a). Pop off dates were set at twelve months for the Ifremer-IRD PSATs which were all used to tag large females (L_T >2m). One popped off prematurely in February 2012 near Norway, slightly northwards of the Arctic Circle. The two others popped off after twelve months according to schedule, in an area close to the original tagging position. They revealed large migrations of these sharks; going westwards to the Mid-Atlantic Ridge for one of them, and from latitudes ranging from 60°N and 36°N (Gibraltar). The

French tagging program deployed a further nine PATs in June 2013, again attached on large females (mean L_T = 2.35 m) and for a planned release at twelve months. Four of these PATs were released after ten months, one did not transmit after one year and the other ones have been released before five months. Data analysis is still in progress and results expected at the next WGEF meeting.

6.7.2 Reproductive biology

Spatial sex-ratio segregation study was based on a large sampling (n = 1770), the likelihood of a nursery ground in St George's Channel and of a pupping area in the grounds along the western Celtic Sea shelf edge. The diet and life-history data were obtained from a research programme carried out by the NGO APECS (Hennache and Jung, 2010) and are available in the Stock Annex.

Since the cessation of target fisheries, there are some limited data (n = 19) available for bycaught porbeagle in the Celtic Sea (Bendall *et al.*, 2012b). The total length range of those specimens varied from 117 to 50 cm (Figure 6.7), and their total weight varied from 12 to 94 kg. The sex ratio value indicated that in this area (during September 2011) the two sexes are spatially mixed. However no fully mature females were sampled.

6.7.3 Genetic information

A preliminary study of the genetic diversity (mitochondrial DNA haplotype and nucleotide diversities) was carried recently out. This study was based on 156 individuals caught both on the Northeast and Northwest Atlantic; the results obtained show no significant population structure across the North Atlantic. However while the mtDNA haplotype diversity was very high, sequence diversity was low, which suggests that most females breed in particular places, indicating the stock is likely to be genetically robust (Pade, 2009). Further studies are still required.

6.8 Exploratory assessment models

6.8.1 Previous studies

The first assessment of the NE Atlantic stock was carried out in 2009 by the joint ICCAT/ICES meeting using a Bayesian Surplus Production (BSP) model (Babcock and Cortes, 2009) and an age-structured production (ASP) model (Porch *et al.*, 2006).

The 2009 assessments have not been updated since, and the results from these are detailed in the Stock Annex.

6.8.2 Population dynamics model

A recent analysis by Campana *et al*. (2013), utilising a forward-projecting age- and sex-structured population dynamics model found that the Canadian porbeagle population could recover from depletion, even at modest fishing mortalities. The population is projected forward from an equilibrium starting abundance (assumed an unfished equilibrium at the beginning of 1961 prior to directed commercial fisheries) and age distribution by adding recruitment and removing catches. All model projections predicted recovery to 20% of spawning stock numbers before 2014 if the fishing mortality rate was kept at or below 4% of the vulnerable biomass. Under the low productivity model, recovery to spawning stock numbers at maximum sustainable yield was predicted to take over 100 years at exploitation rates of 4% of the vulnerable biomass.

The results of this study may need to be re-appraised, depending on improved knowledge of the stock unit(s).

6.9 Quality of assessments

The assessments (and subsequent projections) conducted at the joint ICCAT/ICES meeting that are summarized in the Stock Annex must be considered exploratory assessments, using several assumptions (carrying capacity for the SSB model, F in the historic period in the ASP model).

Hence, it must be noted that:

- There was a lack of cpue data for the peak of the fishery.
- Catch data were considered as underestimates, as not all nations have reported catch data throughout the time period.
- The cpue index used in the assessment was French fleet catch per day. An analysis carried out on years 2001–2008 shows that local abundance varies likely a lot between consecutive years in the French fishing area. Hence, this series may not be reflective of stock abundance.

Consequently, the model outputs should be considered highly uncertain (ICCAT, 2009).

6.10 Reference points

ICCAT uses F/F_{MSY} and B/B_{MSY} as reference points for stock status of pelagic shark stocks. These reference points are relative metrics rather than absolute values. The absolute values of B_{MSY} and F_{MSY} depend on model assumptions and results and are not presented by ICCAT for advisory purposes.

6.11 Conservation considerations

At present, the porbeagle shark subpopulations of the NE Atlantic and Mediterranean are listed as Critically Endangered in the IUCN red list (Stevens *et al.*, 2006a, b).

In 2010, Sweden (on behalf of the member states of the European Union) proposed that porbeagle be added to Appendix II of CITES. This proposal did not get the support of the required majority at the fifteenth CITES Conference of Parties in Doha.

In 2013, a renewed proposal to list porbeagle shark on Appendix II of CITES was accepted at the Conference of Parties (16) Bangkok. However, the implementation of this listing has been delayed by 18 months (14 September 2014) to enable Range States and importing States to address potential implementation issues.

6.12 Management considerations

WGEF/ICCAT considered all available data in 2009. This included updated landings data and cpue from the French and Spanish fisheries. An analysis of the French cpue was undertaken in 2010. It showed that large changes of local abundance may occur in the fishing area and consequently, these cpue should be used with caution to get an abundance index as long as information on porbeagle spatial distribution remains limited.

Using the French cpue series as well as the Spanish cpue series (Figure 6.6), stock projections based on the BSP model demonstrated that low catches (below 200 t) may allow the stock to increase under most credible model scenarios and that the recovery to B_{MSY} could be achieved within 25–50 years under nearly all model scenarios. However, management should account for both the uncertainty in the input parameters for this assessment and the low productivity of the stock.

WGEF reiterates that this species has a low productivity, and is highly susceptible to overexploitation.

The Norwegian and Faroese fisheries have ceased and have not resumed. That no fisheries had developed before restrictive quotas were put in place is considered by WGEF to indicate that the stock had not recovered. However, the time that has elapsed since the end of the northern fisheries is probably longer than the generation time of the stock, so recovery may have taken place although not detected. However, the social and economic environment may have changed too much to allow fisheries to be resumed by the same countries, and fisher knowledge may have been lost. Furthermore, feeding grounds may have moved in relation with changes in prey abundance and distribution. But, in the absence of any quantitative data to demonstrate stock rebuilding, and in regard of this species' low reproductive capacity, WGEF considers the stock is probably still depleted.

WGEF considers that target fishing should not proceed without a programme to evaluate sustainable catch levels. However, WGEF underlined that the present fishing ban hampers any quantitative assessment in the near future.

The maximum landing length (MLL) was adopted by the EC. It constituted a potentially useful management measure in targeted fisheries, as it should deter targeting areas with mature females. However, there are potential benefits from reducing fishing mortality on juveniles. Given the difficulties in measuring (live) sharks, other body dimensions (e.g. height of the first dorsal fin or pre-oral length) that could be pragmatic surrogate measurements could usefully be identified. The correlation of some measurements with fork length is high (Bendall *et al.*, 2012a) but further studies, so as to better account for natural variation (e.g. potential ontogenetic variation and sexual dimorphism) in such measurements, are needed to identify the most appropriate options for managing size restrictions.

Further ecological studies on porbeagle, as highlighted in the scientific recommendations of ICCAT (2009), would help to further develop management measures for this species. Such work could usefully build on recent and ongoing tagging projects.

Studies on porbeagle bycatch should be continued to get operational ways to reduce bycatch, to decrease at-vessel mortality and to improve the post-release survivorship of discarded porbeagle.

All fisheries-dependent data should be provided by the Member States having fisheries for this stock as well as other countries longlining in the ICES area.

There are no fishery-independent survey data. In the absence of target fisheries, a dedicated longline survey covering the main parts of the stock area is needed if stock status is to be monitored appropriately.

6.13 References

Babcock, B. A., and Cortes, E. 2009. Bayesian surplus production model applied to porbeagle catch, CPUE and effort data. ICCAT, Collective Volume of Scientific Papers, SCRS/2009/068, 7 pp.

Bendall, V. A., Ellis, J. R., Hetherington, S. J., McCully, S. R., Righton, D., and Silva, J. F. 2012b. Preliminary observation on the biology and movements of porbeagle *Lamna nasus* around the British Isles. Working document to the ICES Working Group on Elasmobranch Fishes, Lisbon, 19–26 June 2012. 21 pp.

Bendall, V. A., Hetherington, S. J., Ellis, J. R., Smith, S. F., Ives, M. J., Gregson, J. and Riley, A. A. 2012a. Spurdog, porbeagle and common skate bycatch and discard reduction. Fisheries Science Partnership 2011–2012, Final Report; 88 pp.

Biais, G., and Vollette, J. 2009. CPUE of the French porbeagle fishery. WGEF Working Document. 3 pp.

Biais, G., and Vollette, J. 2010. The use of the French long line CPUE to provide an abundance index for porbeagle in the North East Atlantic. ICES Annual Science Conference, Nantes, 20–24 September 2010, Poster ICES CM 2010 / E:42.

Campana, S. E., Gibson, A. J. F., Fowler, M., Dorey A. and Joyce, W. 2013. Population dynamics of Northwest Atlantic porbeagle (*Lamna nasus*), with an assessment of status and projections for recovery. Canadian Science Advisory Secretariat. Research Document 2012/096: 88 pp.

Ellis, J. R., and Shackley, S. E. 1995. Notes on porbeagle sharks, *Lamna nasus*, from the Bristol Channel. *Journal of Fish Biology*, 46: 368–370.

Hennache, C., and Jung, A. 2010. Etude de la pêche palangrière de requin taupe de l'île d'Yeu. Rapport Final. Association pour l'étude et la conservation des sélaciens (APECS), http://www.asso-apecs.org/IMG/pdf/APECS_EPPARTIY_Rapport_ final_BD.pdf. 64 pp.

ICCAT. 2009. Report of the 2009 Porbeagle Stock Assessments Meeting. Copenhagen, Denmark, 22–27 June, 2009. ICCAT, Collective Volume of Scientific Papers, SCRS/2009/014. 42 pp.

ICES. 2009. Report of the Joint Meeting between ICES Working Group on Elasmobranch Fishes (WGEF) and ICCAT Shark Subgroup, 22–29 June 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:16. 424 pp.

ICES. 2010. Report of the Working Group on Elasmobranch Fishes (WGEF). 22–29 June 2010, Horta Portugal. ICES CM 2010/ACOM 19, 560 pp.

ICES. 2011. Report of the Working Group on Elasmobranch Fishes (WGEF), 20–24 June 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:19. 492 pp.

Kohler, N. F., Casey, J. G., and Turner, P. A. 1995. Length–weight relationships for 13 species of sharks from the western North Atlantic. *Fishery Bulletin*, 93: 412–418.

Mejuto, J., and Garcés, A. G. 1984. Shortfin mako, *Isurus oxyrinchus*, and porbeagle, *Lamna nasus*, associated with longline swordfish fishery in NW and N Spain. ICES CM 1984/G:72 Demersal Fish Committee.

Mejuto, J., Ortiz, J., García-Cortés, B., Ortiz de Urbina, J., and Ramos-Cartelle, A. M. 2009. Historical data and standardized catch rates of porbeagle (*Lamna nasus*) caught as bycatch of the Spanish surface longline fishery targeting swordfish (*Xiphias gladius*) in the Atlantic Ocean. ICCAT, Collective Volume of Scientific Papers, SCRS/2009/053. 23 pp.

Pade, N. 2009. Molecular and Spatial Ecology of Porbeagle Sharks, *Lamna nasus* (Bonnaterre, 1788), in the North Atlantic Ocean. Unpublished PhD thesis, University of Aberdeen, Scotland.

Porch, C. E., Eklund, A-M, and Scott, G. P. 2006. A catch-free stock assessment model with application to goliath grouper (*Epinephelus itajara*) off southern Florida. Fishery Bulletin, 104(1): 89–101.

Saunders, R. A., Royer, F., and Clarke, M. W. 2011. Winter migration and diving behaviour of porbeagle shark, *Lamna nasus*, in the Northeast Atlantic. *ICES Journal of Marine Science*, 68: 166–174.

Stevens, J. D. 1990. Further results from a tagging study of pelagic sharks in the North-east Atlantic. *Journal of the Marine Biological Association of the United Kingdom*, 70: 707–720.

Stevens, J., Fowler, S. L., Soldo, A., McCord, M., Baum, J., Acuña, E., and Domingo, A. 2006a. *Lamna nasus* (Northeast Atlantic subpopulation). In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.2. www.iucnredlist.org.

Stevens, J., Fowler, S. L., Soldo, A., McCord, M., Baum, J., Acuña, E., and Domingo, A. 2006b. *Lamna nasus* (Northwest Atlantic subpopulation). In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.2. <www.iucnredlist.org>.

Table 6.1a. Porbeagle in the NE Atlantic. Working Group estimates of porbeagle landings data (tonnes) by country (1926–1970). Data derived from ICCAT, ICES and national data. Data are considered an underestimate.

Year	Estimated Spanish data	Denmark	Norway (NE Atl)	Scotland
1926			279	
1927			457	
1928			611	
1929			832	
1930			1505	
1931			1106	
1932			1603	
1933			3884	
1934			3626	
1935			1993	
1936			2459	
1937			2805	
1938			2733	
1939			2213	
1940			104	
1941			283	
1942			288	
1943			351	
1944			321	
1945			927	
1946			1088	
1947			2824	
1948			1914	
1949			1251	
1950	4	1900	1358	
1951	3	1600	778	
1952	3	1600	606	
1953	4	1100	712	
1954	1	651	594	
1955	2	578	897	
1956	1	446	871	
1957	3.	561	1097	
1958	3	653	1080	7
1959	3	562	1183	9
1960	2	362	1929	10
1961	5	425	1053	9
1962	7	304	444	20
1963	3	173	121	17
1964	6	216	89	5
1965	4	165	204	8
1966	9	131	218	6
1967	8	144	305	7
1968	11	111	677	7
1969	11	100	909	3
1970	10	124	269	5

Table 6.1b. Porbeagle in the NE Atlantic. Working Group estimates of porbeagle landings data (tonnes) by country (1971–2013). Data derived from ICCAT, ICES and national data. Data are considered an underestimate.

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Denmark	**311**	**523**	158	170	265	233	289	112	72	176	158	84	45	38
Faroe Is	**1**		5			1	5	9	25	8	6	17	12	14
France	**550**	**910**	545	380	455	655	450	550	650	640	500	480	490	300
Germany			6	3	4	.	.	.	.	.	.	.	.	.
Iceland			2	2	4	3	3	.	1	1	1	1	1	1
Ireland			.	.	.	.	.	.	.	.	.	.	.	.
Netherlands			.	.	.	.	.	.	.	.	.	.	.	.
Norway	**111**	**293**	230	165	304	259	77	76	106	84	93	33	33	97
Portugal			.	.	.	.	.	.	.	.	.	.	.	.
Spain	**11**	**10**	12	9	12	9	10	11	8	12	12	14	28	20
Spain (Basque Country)														
Sweden		**4**			3			5	1	8	5	6	5	9
UK (E,W, Nl)	**7**	**15**	14	15	16	25			1	3	2	1	2	5
UK (Scot)			13											
Japan	**991**	**1755**												
TOTAL	**1971**	**1972**	985	744	1063	1185	834	763	864	932	777	636	616	484

	1985	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Denmark	72	56	33	33	46	85	80	91	93	86	72	69	85	107	73
Faroe Is	12	33	14	14	14	7	20	76	48	44	8	9	7	10	13
France	196	233	341	327	546	306	466	642	824	644	450	495	435	273	361
Germany	.	.	.	.	.	.	.	1	.	.	.	.	2	0	17
Iceland	1	1	1	1	.	.	1	3	4	5	3	2	3	3	2
Ireland	.	.	.	.	.	.	.	.	.	.	.	.	.	8	2
Netherlands	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
Norway	80	25	12	27	45	35	43	24	26	28	31	19	28	34	23
Portugal	.	3	3	2	2	1	0	1	1	1	1	1	1	0	15
Spain	23	30	61	40	26	46	15	21	49	17	39	23	22	15	11
Spain (Basque Country)											20	12	27	41	1
Sweden	10	5	3	3	2	2	4	3	2	2	1	1	1	1	38
UK (Eng,Wal & Nl)	12	3	3	15	9					0			1	6	7
UK (Scot)															.
Japan	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	2	NA	NA	NA
TOTAL	406	389	471	462	690	482	629	862	1047	827	628	633	612	498	**563**

Table 6.1b. (continued). Porbeagle in the NE Atlantic. Working Group estimates of porbeagle landings data (tonnes) by country (1971–2013). Data derived from ICCAT, FAO, ICES and national data. Data are considered an underestimate.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	76	42	21	20	4	3	2	2	4	0	2	3	.
Faroe Is	8	10	14	5	19	21	13	11	4	.	0	0	.
France	339	439	394	374	246	185	347	221	299	7	2	27	13
Germany	1	3	5	6	5	0	.	0	0	.	0	0	.
Iceland	4	2	0	1	0	1	0	1	1	1	1	2	1
Ireland	6	3	11	18	3	4	8	7	0	0	0	0	.
Netherlands	.	.	0	.	0	.	0	0	0	0	0	0	.
Norway	17	14	19	24	11	27	10	12	10	12	10	14	8
Portugal	4	11	4	57	10	6	2	0	0	.	0	0	.
Spain	23	49	22	9	10	26	6	32	0	.	0	0	.
Spain (Basque Country)	45	16	22	10	11	5	16	13	3	0	2	0	.
Sweden	1	.	.	5	0	.	1	0	0	.	0	0	.
UK (Eng,Wal & NI)	10	7	25	24	24	11	26	12	10	0	0	0	.
UK (Scot)	1	.	.	.	.	.	.	1	0	0	0	0	.
Japan	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	.
TOTAL	535	596	537	553	343	289	431	313	333	20	17	45	22

Table 6.2. Porbeagle in the NE Atlantic. Proportion of small (<50 kg) and large (≥50 kg) porbeagle taken in the French longline fishery 1992–2009 (Source Hennache and Jung, 2010).

	% Weight of in the catches of porbeagle:	
Year	< 50 kg	>50 kg
1992	26.0	74.0
1993	29.7	70.3
1994	33.1	66.9
1995	49.9	53.1
1996	31.9	68.1
1997	39.2	60.8
1998	Data not available by weight category	
1999		
2000		
2001		
2002		
2003	53.7	46.3
2004	44.0	56.0
2005	40.0	60.0
2006	44.3	55.7
2007	44.9	55.1
2008	45.9	54.1
2009	51.8	48.2

Table 6.3. Porbeagle in the NE Atlantic. Length–weight relationships of porbeagle from scientific studies.

Stock	L–W relationship	Sex	n	Length range	Source
NW Atlantic	$W = (1.4823 \times 10^{-5})\ L_F^{2.9641}$	C	15	106–227 cm	Kohler *et al.*, 1995
NE Atlantic (Bristol Channel)	$W = (1.292 \times 10^{-4})\ L_T^{2.4644}$	C	71	114–187 cm	Ellis and Shackley, 1995
NE Atlantic (N/NW Spain)	$W = (2.77 \times 10^{-4})\ L_F^{2.3958}$	M	39		Mejuto and Garcés, 1984
	$W = (3.90 \times 10^{-6})\ L_F^{3.2070}$	F	26		
NE Atlantic (SW England)	$W = (1.07 \times 10^{-5})\ L_T^{2.99}$	C	17		Stevens, 1990
NE Atlantic (Biscay / SW England/W Ireland)	$W = (4 \times 10^{-5})\ L_F^{2.7316}$	M	564	88–230 cm	Hennache and Jung, 2010
	$W = (3 \times 10^{-5})\ L_F^{2.8226}$	F	456	93–249 cm	
	$W = (4 \times 10^{-5})\ L_F^{2.7767}$	C	1020	88–249 cm	

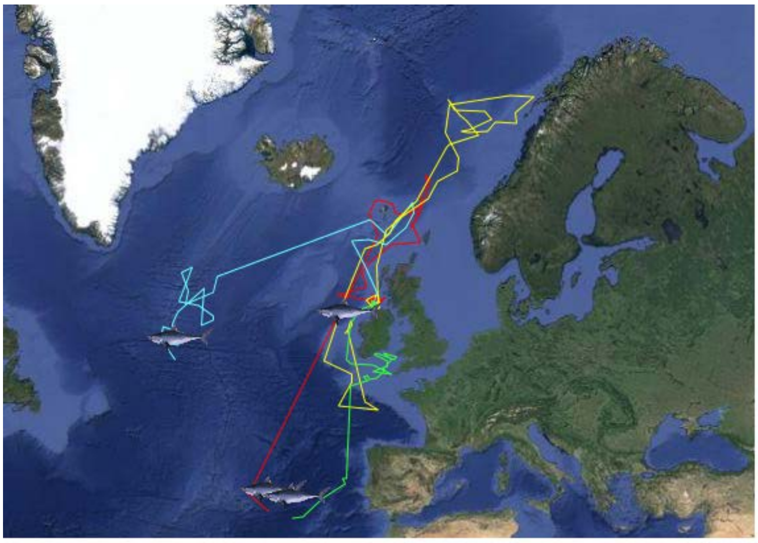
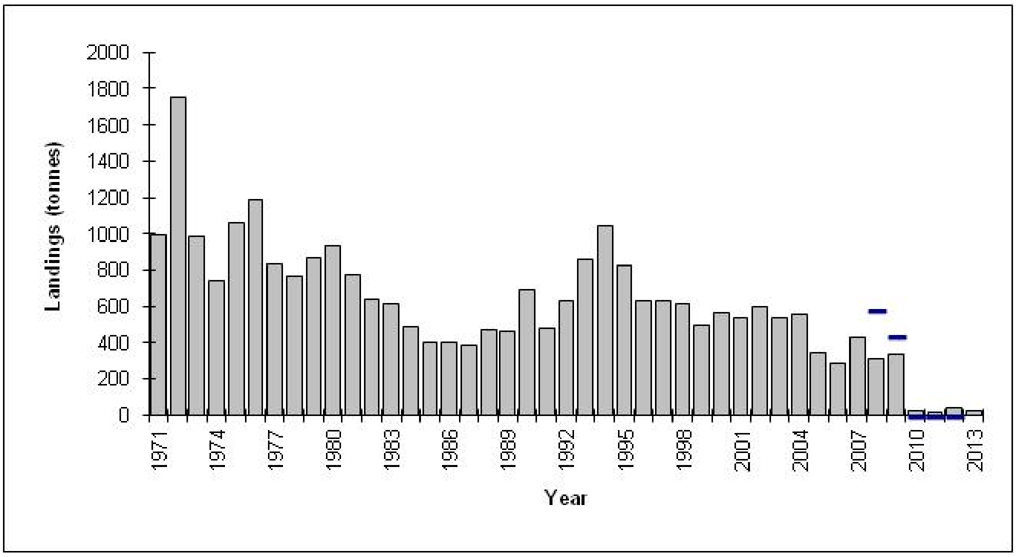


Figure 6.1 Porbeagle in the NE Atlantic. Movement of porbeagle tagged in Irish porbeagle archival tagging programme.



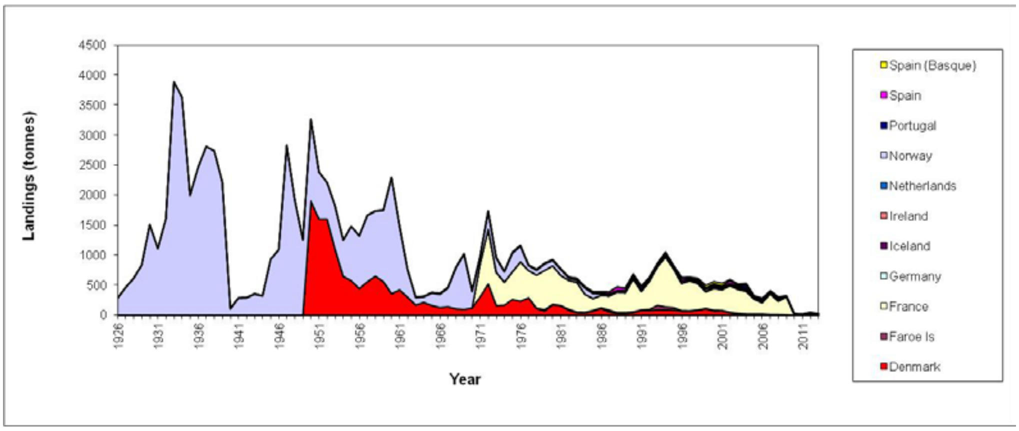


Figure 6.2. Porbeagle in the NE Atlantic. Working Group estimates of landings of porbeagle in the NE Atlantic for 1971–2012 (top, black lines indicates 2008–2013 TAC) and longer term trend in landings (1926–2013) for those fleets reporting catches.

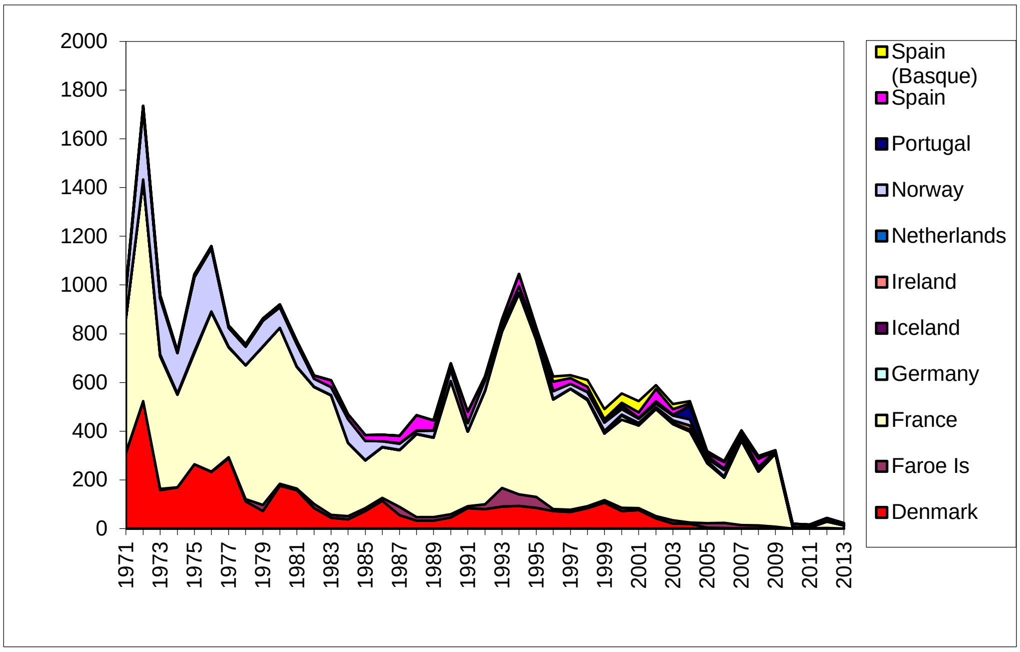


Figure 6.3. Porbeagle in the NE Atlantic. Working Group estimates of landings of porbeagle in the NE Atlantic for 1971–2013 by country.

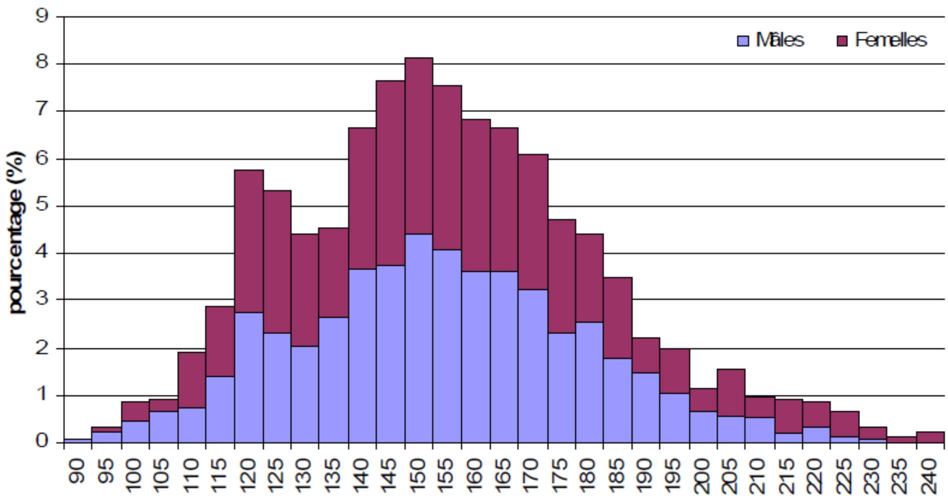


Figure 6.4. Porbeagle in the NE Atlantic. Length–frequency distribution of the landings of the Yeu porbeagle targeted fishery in 2008–2009 (n =1769). Source: Hennache and Jung, 2010.

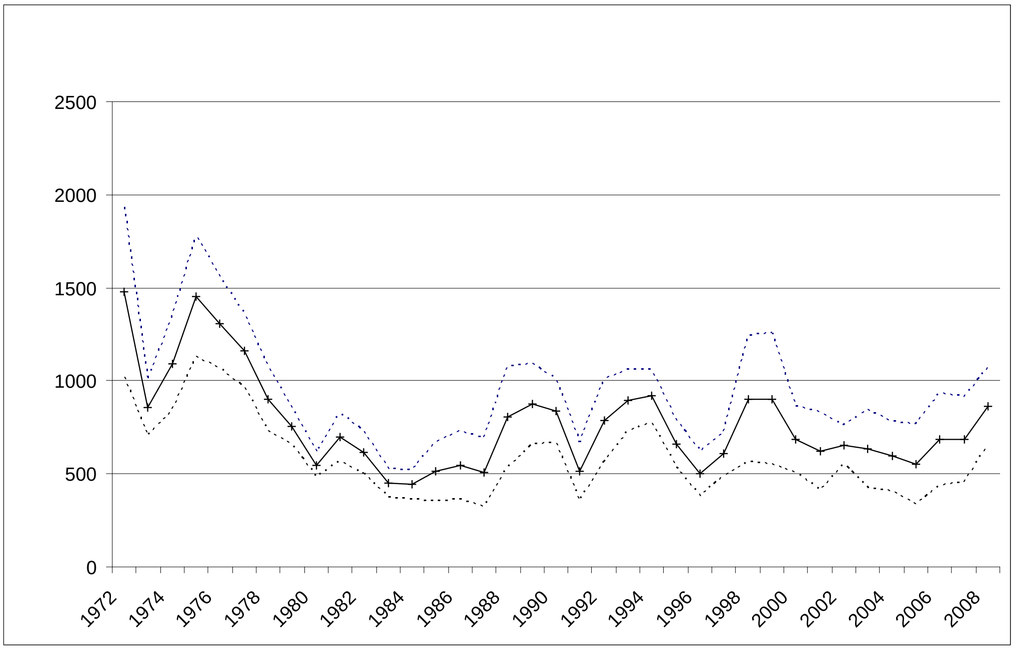


Figure 6.5. Porbeagle in the NE Atlantic. Nominal cpue (kg/day at sea) for porbeagle taken in the French fishery (1972–2008) with confidence interval (± 2 SE of ratio estimate). From Biais and Vollette, 2009.

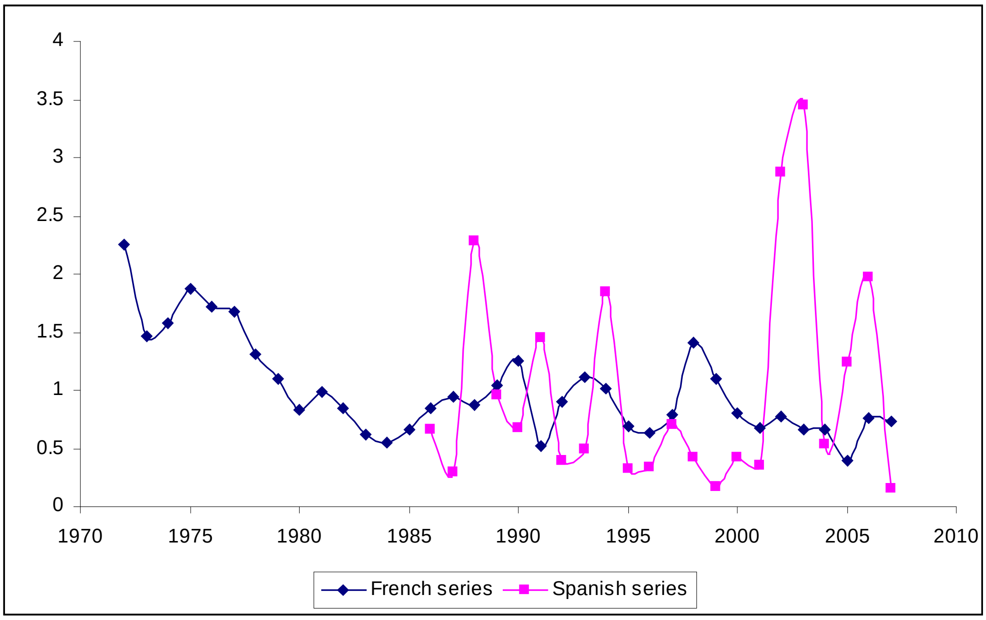


Figure 6.6. Porbeagle in the NE Atlantic. Temporal trends in standardized cpue for the French target longline fishery for porbeagle (1972–2007) and Spanish longline fisheries in the NE Atlantic (1986–2007).

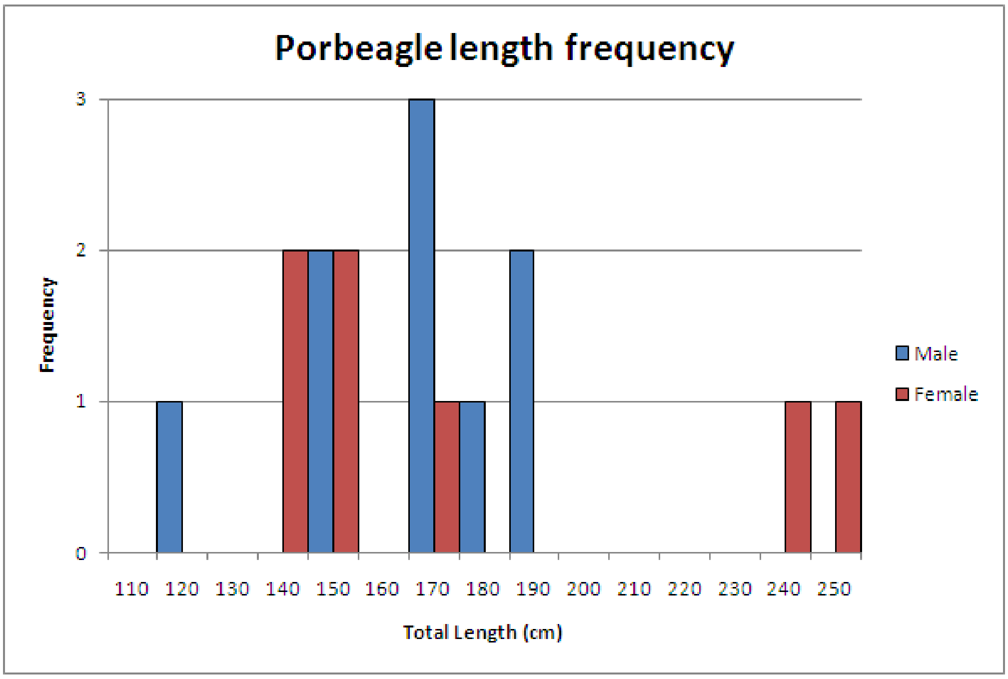


Figure 6.7. Porbeagle in the NE Atlantic. Length–frequency distribution of male and female porbeagle bycaught in fixed gillnets within ICES Divisions VIIf–h during September 2011 (Bendall *et al.*, 2012a).

7 Basking Shark in the Northeast Atlantic (ICES Areas I–XIV)

7.1 Stock distribution

In the Eastern Atlantic, basking shark *Cetorhinus maximus* is present from Iceland, Norway and as far north as the Russian White Sea (southern Barents Sea) and extends south to the Mediterranean Sea (Compagno, 1984; Konstantinov and Nizovtsev, 1980). WGEF considers that basking shark in the ICES area exists as a single stock and management unit. However, the WGEF is aware of recent tagging studies showing both transatlantic and transequatorial migrations, as well as migrations into tropical areas and mesopelagic depths (Gore *et al*., 2008; Skomal *et al*., 2009). Marked seasonality of basking shark sightings and significant correlation between the duration of the sightings season in each year and the North Atlantic Oscillation, has been reported (Witt *et al*., 2012). A genetic study by Hoelzel *et al*. (2006) indicates panmixia, whereas Noble *et al*. (2006) suggested little gene flow between populations in the northern and southern hemispheres. A rough estimate of the population size was given by Hoelzel *et al*. (2006). Migration and mixing levels have yet to be fully determined.

7.2 The fishery

7.2.1 History of the fishery

The fishery for basking shark goes back as far as the middle or end of the 1700s, in Norwegian, Irish and Scottish waters (Moltu, 1932; Strøm, 1762; Parker and Stott, 1965; Myklevoll, 1968; McNally, 1976; Fairfax, 1998). Up to 1000 individuals may have been taken in Irish waters each year at the height of the fishery. Such intensive fisheries stopped during the mid-1800s when the sharks became very scarce.

The Norwegian fleet resumed the fishery in 1920. The landings increased during the 1930s as the fishery gradually expanded to offshore waters across the North Sea and south and west of Ireland, Iceland and Faroes. During 1959–1980, catches ranged between 1266 and 4266 individuals per year, but subsequently declined (Kunzlik, 1988). The geographical and temporal distribution of the Norwegian domestic basking shark fishery changed markedly from year to year, possibly as a consequence of the unpredictable nature of the shark's inshore migration (Stott, 1982).

In Irish waters the basking shark fishery started again in 1947. Between 1000 and 1800 individuals were taken each year from 1951 to 1955 (an average of 1475/year), but there was a decline in catch records from 1956. Average annual catches were 489 individuals from 1956–1960, 107 individuals from 1961–1965, then about 50–60 individuals per year for the remaining years of the fishery (Parker and Stott, 1965; McNally, 1976).

The Scottish fishery started in the 1940s. In all around 970 sharks were taken between 1946 and 1953 (during a period when Norwegian vessels were also catching basking sharks in these waters).

From 1977–2007, an estimated total of 12 347 basking sharks were caught by Norway and Scotland, and of these Norway landed 12 014 individuals with an annual maximum of 1748 individuals landed in 1979 (Figure 7.1).

Data from the Norwegian Directorate of Fisheries revealed that the nominal value of fins increased dramatically from 1979 to 1992, was variable during 1993–2005, and decreased after 2005.

Further information on the history of the fishery is included in the Stock Annex.

7.2.2 The fishery in 2013

There is no longer any directed fishery for basking shark within the ICES area, and their Prohibited listing means EU vessels should release/discard any individuals caught. Five basking sharks (22 t) were caught and landed as dead bycatch in Norway in 2012.

7.2.3 ICES advice applicable

ICES advice has been for a zero TAC since 2006. In 2012 ICES advised on the basis of the precautionary approach that there should be no landings of basking shark and that it should remain on the Prohibited Species List.

7.2.4 Management applicable

Since 2007, the EU has prohibited fishing for, retaining on board, transhipping or landing basking sharks by any vessel in EU waters or EU vessels fishing anywhere (Council regulation (EC) No 41/2006).

Based on ICES advice, Norway banned all directed fisheries and landing of basking shark in 2006 in the Norwegian Economical Zone and in ICES Areas I–XIV. The ban has continued in 2007–2012. During this period live specimens caught as bycatch had to be released immediately, although dead or dying specimens can be landed. Since 2012, landings of basking sharks are not remunerated. Bycatch that is not landed should still be reported (since 2012). Bycatch should be reported both in number of individuals and weight (since 2009).

The basking shark has been protected from killing, taking, disturbance, possession and sale in UK territorial (twelve nautical miles) waters since 1998. They are also protected in two UK Crown Dependencies: Isle of Man and Guernsey (Anon., 2002).

Since 2004, Sweden has forbidden fishing for or landing basking shark.

7.3 Catch data

7.3.1 Landings

Landings data within ICES Areas I–XIV from 1977–2011 are presented in Table 7.1, and Figure 7.2. Landings of basking shark peaked in 1979 at a total of 5266 t, and declined rapidly towards 1988. Another peak in landings was registered in 1992, with 1697 t basking shark landed. Since the ban in direct fishery in 2006/2007, yearly landings have been <30 t.

Reported landings data come from UK (Guernsey) in 1984 and 2009, Portugal (1991–2008), France (1990–2008) and Norway (1977–2011). Most landings are from Subareas I, II and IV and are taken by Norway. For Portugal and France the reported landings were between 0.3 and 2 t. Landings for Portugal in 2004 and 2007 from FishStat were higher, but needs to be confirmed.

Catch in numbers from Scotland and Norway (2007–2012) are presented in Figure 7.1. The trends are very similar to those of landings in biomass, with a first maximum of

1748 individuals in 1979, a second maximum of 573 individuals in 1992, and less than ten individuals after 2006.

The conversion factors used for Norwegian landings (liver and fin weight to live weight) were revised during ICES WGEF 2008. Table 7.2 shows old and revised numbers.

Table 7.3 shows the proportions (%) of basking sharks caught by various gears as reported to the Directorate of Fisheries in Norway from 1990–2011. During most of the 1990s harpoon was the major gear, but remained at a relatively low level from 2000, except for 2005 which was the last year with a directed fishery. After the ban of directed fishery was introduced in 2006, bycatch has been taken primarily in gillnets.

Further information on Norwegian landings of liver and fins, and corresponding official and revised landings in live weight and numbers is included in the Stock Annex.

7.3.2 Discards

Limited quantitative information exists on basking shark discarded bycatch. However, anecdotal information is available indicating that this species is caught in gillnet and trawl fisheries in most parts of the ICES area. Most of this bycatch takes place in summer as the species moves inshore. The total extent of these catches is unknown.

Berrow and Heardman (1994) estimated 77–120 sharks were caught annually in the gillnet fishery in the Celtic Sea. These authors received 28 reports on sharks being entangled in fishing gear around the Irish coast in 1993. In the Isle of Man, bycatch in herring and pot fishery (entanglement in ropes) is estimated at 14–20 sharks annually. Bonfil (1994) estimated that 50 sharks were taken annually by the oceanic gillnet fleet in the Pacific Ocean. Fairfax (1998) reported that basking sharks are sometimes brought up from deep-water trawls near the Scottish coast during winter, and Valeiras *et al.* (2001) reported that of twelve basking sharks were incidentally caught in fixed entanglement nets in Spanish waters between 1988 and 1998, three sharks were sold at landing markets, three live sharks were released, and three dead sharks were discarded at sea. More detailed information can be found in the Stock Annex.

The French NGO APECS reported on 15 accidental catches from the Irish Sea, Atlantic Ocean and Mediterranean Sea (Jung *et al.*, 2012). More detailed data (catch location, gear, and biological data) are given in Table 7.4. This table also includes data on eleven bycatches from the Norwegian coast, published in Norwegian media.

In 2009, observers from French national observer programmes reported three accidentally caught, but released, basking sharks (around four meters long). Two basking sharks were recorded in Area VIa and one in Area IVa. One individual of 8 meters long was recorded in Area VIa in 2010.

In April 2014, two basking sharks were found dead stranded on south Brittany beaches: one male (5 m LT, 650 Kg) and one female (4 m LT, 250 Kg estimated). The female had 1/3 of her dorsal body lacerated with a propeller.

Five specimens of basking shark were caught and discarded by the Norwegian Coastal Reference Fleet in 2007–2009 (Vollen, 2010 WD). All specimens were caught in gillnets by vessels <15 m in ICES Subarea II.

The requirement for EU fleets to discard all basking sharks accidentally caught results on a lack of information on these catches. A protocol for the standardised recording of bycatch and biological information from bycatch would benefit any future assessments of the stock.

7.3.3 Quality of the catch data

The official Norwegian conversion factor used to convert from liver weight and fin weight to live fish was revised in 2008 (Table 7.2). The official Norwegian catch statistics were unchanged from 1977 to 1999, but from 2000–2008 the revised catch figures are applied.

Further information on the revision of the conversion factor is included in the stock annex.

7.3.4 Discard survival

Limited information available, and national observer programmes could usefully collect data on fate (released alive/released dead) of basking shark bycatch.

7.4 Commercial catch composition

There is some information on minimum, maximum and median weights of livers and fins, and corresponding live weights of individual basking sharks caught in Norway during 1992–1997. This information is included in the Stock Annex.

7.5 Commercial catch-effort data

There are no effort or catch per unit of effort (cpue) data available for recent years, as there has been no targeted fishery. Historical cpue data from the Norwegian fishery (1965–1985) are given in the Stock Annex.

7.6 Fishery-independent surveys

Several countries, e.g. Norway, Denmark, Ireland, conduct scientific whale-counting surveys. During these surveys observations of basking sharks are normally recorded. All French scientific surveys (MEDIT, EVHOE, PELGAS, etc.) as well as military planes and vessels record basking shark sightings and report them annually to NGO APECS. A national sight counting program also exists on all the coasts of France; most of the contributions comes from sailors or fishers. A number of Norwegian commercial vessels regularly report observations of whales. A request for reporting the sightings of basking sharks might yield useful effort-related data. There is also a sightings programme in the UK (Marine Conservation Society, 2003; Southall *et al.*, 2005).

7.7 Life-history information

No new information.

A summary of the knowledge of basking shark habitat, reproduction, growth and maturity, food and feeding, and behaviour can be found in the Stock Annex.

Habitat

In a study from 2008, the Irish Basking Shark Study Group tagged two basking sharks with archival satellite tags (Berrow and Johnston, 2010 WD). Both sharks remained on the continental shelf for most of the tagging period; 'Shark A' spent most time in the Irish and Celtic Seas with evidence of a southerly movement in winter to the west coast of France (Figure 7.3), whilst the movements of 'Shark B' were more constrained, remaining off the southwest coast for the whole period with locations off-the-shelf edge and in the Porcupine Bight (Figure 7.3). The greatest depths recorded were 144 m and 136 m, respectively, demonstrating that although 'Shark B' was located over deep water off-the-shelf edge, it was not diving to large depths. The sharks were within 8 m of the surface for 10% and 6% of the time. The study demonstrated that basking sharks were present and active in Irish waters throughout the winter period.

French national sighting program reports about 90 basking sharks encountered off the French coasts every year. Peak sightings occur in May, the two majors areas being south of Brittany and the Casquet in the English Channel (Jung *et al*., 2012 WD). Early sightings are reported off the island of Corsica in February–March; in 2011 one basking shark were reported in Saint Pierre et Miquelon.

Skomal *et al.* (2009) shed further light on apparent winter disappearance of the basking shark. Through satellite archival tags and a novel geolocation technique they demonstrated that sharks tagged in temperate feeding areas off the coast of southern New England moved to the Bahamas, the Caribbean Sea, and onward to the coast of South America and into the southern hemisphere. When in these areas, basking sharks descended to mesopelagic depths (200–1000 m) and in some cases remained there for weeks to months at a time. The authors concluded that basking sharks in the western Atlantic Ocean, which is characterized by dramatic seasonal fluctuations in oceanographic conditions, migrate well beyond their established range into tropical mesopelagic waters. In the eastern Atlantic Ocean, however, only occasional dives to mesopelagic depths have been reported in equivalent tagging studies (Sims *et al.*, 2005). It is hypothesized that, in this area, the relatively stable environmental conditions mediated by the Gulf Stream may limit the extent to which basking sharks need to move during winter to find sufficient food.

The NGO APECS tagged ten basking sharks in 2009 (Stéphan *et al*., 2011). The sharks were tagged with pop-up archival tags (PATs). Eight PATs were deployed in the Irish Sea in cooperation with the Manx Wildlife Trust and three PATs in the Iroise Sea (West Brittany). The PATs released from five to 245 days later. All the sharks tagged in the Irish Sea moved southwards, within the Irish Sea or to the Celtic Sea and, one of them, to the south of the Bay of Biscay. One of the PATs set in the Iroise Sea in 2009 popped off after five days but the second after 38 days and, during this short period, the shark moved quickly northwards, up to West Scotland by the west of Ireland. In 2010–2012, PATs have also been deployed by APECS in 2011 only, Manx Basking Shark Watch and the Irish Basking Shark Study Group. Data processing of transmitted information has not yet been completed.

SPOT Tagging technology has been successfully experimented in the Inner Hebrides (West Scotland) on basking shark since 2012: nine SPOTs were deployed in July 2012 by the basking shark tagging project (Witt *et al*., 2013). One 5–6 meter long female tagged off move 3000 km south, down to the Western African coasts within 135 days of (pop off near the Canary Island in November), the other sharks demonstrated a degree of site fidelity in the Inner Hebrides (at various spatial scale) that will be interesting to consider in a context of spatial planning conservation.

Manx Basking Shark Watch deployed five SPOTs in June 2013 off the Isle of Man; APECS deployed a PAT tag on a 6 meter female in Brittany for eight months' data collection.

7.8 Exploratory assessment models

No assessments have been undertaken.

7.9 Quality of assessments

No assessments have been undertaken.

Further information on migration on and stock mixing is required.

7.10 Reference points

No reference points have been proposed for this stock.

7.11 Conservation considerations

Basking shark is listed as "Endangered" on the Norwegian Red List (Sjøtun *et al.*, 2010).

The Northeast Atlantic subpopulation of basking shark is listed as "Endangered" in the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species. Globally, the species is listed as "Vulnerable" (IUCN, 2012).

Basking shark was listed on Appendix II of the Convention on International Trade in Endangered Species (CITES) in 2002.

Basking shark was listed on Appendices I and II of the Convention on the Conservation of Migratory Species (CMS) in 2005.

Basking shark is listed on Annex I, Highly Migratory Species, of the UN Convention on the Law of the Sea (UNCLOS).

Basking shark was listed on the OSPAR (Convention on the protection of the marine environment of the Northeast Atlantic) list of threatened and/or declining species in 2004.

7.12 Management considerations

The current status of the population is unknown. At present there is no directed fishery for this species. WGEF considers that no directed fishery should be permitted unless a reliable estimate of a sustainable exploitation rate is available.

The species may be found in all ICES areas, and thus the TAC area should correspond to the entire ICES area.

Proper quantification of bycatch and discarding both in weight and numbers of this species in the entire ICES area is required.

Where national legislation prohibits landing of bycaught basking sharks, measures should be put in place to ensure that incidental catches are recorded in weight and numbers, and carcasses or biological material made available for research.

7.13 References

Anon. 2002. Convention on International Trade in Endangered Species (CITES), 2002. Inclusion of Basking Shark *Cetorhinus maximus* in Appendix II. Proponent: United Kingdom (on behalf of the Member States of the European Community). 12th Meeting of the Conference of Parties Proposal 36.

Berrow, S. D. and Heardman, C. 1994. The basking shark *Cetorhinus maximus* (Gunnerus) in Irish waters-patterns of distribution and abundance. *Proceedings of the Royal Irish Academy*, 94B: 101–107.

Berrow, S. D. and Johnston, E. 2010. Basking shark telemetry and tracking in Ireland. Working document for ICES Elasmobranch Working Group (WGEF) 2010.

Bonfil, R. 1994. Overview of world elasmobranch fisheries. FAO Fisheries Technical Paper 341. FAO, Rome.

Compagno, L. J. V. 1984. FAO Species Catalogue. IV. Sharks of the World. 1. Hexanchiformes to Laminiformes. Food and Agriculture Organisation of the United Nations, Rome.

Fairfax, D. 1998. The basking shark in Scotland: natural history, fishery and conservation. Tuckwell Press, East Linton, Scotland. 206 pp.

Gore, M., Rowat, D., Hall, J., Gell, F. R., and Ormond, R. F. 2008. Trans-Atlantic migration and deep mid-ocean diving by basking shark. *Biology Letters*, 4: 395–398.

Hoelzel, A. R., Shivji, M. S., Magnussen, J., and Francis, M. P. 2006. Low worldwide genetic diversity in the basking shark (*Cetorhinusmaximus*). *Biology Letters*, 2: 639–642.

IUCN. 2012. IUCN Red List of Threatened Species.Version 2012.1. http://www.iucnredlist.org>. Downloaded on 22 June 2012.

Jung, A., Wargnier, A., Stéphan, E. and Lefranc, A. 2012. APECS Elasmobranch observation-programs off French coasts. Working Document. ICES Working Group on Elasmobranch Fisheries. WD2012-17; 3 pp.

Konstantinov, K. G., and Nizovtsev, G. P. 1980. The basking shark *Cetorhinus maximus*, in Kandalaksha Bay of the White Sea. Journal of Ichthyology, 19: 155–156.

Kunzlik, P. A. 1988. The Basking Shark. Scottish Fisheries. Information Pamphlet, No. 14. Department of Agriculture and Fisheries for Scotland. Aberdeen.

Marine Conservation Society, 2003. Marine Conservation Society basking shark watch report 1987–2001. Ross-on-Wye, UK: Marine Conservation Society.

McNally, K. 1976. The Sun-Fish Hunt. Blackstaff Press, Belfast.

Moltu, P. 1932. Fiskarsoge for Sunnmøre och Romsdal. Sunnmørsposten aktietrykk.

Myklevoll, S. 1968. Basking shark fishery. *Commercial Fisheries Review*, 30: 59–63.

Noble, L. R., Jones, C. S. Sarginson, J., Metcalfe, J. D., Sims, D. W. and Pawson, M. G. 2006. Conservation Genetics of Basking Sharks. Final Report for Defra Tender CR0288. Report to Wildlife Species Conservation Division, Defra, UK.

Parker, H. W. and Stott, F. C. 1965. Age, size and vertebral calcification in the basking shark *Cetorhinus maximus* (Gunnerus). *Zoologische Mededelingen*, 40: 305–319.

Sims, D. W., Southall, E. J., Metcalfe, J. D., and Pawson, M. G. 2005.Basking Shark Population Assessment. Report to Global Wildlife Division, Defra, UK.

Sjøtun, K., Fredriksen, S., Heggøy, E., Husa,V., Langangen, A., Lindstrøm, E-A., Moy, F., Rueness, J. and Åsen, P. A. 2010. Cyanophyta, Rhodophyta, Chlorophyta, Ochrophyta In: Kålås, J.A., Viken, Å., Henriksen, S. and Skjelseth, S. (eds.) 2010. The 2010 Norwegian Red List for Species. Norwegian Biodiversity Information Centre, Norway.

Skomal, G. B., Zeeman, S. I., Chisholm, J. H., Summers, E. L., Walsh, H. J., McMahon, K. W. and Thorrold, S. R. 2009. Transequatorial migrations by basking sharks in the western Atlantic Ocean. *Current Biology*, 19; 1019–1022.

Southall, E. J., Sims, D. W., Metcalfe, J. D., Doyle, J. I., Fanshawe, S., Lacey, C., Shrimpton, J., Solandt J-L. and Speedie C. D. 2005. Spatial distribution patterns of basking sharks on the European shelf: preliminary comparison of satellite-tag geolocation, survey and public sightings data. Journal of the Marine Biological Association of the United Kingdom, 85: 1083–1088.

Stéphan E., Gadenne H. and Jung A. 2011. Sur_les_traces_du_requin_pelerin. Rapport final du programme de suivi par satellite de requins pèlerins en Atlantique Nord-Est, http://www.asso-apecs.org/IMG/pdf/Rapport_finalSur_les_traces_du_requin_pelerin_-_Fev_2011.pdf, 37pp.

Stott, F. C. 1982. A note on catches of basking sharks, *Cetorhinus maximus* (Gunnerus), off Norway and their relation to possible migration paths. *Journal of Fish Biology*, 21: 227–230.

Strøm, H. 1762. Beskrivelse av fogderiet Søndmør. Del 1. Sorøe 1762.

Valeiras J, Lopez, A and Garcia, M. 2001. Geographical, seasonal occurrence, and incidental fishing capture of the basking shark *Cetorhinus maximus* (*Chondrichthyes*: *Cetorhinidae*). *Journal of the Marine Biological Association*, 80: 3712/1–3.

Vollen, T. 2010. The Norwegian Reference Fleet: Catch and discard of elasmobranchs. Working document for ICES Elasmobranch Working Group (WGEF) 2010.

Witt, M.J., Doherty, P.D., Hawkes, L.A., Brendan J. Godley, B.J., Graham, R.T., and Henderson, S.M. 2013. Basking shark satellite tagging project: post-fieldwork report. *Scottish Natural Heritage Commissioned Report* No. 555.

Witt, M. J., Hardy, T., Johnson, L., Mcclellan, C. M., Pikesley, S. K., Ranger, S., Richardson, P. B., Solandt, J.-L., Speedie, C., Williams, R. and Godley, B .J. 2012. Basking sharks in the northeast Atlantic: spatio-temporal trends from sightings in UK waters. *Marine Ecology Progress Series*, 459: 121–134.

Table 7.1.Basking sharks in the Northeast Atlantic. Total landings (t) of basking sharks in ICES Areas I–XIV from 1977–2010. "."=zero catch, "+" = <0.5 t.

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	
I & II	3680	3349	5120	3642	1772	1970	967	873	1465	1144	164	96	
III & IV	.	.	.	.	.	.	734	1188	.	.	.	10	
Va	.	.	.	.	.	.	.	.	.	.	.	.	
Vb	.	14	.	83	28	.	.	.	.	.	.	.	
VI	.	.	.	.	.	.	.	.	.	.	.	.	
VII	.	278	139	.	.	186	60	1	.	.	.	.	
VIII	.	.	7	.	.	.	.	.	.	.	.	.	
IX	.	.	.	.	.	.	.	.	.	.	1	.	
X	.	.	.	.	.	.	.	.	.	.	.	.	
XII	.	.	.	.	.	.	.	.	.	.	.	.	
XIV	.	.	.	.	.	.	.	.	.	.	.	.	
TOTAL	3680	3641	5266	3725	1800	2156	1761	2062	1465	1144	165	106	
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	
I & II	593	781	533	1613	1374	920	604	792	425	55	31	117	
III & IV	.	116	220	84	.	157	23	.	43	.	.	.	
Va	.	.	.	.	.	.	.	.	.	.	.	.	
Vb	.	.	.	.	.	.	.	.	.	.	.	.	
VI	.	.	.	.	.	.	.	.	.	.	.	.	
VII	.	.	.	.	.	.	.	.	.	.	.	.	
VIII	.	1	+	+	.	+	1	+	2	1	1	1	
IX	+	.	+	+	+	1	1	1	1	.	1	1	
X	.	.	.	.	.	.	.	.	.	.	.	.	
XII	.	.	.	.	.	.	.	.	.	.	.	.	
XIV	.	.	.	.	.	.	.	.	.	.	.	.	
TOTAL	593	897	753	1697	1374	1078	629	793	471	56	33	119	
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
I & II	80	54	128	72	87	6	26	4	.	.	4	22	.
III & IV	.	+	.	.	.	.	.	.	.	.	.	.	.
Va	.	.	.	.	.	.	.	.	.	.	.	.	.
Vb	.	.	.	.	.	.	.	.	.	.	.	.	.
VI	.	.	.	.	.	.	.	.	.	.	.	.	.
VII	.	.	.	.	1	+	.	+	+	.	.	.	.
VIII	.	.	.	.	+	+	+	2	.	.	.	.	.
IX	2	1	1	1	2	.	8	.	.	.	.	.	.
X	1	.	.	26	.	.	3	.	.	.	.	.	.
XII	.	.	.	.	.	.	.	.	.	.	.	.	.
XIV	.	.	.	.	.	.	.	.	.	.	.	.	.
TOTAL	83	55	129	99	90	7	38	7	+	0	4	22	0

Table 7.2.Norwegian landings of liver (kg) and fins (kg) of basking shark (*Cetorhinus maximus*) during 1977–2007, estimated landings in live weight (conversion factors of 4.64 for liver and 40.0 for fins), estimated numbers of landed individuals (from landings of both liver and fins using an average weight per individual of 648.5 kg for liver and 71.5 kg for fins), ICES and Norwegian official landings (applying conversion factors of 10.0 for liver (1977–1995), 100.0 fins (1996–1999), 100.0 for fins (ICES 2000–2008), and 40.0 for fins (Norway 2000–2008)), and landings recommended used by ICES WGEF 2008. In 1995 and 1997, landings of whole individuals measuring 3760 kg (one individual) and 7132 kg (two individuals), respectively, were reported. These weights are included in the official and revised landings and in the estimation of landed numbers.

Year	Liver (kg)	Fins (kg)	Catch from liver (tonnes)	Catch from fins (tonnes)	Landed numbers (livers - fins)	ICES official landings (tonnes)	Norway official landings (tonnes)	Recom-mended by ICESWGEF 2008
1977	793 153	0	3680.2	0.0	1223	7931.5	7931.5	3680.2
1978	784 687	0	3640.9	0.0	1210	7846.9	7846.9	3640.9
1979	1 133 477	95 070	5259.3	3802.8	1748–1330	11 334.8	11 334.8	5259.3
1980	802 756	60 851	3724.8	2434.0	1238–851	8027.6	8027.6	3724.8
1981	387 997	27 191	1800.3	1087.6	598–380	3880.0	3880.0	1800.3
1982	464 606	31 987	2155.8	1279.5	716–447	4646.1	4646.1	2155.8
1983	379 428	24 847	1760.5	993.5	585–348	3794.3	3794.3	1760.5
1984	444 171	23 505	2061.0	940.2	685–329	4441.7	4441.7	2061.0
1985	315 629	16 699	1464.5	668.0	487–234	3156.3	3156.3	1464.5
1986	246 474	12 138	1143.6	485.5	380–170	2464.7	2464.7	1143.6
1987	35 244	3148	163.5	125.9	54–44	352.4	352.4	163.5
1988	22 761	1927	105.6	77.1	35–27	227.6	227.6	105.6
1989	127 775	10 367	592.9	414.7	197–145	1277.8	1277.8	592.9
1990	193 179	18 110	896.4	724.4	298–253	1931.8	1931.8	896.4
1991	162 323	18 337	753.2	733.5	250–256	1623.2	1623.2	753.2
1992	365 761	37 145	1697.1	1485.8	564–520	3657.6	3657.6	1697.1
1993	291 042	34 360	1350.4	1374.4	449–481	2910.4	2910.4	1374.4
1994	176 220	26 922	817.7	1076.9	272–377	1762.2	1762.2	1076.9
1995	10 450	15 571	52.2	626.6	17–219	108.3	108.3	626.6
1996	41 283	19 789	191.6	791.6	64–277	1978.9	1978.9	791.6
1997	57 184	11 520	272.5	467.9	90–163	1159.1	1159.1	467.9
1998	3	1366	0.0	54.6	19	136.6	136.6	54.6
1999	20	770	0.1	30.8	11	77.0	77.0	30.8
2000	51	2926	0.2	117.0	41	292.6	117.0	117.0
2001	0	1997.5	0.0	79.9	28	199.7	79.9	79.9
2002	0	1351.5	0.0	54.1	19	135.2	54.1	54.1
2003	0	3191.5	0.0	127.7	45	319.2	127.7	127.7
2004	0	1808.3	0.0	72.3	25	180.8	72.3	72.3
2005	0	2180.5	0.0	87.2	30	218.1	87.2	87.2
2006	0	160	0.0	6.4	2	16.0	6.4	6.4
2007	0	653	0.0	26.1	9	65.3	26.1	26.1
2008	0	98	0.0	3.9	1	9.8	3.9	3.9

Table 7.3. Basking sharks in the Northeast Atlantic. Proportions (%) of basking sharks caught in different gears as reported to the Norwegian Directorate of Fisheries from 1990–2011.

Year	Area IIa							Area IVa	
	Harpoon	Gillnets	Driftnets*	Undefined nets	Bottom Trawl	Danish seine	Hooks and line	Harpoon	Gillnets
1990	84.0		3.1					12.9	
1991	69.7		1.0					29.3	
1992	83.1		6.0		5.6		0.4	4.9	
1993	99.1	0.8			0.1				
1994	85.4							14.6	
1995	89.8	6.5							3.7
1996	89.1	10.3		0.2		0.4	0.1		
1997	66.7	23.7					0.5	9.1	
1998	67.2	28.5					4.4		
1999	9.1	81.8		7.8	1.3				
2000	33.4	58.7			7.8				
2001		96.0			4.0				
2002	16.3	78.5			5.2				
2003	3.4	89.7			7.2				
2004		100.0							
2005	54.1	44.5		0.5	1.4				
2006		100.0							
2007		100.0							
2008		100.0							
2009									
2010									
2011		50.0					50.0		

*** These driftnets for salmon were banned after 1992.**

Table 7.4.Basking sharks in the Northeast Atlantic. Summary details of bycatch reported from France (A. Jung, WGEF 2012) and Norwegian bycatch reported in media.

Nation	Day	Month	Year	Geog. area	Lat	Lon	Gear	Depth	Length	Weight (kg)	Comment	Source
France	25	Jan	2010	Iroise Sea	48.549	5.124	Gillnet		4–5 m		Released alive	Jung, 2012
France	8	May	2010	Atlanic	46.236	1.592	Gillnet		4.6 m		Discarded	Jung, 2012
France	27	May	2010	Atlantic	47.247	2.964	Gillnet		3.4 m		Discarded, samples, museum collection	Jung, 2012
France		May	2009	Mediter-ranean	42.935	3.063	Gillnet		6–7 m			Jung, 2012
France		May	2009	Mediter-ranean	42.935	3.063	Gillnet		6–7 m			Jung, 2012
France		May	2009	Mediter-ranean	42.935	3.063	Gillnet		6–7 m			Jung, 2012
France	31	May	2009	Atlantic	47.768	4.211			2.5–3 m		Released alive	Jung, 2012
France	18	Nov	2009	Atlantic	43.427	1.695			3.5–4 m		Discarded	Jung, 2012
France	27	Apr	2009	Mediter-ranean	45.841	1.531	Bottom trawl	20 m			Discarded	Jung, 2012
France	20	May	2009	Mediter-ranean	43.051	-3.391	Pelagic trawl	45 m	5 m		Discarded	Jung, 2012
France	30	May	2011	Mediter-ranean	43.328	-5.203	Gillnet		3–6 m		Released alive	Jung, 2012
France	3	Aug	2011	Iroise Sea	48.233	4.483	Gillnet		3–6 m		Discarded, samples	Jung, 2012
France	19	Apr	2011	Atlantic	47.760	4.205	Gillnet	30 m	3–6 m		Discarded, samples, immature	Jung, 2012
France	6	May	2011	Atlantic	47.745	4.218	Gillnet		3–6 m		Released alive, genetic sample	Jung, 2012
France	4	Nov.	2011	Celtic Sea					4 m		Obsmer data, genetic sample	
France	17	May	2013	Atlantic	47.780	4.210	Gillnet		3.3 m		Discarded, samples, immature male	Jung 2013
Norway		Dec	2006	Atlantic	59.03	9.80	Gillnet	50 m	3.5 m	350	Approx. position	Media
Norway		Sep	2006	Atlantic	58.81	9.90	Gillnet		~4 m	500	Discarded, approx. position	Media
Norway		Aug	2007	Atlantic	61.97	5.02	Gillnet		4.5 m	250	Discarded, approx. position	Media
Norway			2007	Atlantic	64.13	8.20	Gillnet		4 m	500	Approx. position	Media
Norway		Sep	2007	Atlantic	58.45	8.86	Gillnet		4–5 m		Approx. position	Media

Nation	Day	Month	Year	Geog. area	Lat	Lon	Gear	Depth	Length	Weight (kg)	Comment	Source
Norway		July	2008	Atlantic	68.11	14.18					Approx. position	Media
Norway		July	2008	Atlantic	62.36	47.00	Gillnet				Released alive, approx. position	Media
Norway		July	2011	Atlantic	70.29	27.28	Gillnet		~10 m		Discarded, approximate position	Media
Norway		July	2011	Atlantic	71.11	23.96	Gillnet				Released alive, approx. position	Media
Norway		May	2012	Atlantic	68.78	11.86	Gillnet		~10 m	~1 t	Landed, approx. position	Media
Norway		May	2012	Atlantic	62.48	5.86	Gillnet				Landed, approx. position	Media

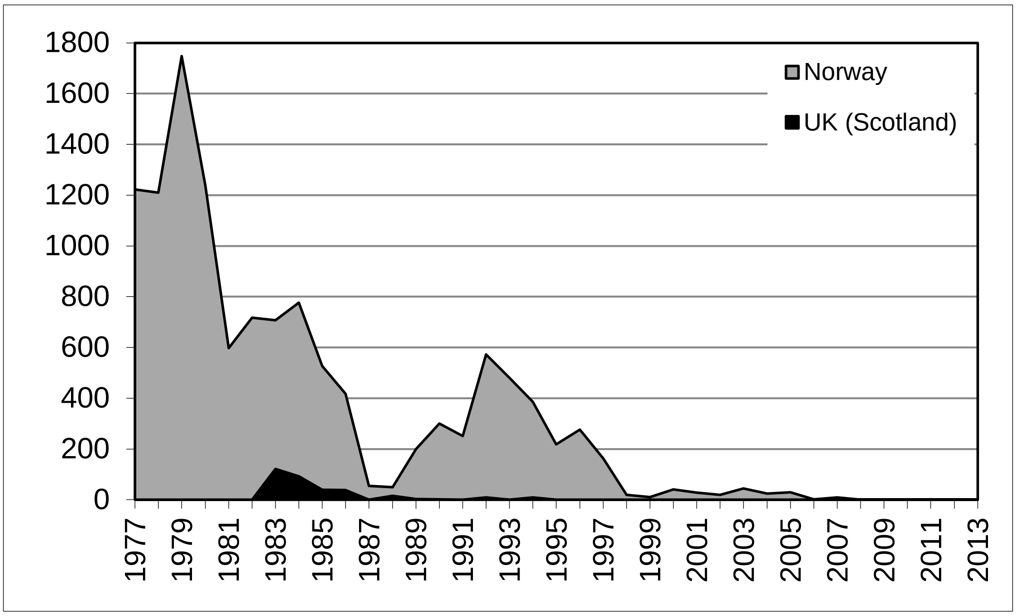


Figure 7.1. Basking sharks in the Northeast Atlantic. Numbers of basking sharks caught by Norway and Scotland in ICES Areas I–XIV from 1977–2013.

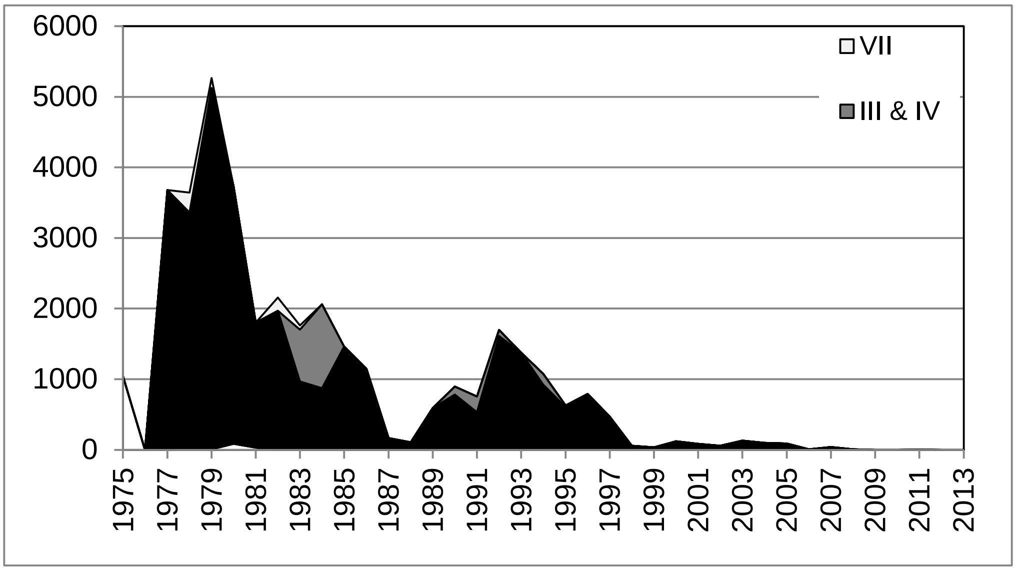


Figure 7.2. Basking sharks in the Northeast Atlantic. Total landings (t) of basking sharks in ICES Areas I–XIV from 1977–2013.

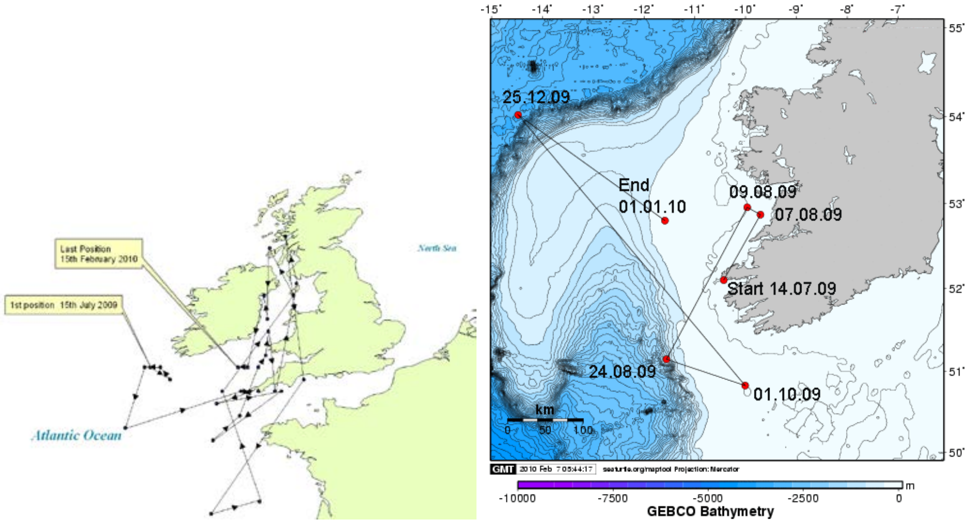


Figure 7.3. Basking sharks in the Northeast Atlantic. Geolocations from basking shark A (left, sex=male) and B (right, sex=unknown). Source: Berrow and Jackson, 2010.

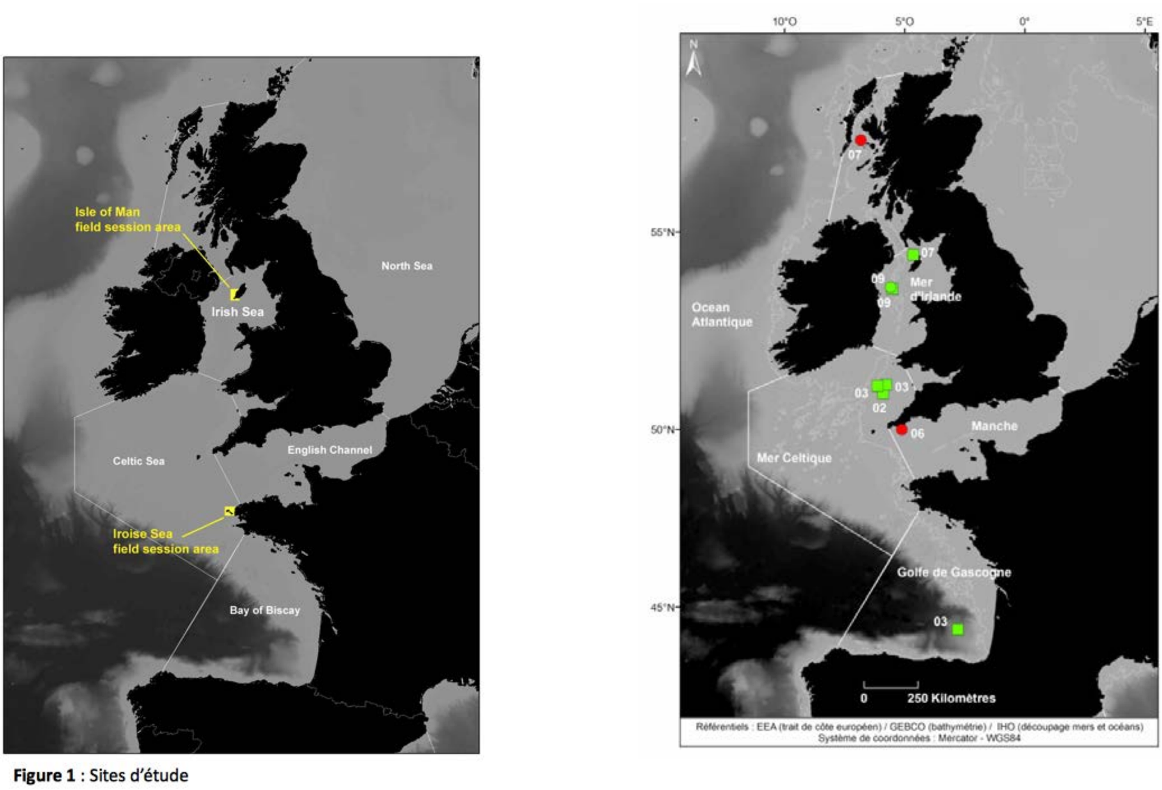


Figure 7.4. Basking sharks in the Northeast Atlantic. Tagging locations and recapture positions of PAT-tagged Basking shark from the APECS tag programme 2009–2010. Source: Stéphan *et al.*, 2011.

8 Blue shark in the North Atlantic (North of 5°N)

8.1 Stock distribution

The DELASS project and the ICCAT Shark Assessment Working Group consider there to be one stock of blue shark *Prionace glauca* in the North Atlantic (Heessen, 2003; Fitzmaurice *et al.*, 2005; ICCAT, 2008). The ICES area is only part of the stock. ICCAT, 2008 considered that the 5°N parallel was the most appropriate division between North and South Atlantic stocks of blue shark. This decision was based on the oceanographic features of the region and to facilitate comparison with fisheries statistics from tuna-like species for which North Atlantic stocks are also assumed to have 5°N as a southern stock boundary.

Assessment of this stock is considered to be the responsibility of ICCAT. WGEF presents a section on blue shark here, to help summarize available data and aid the assessment process in ICCAT.

In March 2014 there was an inter-sessional meeting of the ICCAT Shark species group, and WGEF welcomes their conclusion that they "*recommend the continuation of the joint collaboration with the ICES Working Group on Elasmobranch Fishes; a formal invitation should be sent to the chair of this Working Group for their active participation in the 2015 BSH data preparatory and stock assessment sessions*" (ICCAT, 2014).

8.2 The fishery

8.2.1 History of the fishery

In recent years, more information has become available about fisheries taking blue shark in the North Atlantic. Although the available data are limited, it offers information on the situation in fisheries and trends. Although there are no large-scale directed fisheries for this species, it is a major bycatch in many fisheries for tunas and billfish, where it can comprise up to 70% of the total catches and thereby exceed the actual catch of targeted species (ICCAT, 2005).

Observer data indicated that substantially more sharks are caught as bycatch than reported in catch statistics. Blue sharks are also caught in considerable numbers in recreational fisheries, including in the ICES area (Campana *et al*., 2005).

Since 1998 there has been a Basque artisanal longline fishery targeting blue shark and other pelagic sharks in the Bay of Biscay (Díez *et al*., 2007). This fishery takes place from June to November and historically has involved between three and five vessels. As a consequence of changes in local fishing regulations the number of vessels has been reduced to two since 2008.

8.2.2 The fishery in 2013

No new information. Landings data should be regarded as preliminary and further investigations will be conducted next year.

8.2.3 Advice applicable

ACOM has never provided advice for blue shark in the ICES area. Assessment of this stock is considered to be the responsibility of ICCAT. No specific management advice has been provided by ICCAT for this stock, to date.

8.2.4 Management applicable

There are no measures regulating the catches of blue shark in the North Atlantic.

EC Regulation No. 1185/2003 prohibits the removal of shark fins of this species, and subsequent discarding of the body. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

8.3 Catch data

8.3.1 Landings

It is difficult to accurately quantify landings of blue shark in the North Atlantic, as data are incomplete, and generic reporting of shark catches has resulted in underestimation. Landing data from different sources (ICCAT, FAO and national statistics) vary a lot. Table 8.1 gives the Task I catch data (total landings and discards by stock, flag and major gears) collated by ICCAT, and which appears to provide the most complete landings for this species. ICCAT considers that the reported landings of blue shark were underestimated more so in the early part of the time-series (prior to 1997), with official landings and estimates of a comparable magnitude since 1997, with annual landings in the region of 20 000–40 000 t. However, in 2012 North Atlantic landings were estimated at 74 390 t which represents an increase of nearly 50% on 2010. In 2012, several countries reported landings for the first time including Namibia, South Africa, Uruguay and the Korean Republic. The Mediterranean landings declined to about 40 t, caught by Spain. Italy appears to have stopped reporting the species. The national data reported to ICES for 2012 totalled 1135 t, with the majority of this being reported by Spain (682 t) and Azores.

In the ICES area, blue shark is reported predominantly by Spain, Portugal, Japan and USA, with landings by these countries accounting for 85% of the annual landings in 2012 (Figure 8.1).

Traditionally catches of this species reported to ICES have been minimal (0 to ~2500 t over the last 35 years), therefore in this report the more comprehensive data from ICCAT are presented in the catch table (Table 8.1). In 2012 the main country reporting landings of this species to ICES was Spain, where catch was 682 t. This catch is derived from an artisanal directed pelagic shark longline fishery held by the Basque country. There were also comparatively low levels (<300 t) also reported by France, Portugal (Azores) and the United Kingdom.

Landings data of blue shark from FAO (FishStat) by major fishing area are shown in Figure 8.2. Figure 8.3 presents the different landings reported to ICCAT and FAO respectively. Data reported to ICCAT were not considered reliable estimates for the 2008 stock assessment. Therefore, for the assessment purposes, two other estimates of landings for this stock were prepared (Table 8.2 and Figure 8.4), the tuna ratio and the fin trade index. The tuna ratios derive from logged observations of shark catches relative to tuna catches and are considered underestimated by ICCAT because they do not consider all fisheries (ICCAT, 2008). The fin trade index is inferred from systematic trade observations of shark fins in the Asian market and used to calculate caught shark weights based on catch effort data from the ICCAT database (Clarke *et al*., 2006; ICCAT, 2008).

8.3.2 Discards

The low value of blue shark means that it is not always retained for the market. The most valuable parts of the blue shark are its fins. In some fisheries the fins are retained and the carcasses discarded. In 2013 EU regulation (Regulation EU No 605/2013 of the European Parliament and of the Council of 12 June 2013) closed the loophole in the 2003 ban that had allowed fishermen with permits to remove shark fins on board vessels and land them separately from the bodies by amending Council Regulation (EC) No 1185/2003 on the removal of fins of sharks on board vessels. Accurate estimates of discarding are required in order to quantify total removals from the stock. Currently no such estimates are available. Differences between estimated and reported catch in various fisheries (ICCAT, 2008 and references cited therein) suggest that discarding is widespread in fisheries taking blue shark.

Discard estimates are available only for fisheries from USA, Canada and UK (Bermuda). Numbers for the latter are negligible. USA reported discards in quantities of 63–1136 $t.year^{-1}$, averaging about 390 $t.year^{-1}$ over time (ICCAT, 2006). Discards from Canadian fisheries have been estimated at about 1000 t annually (ICCAT, 2008) compared with estimated annual landings of about 2000 t.

The full extent of bycatch of blue shark cannot be interpreted from present data, but available evidence suggests that longline operations can catch more blue shark than target fish. There is considerable bycatch of blue sharks in Japanese and Taiwanese tuna longliners operating in the Atlantic. However it is not possible, from the information available, to estimate discard rates from these fleets. Discards can be presumed to be far higher than reported (Campana *et al*., 2005), especially in high seas fisheries. It is thought that most discards of whole sharks would be alive on return to the sea. It is noted that discard survival rate is about 60% in longline fisheries and 80% in rod and reel fisheries (Campana *et al*., 2005).

A study conducted on the Canadian pelagic longliners targeting swordfish in the Northwest Atlantic (Campana *et al*., 2009) demonstrated that "*the overall blue shark bycatch mortality in the pelagic longline fishery was estimated at 35%, while the estimated discard mortality for sharks that were released alive was 19%. The annual blue shark catch in the North Atlantic was estimated at about 84 000 t, of which 57 000 t is discarded. A preliminary estimate of 20 000 t of annual dead discards for North Atlantic blue sharks is similar to that of the reported nominal catch, and could substantially change the perception of population health if incorporated into a population-level stock assessment*".

In ICES IXa, information on discards of elasmobranchs in demersal otter trawl, deepwater set longlines, set gillnet and trammelnet fisheries for the period 2004–2013 showed that blue shark was only caught and discarded in the longline fishery in small numbers, and it was not observed in the other fisheries (Prista *et al*., 2014).

8.3.3 Quality of catch data

Catch data are incomplete, and the extent of finning in high seas fisheries is unclear. The historical use of generic shark categories is problematic, although many European countries have begun to report more species-specific data.

Discrepancies have been identified between data reported to ICCAT and that reported to other agencies (ICCAT, 2008). However, work is now underway to consolidate the ICCAT, FAO and EUROSTAT databases (Palma *et al*., 2012). However, landings data are not sufficient to quantify total catch, because discarding is so widespread.

Methods developed to identify shark species from fins (Sebastian *et al.*, 2008; Holmes *et al.*, 2009) could help to gather data on species targeted by illegal fishers, this information will greatly assist in management and conservation.

8.3.4 Discard survival

Blue shark appears to be one of the most frequent shark species captured in longline fisheries. Several studies have reported the at-vessel mortality of longline-caught blue shark to broadly range from about 5–35% (summarised in Ellis *et al.*, 2014 WD). Discard survival in such fisheries can be influenced by several factors, including hook type, soak time and size of shark.

The survival rate at hauling for blue shark was estimated to be 49% for the French pelagic longliners targeting swordfish in the southwestern Indian Ocean; experiments conducted with gear equipped with hook timers indicated also that 29% were alive after eight hours after their capture (Poisson *et al.*, 2010). The survival rate of blue shark at haulback after a soak during the night was lower than that during day longline sets: 100% (Boggs, 1992), 80–90% (Campana *et al.*, 2005), 69% (Diez and Serafy, 2005), and 87% (Francis *et al.*, 2001).

8.4 Commercial catch composition

The information available on blue shark composition in commercial catches is considered incomplete. Japanese catches (landings and discards) from tuna longliners in the North Atlantic are estimated to have fluctuated between 2000–4500 t in recent years. These are higher than reported landings of the target species (bluefin tuna) from Japanese longliners in this period (ICCAT, 2008). Another study of Japanese bluefin tuna longline fishing demonstrated that the ratio of blue shark to the target species was about 1:1 (Boyd, 2008). Data from observed fishing for bluefin tuna by a Chinese Taipei (Taiwanese) vessel in the southern North Atlantic found that blue shark accounted for 76% of shark bycatch, though no information was presented on the percentage of blue shark in the total catch (Dai and Jang, 2008). Blue shark and shortfin mako are estimated together to account for between 69% and 72% of catches from Spanish and Portuguese surface longliners in the North Atlantic (Oceana, 2008).

8.4.1 Conversion factors

Information on the length–weight relationship is available from several scientific studies (Table 8.3) and information on body measurements relationships is summarized in Table 8.4a by sex and Table 8.4b for both sexes combined. Campana *et al.*, 2005 calculated the conversion relationships between dressed weight (W_D) and live weight or round weight (W_R) for NW Atlantic blue shark (n=17) to be:

$$W_R = 0.4 + 1.22\ W_D$$
$$W_D = 0.2 + 0.81\ W_R$$

For the French fisheries the proportion of gutted fish to round weight is 75.19%. There is also a factor for landed round weight to live weight (96.15%), meaning that there is a 4% reduction in weight because of lost moisture (Hareide *et al.*, 2007). There have been various estimates of fin weight to body weight (Mejuto and García-Cortés, 2004; Santos and Garcia, 2005; Hareide *et al.*, 2007; Santana-Garcon *et al.*, 2012; Biery and Pauly, 2012).

8.5 Commercial catch and effort data

In 2008, the following cpue series were available and used for stock assessments by ICCAT:

- US longlines 1986–2007;
- Japanese longlines 1971–2006;
- Irish recreational fisheries 1989–2005;
- US longlines 1957–1986;
- Venezuelan longlines 1994–2007;
- Spanish swordfish longlines 1997–2007.

Details of these series are available in ICCAT, 2008 and are presented in Figure 8.5.

The longer time-series demonstrated steady trends until the mid-1990s. The only exception to that is the US logbook series that demonstrated a large decline from very high levels in 1985. Downward trends since the mid-1990s are apparent from Irish coastal recreational fisheries, Venezuelan longliners, US mid-east coast recreational fisheries and the US commercial longliners, though not from Canadian bluefin tuna and bigeye tuna/swordfish fisheries. However the Canadian data were not used for assessment purposes by ICCAT. Data from the Japanese tuna longline fishery demonstrated a similar peak to the Irish data from the mid-1990s. There was no obvious abundance signal in the Spanish longline cpue, though this series only began after the declines in the other series were already apparent.

Most time-series declined to lowest observed levels in 2004 and 2005, with slight increases afterwards. The US Spanish and Japanese commercial indices displayed decline in recent years than the other series. These cpue series were weighted before included in the stock assessments conducted by ICCAT. The weights used were based on the covered spatial area of the North Atlantic. Series from fisheries with broader spatial extents received greater weights than those with more restricted spatial coverage.

A new standardized cpue series for the period 2004–2012 done for the Taiwanese longline fishery in the Atlantic has been developed and will be used in the assessment planned for 2015 (ICCAT, 2014).

8.6 Fishery-independent surveys

No fishery-independent data are available for the NE Atlantic, although such data exist for parts of the NW Atlantic (Hueter *et al*., 2008). A survey from 1977–1994 conducted by the US NMFS documented a decline among juvenile males blue sharks by 80%, but not among juvenile females, which also occur in fewer numbers in the area, the western North Atlantic off the coast of Massachusetts (Hueter *et al*., 2008). The authors concluded that vulnerability to overfishing in blue sharks is present despite their enhanced levels of fecundity relative to other carcharhinid sharks.

8.7 Life-history information

The blue shark is common in pelagic oceanic waters throughout the tropical and temperate oceans worldwide. It has one of the widest ranges of all the shark species. It may also be found close inshore.

In a satellite telemetry study, Queiroz *et al.* (2010) described complex and diverse types of behaviour depending on water stratification and/or depth (Figure 8.6). Females tagged in the Western channel were able to spend up to 70 days in this shelf edge area in the Bay of Biscay; whereas tagged juveniles showed relatively extensive vertical movements away from the southern nursery areas. Results indicated that the species inhabits waters with a wide temperature range from 10–20°C.

The US National Marine Fisheries Service also conducts a Cooperative Shark Tagging Programme (CSTP; Kohler *et al*., 1998; NMFS, 2006), with tagging in the NE Atlantic also being undertaken under the auspices of the Inshore Fisheries Ireland (formerly the Irish Central Fishing Board) Tagging Programme (Green, 2007 WD) and UK Shark Tagging Programme, and there have been other earlier European tagging studies (e.g. Stevens, 1976). Figure 8.7 shows the tag and release results presented by ICCAT (2012), highlighting the large number tagged to date, and the vast horizontal movements undertaken by blue shark in the Atlantic.

In Australian waters blue sharks exhibit oscillatory dive behaviour between the surface layers to as deep as 560–1000 m. Blue sharks were mainly in 17.5–20.0°C water and spent 35–58% of their time in <50 m depths and 10–16% of their time in >300 m (Stevens *et al*., 2010). The distribution and movements of blue shark are strongly influenced by seasonal variations in water temperature, reproductive condition, and availability of prey. The blue shark is often found in large single sex schools containing individuals of similar size.

Adult blue sharks have no known predators; however, subadults and juveniles are eaten by both shortfin mako and white shark as well as by sea lions. Fishing is likely to be a major contributor to adult mortality. A recent first estimation of fishing mortality rate via satellite tagged sharks being re-captured by fishing vessels ranged from 9 to 33% (Queiroz *et al*., 2010).

Various studies have compiled data on biological information on this species in the North Atlantic and other areas. Some of these data are summarized in Table 8.3 (length–weight relationships), Table 8.5 (growth parameters) and Table 8.6 (other life-history parameters). Based on life-history information, blue shark is considered to be among the most productive shark species (ICCAT, 2008).

In the report of the most recent inter-sessional meeting of the ICCAT shark species group (ICCAT, 2014) there is an update of life-history parameters for blue shark. ICCAT has the intention to review the parameters in order to see if they can be used in future stock assessments.

8.8 Exploratory assessment models

8.8.1 Previous assessments

In 2004, ICCAT completed a preliminary stock assessment (ICCAT, 2005). Although results suggested that the North Atlantic stock were above biomass in support of MSY, the assessment remained conditional on the assumptions made. These assumptions included (i) estimates of historical shark catch, (ii) the relationship between catch rates and abundance, (iii) the initial state of the stock in 1971, and (iv) various life-history parameters. It was pointed out that the data used for the assessment did not meet the requirements for proper assessment (ICCAT, 2006), and further research and better-resolved data collection was highly recommended.

In 2008, three models were used in stock assessment conducted by ICCAT (ICCAT, 2008 and references cited therein): a Bayesian surplus production model, an age-structured model that did not require catch data (catch-free model), and an age-structured production model. Results with the Bayesian surplus production model produced estimates of stock size well above MSY levels (1.5–2* B_{MSY}), and estimated F to be very low (at F_{MSY} or well below it). The carrying capacity of the stock was estimated so high that the increasing estimated catches (25–62 000 t over the time-series) generated very low F estimates. Sensitivity analyses showed that the stock size estimate was dependent on the weighting assigned to the Irish cpue series. Equal weighting of this and the other series produced a stock size at around B_{MSY}. Other sensitivity analyses indicated similar results to the base case run, with the stock well above MSY levels.

The age-structured biomass model displayed different results with either a strong decrease in biomass throughout the series to about 30% of virgin levels, or a less pronounced decline. The prior for the virgin biomass assigned high values to a very small number of biomass values but also indicated that the range of plausible values of this parameter has a heavy tail. This is probably because there is not enough information in the data to update the model and thus provide a narrower range of plausible values and thus provide a more precise estimate of the biomass of the stock.

Preliminary runs of an age-structured model not requiring catch information estimated that F was higher than F_{MSY}, but still low and that the current SSB estimated at around 83% of virgin levels.

8.9 Stock assessment

In 2008, ICCAT concluded that biomass was estimated to be above the level that would support MSY (ICCAT, 2008). These results agreed with earlier work (ICCAT, 2005). Stock status appeared to be close to unfished biomass levels and fishing mortality rates were well below those corresponding to the level at which MSY is reached. However, ICCAT, 2008 pointed out that the results were heavily dependent on the underlying assumptions. In particular the choice of catch data to be used, the weighting of cpue series and various life-history parameters used as input in the model. ICCAT was unable to conduct sensitivity analyses of the input data and assumptions (ICCAT, 2008).

Owing to those weaknesses, no firm conclusions could be drawn from the preliminary assessments conducted by ICCAT. ICCAT, 2008 stated that most models used predicted that this stock was not overfished but did not use these results to infer stock status and to provide management advice.

Blue shark will be assessed by ICCAT in 2015. Due to the fact that more data and more complex models will be used, ICCAT proposed to hold a data preparatory meeting prior to the assessment meeting.

8.10 Quality of assessments

A full evaluation of the sensitivity of results to the results of the 2008 ICCAT assessment was not conducted (ICCAT, 2008). The main difficulties are with regard to the input data, rather than the models used. In particular, further analyses could be conducted into the weighting procedures used and the sensitivity to catch data. The models do not always follow the trends in the cpue series available, especially the longer time-series. Even the best estimates of catch data available only generated very low estimates of fishing mortality. This is because the stock size was estimated to be considerably high. Further analyses are required before any firm conclusions can be drawn about stock status for this species.

It was suggested at the inter-sessional meeting of the ICCAT Shark species group that an integrated stock assessment model, such as Stock Synthesis 3, could be used in the next blue shark stock assessment in addition to the models previously used. Integrated models require a detailed knowledge of the ecological and biological characteristics, for example distributions by sex and stage. Therefore, a collaborative study of the geographical distribution of blue shark by size and sex was recommended. The group will thus conduct a detailed review of all available biological parameters for blue shark in the Atlantic in the data preparatory meeting scheduled for next year as required for stock assessment purposes (ICCAT, 2014).

8.11 Reference points

ICCAT uses F/F_{MSY} and B/B_{MSY} as reference points for stock status of this stock. These reference points are relative metrics rather than absolute values. The absolute values of B_{MSY} and F_{MSY} depend on model assumptions and results and are not presented by ICCAT for advisory purposes.

8.12 Conservation considerations

Blue shark is a highly migratory species that is listed as 'Near Threatened' by the IUCN.

8.13 Management considerations

The stock status of blue shark in the North Atlantic remains unclear. Catch data are highly unreliable. Some cpue series are existent, and where data are available, mainly reveal declines since the mid-1990s. Further work is required to explain the downward trends and to quantify removals from the stock.

The catch data are considered incomplete, and underestimates. Besides unaccounted discards and the substantial occurrence of finning, it becomes obvious that countries supply data to ICCAT that are not available to ICES. For accurate stock assessments of pelagic sharks, better data are required. In addition, reporting procedures must be strengthened so that all landings are reported, and that landings are reported to species level, rather than generic "shark nei" categories. In the absence of reliable landings and catch data, catch ratios and market information derived from observers can provide useful information for understanding blue shark fishery dynamics.

Blue shark is considered to be one of the most productive sharks in the North Atlantic. As such, it can be expected to be more resilient to fishing pressure than other pelagic sharks. However the high degree of susceptibility to longline fishing and the poor quality of the information available to assess the status of this stock is a cause for concern. Given that this species is a significant bycatch, especially in tuna and billfish fisheries, better data should be made available by the countries whose fleets catch it.

8.14 References

Aasen, O. 1966. Blahaien, *Prionace glauca* (Linnaeus, 1758). Fisken og Havet 1:1–15.

Biery, L., and Pauly, D. 2012. A global review of species-specific shark fin to body mass ratios and relevant legislations. *J. Fish. Biol.*, 80 : 1643–1677.

Boggs, C. H. 1992. Depth, capture time and hooked longevity of longline-caught pelagic fish. Timing bites of fish with chips. Fish. Bull. 90:642–658.

Boyd, J.M. 2008. The Japanese bluefin tuna longline fishery in the Northeast Atlantic: Report of an Irish observer. Irish Fisheries Investigations No.20/2008.

Buencuerpo, V., Ríos, S., and Morón, J. 1998. Pelagic sharks associated with the swordfish, *Xiphias gladius*, fishery in the eastern North Atlantic Ocean and the Strait of Gibraltar. *Fishery Bulletin* 96: 667–685.

Campana, S. E., Joyce, W., and Manning, M. J. 2009. Bycatch and discard mortality in commercially caught blue sharks *Prionace glauca* assessed using archival satellite pop-up tags. Mar. Ecol. Prog. Ser. 387:241–253.

Campana, S. E., Marks, L., Joyce, W. Kohler, N. 2005. Catch, by-catch, and indices of population status of blue shark (*Prionace glauca*) in the Canadian Atlantic. International Commission for the Conservation of Atlantic Tunas, Collective Volume of Scientific Papers. ICCAT 58(3): 891–934.

Campana, S., Gonzalez, P., Joyce, W. And Marks, L. 2002. Catch, bycatch and landings of blue shark (*Prionace glauca*) in the Canadian Atlantic. Canadian Stock Assessment, Research Document, 2002/101, Ottawa.

Castro, J. I. 1983. The sharks of North American waters. Texas A&M Univ. Press, College Station, TX, 180 pp.

Castro, J.A. and J. Mejuto. 1995. Reproductive parameters of blue shark, *Prionace glauca*, and other sharks in the Gulf of Guinea. Mar. Freshwater Res. 46:967–973.

Clarke S. C., McAllister M. K., Milner-Gulland E. J., Kirkwood G. P., Michielsens C. G. J., Agnew D.J., Pikitch E.K., Nakano H. And Shivji M.S. 2006. Global estimates of shark catches using trade records from commercial markets. Ecology Letters, 9: 1115–1126.

Cortés, E. 1999. Standardized diet compositions and trophic levels of sharks. ICES Journal of Marine Science 56:707–717.

Dai, X.J and Jiang, R.L. 2008. Shark bycatch observation in the ICCAT waters by Chinese longline observer in 2007. ICCAT SCRS/2008156.

Díez G., Santurtún, M., Ruiz, J., Iriondo, A., Gonzalez. I. And Artetxe, I. 2007. The long line Basque fishery on blue shark (*Prionace glauca*) in the Bay of Biscay (1998–2006). Working Document for ICES Working Group on Elasmobranch Fishes, Galway. 22–28 June, 2007, 9 pp.

Diez, G. A., and J. E. Serafy. 2005. Longline-caught blue shark (*Prionace glauca*): factors affecting the numbers available for live release. Fish. Bull. 103:720–724.

Fitzmaurice, P, Green, P., Keirse, G., Kenny, M. And Clarke, M. 2005. Stock discrimination of blue shark, based on Irish tagging data. International Commission for the Conservation of Atlantic Tunas, Collective Volume of Scientific Papers 58(3): 1171–1178.

Francis, M. P., and Duffy, C. 2005. Length at maturity in three pelagic sharks (*Lamna nasus, Isurus oxyrinchus,* and *Prionace glauca*) from New Zealand. *Fishery Bulletin* 103: 489–500.

Francis, M. P., L. H. Griggs and S. J. Baird. 2001. Pelagic shark bycatch in the New Zealand tuna longline fishery. Mar. Freshwat. Res. 52:165–178.Francis, M. P. And Duffy, C. 2005. Length at maturity in three pelagic sharks (*Lamna nasus, Isurus oxyrinchus* and *Prionace glauca*) from New Zealand. Fishery Bulletin, 103(3): 489–500.

García-Cortés, B. and J. Mejuto. 2002. Size–weight relationships of the swordfish (*Xiphias gladius*) and several pelagic shark species caught in the Spanish surface longline fishery in the Atlantic, Indian and pacific oceans. International Commission for the Conservation of Atlantic Tunas, Collective Volume of Scientific Papers, 54 (4): 1132–1149.

Green, P. 2007. Central Fisheries Board Tagging Programme 1970 to 2006. Working document to WGEF 2007 (PowerPoint display).

Hareide, N.R., J. Carlson, M. Clarke, S. Clarke, J. Ellis, S. Fordham, S. Fowler, M. Pinho, C. Raymakers, F. Serena, B. Seret, and S. Polti. 2007. European Shark Fisheries: a preliminary investigation into fisheries, conversion factors, trade products, markets and management measures. European Elasmobranch Association EEA 2007, 71 p.

Heessen, H. J. L. (Ed.). 2003. Development of elasmobranch assessments DELASS. Final report of DG Fish Study Contract 99/055, 605 pp.

Henderson, A. C., Flannery, K. And Dunne, J. 2001. Observations on the biology and ecology of the blue shark in the North-east Atlantic. Journal of Fish Biology 58: 1347–1358.

Holmes B. H., Steinke D., Ward R. D. 2009. Identification of shark and ray fins using DNA barcoding Fisheries Research 95:280–288. Hueter, R. E. and. Simpfendorfer, C. 2008. Case Study: Trends in Blue Shark Abundance in the Western North Atlantic as Determined by a Fishery-Independent Survey. In: Sharks of the Open Ocean; M. D. Chami, E. K. Pikitch and E. Babcock (eds.) 236–241.

Hueter, R. E. and. Simpfendorfer, C. 2008. Case Study: Trends in Blue Shark Abundance in the Western North Atlantic as Determined by a Fishery-Independent Survey. In: Sharks of the Open Ocean; M. D. Chami, E. K. Pikitch and E. Babcock (eds.) 236–241.

ICCAT. 2005. Report of the 2004 Inter-sessional Meeting of the ICCAT Subcommittee on By-catches: Shark Stock Assessment. SCRS/2004/014.

ICCAT. 2006. Chapter 8.12 SHK-Sharks Report of the Standing Committee on Research and Statistics (SCRS) ICCAT. PLE-014/2006 Madrid, Spain, October 2–6, 2006. 106–113.

ICCAT. 2008. Report of the 2008 shark stock assessments meeting. Madrid, Spain, 1–5 September, 2008. SCRS/2008/017–SHK Assessment, 89 pp.

ICCAT. 2012. Chapter 4.1 Shortfin Mako Stock Assessment and Ecological Risk Assessment Meeting. Olhao, Portugal June 11–18, 2012.

ICCAT. 2014. Inter-sessional meeting of the sharks species group. Piriapolis, Uruguay, March 10–14 2014; 72 pp. (www.iccat.int/Documents/Meetings/Docs/2014_SHK_INTER-SESS_REP.pdf).

Kohler N.F., Casey J.G. and Turner P. A. 1995. Length–weight relationships for 13 species of sharks from the western North Atlantic. Fishery Bulletin, 93: 412–418.

Kohler N.F., Turner P.A., Hoey, J.J., Natanson, L.J., and Briggs, R. 2002. Tag and recapture data for three pelagic shark species: blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), and porbeagle (*Lamna nasus*) in the North Atlantic Ocean. International Commission for the Conservation of Atlantic Tunas, Collective Volume of Scientific Papers, 54 (4): 1231–1260.

Kohler, N.E., Casey, J. G. and Turner, P. A. 1998. NMFS cooperative shark tagging programme, 1962–1993: An atlas of shark tag and recapture data. Marine Fisheries Review, no 60, National Marine Fisheries Service, 86 pp.

MacNeil MA, Campana SE. 2002. Comparison of whole and sectioned vertebrae for determining the age of young blue shark (*Prionace glauca*). J. Northw. Atl. Fish. Sci. 30:77–82.

Mejuto J. and García-Cortés B. 2004. Preliminary relationships between the wet fin weight and body weight of some large pelagic sharks caught by the Spanish surface longline fleet. International Commission for the Conservation of Atlantic Tunas, Collective Volume of Scientific Papers, 56(1): 243–253.

Mejuto J. and García-Cortés B. 2005. Reproductive and distribution parameters of the blue shark *Prionace glauca*, on the basis of on-board observations at sea in the Atlantic, Indian and Pacific Oceans. International Commission for the Conservation of Atlantic Tunas, Collective Volume of Scientific Papers, 58(3): 951–973.

NMFS. 2006. Final Consolidated Atlantic Highly Migratory Species Fishery Management Plan. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Sustainable Fisheries, Highly Migratory Species Management Division, Silver Spring, MD. Public Document. 1600 pp.

Oceana. 2008. Description of European Union surface longline fleet operating in the Atlantic Ocean and compilation of detailed EuroStat data on shark catches by EU fleets in the Atlantic shark catches. ICCAT SCRS 2008/158.

Palma, C., Ortiz, M., de Bruyn, P., Kell, L. and Pallares, P. 2012. Building a consolidated database to crosscheck ICCAT Task-I nominal catch, against EUROSTAT and FAO equivalent statistics. *ICCAT SCRS 2012/078*.

Poisson, F., Gaertner, J.C., Taquet, M., Durbec, J.P., and Bigelow, K. 2010. Effects of lunar cycle and fishing operations on longline-caught pelagic fish: fishing performance, capture time, and survival of fish. Fish. Bull. 108:268–281.

Pratt, H. L. 1979. Reproduction in the blue shark, *Prionace glauca*. Fish. Bull. 77:445–470.

Prista, N., Fernandes, A.C., Maia, C., Moura, T. and Figuerido, I. 2014. Discards of elasmobranchs in the Portuguese fisheries operating in ICES Division XIa: Bottom otter trawl, deep-water set longlines, set gillnet and trammel net fisheries (2004–2013). Working document to ICES WGEF 2014.

Queiroz N, Humphries N.E., Noble L.R., Santos A. M, Sims D. W. 2010. Short-term movements and diving behaviour of satellite-tracked blue sharks *Prionace glauca* in the northeastern Atlantic Ocean. Mar Ecol Prog Ser, Vol. 406: 265–279.

Santana-Garcon, J., Fordham, S. and Fowler, S. 2012. Blue shark *Prionace glauca* fin-to-carcass-mass ratios in Spain and implications for finning ban enforcement. Journal of Fish Biology, 80(5): 1895–1903.

Santos, M. N., and Garcia, A. 2005. Factors for conversion of fin weight into round weight for the blue shark (*Prionace glauca*). International Commission for the Conservation of Atlantic Tunas, Collective Volume of Scientific Papers, 58(3): 935–941.

Sebastian H., Haye P. A. and Shivji M. S. 2008. Characterization of the pelagic shark-fin trade in north-central Chile by genetic identification and trader surveys. Journal of Fish Biology 73, 2293–2304. Skomal, G.B. 1990. Age and growth of the blue shark, *Prionace glauca*, in the North Atlantic. Master's Thesis. University of Rhode Island, Kingston, RI. 82 pp.

Skomal, G. B. 1990. Age and growth of the blue shark, *Prionace glauca*, in the North Atlantic. M.S. thesis, 82 p. Univ. Rhode Island, Kingston, RI.

Skomal, G. B. and L.J. Natanson. 2002. Age and growth of the blue shark (*Prionace glauca*) in the North Atlantic Ocean. International Commission for the Conservation of Atlantic Tunas, Collective Volume of Scientific Papers, 54 (4): 1212–1230.

Skomal, G. B. and L.J. Natanson. 2003. Age and growth of the blue shark (*Prionace glauca*) in the North Atlantic Ocean. Fishery Bulletin, 101:627–639.

Smith, S. E., Au, D. W. and Show, C. 1998. Intrinsic rebound potentials of 26 species of Pacific sharks. Marine and Freshwater Research, 49: 663–78.

Stevens J.D., Bradford R.W., West, G.J. 2010. Satellite tagging of blue sharks (*Prionace glauca*) and other pelagic sharks of eastern Australia: depth behaviour, temperature experience and movements. Marine Biology, 157:575–591.

Stevens, J. D. 1975. Vertebral rings as a means of age determination in the blue shark (*Prionace glauca*). Journal of the Marine Biological Association of the United Kingdom 55, 657–665.

Stevens, J. D. 1976. First results of shark tagging in the North-east Atlantic, 1972–1975. Journal of the Marine Biological Association of the United Kingdom 56: 929–937.

Table 8.1. Blue shark in the North Atlantic. Landings (t) by country 1978–2011 from ICCAT Task I catch data (November 2012). These are considered underestimates, especially prior to 1997.

Stock	Country	1978	1979	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
North Atlantic	Belize																					
	Brasil																					
	Canada								320	147	968	978	680	774	1277	1702	1260	1494	528	831	612	547
	Cape Verde																+					
	China P.R.																					
	Chinese Taipei																					
	EU.Denmark											2	2	1	1		1	2	3	1	1	
	EU.España																			24497	22504	21811
	EU.France	4	12		9	8	14	39	50	67	91	79	130	187	276	322	350	266	278	213	163	399
	EU.Ireland																					66
	EU.Netherlands																					
	EU.Portugal												1387	2257	1583	5726	4669	4722	4843	2630	2440	2227
	EU.United Kingdom												1				+	12			1	+
	FR.St Pierre et Miquelon																					
	Japan																1203	1145	618	489	340	357
	Mexico																	+				
	Panama																					9
	Senegal																					
	Trinidad and																					

Stock	Country	1978	1979	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Tobago																					
	U.S.A.			204		605	107	341	1112	1400	776	751	829	1080	399	1816	601	641	987	391	447	317
	UK.Bermuda																	3	1	1	2	8
	Korea Rep.																					
	Namibia																					
	South Africa																					
	Uruguay																					
	Venezuela																					
N.Atlantic TotalTotal		4	12	204	9	613	121	380	1482	1614	1835	1810	3028	4299	3536	9566	8084	8285	7258	29053	26510	25741
Mediterranean	EU.Cyprus																					
	EU.España																			146	59	20
	EU.France																					
	EU.Italy																					
	EU.Malta																1	1	1	+	+	+
	EU.Portugal																				2	
	Japan																5	7	1	1		
Med TOTAL		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	5.581	8.376	1.768	147.95	60.856	20.445
N.ATL AND MED TOTAL		4	12	204	9	613	121	380	1482	1614	1835	1810	3028	4299	3536	9566	8090	8293	7260	29201	26571	25761

Table 8.1. Cont. Blue Shark in the North Atlantic. Landings (t) by country 1978–2011 from ICCAT Task I catch data. These are considered underestimates, especially prior to 1997.

Stock	Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
North Atlantic	Belize										114	461	1282
	Brasil	7											1980
	Canada	624	581	836	346	965	1134	977	843	+	+	+	+
	Cape Verde												+
	China P.R.		185	104	148				367	109	88	53	240
	Chinese Taipei				171	206	240	588	292	110	73	99	2286
	EU.Denmark	2	1	13	5	1						+	
	EU.España	24112	17362	15666	15975	17314	15006	15464	17038	20788	24465	26094	44966
	EU.France	395	207	221	57	106	120	99	167	119	84	122	115
	EU.Ireland	31	66	11	2	+	+		+	+	+	+	1
	EU.Netherlands									+	1		
	EU.Portugal	2081	2110	2265	5643	2025	4027	4338	5283	6167	6252	8261	14151
	EU.United Kingdom	12	9	6	4	6	5	3	6	6	96	8	10
	FR.St Pierre et Miquelon										1		
	Japan	273	350	386	558	1035	1729	1434	1921	2531	2007	1793	3130
	Mexico	+	6						+			+	+
	Panama							254	892	613	1575		
	Senegal			456					43	134	255	56	203
	Trinidad and Tobago			6	3	2	1	1	+	2	8	9	+
	U.S.A.	429	145	68		72	68	47	54	137	107	172	1183
	UK.Bermuda							+	+	+	+	+	
	Korea Rep.												662

Stock	Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Namibia												2957
	South Africa												318
	Uruguay												725
	Venezuela					9	26	10	18	7	71	74	117
N.Atlantic Total		**27965**	**21022**	**20037**	**22911**	**21740**	**22357**	**23215**	**26925**	**30722**	**35196**	**37204**	**74326**
Mediterranean	EU.Cyprus	9			3	6	5						
	EU.España	31	6	3	3	4	8	61	3	2	7	48	38
	EU.France								+	+	+	1	
	EU.Italy					113	1	95	46	75	175	165	
	EU.Malta	+	+	+	+	+	1	+	2	2	2	1	1
	EU.Portugal	5	41	14	3		56	22				2	
	Japan				1	1	2			2	+		
Med TOTAL		**44**	**47**	**17**	**10**	**125**	**72**	**178**	**51**	**82**	**185**	**216**	**39**
N.ATL AND MED TOTAL		**28010**	**21069**	**20053**	**22921**	**21865**	**22429**	**23394**	**26976**	**30803**	**35381**	**37420**	**74365**

Table 8.2. Blue shark in the North Atlantic. Estimated landings (t) of blue shark 1971–2006 based on reported landings, and as estimated from the ratio of sharks to tuna and tuna-like species, and as estimated by fin trade data (Source: ICCAT Shark Subgroup).

Year	Estimated catch (tuna ratio)	Estimated catch (fin trade data)	ICCAT landings	Fin trade estimates as a proportion of estimated landings	ICCAT landings as a proportion of estimated landings
1971	25 332	-	-	-	-
1972	25 274	-	-	-	-
1973	30 163	-	-	-	-
1974	27 593	-	-	-	-
1975	37 993	-	-	-	-
1976	31 411	-	-	-	-
1977	35 396	-	-	-	-
1978	27 506	-	4	-	0.00
1979	20 108	-	12	-	0.00
1980	27 202	11 392	-	-	-
1981	29 968	12 528	204	0.42	0.01
1982	33 318	13 972	9	0.42	0.00
1983	42 717	13 923	613	0.33	0.01
1984	39 644	15 982	121	0.40	0.00
1985	43 572	14 720	380	0.34	0.01
1986	55 374	18 265	1162	0.33	0.02
1987	58 923	14 906	1467	0.25	0.02
1988	50 284	13 312	867	0.26	0.02
1989	33 242	14 268	832	0.43	0.03
1990	36 129	14 543	2348	0.40	0.06
1991	38 966	21 847	3533	0.56	0.09
1992	38 307	27 604	2343	0.72	0.06
1993	45 057	20 497	7879	0.45	0.17
1994	41 925	27 341	15 407	0.65	0.37
1995	43 885	31 977	13 298	0.73	0.30
1996	42 760	40 539	15 781	0.95	0.37
1997	37 813	42 765	43 028	1.13	1.14
1998	34 617	43 228	39 450	1.25	1.14
1999	33 105	49 068	38 529	1.48	1.16
2000	31 021	51 183	42 721	1.65	1.38
2001	27 713	56 859	37 223	2.05	1.34
2002	25 983	46 826	34 040	1.80	1.31
2003	26 493	47 695	40 059	1.80	1.51
2004	25 510	46 509	39 207	1.82	1.54
2005	25 707	52 759	23 149	2.05	0.90
2006	26 795	61 845	19 796	2.31	0.74

Table 8.3. Blue shark in the North Atlantic. Length–weight relationships for *Prionace glauca* from different populations. Lengths in cm, and weights in kg unless specified in equation. W_R = round weight; W_D = dressed weight.

Stock	L (cm) W (kg) relationship	Sex	n	Length range (cm)	Source
NE Atlantic	WD = (8.04021 x 10-7) LF 3.23189	C	354	75–250 (LF)	García-Cortés and Mejuto, 2002
NW Atlantic	WR = (3.1841 x 10-6) LF 3.1313	C	4529		Castro, 1983
Atlantic	WR = (3.92 x 10-6) LT 3.41	Male	17		Stevens, 1975
Atlantic	WR = (3.184 x 10-7) LT 3.20	Female	450		Stevens, 1975
NW Atlantic	WR = (3.2 x 10-6) LF 3.128	C	720		Campana *et al.*, 2005
NW Atlantic	WD = (1.7 x 10-6) LF 3.205	C	382		Campana *et al.*, 2005

Table 8.4(a). Blue shark in the North Atlantic. Length–length relationships for male, female and both sexes combined of *Prionace glauca* from the NE Atlantic and Straits of Gibraltar (Buencuerpo *et al.*, 1998).

Females	Males	Combined
LF = 1.076 LS + 1.862 (n=1043)	LF = 1.080 LS + 1.552 (n=1276)	LF = 1.079 LS + 1.668 (n=2319)
LT = 1.249 LS + 7.476 (n=1043)	LT = 1.272 LS + 4.466 (n=1272)	LT = 1.262 LS + 5.746 (n=2315)
LUC = 0.219 LS + 4.861 (n=1038)	LUC = 0.316 LS + 2.191 (n=1264)	LUC = 0.306 LS + 3.288 (n=2302)
LT = 1.158 LF + 5.678 (n=1043)	LT = 1.117 LF + 2.958 (n=1272)	LT = 1.167 LF + 4.133 (n=2315)

L_S = standard length; L_F = fork length; L_T = total length; L_{UC} = upper caudal lobe length.

Table 8.4 (b). Blue shark in the North Atlantic. Length–length relationships for both sexes combined of *Prionace glauca* from various populations and sources.

Stock	Relationship	n	Source
NW Atlantic	LF = (0.8313) LT + 1.3908	572	Kohler *et al.*, 1995
NE Atlantic	LF = 0.8203 LT -1.061		Castro and Mejuto, 1995
NW Atlantic	LF = -1.2 +0.842 LT	792	Campana *et al.*, 2005
NW Atlantic	LT = 3.8 + 1.17 LF	792	Campana *et al.*, 2005
NW Atlantic	LCF = 2.1 + 1.0 LSF	782	Campana *et al.*, 2005
NW Atlantic	LSF = -0.8 + 0.98 LCF	782	Campana *et al.*, 2005
NW Atlantic	LF = 23.4 + 3.50 LID	894	Campana *et al.*, 2005
NW Atlantic	LID = -4.3 + 0.273 LF	894	Campana *et al.*, 2005

Table 8.5. Blue shark in the North Atlantic. Von Bertalanffy growth parameters from various studies. (L_∞ in cm (TL), k in years-1, t_0 in years).

Area	L∞	k	t0	Sex	Study
North Atlantic	394	0.133	-0.801	Combined	Aasen, 1966
North Atlantic	423	0,11	-1.035	Combined	Stevens, 1975
NW Atlantic	343	0.16	-0.89	Males	Skomal, 1990
NW Atlantic	375	0.15	-0.87	Females	Skomal, 1990
NE Atlantic	377	0.12	-1.33	Combined	Henderson *et al.*, 2001
North Atlantic	282	0.18	-1.35	Males	Skomal and Natanson, 2002
North Atlantic	310	0.13	-177	Females	Skomal and Natanson, 2002
North Atlantic	287	0.17	-1.43	Combined	Skomal and Natanson, 2003
NW Atlantic	300	0.68	-0.25	Combined	MacNeil and Campana, 2002 (whole ages)
NW Atlantic	302	0.58	-0.24	Combined	MacNeil and Campana, 2002 (section ages)

Table 8.6. Blue shark in the North Atlantic. Biological parameters for blue shark.

Parameter	Values	Sample Size	Area	Reference
Reproduction	Placental viviparity			various
Litter size	25–50 (30 average)			various
Size-at-birth (LT)	30–50 cm			various
Sex ratio (males: females)	1.5:1		NE Atlantic	García-Cortés and Mejuto, 2002
	1:1.44		NE Atlantic	Henderson *et al.*, 2001
	1.33:1		NW Atlantic	Kohler *et al.*, 2002
	1:2.13		NE Atlantic	Kohler *et al.*, 2002
	1:1.07	801	NE Atlantic (N. coast Spain)	Mejuto and García-Cortés, 2005
	1:0.9	158	NE Atlantic (S. coast Spain)	
	1:0.38	2187	N central Atlantic	
	1:0.53	4550	NW Atlantic	
Gestation period	9–12 months			Campana *et al.*, 2002
% of females revealing fecundation signs	0.74	415	NE Atlantic (N. coast Spain)	Mejuto and García-Cortés, 2005
	0	76	NE Atlantic (S. coast Spain)	
	36.27	601	N central Atlantic	
	18.15	1573	NW Atlantic	
% of pregnant females	0	415	NE Atlantic (N. coast Spain)	Mejuto and García-Cortés, 2005
	0	76	NE Atlantic (S. coast Spain)	
	14.6	601	N central Atlantic	
	9.8	1573	NW Atlantic	
Male age-at-maturity (years)	4–6			various
Female age-at-maturity (years)	5–7			various
Male length-at-maturity	180–280 cm (LF)		NW Atlantic	Campana *et al.*, 2002
	190–195 cm (LF)			Francis and Duffy, 2005
	201 cm (LF; 50% maturity)		NW Atlantic	Campana *et al.*, 2005
Female length-at-maturity	220–320 cm (LF)			Campana *et al.*, 2002

Parameter	Values	Sample Size	Area	Reference
	170–190 cm (LF)			Francis and Duffy, 2005
	> 185 cm (LF)			Pratt, 1979
Longevity (years)	16–20			Skomal and Natanson, 2003
Natural mortality (M)	0.23		Worldwide	Campana *et al*., 2005 (mean of various studies)
Productivity (R2m) estimate: intrinsic rebound	0.061 (assuming no fecundity increase)		Pacific	Smith *et al*., 1998
Potential rate of increase per year	43% (unfished)		NW Atlantic	Campana *et al*., 2005
Population doubling time TD (years)	11.4 (assuming no fecundity increase)		Pacific	Smith *et al*., 1998
Trophic level	4.1	14		Cortés, 1999

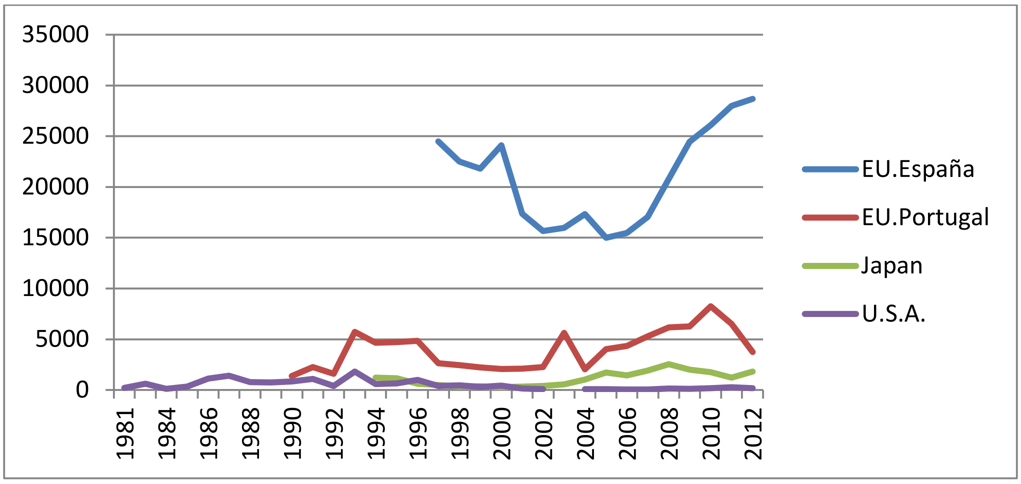


Figure 8.1. Blue shark landing in the Atlantic for the four major countries (85% of the catches) (Source: ICCAT Task I data, version November 2013).

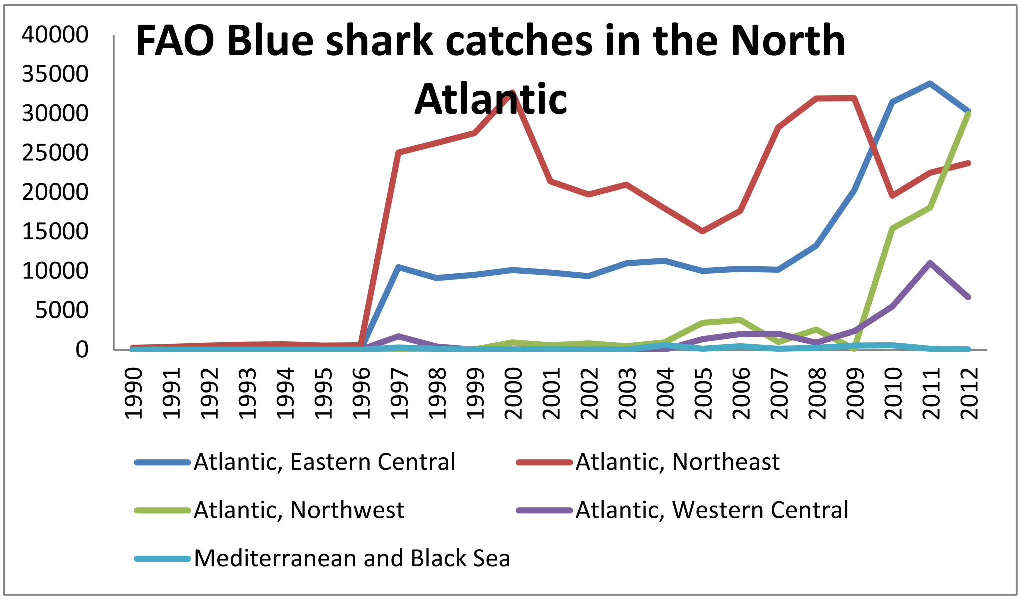


Figure 8.2. Blue shark landing in the Atlantic Ocean for the different areas (Source: FAO, 2014).

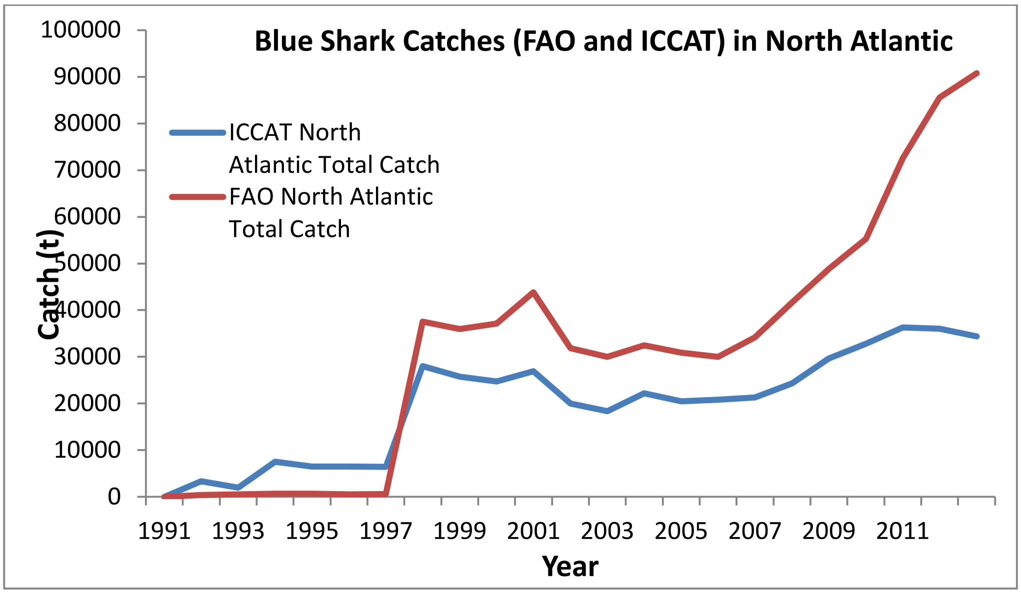


Figure 8.3. Blue shark landings in the North Atlantic from FAO and ICCAT data.

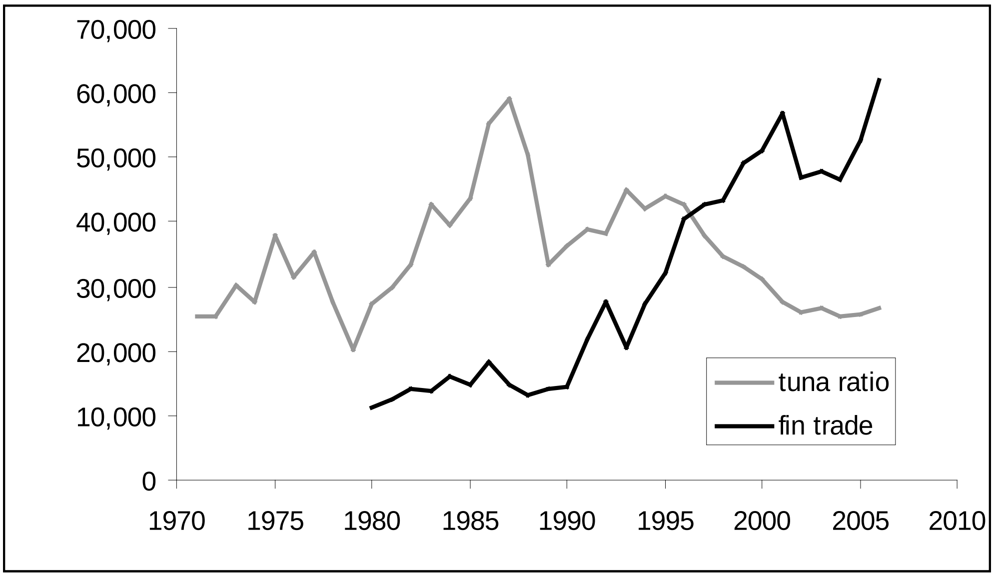


Figure 8.4. Blue shark in the North Atlantic. Two estimates of catch, as presented by ICCAT 2008. Tuna ratio: resulting from application of the method of estimating catches using the ICCAT reported data and the ratio of tunas to shark catch; fin trade: based on the medians scaled to effort partitioned into north and south management units based on effort in the ICCAT database.

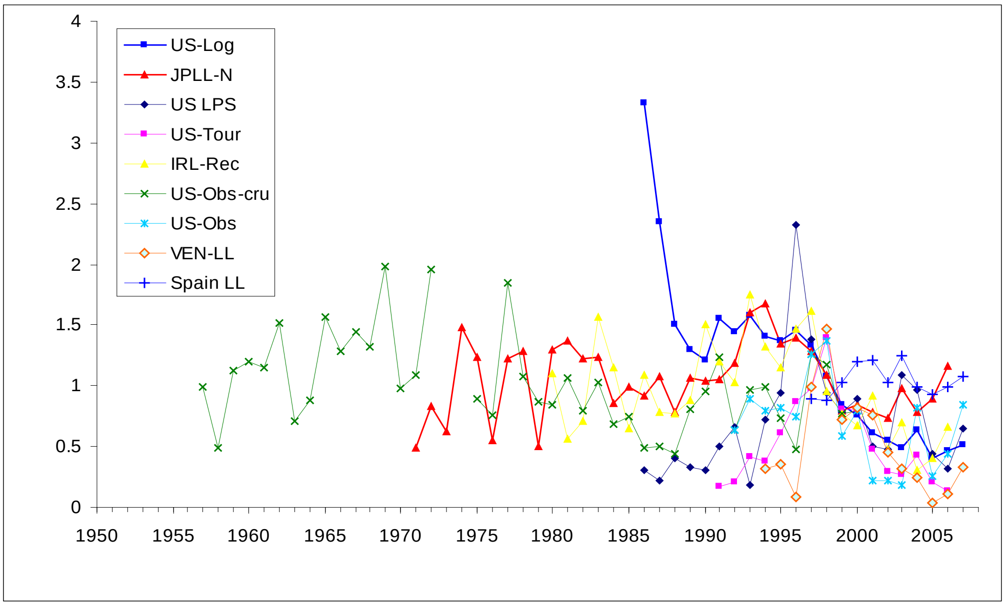


Figure 8.5. Blue shark in the North Atlantic. Cpue indices used in ICCAT assessment in 2008. Indices presented on a relative scale ((Source: ICCAT assessment 2008).

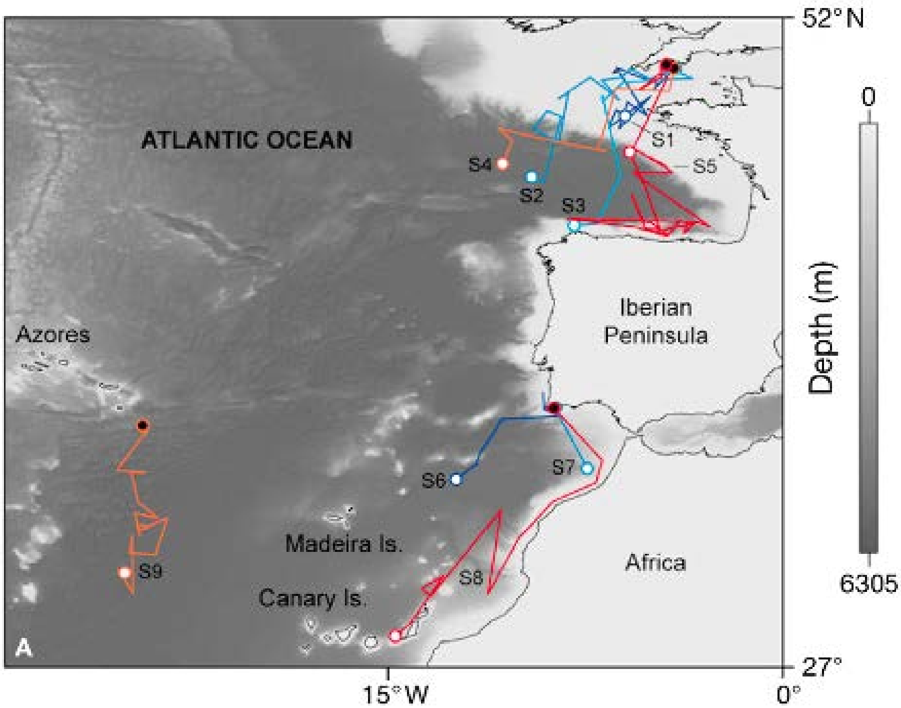
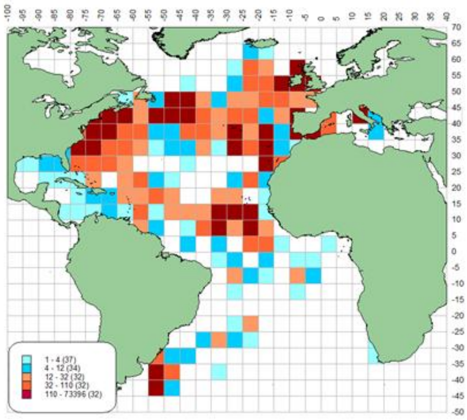
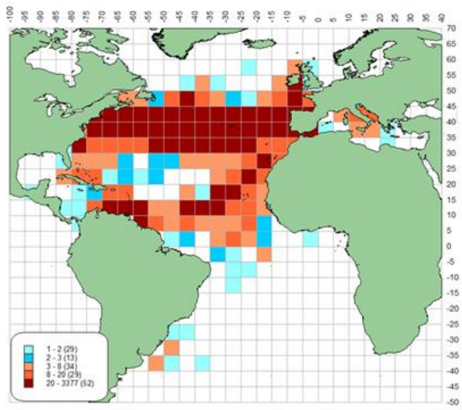


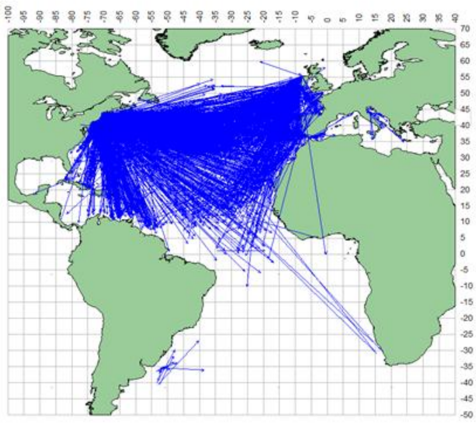
Figure 8.6. Blue shark (*Prionace glauca*) Pop-off satellite-tagged blue shark movement patterns. (A) General movements overlaid on bathymetry; black circles denote tagging locations and white circles the pop-up/capture locations. (B to J) Individual tracks overlaid on sea surface temperature maps; white circles are geolocated positions with date (Source: Queiroz *et al.*, 2010).



a)



b)



c)

Figure 8.7. Blue shark tagging maps, presented by ICCAT (2012), showing a) density of releases, b) density of recoveries, and c) straight line displacement between release and recovery locations.

9 Shortfin mako in the North Atlantic (North of 5°N)

9.1 Stock distribution

A single-stock of shortfin mako *Isurus oxyrinchus* is admitted to exist in the North Atlantic. This conclusion is based on genetic analyses and tagging studies (e.g. Kohler *et al.,* 2002). The International Commission for the Conservation of Atlantic Tunas (ICCAT) tagging database contains over 9200 releases and 1200 recaptures (13% return rate), with around 60% of sharks still at large within two years (Figure 9.1). Almost all releases and recaptures were concentrated in the northeast coast of the US. Genetic studies (Heist *et al*., 1996; Schrey and Heist, 2002) have found no evidence to suggest separate east and west populations in the Atlantic; however the North Atlantic population appears to be isolated from those of other oceans. Therefore, the ICES area is only part of the North Atlantic stock.

Based on the oceanography of equatorial waters, and that other large pelagic species (e.g. swordfish) have a southern stock boundary of 5°N, this is also suggested to be the southern limit of the North Atlantic shortfin mako stock. Hence, the stock area broadly equates with FAO Areas 27, 21, 31 and 34 (in part). The relationship between shortfin mako in the North Atlantic and Mediterranean Sea is unclear, and thus the North Atlantic assessment does not include data from the Mediterranean.

9.2 The fishery

9.2.1 History of the fishery

Shortfin mako is a highly migratory pelagic species that is caught frequently as a bycatch, mostly in pelagic longline fisheries that traditionally target tuna and billfish, and in other high seas tuna fisheries. Like porbeagle shark, it is a relatively high-value species (cf blue shark, which is of lower commercial value), and thus is normally retained (Campana *et al*., 2005). Recreational fisheries on both sides of the North Atlantic also catch this species, with relatively large quantities reported to ICCAT (178 t in 2011) arising from sport and rod and reel fisheries. In these fisheries, some fish are also released alive. They are also taken in Mediterranean fisheries (STECF, 2003). Tudela *et al*., 2005 observed 542 shortfin mako taken as a bycatch in 4140 km of driftnets set in the Alboran Sea between December 2002 and September 2003.

Traditionally catches of this species reported to ICES have been minimal (7 to ~1000 t over the last 20 years); therefore in this report data from ICCAT are presented in the catch table (Table 9.1). The main country reporting landings of this species to ICES in 2012 was Portugal (Azores), where catch was 24.0 t. There were low levels (<2 t) also reported by France and the United Kingdom.

9.2.2 The fishery in 2013

No new information and landings data should be regarded as preliminary.

9.2.3 Advice applicable

ICES does not provide advice for this stock.

Assessment of this stock is considered to be the responsibility of ICCAT. The last ICCAT assessment (2012) recommends, as a precautionary approach, that the fishing mortality of shortfin mako should not be increased until more reliable stock assessment results are available for both the north and south stocks. The next ICCAT assessment for shortfin mako is planned for 2019.

9.2.4 Management applicable

There are no measures regulating the catches of shortfin mako in the North Atlantic.

EC Regulation No. 1185/2003 prohibits the removal of fins and subsequent discarding of the body of this species. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

9.3 Catch data

9.3.1 Landings

Available landings data from ICCAT Task I catch data (total landings and discards by stock, flag and major gears) are presented in Table 9.1. These values may be considered underestimates, because of the inconsistent or generic reporting of shark catches by fleets. Catch series of "unclassified" shark groups represent about 20% on average (ranging from 11% to 32% between 1994 and 2002) of the total ICCAT Task I database of shark catches, and were not included here. At the most recent inter-sessional meeting of the Shark species group in Uruguay in March 2014 it was noted that "*The coverage of Task I and II data of sharks has improved in recent years, especially for the blue, shortfin mako and porbeagle sharks; however, coverage for other shark species was still fragmentary*" (ICCAT, 2014).

In 2011, 3821 t of shortfin mako catch were reported to ICCAT (Figure 9.2) in the North Atlantic (85% from longline fleets, 5% from sport fishing, with the remaining 10% coming from other fleets). Although this is a slight decrease on 2010 landings, catches have been relatively stable over the past five years. The main countries reporting catches in the North Atlantic are Spain, Portugal, USA and Japan (Figure 9.3), accounting for 44%, 27%, 11% and 2% of total reported landings in 2011 respectively. National landings reported to ICES for 2012 were 26 t for the northeast Atlantic, with the majority of this from Area X by Portugal (the Azores: 24 t), and smaller amounts were reported by France and the UK.

In the Mediterranean the total reported landings to ICCAT were just 2 t, from Spain and Cyprus. Since 1997, reported landings in the Mediterranean Sea have always been low (<9 t), with peak reported landings of 17 and 10 t in 2005 and 2006.

Previous ICCAT assessments of shortfin mako used two different estimates of landings for this stock, the tuna ratio (logged observations of shark catches relative to tuna catches) and the fin trade index (shark fin trade observations from the Asian market used to calculate caught shark weights based on catch effort data; Clarke *et al*., 2006; ICCAT 2005 and 2008). These figures were much higher than reported landings.

9.3.2 Discards

Although discard data are also given in Table 9.1, these are considered a large underestimate, with the USA longline being the only fleet to report a small amount of discards from 1987–1996 (1–38 t) and 2007–2010 (7–20 t). There are no reported discards from the Mediterranean Sea. Actual levels of shortfin mako bycatch is difficult to estimate, as available data are limited and documentation is incomplete. A report of the US pelagic longline observer programme stated that of the sharks caught alive, 23% were released alive and 61% retained (ICCAT 2005).

Shortfin mako is a high value species, and many European fisheries land shortfin mako gutted (usually with the head on). Although often landed for their meat in some fisheries, finning (the practice of removing the fins of a shark and returning the remainder of the carcass to the sea) may occur for this species as well, which may result in undocumented catches and mortality in some fleets. Finning regulations have now been introduced in various fisheries, but the extent of finning in IUU fisheries is unknown.

9.3.3 Quality of catch data

Catch data are considered underestimated, and the extent of finning in high seas fisheries is unclear. The historical use of generic shark categories is problematic, although many European countries have begun to report species-specific data in recent years. Despite some important recovery of historical catch series in recent years, ICCAT considers that the overall catch is underestimated, particularly before 2000.

There have been major discrepancies between reported catch in databases from ICCAT, FAO and EuroStat. The ICCAT Secretariat consolidated these three data sources into a unique database, and currently progress is being made on its validation and the associated data mining task (analysis of equivalent data series at various aggregation levels; Palma *et al*., 2012). FAO data have been revised in recent years, and historical catch figures have increased from those previously reported. The catches by FAO area (Figure 9.4) and the total North Atlantic catch are shown along with ICCAT catch totals (Figure 9.2) for comparison.

9.3.4 Discard survival

Several studies have reported the at-vessel mortality of shortfin mako to broadly range from about 30–50% in longline fisheries (summarised in Ellis *et al.*, 2014 WD). Discard survival in such fisheries can be influenced by several factors, including hook type, soak time and size of shark.

9.4 Commercial catch composition

No new information.

9.4.1 Conversion factors

Scientific estimates for the length–weight relationship for shortfin mako are summarized in Table 9.2, conversion factors for different length measurements in Table 9.3. Shortfin mako can be landed in various forms, whole, dressed, with or without heads, fins only, etc. It is therefore important that appropriate conversion factors for these landings are used. FAO (based on Norwegian data) use conversion factors for fresh, gutted, and gutted and headed sharks of 87% and 77%, respectively (Hareide *et al*., 2007).

9.5 Commercial catch and effort data

Cpue data were compiled at the ICCAT assessment meeting in 2004 (ICCAT, 2005) and in 2008, and these indicated a declining trend for this species in the North Atlantic for the years 1975–2004. In the 2012 North Atlantic shortfin mako assessment, six cpue series from longline fleets, from Portugal, Spain, USA, Uruguay, Japan and Brazil,were presented and additionally cpue series was provided from the US Recreational Fishery (Figure 9.5).

Indices of abundance from the US pelagic longline logbook programme (1986–2010) and the US pelagic longline observer programme (1992–2010) showed a concave shape, marked by an initial decline until the late 1990s, followed by an upward trend to 2010 (Cortés, 2012). The National Marine Fisheries Service Marine Recreational Fishery Statistics Survey (MRFSS) data (1981–2010) showed high variability, with high catches in the mid-1990s, followed by a decline, then a stable trend over the last ten years (Babcock, 2010). Standardized cpue from logbook data of the Japanese tuna longline fishery in the North Atlantic Ocean (1994–2010) ranged from 0.07 to 0.1 between 1994 and 2005, and then showed a continuous increasing trend (Semba *et al.*, 2012). In general, the available cpue series showed increasing or flat trends for the final years of each series (since the last stock assessment).

Although the relationship between Atlantic and Mediterranean shortfin mako is unclear, Tudela *et al*. (2005) estimated cpue based on driftnetters from Al Hoceima and Nador fishing in the Alboran Sea. Di Natale and Pelusi (2000) reported data from the Italian large pelagic longline fishery in the Tyrrhenian Sea (1998–1999), and calculated a mean cpue of 1.1 kg per 1000 hooks.

9.6 Fishery-independent surveys

No fishery-independent data from the NE Atlantic are available.

Fishery-independent data are available from the NW Atlantic (Simpfendorfer *et al.*, 2002; Hueter and Simpfendorfer, 2008). Babcock (2010) provided an index of abundance of shortfin mako catch rates from the US East Coast from the National Marine Fisheries Service Marine Recreational Fishery Statistics Survey (MRFSS). A total of 711 shortfin mako were reported between 1981 and 2010. There were 252 686 trips of which about 0.2% caught at least one shortfin mako.

The NMFS of the USA also conducts a Cooperative Shark Tagging Programme (CSTP), which collaborates with the Shark Tagging Programme of Inland Fisheries Ireland (formerly the Irish Central Fisheries Board) (Green, 2007 WD; NMFS, 2006).

At the 2014 ICCAT Inter-sessional meeting of the Shark species a Portuguese research project was presented on mitigation measures for shark bycatch in a pelagic longline fishery in the Atlantic Ocean. Within this research project, an electronic tagging experiment will be carried out. The aim of this experiment is to investigate post-release mortality of shortfin mako.

9.7 Life-history information

Only a few studies have compiled data on biological information on this species. Data available for the North Atlantic stock is given in Table 9.2 (Length–weight relationships), Tables 9.4 (growth parameters), and 9.5 (life-history parameters).

9.7.1 Habitat

Shortfin mako is a common, extremely active, offshore littoral and epipelagic species found in tropical and warm-temperate seas from the surface down to at least 500 m (Compagno, 2001). They are seldom found in waters below 16°C, and in the western North Atlantic they only move onto the continental shelf when surface temperatures exceed 17°C. Observations from South Africa indicate that this species prefers clear water (Compagno, 2001).

9.7.2 Nursery grounds

Published records of potential nursery grounds are lacking. Buencuerpo *et al.* (1998) suggests that the western basin of the Mediterranean is a nursery area. Stevens (2008) suggested that nursery areas would likely be situated close to the coast in highly productive areas, based on the majority of reports, with nursery grounds off West Africa in the North Atlantic.

9.7.3 Diet

Shortfin mako feed primarily on fish, with a wide variety of both pelagic and demersal species observed in stomach contents (Compagno, 2001).

Shortfin mako sampled off southwest Portugal had teleosts as the principal component of their diet (occurring in 87% of the stomachs and accounting for >90% of the contents by weight). Whilst crustaceans and cephalopods were also relatively important in their diet; other elasmobranchs were only present occasionally (Maia *et al.*, 2006).

In the NW Atlantic, bluefish (*Pomatomus saltatrix*) is the most important prey species and comprises about 78% of the diet (Stillwell and Kohler, 1982). These authors estimated that a 68 kg shortfin mako consume about 2 kg of prey per day, and could eat about 8–11 times its body weight per year. Stillwell (1990) subsequently suggested that shortfin mako may consume up to 15 times their weight per year.

The diets of shortfin mako in South African waters indicated that elasmobranchs could be important prey, and marine mammals can also make up a small proportion of the diet (Compagno, 2001).

9.7.4 Life-history parameters

The life-history parameters of the shortfin mako from studies to-date are summarized in Table 9.5. In the report of the most recent inter-sessional meeting of the ICCAT Shark species group there is an update of life-history parameters for shortfin mako. ICCAT has the intention to review the parameters in order to see if they can be used in the stock assessment models (see ICCAT, 2014).

9.8 Exploratory assessment models

9.8.1 Previous assessments

In 2004, ICCAT held an assessment meeting to assess stock status of shortfin mako (ICCAT, 2005). Overall data quantity and quality was considered limited and results were considered provisional. Based on cpue data, it was likely that the North Atlantic stock of shortfin mako has been depleted to about 50% of previous levels. Stock capacity was likely be below MSY and a high to full level of exploitation for this stock was inferred from available data. It was considered that further studies were needed and in particularly the underlying assumptions of the model needed to be optimized before stronger conclusions can be drawn (ICCAT 2005, 2006).

The ICCAT assessment for North Atlantic shortfin mako in 2008, using a Bayesian surplus production (BSP) model, an age-structured production model (ASPM) and a catch-free age structured production model showed that, for most model outcomes, stock depletion was about 50% of biomass estimated for the 1950s. Some model outcomes indicated that the stock biomass was near or below the biomass that would support MSY with current harvest levels above F_{MSY}, whereas others estimated considerably lower levels of depletion and no overfishing (ICCAT, 2011).

9.9 Stock assessment

Assessment of the status of the North Atlantic shortfin mako stock was conducted by ICCAT in 2012 with updated time-series of relative abundance indices and annual catches. Coverage of Task I catch data and number of cpue series had increased since the last stock assessment in 2008, with Task I data being available for most major longline fleets. The 2012 assessment used the Bayesian Surplus Production Model (BSP) software that was used in the 2008 assessment. For the North Atlantic the cpue indices were the US longline logbook series, Japanese longline, Portuguese longline and Spanish longline (Figure 9.5). A number of sensitivity analyses and scenarios were conducted to evaluate the impact of the input data (such as catch reporting prior to 1997 being not well estimated) and model assumptions on model results (ICCAT, 2012).

Additionally, as in the 2008 assessment, a catch-free model was applied to the North Atlantic stock. The Catch-Free Age-Structured Production Model (CFASPM) derives all the fishery information from cpue data rather than a combination of catches and cpue (ICCAT, 2012). A simple length-based method was also employed to check assumptions about selectivity made and for choosing starting or for fixing values of CFASPM model.

The results from the 16 BSP model runs gave very consistent results, despite initial inconsistencies between the catch and cpue data resulting in the model not fitting to the cpue trend very well. All found that the median of the current stock abundance was above B_{MSY} and the median F was smaller than F_{MSY} (except for the run that estimated catches from effort before 1997) (ICCAT, 2012).

The CFASPM model also considered a number of scenarios and sensitivities explored, and as in the BSP model, for all runs, the estimated relative biomass fit the cpue series poorly. The base run estimated a relative depletion of 71% of virgin conditions, with current fishing mortality estimated as 41% of what would be required to drive the stock to MSY (F/F_{MSY}=0.41) and current SSB was estimated at 2.04 times that producing MSY (SSB/SSB_{MSY}=2.04) (ICCAT, 2012). Across all scenarios considered, the estimates of SSB/SSB_{MSY} ranged from 1.63 to 2.04, the estimates of F/F_{MSY} ranged from 0.16 to 0.62 and the biomass depletion with respect to virgin conditions ranged from 0.55 to 0.71 (ICCAT, 2012).

The results indicated in general that the status of the stock is healthy and the probability of overfishing is low. However, they also show inconsistencies between estimated biomass trajectories and input cpue trends, producing wide confidence intervals in estimated trajectories and other parameters (ICCAT, 2012). Taking into consideration results from the modelling approaches used in the assessment, the associated uncertainty, and the relatively low productivity of shortfin mako, the ICCAT shark sub-group recommended as a precautionary approach that the fishing mortality of shortfin mako should not be increased until more reliable stock assessment results are available (ICCAT, 2012).

The next ICCAT assessment of shortfin mako is planned in 2019.

9.10 Quality of assessment

Assessments undertaken by ICCAT are conditional on several assumptions, including the estimates of historical shark catch, the relationship between catch rates and abundance, the initial state of the stock, as well as uncertainty in some life-history parameters.

In the 2012 assessment, the cpue indices were fairly consistent in showing a decline during the 1990s followed by an increase after 2000 (Figure 9.5), however this trend was not consistent with the catches, which were decreasing in the 1990s and stable after 2000 (ICCAT, 2012). Because of this inconsistency between the catch and cpue data the BSP model was not able to fit the trend in the cpue data very well, and the estimated trends in biomass relative to B_{MSY} and fishing mortality rate relative to F_{MSY} were very uncertain, with very broad 80% credibility intervals (ICCAT, 2012). The CFASPM model also found that all runs the estimated relative biomass fit the cpue series poorly which necessitates the further improvement of the biological input parameters, and also the increased investigation and understanding of the cpue series (ICCAT, 2012).

9.11 Reference points

ICCAT uses F/F_{MSY} and B/B_{MSY} as reference points for stock status of this stock. These reference points are relative metrics rather than absolute values. The absolute values of B_{MSY} and F_{MSY} depend on model assumptions and results and are not presented by ICCAT for advisory purposes.

9.12 Conservation considerations

Shortfin mako was listed as 'Near Threatened' until 2008 when it was uplisted to 'Vulnerable' both globally and regionally in the North Atlantic in the IUCN Red List (Cailliet *et al.*, 2009).

In 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Atlantic population of the shortfin mako as threatened (DFO, 2006).

9.13 Management considerations

Catch data of pelagic sharks are considered unreliable, as many sharks are not reported on a species-specific basis, and some fisheries may have only landed fins. As already stated, the landings data are unreliable and particularly pre-2000 should be considered an underestimate. Reporting procedures must be strengthened so that all landings are reported, and that landings are reported to species level, rather than generic "*nei*" categories. The consolidation of three databases (ICCAT, FAO and EUROSTAT) by the ICCAT Secretariat should also strengthen the reliability of catch data in the future.

The 2011 Report of the Standing Committee on Research and Statistics (SCRS) stated that, "*Considering the quantitative and qualitative limitations of the information available to the Committee, the results presented in 2008, as those of the 2004 assessment (Anon. 2005), are not conclusive*" (ICCAT, 2011). Furthermore, "*The Commission should consider taking effective measures to reduce the fishing mortality of these stocks. These measures may include minimum or maximum size limits for landing (for protection of juveniles or the breeding stock, respectively); and any other technical mitigation measures such as gear modifications, time-area restrictions, or others, as appropriate*".

In 1995 the Fisheries Management Plan for pelagic sharks in Atlantic Canada established a catch limit of 100 t annually for the Canadian pelagic longline fishery as well as advising release of live catch.

9.14 References

Anon. 2005. Report of the 2004 Inter-sessional Meeting of the ICCAT Sub-Committee on By-Catches: Shark Stock Assessment (Tokyo, Japan, June 14 to 18, 2004). Collect. Vol. Sci. Pap. ICCAT, 58(3): 799–890.

Babcock, E., A. 2010. Updated index of abundance for shortfin mako sharks from the U.S. marine recreational fisheries statistics survey. *ICCAT SCRS 2012/077*.

Bishop, S. D. H., Francis, M. P., Duffy, C., Montgomery, J. C. 2006. Age, growth, maturity, longevity, and natural mortality of the shortfin mako shark (*Isurus oxyrinchus*) in New Zealand waters. *Marine and Freshwater Research* 57: 143–154.

Buencuerpo, V., Ríos, S., and Morón, J. 1998. Pelagic sharks associated with the swordfish, *Xiphias gladius*, fishery in the eastern North Atlantic Ocean and the Strait of Gibraltar. *Fishery Bulletin* 96: 667–685.

Cailliet, G. M., Cavanagh, R. D., Kulka, D. W., Stevens, J. D., Soldo, A., Clo, S., Macias, D., Baum, J., Kohin, S., Duarte, A., Holtzhausen, J. A., Acuña, E., Amorim, A. and Domingo, A. 2009. *Isurus oxyrinchus (Atlantic subpopulation)*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.1.

Cailliet, G. M., L. K. Martin, J. T. Harvey, D. Kusher, and B. A. Weldon. 1983. Preliminary studies on the age and growth of the blue shark, *Prionace glauca*, common thresher, *Alopias vulpinus*, and shortfin mako, *Isurus oxyrinchus*, from California waters. *In* Proceedings of the international workshop on age determination of oceanic pelagic fish: tunas, billfish, and sharks (E. D. Prince and L. M. Pulos, eds.), p. 179–188. US Dep. Commer., NOAA Tech. Rep. NMFS 8.

Campana, S. E., Marks, L., and Joyce, W. 2004. Biology, fishery and stock status of shortfin mako sharks (*Isurus oxyrinchus*) in Atlantic Canadian waters. Canadian Stock Assessment, Research Document 2004/094, Ottawa.

Campana, S. E., Marks, L., and Joyce, W. 2005. The biology and fishery of shortfin mako sharks (*Isurus oxyrinchus*) in Atlantic Canadian waters. *Fisheries Research* 73: 341–352.

Casey, J. G., and Kohler, N. E. 1992. Tagging studies on the shortfin mako shark (*Isurus oxyrinchus*) in the western North Atlantic. *Australian Journal of Marine and Freshwater Research*, 43: 45–60.

Castro, J. I., Woodley, C. M., and Brudek, R. L. 1999. A Preliminary Evaluation of the Status of Shark Species. FAO Fisheries Technical Paper 380, Rome.

Clarke S. C., McAllister M. K., Milner-Gulland E. J., Kirkwood G. P., Michielsens C. G. J., Agnew D.J., Pikitch E.K., Nakano H. and Shivji M. S. 2006. Global estimates of shark catches using trade records from commercial markets. *Ecology Letters*, 9: 1115–1126.

Cliff, G., Dudley, S. F. J. and Davis, B. 1990. Sharks caught in the protective gillnets off Natal, South Africa. 3. The shortfin mako shark *Isurus oxyrinchus* (Rafinesque). *South African Journal of Marine Science*, 9:115–126.

Compagno, L. J. V. 2001. An annotated and illustrated catalogue of shark species known to date. Volume 2 Bullhead, mackerel and carpet sharks (*Heterodontiformes*, *Lamniformes* and *Orectolobiformes*). *FAO Species Catalogue for Fishery Purposes*, 1(2): 109 pp.

Cortés, E. 1999. Standardized diet compositions and trophic levels of sharks. *ICES Journal of Marine Science*, 56: 707–717.

Cortés, E. 2000. Potential rates of increase and rates of increase per generation for three species of pelagic sharks from the Atlantic Ocean. Col. Vol. Sci. Pap. ICCAT, 51(6): 1822–1828.

Cortés, E. 2012. Standardised catch rates of mako sharks from the US pelagic longline logbook and observer programs using a generalized linear mixed model. *ICCAT SCRS 2012/070*.

DFO. 2006. Recovery Potential Assessment Report of Shortfin Mako Sharks in Atlantic Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/051.

Di Natale A. and Pelusi P. 2000. Effetti della pesca col palangaro derivante sui grandi pelagici e sulle specie accessorie nel Mediterraneo Centrale. Rapporto al Ministero per le Politiche Agricole e Forestali, DGPA, Roma-IV Piano Triennale.

Ellis, J.R.., McCully, S.R. and Poisson, F. 2014. A global review of elasmobranch discard survival studies and implications in relation to the EU 'discard ban'. Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 2014, 48 pp.Francis, M. P., and Duffy, C. 2005. Length at maturity in three pelagic sharks (*Lamna nasus, Isurus oxyrinchus,* and *Prionace glauca*) from New Zealand. *Fishery Bulletin* 103: 489–500.

García-Cortés, B. and Mejuto, J. 2002. Size–weight relationships of the swordfish (*Xiphias gladius*) and several pelagic shark species caught in the Spanish surface longline fishery in the Atlantic, Indian and Pacific Oceans. Coll. Vol. Sci. Pap. ICCAT, 54 (4): 1132–1149.

Green, P. 2007. The Central Fisheries Board Shark Tagging Programme 1970–2006. Working document to WGEF.

Hareide, N. R., Carlson, J., Clarke, M., Clarke, S., Ellis, J., Fordham, S., Fowler, S., Pinho, M., Raymakers, C., Serena, F., Seret, B. and Polti, S. 2007. European Shark Fisheries: a preliminary investigation into fisheries, conversion factors, trade products, markets and management measures. European Elasmobranch Association EEA 2007, 71 pp.

Heist, E. J., Musick, J. A., and Graves, J. E. 1996. Genetic population structure of the shortfin mako (*Isurus oxyrinchus*) inferred from restriction fragment length polymorphism analysis of mitochondrial DNA. *Canadian Journal of Fisheries and Aquatic Sciences*, 53:583–588.

Hueter, R. E. and. Simpfendorfer, C. 2008. Case Study: Trends in Blue Shark Abundance in the Western North Atlantic as Determined by a Fishery-Independent Survey. In: Sharks of the Open Ocean; M. D. Chami, E. K. Pikitch and E. Babcock (eds.) 236–241.

ICCAT. 2005. Report of the 2004 Intersessional Meeting of the ICCAT Subcommittee on Bycatches: shark stock assessment. Coll. Vol. Sci. Pap. ICCAT, 58(3): 799–890.

ICCAT. 2006. Chapter 8.12 SHK-Sharks Report of the Standing Committee on Research and Statistics (SCRS) Madrid, Spain, October 2–6, 2006. ICCAT. PLE-014/2006, 106–113.

ICCAT. 2008. Report of the 2008 shark stock assessments meeting. Madrid, Spain, 1–5 September, 2008. SCRS/2008/017–SHK Assessment, 89 pp.

ICCAT. 2011. Chapter 8.12 SHK-Sharks Report of the Standing Committee on Research and Statistics (SCRS) Madrid, Spain, October 3–7, 2011. ICCAT. 2011-016, 167–180.

ICCAT. 2012. Report of the 2012 shortfin mako stock assessment and ecological risk assessment meeting. Olhão, Portugal. June 11 to 18, 2012.

ICCAT. 2014. Inter-sessional meeting of the sharks species group. Piriapolis, Uruguay, March 10–14 2014; 72 pp. (www.iccat.int/Documents/Meetings/Docs/2014_SHK_INTERSESS_REP.pdf)

Kohler, N. E., Casey, J.G. and Turner, P.A. 1995. Length–weight relationships for 13 species of sharks from the western North Atlantic. *Fishery Bulletin*, 93: 412–418.

Kohler, N. E., Turner, P. A., Hoey, J. J., Natanson, L. J., and Briggs, R. 2002. Tag and recapture data for three pelagic shark species: blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), and porbeagle (*Lamna nasus*) in the North Atlantic Ocean. Col. Vol. Sci. Pap. ICCAT, 54 (4): 1231–1260.

Maia, A., Queiroz, N., Cabral, H. N., Santos, A. M. and Correia, J. P. 2007. Reproductive biology and population dynamics of the shortfin mako, *Isurus oxyrinchus* Rafinesque, 1810, off the southwest Portuguese coast, eastern North Atlantic. *Journal of Applied Ichthyology* 23(3): 246–251.

Maia, A., Queiroz, N., Correia, J. P. and Cabral, H. 2006. Food habits of the shortfin mako, *Isurus oxyrinchus*, off the southwest coast of Portugal. *Environmental Biology of Fishes*, 77:157–167.

Manday, D. G. 1975. Las pesquerias pelagico-oceanicas de corto radio de accíon en la regíon noroccidental de Cuba. Ser. Oceanol. Acad. Cienc. Cuba 31:1–26.

Mejuto, J. and Garcés, A. G. 1984. Shortfin mako, *Isurus oxyrinchus*, and porbeagle, *Lamna nasus*, associated with longline swordfish fishery in NW and N Spain. ICES CM 1984/G:72 Demersal Fish Committee.

Mollet, H. F., Cliff, G., Pratt, H. L., and Stevens, J. D. 2000. Reproductive biology of the female shortfin mako, *Isurus oxyrinchus*, Rafinesque, 1810, with comments on the embryonic development of lamnoids. *Fishery Bulletin* 98: 299–318.

Natanson, L., Kohler, N.E., Ardizzone, D., Cailliet, G. M., Wintner, S. and Mollet, H. 2006. Validated age and growth estimates for the shortfin mako, *Isurus oxyrinchus*, in the North Atlantic Ocean. *Environmental Biology of Fishes*, 77: 367–383.

NMFS. 2006. Final Consolidated Atlantic Highly Migratory Species Fishery Management Plan. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Sustainable Fisheries, Highly Migratory Species Management Division, Silver Spring, MD. Public Document. pp. 1600.

Palma, C., Ortiz, M., de Bruyn, P., Kell L. and Pallares, P. 2012. Building a consolidated database to crosscheck ICCAT Task-I nominal catch, against EUROSTAT and FAO equivalent statistics. *ICCAT SCRS 2012/078*.

Pratt, H. L. and Casey, J. G. 1983. Age and growth of the shortfin mako, *Isurus oxyrinchus*, using four methods. *Canadian Journal of Fisheries and Aquatic Sciences*, 40: 1944–1957.

Schrey, A., and Heist, E. J. 2002. Microsatellite markers for the shortfin mako and cross-species amplification in Lamniformes. *Conservation Genetics*, 3: 459–461.

Semba, Y., Yokawa, K. and Hiraoka, Y. 2012. Standardized CPUE of shortfin mako (*Isurus oxyrinchus*) caught by the Japanese tuna longline fishery in the Atlantic Ocean. *ICCAT SCRS 2012/074*.

Simpfendorfer, C. A., Hueter, R. E., Bergman, U. and Connett, S. M. H. 2002. Results of a fishery-independent survey for pelagic sharks in the western North Atlantic, 1977–1994. *Fisheries Research*, 55: 175–192.

Smith, S. E., Au, D. W., and Show, C. 1998. Intrinsic rebound potentials of 26 species of Pacific sharks. *Marine and Freshwater Research*, 49: 663–78.

STECF. 2003. Report of the Subgroup on Resource Status (SGRST) of the Scientific, Technical and Economic Committee for Fisheries (STECF): Elasmobranch Fisheries. Brussels, 22–25 July 2003. Commission Staff Working Paper SEC (2003) 1427.

Stevens, J. D. 1983. Observations on reproduction in the shortfin mako *Isurus oxyrinchus*. *Copeia* 1983:126–130.

Stevens, J. D. 2008. The biology and ecology of the shortfin mako shark, *Isurus oxyrinchus*. In *'Sharks of the Open Ocean: Biology, Fisheries and Conservation'* (M.D. Camhi, E.K. Pikitch and E.A. Babcock, Eds.). Blackwell Publishing, Oxford, UK, 87–94.

Stevens, J. D., and Wayte, S. E. 1999. A review of Australia's pelagic shark resources. FRDC Proj. Rep. 98/107, 64 p.

Stillwell, C. E. 1990. The ravenous mako. In: Discovering sharks. A volume honouring the work of Stewart Springer (S.H. Gruber, Ed.). Underw. Nat., Bull. American Litter. Soc., 19–20(4/1): 77–78.

Stillwell, C. E. and Kohler, N.E. 1982. Food, feeding habits, and estimates of daily ration of the shortfin mako (*Isurus oxyrinchus*) in the Northwest Atlantic. *Canadian Journal of Fisheries and Aquatic Sciences*, 39: 407–414.

Strasburg, D. W. 1958. Distribution, abundance, and habits of pelagic sharks in the Central Pacific Ocean. *Fisheries Bulletin* 138: 335–361.

Tudela, S., Kai Kai, A., Maynou, F., El Andalossi, M., and Guglielmi, P. 2005. Driftnet fishing and biodiversity conservation: the case study of the large-scale Moroccan driftnet fleet operating in the Alboran Sea (SW Mediterranean). *Biological Conservation* 121: 65–78.

Wood, A. D., Collie, J. S. and Kohler, N. E. 2007, Estimating survival of the shortfin mako *Isurus oxyrinchus* (Rafinesque) in the north-west Atlantic from tag–recapture data. Journal of Fish Biology, 71: 1679–1695. doi: 10.1111/j.1095-8649.2007.01634.x.

Table 9.1. Shortfin mako in the North Atlantic (ATN) and Mediterranean (MED). Available landings (t) of shortfin mako by country from ICCAT Task I catch data. These data are considered underestimates, especially prior to 2000. Landings of <0.5 t are shown as +. Discard data marked * were not updated in 2013.

			1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total Landings	ATN		797	953	2193	1526	3109	2019	3533	3798	2738	2546	2639	3377	3792	5174	3472	3370	4075	3559	4109	4181	3821	4877
	MED								6	8	5	4	7	2	2	2	17	10	2	1	1	2	2	na
Landings	ATN	Longline	584	699	1523	1195	1663	1771	3369	3648	2645	2254	2424	3129	3792	4755	3172	3105	3907	3375	3571	3554	3257	
		Sport (inc. rod and reel)	210	250	667	318	1422	232	164	150	71	292	215	248	0	333	282	257	159	157	163	168	178	
		Other gear codes	3	4	3	13	25	15	12	18	21	22	12	18	103	86	18	7	9	26	375	459	386	
	MED	Longline							6	8	5	4	7	2	2	2	17	10	2	1	1	2	2	
Landings	ATN	Belize																			23	28	69	
		Brasil										0												
		Canada					111	67	110	69	70	78	69	78	73	80	91	71	72	43	53	41	37	
		China P.R.										0							81	16	19	29	18	
		Chinese Taipei													84	57	19	30	25	23	11	13	15	
		EU.España							2416	2199	2051	1566	1684	2047	2068	3404	1751	1918	1816	1895	2216	2091	1667	
		EU.France																			15	2	0	
		EU.Portugal	314	220	796	649	657	691	354	307	327	318	378	415	1249	473	1109	951	1540	1033	1169	1432	1045	
		EU.United Kingdom									2	3	2	1	1	1	0	0	0	1	15	0	0	
		FR.St Pierre et Miquelon																	1	2		4	0	
		Japan	157	318	425	214	592	790	258	892	120	138	105	438	267	572			82	131	98	116	85	
		Korea Rep.																					27	
		Maroc																					420	
		Mexico					10					10	16		10	6	9	5	8	6	7	8	8	
		Panama									1	0						0	49	33	39			
		Philippines									1									1				
		Senegal																	8	17	21	0	1	
		St. Vincent and Grenadines					0			3														

			1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
		Sta. Lucia																		0		0		
		Trinidad and Tobago									1		1	2	3	1	2	1	1	1	1	1		
		U.S.A.	326	415	972	663	1739	470	407	347	159	454	395	415	142	521	469	386	381	354	385	394	408	
		UK.Bermuda							1	2	2							0	0	0	0	0	0	
		Venezuela														58	20	6	11	2	35	22	20	
	MED	EU.Cyprus																1	1	0	0	0	1	
		EU.España							6	7	5	3	2	2	2	2	2	4	1	0	0	1	2	
		EU.France																			0			
		EU.Portugal								1		1	5		0		15	5				0		
		Japan																		0				
Discards*	ATN	Longline	11	38	24	21	29	1											7	9	20	9		
		Other surf.									2								0	1	0	0		
Discards*	ATN	Mexico					1												0					
		U.S.A.	11	38	24	21	28	1											7	10	20	9		
		UK.Bermuda									2													
Total Landings and Discards	ATN		808	991	2217	1547	3138	2020	3533	3798	2740	2546	2639	3377	3792	5174	3472	3370	4082	3569	4129	4190	3821	4877
	MED								6	8	5	4	7	2	2	2	17	10	2	1	1	2	2	na

Table 9.2. Shortfin mako in the North Atlantic. Length–weight relationships for *Isurus oxyrinchus* from different populations.

Stock	L (cm) W (kg) relationship	Sex	n	Length range (cm)	Source
Central Pacific	log W (lb) = –4.608 + 2.925 x log LT				Strasburg, 1958
Cuba	W = 1.193 x 10–6 x LT 3.46	C	23	160–260 (LT)	Manday, 1975
Australia	W = 4.832 x 10–6 x LT 3.10	C	80	58–343 (LT)	Stevens, 1983
South Africa	W = 1.47 x 10–5 x LPC 2.98	C	143	84–260 (LPC)	Cliff *et al.*, 1990
NW Atlantic	WR = (5.2432 x 10–6) LF 3.1407	C	2081	65–338 (LF)	Kohler *et al.*, 1995.
NW Atlantic	W = 7.2999 x LT (m) 3.224	C	63	2.0–3.7 m (LT)	Mollet *et al.*, 2000
southern hemisphere	W = 6.824 x LT (m) 3.137	C	64	2.0–3.4 m (LT)	Mollet *et al.*, 2000
NE Atlantic	WD = (2.80834 x 10–6) LF 3.20182	C	17	70–175 (LF)	García-Cortés and Mejuto, 2002
Tropical east Atlantic	WD = (1.22182 x 10–5) LF 2.89535	C	166	95–250	García-Cortés and Mejuto, 2002
Tropical central Atlantic	WD = (2.52098 x 10–5) LF 2.76078	C	161	120–185	García-Cortés and Mejuto, 2002
Southwest Atlantic	WD = (3.1142 x 10–5) LF 2.7243	C	97	95–240	García-Cortés and Mejuto, 2002

Lengths in cm, and weights in kg unless specified in equation. W_R = round weight; W_D = dressed weight.

Table 9.3. Shortfin mako in the North Atlantic. Length–length relationships for male, female and both sexes combined from the NE Atlantic and Straits of Gibraltar (Source: Buencuerpo *et al.*, 1998). L_S = standard length; L_F = fork length; L_T = total length; L_{UC} = upper caudal lobe length.

Females	Males	Combined
LF = 1.086 LS + 1.630 (n=852)	LF = 1.086 LS + 1.409 (n=911)	LF = 1.086 LS + 1.515 (n=1763)
LT = 0.817 L S + 0.400 (n=852)	LT = 1.209 LS + 0.435 (n=681)	LT = 1.207 LS + 0.971 (n=1533)
LUC = 3.693 L S + 13.094 (n=507)	LUC = 3.795 L S + 10.452 (n=477)	LUC = 3.758 LS + 11.640 (n=1054)
LT = 1.106 LF + 0.052 (n=853)	LT = 1.111 LF – 0.870 (n=911)	LT = 1.108 LF – 0.480 (n=1746)

Table 9.4. Shortfin mako in the North Atlantic. Growth parameters from two studies. Formation of two vertebral bands annually assumed and von Bertalanffy growth function used t_0 in years.

Area	L∞	k	T_0	Sex	Study
Northwest Atlantic	302	0.266	–1	Male	Pratt and Casey, 1983
Northwest Atlantic	345	0.203	–1	Female	Pratt and Casey, 1983*
Atlantic	373.4	–0.203	1.0	Female	Cortés, 2000*
Northwest Atlantic	253	0.125	71.6	Male	Natanson *et al*., 2006**
Northwest Atlantic	366	0.087	88.4	Female	Natanson *et al*., 2006**

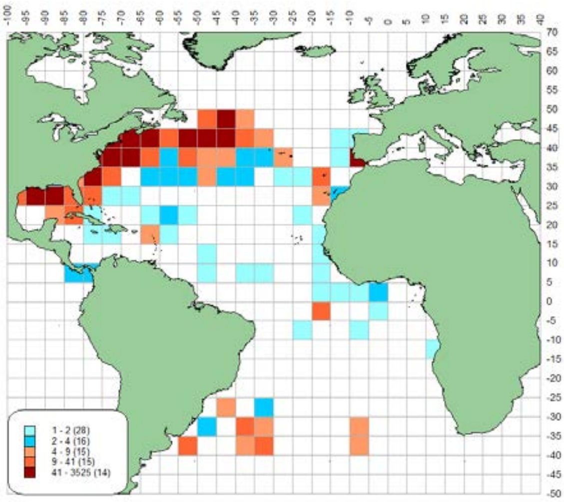
****Gompertz growth function used, t_0 in cm. L∞ in cm (Fork Length), k in years–1.**

Table 9.5. Shortfin mako in the North Atlantic. Life-history information available from the scientific literature.

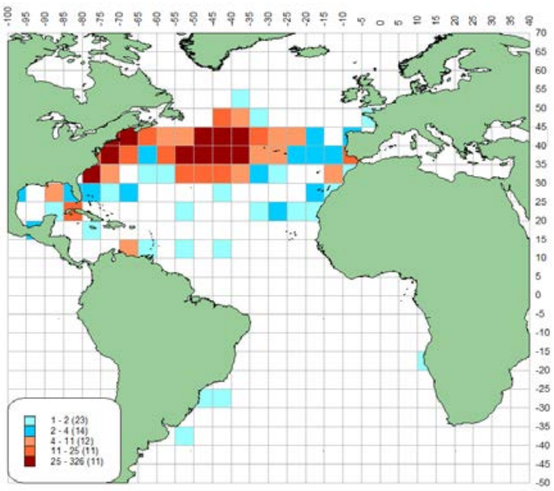
Parameter	Values	Sample Size	Area	Reference
Reproduction	Ovoviviparous with oophagy			Campana *et al*., 2004
Litter size	4–25	35	Worldwide	Mollet *et al*., 2000
	12–20			Castro *et al*., 1999
Size at birth (L_T)	70 cm	188+	Worldwide	Mollet *et al*., 2000
Sex ratio (males: females)	1:1	2188	NW Atlantic	Casey and Kohler, 1992
	1:0.4		NE Atlantic (Spain, Azores)	Mejuto and Garces, 1984
	1:0.9		NE, N central Atlantic and Med	Buencuerpo *et al*., 1998
	1.0:1.4	17	NE Atlantic	García-Cortés and Mejuto, 2002
Gestation period	15–18	26	Worldwide	Mollet *et al*., 2000
Male age-at-first maturity (years)*	2.5			Pratt and Casey, 1983
	9			Cailliet *et al*., 1983
Male age-at-median maturity (years)	7	145	New Zealand	Bishop *et al*., 2006
Female age-at-first maturity (years)*	5			Pratt and Casey, 1983
Female age maturity (years)	19	111	New Zealand	Bishop *et al*., 2006
	7			Pratt and Casey, 1983
Male length-at-first maturity (T_L)	195 cm			Stevens, 1983
Male length-at-maturity (T_L)	197–202 cm (median)	215	New Zealand	Francis and Duffy, 2005

Parameter	Values	Sample Size	Area	Reference
	180 cm (L_F)		NE Atlantic (Portugal)	Maia *et al*., 2007
	200–220		Worldwide	Pratt and Casey, 1983; Mollet *et al*., 2000
Female length-at-first maturity (T_L)	265–280 cm			Cliff *et al*., 1990
Female length-at-maturity (T_L)	301–312 (median)	88	New Zealand	Francis and Duffy, 2005
	270–300 cm (L_T)		Worldwide	Pratt and Casey, 1983; Mollet *et al*., 2000
Age-at-recruitment (year)	0–1			Stevens and Wayte, 1999
Male maximum length (T_L)	296 cm			Compagno, 2001
Female maximum length (T_L)	396 cm 408 cm (estimated)			Compagno, 2001
Lifespan (years)	11.5–17 (oldest aged)			Pratt and Casey, 1983
	45 (estimated longevity)			Cailliet *et al*., 1983
Natural mortality (M)	0.16		Pacific	Smith *et al*., 1998
Annual survival estimate	0.79 (95% C.I. 0.71–0.87)			Wood *et al*. 2007
Growth parameters	61.1 cm year–1 first year 40.6 cm year–1 second year 5.0 cm month–1 in summer 2.1 cm month–1 in winter	262	NE Atlantic (Portugal)	Maia *et al*., 2007
Maximum age (estimated from von Bertalanffy growth eqn.)	28			Smith *et al*., 1998
Productivity (R2m) estimate: intrinsic rebound	0.051 (assuming no fecundity increase)		Pacific	Smith *et al*., 1998
Potential rate of increase per year	8.5%		Atlantic	Cortés, 2000

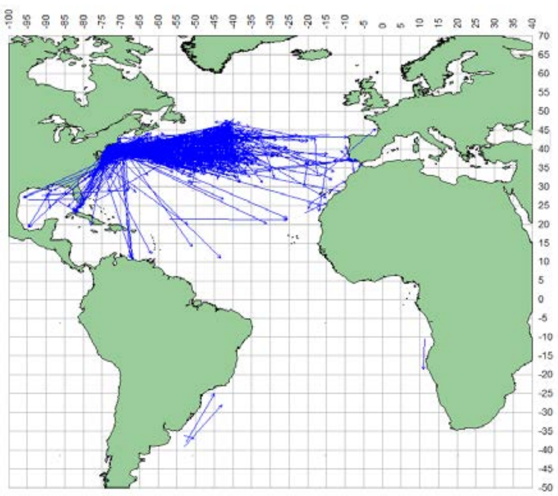
Parameter	Values	Sample Size	Area	Reference
Population doubling time T_D (years)	13.6 (assuming no fecundity increase)		Pacific	Smith *et al*., 1998
Generation time (years)	~ 9		Atlantic	Cortés, 2000
Trophic level	4.3	7		Cortés, 1999



a)



b)



c)

Figure 9.1. Shortfin mako in the North Atlantic Tag and Release distributions for Shortfin Mako in the Atlantic Ocean (a = Density of releases, b = Density of recoveries, c = Straight displacement between release and recovery locations.). Recaptures were 13.4% (Source: ICCAT, 2014).

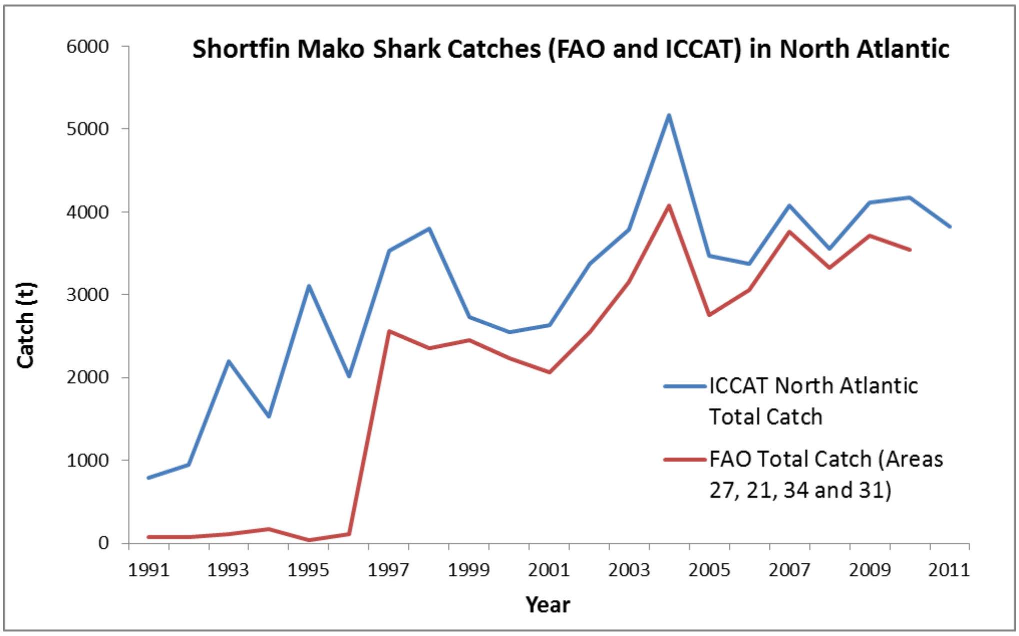


Figure 9.2. Shortfin mako in the North Atlantic Total catches (t) of shortfin mako in the North Atlantic reported to FAO and ICCAT.

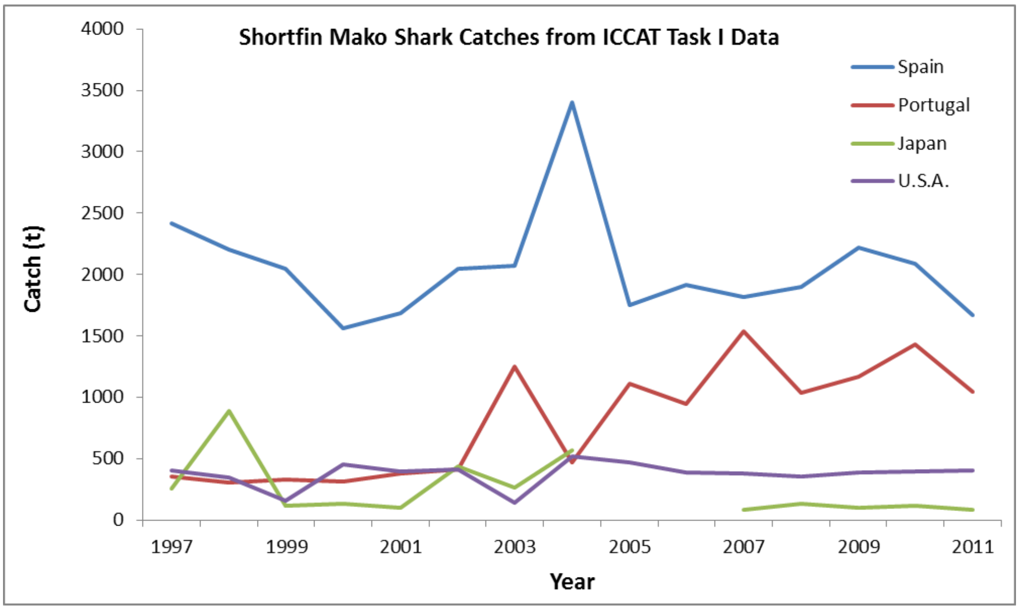


Figure 9.3. Shortfin mako in the North Atlantic Total catches (t) made by the major countries (accounting for 84% of total landings) landing shortfin mako in the North Atlantic reported to ICCAT.

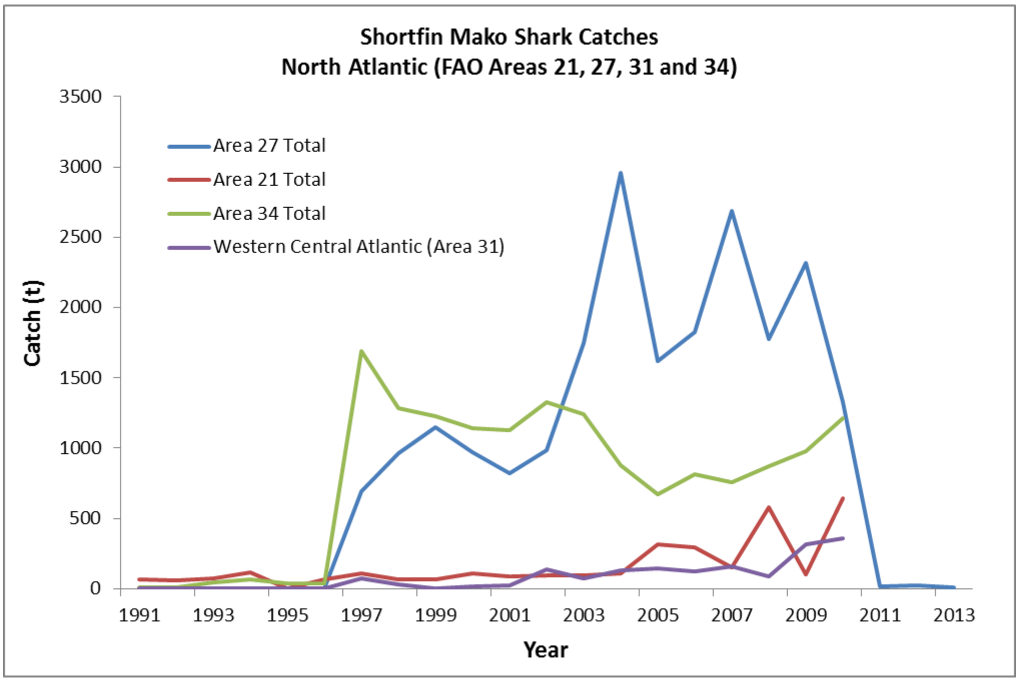


Figure 9.4. Shortfin mako in the North Atlantic Total catches (t) of shortfin mako reported to FAO by major fishing area.

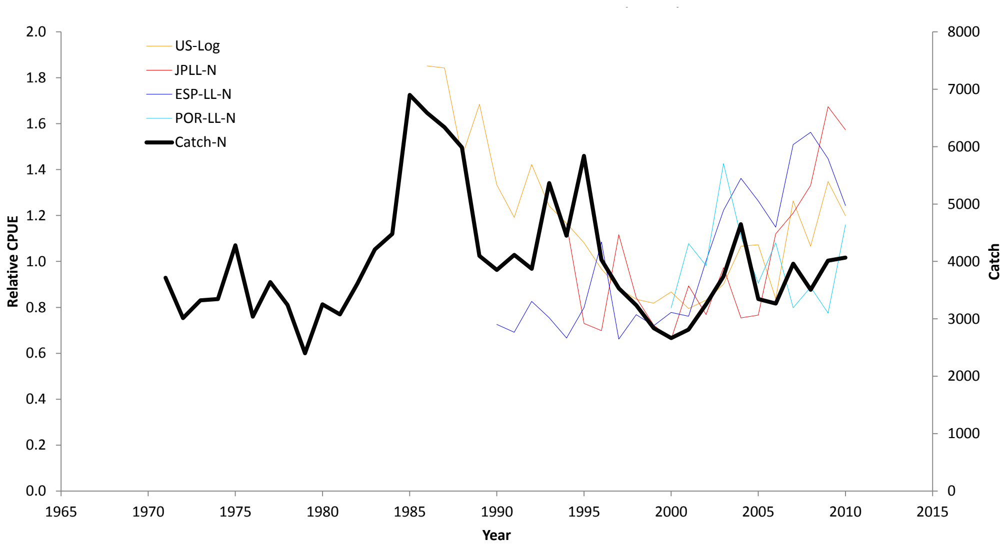


Figure 9.5. Shortfin mako in the North Atlantic Indices of abundance for North Atlantic shortfin mako shark, along with total catches input into the Bayesian Surplus Production model used in the ICCAT 2012 assessment. Figure courtesy of ICCAT.

10 Tope in the Northeast Atlantic

10.1 Stock distribution

WGEF considers there to be a single-stock of tope (or school shark, *Galeorhinus galeus*) in the ICES area. This stock is distributed from Scotland and southern Norway southwards to the coast of northwestern Africa and Mediterranean Sea. The stock area therefore, covers ICES Subareas II–X (where Subareas IV and VI–X are important parts of the stock range, and Subareas II, III and V areas where tope tend to be an occasional vagrant). The stock also extends to the northern part of the CECAF area and may also extend to the Mediterranean Sea (Subareas I–III).

The information used to identify the stock unit is summarized in the stock annex 2009.

10.2 The fishery

10.2.1 History of the fishery

Currently there are no targeted commercial fisheries for tope in the NE Atlantic. Tope is taken as a bycatch in trawl, gillnet and longline fisheries, including demersal and pelagic set gears. Though tope is discarded in some fisheries, other fisheries land this species as bycatch.

Tope is also an important target species in recreational sea angling in several areas, with anglers, angling clubs and charter boat often having catch and release protocols.

10.2.2 The fishery in 2013

There were no major changes to the fishery noted in 2013.

10.2.3 ICES Advice applicable

ICES provided advice for this stock for the first time in 2012, stating "*Based on ICES approach to data-limited stocks, ICES advises that catches should be reduced by 20%. Because the data for catches of tope are not fully documented and considered unreliable (due to the historical use of generic landings categories), ICES is not in a position to quantify the result. Measures to identify pupping areas should be taken*".

10.2.4 Management applicable

Longline fishery of tope is forbidden by EU regulation n°57/2011 of 18th January 2011 in ICES Areas I, IIa, IV, V, VI, VII, VIII, XII and XIV.

In terms of UK fisheries, and following a stakeholder consultation in 2006, Department for Environment, Food and Rural Affairs (DEFRA) introduced a Statutory Instrument in 2008 (SI Number 2008/691) that prohibited fishing for tope other than by rod and line (with anglers fishing using rod and line from boats not allowed to land their catch) and established a tope bycatch limit of 45 kg per day for commercial fisheries targeting other species.

10.3 Catch data

10.3.1 Landings

No accurate estimates of catch are available, as many nations that land tope report an unknown proportion of landings in aggregated landings categories (e.g. dogfish and hounds). Reported species-specific landings, which commenced in 1978 for French fisheries, are given in Table 10.1 and Figure 10.1. Landings indicate that France is one of the main nations landing tope (though data for 1980 and 1981 were not available). The UK also land tope, although species-specific data are lacking for the earlier years, and reported landings have declined since precautionary management measures were introduced. Since 2001, Ireland, Portugal and Spain have also declared species-specific landings.

No species-specific catch data for the Mediterranean Sea and off northwest Africa are available. The degree of possible misreporting or underreporting is not known. Overall available landings appear relatively stable from 1982 to 2003 at around 500 t per year and at 400 t per year since 2004, with a drop to ~300 t in 2011 and 2012.

10.3.2 Discards

Though some discards information is available from various nations, data are limited for most nations and fisheries. Preliminary studies from the UK Discard programme (Silva *et al*., 2013 WD) have indicated that juvenile tope tend to be discarded in demersal trawl fisheries and larger individuals are usually retained. Tope caught in drift and fixed net fisheries are usually retained.

Figure 10.2 shows the retained and discarded tope from the UK Discard programme (Silva *et al*., 2013 WD). In demersal trawl fisheries, topes of 50–94 cm L_T are generally discarded and those over 94 cm L_T are often retained. In drift and fixed net fisheries, tope is mostly retained and range mainly from 70 to 124 cm L_T.

10.3.3 Quality of catch data

Catch data are of poor quality, and biological data are not collected under the Data Collection Regulations. Some generic biological data are available (see Section 10.7).

Following the publication of the GFCM (General Fisheries Commission for the Mediterranean) Report of the Workshop on Stock Assessment of selected species of Elasmobranchs in the GFCM area, WGEF believes that collaboration should continue between ICES and the GFCM. This will encourage the sharing of information and aid the better understanding of elasmobranch fisheries in the Mediterranean, where WGEF data for this region are often lacking.

10.3.4 Discard Survival

Ellis *et al.* (2014 WD) provided references for discard survival of shark species worldwide. Discard survival of members of the Triakidae family appears to be quite variable. Whilst quantitative data are limited in European waters, Fennessy (1994) reported at-vessel mortality of 29% for Arabian smooth-hound *Mustelus mosis* taken in a prawn trawl fishery. Mortality ranged from 57–93% for three triakid sharks taken in an Australian gillnet fishery, despite the soak times being <24 hours (Braccini *et al*., 2012). High survival of triakids has been reported in longline fisheries (Frick *et al*., 2010; Coelho *et al*., 2012).

10.4 Commercial catch composition

No new data available.

10.5 Commercial catch and effort data

No data available.

10.6 Fishery-independent information

10.6.1 Availability of survey data

Although several fishery-independent surveys operate in the stock area, data are limited for most of these. This species is not sampled appropriately in beam trawl surveys (because of low gear selectivity). They are only caught occasionally in GOV trawl and other otter trawl surveys in the North Sea.

The discontinued UK (England and Wales) Q4 IBTS survey in the Celtic Seas ecoregion had observed small numbers of tope, which were tagged and released where possible (ICES, 2008). UK surveys in this area generally caught larger tope at the southern entrance to St George's Channel, and in 2011 several juveniles were captured in the Irish Sea. The Irish IBTS surveys also record small numbers of tope, although one haul (40E2, VIa) in 2006 yielded 59 specimens. Southern and western IBTS surveys may cover a large part of the stock range, and more detailed and updated analyses of these data are required.

During the EVHOE scientific surveys, tope are caught in low but stable numbers. The spatial distribution and abundance across the time-series (1997–2013) is given in Figure 10.3. Similar to the locations reported during UK surveys, the majority of individuals are found at the entrance to St George's Channel and outer Bristol Channel. From this survey, abundance and swept area biomass estimates were also calculated along the time-series (Figure 10.4). The abundance estimates for the whole Celtic Sea (VIIg–k) has been variable and with a large variance around the estimates. In 2012, the estimated abundance was near its highest level and the biomass estimate for the Celtic Sea was also near its highest level of the time-series. Given the high variance, however, these values need to be treated with caution, especially as this species is only caught in low numbers in fisheries independent surveys.

10.6.2 Length distributions

In 2009, data were presented on length distributions found in the Celtic Seas ecoregion during fisheries independent surveys conducted by England and Ireland during quarter 4 (Figure 10.5). Irish surveys recorded 145 tope (2003–2009), of which 110 (76%) were male. English surveys recorded 90 tope, with 56 males (62%) and 34 females (38%). The lengths ranged from 40–163 cm L_T. The length–frequency distributions found between the surveys are noticeably different, with many more large males found in the Irish survey; 75% of the males were greater than 130 cm. The English surveys had a more evenly distributed length range.

Figure 10.6 shows the length distributions of tope caught in various UK surveys in 2004–2009. In the beam trawl survey (Figure 10.6a), two peaks were observed, at 30–54 cm L_T and 70–84 cm L_T respectively. In the North Sea survey (Figure 10.6b) a wide range (30–164 cm L_T) was observed, with a main peak at 30–44 cm L_T. Wide ranges were also observed in the Celtic Sea survey (44–164 cm L_T; Figure 10.6c) and in the western IBTS survey (70–120 cm L_T; Figure 10.6d).

10.6.2.1 Recreational length distributions

A Scottish recreational fishery in the Mull of Galloway has recorded sex, length and weight of captured tope since 2009. While the number of tope tagged has declined, the number of mature fish of both sexes appears to have disproportionally declined (Figure 10.7). This area is thought to be a breeding ground for tope (James Thorburn, pers. comm.), so the lack of mature animals is a cause for concern.

10.6.3 Cpue

Analyses of catch data would need to be undertaken with care, as tope is a relatively large-bodied species (up to 200 cm L_T in the NE Atlantic), and adults are strong swimmers that forage both in pelagic and demersal waters. Hence, they are probably not sampled effectively in IBTS surveys, and survey data generally include a large number of zero hauls.

10.6.4 Tagging information

159 tope were tagged and released by CEFAS over the period 1961–2013, predominately in the Irish Sea and Celtic Sea (Figure 10.8; Burt *et al.*, 2013). Fish were also tagged in the western English Channel and North Sea but in very low numbers (n = 9). Tope were tagged over a wide length range (41–162 cm L_T), the majority being males, with a male to female sex ratio of 1.5:1. A total of four tope were recaptured, and were, on average, at liberty for 1195 days, with a maximum recorded time at liberty of 2403 days. Over the period individual fish had travelled relatively large distances (112–368 km), and all had moved from one ICES division to another. For example, the fish that was at liberty the longest was released in Cardigan Bay (VIIa) in November 2003, was later captured in June 2010 just to the east of the Isle of Wight. It is also noted that a tag from a tope was returned to CEFAS from southern Spain, and although release information could not be located, it is thought it may have been tagged in the 1970s.

In 2012 the UK (Scotland) started an electronic (archival data storage tags that record pressure and temperature) and conventional tagging programme for tope. As of June 2013, 13 tope had been tagged and there were two returns reported from France and Portugal (conventional tag). Further releases were planned in 2013.

The Irish Marine Sportfish Tagging Programme has tagged tope off the Irish coast since 1970. Four fish have been recaptured in the Mediterranean Sea. (Inland Fisheries Ireland, pers comm.; Fitzmaurice 1994; cf. nicematin.com, 29 May 2013, "Le long périple d'un requin hâ, de l'Irlande à la Corse). A tope tagged on 38 July 2001 off Greystones (Ireland) as part of this programme, was caught on 9 May 2013 off Bastia, Corsica (Mediterranean Sea), showing a migration route of 3900 km in twelve years.

10.7 Life-history information

Much biological information is available for tope in European seas and elsewhere in the world, which are summarized in the stock annex of the 2009 report (ICES 2009).

The following relationships and ratios were calculated by Séret and Blaison (2010):

$L_T = 0.0119\ W^{2.7745}$ (n = 10; length range of 60–140 cm L_T; weight in g);
Live weight / eviscerated weight = 1.28 (s.d. 0.05);
Live weight / dressed weight (eviscerated, headed, skinned) = 2.81 (s.d. 0.13);
Smallest mature male = 110 cm L_T, smallest mature female 130 cm L_T, fitting with the ranges 120–135 and 134–140 cm L_T observed for other populations.

Additional data from French surveys were presented in Ramonet *et al.* (2012 WD).

A genetic study (Chabot and Allen, 2009) on the eastern Pacific population including comparisons with samples from Australia, South and North America and UK, shows that there is little to no gene flow between these populations, meaning an apparent lack of migration.

10.7.1 Parturition and nursery grounds

Pups (24–45 cm L_T) are occasionally caught in groundfish surveys, and such data might be able to assist in the preliminary identification of general pupping and/or nursery areas (see Figure 10.5 of ICES, 2007). Most of the pup records in UK surveys are from the southern North Sea (IVc), though they have also been recorded in the northern Bristol Channel (VIIf). The updated locations of pups caught in fisheries-independent surveys across the ICES region could usefully be collated in the near future.

The lack of more precise data on the location of pupping and nursery grounds, and their importance to the stock, precludes spatial management for this species at the present time.

10.8 Exploratory assessment models

10.8.1 Previous studies

No assessments of NE Atlantic tope have been made. Several assessment methods have been applied to the South Australian stock (e.g. Punt and Walker, 1998; Punt *et al*., 2000; Xiao and Walker, 2000).

10.8.2 Data exploration and preliminary modelling

Landing data (see Section 10.3) and survey data (see Section 10.6) are insufficient to allow for an assessment of this species at the present time.

10.9 Stock assessment

No assessment was undertaken, as a consequence of insufficient data.

10.10 Quality of the assessment

No assessment was undertaken, as a consequence of insufficient data.

10.11 Reference points

No reference points have been proposed for this stock.

10.12 Conservation considerations

The IUCN list tope as Vulnerable (globally) and as Data Deficient in the NE Atlantic (Gibson *et al*., 2008).

10.13 Management considerations

Tope is considered highly vulnerable to overexploitation, as they have a low population productivity, relatively low fecundity and protracted reproductive cycle. Furthermore, unmanaged, targeted fisheries elsewhere in the world have resulted in stock collapse (e.g. off California and in South America).

Tope are also an important target species in recreational fisheries; though there are insufficient data to examine the relative economic importance of tope in the recreational angling sector, this may be high in some regions.

Tope is, or has been, a targeted species elsewhere in the world, including Australia/New Zealand, South America and off California. Evidence from these fisheries (see stock annex and references cited therein) suggests that targeted fisheries would need to be managed conservatively, exerting a low level of exploitation.

Australian fisheries managers have used a combination of a legal minimum length, a legal maximum length, legal minimum and maximum gillnet mesh sizes, closed seasons and closed nursery areas. However as tope is taken mainly in mixed fisheries in the ICES area, such measures may be of less utility.

10.14 References

Brachhini, M., Van Rijn, J., and Frick, L. 2012. High post-capture survival for sharks, rays and chimaeras discarded in the main shark fishery of Australia? PloS One, 7(2), e32547, 1–9.

Burt, G. J., Silva, J. F., McCully, S. R., Bendall, V. A. and Ellis, J. R. 2013. Summary results from opportunistic tagging programmes for smooth-hound *Mustelus* spp., greater-spotted dogfish *Scyliorhinus stellaris* and tope *Galeorhinus galeus* around the British Isles. Working Document to the Working Group on Elasmobranch Fishes, Lisbon, Portugal, 17–21 June 2013. 12 pp.

Chabot, C. L., and Allen, L. G. 2009. Global population structure of the tope (*Galeorhinus galeus*) inferred by mitochondrial control region sequence data. *Molecular Ecology*, 18: 545–552.

Coelho, R., Fernandez-Carvalho, J., Lino, P.G., and Santos, M.N. 2012. An overview of the hooking mortality of elasmobranchs caught in a swordfish pelagic longline fishery in the Atlantic Ocean. *Aquatic Living Resources*, 25: 311–319.

Ellis, J.R.., McCully, S.R. and Poisson, F. 2014. A global review of elasmobranch discard survival studies and implications in relation to the EU 'discard ban'. Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 2014. 48 pp.

Fennessy, S.T. 1994. Incidental capture of elasmobranchs by commercial prawn trawlers in the Tugela Bank, Natal, South Africa. South African Journal of Marine Science, 14: 287–296.

Fitzmaurice, P. 1994. Tagging studies of blue sharks and tope off the Irish coast. p. 17. In: S.L. Fowler and R.C. Earll (ed.) Proceedings of the Second European Shark and Ray Workshop,15–16 February 1994, Tag and Release Schemes and Shark and Ray Management Plans.

Frick, L.H., Reina, R.D. and Walker, T.I. 2010. Stress related changes and post-release survival of Port Jackson sharks (*Heterodontus portusjacksoni)* and gummy sharks (*Mustelus antarcticus)* following gill-net and longline capture in captivity. *Journal of Experimental Marine Biology and Ecology*, 385: 29–37.

Gibson, C., Valenti, S.V., Fordham, S.V. and Fowler, S.L. 2008. The Conservation of Northeast Atlantic Chondrichthyans: Report of the IUCN Shark Specialist Group Northeast Atlantic Red List Workshop. viii + 76pp.

ICES. 2007. Report of the Working Group on Elasmobranch Fishes. ICES CM 2007/ACFM:27.

ICES. 2008. Report of the International Bottom Trawl Survey Working Group (IBTSWG), 31 March–4 April 2008, Vigo, Spain. ICES CM 2008 RMC:02; 228 pp.

ICES. 2009. Report of the Joint Meeting between ICES Working Group on Elasmobranch Fishes (WGEF) and ICCAT Shark Subgroup, 22–29 June 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:16. 424 pp.

Punt, A. E., and Walker, T. I. 1998. Stock assessment and risk analysis for the school shark (*Galeorhinus galeus*) off southern Australia. *Marine and Freshwater Research*, 49: 719–731.

Punt, A. E., Pribac, F., Walker, T. I., Taylor, B. L. and Prince, J. D. 2000. Stock assessment of school shark *Galeorhinus galeus* based on a spatially-explicit population dynamics model. *Marine and Freshwater Research,* 51: 205–220.

Ramonet M., Jung, A., Salaun M., Pawlowski, L., Bellail, R., Mahé, J-C., Poisson, F. and Biseau, A. 2012. Elasmobranch morphometric relationship and sexual maturity stages from EVHOE scientific survey in Northeast Atlantic Ocean from 2007 to 2011 campaigns. WGEF WD, June 2012, 26 pp.

Séret, B. and Blaison A. 2010. Requins et raies des pêches françaises. Axe 2. Facteurs de conversion. Convention DPMA / IRD. Rapport, 31 pp.

Silva, J. F., Ellis, J. R., Catchpole, T. L. and Righton, D. 2013. Bycatch and discarding patterns of dogfish and sharks taken in commercial fisheries around the British Isles. Working Document to the Working Group on Elasmobranch Fishes, Lisbon, Portugal, 17–21 June 2013, 31 pp.

Xiao, Y. and Walker, T. I. 2000. Demographic analysis of gummy shark (*Mustelus antarcticus*) and school shark (*Galeorhinus galeus*) off southern Australia by applying a generalized Lotka equation and its dual equation. *Canadian Journal of Fisheries and Aquatic Sciences*, 57: 214–222.

Table 10.1. Tope in the Northeast Atlantic. Reported species-specific landings (tonnes) for the period 1975–2013. These data are considered underestimates as some tope are landed under generic landings categories, and species-specific landings data are not available for the Mediterranean Sea and are limited for Northwest African waters.

ICES Division IIIa–IV	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Denmark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
France	na	na	na	32	22	na	na	26	26	13	31	13	14	18	12	17
Netherlands																
Sweden	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W)	na	na	na	na	na	na	na	8	10	31	36	94	28	22	18	14
UK (Scotland)																-
Total (IIIa-IV)	0	0	0	32	22	0	0	34	36	44	67	107	42	40	30	31
ICES Division V-VII																
France	na	na	na	522	2076	na	na	988	1580	346	339	1141	491	621	407	357
Ireland	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Netherlands																
Spain	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Spain (Basque country)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W)	na	na	na	na	na	na	na	63	51	28	23	21	21	21	55	45
UK (Scotland)																
Total (VI-VII)				522	2076	0	0	1051	1631	374	362	1162	512	642	462	402
ICES Division VIII																
France	na	na	na	na	237	na	na	na	63	119	52	103	97	66	39	34
Spain	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Spain (Basque country)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W)	-	-	-	+	+	+	+	+	+	+	+	1				

ICES Division IIIa–IV	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
UK Scotland																
Total (VIII)				0	237	0	0	0	63	119	52	104	97	66	39	34
ICES Division IX																
Spain	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total (IX)																
ICES Division X																
Portugal	18	na	na	24	15	51	77	42	24	29	24	24	24	34	23	56
Total (X)	18			24	15	51	77	42	24	29	24	24	24	34	23	56
Other																
France	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CECAF area																
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL LANDINGS	18	0	0	578	2350	51	77	1127	1754	567	505	1397	675	782	554	523

Table 10.1. (continued). Tope in the Northeast Atlantic. Reported species-specific landings (tonnes) for the period 1975–2013. These data are considered underestimates as some tope are landed under generic landings categories, and species-specific landings data are not available for the Mediterranean Sea and limited for Northwest African waters.

ICES Division IIIa–IV	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Denmark	-	-	-	-	-	-	.	.	3	8	4	5	5	5
France	16	10	11	12	8	11	5	11		11	11	6	6	3
Netherlands														
Sweden	-	-	-	-	-	-	.	.	.	.	.	.	.	.
UK (E&W)	21	15	15	19	25	14	22	12	14	13	10	13	11	8
UK (Scotland)	-	-	-	-	-	-	.	.	.	.	.	.	.	.
Total (IIIa-IV)	37	25	26	31	33	25	27	23	17	32	25	24	22	16
ICES Division V-VII														
France	391	235	240	235	265	314	409	312		368	394	324	284	209
Ireland	na	na	na	na	na	na	na	na	na	na	4	1	6	4
Netherlands							.	.	.	.	.	.	.	.
Spain	na	na	na	na	na	na	na	na	na	na	+	242	3	na
Spain (Basque country)	-	-	-	-	-	-	.	.	.	.	+	+	3	15
UK (E&W)	47	53	48	49	38	39	34	41	62	98	72	60	55	65
UK (Scotland)														
Total (VI-VII)	438	288	288	284	303	353	443	353	62	466	470	627	351	293
ICES Division VIII														
France	38	34	40	54	44	78	40	46	+	71	58	49	60	16
Spain	na	na	na	na	na	na	na	na	na	na	9	13	10	na
Spain (Basque country)	-	-	-	-	-	-	.	.	.	.	9	6	10	10
UK (E&W)					0	0	0	0	0		1		3	8

ICES Division IIIa–IV	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
UK Scotland														
Total (VIII)	38	34	40	54	44	78	40	46	0	71	77	68	83	34
ICES Division IX														
Spain	na	na	na	na	na	na	na	na	na	na	na	na	na	76
Total (IX)														
ICES Division X														
Portugal	81	80	115	116	124	80	104	128	129	142	82	77	69	51
Total (X)	81	80	115	116	124	80	104	128	129	142	82	77	69	51
Other	.	.	.	.	.	.	.	.	.	.	.	.	.	.
France	-	-	-	-	-	-	.	.	386	.	2	.	.	.
UK (E&W)	-	-	-	+	+	-	.	.	.	.	.	.	.	.
CECAF area	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Portugal	-	-	-	-	-	-	.	.	.	2	1	2	98	na
TOTAL LANDINGS	**593**	**427**	**469**	**485**	**504**	**536**	**615**	**551**	**593**	**713**	**656**	**798**	**622**	**394**

Table 10.1. (continued). Tope in the Northeast Atlantic. Reported species-specific landings (nearest tonne) for the period 1975–2013. These data are considered underestimates as some tope are landed under generic landings categories, and species-specific landings data are not available for the Mediterranean Sea and limited for Northwest African waters.

ICES Division IIIa–IV	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	8	6	4	4	3	2	4	1	1
France	3	6	6	6	7	9	7	4	6
Netherlands									0
Sweden	+	0	0	0	0				
UK (E&W)	10	13	5	2	1	1	4	1	0
UK (Scotland)	.	.	0	0	0	0	0	0	
Total (IIIa-IV)	21	25	15	12	11	13	15	7	7
ICES Division V-VII									
France	181	293	155	187	259	278	199	226	209
Ireland	na	7	3	4	3	3	1	0	0
Netherlands	.	.	.	.	.	2	18	25	11
Spain	na	na	na	60	69	44	12	2	4
Spain (Basque country)	10	.	.	0	0	0			
UK (E&W)	65	74	44	26	22	15	13	15	17
UK (Scotland)			0	7	0	0	0		
Total (VI-VII)	256	374	202	284	352	342	242	268	240
ICES Division VIII									
France	29	40	28	35	74	57	39	39	55
Spain	na	na	na	21	33	11	4	1	5
Spain (Basque country)	14	12	1	12	14	12	17		
UK (E&W)	6	5	0	0	0	0	0	0	0

ICES Division IIIa–IV	2005	2006	2007	2008	2009	2010	2011	2012	2013
UK Scotland				0			0		
Total (VIII)	49	57	29	69	121	80	60	40	61
ICES Division IX									
Spain	na	na	na	96	85	88	89	12	49
Total (IX)									
ICES Division X									
Portugal	45	45	43	47	34	41	44	47	46
Total (X)	45	45	43	47	34	41	44	47	46
Other	.	.	.	.	.	.	.	.	.
France	.	.	.	.	.	.	.	0	.
UK (E&W)	.	.	.	.	.	.	.	.	.
CECAF area	.	.	.	.	.	.	.	.	.
Portugal	na	na	na	na	.	.	.	.	.
TOTAL LANDINGS	**371**	**502**	**288**	**412**	**519**	**476**	**361**	**362**	**354**

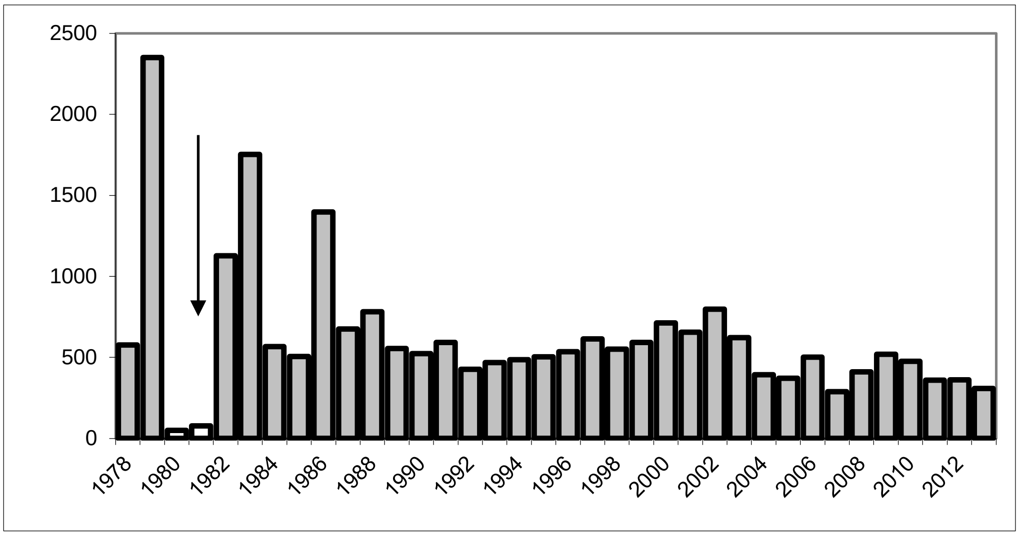


Figure 10.1. Tope in the Northeast Atlantic. Annual landings 1978–2013. These data are considered underestimates as some tope are landed under generic landings categories, and no species-specific landings data are available for the Mediterranean Sea and northwest African waters. Not all data are available for recent years.

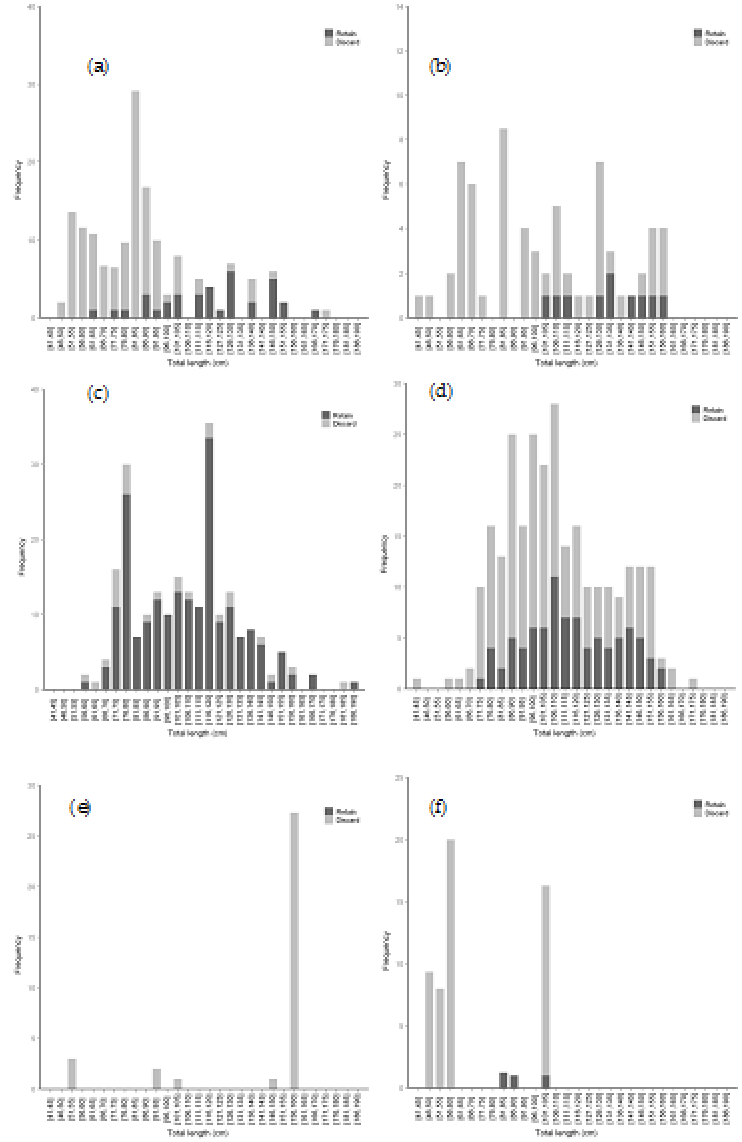


Figure 10.2. Tope in the Northeast Atlantic. Length–frequency of discarded and retained tope *Gale-orhinus galeus* by (a) otter trawl (2002–2007) and (b) otter trawl (2008–2011), (c) gillnet (2002–2007), (d) gillnet (2008–2011), (e) beam trawl (2002–2011) and (f) *Nephrops* trawl (2002–2011) across both ecoregions, as recorded in the Cefas observer programme.

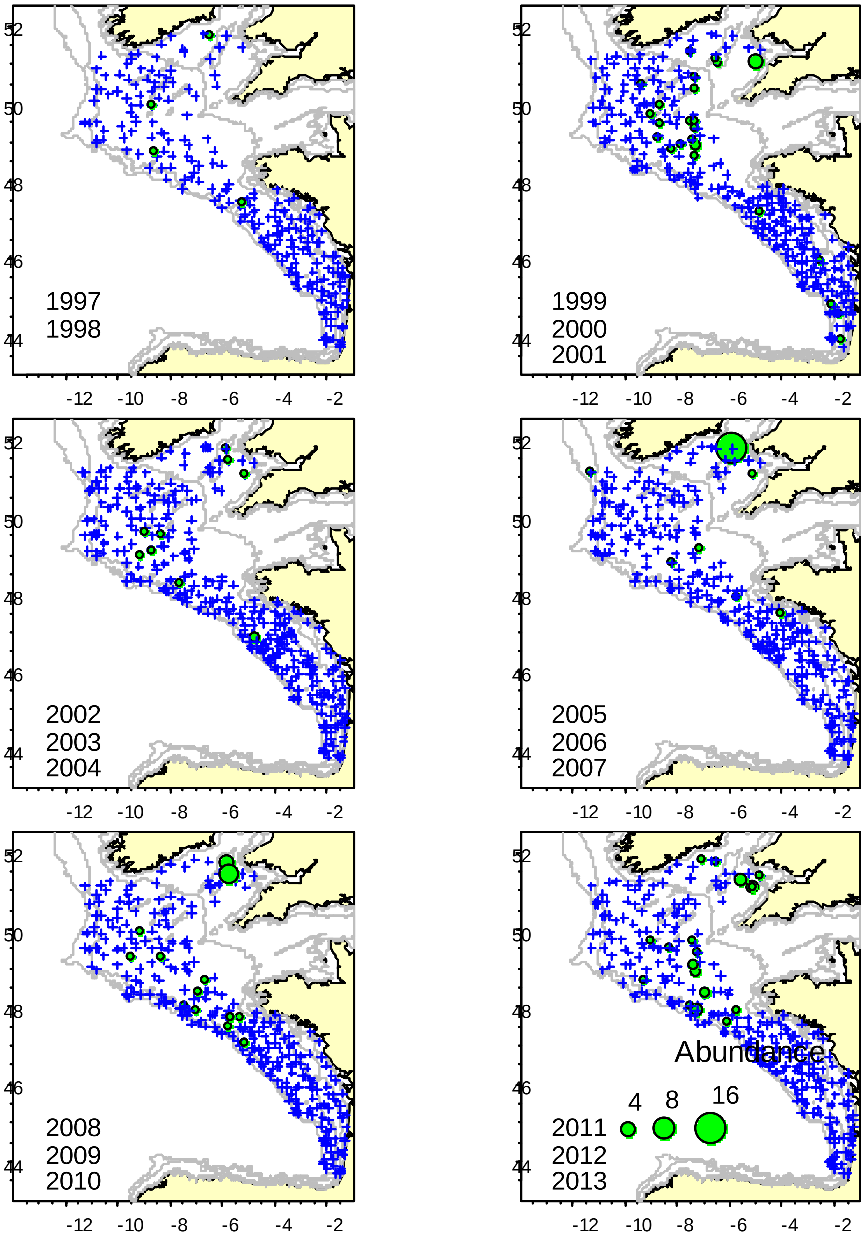


Figure 10.3. Total tope abundance caught in French Q4 Evhoe survey in the Celtic Sea from 1997–2013.

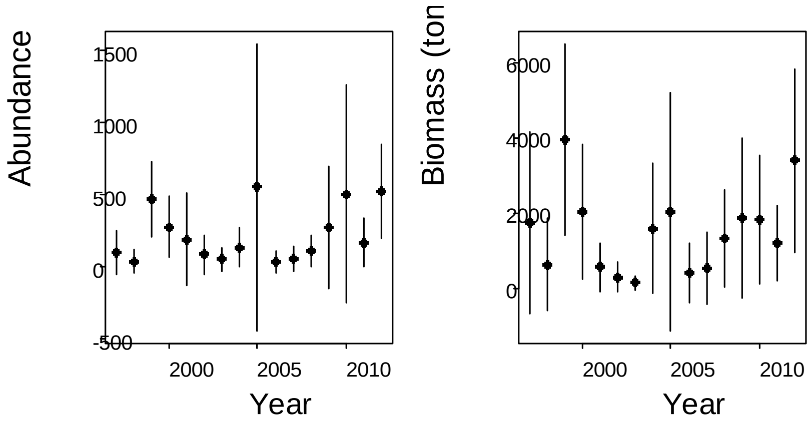


Figure 10.4. Tope abundance and swept area biomass estimates made from French Q4 Evhoe survey in the Celtic Sea from 1997–2013.

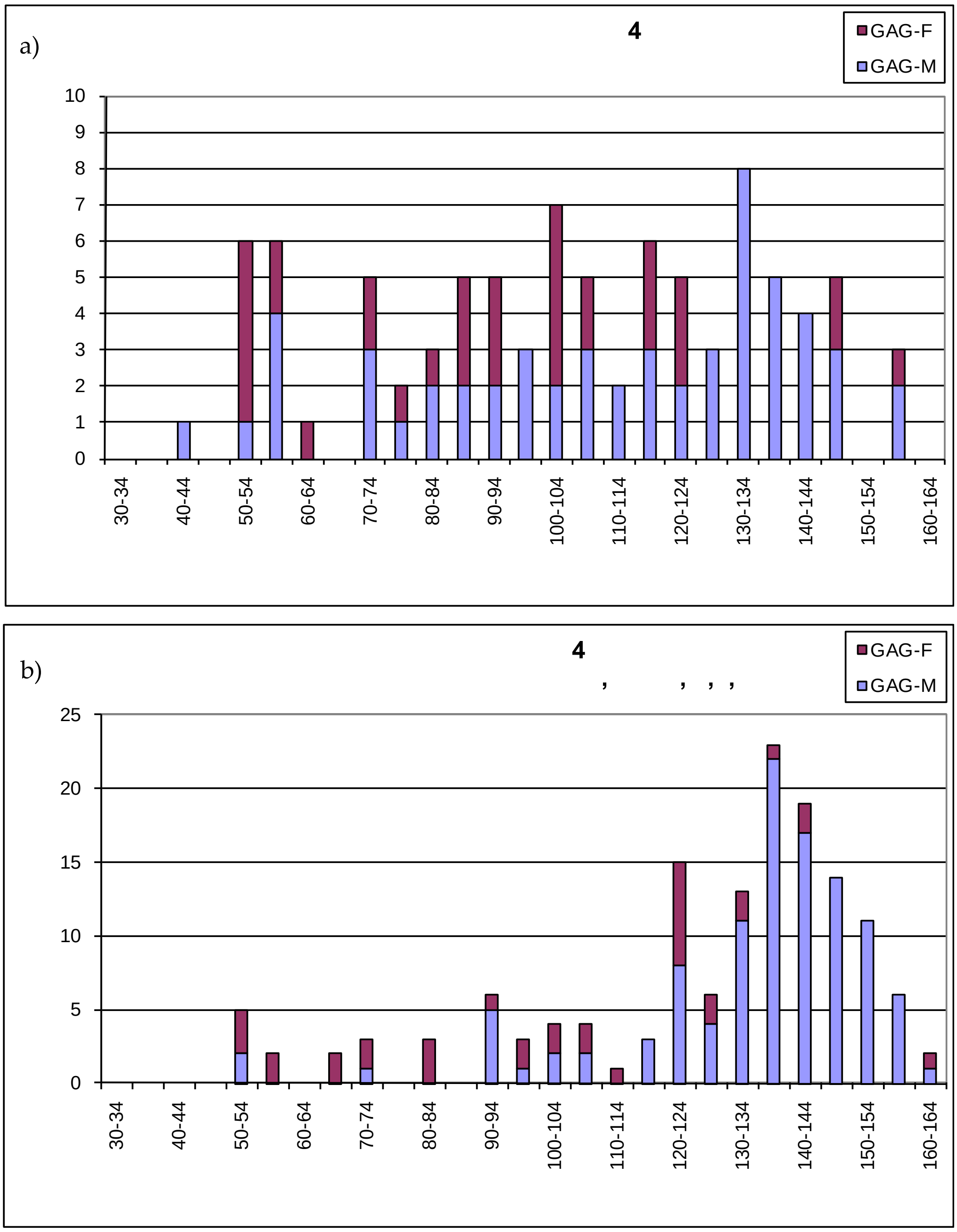
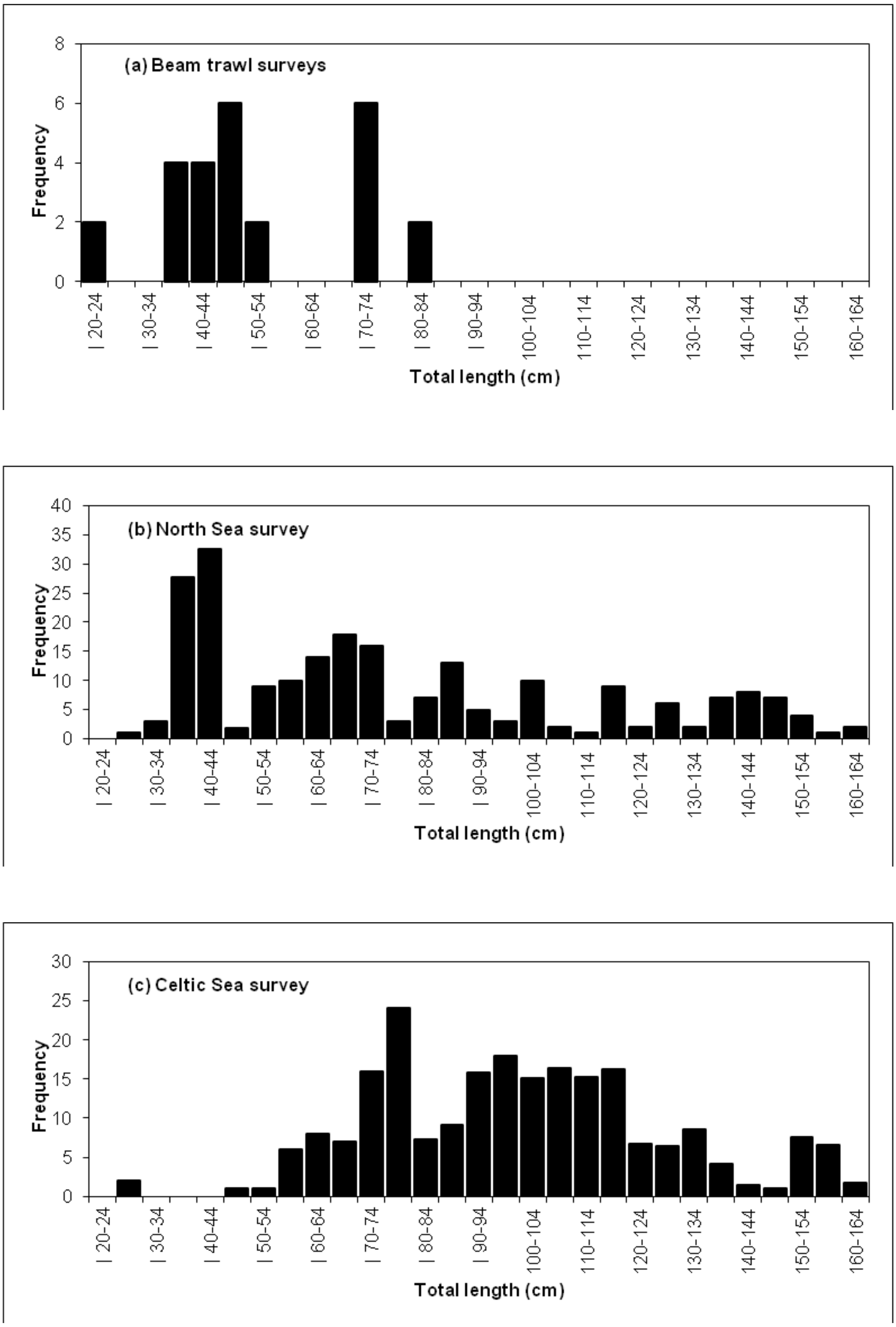


Figure 10.5. Tope in the Northeast Atlantic Tope length distributions from a) English Groundfish Survey data, years 2004–2009, conducted in Q4 in Celtic and Irish Seas, and b) Irish Groundfish Survey data, years 2003–2009, conducted in Q4 in the Celtic Seas ecoregion (ICES Divisions VIa, VIIa–c, g, j, k).


(a) Beam trawl surveys
Frequency
Total length (cm)
(b) North Sea survey
Frequency
Total length (cm)
(c) Celtic Sea survey
Frequency
Total length (cm)

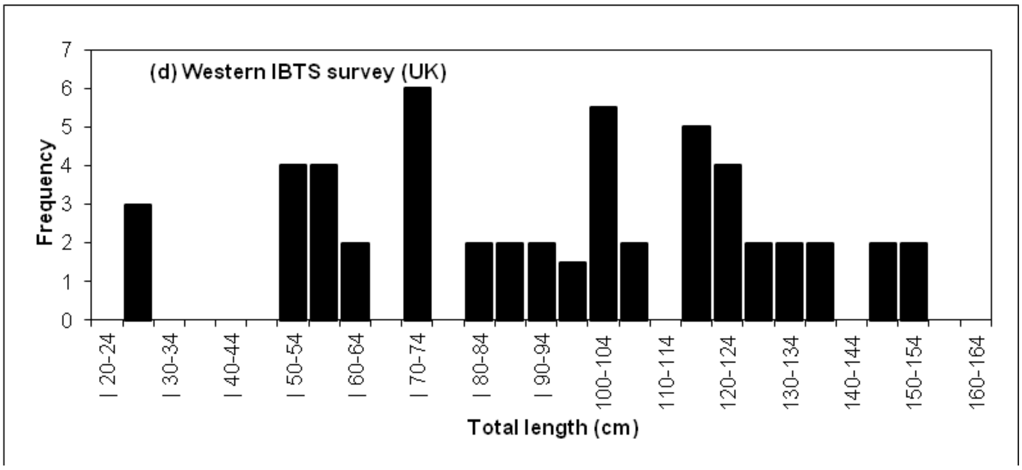


Figure 10.6. Tope in the Northeast Atlantic. Length–frequency distributions of tope from beam trawl survey (a), North Sea Suvey (b), Celtic Sea survey (c) and western IBTS survey/UK (d); years 2004–2009.

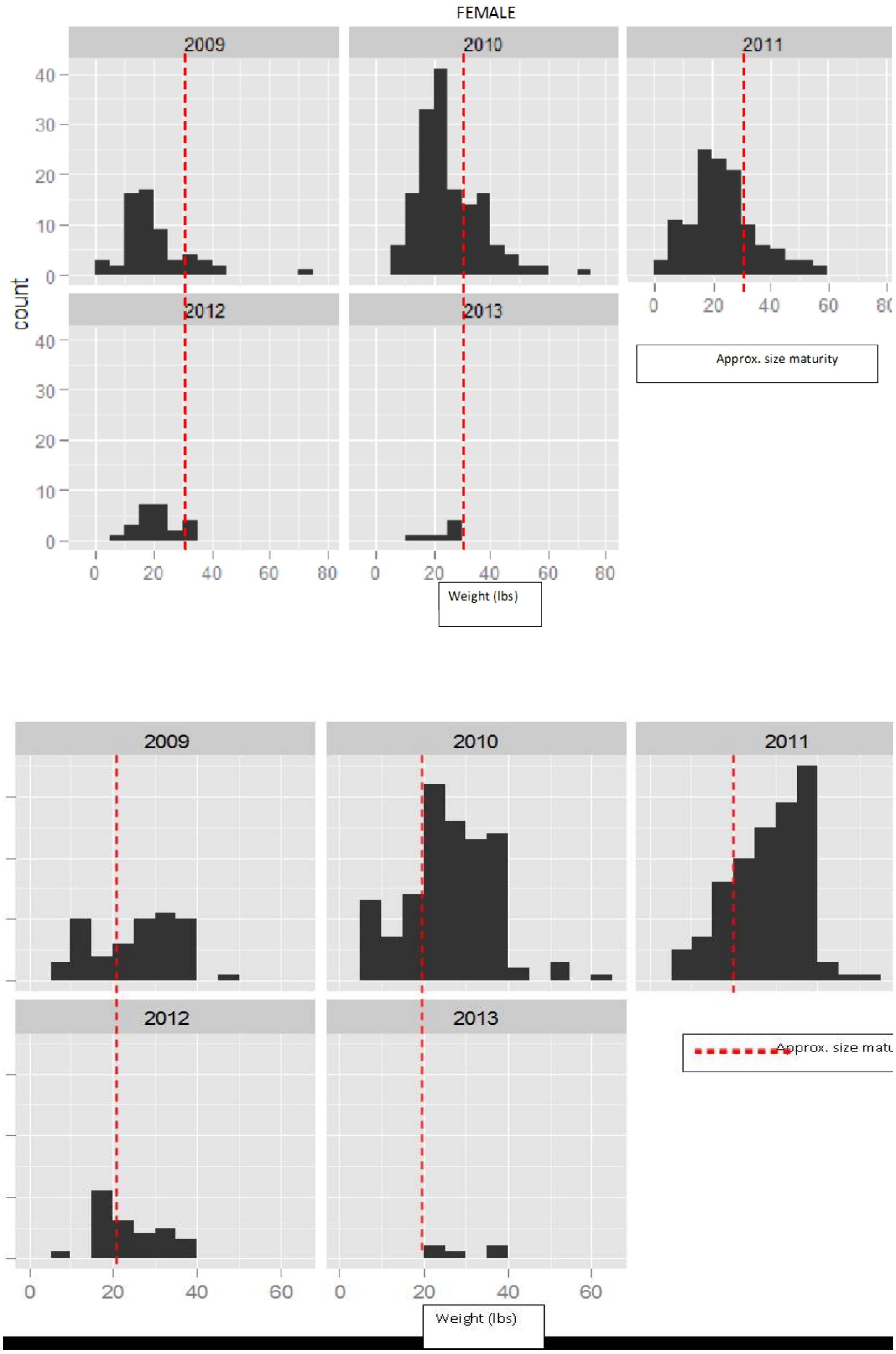


Figure 10.7. Tope in the NE Atlantic. Count by year of captures of female (top) and male (bottom) tope by recreational fishery in the Mull of Galloway, Scotland. The red lines shows approximate weight-at-maturity. Source James Thorburne, University of Aberdeen. Unpublished data.

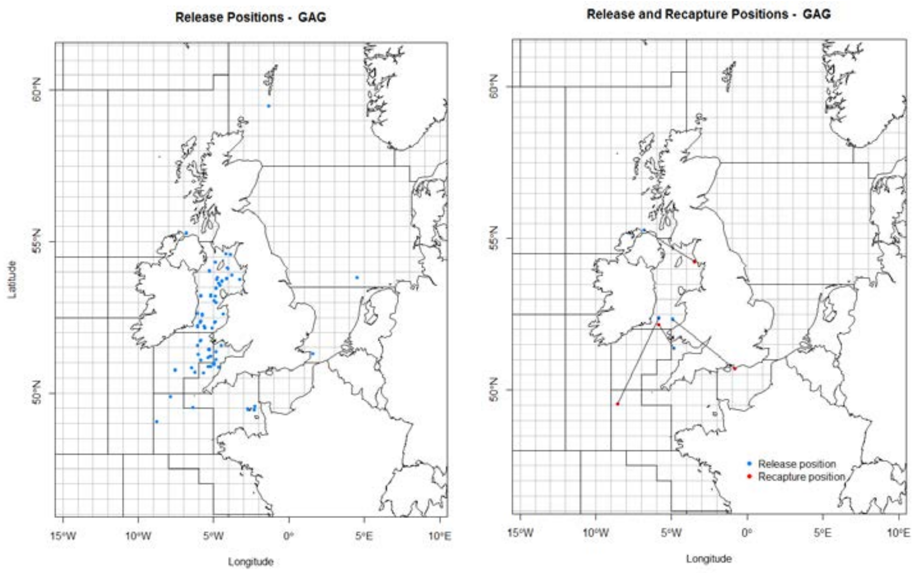


Figure 10.8. Tope in the Northeast Atlantic. Locations of tope *Galeorhinus galeus* (i) released and (ii) release and recapture positions for recaptured fish (2000–2013). Source: Burt *et al.*, WD 2013.

11 Thresher sharks in the Northeast Atlantic and Mediterranean Sea

11.1 Stock distribution

Two species of thresher shark occur in the ICES areas: common thresher *Alopias vulpinus* and bigeye thresher *A. superciliosus.* Of these, *A. vulpinus* is the dominant species taken in the continental shelf fisheries of the ICES area. There is little information on the stock identity of these circumglobal sharks. WGEF assumes there to be a single NE Atlantic and Mediterranean stock of *A. vulpinus*. This stock probably extends into the CECAF area. The presence of a nursery ground in the Alboran Sea provides the rationale for including the Mediterranean Sea within the stock area.

Further information on the stock identity is included in the Stock Annex (ICES, 2009).

11.2 The fishery

11.2.1 History of the fishery

There are no target fisheries for thresher sharks in the NE Atlantic. Both species are caught mainly as a bycatch in longline fisheries for tuna and swordfish but may also be taken in driftnet and gillnet fisheries. The fisheries data for the ICES area are scarce, and are unreliable, because it is likely that the two species (*Alopias vulpinus* and *A. superciliosus*) are mixed in the records.

Both species occur in the Mediterranean Sea. There are no target fisheries but they are taken as a bycatch in various fisheries, including the Moroccan driftnet fishery in the southwest Mediterranean. They are caught by industrial and semi-industrial longline fisheries and by artisanal gillnet fisheries. In France, thresher sharks are caught incidentally mainly by the trawlers operating in the Gulf of Lions targeting small pelagics and are landed in two major harbours (Sète and Port La Nouvelle). Additional bycatch of these sharks will occur in the Straits of Gibraltar.

Further information on the stock identity is included in the Stock Annex.

11.2.2 The fishery in 2013

No new information.

11.2.3 ICES Advice applicable

ICES has never provided advice for stocks of these species.

11.2.4 Management applicable

EC Regulation No. 1185/2003 prohibits the removal of shark fins of this species, and subsequent discarding of the body. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

Article 19 of EC Regulation No. 44/2012 prohibits the retention, transshipment or landing any part or whole carcass of bigeye thresher shark *A. superciliosus* in any fishery, and also prohibits any directed fishery for thresher sharks *Alopias* spp. in the ICCAT area (EU, 2012).

11.3 Catch data

11.3.1 Landings

The landings of thresher sharks are reported irregularly and rather variably; from 3–193 t in the NE Atlantic and the Mediterranean Sea (ICCAT and national data; Tables 11.1–11.2; Figure 11.1). There are large discrepancies between national landings data presented to ICES and that reported to ICCAT (Figure 11.1). The main landing nations are Portugal, Spain and France, although the large quantities reported by Portugal to ICCAT in 2006 and 2007 need to be verified.

Thresher sharks are taken occasionally in ICES Subarea IV and the main catches are from Subareas VI–IX, mainly from VIII (Table 11.2).

Small (2 t or less) irregular landings have been reported by Denmark, Ireland and the UK, since 2000. The countries with more consistent estimated landings are France, Portugal and Spain. The national reported landings of thresher sharks in French waters have typically ranged from 2–22 t, however in 2000 and 2001, reported landings increased to 107–112 t, remained at levels <10 t until 2006 and increased to levels between 27 and 41 t in recent years . However, the French landings reported to ICCAT are larger, at between 9–42 t since 2002. The values of the 2000 and 2001 landings are believed to be overestimates (Poisson and Séret, 2009).

Portuguese estimated national landings began in 1986 and have usually varied from 7–37 t annually, with higher values in 1988, 2006 and 2007. These three years seem suspicious and require verification. It is possible that those figures were from the North and South Atlantic combined. No national landings have been reported to WGEF since 2006, yet catches of 95, 82, 44, 43 and 15 t were reported to ICCAT by Portugal in 2006–2011. For the CECAF area nominal estimated landings were between zero and at most two in 1998.

Spanish landings began in 1997 at 53 t, and after three years declined to 1 t and were null by 2001. From 2003 on landings increased again and in 2004 were an estimated 84 t, falling to 54 t in 2005, with no national landings reported to WGEF after this year, apart from 2 t from the Basque Country in 2009. Landings of 46 t in 2007, 73 t in 2008 and 78 t in 2009, have however been reported by Spain to ICCAT.

The overall estimated landings as reported by national data to WGEF ranged from just 3 t, the lowest level, in 1984 to 143 t in 2005. Landings reported to ICCAT are far greater, with the peak landings of 193 t in 1997, and the lowest level of 19 t in 2003. A distinctly better harmonization between these data is required.

In 2013, 34 t of thresher sharks were landed of which 33 t were derived from France mostly from ICES Subarea VIII (Table 11.2).

11.3.2 Discards

No data available.

11.3.3 Quality of catch data

Thresher sharks have not routinely been reported at either a species-specific or generic level. The two species are recorded mixed or separately; however analysis of the available data seems to indicate that they are often mixed even when recorded under specific names. Also, some discrepancies are observed when different sources of data are compared (e.g. FAO, ICCAT, national data). Landings of thresher shark in coastal waters are most likely to represent *A. vulpinus*, but some of these landings may be reported as 'sharks nei'.

Methods developed to identify shark species based on fins (Sebastian *et al.*, 2008; Holmes *et al.*, 2009) could help in the near future to gather data on species this information will greatly assist in management and conservation.

Following the publication of the GFCM (General Fisheries Commission for the Mediterranean) Report of the Workshop on Stock Assessment of selected species of Elasmobranchs in the GFCM area, WGEF recommends that collaboration should continue between ICES and the GFCM. This will encourage the sharing information and aid on a better understanding of elasmobranch fisheries in the Mediterranean, where WGEF data for this region are often lacking.

11.3.4 Discard survival

Limited information on discard survival from European fisheries, but there have been several studies elsewhere in the world (see Ellis *et al.*, 2014 WD). Braccini *et al.* (2012) found that about two thirds of thresher shark captured in gillnets were dead, even with a short soak time, although this was based on a small sample size. Moderate to high levels of mortality have been reported in pelagic longline fisheries, with most studies indicating that about half of the thresher sharks captured are in poor condition or dead (see Ellis *et al.*, 2014 WD and references therein).

11.4 Commercial catch composition

Length–frequency distributions for *A. vulpinus* have been collected under the Data Collection Regulation (DCF) programme by observers on board French vessels between 2003 and 2009 (Figure 11.2). Given the potential problems of how thresher sharks are measured (standard length, fork length, total length), improved standardisation of length-based information is required.

11.5 Commercial catch and effort data

Limited data on landing and effort are available for the ICES area. ICES and ICCAT should cooperate to collate and interpret commercial catch data from high seas fisheries.

11.6 Fishery-independent surveys

No fishery-independent data are available for the NE Atlantic.

Ifremer implemented a small-scale pilot research programme (Alop project) in the Mediterranean Sea, in close collaboration with the fishing industry and especially with the trawler fishery targeting small pelagic fish in the Gulf of Lions.

The objectives of 'Alop' project were (1) to monitor the landings and to reconstruct the landing time-series of thresher sharks, (2) to collect basic biological parameters and (3) to study the feeding ecology (isotope, fatty acids, and contaminants) of the common thresher shark. Incentive and compensatory measures will be initiated to encourage fishers to release the individuals alive at sea after tagging.

Only part of the Project objectives were accomplished. In relation to migration and despite the short periods of deployment, information was obtained from two tagged specimens in the Gulf of Lions. The behaviour of one female (135 cm L_F) was recorded for 200 days. Horizontal movements within a restricted area of the Gulf of Lion were observed; the female stayed in coastal shelf areas from July to September and moved to deeper waters afterwards, probably as a response to the seasonal cooling of the sea surface temperature. Another specimen (120 cm L_F) stayed most of the time at depths of 10–20 m but occasionally moved down to 800 m.

11.7 Life-history information

Various aspects of the life history, including conversion factors, and nursery grounds for these species are included in the Stock Annex.

Fernandez-Carvalho *et al.* (2011) provided the von Bertalanffy growth parameters for the bigeye thresher shark of the tropical Northeastern Atlantic (Table 11.4) based on 117 specimens ranging from 176–407 cm L_T.

Fernandez-Carvalho *et al.* (2012) provided maturity information for bigeye thresher shark from the Atlantic. Significant differences were found in the size distribution and the sex ratio between the North and South Atlantic ($L_{50\%}$ were estimated as 206.09 cm L_F for females and as 159.74 cm L_F for males).

Data on the fins to carcass mass ratio are scarce for Atlantic specimens of *Alopias vulpinus*, with a recent revision made by Biery and Pauly (2012).

11.7.1 Movements and migrations

Nakano *et al*. (2003) conducted an acoustic telemetry study to identify the short-term horizontal and vertical movement patterns of two immature female *A. superciliosus* in the eastern tropical Pacific Ocean during summer of 1996. Distinct crepuscular vertical migrations were observed; specimens stay between 200–500 m during the day and between 80–130 m at night, with slow ascents and relatively rapid descents during the night, the deepest dive being 723 m. Estimated mean swimming speed over the ground ranged from 1.32 to 2.02 km h^{-1}.

Weng and Block (2004) studied diel vertical migration patterns of two bigeye thresher sharks (*A. superciliosus*) that were caught and tagged with pop-up satellite archival tags in the Gulf of Mexico and near Hawaii. Both showed strong diel movement patterns spending the majority of day in layers below the thermocline (300–500 m and 400–500 m) while night-time was spent mostly in the mixed layer or above the thermocline (10–50 m). The two specimen spent night-time in waters warmer than 20°C and eight or more hours during daytime in deep waters with ambient temperatures of less than 10°C.

Carlson and Gulak (2012) provide results from a tagging programme with archival tags deployed on bigeye thresher sharks. One specimen exhibited a diurnal vertical diving behaviour, spending most of their time between 25 and 50 m depth in waters between 20 and 22°C while the other dove down to 528 m. Deeper dives occurred more often during the day, and by night they tend to stay above the thermocline.

Cao *et al.* (2012) provide data for *A. superciliosus* and *A. vulpinus* around the Marshall Islands: optimum swimming depth 240–360 m and 160–240 m, water temperature 10–16°C and 18–20°C, salinity 34.5–34.7% and 34.5–34.8%, dissolved oxygen 3.0–4.0 ml/l and 1.0–1.5 ml/l respectively.

11.7.2 Nursery grounds

Nursery areas for *A. superciliosus* are admitted to occur off the southwestern Iberian Peninsula and Strait of Gibraltar (Moreno and Moron, 1992), and juveniles of *A. vul-*

pinus are also known to occur in the English Channel and southern North Sea (Ellis, 2004). Further information on potential nursery areas is given in the Stock Annex.

11.7.3 Diet

Both species feed mostly on small schooling fish, including mackerels, clupeids as well as squid and octopus (General Fisheries Commission for the Mediterranean 2010: GFCM:SAC12/2010/Inf.12).

11.8 Exploratory assessments

No specific assessments have ever been made of thresher shark in the NE Atlantic, although they have been included as a part of wider PSAs for the pelagic fish assemblage (see Section 12). The lack of reliable landing estimates (see Section 11.3) and inexistence of fishery-independent survey data hamper the assessments of these stocks.

11.9 Stock assessment

No assessment has been undertaken, as a consequence of insufficient data. Species-specific landings are required and any assessment will need to be undertaken in collaboration with ICCAT.

11.10 Quality of assessments

No assessment has been undertaken.

11.11 Reference points

No reference points have been proposed for these stocks.

11.12 Conservation considerations

In 2006, the IUCN Red List classified thresher shark as Data Deficient (IUCN, 2006), but their status was re-evaluated in 2007 (Camhi, 2008; Camhi *et al*., 2009), and both species are now listed as vulnerable.

Ecological risk assessments undertaken by ICCAT for eleven pelagic sharks indicated that the bigeye thresher has the lowest productivity and highest vulnerability with a productivity rate of 0.010, and that the common thresher is 10th in rank with a productivity rate of 0.141 (ICCAT, 2011).

11.13 Management considerations

The insufficient knowledge on the stock structures, as well as, on the stock status of both thresher shark species occurring in the NE Atlantic. However, Liu *et al*., 1998 consider that *Alopias* spp. are particularly vulnerable to overexploitation and need close monitoring because of their high vulnerability resulting from its low fecundity and relatively high age of sexual maturity.

In 2009, the International Commission for the Conservation of Atlantic Tuna (ICCAT, 2009) recommend the following:

1) "CPCs (The Contracting Parties, Cooperating non-Contracting Parties, Entities or Fishing Entities) shall prohibit, retaining on board, transhipping, landing, storing, selling, or offering for sale any part or whole carcass of

bigeye thresher sharks (*Alopias superciliosus*) in any fishery with exception of a Mexican small-scale coastal fishery with a catch of less than 110 fish.

2) CPCs shall require vessels flying their flag to promptly release unharmed, to the extent practicable, bigeye thresher sharks when brought along side for taking on board the vessel;

3) CPCs should strongly endeavour to ensure that vessels flying their flag do not undertake a directed fishery for species of thresher sharks of the genus *Alopias* spp;

4) CPCs shall require the collection and submission of Task I and Task II data for *Alopias* spp other than *A. superciliosus* in accordance with ICCAT data reporting requirements. The number of discards and releases of *A. superciliosus* must be recorded with indication of status (dead or alive) and reported to ICCAT in accordance with ICCAT data reporting requirements;

5) CPCs shall, where possible, implement research on thresher sharks of the species *Alopias* spp in the Convention area in order to identify potential nursery areas. Based on this research, CPCs shall consider time and area closures and other measures, as appropriate."

Precautionary management measures could be considered for the NE Atlantic thresher sharks, attributable to the fishing effort for large pelagic fish in the region.

11.14 References

Biery, L., and Pauly, D. 2012. A global review of species-specific shark fin to body mass ratios and relevant legislations. *Journal of Fish Biology*, 80 : 1643–1677.

Brachhini, M., Van Rijn, J., and Frick, L. 2012. High post-capture survival for sharks, rays and chimaeras discarded in the main shark fishery of Australia? PloS One, 7(2), e32547, 1–9.

Camhi, M. D. 2008. Conservation status of pelagic elasmobranchs. *In*: Sharks of the Open Ocean: Biology, Fisheries and Conservation (M.D.Camhi, E.K.Pikitch and E.A.Babcock, Eds). Blackwell Publishing, Oxford, UK. pp. 397–417.

Camhi, M. D., Valenti, S. V., Fordham, S. V., Fowler, S. L., and Gibson, C. 2009. The Conservation Status of Pelagic Sharks and Rays: Report of the IUCN Shark Specialist Group Pelagic Shark Red List Workshop. IUCN Species Survival Commission Shark Specialist Group. Newbury, UK. x + 78p.

Cao, D-M., Song, L-M., Zhang, Y., Lv, K-K., and Hu, Z-X. 2012. Environmental preferences of *Alopias superciliosus* and *Alopias vulpinus* in waters near the Marshall Islands. *New Zealand Journal of Marine and Freshwater Research*, 45: 103–119.

Ellis, J. R. 2004. The occurrence of thresher shark off the Suffolk coast. *Transactions of the Suffolk Naturalists' Society*, 40: 73–80.

Ellis, J.R.., McCully, S.R. and Poisson, F. 2014. A global review of elasmobranch discard survival studies and implications in relation to the EU 'discard ban'. Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 2014, 48 pp.

EU. 2012. Council Regulation (EU) No 44/2012 of 17 January 2012 fixing for 2012 the fishing opportunities available in EU waters and, to EU vessels, in certain non- EU waters for certain fish stocks and groups of fish stocks which are subject to international negotiations or agreements. Official Journal of the European Union, L, 25–144.

Fernandez-Carvalho, J., Coelho, R., Erzini, K., and Nevs Santos, M. 2011. Age and growth of the bigeye thresher shark, *Alopias superciliosus*, from the pelagic longline fisheries in the tropical northeastern Atlantic Ocean, determined by vertebral band counts. *Aquatic Living Resources*, 24: 359–368.

Fernandez-Carvalho, J., Coelho, R., Amorim, S., and Santos, M. 2012. Maturity of the bigeye thresher (*Alopias superciliosus*) in the Atlantic Ocean. SCRS/2011/086.

Carlson, J.K., and Gulak, S.J.B. 2012. Habitat use and movements patterns of oceanic whitetip, bigeye thresher and dusky sharks based on archival satellite tags. SCRS/2011/099.

Holmes, B. H., Steinke, D., and Ward, R. D. 2009. Identification of shark and ray fins using DNA barcoding. *Fisheries Research*, 95: 280–288.

ICCAT. 2009. Recommendation Rec.09-07 by ICCAT on the conservation of thresher sharks caught in association with fisheries in the ICCAT convention area.

ICCAT. 2011. Report for biennial period 2010–2011; Part I (2010). Vol. 2. SCRS. 285 p.

ICES. 2009. Report of the Joint Meeting between ICES Working Group on Elasmobranch Fishes (WGEF) and ICCAT Shark Subgroup, 22–29 June 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:16, 424 pp.

IUCN. 2006. 2006 IUCN Red List of Threatened Species. www.iucnredlist.org.

Liu, K.-M., Chiang, P.-J., and Chen, C.-T. 1998. Age and growth estimates of the bigeye thresher shark, *Alopias superciliosus*, in Northeastern Taiwan waters. *Fishery Bulletin*, 96: 482–491.

Moreno, J., and Moron, J. 1992. Reproductive biology of the bigeye thresher shark, *Alopias superciliosus* (Lowe, 1839). *Australian Journal of Marine and Freshwater Research*, 43: 77–86.

Nakano, H., Matsunaga, H., Okamoto, H., and Okazaki, M. 2003. Acoustic tracking of bigeye thresher shark *Alopias superciliosus* in the eastern Pacific Ocean. *Marine Ecology Progress Series*, 265: 255–261.

Poisson F. and Séret B. 2009. Pelagic sharks in the Atlantic and Mediterranean French fisheries: Analysis of catch statistics. ICCAT SCRS/2008/134. Collective Volume of Scientific Papers - ICCAT, 64(5): 1547–1567.

Sebastian, H., Haye, P. A., and Shivji, M. S. 2008. Characterization of the pelagic shark-fin trade in north-central Chile by genetic identification and trader surveys. *Journal of Fish Biology*, 73: 2293–2304.

Weng, K. C., and Block, B. A. 2004. Diel vertical migration of the bigeye thresher shark (*Alopias superciliosus*), a species possessing orbital retia mirabilia. *Fishery Bulletin*, 102: 221–229.

Table 11.1. Thresher sharks in the Northeast Atlantic and Mediterranean Sea. Landings of thresher sharks by European countries from 1997 to 2011 (ICCAT data). Landings prior to 1997 are in combined sharks.

DATA SOURCE	ICCAT				ICCAT			ICCAT	ICCAT	ICCAT		TOTAL
Nation	Spain				Portugal			France	UK	Ireland		
Year	*A. vul.*	*A. sup.*	*Alopias* spp.	Total	*A. vul.*	*Alopias* spp.	Total	*A. vul.*	*A. vul.*	*A. vul.*	*Alopias spp.*	
1997	30	138	25	193								193
1998	44	104	27	175								175
1999	na	na	56	56	1		1					57
2000	8	21	23	52		2	2			+		54
2001	21	35	62	118		2	2					120
2002	11	38	25	74	22		22					96
2003	8	18	1	27	18		18				+	45
2004	16	38	7	61	21		21	23			+	105
2005	na	na	na	?(1)	na			19				19
2006	na	na	na	?(1)	95		95 (2)		+	+		95
2007	14	32	na	46	79	3	81	37	1			165
2008	na	na	73	73	43		43	10	1			127
2009	28	50	na	78	43		43	32	1			154
2010	na	na	na		14		14	27	2			43
2011	na	na	na					41	1			42

(1) Spain previously reported 159 t in 2004 and 105 t in 2005; clarification of these catches is required.

(2) These landings require verification.

Table 11.2. Thresher sharks in the Northeast Atlantic and Mediterranean Sea. Estimates of landings of thresher sharks (*Alopias* spp.) by country and ICES subarea.

		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Azores													
Denmark	IV												
France	VI–IX	3	6	2	7	12	10	9	13	14	14	11	13
Ireland	VI–VIII												
Portugal	VII–IX			7	11	103	13	14	31	13	12	16	7
Portugal	CECAF				+	+	+	+	1	+	+		
Spain (Basque Country)	VIII												
Spain	VII–IX												
UK(E&W)	IV–VII												
Total		3	6	9	18	115	23	23	45	27	26	27	20

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Azores														0	0
Denmark	IV						.	.	+	.					
France	VI,VII, & IX	17	22	18	13	107	112	4	3	1	2	1	2	3	10
France	VIII									2	7	11	10	4	24
Ireland	VI													1	0
Ireland	VII						.	.	+	+			0	0	0
Portugal	VII - IX	13	37	24	12	15	25	21	17	33	80				
Portugal	CECAF	+	1	2	+										
Spain (Basque Country)	VIII														2
Spain	VII - IX		53	54	36	1			3	84	54				
UK(E&W)	IV											0		0	0
UK(E&W)	VII												1	1	1
Total		30	113	98	61	123	137	25	23	120	143	12	13	8	36

		2010	2011	2012	2013
Azores		0	0	0	
Denmark	IV		0		
France	VI,VII, & IX	4	4	6	9
France	VIII	21	36	27	24
Ireland	VI	0	0	0	
Ireland	VII	0	0	0	
Portugal	VII - IX				
Portugal	CECAF				
Spain (Basque Country)	VIII	0			
Spain	VII - IX				
UK(E&W)	IV	1	0	0	0
UK(E&W)	VII	1	1	1	1
Total		27	41	33	34

Table 11.3. Productivity values ranked from lowest to highest for main pelagic sharks in the ICCAT zone (from ICCAT 2011 report).

Species	*Productivity (r)*	*Productivity rank*
BTH (*Alopias superciliosus*)	0.010	1
SMA (*Isurus oxyrinchus*)	0.014	2
LMA (*Isurus paucus*)	0.014	3
POR (*Lamna nasus*)	0.053	4
FAL (*Carcharhinus falciformis*)	0.076	6
OCS (*Carcharhinus longimanus*)	0.087	7
SPL (*Sphyrna lewini*)	0.090	8
SPZ (*Sphyrna zygaena*)	0.124	9
ALV (*Alopias vulpinus*)	0.141	10
PST (*Pteroplatytrygon violacea*)	0.169	11
BSH (*Prionace glauca*)	0.301	12
CRO (*Pseudocarcharias kamoharai*)	-	-

Table 11.4. Von Bertalanffy growth parameters for *Alopias superciliosus* from the tropical North-eastern Atlantic (from Fernandez-Carvalho *et al.*, 2011).

Sex	Model	Parameter	Estimate	SE	95% CI	
					Lower	Upper
Sexes combined	VBGF	L_{inf}	247	18.0	212	283
		k	0.09	0.02	0.05	0.13
	AIC = 860.4	L_0	106	4.8	96	115
	VBGF Fixed L_0	L_{inf}	212	5.9	200	224
	AIC = 870.7	*k*	0.17	0.01	0.14	0.20
Males	VBGF	L_{inf}	206	10.1	186	227
		k	0.18	0.05	0.09	0.27
	AIC = 322.6	L_0	93	9.5	73	112
	VBGF Fixed L_0	L_{inf}	201	6.4	188	214
	AIC = 321.3	*k*	0.22	0.03	0.16	0.27
Females	VBGF	L_{inf}	293	42.6	208	378
		k	0.06	0.02	0.02	0.10
	AIC = 537.2	L_0	111	5.3	100	121
	VBGF Fixed L_0	L_{inf}	223	9.7	204	243
	AIC = 550.2	*k*	0.15	0.02	0.11	0.18

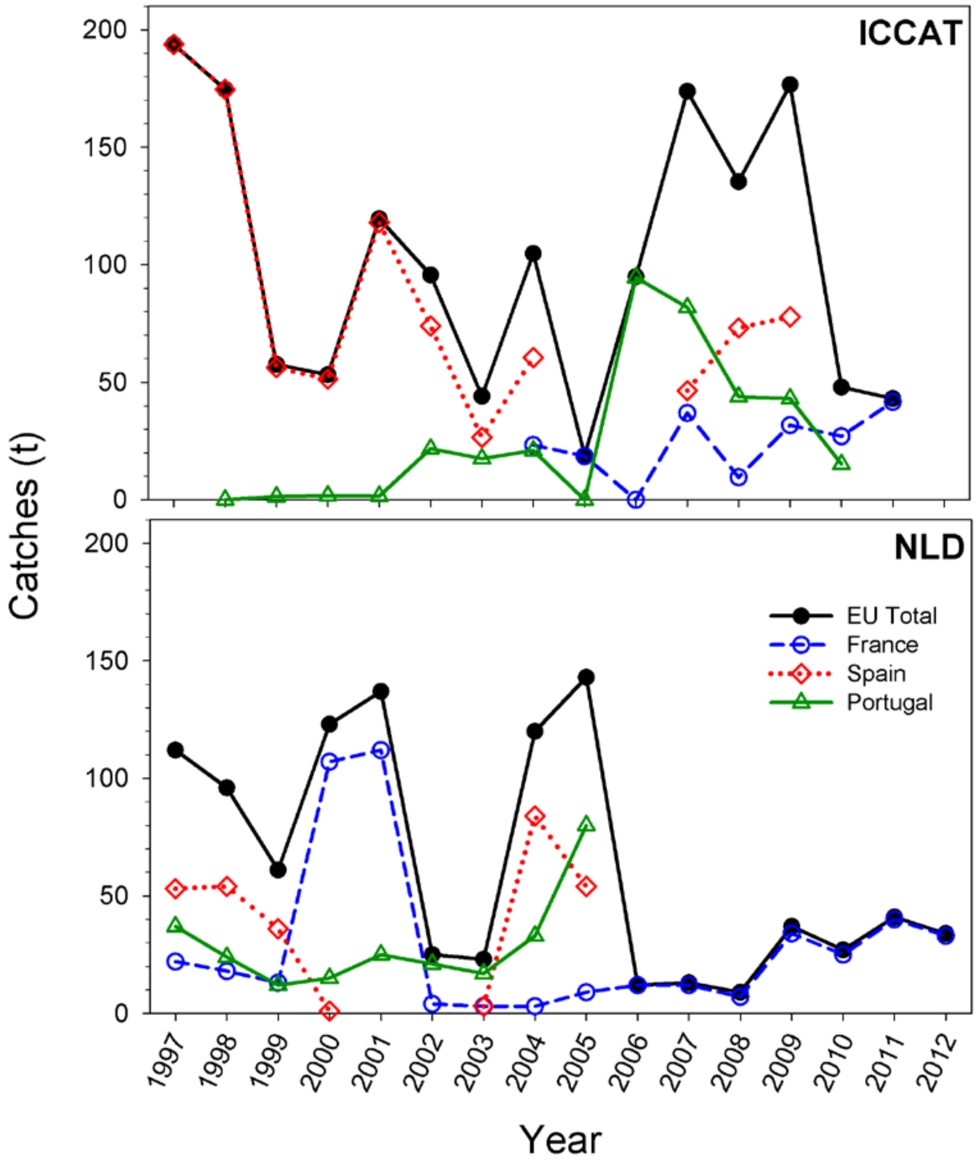


Figure 11.1. Thresher sharks in the Northeast Atlantic and the Mediterranean Sea. Preliminary estimates of landings as reported by Spain, Portugal and France to ICCAT (1997–2011, ICCAT database, upper panel) and national landings data (NLD) reported by these countries to WGEF (lower panel).

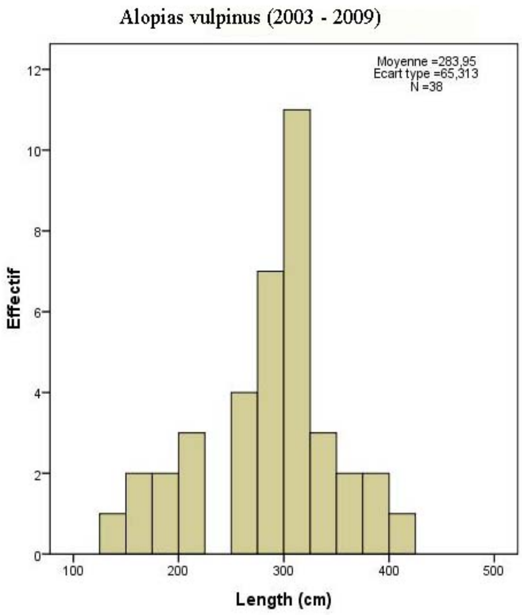


Figure 11.2. Length–frequency distributions for *Alopias vulpinus* sampled in the Divisions VIIIabcd in the framework of the Data Collection Regulation programme by observers on board French vessels between 2003 and 2009 (Fork length).

12 Other pelagic sharks in the Northeast Atlantic

12.1 Ecosystem description and stock boundaries

In addition to the pelagic species discussed in previous sections (Sections 6–11), several other pelagic sharks and rays occur in the ICES area (Table 12.1). Many of these taxa, including the hammerhead sharks (*Sphyrna* spp.) and requiem sharks (*Carcharhinus* spp.) are mainly tropical to warm temperate species, and often coastal, pelagic species. There is limited information with which to examine the stock structure of these species, and the ICES area would only be the northern extremes of their NE Atlantic distribution range. Other species, including long-fin mako, silky shark and oceanic white-tip are truly oceanic and likely to have either North Atlantic or Atlantic stocks, although data to confirm which are limited. These species are found mostly in the south-western parts of the ICES areas (e.g. Iberian Peninsula), though some may occasionally range further north. Some of these species also occur in the Mediterranean Sea.

12.2 The fishery

12.2.1 History of the fishery

These pelagic sharks and rays are taken as bycatch in tuna and swordfish fisheries (mainly longline, but also purse-seine). Some of them, like the hammerheads and the requiem sharks, may constitute a noticeable component of the bycatch and were traditionally landed, whilst others are only recorded sporadically (e.g. white shark, tiger shark and devil ray). Some of these species are an important bycatch in high seas fisheries (e.g. silky shark and oceanic whitetip) and others are taken in continental shelf waters of the ICES area (e.g. various requiem sharks and hammerhead sharks).

12.2.2 The fishery in 2013

No new information is available.

12.2.3 ICES advice applicable

ICES does not provide advice on these stocks.

12.2.4 Management applicable

EC Regulation No. 1185/2003 prohibits the removal of shark fins of these species, and subsequent discarding of the body. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

EC Regulation No 43/2009 prohibits Community vessels to fish for, to retain on board, to tranship and to land white shark (*Carcharodon carcharias*) in all Community and non-Community waters; and also prohibits third-country fishing vessels to fish for, to retain on board, to tranship and to land white shark in all Community waters.

In the same way, EC Regulation No 43/2014 prohibits Community vessels to fish for, to retain on board, to tranship and to land the giant manta ray *Manta birostris*.

ICCAT recommend that Contracting Parties "*prohibit, retaining onboard, transshipping, landing, storing, selling, or offering for sale any part or whole carcass*" of silky shark *Carcharhinus falciformis* (Recommendation 2011–08), oceanic whitetip shark *Carcharhinus* *longimanus* (Recommendation 2010–07) and all hammerhead sharks (Family Sphyrnidae, except bonnethead shark *Sphyrna tiburo*) (Recommendation 2010–08).

12.3 Catch data

12.3.1 Landings

No reliable estimates of catch are available for these species, as many nations that land various other species of pelagic sharks have often recorded them under generic landings categories. Species specific landings reported to ICES are given in Table 12.2 and amount to 765 t from 1999–2012. However, 98% (751 t) of these landings were made between 1999 and 2004. The main country reporting catch of these species during this period was Portugal, with 51 t of *Sphyrna* spp. and 331 t of *Carcharhinus* spp across all areas. During the same period France also reported 331 t of *Carcharhinus* spp, and Spain reported 2 t of *Sphyrna* spp. Since 2004, Portugal has only reported 10 t of *Sphyrna zygaena* (2007–2011), and Spain 4 t of pelagic stingray this year.

Since 1997, landings are also recorded in the ICCAT database (Table 12.3), and these data may provide the best catch estimates available, with a total of 28 614 t between 1997 and 2011. In the Northeast Atlantic, Spain and Portugal are the main countries reporting these species, with Portugal giving catches of 809 t and Spain 3562 t between 1997 and 2011. For Spain, the main catch is reported as *Sphyrna* spp., totalling 2431 t across the time-series. Other countries reporting catch to ICCAT are Senegal (23 420 t), France (518 t), Netherlands (37 t), the UK (12 t) and China-Taipei (4 t). Requiem sharks comprise the largest proportion of the catch at 69% (22 434 t), followed by hammerhead sharks at 30% (5950 t) and longfin mako sharks at 1% (173 t).

There are few catch data for the other pelagic species (e.g. tiger shark, devil ray and pelagic stingray) in national datasets, nor in the ICCAT database, except for some sporadic records of tiger sharks (45 t of which 37 t was made by the Netherlands in 2007, and the rest by Spain) in the ICCAT database between 1997 and 2011. Dutch records for tiger shark are thought to relate to an incorrect species code being used.

Catch data are provided for the Spanish longline swordfish fisheries in the NE Atlantic in 1997–1999 (Castro *et al.*, 2000; Mejuto *et al.*, 2002). They show that 99% of the bycatch of offshore longline fisheries consisted of pelagic sharks (Table 12.4), although 87% was blue shark.

Available landings data from FAO FishStat for the NE Atlantic (Table 12.5) are considered to be underestimates, as a consequence of the inconsistent reporting; however this is the only database to report devil ray landings (17 t by Spain 2004–2011).

12.3.2 Discards

No data available. Some species are usually retained, although pelagic stingray is most often discarded.

12.3.3 Quality of catch data

Catch data are of poor quality, except for some occasional studies of the Spanish Atlantic swordfish longline fishery (e.g. Castro *et al.*, 2000; Mejuto *et al.*, 2002). Biological data are not collected under the Data Collection Regulations, although some generic biological data are available (see Section 12.7). Species-specific identification in the field is problematic for some genera (e.g. *Carcharhinus* and *Sphyrna*).

Methods developed to identify shark species from fins (Sebastian *et al.*, 2008; Holmes *et al.*, 2009) could be used to gather data on species retained in IUU fisheries on the high seas, this information should aid in management and conservation.

12.3.4 Discard survival

There have been several studies on the at-vessel mortality of pelagic sharks in longline fisheries, although less data are available for purse seine fisheries. These studies were reviewed in Ellis *et al.* (2014 WD).

12.4 Commercial catch composition

Data on the species and length composition of these sharks are limited.

12.5 Commercial catch and effort data

No cpue data are available to WGEF for these pelagic sharks in the ICES area. However Cramer and Adams, 1998; Cramer *et al.*, 1998 and Cramer, 1999 provided catch rates for the Atlantic US longline fishery targeting tunas and swordfish; where cpue ranged from 2.7 individuals/1000 hooks in 1996 to 0.35 ind./1000 hooks in 1997. ICCAT is the main source for appropriate catch and effort data for pelagic sharks.

12.6 Fishery-independent data

No fishery-independent data are available for these species.

12.7 Life-history information

Little information is available on nursery or pupping grounds. Silky shark are thought to use the outer continental shelf as primary nursery ground (Springer, 1967; Yokota and Lessa, 2006), and young oceanic whitetip have been found offshore along the SE coast of the USA, suggesting offshore nurseries over the continental shelf (Seki *et al.*, 1998). Scalloped hammerhead nurseries are usually in shallow coastal waters.

The overall biology of several species has been reviewed, including white shark (Bruce, 2008), silky shark (Bonfil, 2008), oceanic whitetip (Bonfil *et al.*, 2008) and pelagic stingray (Neer, 2008). Other biological information is available in Branstetter, 1987; 1990; Stevens and Lyle, 1989; Shungo *et al.*, 2003 and Piercy *et al.*, 2007. A summary of the main biological parameters is given in Table 12.6.

Recent genetic analysis show that *Mobula mobular* from the Mediterranean Sea and adjacent NE Atlantic waters should be identical to the more wide-ranging *Mobula japonica* (Poortvliet *et al.*, in prep.). In relation to *M. mobular*, Fortuna *et al.* (2014) estimated the size of the population of *M. mobular* in the Adriatic Sea as 3255 adults, from 60 field observations and available biological parameters. It was reported that several hundred (estimates varied from 200 to 500) of this "endangered" and protected ray were caught by fishermen of the Gaza Strip on 27 February 2013.

12.8 Exploratory assessments

No specific assessments have been made of these stocks in the NE Atlantic. Cortés *et al.* (2010) undertook a level 3 quantitative Ecological Risk Assessment (ERA) for eleven pelagic elasmobranchs (blue shark, shortfin and longfin mako, bigeye and common thresher, oceanic whitetip, silky, porbeagle, scalloped and smooth hammerhead, and pelagic stingray). Of these species, silky shark was found to be high risk (along with shortfin mako and bigeye thresher sharks), and oceanic whitetip and longfin mako sharks were also considered to be highly vulnerable.

McCully *et al*. (2012) undertook a level 2, semi-quantitative ERA for pelagic fish in the Celtic Sea area, and of the 19 species considered (eight of which were elasmobranchs), porbeagle and shortfin mako sharks were found to be at the highest risk in longline and setnet fisheries, followed by common thresher. A comparable analysis examining the pelagic ecosystem for the Northeast Atlantic would be a useful exercise.

12.9 Stock assessment

No stock assessments have been undertaken.

12.10 Quality of the assessment

No assessment has been undertaken.

12.11 Reference points

No reference points have been proposed for these stocks.

12.12 Conservation consideration

The IUCN have assessed devil ray as 'Endangered', white shark, longfin mako, oceanic white-tip, dusky shark and sandbar shark as 'Vulnerable' and silky shark as 'Near threatened'. Pelagic stingray, which is generally discarded, was assessed as 'Least Concern' (Gibson *et al*., 2008).

The following species are included in the Memorandum of Understanding for Sharks (MoU-Sharks) of the Convention of Migratory Species (CMS): *Carcharodon carcharias*, *Isurus paucus* and *Manta birostris*.

12.13 Management considerations

Retaining on board, transhipping or landing any part or whole carcass of oceanic whitetip sharks (*Carcharhinus longimanus*) and silky shark (*Carcharhinus falciformis*) taken in any fishery is prohibited in the ICCAT area by the EU regulation n° 44/2012.

There is a paucity of the fishery data on these species, and this hampers the provision of management advice. Some of the species have conservation status: for example white shark is listed on Appendix II of the Barcelona Convention, Appendix II of the Bern Convention, Appendices I/II of the CMS and Appendix I of CITES.

In 2013, *Carcharhinus longimanus*, *Sphyrna lewini*, *Sphyrna mokarran*, *Sphyran zygaena*, *Manta birostris* and *Manta alfredi* were listed on Appendix II of CITES (Conference of Parties 16, Bangkok). The implementation of these listings was delayed by 18 months (14 September 2014) to enable Range States and importing States to address potential implementation issues.

In 2012, a consortium of scientific institutions (AZTI, IEO, IRD and Ifremer) obtained a contact from the EC to review the fishery and biological data on major pelagic sharks and rays. The aim was to identify the gaps that could be filled up in the frame of the implementation of the EU shark action plan (EUPOA-Sharks) in order to improve the monitoring of major elasmobranch species caught by both artisanal and industrial large pelagic fisheries on the high seas of the Atlantic, Indian and Pacific Oceans. It reviews and prioritises the gaps identified to develop a research programme to fill them in, to support the formulation of scientific advice for management. The main gaps concern fishery statistics, which are often not broken down by species, a lack of size–frequency data and regional biological/ecological information. The final report was given to the DG-Mare of the EU in May 2013 (DG-Mare, 2013).

In 2013, the shark species group of ICCAT proposed the framework of a Shark Research and Data Collection Program (SRDCP) to fill up the gaps in our knowledge on pelagic sharks that are responsible for much of the uncertainty in stock assessments, and have caused constraints to the provision of scientific advice. The final report is available at ICCAT website (ICCAT, 2013).

12.14 References

Bonfil, R. 2008. The biology and ecology of the silky shark, *Carcharhinus falciformis*. In *'Sharks of the Open Ocean: Biology, Fisheries and Conservation'* (M.D.Camhi, E.K.Pikitch and E.A.Babcock, Eds). Blackwell Publishing, Oxford, UK, 114–127.

Bonfil, R., Clarke, S. and Nakano, H. 2008. The biology and ecology of the oceanic whitetip shark, *Carcharhinus longimanus*. In *'Sharks of the Open Ocean: Biology, Fisheries and Conservation'* (M.D.Camhi, E.K.Pikitch and E.A.Babcock, Eds). Blackwell Publishing, Oxford, UK, 128–139.

Branstetter, S. 1987. Age, growth and reproductive biology of the silky shark, *Carcharhinus falciformis* and the scalloped hammerhead, *Sphyrna lewini,* from the northwestern Gulf of Mexico. *Environmental Biology of Fishes*, 19: 161–173.

Branstetter, S. 1990. Early life-history implications of selected *Carcharinoid* and *Lamnoid* sharks of the Northwest Atlantic. *NOAA Technical Report NMFS*, 90: 17–28.

Bruce, B. D. 2008. The biology and ecology of the white shark, *Carcharodon carcharias*. In *'Sharks of the Open Ocean: Biology, Fisheries and Conservation'* (M.D.Camhi, E.K.Pikitch and E.A.Babcock, eds). Blackwell Publishing, Oxford, UK, 69–81.

Castro, J., de la Serna, J.M., Macias, D., and Mejuto J. 2000. Estimaciones centificas preliminares de los desembarcos de especies asociadas realizados por la flota española de palange de superficie en 1997 y 1998. ICCAT SCRS/1999/082, Collection of Scientific Papers, 51(6): 1882–1893.

Cortés, E. Arocha, F. Beerkircher, L. Carvalho, F. Domingo, A. Heupel, M., Holtzhausen, H. Santos, M.N., Ribera, M. and Simpfendorfer C. 2010. Ecological Risk Assessment of pelagic sharks caught in Atlantic pelagic longline fisheries. *Aquatic Living Resources,* 23: 25–34.

Cramer, J. 1999. Pelagic longline bycatch. ICCAT Working document SCRS/99/90.

Cramer J., Bertolino A. and Scott G.P. 1998. Estimates of recent shark bycatch by US vessels fishing for Atlantic tuna and tuna-like species. ICCAT SCRS/1997/058, Collection of Scientific Papers, 48(3): 117–128.

Cramer, J., and Adams H. M. 1998. Pelagic longline bycatch. ICCAT Working document SCRS/98/113.

DG-Mare. 2013. Studies for Carrying out the Common Fisheries Policy (Reference: Mare/2010/11) LOT 2: Provision of scientific advice for the purpose of the implementation of the EUPOA sharks. Final report for the Directorate-General for Maritime Affairs and Fisheries. AZTI, IRD, Ifremer, IEO, 31st May 2013, 474 pp.

Ellis, J. R., McCully, S. R. and Poisson, F. 2014. A global review of elasmobranch discard survival studies and implications in relation to the EU 'discard ban'. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014, 48 pp.

Fortuna, C., Kell, L., Holcer, D., Canese, S., Filidei, E., Mackelworth, P. and Donavan, G. 2014. Summer distribution and abundance of the giant devil ray (*Mobula mobular*) in the Adriatic

Sea: Beseline data for an iterative management framework. Scientia Marina 78(2): doi:10.3989:scimar.03920.30D.

Gibson, C., Valenti, S. V., Fordham, S. V. and Fowler, S. L. 2008. The Conservation of Northeast Atlantic Chondrichthyans. Report of the IUCN Shark Specialist Group Northeast Atlantic Red List Workshop. viii + 76pp.

Holmes B. H., Steinke D., Ward R. D. 2009. Identification of shark and ray fins using DNA barcoding Fisheries Research 95: 280–288.

Hueter, R. E. And. Simpfendorfer, C. 2008. Case Study: Trends in Blue Shark Abundance in the Western North Atlantic as Determined by a Fishery-Independent Survey. In: Sharks of the Open Ocean; M. D. Chami, E. K. Pikitch and E. Babcock (eds.) 236–241.

ICCAT. 2013. Report of the 2013 inter-sessional meeting of the shark species group. Mindelo, Cape Verde, April 8–12, 2013. 81 pp.

ICES. 2007. Report of the Working Group for Regional Ecosystem Description (WGRED), 19–23 February 2007, ICES Headquarters, Copenhagen. ICES CM 2007/ACE:02. 153 pp.

Poortvliet, M., Olsen, J., Croll, D., Bernardi, G., Newton, K., Kollias, S., O'Sullivan, J., Fernando, D., Steven, G., Galván Magaña, F., Séret, B., Wintner, S., Hoarau, G. In preparation. Old lineage, recent species: a dated molecular phylogeny of manta and devil rays (Mobulidae) based on mitogenome and nuclear sequences.

McCully, S. R., Scott, F., Ellis, J. R. and Pilling, G. M. 2012. Productivity and susceptibility analysis: Application and suitability for data poor assessment of UK elasmobranchs. ICCAT SCRS/2012/079.

Mejuto, J., Garcia-Cortes, B., and de la Serna, J. M. 2002. Preliminary scientific estimations of by-catches landed by the Spanish surface longline fleet in 1999 in the Atlantic Ocean and Mediterranean Sea. ICCAT SCRS/2001/049, Collection of Scientific Papers, 54(4): 1150–1163.

Neer, J. A. 2008. The biology and ecology of the pelagic stingray, *Pteroplatytrygon violacea* (Bonaparte, 1832). In *'Sharks of the Open Ocean: Biology, Fisheries and Conservation'* (M. D.Camhi, E. K. Pikitch and E. A. Babcock, eds). Blackwell Publishing, Oxford, UK, 152–159.

Piercy, A. N, Carlson, J. K, Sulikowski, J. A., and Burgess, G. H. 2007. Age and growth of the scalloped hammerhead shark, *Sphyrna lewini*, in the Northwest Atlantic Ocean and Gulf of Mexico. *Marine and Freshwater Research*, 58: 34–40.

Sebastian H., Haye P. A. and Shivji M. S. 2008. Characterization of the pelagic shark-fin trade in north-central Chile by genetic identification and trader surveys. *Journal of Fish Biology* 73, 2293–2304.

Skomal, G.B. 1990. Age and growth of the blue shark, *Prionace glauca*, in the North Atlantic. Master's Thesis. University of Rhode Island, Kingston, RI. 82 pp.

Shungo, O., Hideki, N. and Sho, T. 2003. Age and growth of the silky shark *Carcharhinus falciformis* from the Pacific Ocean. *Fisheries Sciences*, 69(3): 456.

Spinger, S. 1967. Social organizations of shark populations. *In*: Gilbert P.W. (ed.) Sharks, Skates and Rays. John Hopkins Press, Baltimore, 149–174.

Seki, T., Taniuchi, T., Nakano, H., and Shimizu, M. 1998. Age, growth and reproduction of the oceanic whitetip shark from the Pacific Ocean. *Fisheries Sciences*, 64: 14–20.

Stevens, J. D., and Lyle, J. M. 1989. Biology of three hammerhead sharks (*Eusphyrna blochii, Sphyrna mokarran* and *S. lewini*) from northern Australia. *Australian Journal of Marine and Freshwater Research*, 40: 129–146.

Yokota, L. and Lessa, R. P. 2006. A nursery area for sharks and rays in Northeastern Brazil. *Environmental Biology of Fishes*, 75: 349–360.

Table 12.1. Other pelagic sharks in the Northeast Atlantic. Summary of the distribution of pelagic elasmobranchs in the ICES area. Species that are resident or caught frequently in an area are denoted ●, species that may occur as occasional vagrants denoted ⦿ and species that have not been recorded in an area are denoted ○. Adapted from Whitehead *et al.* (1989).

Family	Common name	Scientific name	ICES SubArea			
			VII	VIII	IX	Notes
Lamnidae	White shark	*Carcharodon carcharias*	○	⦿	⦿	[1]
	Longfin mako	*Isurus paucus*	○	○	⦿	
Carcharhinidae	Spinner shark	*Carcharhinus brevipinna*	○	○	⦿	
	Silky shark	*Carcarhinus falciformis*	○	○	⦿	
	Blacktip shark	*Carcharhinus limbatus*	○	○	⦿	
	Oceanic whitetip	*Carcharhinus longimanus*	○	⦿	⦿	[2]
	Dusky shark	*Carcharhinus obscurus*	○	○	⦿	
	Sandbar shark	*Carcharhinus plumbeus*	○	⦿	⦿	
	Night shark	*Carcharhinus signatus*	○	○	⦿	
	Tiger shark	*Galeocerdo cuvier*	?	?	⦿	[3]
Sphyrnidae	Scalloped hammerhead	*Sphyrna lewini*	○	○	⦿	
	Great hammerhead	*Sphyrna mokarran*	○	○	?	
	Smooth hammerhead	*Sphyrna zygaena*	⦿	⦿	⦿	
Dasyatidae	Pelagic stingray	*Pteroplatytrygon violacea*	⦿	⦿	⦿	[4]
Mobulidae	Devil ray	*Mobula mobular*	⦿	⦿	⦿	[5]
	Giant manta	*Manta birostris*	○	○	?	

[1] Three records from the Bay of Biscay; [2] One individual stranded in Swedish waters; [3] Some unconfirmed sightings in northern Europe; [4] Two specimens recorded from the North Sea; [5] Individual specimens reported from the Bay of Biscay (capture) and Celtic Sea (stranding).

Table 12.2. Other pelagic sharks in the Northeast Atlantic. Summary of landing data reported to WGEF of hammerhead and requiem sharks in the ICES subareas from 1999 to 2013; reported landings post 2004 are limited.

Species	Country	ICES area	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Hammerhead sharks (*Sphyrna* spp.)	Portugal	VIIIc	1											0	0	0	
		IX	6	8	4	5	5							0	0	0	
		IXa						18						0	0	0	
		X	1				2	1									
	Spain	IX a, b						2						0	0	0	
Sphyrna zygaena	Portugal	X									3	1	2	2	1	1	
Total *Sphyrna*			8	8	4	5	7	21			3	1	2	2	1	1	0
Requiem sharks (*Carcharhinus* spp.)	Portugal	VIb		1		1											
		IX		1		7	129	2									
		IXb						3									
		X	9	24	31	47	16	43									
		IX a, b						17									
	Spain	VIIIa															
	France		9	26	31	55	145	65									
Total Requiem			17	34	35	60	152	86									
Pelagic stingray	Spain	IXa													4		
Total pelgic sharks (all areas)			26	60	66	115	297	151	0	0	3	1	2	2	5	0,7	0

Table 12.3. Other pelagic sharks recorded in the ICCAT Task I Catch database for the Northeast Atlantic (1997–2012). Landings in 2011 and 2012 not yet available by country.

Country	Species Code	Scientific Name	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Spain	CCP	*Carcharhinus plumbeus*													4	0		
	CCS	*Carcharhinus signatus*		2			0			0						2		
	FAL	*Carcharhinus falciformis*		10			1			4			59		20			3
	OCS	*Carcharhinus longimanus*		2		0	4	0							18	56		
	RSK	*Carcharhinidae*		158	60		100	80	86	97				28				
	SPZ	*Sphyrna zygaena*		3		1	4	1		12			2		0			
	SPK	*Sphyrna mokarran*		1														
	SPL	*Sphyrna lewini*		3					0	2								
	SPN	*Sphyrna* spp	353	343		312	249	363	231	364			103		113			
	SPY	*Sphyrnidae*												124				
	LMA	*Isurus paucus*		3		4	16	24	24	28			16		37	20		
	TIG	*Galeocerdo cuvier*	1	3		1	1	1	0	0			0		1			
Portugal	OCS	*Carcharhinus longimanus*										0		1	1	18		
	CCS	*Carcharhinus signatus*						1457			5247	1035	1343					
	CVX	*Carcharhiniformes*											483					
	RSK	*Carcharhinidae*							155			18	5			0		
	SPZ	*Sphyrna zygaena*							1			4			0	6		
	SPN	*Sphyrna* spp				0	0		6			17	6	5	10	42		
	LMA	*Isurus paucus*														1		
Senegal	WSH	*Carcharodon carcharias*														18		
	DUS	*Carcharhinus obscurus*													1	0		
	OCS	*Carcharhinus longimanus*													1			
	RSK	*Carcharhinidae*									154		37					
	SPN	*Sphyrna* spp									311	173	217					
	SPZ	*Sphyrna zygaena*						1428			7		4	103				

Table 12.3. Continued. Other pelagic sharks recorded in the ICCAT Task I Catch database for the Northeast Atlantic (1997–2012).

Country	Species Code	Scientific Name	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
France	**RSK**	***Carcharhinidae***												**507**	**2**	**0**		
	SPL	***Sphyrna lewini***													**0**			
Netherlands	**TIG**	***Galeocerdo cuvier***											**37**					
United Kingdom	**SPL**	***Sphyrna lewini***													**12**	**0**		
Chinese Taipei	**FAL**	***Carcharhinus falciformis***												**1**	**3**			
	***Carcharhinus* spp. Total**		**0**	**172**	**60**	**0**	**104**	**1537**	**242**	**101**	**5401**	**1053**	**1927**	**536**	**48**	**94**	**200**	**17**
	***Sphyrna* spp. Total**		**353**	**349**	**0**	**313**	**253**	**1792**	**239**	**378**	**318**	**194**	**332**	**232**	**135**	**48**	**0**	**1**
	Total all species		**355**	**527**	**60**	**318**	**374**	**3354**	**505**	**508**	**5719**	**1247**	**2312**	**768**	**221**	**163**	**200**	**18**

Table 12.4. Other pelagic sharks in the Northeast Atlantic. Sharks bycatches of the Spanish swordfish longline fisheries in the NE Atlantic. Data from Castro *et al.*, 2000 and Mejuto *et al.*, 2002.

Shark bycatches of the Spanish longline swordfish fishery								
NE Atlantic	*Carcharhinus* spp.	*Sphyrna* spp.	*Galeocerdo cuvier*	*Isurus paucus*	*Mobula* spp.	Total bycatch	% sharks	% blue shark
1997	148	382	3	8		28 000	99.4	87.5
1998	190	396	5	8	7	26 000	99.4	86.5
1999	99	240	4	18	1	25 000	98.6	87.2

Table 12.5. Other pelagic sharks in the Northeast Atlantic. Reported landings (t) by country (Source FAO Fish-Stat) for Atlantic, northeast fishing area.

FAO FISHSTAT (2014)		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Country	Species																
Portugal	*Sphyrna zygaena*			8	8	4	5	7	20	3	13	9	7	5	4	0	0
Spain	*Mobula mobular*								1	3	3	2	1	3	4	5	0
	Sphyrna zygaena								5	10	< 0,5	3	2	1	< 0,5		
	Galeocerdo cuvier								2	4	5	3	2	-	< 0,5		
France	*Pteroplatytrygon violacea*																1
TOTAL		0	0		8	4	5	7	28	20	21	17	12	9	8	5	1

Table 12.6. Other pelagic sharks in the Northeast Atlantic. Preliminary compilation of life-history information for NE Atlantic sharks.

	Distribution Depth range	Max. TL cm	Egg development	Maturity size cm	Age at maturity (years)	Gestation period (months)	Litter size	Size at birth (cm)	Lifespan years	Growth	Trophic level
White shark *Carcharodon carcharias*	Cosmopolitan 0–1280 m	720	Ovoviviparous+ oophagy	372–402	8–10	?	7–14	120–150	36	L∞ = 544 K= 0.065 T0 = –4.40	4.42–4.53
Longfin mako *Isurus paucus*	Cosmopolitan	417	Ovoviviparous	> 245 F			2	97–120			4.5
Silky shark *Carcharhinus falciformis*	Circumtropical 0–500 m	350	Viviparous	210–220 M 225 F	6–7 7–9	12	2–15	57–87	25	L∞ = 291/315 K= 0.153 / 0.1 T0 = –2.2 / –3.1	4.4–4.52
Spinner shark *Carcharhinus brevipinna*	Circumtropical 0–100 m	300	Viviparous	176–212	7.8–7.9	10–12	Up to 20	60–80		L∞ = 214 FL K= 0.210 T0 = –1 .94	4.2–4.5
Oceanic whitetip *Carcharhinus longimanus*	Cosmopolitan 0–180 m	396	Viviparous	175–189	4–7	10–12	1–15	60–65	22	L∞ = 245 / 285 K= 0.103 / 0.1 T0 = 2.7 / – 3.39	4.16–4.39
Dusky shark *Carcharhinus obscurus*	Circumglobal	420	Viviaparous	220–280	14–18	22–24	3–14	70–100	40	L∞ = 349 / 373 K= 0.039/ 0.038 T0 = –7.04/ –6.28	4.42–4.61
Sandbar shark *Carcharhinus plumbeus*	Circumglobal 0–1800 m	250	Viviparous	130–183	13–16	12	1–14	56–75	32	L∞ = 186 FL K= 0.046 T0 = –6.45	4.23–4.49

	Distribution Depth range	Max. TL cm	Egg development	Maturity size cm	Age at maturity (years)	Gestation period (months)	Litter size	Size at birth (cm)	Lifespan years	Growth	Trophic level
Night shark *Carcharhinus signatus*	Atlantic 0–600 m	280	Viviparous	185–200	8–10	~12	4–12	60		L∞ = 256 / 265 K= 0.124 / 0.114 T0 = –2.54 / – 2.7	4.44–4.5
Tiger shark *Galeocerdo cuvier*	Circumglobal 0–350 m	740	Ovoviviparous	316–323	8–10	13–16	10–82	51–104	50	L∞ = 388 / 440 K= 0.18 / 0.107 T0 = –1.13 / –2.35	4.54–4.63
Scalloped hammerhead *Sphyrna lewini*	Cosmopolitan 0–512 m	430	Viviparous	140–250	10–15	9–10	13–31	45–50	35	L∞ = 320 / 321 K= 0.249 / 0.222 T0 = –0.41 / – 0.75	4.0–4.21
Great hammerhead *Sphyrna mokarran*	Circumglobal 1–300 m	610	Viviparous	250–292		11	13–42	60–70		L∞ = 264 / 308 (FL) K= 0.16 / 0.11 T0 = -1.99 / -2.86	4.23–4.43
Smooth hammerhead *Sphyrna zygaena*	Circumglobal 0–200 m	500	Viviparous	210–265		10–11	20–50	50–60			4.32–4.5
Pelagic stingray *Pteroplatytrygon violacea*	Cosmopolitan 37–238	160	Ovoviviparous	35–40 DW	2–3	2–4	4–9	15–25 DW	~10	L∞ = 116 DW K= 0.0180	4.36
Devil ray *Mobula mobular*	NE Atl. + Med. epipelagic	520	Ovoviviparous			25	1	≤ 166 DW			3.71

13 Demersal elasmobranchs in the Barents Sea

13.1 Ecoregion and stock boundaries

Lynghammar *et al*. (2013) reviewed the occurrence of all chondrichthyan fishes in the Barents Sea ecoregion. Skate species inhabiting the offshore area are thorny skate *Amblyraja radiata*, Arctic skate *Amblyraja hyperborea*, round skate *Rajella fyllae*, spinytail skate *Bathyraja spinicauda*, common skate *Dipturus batis* complex, sailray *Rajella lintea*, longnose skate *Dipturus oxyrinchus* and shagreen ray *Leucoraja fullonica* (Andriyashev, 1954; Dolgov, 2000; Dolgov *et al*., 2005a; Wienerroither *et al*., 2011), but few occur in high abundances. All skate species occurring in the offshore areas are also found in the coastal areas of this ecoregion, with the exception of *A. hyperborea, D. oxyrinchus* and *R. lintea* (Williams *et al*., 2008). The spatial distribution of chondrichthyan fishes in the Barents Sea, as observed in recent surveys, has been described by Wienerroither *et al*. (2011; 2013). With regards to sharks, Greenland shark *Somniosus microcephalus* occurs in this ecoregion (Section 24).

Amblyraja radiata is the dominant species, comprising 96% by number and about 92% by biomass of skates caught in surveys or as bycatch. The next most abundant species are *A. hyperborea* and *R. fyllae* (3% and 2% by number, respectively), and the remaining species are scarce (Dolgov *et al*., 2005a; Drevetnyak *et al*., 2005).

The species composition of skates caught in the Barents Sea differs from those recorded in the Norwegian Deep and northeastern Norwegian Sea (Skjaeraasen and Bergstad, 2000; 2001). Although *A. radiata* is the dominant species in both areas, the proportion of warmer-water species (*B. spinicauda* and *R. lintea*) is lower and the portion of cold-water species (*A. hyperborea*) is higher in the Barents Sea.

Stock boundaries are not known for the species in this area. Neither are the potential movements of species between the coastal and offshore areas. The adjacent Norwegian coastal area has been included within the Barents Sea ecoregion. Further investigations are necessary to determine potential migrations or interactions of elasmobranch populations within this ecoregion and adjacent areas.

13.2 The fishery

13.2.1 History of the fishery

All skate species in the ecoregion may be taken as bycatch in demersal fisheries, but there are no directed fisheries targeting skates in the Barents Sea. Detailed data on catches of skates from the Barents Sea are only available from bycatch records and surveys from 1996–2001 and 1998–2001, respectively (provided by Dolgov *et al*., 2005a; 2005b). Bottom-trawl fisheries target cod *Gadus morhua* and haddock *Melanogrammus aeglefinus* mainly, and longline fisheries target cod, blue catfish *Anarhichas denticulatus* and Greenland halibut *Reinhardtius hippoglossoides*. These are conducted through all seasons and have a skate bycatch, which is generally discarded. Dolgov *et al*. (2005b) estimated the total catch of skates taken by the Russian fishing fleet operating in the Barents Sea and adjacent waters in 1996–2001, and found that it ranged from 723–1891 t (average of 1250 t per year). *A. radiata* accounted for 90–95% of the total skate bycatch.

13.2.2 The fishery in 2013

No new information.

13.2.3 ICES advice applicable

ICES has never provided advice for any of the skate stocks in this ecoregion.

13.2.4 Management applicable in 2013

There are no TACs for any of the skate species in this ecoregion.

Norway has a general ban on discarding. Since 2010 all dead or dying skates and other fish in the catches should be landed, whereas live specimens can be discarded.

13.3 Catch data

13.3.1 Landings

For ICES Subarea I, landings data are limited and only available for all skate species combined (Table 13.1; Figure 13.1). Landings from the most westerly parts of the Barents Sea ecoregion fall within Subarea II (see Section 14). Russia and Norway are the main countries landing skates from the Barents Sea. Russian landings are not available since 2011.

Elasmobranch landings in ICES Subarea I have generally been low, but there have been large fluctuations in Russian landings. The peak in Russian landings in the 1980s corresponds to an experimental fishery for skates, whereby bycatches were landed as opposed to discarded (Dolgov, personal communication, 2006).

13.3.2 Discards

Estimates by Dolgov *et al.* (2005b) indicated that the total annual bycatch of skates from commercial trawl and longline fisheries in the Barents Sea ranged from 723–1891 t. *A. radiata* accounted for 90–95% of the total skate catch. *A. radiata* also dominated catches by the Norwegian Reference Fleet (and thereby presumably discards) in ICES Subarea I in 2008–2009 (Vollen, 2010 WD).

13.3.3 Quality of catch data

There is a lack of species-specific data in reported landings. Also, landings data do not reflect the true catches of skates in the commercial fishery in the Barents Sea as some fleets discard skates of low commercial value.

The Norwegian oceanic reference fleet (commercial vessels) collect biological data for the Institute of Marine Research (IMR) in Bergen, and some of these vessels are trawlers and longliners operating in the Barents Sea in various parts of the year. Personnel on board these vessels are obliged to measure the quantity of all fish species, including elasmobranchs. Data from 2008–2009 were analysed for species composition of elasmobranchs and reported to the WGEF (Vollen, 2010 WD). The results supported earlier findings regarding the dominance of *A. radiata* (>95% of both weight and numbers) in catches from ICES Subarea I (Table 13.2). It is concluded that most skates are discarded, as the yearly catch/vessel reported by the reference fleet is very high compared with corresponding numbers from the official Norwegian landings statistics. Future analysis of these data should include quantities and proportions of elasmobranchs in relation to commercial teleosts such as cod and haddock.

13.3.4 Discard survival

No data available to WGEF for the fisheries in this ecoregion.

13.4 Commercial catch composition

13.4.1 Species and size composition

Generally, larger skates are more often caught in longline fisheries than in trawl fisheries (Dolgov *et al*., 2005b).

Vinnichenko *et al.* (2010 WD) reported that catches of skates in Russian trawl and longline bottom fisheries in 2009 (60–400 m depths) were dominated by *A. radiata* (90–95%). Although some seasonal differences were found, *A. radiata* ranged from 7–61 cm total length. On average, males predominated in the samples, with a sex ratio of 1.2:1. Length compositions for commercial bottom trawl catches are given in Figure 13.2. Other species occurring were *R. fyllae*, *A. hyperborea*, *B. spinicauda* and *R. lintea*. These findings were supported by data from the Norwegian Reference Fleet for 2008–2009 (Vollen, 2010 WD).

Dolgov *et al.* (2005b) reported mean length and sex ratio for four species of skate in the Barents Sea. The sex ratio was 1:1 in commercial catches for all skate species except *A. hyperborea*, of which males dominated in the longline fishery (see ICES, 2007 for further information).

13.5 Commercial catch and effort data

Some relative cpue data are available for *A. radiata*, *A. hyperborea*, *R. fyllae* and *D. batis* complex in trawl and longline fisheries, respectively. Total catches of skates in Russian fisheries in the Barents Sea and adjacent areas for the years 1996–2001 were summarized in ICES (2007).

Catch data from other nations are limited and analyses of more recent Russian data are required.

13.6 Fishery-independent surveys

13.6.1 Russian bottom trawl survey (RU-BTr-Q4)

For the offshore areas, data from October–December survey cruises (RU-BTr-Q4) were available (Dolgov *et al*., 2005b; Drevetnyak *et al*., 2005; summarized in ICES, 2007) for the years 1996–2003. These studies described the distribution and habitat utilization of skates (*A. radiata*, *A. hyperborea*, *R. fyllae*, *D. batis* complex, *B. spinicauda* and *R. lintea*) in the Barents Sea.

Vinnichenko *et al.* (2010 WD) reported on catches of *A. radiata* from the 2009 Russian bottom trawl survey in October–December (RU-BTr-Q4). Individuals of 8–61 cm in length were found, but catches were dominated by males 41–56 cm long and females 31–50 cm long (Figure 13.3). The average length of males (41.6 cm) was greater than that of females (38.8 cm), and the sex ratio was about equal (1.02:1).

13.6.2 Norwegian coastal survey (NOcoast-Aco-Q4)

The distribution and diversity of elasmobranch species in the northern Norwegian coastal areas were assessed by Williams *et al.* (2008) and Wienerroither *et al.* (2011, 2013). The results were summarized in ICES (2007; 2008). New data from this survey should be analysed and presented to the WGEF, as some of the issues regarding species misidentification have been resolved.

13.6.3 Deep stations from multiple Norwegian surveys (NO-GH-Btr-Q3 and others)

Vollen (2009 WD) reported on elasmobranch catches from deep trawl hauls (400–1400 m) along the continental slope (62–81°N) in 2003-2009. The area investigated covered the Norwegian Sea ecoregion, as well as the border between the Norwegian Sea and Barents Sea ecoregions. Results were summarized in ICES (2009), in the Norwegian Sea ecoregion (Section 14).

13.6.4 Joint Russian-Norwegian surveys (BS-NoRu-Q1 (BTr), Eco-NoRu-Q3 (Aco)/Eco-NoRu-Q3 (Btr))

Two joint Russian–Norwegian surveys are conducted in the Barents Sea. The cruises run in February (BS-NoRu-Q1 (BTr)), in the southern Barents Sea northwards to the latitude of Bear Island, and August–September (Eco-NoRu-Q3 (Aco)/Eco-NoRu-Q3 (Btr)), covering the whole of the Barents Sea including waters near Spitsbergen and Franz Josef Land. The Norwegian part of the February survey started in 1981, but data on elasmobranchs are missing for some years. The August–September survey started in 2003. All skate species were recorded during these surveys, and data on length were collected, as well as some biological data on board of Russian vessels. However due to initial species identification problems, species-specific data should only be used from the years 2006–2007 onwards (Norwegian data). Data analyses derived from 2007 survey were presented by Vinnichenko *et al.* (2010 WD):

A. hyperborea Fishes with length ranging from 11 to 80 cm occurred in August–September 2009 catches. The catches were dominated by males with length varying from 21 to 71 cm with two maxima at 26 and 66 cm. The length of most of the females varied from 41 to 76 cm (Figure 13.4). The mean length of males (52.4 cm) was significantly lower than that of females (56.3 cm). Males predominated in the catches (sex ratio of 1.5:1).

B. spinicauda: Individuals over a length range of 86–140 cm were caught in August–September 2009. They were feeding on herring and capelin.

A. radiata: Individuals over a length range of 11–56 cm were caught in February 2009 (Figure 13.5). The lengths of males were mainly 46–55 cm; that of females 36–50 cm. A low proportion of specimens were <31 cm. The average length of males (43.8 cm) was larger than that of females (35.2 cm). The sex ratio in catches was approximately equal (1.01:1).

In August–September 2009, the length of *A. radiata* varied from 7 to 57 cm (Figure 13.6). The length–frequency distribution shows several modes reflecting the occurrence of different size/age classes of *A. radiata*. The mean length of males (41.8 cm) was larger than that of females (38.0 cm). The catches were dominated by males (sex ratio of 1.2:1).

Vinnichenko *et al.* (2010 WD) also reported on compiled data for *A. radiata* from the 2009 Russian surveys (October–December) and the 2009 joint Russian–Norwegian surveys (February and August–September). By the data averaged for the year, males predominated in samples, and the sex ratio was 1.2:1. More than half of the individuals (55–60%) were in a maturing stage, 35–40% of the fish were mature and only 2–3% were active or advanced (Figure 13.7). The diet comprised various fish species and decapod crustaceans (39% and 35% by weight, respectively; Figure 13.8). Among fish, capelin and haddock juveniles were intensively consumed, among the decapods, the northern shrimp *Pandalus borealis* and spider crabs *Hyas* spp.

13.6.5 Quality of survey data

The difficulties associated in identifying skate species are a serious concern when considering the validity of the survey data used for assessment purposes. Williams (2007) gave a detailed description of identification issues for *A. radiata* vs. *R. clavata* in the Norwegian Sea ecoregion. Also, the occurrence of *D. batis* complex (possibly confused with *B. spinicauda*, see depth distribution of the two species in Dolgov *et al.* (2005a)) and *L. fullonica* in the Barents Sea have been questioned by Lynghammar *et al.* (in press), as no specimens could be obtained for genetic analyses since 2007. As a consequence the survey data for skates must be thoroughly examined and quality checked before these are used in assessments.

In order to achieve a satisfactory quality of survey data in future, better identification practices, using appropriate identification literature, needs to be put in place. Ongoing work to improve future sampling at the Institute of Marine Research includes workshops to educate staff as well as improved field guides and keys used for species identification.

13.7 Life-history information

Length data for *A. radiata, A. hyperborea, R. fyllae, D. batis* complex and *B. spinicauda* are available in Dolgov *et al.* (2005a; 2005b) and Vinnichenko *et al.* (2010 WD; see ICES, 2007; 2010). Some biological information is available in the literature (e.g. Berestovskii, 1994). Sampling of elasmobranch egg-cases has been included in Norwegian trawl surveys from mid-2009, and may provide future information on nursery grounds.

13.8 Exploratory assessment models

No assessments have been conducted.

13.9 Quality of assessments

No assessments have been conducted, as a consequence of insufficient data. Analyses of survey trends may allow the general status of the more frequent species to be evaluated, although taxonomic irregularities need to be addressed first.

13.10 Reference points

No reference points have been proposed.

13.11 Conservation considerations

See Section 12.11.

13.12 Management considerations

There are no TACs for any of the demersal skates in this region. The elasmobranch fauna of the Barents Sea is little studied and comprises relatively few species. The most abundant skate in the area is *A. radiata*, which is widespread and abundant in this and adjacent waters. Further studies are required, particularly for some of the larger-bodied skates, which may be more vulnerable to overfishing.

13.13 References

Andriyashev, A. P. 1954. Fishes of the Arctic seas of the USSR. Guide to identification of USSR fauna of the Zoological Institute of the USSR Academy of Science, Acad. Sci. Press, No. 53. 566 pp. (in Russian).

Berestovskii, E. G. 1994. Reproductive biology of skates of the family Rajidae in the seas of the far north. *Journal of Ichthyology*, 34: 26–37.

Dolgov, A. V. 2000. New data on composition and distribution of the Barents Sea ichthyofauna. ICES C.M. 2000/Mini:12. 13 pp.

Dolgov, A. V., Drevetnyak, K. V. and Gusev, E. V. 2005a. The status of skate stocks in the Barents Sea. *Journal of Northwest Atlantic Fisheries Science*, 35: 249–260.

Dolgov, A. V., Grekov, A. A., Shestopal, I. P. and Sokolov, K. M. 2005b. By-catch of skates in trawl and long-line fisheries in the Barents Sea. *Journal of Northwest Atlantic Fisheries Science,* 35: 357–366.

Drevetnyak, K. V., Dolgov, A. V., Sokolov, K. M., Gusev, E. V. and Grekov, A. A. 2005. Skates in the Barents Sea: stock status and catch by fishing fleet. ICES CM 2005/ N:11. 14 pp.

ICES. 2007. Report of the Working Group Elasmobranch Fishes (WGEF), 22–28 June 2007, Galway, Ireland. ICES CM 2007/ACFM:27. 318 pp.

ICES. 2008. Report of the Working Group Elasmobranch Fishes (WGEF), 3–6 March 2008, Copenhagen, Denmark. ICES CM 2008/ACOM:16. 332 pp.

ICES. 2009. Report of the Joint Meeting between ICES Working Group on Elasmobranch Fishes (WGEF) and ICCAT Shark Subgroup, 22–29 June 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:16. 424 pp.

ICES. 2010. Report of the Working Group on Elasmobranch Fishes (WGEF), 22–29 June 2010, Horta, Portugal. ICES CM 2010/ACOM:19. 519 pp.

Lynghammar, A., Christiansen, J. S., Mecklenburg, C. W., Karamushko, O. V., Møller, P. R. and Gallucci, V. F. 2013. Species richness and distribution of chondrichthyan fishes in the Arctic Ocean and adjacent seas. *Biodiversity*, 14: 57–66.

Lynghammar, A., Christiansen, J. S., Griffiths, A. M., Fevolden, S-E., Hop, H. and Bakken, T. In press. DNA barcoding of the northern Northeast Atlantic skates (Chondrichthyes, Rajidae), with remarks on the widely distributed starry ray. *Zoologica Scripta*, doi: 10.1111/zsc.12064.

Skjaeraasen, J. E. and Bergstad, O. A. 2000. Distribution and feeding ecology of *Raja radiata* in the northeastern North Sea and Skagerrak (Norwegian Deep). *ICES Journal of Marine Science*, 57: 1249–1260.

Skjaeraasen, J. E. and Bergstad, O. A. 2001. Notes on the distribution and length composition of *Raja linteus, R. fyllae, R. hyperborea* and *Bathyraja spinicauda* (Pisces: Rajidae) in the deep northeastern North Sea and on the slope of the eastern Norwegian Sea. *ICES Journal of Marine Science*, 58: 21–28.

Vinnichenko, V. I., Dolgov, A. V., Yurko, A. S., Zhivov, B. D. and Safronov, A. M. 2010. Russian research and fisheries of sharks and skates in the Northeast Atlantic in 2009. Working document for the ICES Elasmobranch Working Group (WGEF) 2010.

Vollen, T. 2009. Distribution of chondrichthyan species in Norwegian deep-sea waters. Working document for the ICES Elasmobranch Working Group (WGEF) 2009.

Vollen, T. 2010. The Norwegian Reference Fleet: Catch and discard of elasmobranchs. Working document for the ICES Elasmobranch Working Group (WGEF) 2010.

Wienerroither, R., Johannesen, E., Dolgov, A., Byrkjedal, I., Bjelland, O, Drevetnyak, K., Eriksen, K. B., Høines, Å., Langhelle, G., Langøy, H., Prokhorova, T., Prozorkevich, D. and

Wenneck, T. 2011. Atlas of the Barents Sea Fishes. IMR/PINRO Joint Report Series 1-2011. ISSN 1502-8828.

Wienerroither, R., Johannesen, E., Dolgov, A., Byrkjedal, I., Aglen, A., Bjelland, O., Drevetnyak, K., Eriksen, K. B., Høines, Å., Langhelle, G., Langøy, H., Murashko, P., Prokhorova, T., Prozorkevich, D., Smirnov, O. and Wenneck, T. 2013. Atlas of the Barents Sea Fishes based on the winter survey. IMR-PINRO Joint Report Series 2-2013. ISSN 1502-8828. 220 pp.

Williams, T. 2007. Cartilaginous fishes along the North-Norwegian coast. Distributions and densities with regard to fishing and sea temperature. Master thesis in International Fisheries Management. Norwegian College of Fishery Science. University of Tromsø. 62 pp. http://www.ub.uit.no/munin/handle/10037/975.

Williams, T., Helle, K. and Aschan, M. 2008. The distribution of chondrichthyans along the north coast of Norway. *ICES Journal of Marine Science*, 65: 1161–1174.

Table 13.1. Demersal elasmobranchs in the Barents Sea. Total landings of skates and rays from ICES Subdivision I, 1973–2013. Total landings (tonnes). "n.a." = no data available, "." = means zero catch, "+" = <0.5 tonnes.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Belgium	.	.	.	1	.	.	.	.	.	.	.	.	.	.
France	.	.	.	81	49	44	.	.	.	.	.	.	.	.
Germany	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Iceland	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Norway	.	.	.	1	3	4	8	2	2	2	1	10	11	3
Portugal	.	.	100	11	1	.	.	+	.	.	.	.	.	.
USSR/Russian Fed.	n.a.	n.a.	n.a.	n.a.	n.a.	1126	168	93	3	1	n.a.	563	619	2137
Spain	.	.	.	.	.	.	.	.	.	.	.	.	.	.
UK(E&W)	78	46	49	33	70	9	8	4	+	1	.	+	+	+
UK(Scotland)	.	.	1	2	2	.	.	.	.	.	.	.	.	.
Total	78	46	150	129	125	1183	184	99	5	4	1	573	630	2140
	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Belgium	.	.	.	.	.	.	.	.	.	.	.	.	.	.
France	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Germany	.	.	.	.	.	.	.	2	.	.	.	.	.	.
Iceland	.	.	.	.	.	.	1	.	.	+	1	.	.	4
Norway	14	7	4	1	5	24	29	72	9	27	3	13	21	12
Portugal	.	.	.	.	.	.	.	.	.	.	.	.	.	.
USSR/Russian Fed.	2364	2051	1235	246	n.a.	399	390	369	n.a.	n.a.	399	790	568	502
Spain	.	.	.	.	.	.	.	.	7	.	.	.	.	.
UK(E&W)	2	.	+	.	.	.	.	.	.	.	.	.	+	.
UK(Scotland)	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Total	2380	2058	1239	247	5	423	420	443	16	27	403	803	589	518
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	
Belgium	.	.	.	.	.	.	.	.	.	.	.	.	.	
France	.	.	.	.	.	.	.	.	.	.	.	.	.	
Germany	.	.	.	.	.	.	+	.	.	+	.	.	0.0	
Iceland	.	.	.	3	3	.	.	.	.	.	.	.	.	
Norway	30	26	2	1	4	13	4	72	15	9	31	109	171	
Portugal	.	.	.	+	.	.	.	.	.	.	.	.	.	
USSR/Russian Fed.	218	173	38	69	37	48	24	6	2	1	n.a.	n.a.	n.a.	
Spain	.	.	.	.	.	.	.	.	.	.	.	.	.	
UK(E&W)	.	.	.	.	.	.	.	.	.	.	+	.	.	
UK(Scotland)	.	.	.	.	.	.	.	.	.	.	.	.	.	
Total	248	199	40	73	44	61	28	78	17	10	31	109	171	

Table 13.2. Demersal elasmobranchs in the Barents Sea. Species composition of elasmobranch catches in ICES Subdivision I by the Norwegian Oceanic Reference Fleet (2008–2009). Total catch of elasmobranchs, presented both as percentage of biomass and percentage of catch. (Source: Vollen, 2010 WD).

	Total catch (% biomass)		Total catch (% numbers)	
Species	Longlines	Trawl	Longlines	Trawl
Amblyraja radiata	96.4	99.7	97.3	98.5
Amblyraja hyperborea	+		+	
Dipturus batis complex	0.2		+	
Rajella fyllae	0.1		0.2	
Dipturus oxyrinchus		0.3		1.5
Bathyraja spinicauda	0.3		0.1	
Skates indet	2.9		2.4	

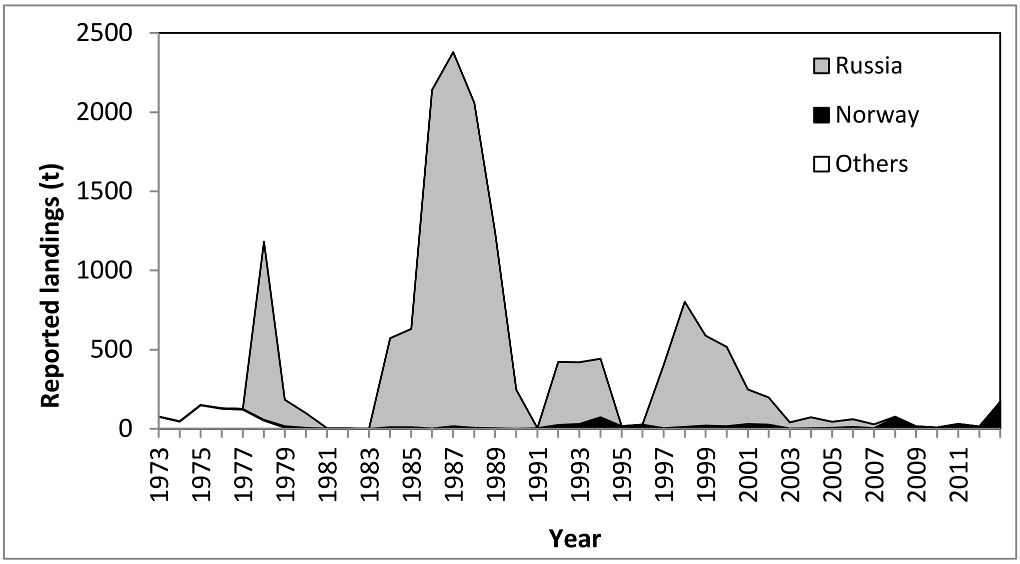


Figure 13.1. Demersal elasmobranchs in the Barents Sea. Skates and rays from ICES Subdivision 1, 1973–2013. Total landings (tonnes).

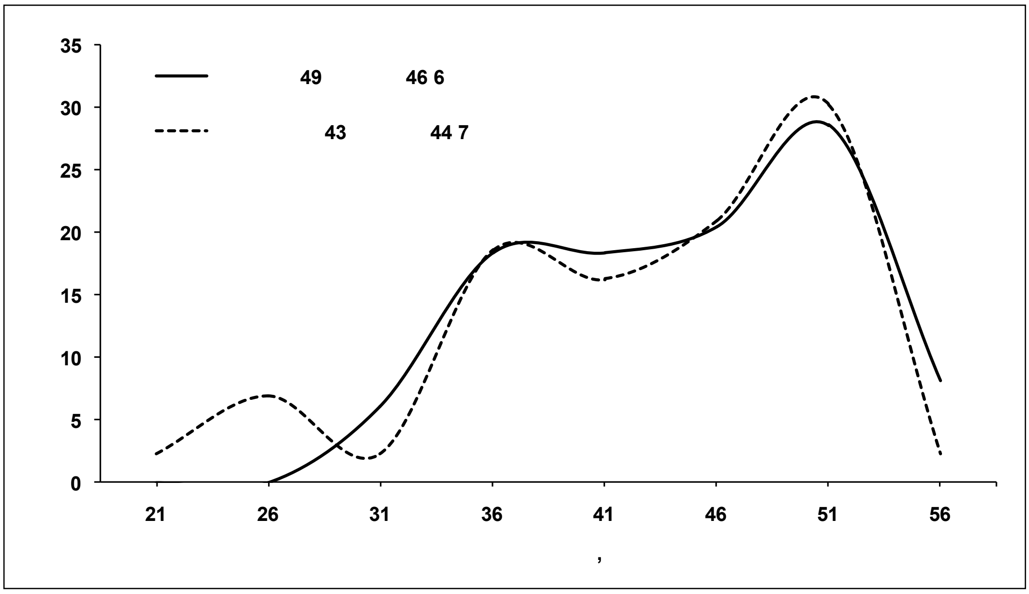


Figure 13.2. Demersal elasmobranchs in the Barents Sea. Length composition of *A. radiata* from commercial bottom-trawl catches in the Barents Sea in 2009. (Source: Vinnichenko *et al.*, 2010 WD).

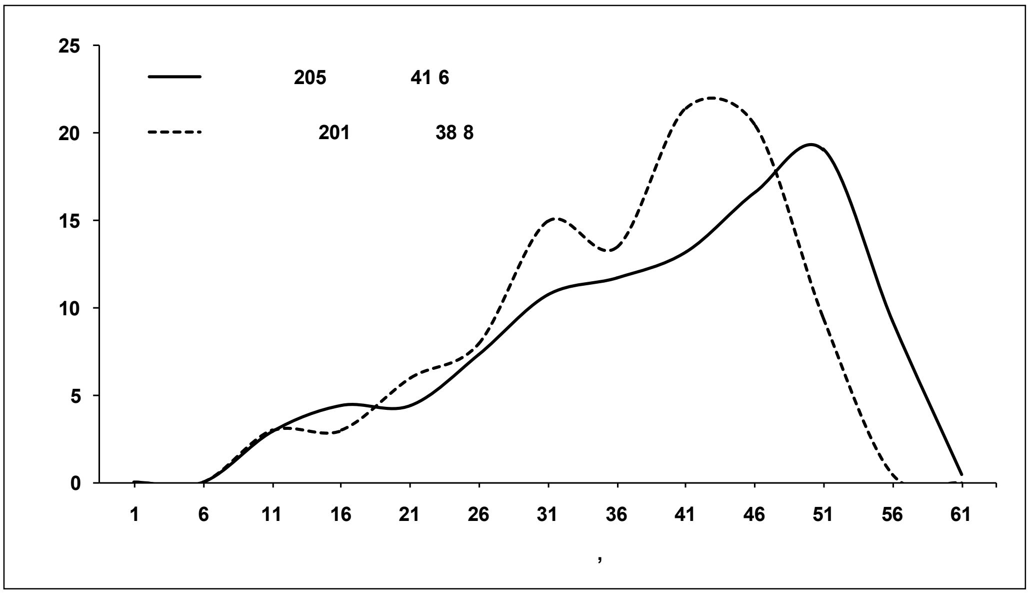


Figure 13.3. Demersal elasmobranchs in the Barents Sea. Length composition of *A. radiata* in the Barents Sea (Area I) based on data of the Russian demersal survey (October–December 2009). (Source: Vinnichenko *et al.*, 2010 WD).

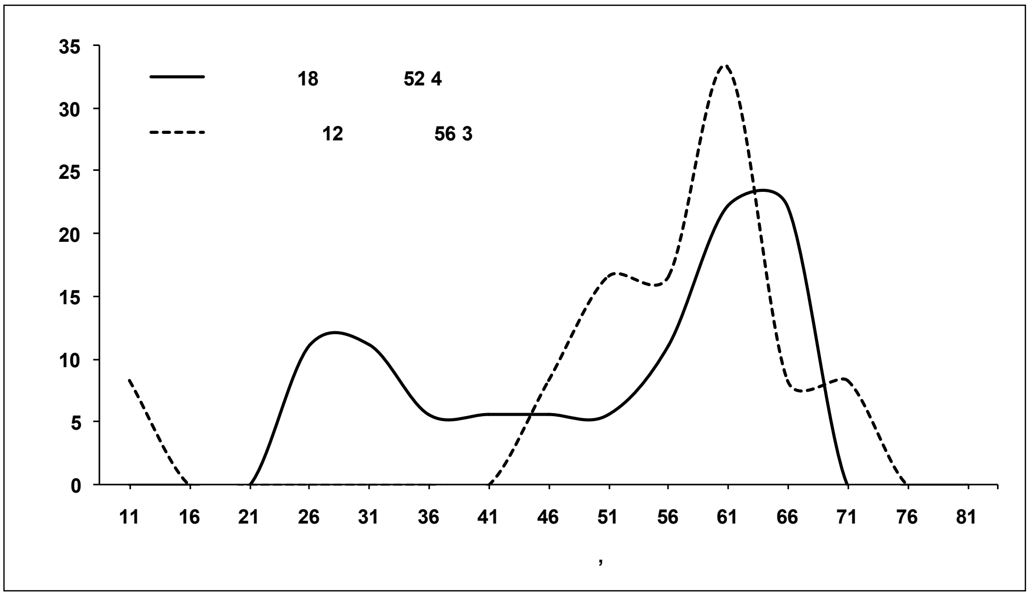


Figure 13.4. Demersal elasmobranchs in the Barents Sea. Length composition of *A. hyperborea* in the Barents Sea (Area I) based on data of the joint Russian–Norwegian ecosystem survey (August–September 2009). (Source: Vinnichenko *et al.*, 2010 WD).

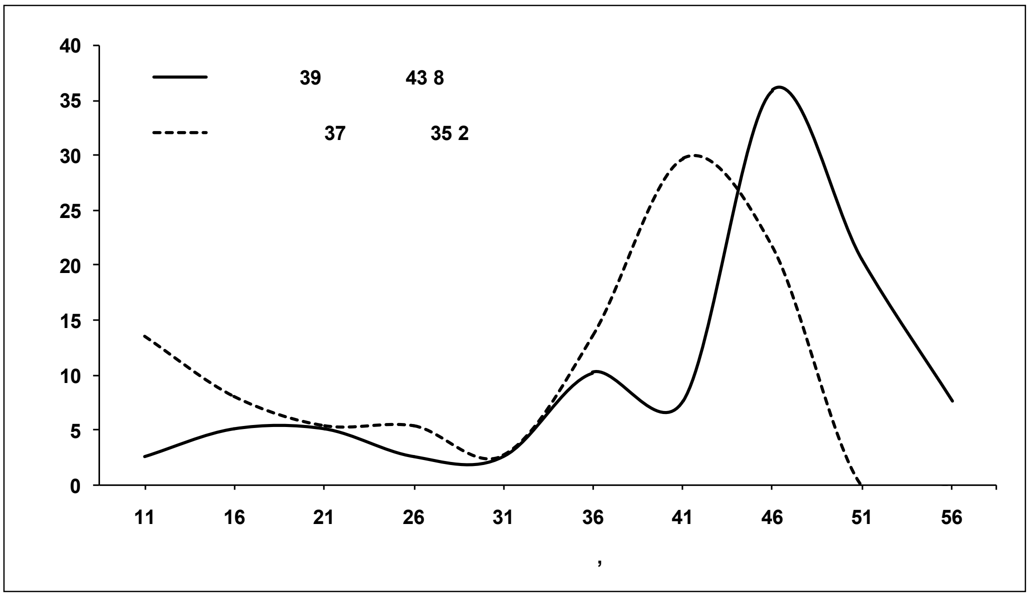


Figure 13.5. Demersal elasmobranchs in the Barents Sea. Length composition of *A. radiata* in the Barents Sea (Area I) based on data of the joint Russian–Norwegian winter survey (February 2009). (Source: Vinnichenko *et al.*, 2010 WD).

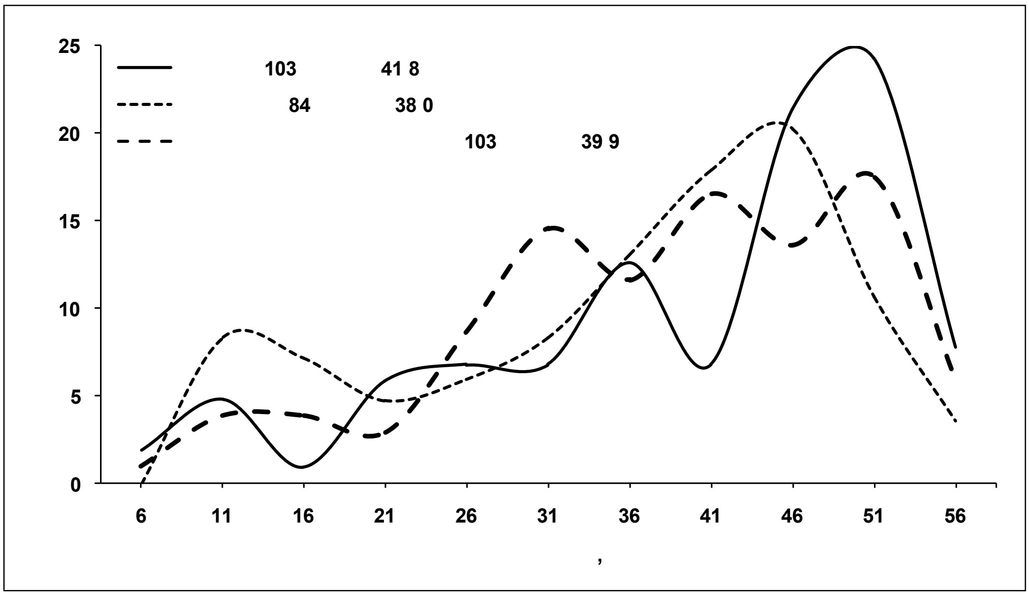


Figure 13.6. Demersal elasmobranchs in the Barents Sea. Length composition of *A. radiata* in the Barents Sea (Subarea I) based on data of the joint Russian–Norwegian ecosystem survey (August–September 2009). (Source: Vinnichenko *et al.*, 2010 WD).

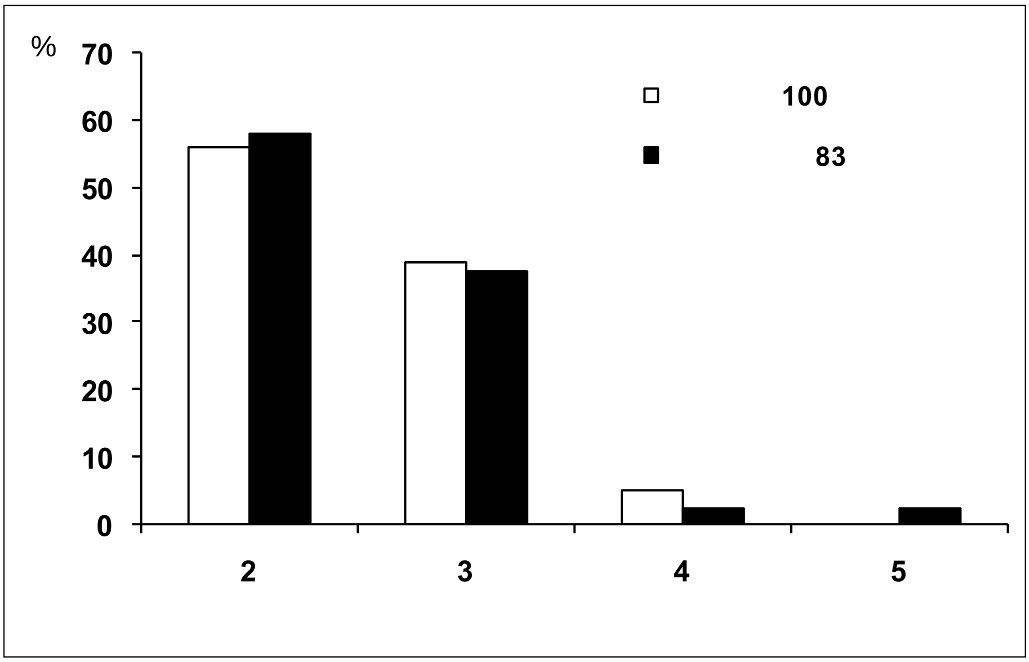


Figure 13.7. Demersal elasmobranchs in the Barents Sea. Maturity of *A. radiata* in bottom trawl catches in the Barents Sea in 2009. (Source: Vinnichenko *et al.*, 2010 WD).

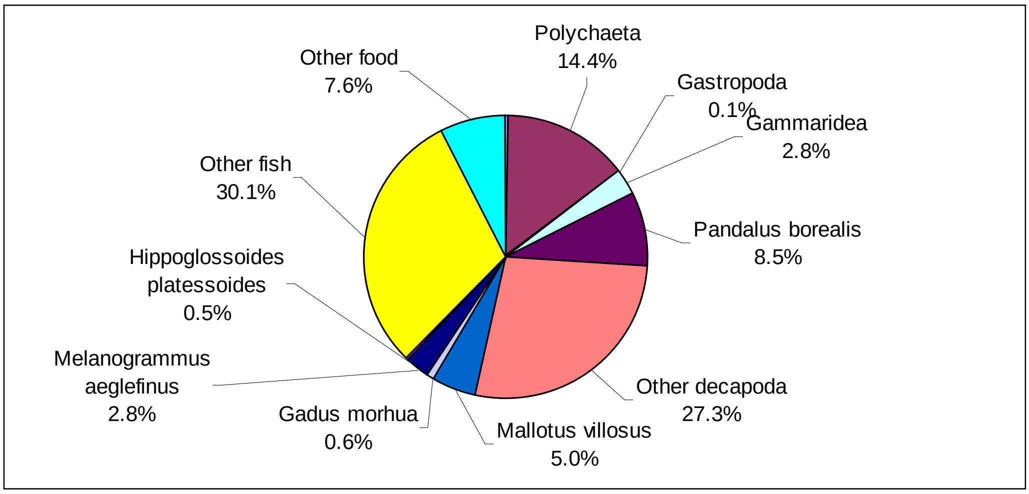


Figure 13.8. Demersal elasmobranchs in the Barents Sea. Food composition of *A. radiata* in the Barents Sea (Area I) in 2009, % by weight (N=169, 27% empty stomachs). (Source: Vinnichenko *et al.*, 2010 WD).

14 Demersal elasmobranchs in the Norwegian Sea

14.1 Ecoregion and stock boundaries

The occurrence of chondrichthyan species in the Norwegian Sea ecoregion has been reviewed by Lynghammar *et al*. (2013). In the coastal areas, thorny skate *Amblyraja radiata* is the most abundant skate species (Williams *et al*., 2008). While more abundant in the north, this species occurs in fairly large numbers at all latitudes along the coast. Other species that have been confirmed in the coastal area are thornback ray *Raja clavata,* common skate *Dipturus batis* complex, sailray *Rajella lintea,* Norwegian skate *Dipturus nidarosiensis,* sandy ray *Leucoraja circularis*, shagreen ray *Leucoraja fullonica,* round skate *Rajella fyllae*, arctic skate *Amblyraja hyperborea* and spinytail skate *Bathyraja spinicauda*. Long-nose skate *Dipturus oxyrinchus* is distributed mainly along the southern section of coastline, south of latitude 65°N. Records of *R. brachyura* and *R. montagui* need to be confirmed by voucher specimens, although they are present in catch statistics (Lynghammar *et al*., in press).

In deeper areas of the Norwegian Sea, *A. radiata* and *A. hyperborea* are the two most numerous species, but *B. spinicauda* and *R. fyllae* also occur regularly (Skjaeraasen and Bergstad, 2001; Vollen, 2009 WD). These species of skates are particularly abundant north of 70°N (Vollen, 2009 WD).

Sharks in the Norwegian Sea ecoregion include spurdog *Squalus acanthias* (Section 2) and several deeper water species (Section 5), such as velvet belly lantern shark *Etmopterus spinax,* blackmouth catshark *Galeus melastomus* and Greenland shark *Somniosus microcephalus* (Section 24). Other species reported in Norwegian fisheries include lesser-spotted dogfish *Scyliorhinus canicula* (Section 25), porbeagle *Lamna nasus* (Section 6) and basking shark *Cetorhinus maximus* (Section 7).

Stock boundaries are not known for the species in this area, neither are the potential movements of species between the coastal and offshore areas. Further investigations are necessary to determine potential migrations or interactions of elasmobranch populations within this ecoregion and adjacent areas.

14.2 The fishery

14.2.1 History of the fishery

There is no directed fishery on skates and rays in the Norwegian Sea, though they are caught in mixed fisheries targeting various teleost species. Landings data for skates are shown in Table 14.1 and Figure 14.1 for the years 1973–2013.

14.2.2 The fishery in 2013

No new information.

14.2.3 ICES advice applicable

ICES has never provided advice for any of the skate stocks in this ecoregion.

14.2.4 Management applicable

There are no TACs for any of the skate stocks in this ecoregion.

Norway has a general ban on discarding. Since 2010 all dead or dying skates in the catches should be landed, whereas live specimens can be discarded.

14.3 Catch data

14.3.1 Landings

For ICES Subarea II, landings data are limited and, for skates, not species disaggregated (Table 14.1 and Figure 14.1). This subarea covers all of the Norwegian Sea ecoregion, but also includes the most westerly parts of the Barents Sea ecoregion (Section 13).

Overall landings throughout time have been low, at about 200–300 t per year for all fishing countries, with moderate fluctuations. The peak in the late 1980s resulted from Russian fisheries landing over 1900 t of skates in 1987, subsequently dropping to low levels two years later. This peak was a consequence of an experimental fishery, when skate bycatch was landed, whereas normally they are discarded (Dolgov, pers. comm.). Russia and Norway are the main countries landing skates from the Norwegian Sea.

Norwegian landings of sharks were reported by species for 2013. Landings of blackmoth dogfish *Galeus melastomus* were 21 tonnes. Other sharks landed in this area include porbeagle, spurdog and velvet belly (*Etmopterus spinax*). These are reported in Sections 6, 2 and 5, respectively.

Landings data (usually not discriminated at species level) have been provided by Norway, France, and Scotland in recent years. Russian landings have not been available since 2011.

14.3.2 Discard data

Vollen (2010 WD) reported on catch and discards by the Norwegian Reference Fleet in ICES Subarea II. More detailed results are given in Section 14.4.2.

14.3.3 Quality of catch data

Catch data are not species disaggregated.

14.3.4 Discard survival

No data available to WGEF for the fisheries in this ecoregion.

14.4 Commercial catch composition

14.4.1 Species and size composition

In 2009, Russian landings of skates were taken as bycatch during the longline and trawl demersal fisheries at depths ranging from 50 to 900 m deep in February–November. *A. radiata* made up the bulk of bycatch. *R. fyllae*, *A. hyperborea* and *B. spinicauda* were found in minor quantities (Vinnichenko *et al.*, 2010 WD).

A. radiata ranging from 27–58 cm total length were recorded in the commercial catches from bottom trawlers. The catches primarily comprised males of 41–55 cm and females of 36–50 cm length (Figure 14.2).

The percentage of small individuals was lower than in the Barents Sea. The mean length of females (43.7 cm) was smaller than that of males (45.0 cm). Males were slightly more abundant in catches (sex ratio of 1.1:1).

Vinnichenko *et al.* (2010 WD) presented data on *A. radiata* compiled from samples taken by scientific observers on commercial fishing vessels, the Russian survey and the joint Russian–Norwegian surveys. These are presented in Section 14.6.4.

14.4.2 Quality of the data

Information on the species composition of commercial catches is required.

Data from the Norwegian Reference Fleet demonstrated that elasmobranch catches in ICES Subarea II were dominated by *A. radiata* and *R. clavata* (although misidentification problems may exist) (Table 14.3; Vollen, 2010 WD). For vessels in the Oceanic Reference Fleet, bycatch of elasmobranchs differed between bottom trawl, bottom gillnets and longlines. Whereas *A. radiata* made up the bulk of trawl and longline catches (55% and 79% by numbers, respectively), *R. clavata* dominated gillnet catches (82%). This was probably influenced by the dominance of northerly stations in trawl and longline data, and more southerly stations in gillnet data, but misidentifications problems cannot be discarded, and should therefore be investigated more thoroughly. Catches of *A. radiata* were higher in this subarea than in ICES Subarea I for trawl catches (61 kg/100 trawl hours for Subarea II vs. 43 kg/100 trawl hours for Subarea I), but lower for longline catches (119 kg/10 000 hooks vs. 135 kg/10 000 hooks, respectively).

The data from the Coastal Reference Fleet demonstrated that *D. batis* complex (possibly misidentified) and unidentified skates dominated the landed catches in this area (39% and 33% by weight, respectively). Discards were dominated by unidentified skates (32% by weight). As opposed to the Oceanic Reference Fleet, *A. radiata* was only sporadically recorded in this area.

14.5 Commercial catch and effort data

No information.

14.6 Fishery-independent surveys

14.6.1 Russian bottom trawl survey (RU-BTr-Q4)

Vinnichenko *et al.* (2010 WD) reported catches from the 2009 survey, were dominated by *A. radiata*, specimens length varied from 10 to 56 cm (Figure 14.3). In the size distribution, different size/age classes of the skate were very distinct. The mean length of males (37.7 cm) and females (37.4 cm) were similar and the sex ratio was 1.05:1, males slightly predominated in the catches.

A. hyperborea of 17–91 cm (specimens exceeding 131 cm were not considered since it is admitted that they are typing errors or species misidentifications) in length were recorded in the catches (Figure 14.4). Predominating were males of 46–50 cm and 61–75 cm, as well as females in the 56–65 cm and 76–80 cm length classes. The mean lengths of males (65.1 cm) and females (65.8 cm) were very similar. Mainly males were present in the catches with a sex ratio of 5:1.

14.6.2 Norwegian coastal survey (NOcoast-Aco-4Q)

The distribution and diversity of elasmobranchs in northern Norwegian coastal areas was summarized by Williams *et al.* (2008),-based on survey data from 1992–2005. The southern portion of the coastal area studied was incorporated within the Norwegian

Sea ecoregion, and the Barents Sea was defined as the border between Norwegian Directorate of Fisheries Statistical Areas 04 and 05.

Thirteen skate species and four species of sharks were recorded inhabiting the coastal region (Table 14.2). Regularly occurring skates were *A. radiata, A. hyperborea, D. batis* complex, *D. nidarosiensis, D. oxyrinchus, Raja clavata, Rajella fyllae, L. fullonica*. Occasional or single observations were made of *B. spinicauda*, *R. lintea* and *L. circularis* (also *R. montagui*, *R. brachyura* were nominally recorded, but see Section 14.6.5). Four species of shark were identified: *E. spinax, G. melastomus* and *S. acanthias*, as well as one specimen of *S. microcephalus.*

Although no clear shifts in abundance over time were detected for any species, more robust assessment is necessary to better identify temporal trends in abundances.

14.6.3 Deep stations from multiple Norwegian surveys (NO-GH-Btr-Q3 and others)

Vollen (2009 WD) reported on elasmobranch catches from 3185 deep trawl hauls (400–1400 m) at the continental slope (62–81°N), the Barents Sea and Skagerrak. Data were combined from multiple deep-water surveys during the period 2003–2009. Data from the Skagerrak are excluded in this section, whereas parts of the Barents Sea ecoregion are included. A total of nine species were recorded; six skates and three sharks. *A. radiata* and *A. hyperborea* were the dominating species north of 62°N (ICES Subarea II), whereas *E. spinax* were most numerous in the Norwegian Deep (ICES Division IIIa). *B. spinicauda* and *R. fyllae* also occurred frequently in the catches in all areas. Recordings of *R. clavata* were considered to be misidentifications of other species. Results were reported in more detail in ICES (2009).

14.6.4 Joint Russian-Norwegian survey (BS-NoRu-Q1 (BTr), Eco-NoRu-Q3 (Aco)/Eco-NoRu-Q3 (Btr))

Two joint Russian–Norwegian surveys are conducted in the Barents Sea. These surveys run in February (BS-NoRu-Q1 (BTr)), in the southern Barents Sea northwards to the latitude of Bear Island, and August–September (Eco-NoRu-Q3 (Aco)/Eco-NoRu-Q3 (Btr)), practically covering the whole of the Barents Sea, including waters near Spitsbergen and Franz Josef Land. The Norwegian part of the February survey started in 1981, but data on elasmobranchs are missing for some years. The August–September survey started in 2003. All skates are recorded during these surveys, and data on length distributions as well as some biological data (on board of Russian vessels) are collected. As a result of initial problems with the species identification, species-specific data should only be used from the years 2006–2007 onwards (for Norwegian data). Analyses of data from these surveys are not completed, but some data were presented from the 2009 surveys by Vinnichenko *et al.* (2010 WD).

A. radiata was the dominant species in the August–September survey. The length of individuals varied from 5 to 61 cm (Figure 14.5). The average length was 33–37 cm (Vinnichenko *et al.*, 2010 WD).

Vinnichenko *et al.* (2010 WD) also presented data on *A. radiata* compiled for both samples taken by scientific observers on commercial fishing vessels, the Russian survey and the joint Russian–Norwegian surveys. Males prevailed in the samples (1.7:1). Most males and females (over 70%) were immature, the rest were in maturing stage or were mature (Figure 14.6). Unlike the Barents Sea, no individuals at the active stage were reported in the area. Prevailing prey were bottom decapods (spider crabs *Hyas* spp. and northern shrimp *Pandalus borealis*) and fish (capelin *Mallotus villosus* and Atlantic hookear scuplin *Artediellus atlanticus*), which accounted for 47% and 31% by weight, respectively (Figure 14.7).

14.6.5 Quality of survey data

The difficulties associated in identifying skate species are a concern when considering the validity of the data used for the assessment. Identification problems between *A. radiata* and *R. clavata* was given in Williams (2007) and summarized in ICES (2007). Despite sampling effort done since 2007, Lynghammar *et al.* (in press) did not obtain a single specimen of the *D. batis* complex, *L. fullonica*, *R. brachyura* or *R. montagui* in the Norwegian Sea: This suggest the existence of misidentification problems. The two former species have been confirmed to exist in the area in historical times, whereas the two latter have never been confirmed. *R. montagui* from central Norway was known from a museum specimen, but Lynghammar *et al.* (in press) identified it as *R. clavata*.

In order to achieve a better quality of survey data in future, identification practices, using appropriate identification literature, needs to be put in place. Ongoing work to improve future sampling at the Institute of Marine Research includes workshops to educate staff as well as improved guides and keys used for species identification.

14.7 Life-history information

Length data are available for *A. radiata* and *A. hyperborea* in Vinnichenko *et al.* (2010 WD; see ICES, 2010). Some biological information is available in the literature (e.g. Berestovskii, 1994). Sampling of elasmobranch egg-cases was included in Norwegian trawl surveys from mid-2009, and may provide future information on nursery grounds.

14.8 Exploratory assessment models

No assessments have been conducted, as a consequence of insufficient data.

14.9 Quality of assessments

No assessments have been conducted, as a consequence of insufficient data. Analyses of survey trends may allow to evaluate the status of the more frequent species, although taxonomic irregularities need to be addressed first.

14.10 Reference points

No reference points have been proposed for any of these skate stocks.

14.11 Conservation considerations

The International Union for Conservation of Nature and Natural Resources (IUCN Red List of Threatened species (IUCN, 2014) listings for species occurring in this area include:

"Critically endangered": *D. batis* complex;

"Vulnerable": *L. circularis;*

"Near threatened": *B. spinicauda, D. nidarosiensis, D. oxyrinchus, L. fullonica* and *R. clavata.*

None of these IUCN assessments have been updated since 2009.

Demersal elasmobranchs listed on the Norwegian Red List, other than "Least concern" (Gjøsæter *et al.*, 2010), include *D. batis* complex ("Critically endangered") and *B. spinicauda*, *D. nidarosiensis* and *L. fullonica* (all "Near threatened").

14.12 Management considerations

There are no TACs for any of the skates in this ecoregion. The demersal elasmobranch fauna of the Norwegian Sea comprises several species that occur in the Barents Sea (Section 13) and/or the North Sea (Section 15). Further investigations are required, and could also offer valuable additional information for managing the neighbouring ecoregions.

14.13 References

Berestovskii, E. G. 1994. Reproductive biology of skates of the family Rajidae in the seas of the far north. *Journal of Ichthyology*, 34(6): 26–37.

Gjøsæter, J., Hesthagen, T., Borgstrøm, R., Brabrand, Å., Byrkjedal, I., Christiansen, J. S., Nedreaas, K., Pethon, P., Uiblein, F., Vøllestad, L. A. and Wienerroither, R. 2010. Fisker "Pisces". *In* Kålås, J. A., Viken, Å., Henriksen, S. and Skjelseth, S. (eds.) 2010. The Norwegian Red List for Species. Norwegian Biodiversity Information Centre, Norway.

ICES. 2007. Report of the Working Group Elasmobranch Fishes (WGEF), 22–28 June 2007, Galway, Ireland. ICES CM 2007/ACFM:27. 318 pp.

ICES. 2009. Report of the Joint Meeting between ICES Working Group on Elasmobranch Fishes (WGEF) and ICCAT Shark Subgroup, 22–29 June 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:16. 424 pp.

ICES. 2010. Report of the Working Group on Elasmobranch Fishes (WGEF), 22–29 June 2010, Horta, Portuga. ICES CM 2010/ACOM:19. 558 pp.

IUCN. 2014. IUCN Red List of Threatened Species. Version 2014.1. http://www.iucnredlist.org>. Downloaded on 18 June 2014.

Lynghammar, A., Christiansen, J. S., Mecklenburg, C. W., Karamushko, O. V., Møller, P. R. and Gallucci, V. F. 2013. Species richness and distribution of chondrichthyan fishes in the Arctic Ocean and adjacent seas. *Biodiversity*, 14(1): 57–66.

Lynghammar, A., Christiansen, J. S., Griffiths, A. M., Fevolden, S-E., Hop, H. and Bakken, T. In press. DNA barcoding of the northern Northeast Atlantic skates (Chondrichthyes, Rajidae), with remarks on the widely distributed starry ray. *Zoologica Scripta*, doi: 10.1111/zsc.12064.

Skjaeraasen, J. E. and Bergstad, O. A. 2001. Notes on the distribution and length composition of *Raja linteus, R. fyllae, R. hyperborea* and *Bathyraja spinicauda* (Pisces: Rajidae) in the deep northeastern North Sea and on the slope of the eastern Norwegian Sea. *ICES Journal of Marine Science*, 58: 21–28.

Vinnichenko, V.I., Dolgov, A.V., Yurko, A.S., Zhivov, B.D. and Safronov, A.M. 2010. Russian research and fisheries of sharks and skates in the Northeast Atlantic in 2009. Working document for the ICES Elasmobranch Working Group (WGEF) 2010.

Vollen, T. 2009. Distribution of chondrichthyan species in Norwegian deep-sea waters. Working document for the ICES Elasmobranch Working Group (WGEF) 2009.

Vollen, T. 2010. The Norwegian Reference Fleet: Catch and discard of elasmobranchs. Working document for the ICES Elasmobranch Working Group (WGEF) 2010.

Williams, T. 2007. Cartilaginous fishes along the North-Norwegian coast. Distributions and densities with regard to fishing and sea temperature. Master thesis in International Fisheries Management. Norwegian College of Fishery Science. University of Tromsø, 62 pages, http://www.ub.uit.no/munin/handle/10037/975.

Williams, T., Aschan, M. and Helle, K. 2007. Distribution of Chondrichthyan species along the North-Norwegian coast. Working Document for the ICES Elasmobranch Working Group (WGEF) 2007.

Williams, T., Helle, K. and Aschan, M. 2008. The distribution of chondrichthyans along the north coast of Norway. *ICES Journal of Marine Science*, 65: 1161–1174.

Table 14.1. Demersal elasmobranchs in the Norwegian Sea. Total landings (t) of skates and rays from ICES Subdivisions II, IIa and IIb from 1973–2013. Ireland (1 ton in 2007), Denmark (+ in 1994 and Sweden (+ in 1975) are not included in the landings table). "n.a." = no data available, "." = means zero catch, "+" = < 0.5 tonnes.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Belgium	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Estonia	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Faroe Islands	.	.	.	5	2	1	1	.	.	.	.	.	.	4
France	.	.	1	68	61	18	2	1	12	109	2	6	5	11
Germany	+	1	52	12	59	114	84	85	53	7	2	112	124	102
Iceland	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Netherlands	.	.	.	.	.	.	2	.	.	.	.	.	.	.
Norway	201	158	89	34	99	82	126	191	137	110	96	150	104	133
Portugal	.	.	.	34	39	.	.	.	.	.	.	.	.	.
USSR/Russ. Fed.	.	.	.	.	.	302	99	39	.	.	.	537	261	1633
Spain	.	.	.	.	.	.	.	.	.	.	28		17	5
UK – E, W & NI	65	18	14	20	90	10	6	2	+	+	.	5	1	2
UK - Scotland	2	1	.	+	1	+	.	.	.	.	.	.	+	+
Total	268	178	157	173	351	527	320	318	202	226	128	810	512	189

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Belgium	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Estonia	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Faroe Islands	.	15	.	42	.	2	.	.	.	.	.	.	.	.
France	21	42	8	56	11	15	9	7	8	6	8	5	.	5
Germany	95	76	32	52	.	+	.	.	.	.	.	.	.	2
Iceland	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Netherlands	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Norway	214	112	148	216	235	135	286	151	239	198	169	214	239	244
Portugal	.	.	.	.	.	.	22	11	.	10	28	46	10	6
USSR/Russ. Fed.	1921	1647	867	208	n.a.	181	112	257	n.a.	n.a.	77	139	247	400
Spain	.	9	.	.	.	.	.	.	3	.	3	15	6	.
UK - E, W & NI	4	.	2	1	+	1	+	+	1	4	.	+	1	+
UK - Scotland	2	+	+	+	+	+	+	.	+	+	+	+	1	1
Total	2257	1902	1057	575	246	334	429	426	251	218	285	419	504	658

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	.	.	.	.	.	.	.	.	.	.	.	.	.
Estonia	.	5	.	.	4	.	.	.	.	.	.	n.a.	.
Faroe Islands	.	.	2	12	15	13	9	13	4	3	n.a.	.	.
France	4	7	2	7	8	.	4	2	1	3	+	1	.
Germany	.	2	2	7	1	.	.	.	.	1	.	.	.
Iceland	4	.	.	.	.	.	.	.	.	.	.	.	.
Netherlands	.	.	.	.	.	.	.	.	.	.	.	.	.
Norway	233	118	111	135	133	146	189	259	257	250	197	123	146
Portugal	3	.	8	2	1	14	13	2	.	.	.	.	.
USSR/Russ. Fed.	113	38	6	50	20	16	20	.	8	2	n.a.	n.a.	n.a.
Spain	7	11	32	.	2	.	.	.	.	.	.	.	.
UK - E, W & NI	.	.	.	.	.	+	.	.	.	.	.	.	.
UK – Scotland	1	3	3	.	2	4	1	1	+	.	.	.	1
Total	365	184	166	213	186	193	237	277	270	259	197	124	147

Table 14.2. Catch data (number of individuals per species) for the Norwegian Sea ecoregion from the Annual Autumn Bottom-trawl Surveys of the North Norwegian Coast, from 1992 to 2005. (Source: adapted from Williams et al., 2007 WD)

Species	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total catch	Total % of positive samples	Catch rate (No. per survey)
Amblyraja radiata	7	44	23	15	8	41	9	16	9	6	10	10	19	9	226	11%	17.4
Bathyraja spinicauda	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0%	0.1
Rajella fyllae	0	4	0	0	0	1	0	0	0	0	5	6	4	0	20	1%	1.5
Raja clavata	0	4	15	1	0	2	3	6	0	0	0	0	2	0	33	2%	2.5
Dipturus batis complex	0	2	0	1	3	7	7	1	1	1	1	0	0	0	24	1%	1.8
Leucoraja fullonica	0	0	0	0	0	0	0	4	3	9	3	0	0	1	20	1%	1.5
Leucoraja circularis	0	0	0	0	0	0	0	0	1	0	1	9	5	7	23	1%	1.8
*Raja montagui**	0	0	0	0	0	0	0	2	1	0	1	0	1	0	5	<1%	0.4
Dipturus oxyrinchus	0	0	54	3	2	30	2	0	0	1	2	6	4	2	106	5%	8.2
Dipturus nidarosiensis	0	0	0	0	1	1	0	0	0	3	1	0	1	0	7	<1%	0.5
Amblyraja hyperborea	0	0	1	0	0	0	0	0	0	0	4	0	1	0	6	<1%	0.5
*Raja brachyura**	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4	<1%	0.3
Rajella lintea	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	<1%	0.1
Galeus melastomus	0	24	1883	1197	105	1269	189	480	258	812	1196	275	640	48	8376	24%	644.3
Etmopterus spinax	0	829	8453	473	1061	2733	584	3881	1485	1401	2417	785	2305	1369	27 776	33%	2136.6
Squalus acanthias	0	21	51	26	20	5	106	168	12	68	43	21	104	17	662	8%	50.9
Somniosus microcephalus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	<1%	0.1
Number of samples	17	163	106	77	74	96	78	81	76	56	78	65	77	63			

***Probably misidentifications, the occurrence of the species in the area has not been confirmed (see Section 14.6.5).**

Table 14.3. Demersal elasmobranchs in the Norwegian Sea. Species composition of elasmobranch catches in ICES Subarea II by the Norwegian Oceanic (2008–2009) and Coastal Reference Fleet (2007–2008). Data for the Oceanic Reference Fleet is Total catch of elasmobranchs as percentage of biomass and percentage of numbers. Data for the Coastal Reference Fleet is percentage in numbers of landed catch and discarded catch. (Source: Adapted from Vollen, 2010 WD).

	Oceanic Reference Fleet			Oceanic Reference Fleet			Coastal Reference Fleet	
	Total catch (% biomass)			Total catch (% numbers)			Landed	Discarded
Species	Lines	Nets	Trawls	Lines	Nets	Trawls	Nets	Nets
Skates								
Bathyraja spinicauda	0.5		0.4	0.2		0.5		
Amblyraja hyperborea	5.4			2.9			0.1	
Amblyraja radiata	79.5	6.3	55.1	78.9	7.8	54.5		1.8
Dipturus batis complex	0.2			0.1			38.7	0.4
Dipturus oxyrinchus	+		0.1	+		0.1	0.7	7.4
Dipturus nidarosiensis								+
Leucoraja fullonica	0.2	11.4	1.5	0.1	0.9	2.8		
Raja clavata		74.5	9.4		82.2	9.4	6.5	0.8
Rajella fyllae	2.2	0.6	3.2	3.8	1.1	5.5	0.7	1.1
Skates indet	3.6			5.0			33.4	18.2
Rajella lintea	0.2			0.1				2.0
Sharks								
Etmopterus spinax	1.0			3.3				4.2
Somniosus microcephalus								0.5
Squalus acanthias	0.2	0.3	+	0.1	0.4	0.1	7.9	7.3
Cetorhinus maximus								0.2
Lamna nasus							10.8	0.1
Galeus melastomus	1.4			2.2			0.1	11.3
Scyliorhinus canicula								0.3
Galeorhinus galeus								+
Chimaeras								
Chimaera monstrosa	5.6	6.9	30.3	3.4	7.5	27.2	1.1	44.5
Total skates	**91.8**	**92.8**	**69.7**	**91.0**	**92.1**	**72.7**	**80.1**	**31.7**
Total sharks	**2.6**	**0.3**	**0.0**	**5.6**	**0.4**	**0.1**	**18.8**	**23.8**
Total chimaeras	**5.6**	**6.9**	**30.3**	**3.4**	**7.5**	**27.2**	**1.1**	**44.5**

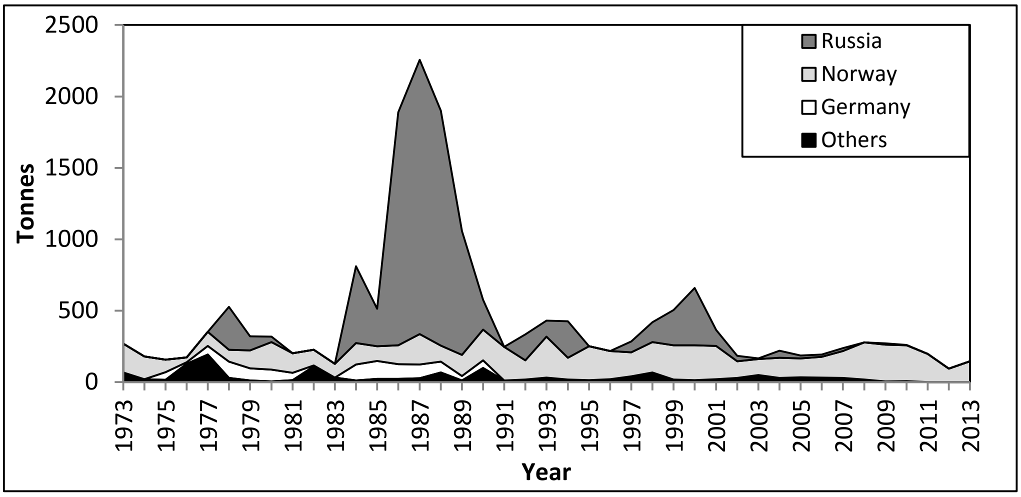


Figure 14.1. Demersal elasmobranchs in the Norwegian Sea. Total landings (t) of skates and rays from ICES Subdivisions II, IIa and IIb from 1973–2012.

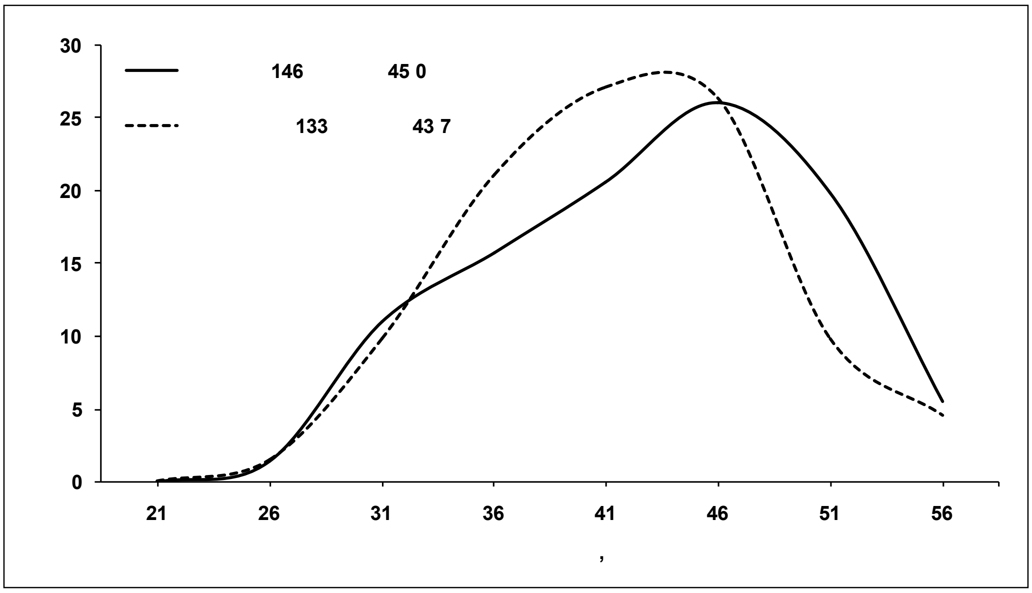


Figure 14.2. Demersal elasmobranchs in the Norwegian Sea. Length composition of *A. radiata* from commercial bottom-trawl catches in the Norwegian Sea in 2009. (Source: Vinnichenko *et al.*, 2010 WD).

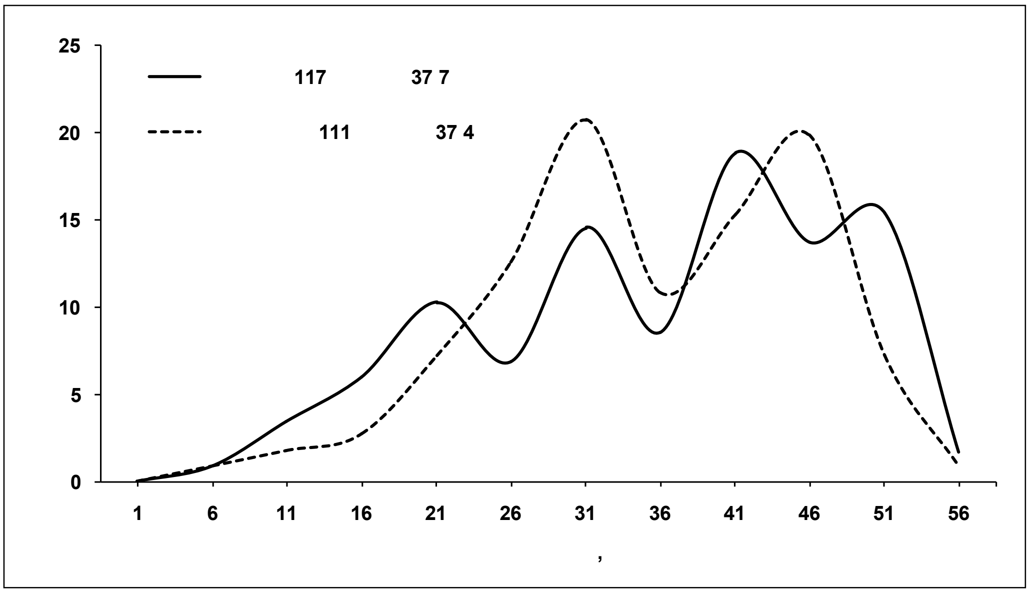


Figure 14.3. Demersal elasmobranchs in the Norwegian Sea. Length composition of *A. radiata* in the Norwegian Sea (Division IIb) based on data of the Russian demersal survey (October–December 2009). (Source: Vinnichenko *et al.*, 2010 WD).

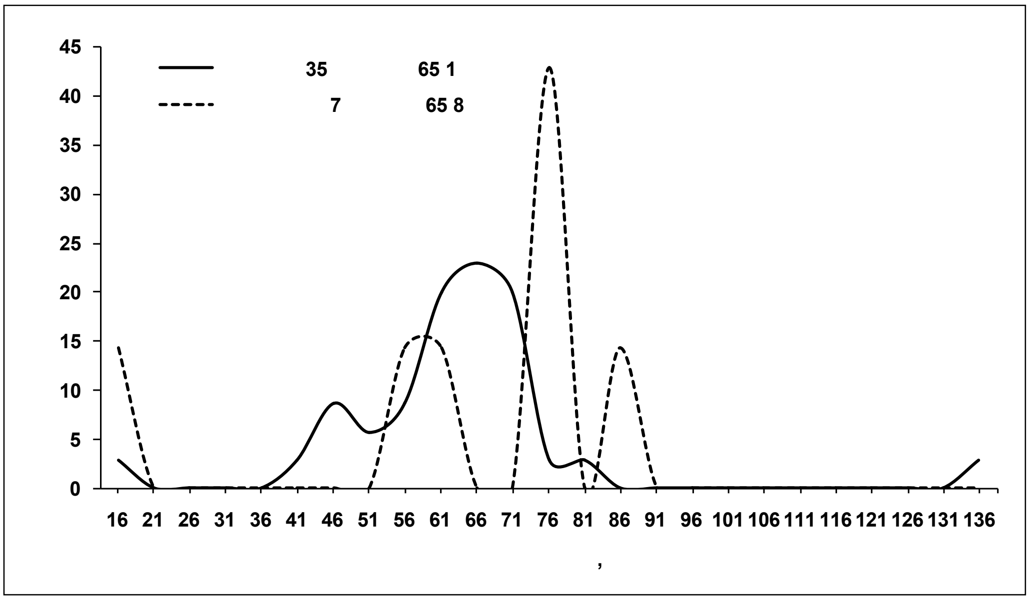


Figure 14.4. Demersal elasmobranchs in the Norwegian Sea. Length composition of *A. hyperborea* in the Norwegian Sea (Division IIb) based on data of the Russian demersal survey (October–December 2009). Specimens exceeding 131 cm are probably typing errors or misidentifications. (Source: Vinnichenko *et al.*, 2010 WD).

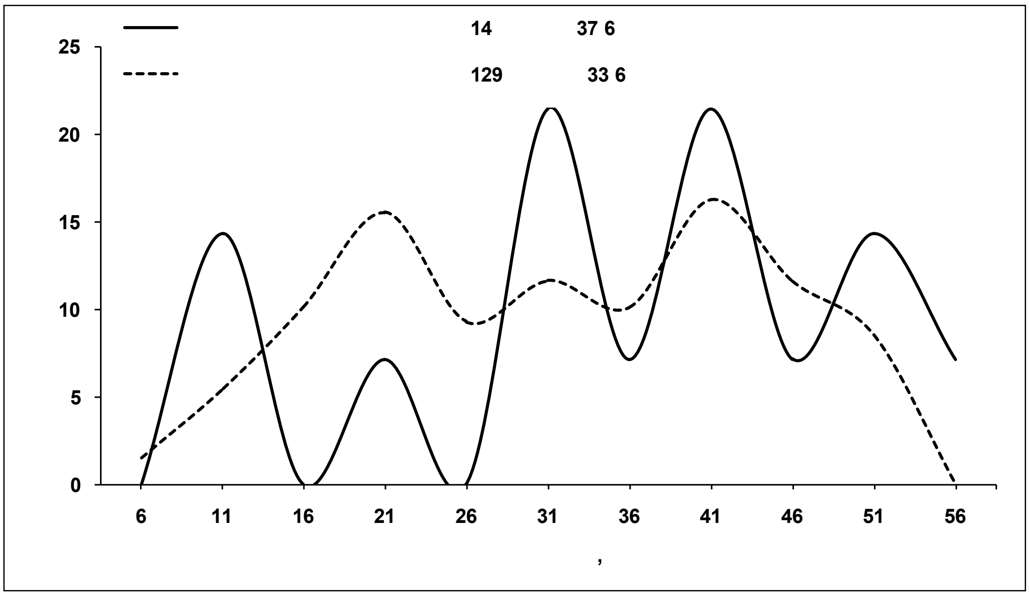


Figure 14.5. Demersal elasmobranchs in the Norwegian Sea. Length composition of *A. radiata* in the Norwegian Sea (Divisions IIa and IIb) based on data of the joint Russian–Norwegian ecosystem survey (August–September 2009). (Source: Vinnichenko *et al.*, 2010 WD).

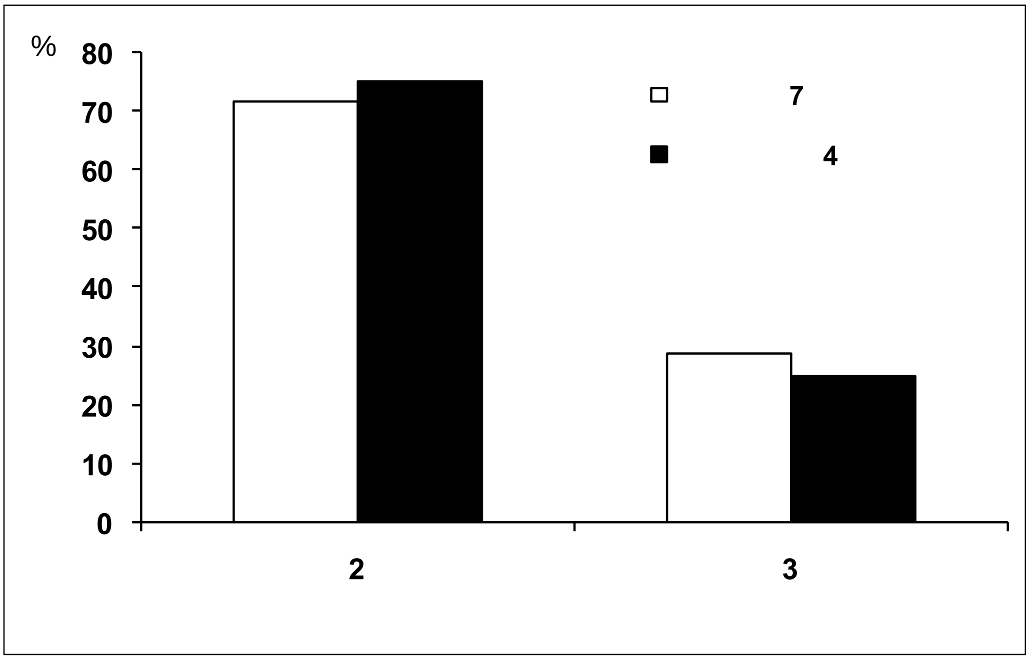


Figure 14.6. Demersal elasmobranchs in the Norwegian Sea. Maturity of *A. radiata* in bottom trawl catches in the Norwegian Sea in 2009. (Source: Vinnichenko *et al.*, 2010 WD).

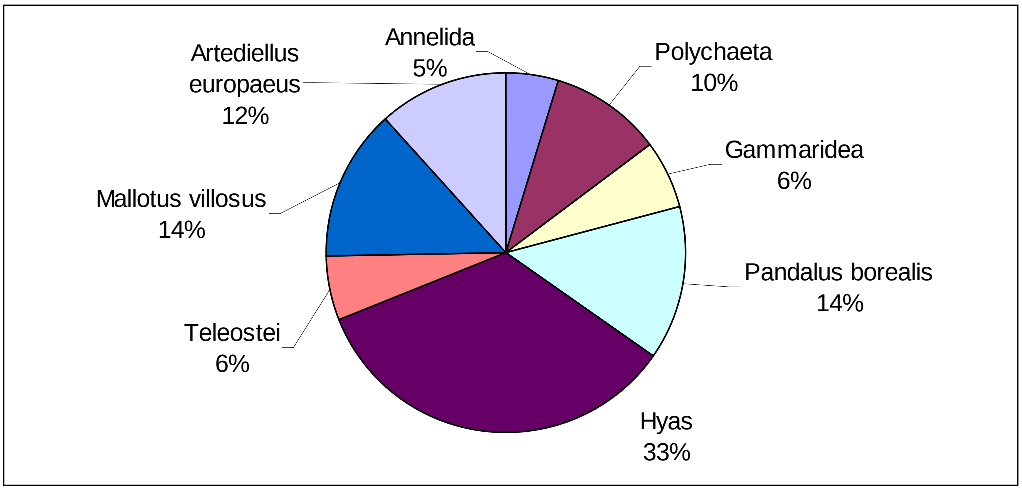


Figure 14.7. Demersal elasmobranchs in the Norwegian Sea. Food composition of *A. radiata* in the Norwegian Sea in November 2009 (% by weight; N=11 stomachs, 9.0 % empty stomachs). (Source: Vinnichenko *et al.*, 2010 WD).

15 Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel

15.1 Ecoregion and stock boundaries

In the North Sea about ten skate and ray species occur, as well as about ten demersal shark species (Daan *et al.*, 2005). Thornback ray *Raja clavata* is probably the most important skate for the commercial fisheries. Preliminary assessments on this species were presented in ICES (2005, 2007), based on research survey data. WGEF is still concerned over the possibility of misidentification of skates in some recent IBTS surveys, especially differentiation between *R. clavata* and starry ray *Amblyraja radiata*.

R. clavata in the Greater Thames Estuary (southern part of ICES Division IVc) is known to move into the eastern English Channel (VIId). For most other demersal species in the North Sea ecoregion the stock boundaries are not well known. The stocks of cuckoo ray *Leucoraja naevus*, spotted ray *R. montagui* and *R. clavata* (northern North Sea) probably continue into the waters west of Scotland and, in the case of *R. montagui,* also into the eastern English Channel). The stock boundary of the common skate *Dipturus batis* complex is likely to continue to the west of Scotland and into the Norwegian Sea, but most specimens from this ecoregion are likely to be *Dipturus* cf. *intermedia*, although the presence and extent of *Dipturus batis* (cf. *flossada*) in this region are unknown. Blonde ray *Raja brachyura* has a patchy distribution, occurring in the southern North Sea (presumably extending to the eastern English Channel) and northwestern North Sea (and this stock may extend to northwest Scotland).

15.2 The fishery

15.2.1 History of the fishery

Demersal elasmobranchs are caught as a bycatch in the mixed demersal fisheries for roundfish and flatfish. A few inshore vessels target skates and rays with tanglenets and longlines. For a description of the demersal fisheries see the Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (ICES, 2009a) and the report of the DELASS project (Heessen, 2003).

The 25% bycatch ratio brought in by the EC (see also Section 15.2.4) has restrained some fisheries and may have resulted in misreporting since 2007, both of area and species composition.

15.2.2 The fishery in 2013

Landings tables for the relevant species are provided in Tables 15.1–15.7. The landings generally peaked in the middle of the 1980s and declined steadily thereafter in the North Sea. A similar trend as observed for Area VIId although an increase was observed since 2005.

15.2.3 ICES Advice applicable

In 2012 ICES provided advice on the overall exploitation (landings and discards) of the skate assemblage, and also on individual species for 2013 and 2014. Individual advice has been given for each of the main stocks, on the basis of ICES approach to data-limited stocks. However, ICES did not advise that individual TACs be established for each species at present, because the catch statistics for individual species are not reliable.

The advice stated that there should be no targeted fishery for undulate ray *Raja undulata* (see Section 18 for further details) and *D. batis* complex should be allowed, and measures should be taken to minimize bycatch. Furthermore, based on ICES approach to data-limited stocks, ICES advised that catches could be increased by a maximum of 20% for *R. clavata*, *R. montagui* and *L. naevus* and catches should be reduced by at least 20% for blonde ray *R. brachyura* and small-eyed ray *Raja microocellata* (see Section 18 for further details). For starry ray (thorny skate) *Amblyraja radiata,* ICES advised that catches should be reduced by 36%.

For the other species found in this region (Norwegian skate *Dipturus nidarosiensis,* longnosed skate *Dipturus oxyrhincus,* sandy ray *Leucoraja circularis,* shagreen ray *Leucoraja fullonica* and sailray *Rajella lintea*), ICES advised that catches should be reduced by at least 20%.

15.2.3.1 State of the stocks

In 2012 WGEF provided a qualitative summary of the general status of the major species based on surveys and landings was given by WGEF. It should be noted that this perception has not changed.

D. batis complex is depleted. It was formerly widely distributed over much of the North Sea but is now found only rarely, and only in the northern North Sea. The distribution extends into the west of Scotland and the Norwegian Sea [Note: This perception was based on comparisons of historical and contemporary trawl survey data]

R. clavata distribution area and abundance have decreased over the past century, with the stock concentrated in the southwestern North Sea where it is the main commercial skate species. Its distribution extends into the eastern Channel. Survey catch trends in Division IVc and VIId have been stable/increasing in recent years. The status of *R. clavata* in Divisions IVa, b is uncertain.

R. montagui stable/increasing. The area occupied has fluctuated without trend. Abundance in the North Sea is increasing since 2000, in the eastern Channel a slight increase can be observed during recent years.

A. radiata stable. Survey catch rates increased from the early 1970s to the early 1990s and have decreased since then.

L. naevus stable. Since 1990 the area occupied has fluctuated without trend. Abundance has decreased since the early 1990s, but has been stable in recent years.

R. brachyura uncertain. This species has a patchy occurrence in the North Sea. It is at the edge of its distributional range in this area.

15.2.4 Management applicable

In 1999 the EC first introduced a common TAC for “skates and rays”. From 2008 onwards the EC has obliged Member States to provide species-specific landings data for the major North Sea species: *R. clavata, R. montagui, R. brachyura*, *L. naevus, A. radiata* and *D. batis* complex. WGEF is of the opinion that this measure is ultimately expected to improve our understanding of the skate fisheries in the area.

The TAC for skates and rays for 2014 for the different parts of the area was: 1256 t for IIa and IV, 798 t for VIId and 47 t for IIIa. The TAC does not apply for *D. batis* and *R. undulata,* or for *R. clavata* (Division IIIa) and “*when accidentally caught, these species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid a safe release of the species*”. Some transfer (5%) between TAC areas of VIId and the Celtic Seas ecoregion is allowed, which may account for some of the overshooting of the TAC in VIId.

YEAR	TAC	TAC FOR AREAS IIA AND IV	TAC FOR VIID	TAC FOR IIIA	LANDINGS
1999	6060				3997
2000	6060				3992
2001	4848				4011
2002	4848				3904
2003	4121				3797
2004	3503				3237
2005	3220				3030
2006	2737				2845
2007	2190[1)]				3141
2008	1643[2)]				3025
2009	2755	1643	1044	68	3192
2010	2342	1397	887	58	2951
2011	2342[)]	1397	887	58	2672
2012	2340[)]	1395	887	58	2738
2013	2106	1256	798	52	3000
2014	2101	1256[3)]	798[3)]	47[3)]	

[1)] Considered as bycatch quota. These species shall not comprise more than 25% by live weight of the catch retained on board.

[2)] Catches of Cuckoo ray (*Leucoraja naevus*), Thornback ray (*Raja clavata*), Blonde ray (*Raja brachyura*), Spotted ray (*Raja montagui*), Starry ray (*Amblyraja radiata*) and Common skate (*Dipturus batis* complex) shall be reported separately.

[3)] Shall not apply to common skate (*Dipturus batis*) complex (*Dipturus* cf. *flossada* and *Dipturus* cf. *intermedia*), undulate ray (*Raja undulata*) and starry ray (*Amblyraja radiata*). When accidentally caught, these species shall not be harmed. Specimens shall be promptly released. Fishermen shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

Within the North Sea ecoregion, some of the UK's Inshore Fisheries and Conservation Authorities (IFCAs), formerly Sea Fisheries Committees, have a minimum landing size of 40 cm disc width for skates and rays.

Since 2009, Norway has a discards ban that applies to skates and sharks, as well as other fish, in the Norwegian Economic Zone. However, discarding of skates is likely to have continued, although the precise quantity is unknown.

15.3 Catch data

15.3.1 Landings

The landings tables for all skates and rays combined (Tables 15.1–15.4) were updated. Since 2008, EC member states are required to provide species-specific landings data for the main species of rays and skates (Tables 15.5–15.7).

Figure 15.1 shows the total international landings of rays and skates from IIIa and IV combined, and VIId since 1973, plus the TAC for recent years. Data from 1973 onwards are WG estimates. Figure 15.2 shows the landings by country for the whole North Sea ecoregion.

15.3.2 Discard data

Information on discards in the different demersal fisheries is being collected by several Member States.

Length–frequency distributions of discarded and retained elasmobranchs (for the period 1998–2006) were provided by UK-England (ICES, 2006), with updated information in Ellis *et al*. (2010).

Silva *et al*. (2012) investigated the UK skate catches, including those from the North Sea, and using observer data, discussed discarding patterns. In general, 50% retention occurred at 49–51 cm. for the main commercial skate species, and nearly all skates with total length larger than 60 cm were retained. *A. radiata* was generally discarded across the entire length range (12–69 cm).

15.3.3 Quality of the catch data

In 2008 the EC asked Member States to start reporting their landings of skates and rays by (major) species. Official species-specific landings should therefore be available for six years now; however compliance with this varies from 0–100% by region and Member State (see Section 15.4.1). The quality of the species-specific data is discussed in Section 15.4.2.

Several nations have market sampling and discard observer programmes that can also provide information on the species composition, although comparable information is lacking for earlier periods. Updated analyses of these data are required.

15.3.4 Discard survival

Ellis *et al. (*2014 WD) provided a review of discard survival studies. Skates taken in coastal fisheries using trawls, longlines, gillnets and tanglenets generally show low at-vessel mortality (Ellis *et al.*, 2008a), though it should be noted that the inshore fleet generally have limited soak times and haul durations. Studies for beam trawlers indicate that just over 70% of skates may survive (Depestele *et al.*, 2014).

15.4 Commercial landings composition

15.4.1 Species and size composition

From 2008 onwards all EU countries are obliged to register species-specific landings for the main skate species. In the past, only France and Sweden provided landings data by species based on information from logbooks and auction. However, the accuracy of some of these data was doubtful. The landings for each country have been analysed to determine the percentage of landings that have been reported to species-specific level. It can be seen that this percentage varies between regions and countries (Tables 15.5–15.7). Belgium, France, the Netherlands, UK-England and UK-Scotland demonstrate a consistent high level of species-specific declaration for Areas IV and VIId; in 2013 they declared 99%, 81%, 99%, 97% and 75% of their landings in Area IV to species level respectively, and 97%, 91%, 69%, 100% and 0.5% of their landings in Division VIId to species level respectively (Tables 15.6–15.7). Sweden mainly landed rays and skates from Area IIIa, and 100% of landings were declared at species level. Denmark, Germany and Norway (Areas IIIa, IV) did not declare any landings to species level (Tables 15.5–15.6), and species-specific landings data are required. However, the Norwegian Reference Fleet does provide some information on species composition, but this cannot be regarded as representative of the whole Norwegian fishery.

The species composition (percentage) for landings by the Dutch beam trawl fleet based on market sampling for 2000–2007 is presented in Table 15.8. Table 15.9 gives length compositions of these landings. Figure 15.3 shows the length–frequency of sampled Dutch skate and ray landings in 2012.

15.4.2 Quality of data

The WG is of the opinion that analyses of data from market sampling and observer programmes can provide reliable data on the recent species composition of landings and discards, and such data should be used to validate and/or complement reported landings data.

From 2008 onwards improved species-specific landings are available. Such data can be compared with market sampling and observer programmes to determine whether species identification has occurred correctly. The market sampling programme of the Dutch beam trawl fishery from 2000–2007 demonstrated that *R. montagui* and *R. clavata* are the most common species landed, followed by *R. brachyura* (Table 15.8). Since the species-specific landings data were available (from 2008 onwards), it appears that the percentage of *R. brachyura* has decreased in the Dutch landings (Table 15.6; ICES, 2009b, 2010, 2011a, 2012) compared with 2000–2007. It is likely that misidentification has occurred (especially between *R. montagui* and *R. brachyura*). This probably affects most nations reporting these two species.

Landings of white skate *Rostroraja alba* and *R. microocellata* as reported by France in ICES Area IV, Arctic skate *Amblyraja hyperborea* as reported by France in ICES Areas IV and VIId, and *D. oxyrinchus* as reported by the UK (England) in ICES Area VIId are likely the result of misidentification or incorrect use of species codes. Furthermore, landings of *L. circularis* reported by Belgium in ICES Area VIId are unlikely and could possibly have been *R. microocellata*, as both species are sometime known locally as 'sandy ray'. Very low landings (39 kg) of *R. alba* were reported by UK (England) in ICES Areas IV and VIId, but the accuracy of this species identification remains unclear.

These examples demonstrate that more robust protocols for ensuring correct identification are still needed, both at sea and in the market. The species-specific landings data also demonstrate that some nations still report a considerable proportion of unidentified ray and skate landings or do not report species-specific landing data at all.

In 1981 France reported exceptionally high landings for IV and VIId. This is likely to be caused by misreporting. Misreporting may also have taken place in 2007 as a consequence of limited quota and the 25% bycatch limitation.

15.5 Commercial catch–effort data

There are no effort data specifically for North Sea skates and rays.

15.6 Fishery-independent surveys

Time-series of abundance indices for the most relevant species, based on North Sea IBTS surveys for the years 1977–2013, are shown in Figures 15.4 and 15.5. Mean, maximum and minimum lengths per year for the North Sea IBTS survey are shown in Figures 15.6 and 15.7. Annual distribution of French CGFS and UK BTS survey cpue are shown in Figures 15.8 and 15.9. Data were extracted from the DATRAS database or supplied by national laboratories. Table 15.10 gives an overview of the cpue series for the IBTS and CGFS.

15.6.1 International Bottom Trawl Survey North Sea Q1 (IBTS-Q1) and Q3 (IBTS-Q3)

Fishery-independent data are available from the International Bottom Trawl Survey (IBTS), in winter and summer, and from different beam trawl surveys (in summer). An overview of North Sea elasmobranchs based on survey data was presented in Daan *et al.*, 2005. Distribution maps are provided in ICES, 2005 and ICES, 2006, and in Figure 15.10.

Daan *et al.*, 2005 also analysed the time-series of abundance for the major species caught for the period 1977–2004 (see Figure 12.3 of ICES, 2006). *A. radiata* appears to have increased from the late seventies to the early eighties, followed by a decline. The reasons for this decline are unknown, but could include changing environmental conditions, multi-species interactions (including with other skates), or fishing impacts, or even improved species identification. The same patterns seem to apply to *L. naevus* and *R. montagui*, these species increase in the most recent ten years in the winter and the summer survey. *D. batis* demonstrated an overall decline, supporting the findings of ICES, 2006. *R. clavata* has largely remained stable in recent years, with one outlier in 1991 owing to a single exceptionally large catch (confirmed record).

15.6.2 Channel groundfish survey

Martin *et al.*, 2005 analysed data from the Channel Groundfish Survey (CGFS) and the Eastern Channel Beam Trawl Survey (UK (BTS-Q3)) for the years 1989–2004. Migratory patterns related to spawning and nursery areas were postulated, with the coast of southeast England an important habitat for *R. clavata*. Updated analyses for this survey were recently published by Martin *et al*. (2010, 2012). CGFS continued in 2013, where high indices were noted for *R. clavata* and *R. undulata*. While most species fluctuate without clear trend, *R. clavata* has increased in the last ten years. Information on *R. undulata* is presented in Section 18, as the main part of the stock is considered to occur in Division VIIe.

15.6.3 Beam trawl surveys

The UK (BTS-Q3) started in the late 1980s, although the survey grid was not standardized until 1993 (see Ellis *et al*., 2005; Parker-Humphreys, 2005 and Ellis, 2010 WD for a description of the survey). The primary target species for the survey are commercial flatfish (plaice and sole) and so most sampling effort occurs in relatively shallow water. *Raja brachyura*, *R. clavata*, *R. montagui* and *R. undulata* are all sampled during this survey.

Catch rates (n.h^{-1}) for this survey were updated, although the subsequent analyses omitting data collected prior to 1993 (Figure 15.9; Table 15.11). For lesser-spotted dogfish mainly adults are being caught, whereas for the other species the catches consist mostly of juvenile fish, which is likely to be an effect of the shallow area covered in this survey and that the gear is less effective for larger skates.

Although *R. brachyura* have generally increased over the period, catch rates for this species are low and variable. Catch rates for *R. montagui* have declined in recent years. Given that this survey generally catches juveniles of this species and of *R. brachyura*, it is unclear as to whether there may have been some identification issues involved in these contrasting trends. *R. clavata* have broadly increased over the period, though the greatest catches and increase is from stations in IVc. Over the entire time-series, there have been a limited number of stations routinely fished in this division, although an increased number of sampling stations have been fished in recent years. So these data should be examined in future studies. Only small numbers of *R. undulata* are captured in this survey (VIId is the eastern part of their geographic range). The species was absent in 2006 and 2007 but was caught again in the following years.

15.6.4 Others

French surveys are held at coastal area and are dedicated to sample scallops and coastal fish nurseries and communities which include a bycatch of skates these include Comor (dedicate to scallop abundance estimation in VIId) NourSom (fish nurseries in the Somme estuary area, VIId) and NourSeine (fish nursery in the seine Bay, VIId) were not used so far.

15.7 Life-history information

Elasmobranchs are not routinely aged, although techniques for ageing are available (e.g. Walker, 1999; Serra-Pereira *et al.,* 2005). Limited numbers of species have been aged in special studies.

Updated length–weight conversion factors and lengths-at-maturity are available for nine skate species (McCully *et al*., 2012). Three species had conversion factors specific to the North Sea ecoregion, with the lengths at maturity for both sexes of *L. naevus*, and female *R. clavata*, being significantly smaller in the North Sea than the Celtic Seas ecoregion.

Demographic modelling requires more accurate life-history parameters, in terms of age or length and fecundity. For example, recent studies of the numbers of egg-cases laid by captive female *R. clavata* were 38–66 eggs over the course of the egg-laying season (Ellis, unpublished), whereas other studies using oocyte counts and the proportion of females carrying eggs have suggested that the fecundity may be >100.

15.7.1 Ecologically important habitats

Ecologically important habitats for the demersal elasmobranchs would include (a) oviposition (egg-laying) sites for oviparous species; (b) pupping grounds for viviparous species; (c) nursery grounds; (d) habitats of the rare species, as well as other sites where there can be large aggregations (e.g. for mating or feeding).

Little is known about the presence of egg-laying and pupping grounds, although parts of the southern North Sea (e.g. the Thames area) are known to have large numbers of juveniles (Ellis *et al*., 2005).

Trawl surveys could usefully provide information on catches of (viable) skate egg-cases. This recommendation has therefore been put into the offshore and inshore manuals of the trawl surveys (ICES, 2011b). The Netherlands already collects data on viable elasmobranch egg cases.

Surveys may be able to provide information on the locations of nursery grounds and other juvenile habitats, and these should be further investigated to identify sites where there are large numbers of 0-groups and where these life-history stages are found on a regular basis.

Little is known about the habitats of the rare elasmobranch species, and further investigations on these are required (e.g. Martin *et al*., 2010; 2012; Ellis *et al*., 2012).

15.8 Exploratory assessment models

Given the lack of longer term species-specific data from commercial fleets and limited biological information the status of North Sea demersal elasmobranchs has been evaluated based on survey data, including historical information.

15.8.1 GAM analyses of survey trends

The GAM analysis focused on *A. radiata* in the IBTS-Q1 and IBTS-Q3 surveys and also *Scyliorhinus canicula* (see Section 25) in the CGFS, UK-BTS, IBTS-Q1 and IBTS-Q3 surveys. The length-based cpues per haul for the period 1977–Q1 2014 were used as input data. This dataset contains information on the survey, geographic position of the haul, depth, length of each individual measured to the nearest centimetre, year of haul, and survey quarter. These variables were used to predict cpue in a GAM analysis (Wood, 2006). The cpue in is given as n/hr. Given the nature of the data, we assumed a negative binomial error distribution with a log link. Results in terms of predicted mean cpue per year and length (at a given location with corresponding depth) and the spatial distribution of the catches are given in Figures 15.11. The name of the survey was taken into account as a nuisance variable that describes the difference in catchability among the surveys. Future work on these analyses could include converting the cpue indices to numbers per unit area (density estimates). Once the cpue estimates are analysed in terms of numbers per unit area, total biomass estimates can be further determined.

15.8.2 Estimation of abundance and spatial analysis–application of the SPANdex method

In 2007 the SPANdex approach was used to examine changes in abundance and distribution of four more common skate species in the North Sea (*A. radiata, L. naveus, R. clavata* and *R. montagui*).

Density surfaces (distribution based strata) were created using potential mapping in SPANS (Anon, 2003). Quarter 1 catch rate data from the North Sea IBTS survey (IBTS-Q1) employing a GOV demersal trawl, from 1980 to 2006 were used for the analysis.

The distribution maps of all four skate species (*A. radiata, L. naveus, R. clavata* and *R. montagui*) demonstrated that these species have been restricted to the consistent areas. The area occupied (AO) changes over time (Figure 15.12). Overall, it is clear from this study that AO may not reflect population changes and should therefore be used with caution when being used as metric for population status.

15.8.3 Previous assessments of *R. clavata*

Under the DELASS project (Heessen, 2003), various analyses of survey data were conducted (ICES, 2002). The high frequency of zero catches in combination with a few, in some cases, high catches were analysed statistically using a two-stage model approach. First, the probability of getting a catch with at least one *R. clavata* was made using a GLM with a binomial distribution and a logit link function. Non-zero catches were then modelled using a Gamma distribution and a log link function.

ICES (2002) concluded that "The North Sea stock of thornback ray has steadily declined since the start of the 20th century. One hundred years ago, the distribution area of the stock included almost the whole North Sea. Today, survey data demonstrate a concentration in the southwest North Sea (from the Thames Estuary to the Wash), and this reduced distribution area is confirmed by the steep decrease in the probability of a catch including thornback ray estimated by statistical models. Apparently, there are still patches left in the North Sea with stable local populations. Whether these areas are self-sustaining and whether the number of patches will remain high enough for a sustained North Sea population is, however, unknown."

ICES (2005) subsequently undertook GIS analyses of survey data, and these studies also suggested that the stock was concentrated in the southwestern North Sea (see Sections 10.5 and 10.8 of ICES, 2005) and the stock area had declined.

From comparisons of recent survey data with data for the early 1900s it can be seen that, in the first decade of the 20th century, *R. clavata* was widely distributed over the southern North Sea, with centres of abundance in the southwestern North Sea and in the German Bight, north of Helgoland. The area over which the species is distributed in recent years is much smaller than 100 years ago. The species has disappeared from the southeastern North Sea (German Bight), and catches in the Southern Bight have become limited to the western part only (see also ICES, 2002).

15.9 Stock assessment

Updated assessments for the skates in this ecoregion are scheduled for 2015.

15.10 Quality of assessments

Analyses of survey data for *R. clavata* undertaken by ICES (2002; 2005) may have been compromised by misidentifications in submitted IBTS data, and so the extent of the decline in distribution reported in these reports may be exaggerated. The distribution of *R. clavata* in the southern North Sea has certainly contracted to the southwestern North Sea, and they are now rare in the southeastern North Sea, where they previously occurred (as indicated by historical surveys). The perceived decline in catches in the northeastern North Sea may have been based, at least in part, on catches of *A. radiata*. Excluding questionable records from analyses still indicates that the area occupied by *R. clavata* has declined, with the stock concentrated in the southwestern North Sea, with catch trends in IVc more stable/increasing in recent times (ICES, 2007).

15.11 Reference points

No reference points have been proposed for *R. clavata* or other elasmobranch stocks in this ecoregion.

15.12 Conservation considerations

The *D. batis*-complex is considered 'Critically Endangered by the IUCN and *D. batis*, *R. montagui*, and *R. clavata* are all on the OSPAR list of Threatened and Declining species.

In Sweden a number of demersal and deep-water elasmobranchs are contained in the Swedish Red List (Gärdenfors, 2010), with *R. lintea* considered Near Threatened, *R. clavata* and rabbit fish *Chimaera monstrosa* are considered Endangered, and *D. batis* is considered Regionally Extirpated.

In Norway a number of demersal elasmobranchs are listed on the Norwegian Red List (Gjøsæter *et al*., 2010) including various skates: *D. batis* (complex) is considered Critically Endangered and *B. spinicauda*, *D. nidarosiensis* and *L. fullonica* are considered Near Threatened.

15.13 Management considerations

Demersal elasmobranchs are usually caught in mixed fisheries for demersal teleosts, although some inshore longline and gillnet fisheries target *R. clavata* in seasonal fisheries in the southwestern North Sea. Up to 2008 they have traditionally been landed and reported in mixed categories such as "skates and rays" and "sharks". For assessment purposes species-specific landings data are essential. Some doubts exist as to the quality of the data provided. Particularly the distinction between *R. montagui* and *R. brachyura* may need to be improved. Further sampling of commercial catches to validate species-specific landings is therefore required.

Landings have been at or above the TAC since 2006 (but slightly above VIId, possibly due to transfer between VIId and VIIe) (Figure 15.1) and may have become restrictive for some fisheries. Since its introduction the TAC has gradually been reduced. In 2009–2013 there were three separate TACs for Areas IIa and IV combined, for IIIa and for VIId. Further reductions in TAC may induce regulatory discarding.

Discard survivorship can be high for inshore trawlers in the SW North Sea, as tow duration tends to be relatively short and line fisheries also have a high discard survival (Ellis *et al*., 2008a, b). Discard survival from gillnet catches is also potentially high, depending on soak-time. Preliminary studies of survival from beam trawlers also indicated potentially high (>70%) survival for skates (Depestele *et al.*, 2014).

From 2008 onwards, species-specific landings data for the major skate species have been required. WGEF have noted an increasing proportion of skate landings reported to species, and whilst there are some inconsistencies, the overall proportions are in line what would be expected given survey information. Continuation of such data collection would aid in species-specific fisheries management.

As a consequence of effort restrictions and high fuel prices, effort has reduced, but can also result in using different gears with different catchabilities for rays and skates. Also some fisheries may redirect effort to fishing grounds closer to port, which may affect more coastal species, such as. *R. clavata* occuring in the Thames estuary and the Wash in the southwestern North Sea.

The TAC for "skates and rays" should only apply to Areas IIIa, IV and VIId and not to IIa because only a part of IIa belongs to the present North Sea ecoregion.

Current TAC regulations have a condition so that "*up to 5%* [of the TAC for Union waters of VIa, VIb, VIIa–c and VIIe–k] *may be fished in Union waters of VIId*". Whilst it is pragmatic to allowing vessels in the English Channel (VIId,e) to transfer quota between these divisions, further studies to examine the implications of this needs to be evaluated. For example, 5% of the overall 2014 quota for VIa, VIb, VIIa–c and VIIe–k (8032 t) is 401.6 t, which is more than half of the 2014 TAC for VIId (798 t). Whilst this is a theoretical maximum and unlikely to be realised, further studies of this issue are required.

Technical interactions of fisheries in this ecoregion are demonstrated in Table 15.12.

15.14 References

Anon. 2003. Geomatica V. 9 Users Guide. PCI Geomatics, 50 West Wilmot St Richmond Hill. Ont.

Daan, N., Heessen, H.J.L., and ter Hofstede, R. 2005. North Sea Elasmobranchs: distribution, abundance and biodiversity. ICES CM 2005/N:06.

Depestele, J., Desender, M., Benoît, H. P., Polet, H., and Vincx, M. 2014. Short-term survival of discarded target fish and non-target invertebrate species in the "eurocutter" beam trawl fishery of the southern North Sea. *Fisheries Research*, 154: 82–92.

Ellis, J.R., Burt, G.J. and Cox, L.P.N. 2008a. Thames ray tagging and survival. Cefas Fisheries Science Partnership 2007/2008, Programme 19, Final Report, 54 pp.

Ellis, J.R., Burt, G.J., Cox, L.P.N., Kulka, D.W, and Payne, A.I.L. 2008b. The status and management of thornback ray *Raja clavata* in the southwestern North Sea. ICES CM 2008/K:13, 45 pp.

Ellis, J.R., Dulvy, N.K., Jennings, S., Parker-Humphreys, M. and Rogers, S.I. 2005. Assessing the status of demersal elasmobranchs in UK waters: a review. Journal of the Marine Biological Association of the United Kingdom, 85: 1025–1047.

Ellis, J.R., McCully, S.R. and Brown, M.J. 2012. An overview of the biology and status of undulate ray *Raja undulata*. Journal of Fish Biology, 80: 1057–1074.

Ellis, J.R.., McCully, S.R. and Poisson, F. 2014. A global review of elasmobranch discard survival studies and implications in relation to the EU 'discard ban'. Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 2014, 48 pp.

Ellis, J.R., Silva, J.F., McCully, S.R., Evans, M. and Catchpole, T. 2010. UK fisheries for skates (Rajidae): History and development of the fishery, recent management actions and survivorship of discards. ICES CM 2010/E:10.

Gärdenfors, U. (Ed.). 2010. Rödlistade arter i Sverige 2010- The 2010 Red List of Swedish Species. Artdatbanken, SLU, Uppsala. Available via http://www.slu.se/Global/externwebben/centrumbildningar-projekt/artdatabanken/Dokument/R%c3%b6dlistan/Artgrupper/Rodlista2010-fiskar.pdf.

Gjøsæter, J., Hesthagen, T., Borgstrøm, R., Brabrand, Å., Byrkjedal, I., Christiansen, J. S., Nedreaas, K., Pethon, P., Uiblein, F., Vøllestad, L. A. and Wienerroither, R. 2010. Fisker "Pisces". In Kålås, J. A., Viken, Å., Henriksen, S. and Skjelseth, S. (eds.) 2010. The Norwegian Red List for Species. Norwegian Biodiversity Information Centre, Norway.

Heessen, H.J.L. (Ed.) 2003. Development of elasmobranch assessments DELASS. Final report of DG Fish Study Contract 99/055, 605 pp.

HVMFS. 2004. Fiskeriverkets föreskrifter (FIFS 2004:36) om fiske i Skagerrak, Kattegatt och Östersjön. FIFS 2004:36. [in Swedish] Available via https://www.havochvatten.se/download/18.2a9b232013c3e8ee03e1eee/1360262518145/HVMFS-FIFS+2004-36+keu+130201.pdf.

ICES. 2002. Report of the Working Group on Elasmobranch Fishes (WGEF), 6–10 May, Copenhagen, Denmark. ICES CM 2002/G:08, 119 pp.

ICES. 2005. Report of the Working Group on Elasmobranch Fishes (WGEF), 14–21 June, Lisbon, Portugal. ICES CM 2006/ACFM:03, 232 pp.

ICES. 2006. Report of the Working Group on Elasmobranch Fishes (WGEF), 14–21 June 2005, Copenhagen, Denmark. ICES CM 2006/ACFM:31, 291 pp.

ICES. 2007. Report of the Working Group on Elasmobranch Fishes (WGEF), 22–28 June, Galway, Ireland. ICES CM 2007/ACFM:27, 318 pp.

ICES. 2008. Demersal Elasmobranchs in the North Sea (Subarea IV), Skagerrak (Division IIIa), and eastern English Channel (Division VIId). ICES Advice 2008, Book 6, Section 6.4.30, 201–205.

ICES. 2009a. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak-Combined Spring and Autumn (WGNSSK). ICES CM 2009\ACOM:10.

ICES. 2009b. Report of the Joint meeting between ICES Working Group on Elasmobranch Fishes (WGEF) and ICCAT Shark Subgroup, 22–29 June 2009, Copenhagen, Denmark. ICES CM 2009.ACOM:16. 422 pp.

ICES. 2010. Report of the Working Group on Elasmobranch Fishes (WGEF), 22–29 June 2010, Horta, Portugal. ICES CM 2010/ACOM:19. 519 pp.

ICES. 2011a. Report of the Working Group on Elasmobranch Fishes (WGEF), 20–24 June 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:19. 488 pp.

ICES. 2011b. Report of the Working Group on Beam Trawl Surveys (WGBEAM). ICES CM 2011/SSGESST:14.

ICES. 2012. Report of the Working Group on Elasmobranch Fishes (WGEF), 19–26 June 2012, Lisbon, Portugal. ICES CM 2012/ACOM:19. 532 pp.

Martin C.S., Vaz, S., Ellis, J.R., Coppin, F., Le Roy, D. and Carpentier, A. 2010. Spatio-temporal patterns of demersal elasmobranchs in trawl surveys in the eastern English Channel (1988–2008). Marine Ecology Progress Series, 417: 211–228.

Martin, C.S., Vaz, S., Ellis, J.R., Lauria, V., Coppin, F., and Carpentier, A. 2012. Modelled distributions of ten demersal elasmobranchs of the eastern English Channel in relation to the environment. Journal of Experimental Marine Biology and Ecology, 418/419: 91–103.

Martin, C.S., Vaz, S., Ernande, B., Ellis, J.R., Eastwood, P.D., Coppin, F., Harrop, S., Meaden, G.J., and Carpentier, A. 2005. Spatial distributions (1989–2004) and preferential habitats of thornback ray and lesser-spotted dogfish in the eastern English Channel. ICES CM 2005/N:23, 27 pp.

McCully, S.R., Scott, F., and Ellis, J.R. 2012. Lengths-at-maturity and conversion factors for skates (Rajidae) around the British Isles, with an analysis of data in the literature. ICES Journal of Marine Science, 69: 1812–1822.

Parker-Humphreys, M. 2005. Distribution and relative abundance of demersal fishes from beam trawl surveys in the Eastern English Channel (ICES Division VIId) and the southern North Sea (ICES Division IVc) 1993–2001. Science Series Technical Report, Cefas, Lowestoft, 124, 92 pp.

Serra-Pereira, B., Figueiredo, I., Bordalo-Machado, P., Farias, I., Moura, T., and Serrano Gordo, L. 2005. Age and growth of *Raja clavata* Linnaeus, 1758-evaluation of ageing precision using different types of caudal denticles. ICES CM 2005/N:17.

Silva, J.F., Ellis, J.R and Catchpole, T.L. 2012. Species composition of skates (Rajidae) in commercial fisheries around the British Isles and their discarding patterns. Journal of Fish Biology, 80(5): 1678–1703.

Walker, P.A. 1999. Fleeting images: Dynamics of North Sea Ray populations. PhD Thesis, University of Amsterdam, the Netherlands, 145 pp.

Wood, S. N. 2006. Generalized Additive Models: an Introduction with R. Boca Raton: Chapman and Hall–CRC.

Table 15.1. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Total landings of skates (Rajidae) in ICES Division IIIa (in tonnes). "." indicates zero landings, "+" indicates landings <0.5 and "n.a." indicates not available.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0
Denmark	11	41	56	22	36	129	65	26	8	5	12	12	44	16	18
Germany	.	.	.	.	.	.	.	1	.	.	.	.	+	.	0
Iceland	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0
Netherlands	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Norway	208	123	154	159	163	85	94	51	13	23	33	24	25	18	51
Sweden	2	2	12	13	9	20	10	18	11	6	2	10	3	3	6
UK (E, W_& NI)	.	.	.	.	.	.	.	.	.	.	.	.	.		
UK (Scotland)	.	.	.	.	.	.	.	.	.	.	.	.	.		
Total	221	166	222	194	208	234	169	95	32	34	47	45	72	37	75

Table 15.2. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Total landings of skates (Rajidae) in ICES Subarea IV (in tonnes). Note that "." indicates zero landings, "+" indicates landings <0.5 and "n.a." indicates not available.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	336	332	370	436	323	276	327	350	272	371	299	294	231	183	215
Denmark	45	93	65	34	33	25	23	26	27	23	29	30	38	20	45
Faroe Islands	.	.	.	.	.	.	.	.	.	.	.	n.a.	n.a.	n.a.	n.a.
France	41	31	61	62	36	37	34	15	56	69	74	89	57	47	53
Germany	16	23	11	22	21	17	29	16	17	30	21	32	19	17	25
Iceland	.	.	.	.	.	.	.	.	.	.	.	.	.	.	n.a.
Ireland	.	.	.	.	.	.	.	.	119	.	.	.	.	.	.
Netherlands	515	693	834	805	686	561	680	603	721	564	379	390	212	431	313
Norway	152	161	173	83	113	77	87	96	71	97	119	105	56	41	73
Poland	.	.	.	.	.	.	.	.	.	.	.	.	n.a.	n.a.	n.a.
Sweden	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
UK (E, W_& NI)	618	516	476	500	537	550	434	348	329	392	348	372	413	356	470
UK (Scotland)	965	860	822	853	741	512	404	374	331	343	311	289	358	305	321
Total	2688	2709	2812	2794	2490	2055	2018	1801	1944	1889	1580	1602	1383	1401	1515

Table 15.3. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Total landings of skates (Rajidae) in ICES Division VIId (in tonnes). "." indicates zero landings, "+" indicates landings <0.5 and "n.a." indicates not available.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	93	69	79	113	153	96	94	109	164	174	125	111	103	105	131
France	558	693	729	725	796	695	602	687	792	710	1270	1043	954	1010	1080
Germany	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Ireland	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Netherlands	.	.	.	.	.	.	.	13	21	13	10	11	12	14	4
Spain	.	.	.	.	.	.	.	.	.	.	.	.	0	.*	.*
UK (E, W_& NI)	437	355	169	140	186	157	147	139	188	199	152	133	141	166	189
UK (Scotland)	.	.	.	.	.	.	.	2	.	6	8	5	6	4	5
Total	1088	1117	977	978	1135	948	843	948	1165	1102	1564	1303	1217	1300	1409

***includes Basque country landings.**

Table 15.4. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Total landings of skates (Rajidae) in the North Seas ecoregion (IIIa, IV, VIId) (in tonnes). "." indicates zero landings, "+" indicates landings <0.5 and "n.a." indicates not available.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	429	401	449	548	476	372	422	459	436	545	424	405	334	288	346
Denmark	56	134	121	56	69	154	88	52	35	28	41	42	81	36	63
Faroe Islands	.	.	.	.	.	.	.	.	.	.	.	n.a.	n.a.	n.a.	0
France	599	724	790	725	796	732	636	701	848	779	1344	1132	1011	1057	1133
Germany	16	23	11	22	21	17	29	17	17	30	21	32	19	17	25
Iceland	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ireland	.	.	.	.	.	.	.	.	119	.	.	.	.	.	.
Netherlands	515	693	834	805	686	561	680	615	742	577	389	401	224	446	317
Norway	360	284	327	242	276	162	181	120	84	120	152	129	81	59	124
Poland	.	.	.	.	.	.	.	.	.	.	.	.	n.a.	n.a.	0
Spain	.	.	.	.	.	.	.	.	.	.	.	.	.	.*	.*
Sweden	2	2	12	13	9	20	10	18	11	6	2	10	4	3	6
UK (E&W and NI)	1055	871	645	640	723	707	580	487	517	591	500	504	555	522	659
UK (Scotland)	965	860	822	853	741	512	404	375	331	349	320	295	365	310	326
Total of submitted data	3997	3992	4011	3904	3797	3237	3030	2845	3141	3025	3192	2951	2672	2738	3000

***includes Basque country landings.**

Table 15.5. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Species-specific landings and species composition of skates (Rajidae) from ICES Division IIIa in 2013.

Area IIIa	Species Categories	Weight (t)	% of national catch	% excluding generic categories
BELGIUM	*Raja brachyura*	0.0	100.0%	100.0%
	Total:	0.0	100.0%	
Percent of catch as species-specific landings:			100.0%	
DENMARK	Skates and rays	18.2	100.0%	
	Total:	18.2	100.0%	
Percent of catch as species-specific landings:			0%	
SWEDEN	*Dipturus batis*	1.7	29.8%	29.8%
	Rajella lintea	4.0	70.2%	70.2%
	Total:	5.7	100.0%	
Percent of catch as species-specific landings:			100%	
FRANCE	*Leucoraja naevus*	0.0	100.0%	
	Total:	0.0	100.0%	
Percent of catch as species-specific landings:			100%	

Table 15.6. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Species-specific landings and species composition of skates (Rajidae) from ICES Subarea IV in 2013.

Area IV	Species Categories	Weight (t)	% of national catch	% excluding generic categories
BELGIUM	*Leucoraja circularis*	0.2	0.1%	0.1%
	Leucoraja naevus	0.6	0.3%	0.3%
	Raja brachyura	87.6	41.2%	41.7%
	Raja clavata	113.4	53.3%	53.9%
	Raja montagui	11.0	5.2%	5.2%
	Skates and rays	2.5	1.2%	
	Total:	212.7	100.0%	
Percent of catch as species-specific landings:			98.8%	
DENMARK	Skates and rays	45.0	100.0%	
	Total:	45.0	100.0%	
Percent of catch as species-specific landings:			0.0%	
FRANCE	*Amblyraja hyperborea*	0.0	0.0%	0.0%
	Leucoraja naevus	0.0	0.1%	0.1%
	Rostroraja alba	1.3	2.5%	3.1%
	Raja brachyura	0.1	0.2%	0.2%
	Leucoraja circularis	0.0	0.0%	0.0%
	Raja clavata	39.9	75.7%	93.6%
	Raja montagui	1.2	2.4%	2.9%
	Amblyraja radiata	0.0	0.0%	0.0%
	Raja undulata	0.0	0.1%	0.1%
	Skates and rays	10.1	19.1%	
	Total:	52.7	100.0%	
Percent of catch as species-specific landings:			80.9%	
GERMANY	Skates and rays	25.1	100.0%	
	Total:	25.1	100.0%	
Percent of catch as species-specific landings:			0.0%	
NETHERLANDS	*Leucoraja naevus*	4.3	1.4%	1.4%
	Raja brachyura	38.7	12.4%	12.5%
	Raja clavata	146.3	46.8%	47.4%
	Raja montagui	119.3	38.1%	38.7%
	Skates and rays	4.2	1.3%	
	Total:	312.8	100.0%	
Percent of catch as species-specific landings:			98.7%	
SWEDEN	*Dipturus batis*	0.1	36.0%	
	Rajella lintea	0.2	64.0%	
	Total:	0.3	100.0%	
Percent of catch as species-specific landings:			100.0%	

Table 15.6. Continued.

Area IV	Species Categories	Weight (t)	% of national catch	% excluding generic categories
UK (E,W and NI)	*Amblyraja hyperborea*	0.1	0.0%	0.0%
	Amblyraja radiata	0.0	0.0%	0.0%
	Dipturus batis complex	0.3	0.1%	0.1%
	Leucoraja naevus	0.7	0.2%	0.2%
	Rostroraja alba	0.0	0.0%	0.0%
	Raja brachyura	35.7	7.6%	7.8%
	Raja clavata	385.0	81.9%	84.1%
	Raja microocellata	0.0	0.0%	0.0%
	Raja montagui	35.7	7.6%	7.8%
	Skates and rays	12.4	2.6%	
	Total:	470.0	100.0%	
Percent of catch as species-specific landings:			97.4%	
UK (Scotland)	*Dipturus batis* complex	0.5	0.2%	0.3%
	Leucoraja circularis	2.9	1.1%	1.5%
	Leucoraja naevus	122.0	47.6%	63.5%
	Raja clavata	40.9	15.9%	21.3%
	Raja montagui	84.9	33.1%	44.2%
	Rostroraja alba	5.4	2.1%	2.8%
	Skates and rays	64.6	25.2%	
	Total:	256.6	100.0%	
Percent of catch as species-specific landings:			74.8%	

Table 15.7. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Species-specific landings and species composition of skates (Rajidae) from ICES Division VIId in 2013.

Area VIId	Species Categories	Weight (t)	% of national catch	% excluding generic categories
BELGIUM	*Leucoraja circularis*	5.0	3.8%	3.9%
	Leucoraja naevus	0.6	0.5%	0.5%
	Raja brachyura	32.1	24.6%	25.4%
	Raja clavata	88.0	67.3%	69.6%
	Raja montagui	0.6	0.5%	0.5%
	Skates and rays	4.3	3.3%	
	Total:	130.7	100.0%	
Percent of catch as species-specific landings:			96.7%	
FRANCE	*Dipturus batis* complex	0.0	0.0%	0.0%
	Amblyraja hyperborea	0.1	0.0%	0.0%
	Leucoraja fullonica	0.3	0.0%	0.0%
	Leucoraja naevus	12.5	1.2%	1.3%
	Rostroraja alba	13.4	1.2%	1.4%
	Raja brachyura	23.2	2.1%	2.4%
	Leucoraja circularis	0.0	0.0%	0.0%
	Raja clavata	905.3	83.8%	91.8%
	Raja microocellata	4.6	0.4%	0.5%
	Raja montagui	25.4	2.4%	2.6%
	Amblyraja radiata	0.0	0.0%	0.0%
	Raja undulata	0.9	0.1%	0.1%
	Skates and rays	94.7	8.8%	
	Total:	1080.4	100.0%	
Percent of catch as species-specific landings:			91.2%	
NETHERLANDS	*Leucoraja naevus*	0.0	1.0%	1.5%
	Raja brachyura	0.1	3.3%	4.9%
	Raja clavata	2.8	62.6%	91.1%
	Raja montagui	0.1	1.7%	2.5%
	Skates and rays	1.4	31.3%	
	Total:	4.4	100.0%	
Percent of catch as species-specific landings:			68.7%	

Table 15.7. Continued.

Area VIId	Species categories	Weight(t)	% of national ctach	% excluding generic categories
UK (Excl. Scotland)	*Amblyraja radiata*	0.0	0.0%	0.0%
	Dipturus oxyrinchus	0.5	0.3%	0.3%
	Leucoraja fullonica	0.0	0.0%	0.0%
	Leucoraja naevus	0.7	0.4%	0.4%
	Raja brachyura	36.9	19.5%	19.6%
	Raja clavata	141.7	74.9%	75.1%
	Raja microocellata	3.1	1.6%	1.6%
	Raja montagui	5.8	3.1%	3.1%
	Skates and rays	0.4	0.2%	
	Total:	189.0	100.0%	
Percent of catch as species-specific landings:			99.8%	
UK (Scotland)	*Raja clavata*	0.0	0.5%	100.0%
	Skates and rays	4.8	99.5%	
	Total:	4.9	100.0%	
Percent of catch as species-specific landings:			0.5%	

Table 15.8. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel: quantification of species composition (%) for North Sea skates and rays in Dutch beam trawl fishery based on market sampling.

Year	*A. radiata*	*L. naevus*	*R. brachyura*	*R. clavata*	*R. montagui*
2000	0.2	0.5	19.6	38.2	41.5
2001	0.2	0.5	13.8	37.7	47.8
2002			31.1	28.1	40.8
2003			26.9	27.0	46.1
2004			20.7	38.7	40.6
2005	0.2	0.2	29.8	23.3	46.5
2006			25.3	40.9	33.8
2007			28.9	33.6	37.4

Table 15.9. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel: North Sea rays and skates. Length–frequency distributions in the Dutch beam trawl fleet (numbers in '000).

Country: the Netherlands
Gear: beam trawl
Category: landings

	Raja clavata						*Raja montagui*						*Raja brachyura*					
length	2000	2001	2005	2006	2007	2008	2000	2001	2005	2006	2007	2008	2000	2001	2005	2006	2007	2008
25																		
30	0.6	1.9	3.0	0.3	1.0	0.5	3.5	0.5	0.9	0.5		0.2						
35	9.4	11.2	7.8	8.6	7.1	3.0	34.2	6.3	4.7	2.5	0.4	0.2	1.2	1.0	0.3	1.5		
40	16.8	19.9	14.2	13.4	30.5	4.0	75.6	33.5	14.0	15.8	9.7	6.3	1.2	1.5	2.1	5.5	3.8	
45	17.5	20.3	11.2	26.2	27.2	8.5	85.9	60.3	36.9	52.5	32.2	16.1	1.2	3.3	6.0	3.9	7.2	0.1
50	23.0	36.4	18.2	40.0	36.0	15.2	58.3	72.5	47.6	59.6	52.6	45.4	2.7	5.6	7.7	3.5	3.8	0.6
55	16.0	35.3	12.9	26.6	30.9	17.7	42.7	54.6	49.9	34.6	50.8	58.9	3.1	4.9	9.6	7.7	5.1	0.7
60	12.1	22.8	14.7	20.0	19.1	16.6	26.1	42.4	44.2	25.3	40.5	71.7	0.6	5.3	6.8	7.5	5.1	0.8
65	5.3	15.3	5.7	16.7	17.5	14.9	10.4	16.1	13.7	4.7	12.4	26.1	1.0	3.6	8.0	7.6	6.1	0.7
70	5.3	5.2	6.2	11.8	12.3	14.6	2.0	2.3	0.9	1.1	0.5	1.2	1.6	2.1	6.1	4.5	5.9	0.5
75	4.7	5.5	5.2	8.1	6.9	9.8	0.3		0.1				1.8	2.7	3.1	5.4	6.8	0.8
80	3.7	3.5	2.2	3.7	5.4	5.0							1.6	1.9	4.2	5.1	8.2	0.5
85	3.4	2.3	1.8	1.9	1.8	2.9							1.1	1.5	3.1	2.3	6.0	0.5
90	1.2	0.6	0.7	0.9	1.0	0.9							0.5	1.9	2.4	2.0	2.8	0.4
95	0.8	0.3	0.1		0.1	0.4							0.1	0.6	1.6	1.2	2.6	0.2
100						0							0.1		0.2	0.3	0.1	0.0
105															0.3			0.0
110	0.1																	
sum	119.8	180.5	103.9	178.2	197	114.0	339.2	288.4	212.9	196.6	199.2	226.1	17.7	35.8	61.5	58.0	63.5	5.8

Table 15.10. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of abundance estimates (n/hr) IBTS Q1, IBTS Q3 (roundfish areas 1–7), and eastern Channel CGFS Q4 data in the period 1989–2014. All data are abstracted from DATRAS. Data for IBTS are extracted as cpue per length per statistical rectangle) on 19th June 2014, while data for CGFS are extracted as exchange data).

	Amblyraja radiata			Leucoraja naevus			Raja clavata			Raja montagui			Scyliorhinus canicula		
Year	IBTS Q1	IBTS Q3	CGFS Q4	IBTS Q1	IBTS Q3	CGFSQ4	IBTS Q1	IBTS Q3	CGFS Q4	IBTS Q1	IBTS Q3	CGFS Q4	IBTS Q1	IBTS Q3	CGFS Q4
1977	1.87			0.22			0.26			0.03			0.00		
1978	1.66			1.79			1.18			0.38			0.09		
1979	3.39			0.06			0.91			0.00			0.05		
1980	0.72			0.06			0.35			0.03			0.35		
1981	2.53			0.36			0.64			0.00			0.00		
1982	0.62			0.10			0.64			0.40			0.18		
1983	1.64			0.44			1.65			0.23			0.30		
1984	4.27			0.26			1.90			0.60			0.35		
1985	2.10			0.50			0.98			0.40			0.40		
1986	3.63			0.38			1.34			0.23			0.54		
1987	8.29			0.19			2.37			0.20			0.33		
1988	3.00			0.62			0.32			0.13			0.27		
1989	7.25		0.00	0.74		0.00	1.85		3.40	0.30		0.54	0.31		40.19
1990	4.96		0.00	0.53		0.05	1.36		1.61	0.21		0.62	1.44		12.28
1991	3.95	7.87	0.04	0.44	0.29	0.00	42.44	1.27	0.86	2.48	0.36	0.16	0.55	0.84	14.08
1992	7.28	2.28	0.00	0.75	0.41	0.00	2.17	1.22	1.60	0.28	0.40	0.02	0.93	1.96	25.93
1993	11.22	1.68	0.00	0.81	0.11	0.00	0.53	1.04	1.16	0.30	0.41	0.36	0.48	0.92	15.17
1994	3.79	1.93	0.00	0.62	0.19	0.15	0.70	0.11	0.94	0.27	0.65	0.27	0.67	1.63	14.00
1995	8.02	1.85	0.00	0.53	0.09	0.07	0.12	0.04	0.86	0.63	0.21	0.24	1.26	0.40	12.94
1996	5.69	2.34	0.00	0.43	0.12	0.03	0.71	0.69	1.45	0.24	0.25	0.21	0.78	1.80	5.90

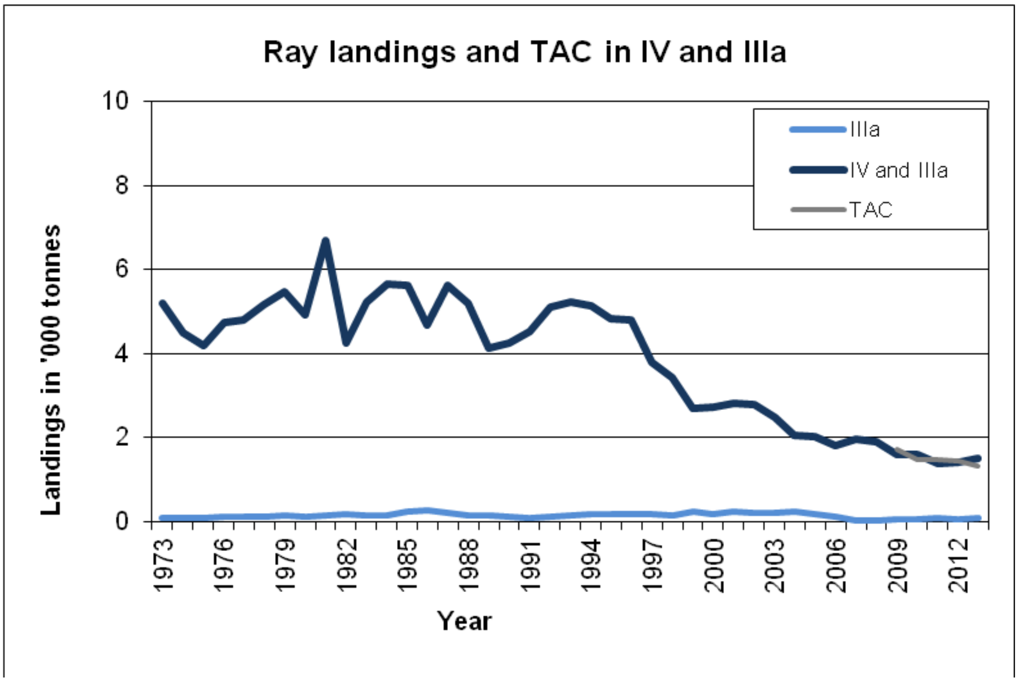
	Amblyraja radiata			*Leucoraja naevus*			*Raja clavata*			*Raja montagui*			*Scyliorhinus canicula*		
Year	**IBTS Q1**	**IBTS Q3**	**CGFS Q4**	**IBTS Q1**	**IBTS Q3**	**CGFSQ4**	**IBTS Q1**	**IBTS Q3**	**CGFS Q4**	**IBTS Q1**	**IBTS Q3**	**CGFS Q4**	**IBTS Q1**	**IBTS Q3**	**CGFS Q4**
1997	4.82	2.18	0.00	0.27	0.42	0.08	1.14	0.27	3.20	0.70	0.00	0.86	0.91	0.83	31.20
1998	5.09	2.19	0.00	0.46	0.08	0.03	1.11	0.05	1.71	0.31	0.20	0.45	0.49	1.09	25.37
1999	6.72	2.76	0.04	0.33	0.38	0.00	0.40	0.14	2.87	0.24	0.99	0.04	1.17	1.80	24.73
2000	7.75	3.07	0.00	0.45	0.45	0.02	0.88	0.04	2.59	0.23	0.01	0.08	1.73	1.29	34.15
2001	2.68	5.18	0.00	0.31	0.57	0.00	0.90	0.17	1.78	0.18	0.10	0.06	1.49	1.57	21.12
2002	4.19	2.93	0.00	0.45	0.49	0.01	1.06	0.72	2.22	0.53	0.05	0.18	2.90	3.41	24.59
2003	4.61	3.41	0.02	0.25	0.29	0.00	1.03	0.05	5.09	0.46	0.09	0.16	4.07	1.68	35.08
2004	4.33	1.85	0.00	0.33	0.31	0.05	0.48	0.13	2.02	0.37	0.14	0.02	3.36	3.29	20.00
2005	3.70	2.10	0.00	0.33	0.40	0.02	1.03	0.05	3.30	0.65	0.36	0.20	2.79	3.22	33.21
2006	2.26	2.37	0.00	0.36	0.46	0.01	1.17	0.64	2.38	0.18	0.36	0.10	4.84	7.46	29.61
2007	4.22	3.82	0.00	0.44	0.33	0.00	0.52	0.13	2.83	0.66	0.76	0.45	5.69	2.90	44.22
2008	3.14	2.51	0.02	0.41	1.11	0.00	2.02	0.62	3.17	1.88	0.27	0.01	6.12	6.58	24.53
2009	1.33	2.98	0.00	0.35	0.59	0.02	2.58	0.71	3.10	0.98	0.90	0.00	5.78	6.87	26.32
2010	1.57	2.24	0.00	0.44	0.64	0.00	0.55	0.57	2.41	1.11	0.86	0.02	5.56	9.13	19.74
2011	1.28	2.41	0.00	0.41	0.61	0.03	0.19	0.35	4.68	0.78	1.01	0.22	4.14	8.29	22.34
2012	1.67	1.95	0.00	0.66	0.69	0.00	2.93	0.79	4.61	1.57	1.16	0.12	23.26	8.02	28.46
2013	1.19	1.43	0.00	0.78	0.53	0.00	1.06	2.24	6.48	1.51	1.33	0.16	19.00	18.3	30.64
2014	1.08		na	0.45		Na	1.31		na	0.99		na	6.84		na

Table 15.11. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Time-series of abundance estimates (n/hr) IBTS data in the period 1993–2014. Data are obtained from J. Ellis in June 2014.

	Raja brachyura	*Raja clavata*	*Raja microocellata*	*Raja montagui*	*Raja undulata*	*Scyliorhinus canicula*	*Scyliorhinus stellaris*
Year	UKBTS	UKBTS	UKBTS	UKBTS	UKBTS	UKBTS	UKBTS
1993	0.48	3.82	0.06	0.74	0.12	10.91	0.00
1994	0.14	4.20	0.07	0.81	0.06	8.18	0.00
1995	0.10	2.54	0.06	1.63	0.01	7.13	0.06
1996	0.05	3.60	0.00	0.50	0.34	4.85	0.00
1997	0.03	4.24	0.20	0.92	0.05	12.38	0.03
1998	0.05	2.85	0.06	0.98	0.17	7.53	0.17
1999	0.27	4.97	0.19	0.79	0.40	6.18	0.03
2000	0.10	4.02	0.10	0.65	0.47	5.76	0.00
2001	0.20	5.25	0.00	0.30	0.17	6.45	0.33
2002	0.18	3.76	0.00	0.83	0.08	9.43	0.07
2003	0.15	4.06	0.00	0.78	0.16	4.51	0.07
2004	0.16	3.85	0.09	0.97	0.19	11.76	0.10
2005	0.31	4.58	0.00	0.31	0.16	13.66	0.09
2006	0.06	9.86	0.25	0.47	0.00	4.42	0.23
2007	0.21	4.54	0.05	0.30	0.00	12.53	0.11
2008	0.07	4.34	0.06	0.31	0.21	11.19	0.06
2009	0.17	4.27	0.05	0.25	0.26	8.60	0.00
2010	0.02	7.46	0.10	0.32	0.04	11.82	0.40
2011	0.13	9.11	0.20	0.49	0.35	7.25	0.02
2012	0.07	6.43	0.00	0.34	0.55	10.67	0.00
2013	0.21	8.56	0.01	0.30	0.31	12.22	0.05

Table 15.12. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Technical interactions of otter trawl (OT), beam trawl (BT), gillnet (GN), industrial (Ind). It is also recognized that there are interactions between skates and rays with cod fisheries in IVc and VIId.

		Cod 347d	Cod katt.	Had 34	Whg 47d	Sai 346	Ang 346	Ple 4	Ple 7d	Ple 3a	Sol 3a	Sol 4	Sol 7d	San 4	Nop 4	Nep stocks	Pan stocks	DemRays 347	DemSharks 347
Main gears	Cod 347d		L	H	H	M	??	M	M	M	M	M	M	L	L	H	??	L	L
	Cod kattegat	BT, OT		L	0	0	??	0	0	M	M	0	0	0	0	H	??	L	L
	Had 34	OT			H	M	??	L	0	L	L	L	0	L	L	H	??	L	L
	Whg 47d	OT				M	??	M	M	0	0	M	M	L	L	H	??	L	L
	Sai 346	OT					??	L	0	L	L	L	0	L	L	L	??	L	L
	Ang 346																	L	L
	Ple 4	BT		OT	BT	OT	??		0	0	0	H	0	L	L	L	??	H	H
	Ple 7d	BT			BT, OT		??			0	0	0	H	L	L	L	??	H	H
	Ple 3a	BT, OT	BT, OT	OT			??				H	0	0	0	0	L	??	L	L
	Sol 3a	BT,OT,GN	BT,OT,GN	OT	BT, OT					BT		0	0	0	0	L	??	L	L
	Sol 4	BT		OT	BT	OT		BT					0	0	0	L	??	H	H
	Sol 7d	BT			BT				BT					0	0	L	??	H	H
	San 4	Ind		Ind	Ind	Ind									M	0	0	L	L
	Nop 4	Ind		Ind	Ind	Ind								Ind		0	0	L	L
	Nep. stocks																H?	L	L
	Pan. stocks																	L	L
	DemRays 347							BT	BT			BT	BT						H
	DemShar 347																		



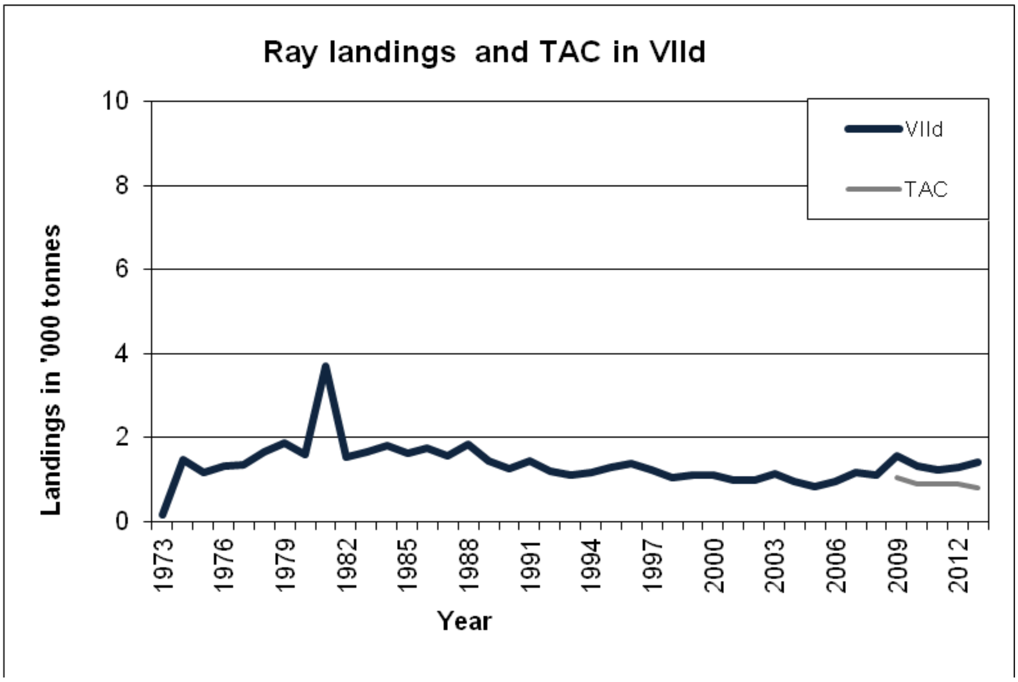


Figure 15.1. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel: total international landings of rays and skates in IIIa and IV, and in VIId since 1973, based on WG estimates. TAC for both areas is added.

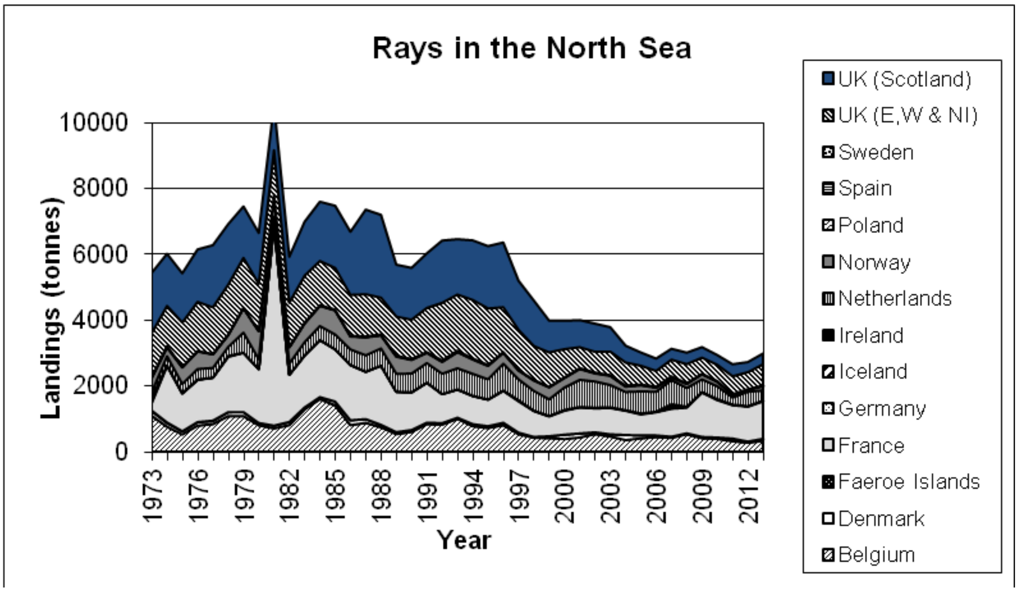


Figure 15.2. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Landings (t) of rays and skates from Skagerrak (IIIa), the North Sea (IV) and the eastern Channel (VIId).

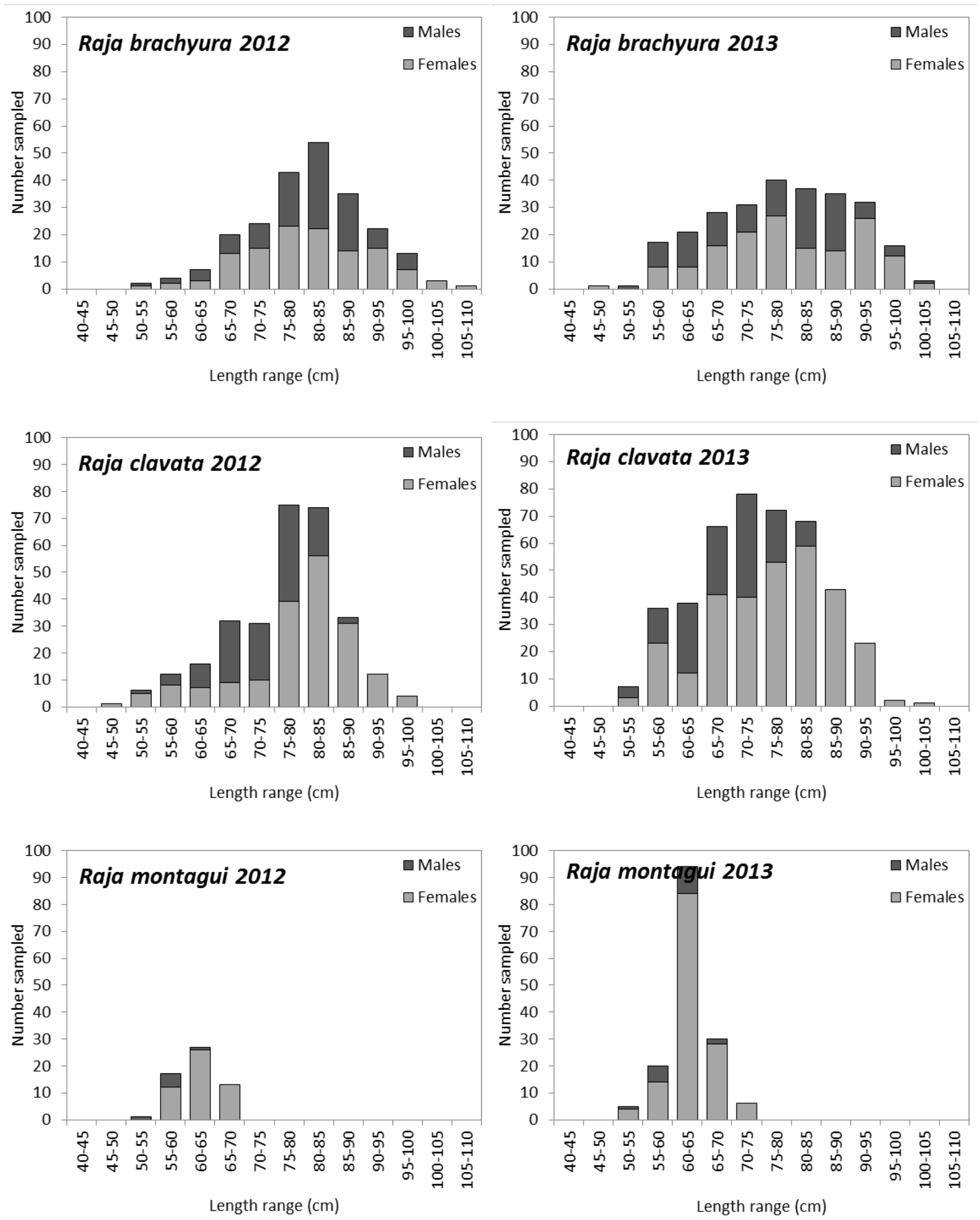


Figure 15.3. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Length–frequency distribution of the number of *R. brachyura*, *R. clavata* and *R. montagui* individuals measured during the market sampling programme of the Dutch beam trawl fleet in 2012 and 2013.

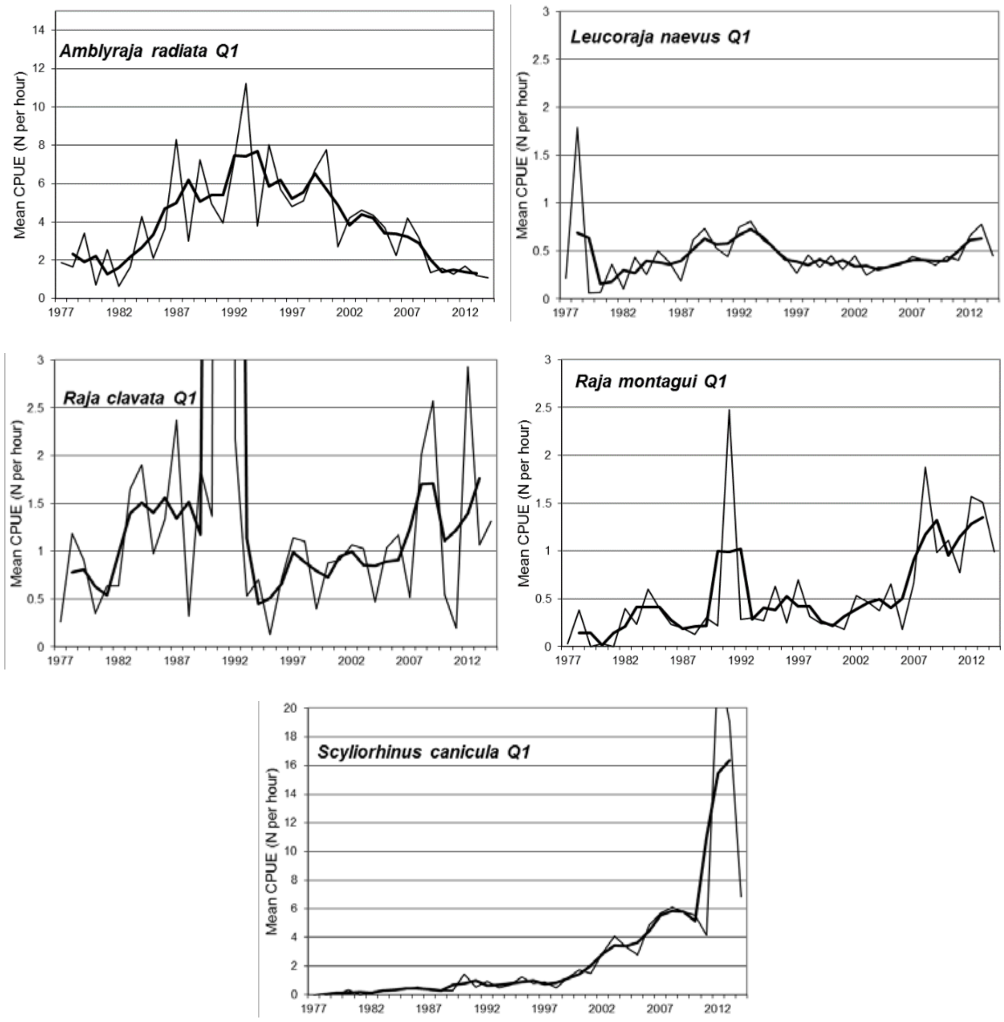


Figure 15.4. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Average catch (N per hour) and three year running mean during the North Sea IBTS-Q1 in the years 1977–2014 in roundfish Areas 1–7. Data extracted from the DATRAS database (selected for cpue per length per statrec) on 19th June 2014.

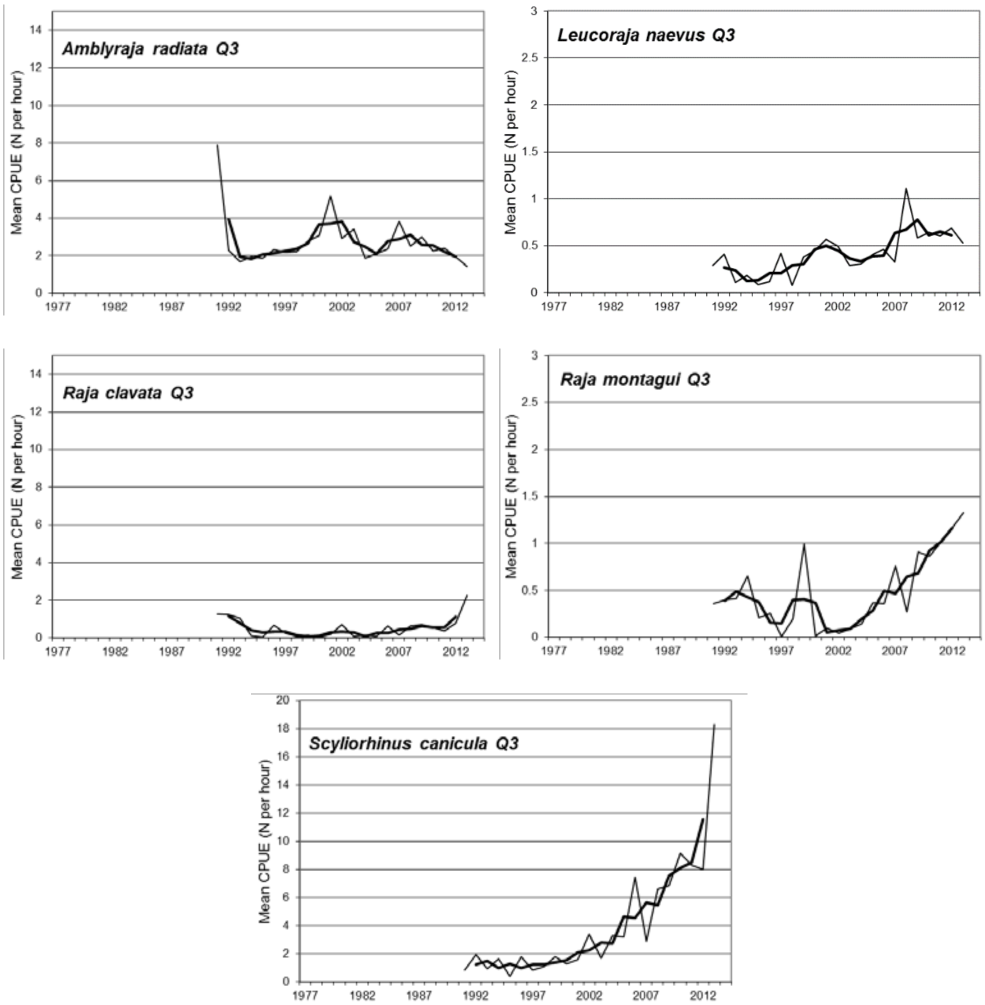


Figure 15.5. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Average catch (N per hour) and three year running mean during the North Sea IBTS-Q3 in roundfish Areas 1–7. Data extracted from the DATRAS database (selected for cpue per length per statrec) on 19th June 2014.

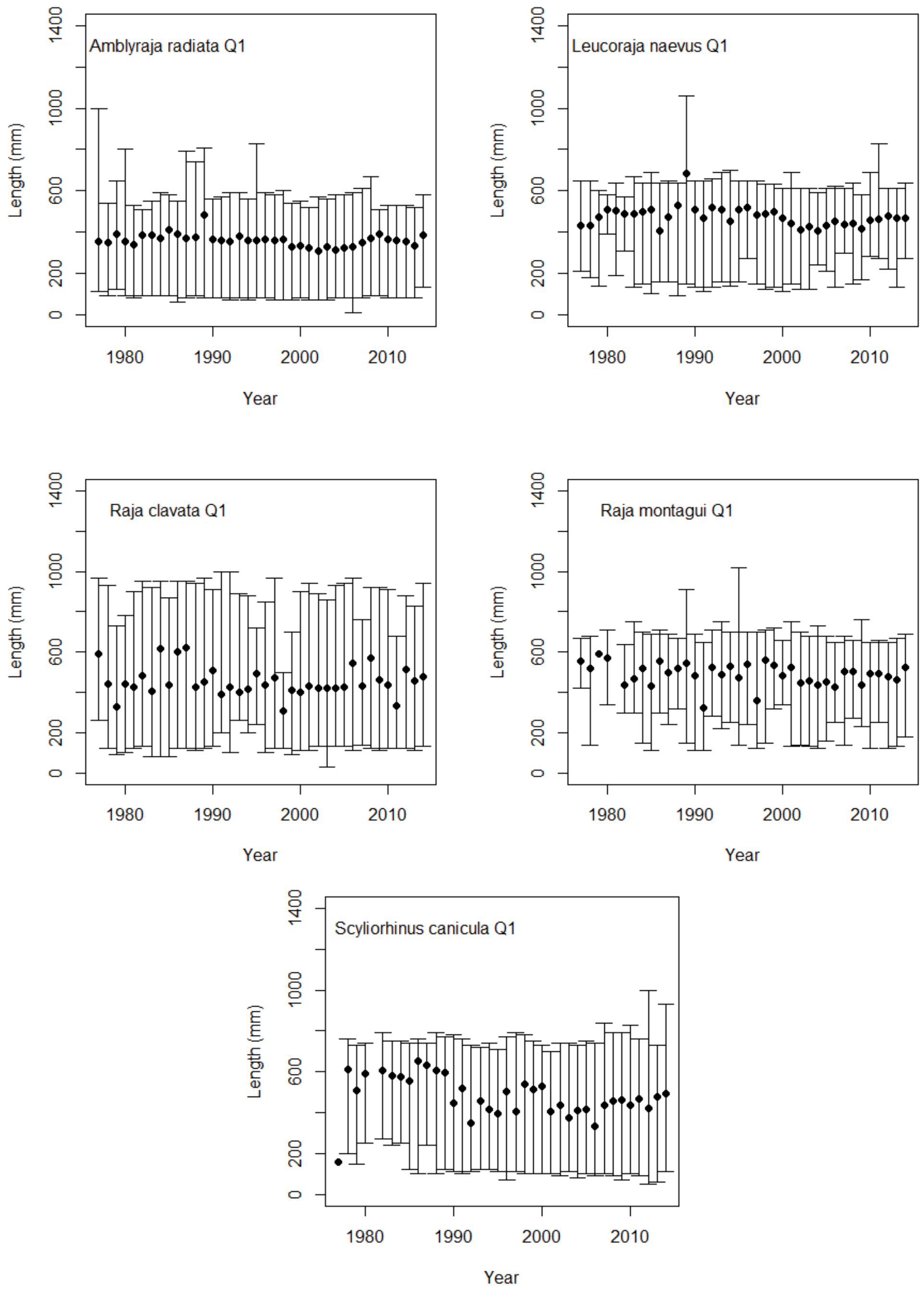


Figure 15.6. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Average length (dots) and length range during the North Sea IBTS-Q1 in roundfish Areas 1–7. Data extracted from the DATRAS database (selected for cpue per length per statrec) on 19th June 2014. NOTE: There are still some incorrect data in DATRAS, with some length records of all species (except *R. clavata*) that are >L_{max}.

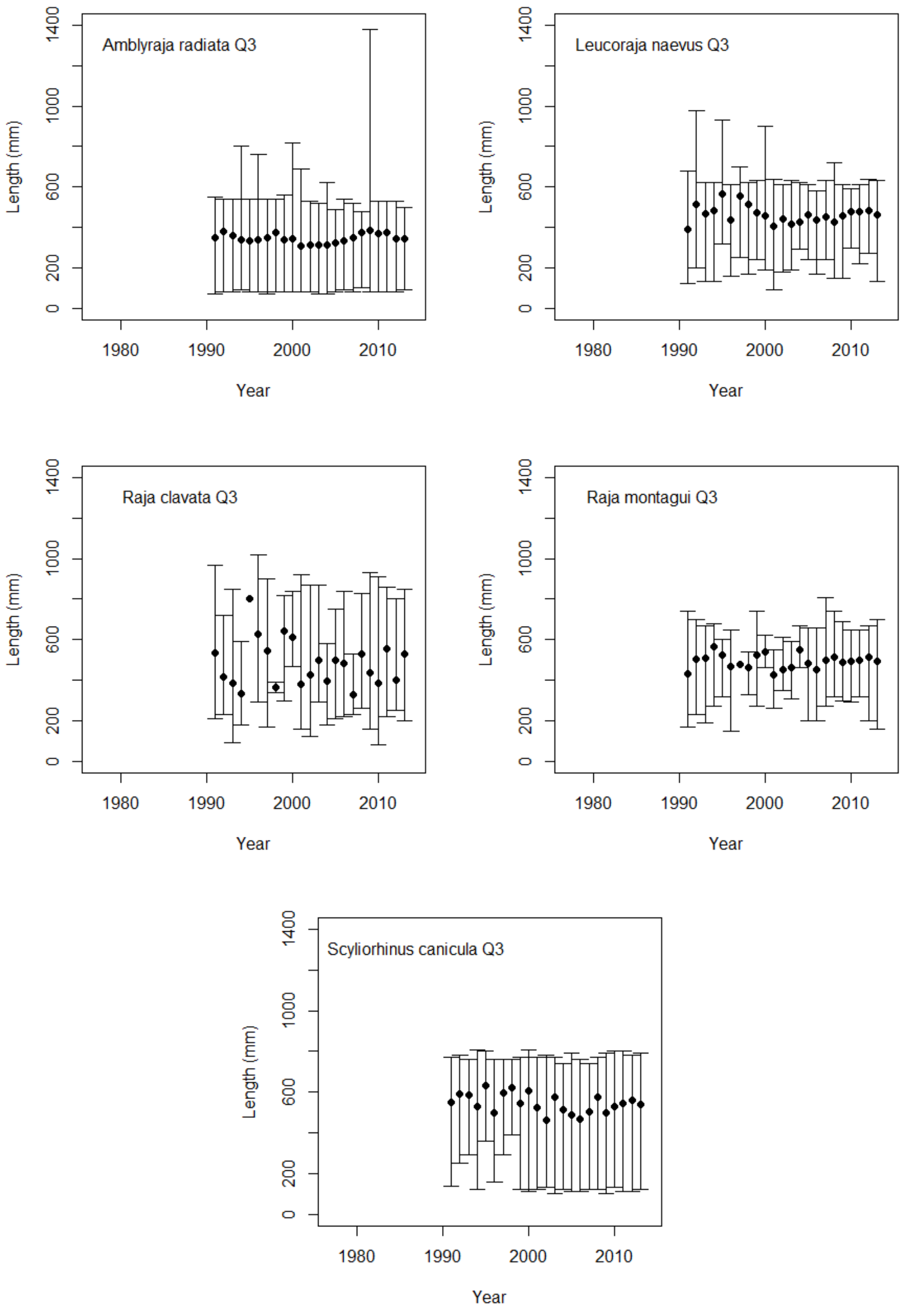


Figure 15.7. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Average length (dots) and length range during the North Sea IBTS-Q3 in roundfish Areas 1–7. Data extracted from the DATRAS database (selected for cpue per length per statrec) on 19th June 2014. Note: There are still some incorrect data in DATRAS, with some length records for *A. radiata* and *L. naevus* >L_{max}.

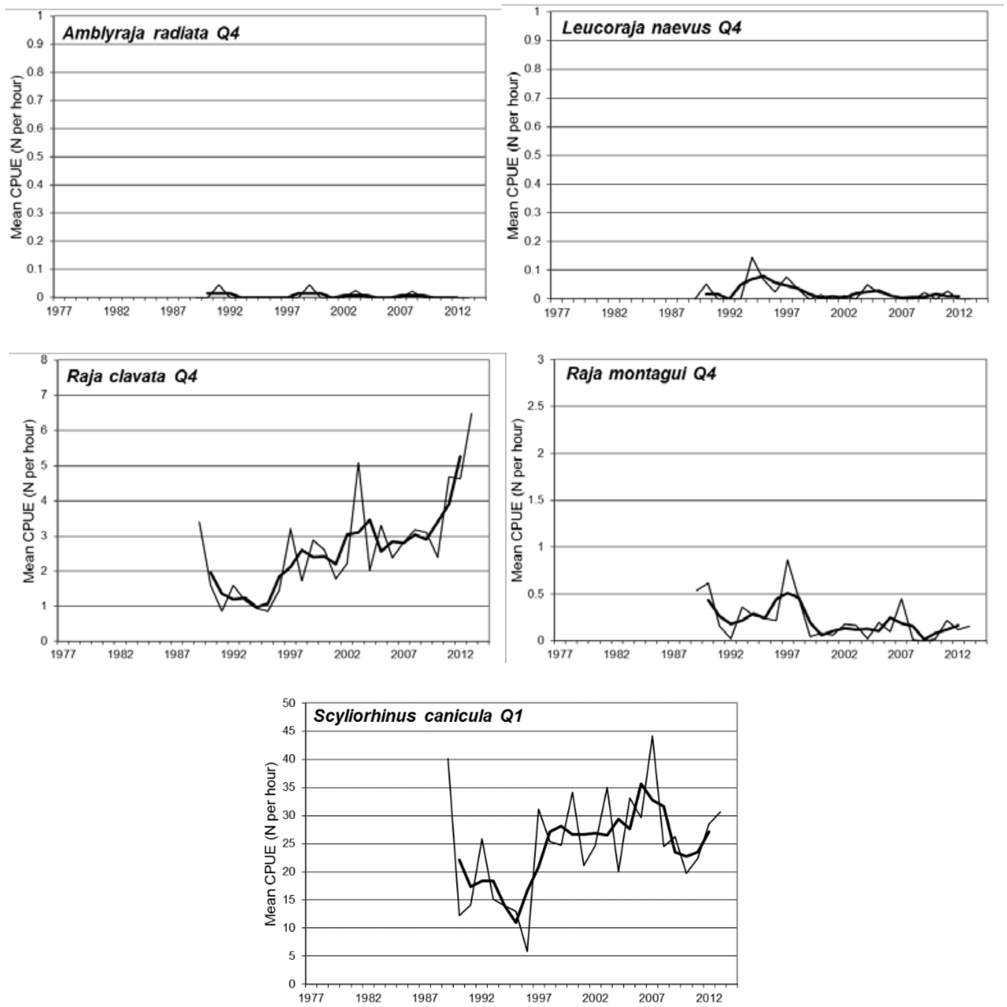


Figure 15.8. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Average catch (N per hour) and three year running mean during the Eastern Channel CGFS-Q4 survey. Data extracted from the DATRAS database (selected for exchange data that were converted to cpue per length per statrec) on 20th June 2014.

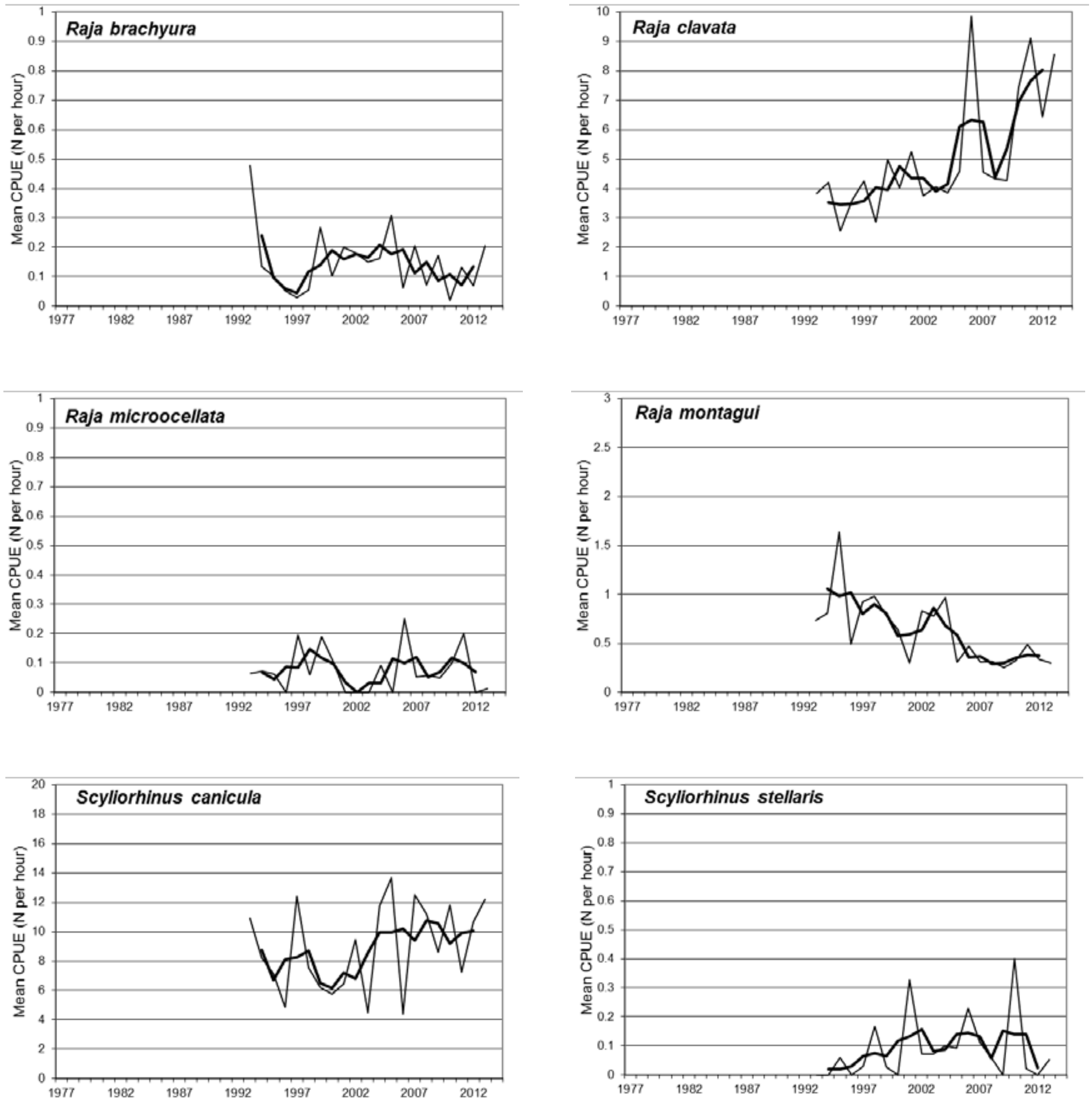


Figure 15.9. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Average catch (N per hour) and three year running mean during the UK BTS survey. Data obtained from J. Ellis on 20th June 2014.

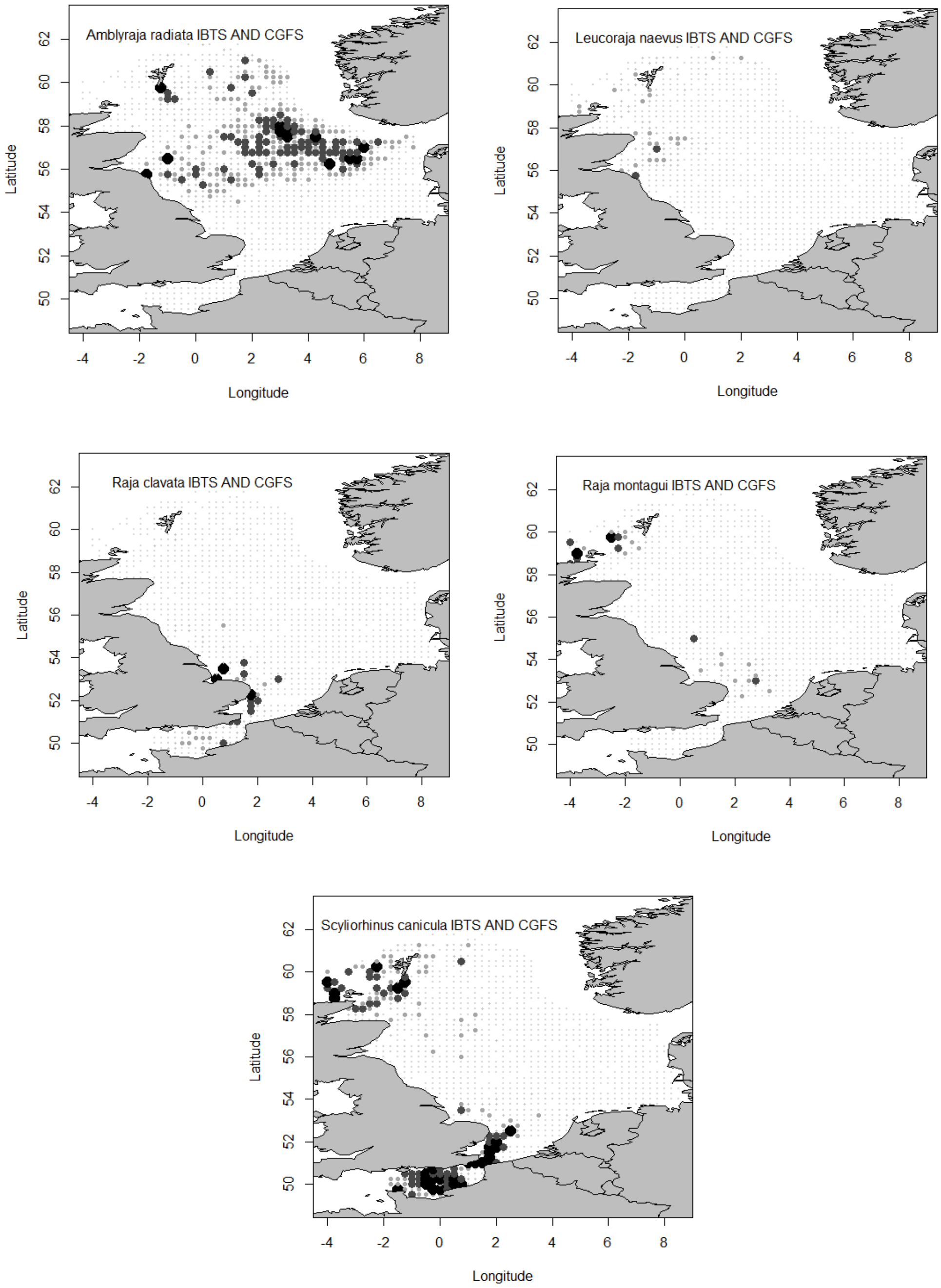


Figure 15.10. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and Eastern Channel: distribution plots based on IBTS Q1, IBTS Q3 (roundfish areas 1–7), and eastern Channel CGFS Q4 data in the period 1989–2014. All data are abstracted from DATRAS. Data for IBTS are extracted as cpue per length per statistical rectangle) on 19th June 2014, while data for CGFS are extracted as exchange data. Bubble scale is equal in all panels.

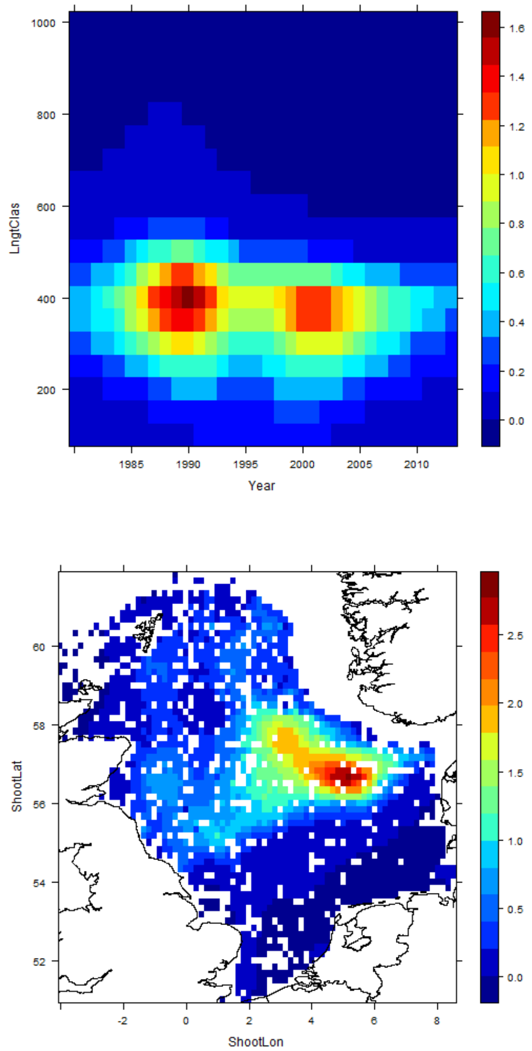


Figure 15.11. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. *Amblyraja radiata* in the North Sea. Results of GAM analysis of the IBTS-Q1 and Q3 data.

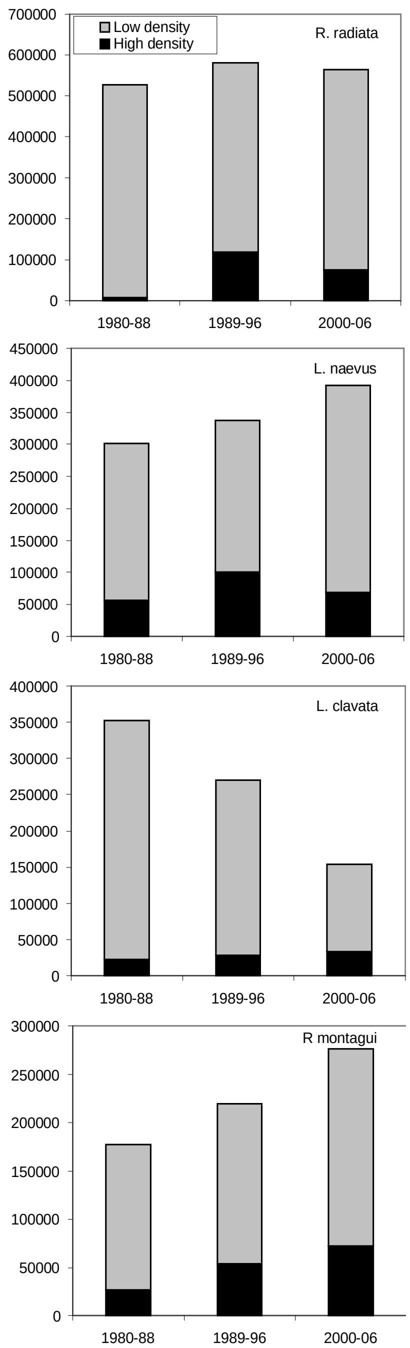


Figure 15.12. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Area occupied during three periods illustrated in the distribution maps for *Amblyraja radiata, Leucoraja naevus, Raja clavata* and *R. montagui* (Source: ICES, 2007).

16 Demersal elasmobranchs at Iceland and East Greenland

16.1 Ecoregion and stock boundaries

The elasmobranch fauna off Iceland and Greenland is little studied and comprises relatively few species. The number of species decreases as the water temperature gets colder, and only a few elasmobranch species are common in Icelandic and Greenland waters. The most abundant elasmobranch species occurring in this ecoregion is the starry ray (or thorny skate) *Amblyraja radiata*.

In Icelandic waters others species include Arctic skate *Amblyraja hyperborea,* Jensen's skate *Amblyraja jenseni,* common skate *Dipturus batis*-complex, Norwegian skate *Dipturus nidarosienis,* shagreen ray *Leucoraja fullonica*, roughskin skate *Malacoraja spinacidermis,* Krefft's skate, *Malacoraja kreffti*, deep-water ray *Rajella bathyphila*, Bigelow's skate *Rajella bigelowi,* round skate *Rajella fyllae*, sailray *Rajella lintea* (former *D. linteus*) and spinytail skate *Bathyraja spinicauda.*

In Greenland waters skates and rays include the commonly found *R. fyllae, B. spinicauda* and *A. hyperborea* and rarer species such as *R. bathyphila*, *M. spinacidermis, R. lintea*, *A. jenseni* and *R. bigelowi* (Möller *et al.*, 2010).

Dogfish and sharks in this ecoregion include spurdog *Squalus acanthias* (Section 2); Portuguese dogfish *Centroscymnus coelolepis* and leafscale gulper shark *Centrophorus squamosus* (Section 3); birdbeak dogfish *Deania calcea*, black dogfish *Centroscyllium fabricii*, great lantern shark *Etmopterus princeps*, velvet belly *E. spinax*, longnose velvet dogfish *Centroselachus crepidater* and six gill shark *Hexanchus griseus* (Section 5); porbeagle *Lamna nasus* (Section 6); basking shark *Cetorhinus maximus* (Section 7); Greenland shark *Somniosus microcephalus* (Section 24); and various scyliorhinid catsharks such as Iceland catshark *Apristurus laurussonii,* white ghost catshark *Apristurus aphyodes*, and mouse catshark *Galeus murinus.*

Chimaeras (rabbitfish *Chimaera monstrosa*, spearnose chimaera *Rhinochimaera atlantica*, large-eyed rabbitfish *Hydrolagus mirabilis*, smalleyed abbitfish *Hydrolagus affinis*, narrownose chimaera *Harriotta raleighana*) all occur in the area.

Stock boundaries are not known for the species in this area. Neither are the potential movements of species between the coastal and offshore areas. Further investigations are necessary to determine potential migrations or interactions of elasmobranch populations within this ecoregion and neighbouring areas.

16.2 The fishery

16.2.1 History of the fishery

Skates and sharks are mainly a bycatch in fisheries, with Iceland the main fishing nation operating in the ecoregion. *Dipturus batis*-complex is taken with a variety of fishing gears (Figure 16.1a). They used to be regarded as fairly common in Icelandic waters, but landings may now only be about 10% of what was landed 50 years ago. A large part of the landed catch goes to local consumption as *D. batis*-complex is a traditional food in Iceland, particularly at Christmas time. The other part of the landed catch is processed and mainly exported to Belgium.

A. radiata has always been a bycatch in a variety of fishing gears around Iceland but was usually discarded. The increase in landings since the 1990s is mostly explained by increased retention compensating for declining abundance of *D. batis*-complex.

Landings are reported mainly from the longline fishery (Figure 16.1b). The landed catch has grown from virtually nothing in 1980 to more than 1000 t annually between 1995 and 2004. Thereafter, landings declined but have been increasing again to levels exceeding 1800 t in 2012. A relatively large share goes to local consumption.

16.2.2 The fishery in 2013

No new information.

16.2.3 ICES advice applicable

ICES does not provide advice on these stocks.

16.2.4 Management applicable

There is no TAC for demersal skates in these areas.

16.3 Catch data

16.3.1 Landings

Reported landings of skates from Iceland (Division Va) and eastern Greenland (Subarea XIV) are given in Table 16.1. Icelandic national data for estimated landings of common skate the *D. batis*-complex (1973–2013), *A. radiata* (1977–2013), *R. lintea* (2000–2013) and *L. fullonica* (1993–2013) were updated. Table 16.1 contains national data from Iceland, data from the ICES database (ICES, 2012) and landings statistics from the Faroese national database (www.hagstova.fo). Database entries for all species were updated with national landings data provided by Iceland for the years 2003–2013.

Prior to 1992 all skates, except *A. radiata* and *D. batis*-complex, were reported as '*Raja* rays nei'. *A. radiata* and *Dipturus batis*-complex have, on average, accounted for about 98% of the annual skate landings since 1992, since when it is thought that all species are reported to species level. Only small quantities of *L. fullonica*, *R. lintea* and *B. spinicauda* have been reported. Fishers do not usually distinguish between *L. fullonica* and *R. lintea* in Icelandic waters. Therefore the landings of *R. lintea* are likely to be underestimated and landings of *L. fullonica* overestimated, as landings of the latter species include some *R. lintea*. *L. fullonica* generally is relatively rare in Icelandic waters. Landings of the *D. batis*-complex could also sometimes be *R. lintea.*

From 1973–2013, 13 countries have reported landings of skates, demersal sharks and chimaeras from Divisions Va (Iceland) and XIVa and XIVb (East Greenland). Iceland is the main nation fishing in these areas.

Reported skate landings peaked at 2500 t in 1951. Since then the landings of the *D. batis*-complex have decreased but landings of *A. radiata* have increased in later years. Landings of *A. radiata* were under 1000 t since 2005 but increased to about 1900 t in 2012 contributing the bulk of landings of elasmobranchs in this ecoregion (Table 16.1, Figures 16.2 and 16.3). Overall, over 95% of the skate landings came from Division Va. The share taken by Iceland from this area increased from <50% in the 1970s to nearly 100% from 1999 to 2013.

Information on bycatch of elasmobranchs in East Greenland waters is unavailable but several species are probably taken and discarded in fisheries for cod, shrimp and Greenland halibut *Reinhardtius hippoglossoides*. Anecdotal information indicates that some Greenland sharks taken in the shrimp fishery are landed in Iceland, but the amount is not known.

16.3.2 Discards

No information regarding discards was available.

16.3.3 Quality of catch data

The major nation fishing skates in this area now provides species-specific information, but species identification needs improvement.

16.3.4 Discard survival

No data available to WGEF for the fisheries in this ecoregion.

16.4 Commercial catch composition

16.4.1 Length and sex composition

No information regarding the length distribution or sex ratio from commercial landings was available.

16.4.2 Quality of data

No data available.

16.5 Commercial catch and effort data

No data available.

16.6 Fishery-independent surveys

16.6.1 Availability of survey data

Greenland surveys

Since 1998, the Greenland surveys (GR-GHXIVB) have covered the area between 61°45'–67°N at depths of 400–1500 m, although the area between 63–64°N was not covered by the surveys, as the bottom topography was too steep and rough. The surveys are aimed at Greenland halibut, although all fish species are recorded. The surveys use an ALFREDO III trawl (wingspread of about 21 m, headline height of about 5.8 m, and a mesh size of 30 mm in the codend) on rock-hopper groundgear. These data were presented to WGEF in a working paper by Jørgensen (2006) and are summarized in Table 16.2. Another source of survey data in Greenland waters is the German Greenland groundfish survey GER (GRL)-GFS-Q4, and these data need to be further explored.

Surveys in Icelandic waters

The Icelandic autumn groundfish survey (IS-SMH) is the main source of fishery iNdependent data for many of the elasmobranch species in Icelandic waters. Further, data can be compiled for some species from other surveys e.g. spring groundfish survey (IS-SMB), shrimp and flatfish surveys undertaken at the MRI.

The IS-SMH survey covers Icelandic shelf and slope at depths of 20–1500 m. It is a stratified systematic survey with standardized fishing methods. Small-meshed bottom trawls (40 mm in the coded) equipped with rock-hopper are towed at a speed of 3.8 knots for predetermined distance of 3 nautical miles (See Björnsson *et al.*, 2007 for detailed description of methodology).

Catch data and frequency of occurrence for skates from IS-SMH is summarised in Table 16.3. Catch data (number of individuals per survey) of all demersal elasmobranchs, for the years 1996–2006, can be found in Björnsson *et al.* (2007).

16.7 Life-history information

Published information on life history of skates and rays in Icelandic waters is scarce.

Amblyraja radiata is by far the most abundant elasmobranch species in Icelandic waters, with a widespread distribution over the Icelandic shelf and upper slope (see Figure 16.4 for the distribution in IS-SMH 2013). Seasonal differences in distributional patterns have been noted, with *A. radiata* much less abundant on the shelf during autumn surveys (IS-SMH) than in spring survey (IS-SMB), and the bulk of catches in IS-SMH is taken on shelf break/slope north and east of Iceland (see Björnsson *et al.*, 2007). Anecdotal information suggests that *A. radiata* undertakes seasonal migrations in relation with egg-laying activity, but this remains to be investigated. Trawl survey data may provide useful information on catches of viable skate eggcases and/or on nursery grounds.

Length–frequency distributions of *A. radiata* in IS-SMH is shown in Figure 16.5. Length-at-maturity is 46.1 cm and 42.2 cm for males and females, respectively, and is considered small compared to adjacent waters to the south (Templeman, 1987).

16.8 Exploratory assessment models

No assessments have been conducted, as a consequence of insufficient data. Abundance indices and biomass estimates for *A. radiata* have been calculated based on IS-SMB and IS-SMH, with a decreasing trend in large skates (>50 cm) observed (Björnsson *et al.*, 2007). Preliminary results indicate negative survey trends in major size groups in recent years (Jakobsdóttir, unpubl. material).

16.9 Stock assessment

No assessments have been undertaken for the skates in this ecoregion.

16.10 Quality of assessments

Exploratory analyses of survey trends have been conducted for *A. radiata*. However, the majority of commercial landings are taken in other gears than bottom trawl (Figure 16.1) and this should be considered.

16.11 Reference points

No reference points have been proposed for any of these species.

16.12 Conservation considerations

The *D. batis*-complex has been found to be vulnerable to exploitation and has been near-extirpated in the Irish and North Seas. Further investigation into the *D. batis*-complex and other large-bodied skates in Iceland and east Greenland is required.

16.13 Management considerations

The elasmobranch fauna off Iceland and Greenland is little studied and comprises relatively few species (22 sharks, 15 skates and six chimaeras). Most of the landings of skates are now reported to species.

The most abundant demersal elasmobranch in the area is *A. radiata*, which is widespread and abundant in this and adjacent waters. Negative survey trends for large size starry rays have been observed (Björnsson *et al.*, 2007). Preliminary results of more recent data indicate negative survey trends for this species and needs to be investigated further.

16.14 References

Björnsson, H., Sólmundsson, J., Kristinsson, K., Steinarsson, B.Æ., Hjörleifsson, E., Jónsson, E., Pálsson, J., Pálsson, Ó.K., Bogason, V., Sigurðsson, Þ. 2007. Stofnmæling botnfiska á Íslandsmiðum (SMB) 1985–2006 og stofnmæling botnfiska að haustlagi (SMH) 1996–2006. The Icelandic groundfish surveys in spring 1985–2006 and in autumn 1996–2006. In Fjölrit Hafrannsóknastofnunarinnar / MRI Reykjavík, Technical Report no. 131, 220 pp. (Available at http://www.hafro.is/Bokasafn/Timarit/fjolr.htm).

ICES. 2012. Official catch statistics 1950–2010. EUROBASE/ICES database on catch statistics (Available at www.ices.dk).

Jørgensen, O. A. 2006. Elasmobranchs at East Greenland, ICES Division 14B. Working paper ICES Elasmobranch WG. June 2006.

Möller, P. R., Nielsen, J. G., Knudsen, S. W., Poulsen, J. Y., Sunksen, K. and Jorgensen, O. A. 2010. A checklist of the fish fauna of Greenland waters. *Zootaxa*, 1–84.

Templeman, W. 1987. Differences in Sexual Maturity and Related Characteristiics Between Populatons of Thorny skate (*Raja radiata*) in The Northwest Atlantic. *J.Northw.Atl.Fish.Sci.* **7**, 155–167.

Electronic references

http://www.fisheries.is/main-species/cartilaginous-fishes/Accessed 18th June 2014.

http://www.fisheries.is/main-species/cartilaginous-fishes/grey-skate/ 18th June 2014.

http://www.fisheries.is/main-species/cartilaginous-fishes/starry-ray/18th June 2014.

http://www.hagstova.fo 18th June 2014.

Table 16.1. Demersal elasmobranchs at Iceland and East Greenland. Reported landings of skates from Iceland (Subarea Va) and East Greenland (XIV) Data from Icelandic national data, ICES database (ICES, 2012) and Faroese landings from Faroes national statistics website (www.hagstova.fo).

WG ESTIMATES OF LANDINGS (T) OF ELASMOBRANCHS IN ICES AREA VA AND XIV

			1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Common skate	*Dipturus batis*-complex	Iceland	364	275	188	333	442	424	403	196	229	245	185	178	120	108
Starry ray	*Amblyraja radiata*	Iceland	0	0	0	0	0	0	0	0	0	9	12	46	15	44
Raja rays nei	*Raja* rays nei	Belgium	59	51	62	36	41	23	27	36	28	11	15	15	19	18
		Faeroe Islands	80	56	43	35	75	27	37	21	25	23	73	24	21	0
		Germany	76	41	49	41	37	10	2	1	2	2	4	3	2	1
		Norway	1	0	63	4	2	3	2	3	6	1	10	3	5	0
		UK - England & Wales	385	187	195	106	5	0	0	0	0	0	0	0	0	0
		UK - Scotland	5	8	14	8	0	0	0	0	0	0	0	0	0	0
Total			970	618	614	563	602	487	471	257	290	291	299	269	182	171

WG ESTIMATES OF LANDINGS (T) OF ELASMOBRANCHS IN ICES AREA Va AND XIV

			1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Common skate	*Dipturus batis*-complex	Iceland	130	152	152	222	304	363	274	299	245	181	118	108	80	94
		Norway	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Starry ray	*Amblyraja radiata*	Iceland	125	39	100	163	286	317	294	1206	1749	1493	1430	1252	996	1076
Shagreen ray	*Leucoraja fullonica*	Iceland	0	0	0	0	0	0	2	12	24	19	16	12	21	27
Raja rays nei	*Raja* rays nei	Belgium	22	20	22	6	9	6	3	0	0	0	0	0	0	0
		Faeroe Islands	8	2	2	16	5	2	3	4	9	2	2	7	5	0
		Germany	0	0	0	1	3	1	2	0	9	0	0	1	0	7
		Norway	0	0	0	0	0	25	8	8	7	10	2	19	8	3
		Portugal	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		UK - Eng+Wales+N.Irl.	0	0	0	0	0	1	2		4	0	0	1	2	0
Total			285	213	276	408	607	715	588	1529	2047	1705	1569	1400	1112	1210

	WG ESTIMATES OF LANDINGS (T) OF ELASMOBRANCHS IN ICES AREA Va AND XIV														
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Common skate	*Dipturus batis*-complex	Iceland	82	59	120	145	167	137	117	127	128	117	125	130	153
		Norway	0	0	0	0	0	0	0	0	0	0	0	0	0
Starry ray	*Amblyraja radiata*	Iceland	1211	1781	1491	1013	657	530	473	636	710	950	1329	1981	1719
Sailray	*Dipturus linteus*	Iceland	0	0	10	8	20	0	0	0	8	12	9	9	7
Shagreen ray	*Leucoraja fullonica*	Iceland	37	32	17	23	16	16	25	4	33	19	17	21	37
Raja rays nei	*Raja* rays nei	Faeroe Islands	2	2	0	8	9	16	7	11	n.a.	n.a.	0	5	6
		Germany	0	0	0	0	0	0	0	0	0	0	0	0	0
		France												0	0
		Iceland	0	0	0	0	0	8	0	10	0	0	0	0	0
		Norway	6	5	1	0	0	7	0	1	2	80	4	0	+
		Portugal	1	0	0	0	0	0	0	0	0	0	0	0	0
		Russian Federation	0	0	0	2	6	3	0	0	n.a.	n.a.	0	0	na
		Spain	0	0	15	0	0	0	0	0	0	0		0	0
		UK - Eng+Wales+N.Irl.	1	0	0	1	0	1	0	0	0	0	0	0	0
		UK - Scotland	0	0	1	0	0	0	0	0	0	0	0	0	0
Thornb. ray	*Raja raja clavata*	France								0	0	0	1	0	0
Total			1340	1879	1655	1200	875	718	622	789	881	1178	1485	2146	1921

Table 16.2. Demersal elasmobranchs at Iceland and East Greenland. Demersal elasmobranch species captured during groundfish surveys at East Greenland during 1998–2005. Total number, observed maximum weight (kg), depth range (m) and bottom temperature range ºC and most northern position (decimal degrees; adapted from Jørgensen, 2006).

Species	N	Max wt (kg)	Depth range (m)	Temp range (°C)	Maximum latitude
Bathyraja spinicauda	82	61.5	548–1455	0.5–5.6	65.46ºN
Rajella bathyphila	57	45.3	476–1493	0.3–4.1	65.44ºN
Rajella fyllae	117	4.8	411–1449	0.8–5.9	65.46ºN
Amblyraja hyperborea	12	23.4	520–1481	0.5–5.4	65.47ºN
Amblyraja radiata	483	22.1	411–1281	0.8–6.6	66.21ºN
Malacoraja spinacidermis	3	3.1	1282–1450	2.3–2.7	62.25ºN
Apristurus laurussoni	3	0.7	836–1255	1.7–4.3	65.22ºN
Centroscyllium fabricii	812	128	415–1492	0.6–5.1	65.40ºN
Somniosus microcephalus	9	500	512–1112	1.4–4.9	65.35ºN

Table 16.3. Demersal Elasmobranchs at Iceland and East Greenland. Catch data of skates and rays in MRI annual autumn groundfish survey at Iceland (Subarea Va), giving the numbers of individuals caught (N) and the frequency of occurrence (percentage of stations where species was collected, O%). 2011 survey (noted with asterisk) was discontinued and therefore data collection incomplete.

	2000		2001		2002		2003		2004		2005		2006	
	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O
Dipturus batis-complex	6	<1	1	<1	3	<1	3	<1	1	<1	4	<1	6	1
Amblyraja radiata	1589	48	1413	45	1442	49	1379	49	1957	51	1678	53	1716	52
Rajella lintea	2	<1	0	0	0	0	0	0	0	0	0	0	2	<1
Amblyraja hyperborea	110	9	160	9	80	8	88	8	97	9	104	8	120	10
Rajella fyllae	24	4	54	8	53	8	77	6	37	6	53	7	81	8
Bathyraja spinicauda	7	2	11	2	10	2	25	1	12	2	16	2	21	2
Rajella bathyphila	1	<1	0	0	0	0	1	<1	0	0	1	<1	0	0
Rajella bigelowi	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	2007		2008		2009		2010		2011*		2012		2013	
	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O	N	%O
Dipturus batis-complex	7	1	7	1	9	1	4	<1	1	1	0	<1	0	0
Amblyraja radiata	1474	52	1569	48	1590	39	1399	46	295	42	918	34	1142	41
Rajella lintea	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amblyraja hyperborea	59	10	90	9	103	9	86	10	27	8	73	7	63	8
Rajella fyllae	44	8	106	5	48	10	70	7	36	5	24	17	35	4
Bathyraja spinicauda	7	2	18	2	11	2	1	2	2	0	11	1	4	2
Rajella bathyphila	0	0	2	<1	0	0	0	0	0	0	0	0	0	0
Rajella bigelowi	0	0	1	<1	0	0	0	0	0	0	0	0	0	0

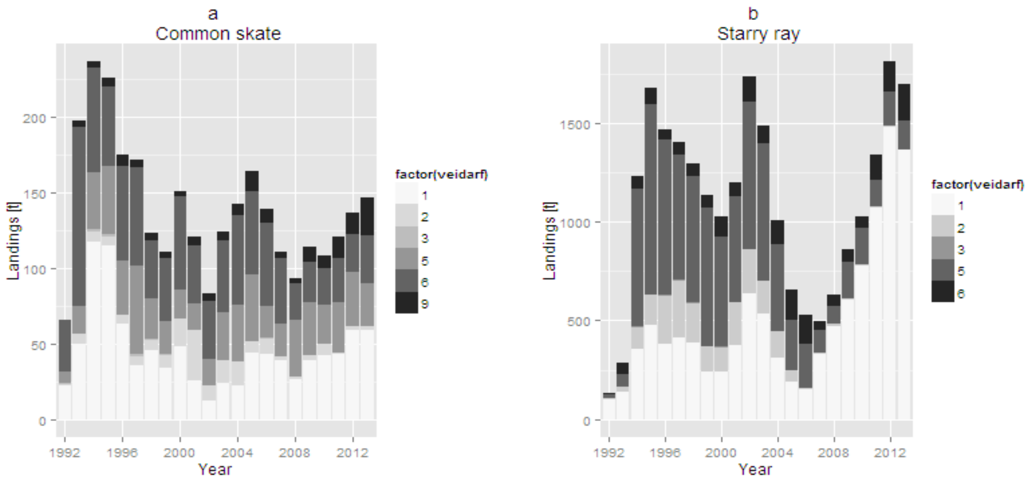


Figure 16.1. Demersal Elasmobranchs at Iceland and East Greenland. Icelandic landings of (a) common skate *Dipturus batis*-complex and (b) starry ray *A. radiata* at Iceland. Bycatch landings by fishing gears (1: longline, 2: gillnet, 3: handline, 5: Danish seine, 6: Bottom trawl, 9: *Nephrops* trawl).

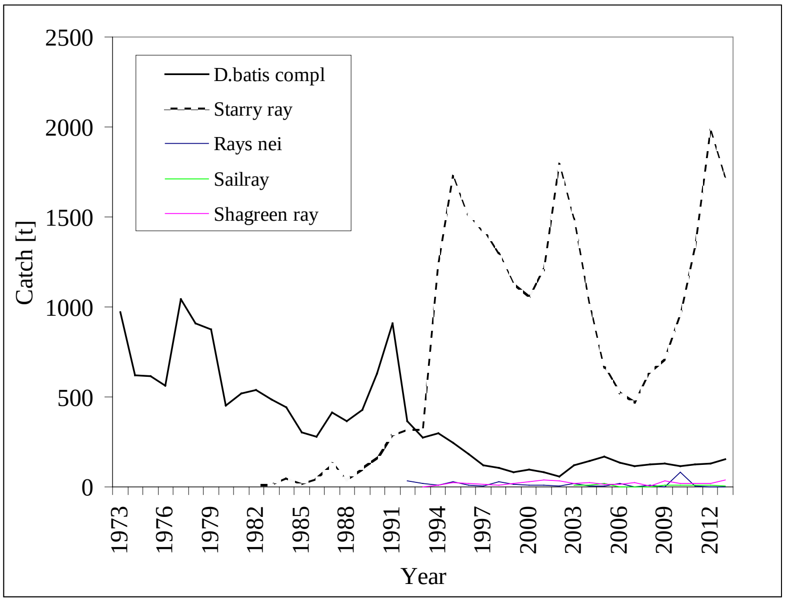


Figure 16.2. Demersal Elasmobranchs at Iceland and East Greenland. Landings of skates at Iceland (Subarea Va). Prior to 1992 all rays nei are assumed to belong to *Dipturus batis*-complex (see earlier reports). WG estimates of the most commonly reported rays and skates, 1973–2013. (ICES, 2012, national landings data and Faroese statistical database www.hagstova.fo).

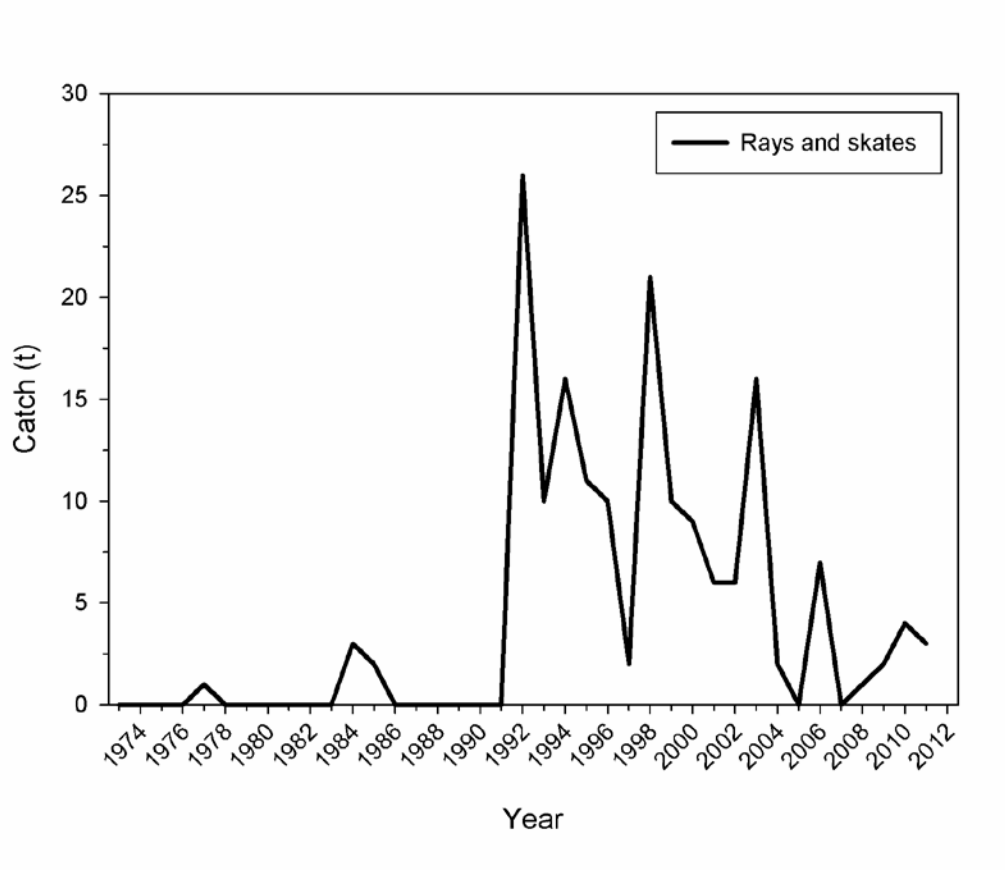


Figure 16.3. Demersal Elasmobranchs at Iceland and East Greenland. Landings of skates from East Greenland (Subarea XIV). WG estimates of the most commonly reported rays and skates, 1973–2011 (ICES, 2012 and national landings data).

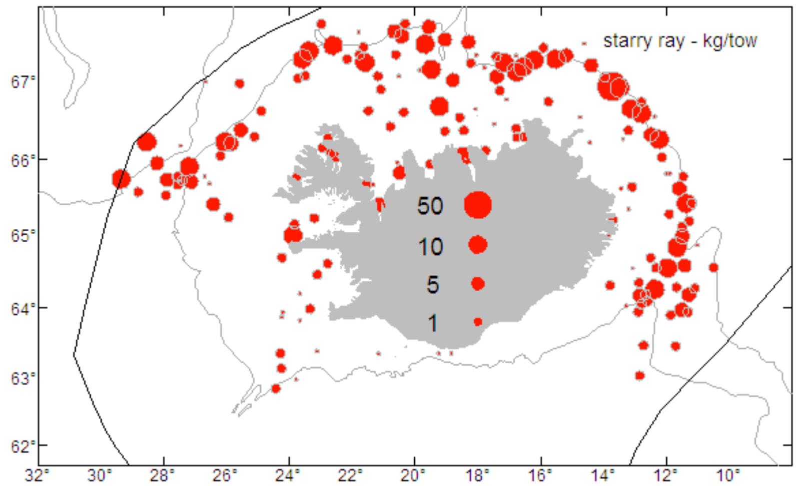


Figure 16.4. Demersal Elasmobranchs at Iceland and East Greenland. Spatial distribution of starry ray *A. radiata* in Icelandic waters (Subarea Va) from the 2013 autumn survey. Filled circle represent relative amount (kg per standardized tow).

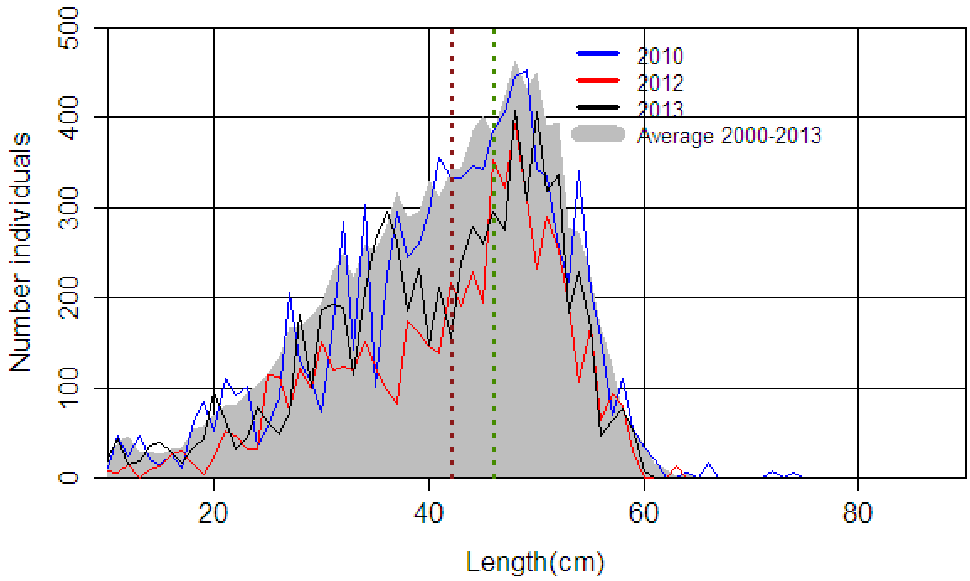


Figure 16.5. Demersal Elasmobranchs at Iceland and East Greenland. Length distribution of starry ray *A. radiata* in Icelandic waters (Subarea Va) as observed in the annual autumn survey. Grey area shows average for years 2000–2013. Blue, red and black lines represent average for 2010, 2012 and 2013 respectively. Broken lines indicate length-at-maturity (L50); green line: 46.1 cm, red line: 42.2 cm for males and females respectively (Jakobsdóttir, unpubl.material).

17 Demersal elasmobranchs at the Faroe Islands

17.1 Ecoregion and stock boundaries

The elasmobranch fauna off the Faroe Islands (ICES Divisions Vb1, Vb2) is little scientifically studied, though it is likely to be similar to that occurring in the northern North Sea and off NW Scotland and Iceland.

Skates recorded in the area include Arctic skate *Amblyraja hyperborea*, starry ray (thorny skate) *Amblyraja radiata*, common skate (*Dipturus batis* complex), long-nosed skate *Dipturus oxyrinchus*, sandy ray *Leucoraja circularis*, shagreen ray *Leucoraja fullonica*, cuckoo ray *Leucoraja naevus*, spotted ray *Raja montagui*, thornback ray *Raja clavata*, round skate *Rajella fyllae* and sailray *Rajella lintea* (formerly *Dipturus linteus*).

Demersal sharks include spurdog *Squalus acanthias* (Section 2), several deep-water species (Leafscale gulper shark *Centrophorus squamosus*, black dogfish *Centroscyllium fabricii*, birdbeak dogfish *Deania calcea*, longnose velvet dogfish *Centroselachus crepidater*, smallmouth velvet dogfish *Scymnodon obscurus;* Section 5), Greenland shark *Somniosus microcephalus* (Section 24) and various scyliorhinids, such as mouse catshark *Galeus murinus* and blackmouth catshark *Galeus melastomus*.

Several chimaeras also occur in the area: rabbitfish *Chimaera monstrosa*, large-eyed rabbitfish *Hydrolagus mirabilis*, narrownose chimaera *Harriotta raleighana* and spearnose chimaera *Rhinochimaera atlantica*.

Stock boundaries are not known for the species in this area. Neither are the potential movements of species between the coastal and offshore areas. Further investigations are necessary to determine potential migrations or interactions of elasmobranch populations within this ecoregion and neighbouring areas.

17.2 The fishery

17.2.1 History of the fishery

Since 1973, seven countries have reported landings of demersal elasmobranchs from Division Vb, with the bulk of catches consisting of skates. In earlier years, Scottish vessels landed the largest portion of catches, while since the 1980s the largest share is caught by Faroese vessels. These include trawlers and, to a lesser extent, longliners and gillnetters. Norwegian vessels fishing in this area are longliners that target ling, tusk and cod. UK vessels include a small number of large Scottish trawlers that are occasionally obtain quotas to fish in Faroese waters and target gadoids and deeper water species. French vessels fishing in this area are probably from the same fleet that prosecute the mixed deep-water and shelf fishery west of the UK. Demersal elasmobranchs likely represent a minor to moderate bycatch in these fisheries.

In 2007, a Russian longliner started fishing deep-water sharks in the Faroese Fishing Zone (FFZ) and on the Reykjanes Ridge. The total catch of the elasmobranchs in those and other NEA areas amounted to 483 t (Vinnichenko, 2008). Detailed info about the former Russian fishery can be found in ICES (2010).

17.2.2 The fishery in 2013

In 2012 landings from ICES Division Vb were reported by France. Faroese landings were extracted from the Faroese national statistics database (www.hagstova.fo).

17.2.3 ICES advice applicable

ICES does not provide advice on the skate stocks in this area.

17.2.4 Management applicable

The majority of the area is managed by the Faroes through fishing effort based system which restricts fishing days for demersal gadoids. Some EU vessels have been able to gain access to the Faroes EEZ where they have been managed under individual quotas for the main target species.

17.3 Catch data

17.3.1 Landings

Landings of skates are mainly unidentified at species level and are presented in Table 17.1. The French reported landings of the *D. batis* complex are likely not represent its entire catch as an unknown quantity is included in the category of unidentified rays. Total landings of skates combined are shown in Figure 17.1.

WGEF noted a large decline in the Faroese landings in 2009 (ICES, 2012). However, updated landings data from ICES database in 2011 (ICES, 2011) and from official Faroese landing statistics (www.hagstova.fo) for 2009 and more recent years do not confirm that decline. Landings in 2013 are similar to previous years 2007–2012.

17.3.2 Discards

The amount of discarding of skates and demersal sharks is unknown.

17.3.3 Quality of catch data

Species-specific information for commercial catches is lacking.

17.3.4 Discard survival

No data available to WGEF for the fisheries in this ecoregion.

17.4 Commercial catch composition

17.4.1 Species and size composition

All skates in Division Vb, with the exception of French landings, were reported as '*Raja* rays nei' before 2008 (see Table 17.1). There was no available port sampling data to split these landings by species. It is likely that catches included the *D. batis*-complex, *L. fullonica, R. clavata* and *A. radiata*.

No information regarding size composition or sex ratio from commercial landings was available.

17.4.2 Quality of data

Information on the species and length composition is required.

17.5 Commercial catch and effort data

No information available to WGEF.

17.6 Fishery-independent surveys

No survey data were available. Magnussen (2002) summarized the demersal fish assemblages from the Faroe Bank, based on the analysis of routine survey data collected by the RV Magnus Heinason since 1983. Data on elasmobranchs taken in these surveys are summarized in Table 17.2. A more detailed analysis of the demersal elasmobranchs taken in Faroese surveys is still to be undertaken.

17.7 Life-history information

No new information. Trawl survey data may provide useful information on catches of viable skate egg cases and/or on nursery grounds.

17.8 Exploratory assessments

No exploratory assessments have been undertaken due to insufficient data being available to WGEF. Analyses of survey data may indicate the general status of the more frequent species.

17.9 Stock assessment

No assessments have been conducted.

17.10 Quality of assessments

No assessments have been conducted.

17.11 Reference points

No reference points have been proposed for any of these species.

17.12 Conservation considerations

See Sections 15.12 and 18.12.

17.13 Management considerations

Total international reported landings of skates declined from 1973–2003 but increased to above the average of the time-series in 2004–2006. Since then, landings declined below the long-term average again. Without detailed information on the fisheries that include better differentiation of species, amounts of discards, sizes caught, it is not possible to provide information on the pattern of exploitation or on the status of stocks.

The elasmobranch fauna off the Faroe Islands is little scientific studied, though it is likely to be somewhat similar to that occurring in the northern North Sea and off Iceland. Further studies to describe the demersal elasmobranch fauna of this region and to conduct preliminary analyses of fishery-independent survey data are required.

The *D. batis* complex has been demonstrated to be vulnerable to exploitation and has been near-extirpated in the Irish and North Seas, further investigation on the *D. batis* complex and other skates in the Faroe Islands is required, including the data analysis from fishery-independent sources.

17.14 References

ICES. 2010. Report of the Working Group on Elasmobranch Fishes (WGEF), 22–29 June 2010, Horta, Portugal. ICES CM 2010/ACOM:19. 558 pp.

ICES. 2011. Official catch statistics 1950–2010. EuroBase/ ICES database on catch statistics http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx.

ICES. 2012. Report of the Working Group on Elasmobranch Fishes (WGEF), 19–26 June 2012, Lisbon, Portugal. ICES CM 2011/ACOM:19. 551 pp.

Magnussen, E. 2002.Demersal fish assemblages of the Faroe Bank: Species composition, distribution, biomass spectrum and diversity. *Marine Ecology Progress Series*, 238: 211–225.

Vinnichenko, V.I. 2008. Russian deep-sea investigations and fisheries in the Northeast Atlantic in 2007. Working Document for the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources, ICES, 9 pp.

Electronic references

http://www.hagstova.fo Accessed 19th June 2014.

Table 17.1. Demersal elasmobranchs at the Faroe Islands. Reported landings of skates and rays from the Faroes area (Division Vb). Data were updated with ICES database landings data (ICES, 2012) for years 2000–2012 and also contain national landings data provided to the WG. Faroese landings for 2013 were extracted from Faroese national statistics database available on www.hagstova.fo.

WG Estimates of Landings (t) of Rays in ICES Area Vb														
Species	Country	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Raja rays nei	Faroe Islands	150	95	107	136	164	201	202	198	135	221	211	281	277
	France	0	0	30	57	159	7	3	0	4	2	0	0	0
	Germany	47	33	36	15	23	55	14	7	1	3	3	3	1
	Netherlands	0	0	1	1	0	0	0	0	0	0	0	0	0
	Norway	29	27	37	42	46	64	37	18	21	13	32	35	14
	UKEWNI	62	33	45	50	10	5	4	2	0	0	0	0	0
	UK - Scotland	322	205	205	226	164	99	104	66	11	32	20	1	1
Dipturus batis	France	0	0	0	0	0	5	0	0	0	0	0	0	0
Leucoraja naevus	France	0	0	0	0	0	0	1	0	0	0	0	0	0
Raja clavata	France	0	0	0	0	0	0	10	0	0	1	6	23	38
	Total	610	393	461	527	566	436	375	291	172	272	272	343	331

Table 17.1. Continued. Demersal elasmobranchs at the Faroe Islands. Reported landings of skates and rays from the Faroes area (Division Vb). Data were updated with ICES database landings data (ICES, 2012) for years 2000–2012 and also contain national landings data provided to the WG. Faroese landings for 2013 were extracted from Faroese national statistics database available on www.hagstova.fo.

WG Estimates of Landings (t) of Rays in ICES Area Vb

Species	Country	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Raja rays nei	Denmark	0	1	0	0	0	0	0	0	0	0	0	0	0
	Faroe Islands	258	171	92	136	102	207	254	203	167	220	165	178	144
	France	1	6	5	8	5	0	0	0	0	1	1	2	0
	Germany	1	1	0	0	0	1	1	1	3	0	0	0	0
	Norway	22	11	29	84	96	81	37	75	20	14	60	14	45
	UKEWNI	0	1	0	0	0	1	0	12	3	3	0	6	0
	UK - Scotland	0	1	0	1	2	0	5	1	5	4	4	5	7
Dipturus batis	France	5	6	7	13	12	5	1	0	0	1	2	3	0
Leucoraja naevus	France	0	2	2	0	0	0	0	0	0	0	0	0	0
Dipturus oxyrinchus	France	0	0	0	0	0	0	0	0	0	0	0	0	0
Raja clavata	France	0	0	0	0	0	0	0	0	0	0	0	0	0
Raja montagui	France	0	0	0	0	0	0	0	0	0	0	0	0	0
Dasyatis pastinaca	France	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucoraja circularis	France	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucoraja fullonica	France	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	287	200	135	242	217	295	298	292	198	243	232	208	196

Table 17.1. Continued. Demersal elasmobranchs at the Faroe Islands. Reported landings of skates from the Faroes area (Division Vb). Data were updated with ICES database landings data (ICES, 2012) for years 2000–2012 and also contain national landings data provided to the WG. Faroese landings for 2013 were extracted from Faroese national statistics database available on www.hagstova.fo.

WG ESTIMATES OF LANDINGS (T) OF RAYS IN ICES AREA VB

Species	Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Raja rays nei	Faroe Islands	175	0	76	25	98	272	274	238	185	179	150	177	182	200	198
	France	2	0	0	1	5	10	7	19	8	9	5	0	0	0	0
	Germany	1	1	0	0	2	1	0	0	0	0	0	0	0	0	0
	Norway	45	50	21	15	5	0	11	10	16	5	4	11	0	0	0
	UKEWNI	0	23	2	0	2	15	5	0	0	0	0	0	0	0	0
	UK - Scotland	6	12	25	12	6	5	25	2	2	2	4	3	0	0	0
Dipturus batis	Norway	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
	France	4	2	2	2	3	5	2	3	1	0	0	0	0	0	0
	UK - Scotland	0	0	0	0	0	0	0	0	0	0	4	4	0	0	0
Leucoraja naevus	France	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	UK - Scotland	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Dipturus oxyrinchus	France	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Raja clavata	France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	UK - Scotland	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Raja montagui	France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dasyatis pastinaca	France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucoraja circularis	France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucoraja fullonica	France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rostroraja alba	France	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0
	UK - Scotland	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0
	Total	233	89	129	55	122	308	324	272	212	200	170	200	182	201	198

Table 17.2. Demersal elasmobranchs at the Faroe Islands. Elasmobranchs caught on the Faroe Bank during bottom-trawl surveys (1983–1996) by depth band. Symbols indicate frequency of occurrence in hauls (*: 60–100% of hauls, **: 10–60% of hauls, *: 3–10% of hauls, + : <3% of hauls). Adapted from Magnussen, 2002.**

Species	<100 m	100–200 m	200–300 m	300–400 m	400–500 m	>500 m	Total
Galeus melastomus	–	+	*	*	**	**	*
Galeorhinus galeus	–	+	–	–	–	*	+
Squalus acanthias	–	*	*	**	*	**	*
Etmopterus spinax	–	+	–	–	*	**	*
Centroscyllium fabricii	–	–	–	–	*	–	+
Amblyraja radiata	–	–	–	–	–	**	+
Dipturus batis	–	*	*	–	–	**	*
Leucoraja fullonica	–	+	+	–	–	*	+
Leucoraja circularis	–	–	*	–	–	–	+
Rajella fyllae	–	+	–	–	–	–	+
Rajella lintea	*	+	–	–	–	–	+
Raja clavata	–	+	–	–	–	–	+
Chimaera monstrosa	*	*	**	***	***	***	**

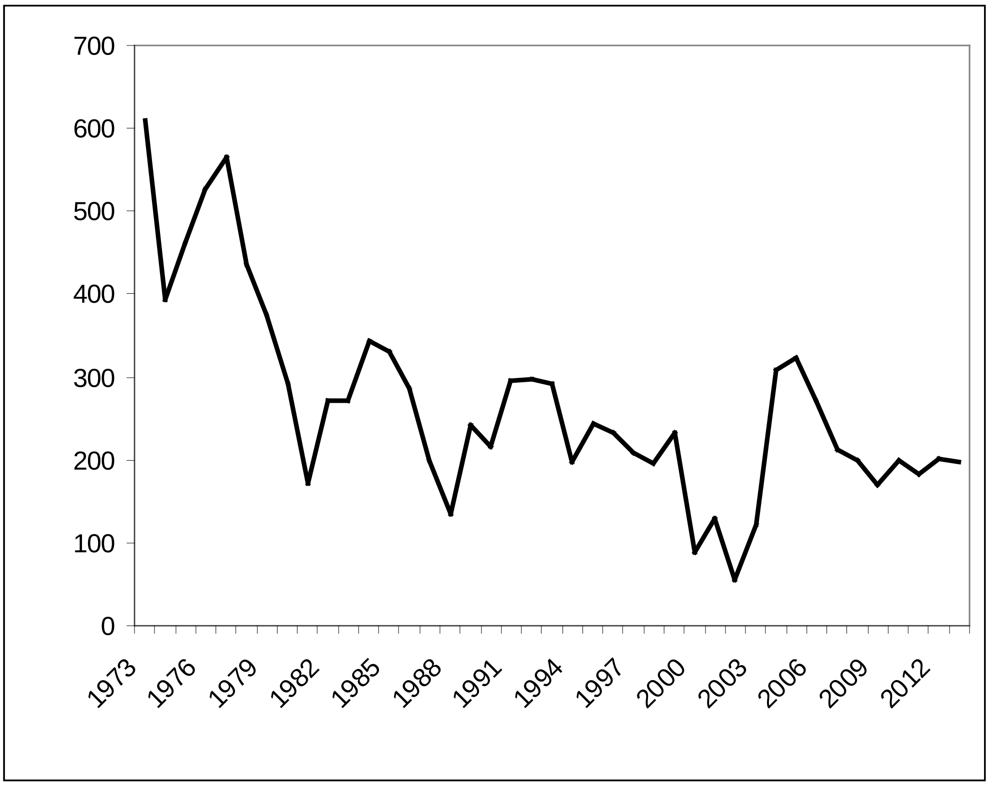


Figure 17.1. Demersal elasmobranchs at the Faroe Islands (Subarea Vb). Reported landings of skates and rays from 1973–2012 based on ICES database (ICES, 2012), national landings data and Faroese national statistics database (www.hagstova.fo).

18 Skate and rays in the Celtic Seas (ICES Subareas VI and VII (except Division VIId))

18.1 Ecoregion and stock boundaries

The Celtic Seas ecoregion covers west of Scotland (VIa), Rockall (VIb), Irish Sea (VIIa), Bristol Channel (VIIf), the western English Channel (VIIe), and the Celtic Sea and west of Ireland (VIIb–c, g–k). This ecoregion broadly equates with the area covered by the North Western Waters RAC (NWWRAC). The southwestern sector of ICES Division VIIk is contained in the oceanic Northeast Atlantic ecoregion.

Whereas some demersal elasmobranchs, such as spurdog (Section 2), tope (Section 10), smooth-hounds (Section 21) and lesser-spotted dogfish (Section 25), are widespread throughout this region, there are some important regional differences in the distributions of other species, especially the skates (Rajidae) which were described in earlier reports (see ICES, 2010), and are summarized in Table 18.1.

The stock identity for many of these species is not fully understood. Genetic studies have only been undertaken for a few species (e.g. *Raja clavata*, Chevolot *et al.*, 2006). There have been several tagging studies of skates in this ecoregion (Pawson and Nichols, 1994; Ellis *et al.*, 2011; Ellis *et al.*, 2012a WD; Stéphan *et al.*, 2013 WD; Wögerbauer *et al.*, 2014 WD).

Further studies to better understand stock structure are required, especially in the case of the offshore species, such as *Leucoraja naevus*, *L. fullonica and L. circularis* for which it is unclear as to the degree of connectivity of populations in the Celtic Sea, Irish Sea and off NW Scotland, as well as with adjacent ICES Divisions in other ecoregions (IVa, VIII).

Further tagging studies could also be usefully undertaken to better understand the stock structure of species with patchy distributions, such as *Raja brachyura* and *R. undulata*. Preliminary results of skate tagging in the western English Channel have indicated high site fidelity for these species (Ellis *et al.*, 2011; Stéphan *et al.*, 2013 WD).

18.2 The fishery

18.2.1 History of the fishery

Most skate species in the Celtic Seas ecoregion are taken as a bycatch in mixed demersal fisheries, which are either directed at flatfish or gadoids. The main countries involved in these fisheries are France, UK, Belgium and Ireland, with smaller catches by Spain, UK (Scotland), Norway and the Netherlands. The main gears used are otter trawl, beam trawl and bottom-set gillnets.

There are some localized, inshore fisheries targeting skates (e.g. *R. clavata*) using longline and tanglenets, and some trawl fisheries targeting various skate species in the southern Irish Sea (VIIa) and Bristol Channel (VIIf) at some times of year.

There is also a large recreational fishery for skates and rays, particularly for those species close to shore, with some ports having locally important charter boat fisheries. There is likely to be some retention of skates, although the levels of these catches are unknown.

18.2.2 The fishery in 2013

TAC and quota regulations may have been restrictive for some fisheries, and the inclusion of common skate (*Dipturus batis*-complex) and undulate ray *R. undulata* on the prohibited species list has resulted in increased discarding of these species, especially in areas where they are locally common.

It has been suggested that the English gillnet fishery in the Celtic Sea has moved eastwards, due to increasing discarding of *Dipturus batis*-complex (see Bendall *et al.*, 2012) although further studies are required to examine the spatial distribution of fishing activity.

Landings tables for the relevant species are provided in Tables 18.2–18.3.

18.2.3 ICES advice applicable

ICES provided advice for several species/stocks in this region in 2012 as summarized below:

Skates (Rajidae)

"ICES provides advice on the overall exploitation (landings and discards) of the ray and skates species assemblage, and also individual species …. ICES does not advise that species-specific TACs be established, at present. This is because a TAC is not considered the most effective means to regulate fishing mortality in these, mostly bycatch, species.

ICES advises that a suite of species- and fishery-specific measures be developed to manage the fisheries on the commercial species and achieve recovery of the depleted species. Such measures should be developed by management authorities involving all stakeholders; ICES could assist in this process.

Management measures should be framed in a mixed-fisheries context, considering the overall behaviour of demersal fleets, and the drivers for such behaviour. These species are mainly caught in mixed fisheries. When the TAC is exhausted, catches continue to take place, but are discarded. In order to achieve optimal harvesting of the commercial species, and to assist recovery of the depleted species, a suite of measures should be put in place.

Closure to fishing of spawning and/or nursery grounds, and measures to protect the spawning component of the population (e.g. maximum landing size) are powerful tools to protect rays and skates. In some cases, single-species TACs may be appropriate, but their effects should be carefully evaluated for each specific case before implementation.

Given that the European Community intends to introduce a ban on discards, minimum or maximum landing sizes should be carefully considered before they are introduced, because they could lead to increased discards.

Species-specific advice was provided for the following stocks:

- Blonde ray (*Raja brachyura*) in Subarea VI (West of Scotland);
- Blonde ray (*Raja brachyura*) in Divisions VIIa, f, g (Irish and Celtic Sea);
- Blonde ray (*Raja brachyura*) in Division VIIe (Western English Channel);
- Thornback ray (*Raja clavata*) in Subarea VI (West of Scotland);
- Thornback ray (*Raja clavata*) in Divisions VIIa, f, g (Irish and Celtic Sea);

- Thornback ray (*Raja clavata*) in Division VIIe (Western English Channel);
- Small-eyed ray (*Raja microocellata*) in Divisions VIIf, g (Celtic Sea);
- Small-eyed ray (*Raja microocellata*) in Division VIIe (Western English Channel);
- Spotted ray (*Raja montagui*) in Subarea VI (West of Scotland);
- Spotted ray (*Raja montagui*) in Divisions VIIa, f, g (Irish and Celtic Sea);
- Undulate ray (*Raja undulata*) in Division VIIj (Great Sole Bank);
- Sandy ray (*Leucoraja circularis*) in the Celtic Sea ecoregion;
- Shagreen ray (*Leucoraja fullonica*) in the Celtic Sea ecoregion;
- Cuckoo ray (*Leucoraja naevus*) in the Celtic Sea ecoregion;
- Common skate, *Dipturus batis* complex (flapper skate (*Dipturus cf. flossada*) and blue skate (*Dipturus cf. intermedia*)) in the Celtic Sea ecoregion;
- Other ray and skate species in the Celtic Sea ecoregion.

As species-specific landings data are not complete, it is not possible to quantify the current catch and so ICES did not advise that an individual TAC be set for individual stocks, at present. However, it was noted that, based on the ICES approach to data-limited stocks, that catches of *R. microocellata* (VIIf, g) and *Leucoraja naevus* (Celtic Sea ecoregion) should be decreased by at least 36%, *R. montagui* (VI) should be decreased by at least 23%, and catches of *R. brachyura* (VI), *R. brachyura* (Divisions VIIa, f, g), *Raja microocellata* (VIId,e) *Leucoraja circularis* (Celtic Sea ecoregion) and *Leucoraja fullonica* (Celtic Sea ecoregion) should all be decreased by 20%, compared to the last three years' average. ICES also advised that catches of *R. clavata* (both VI and Divisions VIIa, f, g) and *R. montagui* (VIIa, f, g) could be increased by a maximum of 20%. Based on the precautionary approach, ICES also advised that there should be no targeted fishery for *R. undulata*, *Dipturus* cf. *flossada* or *Dipturus* cf. *intermedia*.

In 2010, ICES was asked to comment on the listings of common skate and undulate ray as 'prohibited species' on EC TAC and quota regulations.

For undulate ray, ICES advised "There is no basis in the current or previous ICES advice for the listing of undulate ray as a prohibited species. Therefore it should not appear on the prohibited species list in either the Celtic Seas or the Biscay/Iberia ecoregion fisheries legislation … In view of the poor knowledge and patchy distribution of these populations, ICES recommends a precautionary approach to the exploitation of these populations of undulate ray".

For common skate, ICES advised "There is no basis in the current or previous ICES advice for the listing of the common skate (*Dipturus batis*) as a prohibited species. Therefore it should not appear on the prohibited species list in either the Celtic Seas or the Biscay/Iberia ecoregion fisheries legislation. In the Celtic Seas ecoregion, ICES considers that stocks of the common skate complex is depleted, and that protective management measures are required. There should be no target fishing on the common skate, and there should be a TAC set at 0".

18.2.4 Management applicable

A TAC for skates in VI and VIIa–c, e–k was first established for 2009 and set at 15 748 t. Since then, the TAC has been reduced by approximately 15% (in 2010), 15% (in 2011), 13% (in 2012) and 10% (for 2013). The history of the regulations is as follows:

Year	TAC for EC waters of VIa–b and VIIa–c, e–k	Other measures	Regulation
2009	15 748 t	1,2	Council Regulation (EC) No 43/2009 of 16 January 2009
2010	13 387 t	1,2,3	Council Regulation (EU) No 23/2010 of 14 January 2010
2011	11 379 t	1,2,3	Council Regulation (EU) No 57/2011 of 18 January 2011
2012	9915 t	1,2,3	Council Regulation (EU) No 43/2012 of 17 January 2012
2013	8924 t	1,2,3	Council Regulation (EU) No 39/2013 of 21 January 2013
2014	8032 t	1,2,3	Council Regulation (EU) No 43/2014 of 20 January 2014

1) Catches of cuckoo ray (*L. naevus*), thornback ray (*R. clavata*), blonde ray (*R. brachyura*), spotted ray (*R. montagui*), small-eyed ray (*R. microocellata*) sandy ray (*L. circularis*), shagreen ray (*L. fullonica*) should be reported separately.

2) Does not apply to undulate ray (*R. undulata*), common skate (*D. batis*), Norwegian skate (*D. nidarosiensis*) and white skate (*Rostroraja alba*). Catches of these species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

3) Of which up to 5% may be fished in EU waters of VIId.

There are also mesh-size regulations for target fisheries, the EC action plan for the conservation and management of sharks (EC, 2009), and some local bylaws and initiatives, which were detailed in ICES (2010).

18.2.5 Proposed management plans

A management plan for skates in the Celtic Seas ecoregion has been under development through the North-Western Waters Regional Advisory Council (NWWRAC). The plan would primarily manage skates in the Irish Sea (VIIa) and Celtic Sea (VIIg) by means of voluntary closed areas that would protect spawning/juvenile fish during the spawning season. Proposals to manage skates with separate TACs and management for *Raja* spp. and *Leucoraja* spp. were not agreed. The plan has not yet been fully implemented, with just one closed area currently in place. The plan has not yet been evaluated by ICES.

In 2012 the NWWRAC submitted a special request to ICES for separate advice for the two species within the *Dipturus batis* complex. However it is not yet possible to provide advice on this basis.

Fishermen off North Devon have a voluntary seasonal closed area over what they consider to be a nursery ground.

18.3 Catch data

18.3.1 Landings

Landings data for skates (Rajidae) were supplied by all nations. Data for 2013 are considered provisional.

Landings by country are given in Table 18.2. Landings for the entire time-series are shown in Figure 18.1(a–c). Where species-specific landings have been provided they have also been included in the total for the relevant year. Although there are about 15 countries involved in the skate fisheries in this ecoregion, only six (France, UK (England, Wales and Northern Ireland), Belgium, Ireland, UK (Scotland) and Spain) have continually landed large quantities.

Landings are highly variable, with lows of approximately 14 000 t in the mid-1970s and 1990s, and highs of just over 20 000 t in the early and late 1980s and late 1990s. Although landings have fluctuated over most of the time-series, there has been a steady decline in landings since 2000. Annual reported landings have been less than 10 000 t since 2008 (noting that the TAC was established in 2009), and are now at their lowest level in the time-series at ~7500 t.

West of Scotland (VIa)

Recent reported landings, at about less than 400 t, are at their lowest point since 1973, with almost all countries declaring less than preceding years. In contrast, average landings in the early 1990s were about 3000 t. Landings have been less than 1000 t since 2006, and less than 500 t for the last five years.

Rockall (VIb)

Reported landings from Rockall in the 1990s were about 500 t per year, but have been under 200 t for the last decade, and are now at their lowest level. The increased landings in the mid-1990s were a result of new landings of 300–400 t per year by Spanish vessels. These no longer appear to take place since no Spanish landings have been reported in this area in recent years. It is not clear what proportion of these catches may have been taken from Hatton Bank (VIb1 and XIIb). One to three Russian longliners fished in this area in 2008–2009, mainly catching deep-water species, including sharks, but also catching 7 t of deep-water skate species.

Irish Sea (VIIa)

Reported landings in the Irish Sea vary considerably, and ranged from over 1500 t in 1995 to ca. 5000 t in the late 1980s. Since 2006, annual landings have been <2000 t, and are now at just over 1000 t and their lowest level (except 2009). This may be as a result of reduced fishing effort and effort changes because of the cod recovery programme in the area, where whitefish boats have switched to *Nephrops* fishing, with the latter thought to have a lower skate bycatch. Most landings are from Ireland, UK and Belgium.

Bristol Channel (VIIf)

Following an increase in reported landings in the mid-1970s, skate landings in VIIf ranged from 1000–1600 t in recent years. Landings are predominantly from three countries (UK, France and Belgium) and are stable at just over 1000 t.

Western English Channel, Celtic Sea and west of Ireland (VIIb–c,e,g–k)

Annual reported landings from Divisions VIIb–c,j–k were in the general range of 500–1200 t from 1973–1995. Landings then increased during the period 1996–2003, with some annual landings of approximately 4000 t, however the level of misreporting in this period is unknown. Landings declined after 2007 to less than 1000 t per year, which is of a comparable magnitude to earlier landings, and are now just over 500 t.

Landings are consistently higher in the southern parts of this region (Divisions VIIe,g–h), and these have reduced from ca. 8000 t per year (from 1973–2000) to just over 4000 t in recent years and are now at their lowest level of the 40-year time-series.

18.3.2 Skate landing categories

Historically, most skate landings were reported under a generic landing category, although some nations (e.g. France) reported some species-specific landings data. There has been a legal requirement to report most skate landings to species level throughout this ecoregion since 2010. On average, 94% of the 2013 landings are reported to species level, with a continuous decline in landings declared in generic categories since 2011. Earlier reports have highlighted various issues regarding the quality of these data (ICES, 2010, 2011, 2012), and this is further discussed in Section 18.4.3.

A recent study by Silva *et al.* (2012) examined the species-specific data recorded by the UK (England and Wales). Although there were some erroneous or potentially erroneous records, the regional species composition was broadly comparable to that recorded by scientific observers on commercial vessels, and data quality seemed to be improving. Comparable studies to critically evaluate other national data and identify potential errors are still required, so as to better identify where improved training and/or market sampling may improve data quality.

18.3.3 Discards

There may be widespread discarding of skates, including of smaller (less marketable) individuals, prohibited species, as well as regulatory discards (when vessels have restrictive quota).

Discard information for skates taken in UK (English and Welsh) fleets were summarised (Ellis *et al*., 2010; Silva *et al*., 2012) and detailed analyses of discards data from other nations are required.

18.3.4 Discard survival

Studies in UK waters have examined the discard survival of various skates in a range of fisheries. Skate discard survival is approximately 55% in otter trawl fisheries (Enever *et al*., 2009), but this is influenced by the other catch component of the trawl. In other areas, it has also been observed that *R. clavata* caught by inshore trawlers (which tend to have a short tow duration, due to the increased amount of weed in the water in inshore areas) tend to be lively on capture and commercially caught fish tagged and released have good return rates (Ellis *et al*., 2008), indicating a higher discard survival from such fisheries.

Studies on beam trawlers indicate that survival of skates may be up to 50% when tow duration is <2 hours, but is likely to increase with higher tow duration. Inshore gillnet fisheries have a relatively high discard survival when soak time is short (survival is >95% when soak times are ca. 24 hours), but longer soak times (40–48 hours) resulted in higher mortality rates (Ellis *et al.*, 2014 WD). The soak times for offshore gillnet fisheries are generally greater, and so there is also an increased mortality, and also an increased incidence of scavenging by isopods (Bendall *et al.*, 2012; Ellis *et al.*, 2012a WD).

It should also be recognised that studies such as above are typically based on data collected by scientists at sea, with skates handled with due care and immediately after capture. Hence, the normal practices on commercial vessels, in terms of how the catches are processed and fish handled could result in reduced survival in comparison to scientific studies.

18.3.5 Quality of catch data

Historical skate landings were reported at the family level, and there have been improvements to species-specific landings data in recent years, although the current time-series is quite limited. Observer programmes to examine the catch and discards on commercial vessels continue to provide important information and further analyses of these data are required for most Member States. The future use of discards data will need to be explored in conjunction with estimates of discard survival.

Commercial species-specific catch data are either limited or are sampled in insufficient numbers to be used for evaluating the stocks at the current time, although this situation is continually improving. Concerns over species-specific issues are outlined in Section 18.4.3.

18.3.6 Case study: estimating the discards of *Raja undulata* in the English Channel (VIId,e)

Discards of *R. undulata* based on French on-board observations was estimated by raising observed discards to the total French fishing fleet in VIId and VIIe in 2013. Observed discards were raised to the total effort, in fishing days, by quarter and DCF level five métiers in VIId and VIIe separately using the R Cost package (see Leblanc *et al.*, WD 2014 for details). The overall discards were summed up for VIId and VIIe. The accuracy of estimates was evaluated using coefficient of variation CVs and it was considered reliable for towed gears in VIId and VIIe and for longlines in VIId. Larger CVs were obtained for fixed nets métiers probably due to the problem of effort-raising. The total discards of netters was estimated as raising the discards in observed fishing trips of these métiers by the proportion of observed to total discards for towed gears (i.e. assuming that the sampling proportion is the same for netters and towed gears).

The preliminary estimates of discards of *Raja undulata* by French vessels (by DCF level five métier, towed gears only) in VIIe in 2013 were 116.3 t (OTB_CEP), 738.6 t (OTB_DEF), 5.7 t (OTT_CEP) and 14.9 t(TBB_DEF), with a total of ca. 875 t for these gears. Estimated discards for this species by French vessels (by DCF level five métier, towed gears and longline only) in VIId in 2013 were 20.3 t (LLS_DEF), 4.9 t (OTB_CEP), 38.9 t (OTB_DEF) and 2.2 t (TBB_DEF), with a total of 66.4 t for these gears combined.

In VIIe, the observed discards in netters were 0.951 of observed discards in towed gears. In VIId, this proportion was 0.085. Therefore total discards by netters were estimated at 833 t (VIIe) and 4 t (VIId). The total estimated discards in VIId,e by all métiers was 1778 t in 2013, with comparable values estimated for both 2011 and 2012 (Leblanc *et al.*, 2014 WD).

Assuming a commercial size of *R. undulata* as 50 cm total length, the fraction of the total discard that is large that 50 cm was estimated using the length distribution of discards in towed gears and a relationship between weight (W, kg) and length (L, cm) of W =

0.00000415*L^3.12428 (sexes combined, Dorel, 1986). This resulted in an estimated 620 and 15 t for active gears in VIIe and VIId respectively. Because nets and longlines are more selective, all catches were assumed larger than 50 cm. Thus the total estimate of discarded undulate ray of marketable size, i.e. regulatory discard, in 2013 was estimated to 1500 t.

18.4 Commercial catch composition

18.4.1 Species composition

National species-specific landings data were available for Belgium, France, Ireland and the UK (Table 18.3).

Within the waters off NW Scotland (VIa), Scottish landings were the highest (185 t) with catches dominated by *R. clavata* (56%), *R. montagui* (14%) and *L. naevus* (11.9%). Irish landings (94 t) were mainly of *R. clavata* (72%) and *R. brachyura* (12.5%). French skate landings (85 t) were dominated by *R. clavata* (33%), *L. naevus* (27%) and *R. montagui* (19%), with smaller quantities of *L. circularis,* and *L. fullonica*. *D. oxyrinchus* catches had reduced from 14.4% of identified skates in 2012, to 8.6% in 2013. The reported landings of *D. oxyrinchus* in this area needs further study, as it is unclear as to whether such landings may be misidentified *D. batis*-complex. Indeed, recent studies have questioned the accuracy of landing data for large, long-snouted skates (Iglesias *et al*., 2010).

Within the Irish Sea (VIIa), Belgian landings (370 t) were dominated by *R. brachyura* (41%), *R. clavata* (49%) and *L. naevus* (10%), and Irish landings (411 t) also indicated a high proportion of these three species (*R. brachyura:* 77%, *R. montagui:* 6%, *R. clavata*: 13%). English landings (213 t) were dominated more by *R. clavata* (89%), although *R. brachyura* (4%) was still an important species. In contrast, French landings (5.8 t) were dominated by *R. montagui* (85.5%), and so there may still be some confusion between *R. brachyura* and *R. montagui*.

Skate landings in the western English Channel were comprised mostly of *R. brachyura, R. clavata, R. montagui* and *L. naevus,* and this was evident in landings from France (960 t) and England (550 t). These species also dominated the landings in the Bristol Channel (VIIf), although *R. microocellata* was also an important component in UK landings and, to a lesser extent, French landings. The latter species was also thought to be an important component of Belgian landings, although they continue to report catches as *L. circularis* (both species are known by the common name 'sandy ray'). The relative proportion of *Raja* spp. typically decreases further offshore in VIIg,h, with Belgium, Ireland, France and the UK all reporting *L. naevus* as the main species (ca. 80% of landings) in VIIh.

18.4.2 Size composition

Although no data were examined this year, length frequencies for the more common species have been shown in earlier studies (ICES, 2007, 2011; Johnston and Clarke, 2011 WD; Silva *et al*., 2012).

18.4.3 Quality of data

There is still some concern over some of the species identifications being reported. Although several national laboratories are undertaking market sampling, more critical analyses of these data are required to ensure that species identification issues are resolved (e.g. Silva *et al*., 2012) and that the methods of raising the data are appropriate and can allow for seasonal, geographical and gear-related differences in the species composition of skate landings to be examined. While there are market sampling programmes in place in several countries, skates are sometimes treated as low-priority species, so may not be sampled as effectively as they might be.

There are concerns that as certain species are added to the prohibited species list, these may be declared in generic categories or as morphologically similar species, rather than be declared to species level. Further studies to better understand landings of *Dipturus* spp. are required by those nations landing such taxa.

Although the quality of other species-specific appears to be improving, there are issues regarding:

- Belgian landings of *L. circularis* in VIIa,f,g are thought to represent *R. microocellata*, and efforts should be made to ensure such data are reported accurately in future years;
- Data for *R. brachyura* and *R. montagui* may be confounded, and all nations could usefully make attempts to improve the data quality for these species;
- Scotland and France both report landings of *R. alba* (a prohibited species), although it is possible that these landings refer to *L. fullonica.* Efforts should be made to ensure such data for these species are checked and reported accurately in future years;
- UK, Ireland, France and Belgium all reported landings of *A. radiata* and the UK also reports *A. hyperborea* from this ecoregion. Although the quantities involved are small, they are thought to represent other skate species of code errors.

18.5 Commercial catch and effort data

18.5.1 Case study: commercial landing per unit of effort

Irish raw lpue trends in units of both fishing days and fishing hours at several aggregation levels were examined by Davie (2014 WD). Two levels of species aggregation were examined, a general skate category for all species reported by Irish fishers to provide a longer trend in targeting practices. This grouping was also disaggregated into four species (*Raja brachyura*, *R. clavata, R. montagui* and *L. naevus*) for the years 2011–2013, as the reporting of individual species has become standard practice.

These were examined firstly broken down by gear types then by métier. The methodology and specific details of all identified métiers is given in Davie and Lordan (2011) for trawl gears and Davie (2013) for other gear types. A total of 58 Irish targeted métiers were defined from this process, of which six may have skates as one of the main target species.

Spatial lpue distributions of the four species were examined by gear type, métier and for seasonal variability (quarter). The former two coupled with spatial trends. Reported landings were linked to vessel monitoring system (VMS) data to generate fishing effort and position data as per Gerritsen and Lordan (2011).

The text below focuses on lpues in fishing days within Divisions VIIa, VIIf, and VIIg.

In general terms, overall skate landings declined between 2003 and 2009, after which landings increased to a stable, higher level due to increased otter trawl landings, until the last year where landings declined (Figure 18.2). Fishing effort in these areas are high (particularly VIIa and VIIg) and dominated by otter trawl effort. Overall a slight decline has occurred within the last three years (Figure 18.3). A general declining lpue trend was occurred over the last eleven years (Figure 18.4). Between gears, beam trawls showed the greatest lpue (≥100 kg per fishing day), although dropping below this in 2013. All other gears result in lower lpues, of which demersal otter trawlers have overall been the greatest.

Breaking landings into their constituent target métiers, the greatest landings over the period originated from skate-targeting métiers, most noticeably small mesh (80–99 mm) beam trawling for plaice *Pleuronectes platessa,* common sole *Solea solea* and skates within the Irish and Celtic Seas, and small mesh (70–99 mm) otter trawlers targeting plaice and skates in the same general areas (Figure 18.5). Smaller landings occurred in many other métiers where skates are a bycatch, the most noticeable of these the small mesh (80–99 mm) beam trawl métier targeting megrim *Lepidorhombus* spp., anglerfish *Lophius* spp., witch *Glyptocephalus cynoglossus* and lemon sole *Microstomus kitt* in the Irish and Celtic Seas. In 2012–2013, the picture appears to be shifting with increasing landings from the large mesh (≥100 mm) plaice and skate targeting otter trawl métier within the Irish Sea.

In relation to lpues the picture shifts quite dramatically by métier compared to gear based lpues. Removing the effort associated with the *Nephrops* otter trawl fisheries and focusing on métiers indicated a greater lpues being achieved by demersal trawl than beam trawl (Figure 18.6). By-métier lpues are much higher than the general gear categories. Values of over 1 t per day are achieved for the métier targeting both plaice and skates with larger mesh otter trawls in the Irish Sea.

Differences in lpue and trend were identified between the same gear type using large mesh and smaller mesh targeting the same two primary species. The large mesh Irish Sea plaice and skate métier shows a fluctuating increasing trend while the small mesh plaice and skate métier operating across a wider area has shown a more variable tend with sharp declines in the last two years. In comparison, lpues from small mesh beam trawling for skates, plaice and common sole within the Irish and Celtic Seas, although much lower, have remained more consistent over time, with a slight increasing trend. Such differences between trends highlight the importance of accounting for differing targeting behaviour of fishers. Individual species data were limited to the last three years.

Raja brachyura has, by far, the greatest lpue values of the four species, with each of the remaining species achieving less than 12 kg per fishing day for any one gear in the last two years (Figure 18.7). As with combined skate species, beam trawling has the greatest lpue values for all except *R. clavata*. For these, in the last year otter trawler (and demersal seine) lpues increase to above those of beam trawls. Breaking this down by targeting métiers, *R. brachyura* and *R. montagui* achieve the greatest lpues in large mesh Irish Sea focused plaice and skate otter trawling (Figure 18.8), followed by small mesh beam trawling for skate, plaice and common sole within the Irish and Celtic Seas, and small mesh plaice and skate métier operating across a wider area. Lpues for *R. brachyura* appear to be stable or in slight decline (the last of the three métiers has declined) whilst *R. montagui* lpues have dropped. The greatest lpues for *L. naevus* were achieved by the small mesh beam trawling for skates, plaice and common sole métier up until 2013, when levels dropped dramatically. While for *R. clavata*, higher lpues were obtained by the small mesh plaice and skate métier. Lpues for this species appear to be increasing. The varying importance of métiers and their differing trends highlights the importance of considering species separately. A combined group masks individual species targeting behaviours and lpue trends within métiers.

VMS based distribution maps of landings from 2011–2013 are given in Figures 18.9–18.16, where the first four are for beam trawls, the remainder are otter trawls. Within the areas of the Irish and Celtic Seas fished by the Irish beam trawl fleet, differences were observed in distribution. Each of the four species has noticeable lpues within the *Nephrops* fishing grounds of the Irish Sea. *Raja brachyura* shows dominant lpues from this area and lower levels in several other isolated areas of VIIa. Lpues from the Celtic Sea are low. *R. montagui* had a similar, albeit more patchy lpue distribution. There was also a patch of higher lpue off the Welsh coast. The same patch had high lpue of *R. clavata* in addition to a patch close to the southeast Irish coast. In contrast, *L. naevus* had a patch of high lpue to the southwest of Ireland.

Otter trawl activity was far more diverse, covering a far greater range of fishing grounds. From this, a patch of thornback high lpues was observed off the southeast coast of Ireland, in addition to areas in VIa and small coastal hot spots around the west of Ireland. Although there was a wide distribution of low levels of lpue of *R. brachyura*, there was a distinctive patch of high lpues within the Irish Sea in and around the *Nephrops* fishing grounds. There was also a small patch between the tip of southeast Ireland and southern tip of Wales. *Raja montagui* had the same high lpue value distribution within the Irish Sea, although there were also some other small areas of high lpue. *Leucoraja naevus* had high lpues further offshore within the area of VIIh,j in what appeared to be strips of fishing activity. In addition to this, there were patches to the west of Ireland resulting in higher lpues including an area between the Aran fishing grounds and the continental slope.

Using these maps, areas of species dominance could be identified, such as otter trawling in ICES rectangle 33E3 where *R. clavata* is the dominant skate landed. Making the assumption that *R. clavata* have consistently been the dominant skate species within this rectangle, landings and lpues could be reconstructed back in time. Taking the average (2011–2013) contribution of *R. clavata* to the species identified otter trawl landings from this rectangle and applying this to the total skate landings from the rectangles generated a *R. clavata* landings trend and subsequently lpue trend (Figure 18.17). The generated trend shows reduced landings and effort for this rectangle since 2007 although lpue remained high. Lpue dropped to lowest assumed levels of the eleven year period in 2012 and 2013.

Quarterly gear based VMS maps for each species are given in Figures 18.18–18.25, this time the beam and otter trawl figures are grouped for each species rather than by gear type. The maps combine the last three years of data to reduce annual variability in any seasonal distribution and maintain sufficient data for confidentiality. From these maps, no particular pattern in seasonal variability was apparent for *R. brachyura* or *R. montagui*. *Leucoraja naevus* and *R. clavata* showed some distinction between summer and winter months. The lpue of *L. naevus* were greater between the Aran and slope fishing grounds during the first and last quarter, and higher values from beam trawling in the Irish Sea during quarter 2. *Raja clavata* had greater lpues during quarters 1 and 4 within the more inshore waters of the southeast Irish coast, in contrast to lower otter trawl lpues in VIa during the first quarter.

18.5.2 Recreational cpue

Data supplied by the Inshore Fisheries Ireland (Wögerbauer *et al.*, 2014 WD) shows that tag and recapture rates of *R. undulata* in Tralee Bay (VIIj) has significantly declined since the 1970s. Although these data do not allow for potential changes in effort, it suggests that this stock is over-exploited (Figure 18.26).

18.6 Fishery-independent surveys

Groundfish surveys provide valuable information on the spatial and temporal patterns in the species composition, size composition, sex ratio and relative abundance of various demersal elasmobranchs, including some biological studies. Several fishery-independent surveys operate in the Celtic Seas ecoregion (Figure 18.27). It is noted that these surveys were not designed primarily to inform on the populations of demersal elasmobranchs, and so the gears used, timing of the surveys and distribution of sampling stations may not be optimal for informing on some species and/or life-history stages. However, these surveys provide the longest time-series of species-specific information for demersal elasmobranchs for many parts of the ecoregion.

The manual for the SWIBTS was revised in 2010 to provide updated information on the various surveys (ICES, 2010; 2012). Definitions and measurements of the various groundgear and nets used in these surveys, and referred to in the sections below, can be found in these manuals.

Updated catch rate analyses for four surveys (Porcupine Bank, Irish groundfish survey, EVHOE and the UK (England) beam trawl survey) were provided this year (Figures 18.28–18.33), with other surveys providing supporting information (Figures 18.34–18.36). Individual stock sheets, providing the state of each stock based on survey trends in length and abundance were provided in ICES (2013b, Supplementary Material).

18.6.1 Southern and Western International Bottom Trawl Surveys

UK (Scotland), UK (Northern Ireland), Ireland, France and Spain undertake trawl surveys in the Celtic Seas ecoregion, as part of the internationally coordinated IBTS surveys for southern and western waters (Figure 18.27), with UK (England) a former participant. Although the trawl gears used in these surveys are not standardized (Table 18.4), individual surveys can provide survey-specific indices. Most surveys are in Q4, with some nations also conducting surveys in Q1.

18.6.1.1 French EVHOE Groundfish Survey (EVHOE-WIBTS-Q4)

The French EVHOE survey has been carried out in Bay of Biscay since 1987 and in the Celtic Sea since 1995, when it came under the auspices of the IBTS. Mahé and Poulard (2005) undertook preliminary data analyses, and reported that 26 species of elasmobranch had been recorded in the Bay of Biscay and 19 species in the Celtic Sea.

This survey was used to provide information on the following species: *L. naevus, L. fullonica, R. montagui* and *R. clavata* in the Celtic Sea (Figure 18.28 a–g).

18.6.1.2 Irish Groundfish Survey (IGFS-WIBTS-Q4)

The Irish Groundfish Survey has taken place since 2003. The survey has a random stratified design, with four depth strata. Approximately 185 stations are trawled annually around the Irish coast, with the exception of the Irish Sea, which is covered by Northern Ireland surveys. Fifteen skate species have been reported from this survey, as well as four species of dogfish and occasional pelagic and deep-water sharks. Analyses of these data were presented in earlier reports (see ICES, 2010b; 2012) and this survey provides abundance indices for ICES Areas VIa and VIIafg, for the following species: *R. montagui, R. clavata* and *L. naevus* (Figure 18.29 a–f).

18.6.1.3 Spanish Porcupine Groundfish Survey (SpPGFS-WIBTS-Q4)

The annual Spanish Porcupine bottom trawl survey, which started in 2001, collects data on the distribution and relative abundance, and biological information of commercial fish in the Porcupine Bank Area (ICES Divisions VIIb,k). The target species for this survey are hake, anglerfish, white anglerfish, megrim, four-spot megrim, *Nephrops* and blue whiting. The survey follows a random stratified design with two geographical strata (northern and southern) and three depth strata (170–300 m, 301–450 m, 451–800 m). Stations are randomly allocated within each stratum. The gear used is a Porcupine baca 39/52 with 3 m vertical opening, 23 m wing spread and 134 m door spread, hauls last 30 minutes.

L. naevus occurs mainly on the shallower grounds close to the Irish shelf and on the central mound in the bank, with *L. circularis* occurring in deeper waters around the Porcupine Bank. This survey provides information for *L. naevus, L. circularis* and *D. batis* complex (Figures 18.30–18.32; Fernández-Zapico *et al.*, 2013 WD; Ruiz-Pico *et al.*, 2014 WD).

18.6.1.4 UK (England and Wales) Western Groundfish Survey (EngW-WIBTS-Q4)

The UK (England and Wales) survey used a modified GOV trawl with standard groundgear ‘A’ on fine grounds, and groundgear ‘D’ on coarser grounds (2004–2011). Preliminary data analyses were presented at a previous meeting (ICES, 2010) and biological data from this survey were used to inform on the length at maturity for several skate species (McCully *et al.,* 2012).

This survey was discontinued in 2012, although in 2013 there was a trial to move this survey to Q1.

18.6.1.5 UK (Northern Ireland) Groundfish Survey - October (NIGFS-WIBTS-Q4)

UK (Northern Ireland) has undertaken annual Q4 (and Q1, see below) trawl survey of the Irish Sea since 1992. The gear deployed is a commercial rock-hopper trawl fitted with a 20 mm liner in the codend and is towed for a set time period, (either 20 minutes or one hour) to allow comparison between tows and years. The Agri-Food and Biosciences Institute AFBI (NI) in Northern Ireland previously analysed available survey data from the northern VIIa (N) region (see NIEA, 2008; ICES, 2010).

The absence of participation from UK (Northern Ireland) precluded further analyses of these survey data in recent years.

18.6.1.6 UK (Northern Ireland) Groundfish Survey - March (NIGFS-WIBTS-Q1)

UK (Northern Ireland) also undertake Q1 groundfish surveys in the Irish Sea (see above for further information).

18.6.1.7 Scottish West Coast Groundfish Survey Q4 (ScoGFS-WIBTS-Q4)

The Scottish Quarter 4 west coast groundfish survey, began in 1990, covers a depth range of 20–500 m. The survey originally covered an area west of the British Isles, from 56–61°N and bounded by the 200 m depth-contour and the coast. Initially the survey area did not include the area of the Minch and the North Channel of the Irish Sea but gradually the spatial coverage has been altered until now it mimics the Quarter 1 survey.

The survey uses a GOV, which originally used groundgear 'C', now uses a variant of groundgear 'D'. A change of research vessel took place in 1998, and haul duration was reduced from 60 to 30 minutes at this time.

No updated analyses of these data were undertaken in recent years, although information was given in ICES (2010; Figure 18.36).

18.6.1.8 Scottish West Coast Groundfish Survey Q1 (ScoGFS-WIBTS-Q1)

The UK (Scotland) Q1 west coast survey covers a similar area to the Q4 survey. No updated analyses of these data have been undertaken in recent years, although information was provided during previous meetings (ICES, 2010; Figure 18.36).

18.6.1.9 Rockall survey (Rock-IBTS-Q3)

A Q3 survey of the Rockall Bank has also been conducted since 1991. During the period 1998–2004 this survey was conducted only in alternate years, with a deep-water survey along the shelf edge in VIa carried out in the intervening years. Since 2005, both surveys have been carried out annually.

The survey at Rockall has very low catch rates for all elasmobranchs. The most commonly caught demersal skates in this survey are *R. clavata*, and *D. batis*-complex, but the catch rates of even these are typically less than ten individuals per survey. The survey is therefore only useful as an indicator of whether a species is present in this part of Division VIb. Other demersal elasmobranchs which have caught occasionally in this survey include *L. circularis, L. fullonica, R. montagui, D. oxyrinchus* and *Rajella fyllae*. There is limited survey data for skates from the deeper water of Division VIb.

18.6.2 Beam trawl surveys

Three beam trawl surveys operate (or have operated) in this ecoregion (Table 18.4), surveying the Irish Sea, Bristol Channel and western English Channel.

18.6.2.1 UK (England and Wales) Irish Sea and Bristol Channel beam trawl survey (EngW-BTS-Q3)

An annual survey with a 4 m beam trawl is undertaken in the Irish Sea and Bristol Channel each September (Parker-Humphreys, 2004a,b; Ellis *et al.*, 2005). The primary target species for the survey are commercial flatfish (plaice and sole) and so most sampling effort occurs in coastal water. Preliminary studies of survey data indicate that the gear used may not sample larger skates effectively, although this gear should be suitable for sampling smaller skate species (e.g. *R. montagui* and *L. naevus*) and juveniles and subadults of the larger species.

R. brachyura, R. clavata, R. microocellata (VIIf), *R. montagui* and *L. naevus* (VIIa) are all sampled during this survey and are used to provide abundance indices. Biological data from this survey have been used to examine the length-at-maturity for several skate species (McCully *et al.*, 2012).

Catch rates (ind.h^{-1}) are summarized (see Figure 18.33a–e), with analyses (a) omitting data collected prior to 1993, and (b) only including those fixed stations fished at least 18 times during the 21 year time-series (1993–2013).

18.6.2.2 UK (England) beam trawl in Start Bay, VIIe (Eng-WEC-BTS-Q4)

A beam trawl survey of a fixed station grid in and around the Great West Bay (between Start Point and Portland) during October, using 4 m beam trawl. It was usually undertaken on the commercial vessel FV *Carhelmar* (with twin beam trawls) although it was undertaken by RV *Corsytes* (single beam trawl) in occasional years. Detailed analyses of the demersal elasmobranchs taken in this survey were undertaken (Burt *et al.*, 2013) and summary data provided here (Figure 18.34). This survey is now discontinued, but it is considered that it provided adequate sampling of *R. brachyura, R. clavata* and *R. montagui.*

18.6.2.3 UK (England) beam trawl in western English Channel (Eng-WEC-BTS-Q1)

A beam trawl survey (using twin 4 m beam trawls) is undertaken in the western English Channel during March. This survey has a random-stratified survey design. Information from this survey was used to examine the distribution of *R. undulata* (ICES, 2010; Ellis *et al.*, 2012b). Detailed analyses of the distribution and length ranges of demersal elasmobranchs taken in this survey were provided by Silva *et al.* (2014 WD), and provided here (Figures 18.35a–f).

18.6.3 Other sources of survey data

18.6.3.1 UK Portuguese high headline trawl 1Q (PHHT-Q1)

This Q1 survey with Portuguese high headline trawl (PHHT) was undertaken in the Celtic Sea (ICES Division VIIe–j) from 1982–2003, although the survey grid was better standardized from 1987–2002. These data have been examined in previous years, and provide a useful perspective of the species present in the area at that time. For example, it provides additional information on the distribution of *D. batis* complex and *L. fullonica*.

18.6.3.2 Additional Irish surveys

An annual survey to collect maturity data for commercially important demersal fish, mainly whitefish and skates, took place during the spring-spawning season (2004–2009). Different areas were surveyed each year, so annual trends cannot be derived. An annual deep-water trawl survey to the west of Ireland (2006–2009) over the depth range 500–1800 m. This may provide limited data for certain skate species.

18.6.4 Temporal trends in catch rates

Given the very recent introduction of species-specific landings and discard observer programmes, the status of demersal elasmobranchs of this ecoregion is based primarily on the evaluation of fishery-independent trawl surveys. The available survey data have been used to evaluate the status of the stocks under the ICES approach to data-limited stocks (Section 18.9).

18.6.5 Quality of data

18.6.5.1 Species identification in surveys

There are identification problems with certain skate species that may increase uncertainty in the quality of survey data. *Raja montagui* and *R. brachyura* may be confused, and the identification of neonatal specimens of *R. clavata*, *R. brachyura* and *R. montagui* can also be problematic.

Many recent surveys in the ecoregion have attempted to ensure that data collected for the common skate-complex be differentiated, and whereas national delegates have confirmed which species have been caught, survey data can only be uploaded to DATRAS for the complex, as the two species do not have valid taxonomic codes as yet. Work to clarify the taxonomic problems was discussed intersessionally and will hopefully be resolved by the IUZN soon.

18.6.5.2 Gear performance

There are several scientific trawl surveys in the ecoregion using different types of trawl gears. Beam trawl surveys operate in VIIa,e,f, and this gear would appear to be a suitable sampling tool for lesser-spotted dogfish, juvenile smooth-hounds and smaller skates. However, this gear may not be appropriate to informing on larger skates.

The western IBTS surveys use a variety of trawl gears deemed appropriate to the grounds on which they fish, and so include trawls with rock-hopper discs or bobbins, as well as standard groundgears on fine ground. There is insufficient knowledge of the catchability of demersal elasmobranchs in these various gears.

18.6.5.3 Degree of survey effort in relation to localised populations

Several demersal elasmobranch species that occur sporadically throughout much of the Celtic Seas ecoregion have certain sites where they are locally abundant. Localized depletions of the species at these sites could therefore have a major impact on the population as a whole. Hence, the status of such species may need to be monitored and assessed on a more localised scale.

In the case of *Raja microocellata*, which is locally abundant in the Bristol Channel (VIIf), there are many sampling stations in this area from the UK (England and Wales) beam trawl survey, and so WGEF should be able to monitor and evaluate their status.

However, some other species have more discrete areas in which they are abundant, and as such existing survey data may be limited. This is especially noteworthy for some of the more coastal species. More detailed studies of existing data are required to better inform on the status of:

- *Raja undulata* in Tralee Bay and southwest Ireland (VIIb,j; Figure 18.37) and the middle of the English Channel (VIId,e; Figures 18.38–18.40);
- *Raja brachyura* in areas of high abundance.

In some instances, it may be that available survey data will not be appropriate to evaluate some of these species, and dedicated inshore surveys using an appropriate gear and census method may be required if these stocks are to be better evaluated.

18.7 Life-history information

Various published biological studies provide maturity and age data for skates in the Celtic Seas (e.g. Fahy, 1989; Gallagher, 2000; Gallagher *et al.*, 2005; McCully *et al.*, 2012).

18.7.1 Ecologically important habitats

Ecologically important habitats for the demersal elasmobranchs would include (a) any oviposition (egg-laying) sites for oviparous species; (b) pupping grounds for viviparous species; (c) nursery grounds; (d) habitats of the rarer species, as well as other sites where there can be large aggregations (e.g. for mating or feeding).

Surveys may be able to provide information on the locations of nursery grounds and other juvenile habitats, and these should be further investigated to identify sites where there are large numbers of 0-groups and where these life-history stages are found on a regular basis.

Little is known about the habitats of the rarer elasmobranch species, and further investigations on these are required. Wearmouth and Sims (2009) undertook a tagging study of *Dipturus batis*, and tagging studies have recently been undertaken for this complex in the Celtic Sea (Bendall *et al.*, 2012).

Juveniles of many species are found in most groundfish surveys and in discards, although usually in small numbers. Annual beam trawl surveys in September catch recently hatched *R. clavata* (ca. 10 cm total length). Although catches of 0-groups tend to be low and may not be accurate indicators of recruitment, a more critical examination of these data could usefully be undertaken. However for areas where elasmobranch catches are low, such as skates in VIIj, it will not be possible to estimate recruitment without dedicated surveys.

18.7.2 Case study: identification of potential nursery and possible spawning grounds

All countries funded under the EU Data Collection Framework collect at-sea observations on catch and discard levels of fish caught on commercial surveys. These observer programmes routinely collect species and length data from commercial and non-commercial species. Sex data may also be collected for certain species. A 2014 study (Johnston *et al.*, 2014 WD) looked at these data for selected skate species collected by Irish, UK and French observer programmes.

National programmes supplied data in different formats, so these were pooled into a common Excel spreadsheet, recording species, sex, length, number-at-length, and the latitude and longitude of the haul. Maps were created using ArcMap 10.2.

Maps were made of nominal nursery grounds and the locations of adult females during Q2. The latter was a proxy for nominal spawning grounds, as direct measurements of maturity stage (i.e. of females with egg-cases exuding) are not made during DCF-funded observer programmes. Each of the grounds was made by mapping fish at appropriate size thresholds. There was no distinction made between landed and discarded fish and the size thresholds were:

Nominal nursery grounds: Length at birth to length at birth + 15 cm.

Adult spawners: Females, greater than length at first maturity caught during Q2.

Biological references were taken from the following sources:

Species	Length at birth (cm)	Length at first maturity (cm)	Source
Dipturus spp.	20	115	McCully *et al.*, 2012
Leucoraja fullonica	21	75	McCully *et al.*, 2012
Leucoraja naevus	10	51	ICES, 2004
Raja brachyura	13	60	McCully *et al.*, 2012
Raja clavata	11.8	60	Ryland and Ajayi, 1984
Raja microocellata	10	57.5	Ryland and Ajayi, 1984
Raja montagui	10	57.3	Ryland and Ajayi, 1984
Raja undulata	10	70	Coelho and Erzini, 2002

Locations of finds of egg-cases of certain skate species along the Irish coastline were made available (Sarah Varian, pers. comm.) These are illustrated where appropriate (Figures 18.41a–h).

Initial examination of these maps shows certain areas of local abundance for most species. Perhaps of more importance, gaps are shown in the distribution (e.g. *L. naevus* between catches in VI and VII), which may be useful for future refinements of stock identity. The overlap of potential protected areas to protect juvenile or spawning females with existing marine protected areas is illustrated in Figure 18.42.

18.8 Exploratory assessment models

18.8.1 Case study: The utility of catchability corrected survey biomass

Exploratory assessments of skate abundance, primarily in the Irish Sea (VIIa) are provided below, based on the work of Shephard *et al.* (2014 WD).

18.8.1.1 Catchability corrected survey biomass

Species catchabilities from Fraser *et al.* (2007) were used to derive skate population biomass estimates from survey data, and combine these with discard and landings records to yield empirical estimates of HR. Survey-based HR estimates for each species were compared to values derived by fitting catch curves to fish length frequencies in the survey data and from an Irish discard observer scheme in the Irish Sea (ICES VIIa). Differences in the life histories of fish means that sustainable levels of fishing mortality (as a Harvest Rate, HR) vary considerably among demersal fish species, and are likely to be low for most skates relative to teleosts. It is useful to be able to compare HR with appropriate reference levels for 'sustainable' mortality. Three precautionary HR reference points for each tested species, based on established approaches, and compare these estimated reference levels with observed annual HR values.

Three fisheries-independent surveys were analysed: the Irish Groundfish Survey (IGFS) in ICES VIIg, the Northern Ireland Groundfish Survey (NIGFS) in VIIa, and UK Beam Trawl Survey (UK BTS) in VIIa. For species were considered: *Raja montagui*, *R. clavata*, *R. brachyura* and *Leucoraja naevus*.

i) Using survey data (2011–2012), catch numbers-at-length were converted to weight (W) at-length using weight-at-length relationships ($W=\alpha L^{\beta}$), where the parameters α and β were obtained from the North Sea Q1 IBTS.

ii) Catch weights (kg) at length (cm) of each species in each trawl sample were raised from trawl swept area (trawl wingspread multiplied by distance trawled, m) to 1 km^2, to derive a first estimate of density ($kg.km^{-2}$) at length for each unique haul.

iii) For the otter trawl surveys (IGFS and NIGFS), size (length)-based raising factors from Fraser *et al.* (2007) were applied to haul density estimates for 'small' (< length at maximum abundance in species length–frequency distribution) fish of each species to account for q in the survey GOV trawl. For each species in the GOV, we used q = 1 for 'large' fish. For the beam trawl survey (UK BTS), we used q = 1 for small fish and q = 0.75 for large fish by species.

iv) For each species in each year, catchability-corrected density-at-length was summed across all length groups by haul to produce individual haul estimates of species density ($kg.km^{-2}$) by ICES rectangle.

v) For each species in each year, the mean of haul density estimates was calculated for each ICES rectangle. This produced a mean annual estimate of species density (kg km^{-2}) by rectangle. For each rectangle, mean annual species density estimates (kg km^{-2}) were then multiplied by the sea area of given rectangles (km^2) to produce an estimate of total biomass by rectangle (kg). These biomass estimates were summed across all study rectangles for each year to produce estimates of total biomass (TSB) for each species in the study area.

vi) Shephard *et al.* (In press) use a stratified re-sampling approach to account for uncertainty in survey catch and this is strongly recommended. Due to time constraints, we do not include uncertainty in the current analysis for Celtic Sea skates.

18.8.1.2 Harvesting Rate HR

Catch data: Discard data for VIIa and VIIg came from an Irish observer programme that serves the Data Collection Regulation (EC No. 1639/2001). Fishing trips are sampled at a rate proportional to métier activity, with sampling coverage of the Irish fleet being approximately 1% during the study period. Sampling trips are selected randomly, and so the distribution of fishing activity sampled is considered representative of the population as a whole (Marine Institute, unpublished). Discard data were extracted by species, gear, quarter and year. If a sampled fishing trip included hauls outside study rectangles, then the proportion of the fishing effort inside the area was used. Discard weight was raised to Irish fleet level by dividing it by the proportion of total Irish effort covered by discard sampling. Discard records were raised by gear according to the proportion (range = 51–58% in the study period) of annual international effort by mobile gears (kilowatt hours = vessel engine power multiplied by time) in the study area recorded by Irish vessels (STECF, 2013). For years where effort for a given nation was not reported to STECF, the mean annual value for that nation was applied. Skate landings by nation for VIIa and VIIg were taken from the 2013 WGEF report (ICES, 2013b); data for each species was summed by year for each region.

HR calculation: For each species, annual (2011–2012) HR for the study area was then estimated, equal to:

$$HR_y = \frac{C_y}{C_y + B_y^{sur}}$$

where C_y is the total catch (landings and discards) and B_y^{sur} is the catchability-corrected survey-based estimate of total biomass.

18.8.1.3 Validation using catch curves

The survey method used here was validated previously by comparing output estimates of TSB and HR for cod and whiting in a standard area (ICES VIIg) with independent estimates from analytical (age-structured) assessments for 'Celtic Sea cod' and 'whiting in Divisions VIIe–k' (Shephard *et al.*, in press). Estimates of HR for cod and whiting compared closely between age-structured and survey-based assessments. For the current analysis, we compared our survey-based estimates of HR to HR-converted F derived from catch curves. Catch curves for each of the two survey areas were derived from length–frequency data from the IGFS, the NIGFS and the IGFS and NIGFS combined, and from the Irish discard observer programme in VIIa.

18.8.1.4 Precautionary reference levels

To gain some insight into the likely ecological significance of observed *HR* for non-target species, estimates for each species were compared to three sets of candidate reference levels: (i) from a meta-analysis of 245 fish species, Zhou *et al.* (2012) suggested that F_{MSY} could be estimated as 0.41 *M* for chondrichthyans, (M values for these chondrichthyans are provided in Table 18.5) (ii) for many of the demersal species in the Celtic Sea, Le Quesne and Jennings (2012) provided estimates of F_{40} (the *F* that reduces SSB-per-recruit to 40% of that in the absence of fishing). We used F_{40} estimates from Le Quesne and Jennings (2012, their Table S1) to derive a list of HR_{40} estimates. Finally, (iii) we used HR-converted F reference points for each species derived from the Gislasim method. For the current analysis, we average across these three reference points to derive a single precautionary HR reference point for each of the four case study species.

18.8.1.5 Survey-based biomass and HR

Biomass and HR varied among species and among survey series, with greater biomass for *R. montagui* and *R. clavata*. *Raja brachyura* recorded some larger values of HR, while *L. naevus* tended to have lowest biomass and consistently high HR (Table 18.6).

18.8.1.6 Catch curve HR

The quality of length–frequency data varied among surveys and species, with insufficient data for curve fitting in some cases. (Figures 18.43–18.44). Catch curve estimates of HR were similar to survey-based estimates for *R. clavata*, but consistently higher than survey estimates for the other three species. Catch curve estimates of HR were also more consistent among dataseries than for the survey method. As with survey estimates, the greatest HR values were recorded for *L. naevus* (Table 18.7).

18.8.1.7 Precautionary reference levels

The three approaches produced considerable differences in HR reference points (Table 18.7). Applying the mean HR reference point to survey-based HR estimates suggested that *R. montagui* and *R. clavata* may be exploited within sustainable limits, while *L. naevus* and *R. brachyura* are likely to be overexploited (Figure 18.45). HR estimates from catch curves were typically greater than survey-based estimates, but maintained the general suggestion that *R. montagui* and *R. clavata* stocks were in a better state for than *L. naevus* and *R. brachyura* (Figure 18.45).

18.8.1.8 Discussion

Shephard *et al.* (in press) presented a survey-based approach for assessment of surveyed but data-poor fish species, and a simplified version of this approach was used here to estimate biomass and HR for four skate species in the Celtic Seas. These exploratory analyses indicated that *R. montagui* and *R. clavata* stocks may be exploited close to precautionary limits, but that *L. naevus* and *R. brachyura* may be overexploited. These results are broadly consistent with survey trends that suggest recent recovery in abundance of *R. clavata* and *R. montagui* (ICES 2013b). With further development, survey-based assessments may be able to help set precautionary targets, as well as evaluating status.

However, members of WGEF noted some important elements that should be further developed in the survey-based assessment approach:

Catchability coefficients: An improved definition of catchability coefficients *q* for skates in the different survey gears should be considered. Fraser *et al.* (2007) offered a valid starting point, but expert knowledge can be applied to account for e.g. declining catch rates of larger individuals in beam trawl gear.

Natural mortality and seasonal fishing pressure: The current calculation of a survey-based HR given in Shephard *et al.* (In press) uses the following:

$$HR_y = \frac{C_y}{C_y + B_y^{sur}} \qquad 1$$

where C_y is the total catch (landings and discards) and B_y^{sur} is a survey-based estimate of total biomass. The denominator in equation 1 serves to "back-calculate" the biomass to the beginning of year *y*, accounting for mortality due to fishing. However, there are two problems with this: (a) natural mortality is ignored, which would positively bias HR_y, and (b) the total annual catch appears in the denominator instead of just that proportion taken prior to the survey, which would negatively bias HR_y.

If the survey is held late in the year (when most of the catch has taken place) the overall effect could be that HR_y is positively biased.

The following adjustments could address these problems:

$$HR_y = \frac{C_y}{\rho C_y e^{(\alpha+0.5\delta)M} + B_y^{sur} e^{\lambda M}} \qquad 2$$

where

$$\delta = \max\{\min(\lambda - \alpha ; \beta - \alpha) ; 0\} \qquad 3$$

and the additional parameters are as follows:

ρ the proportion of the catch taken prior to the start of the survey, which can, if appropriate, be calculated as:

$$\rho = \delta / (\beta - \alpha) \qquad 4$$

[note that if no catch is taken prior to the start of the survey and equation 4 is not used, ρ has to be set to zero];

- α the time the fishing season starts, expressed as a proportion of the year;
- β the time the fishing season ends, expressed as a proportion of the year;
- λ the time the survey starts, expressed as a proportion of the year; and
- M annual natural mortality.

Note that, typically, $\alpha = 0$ and, $\beta = 1$, so that equations 2 and 3 simplify to:

$$HR_y = \frac{C_y}{\rho C_y e^{0.5\lambda M} + B_y^{sur} e^{\lambda M}} \quad 5$$

and if in addition equation 4 is used (if appropriate), equation 5 reduces further to:

$$HR_y = \frac{C_y}{\lambda C_y e^{0.5\lambda M} + B_y^{sur} e^{\lambda M}} \quad 6$$

so that the only two additional parameters needed are λ and M compared to equation 1.

Spatial stratification of survey biomass estimates: Skates in the Celtic Seas show strong heterogeneity in their spatial distribution (Shephard *et al.*, 2012). Shephard *et al.* (In press) currently stratify survey data by ICES rectangle, but data-driven stratification would probably better capture distribution. For future work, WGEF suggest that survey haul stations could be allocated to categories of abundance based on historical catch. Biomass density (kg km^{-2}) can then be raised for these categories where the number of hauls in each category as a proportion of the total number of hauls in a given survey year is assumed to correspond to the proportion of the total survey area sampled by those hauls.

Catch curves: Shephard *et al.* (In press) validated their approach by comparing survey-based estimates of TSB and HR for cod and whiting with estimates from analytical (age-structured) stock assessments from the same area. In the current analysis, catch curves were used to produce an independent (the underlying data are the same, but the methods are independent) HR estimate for each Celtic Seas skate stock (Table 18.7). Catch curves are a widely accepted assessment method, but carry considerable assumptions. A key issue is subjectivity in selecting the range of length data to which to fit the curve. In theory, the curve should be fitted to the declining 'limb' of the length distribution (Figure 18.44), which is assumed to comprise length classes that are fully selected by the fishing gear, but identifying this 'limb' does not follow an objective rule.

Precautionary reference levels: Three alternative HR reference points were presented (Table 18.8). Each reference point was derived using a different method, and each makes assumptions about life history and how this constrains susceptibility to fishing pressure. Further work is required to identify and justify optimal HR reference points for each species. Reference points as calculated for each species by area and survey are presented in Table 18.9.

WGEF uses survey cpue time-series to describe trends in relative abundance of several skate species. Survey trends enable an evaluation of whether population state is likely to be declining, stable or improving relative to recent values. The new survey-based approach considered above has potential to provide a context for survey trends, by quantifying biomass and exploitation status with reference to MSY reference points. With further development of the method (see above), this would represent a significant step forward in the assessment of skate species.

18.8.2 Productivity-Susceptibility Analysis

A preliminary PSA of elasmobranchs in the Celtic Seas ecoregion was run in 2013 (McCully *et al.*, 2013). Results of vulnerability scores and rankings within both fisheries of the Celtic Seas demersal elasmobranch stock were presented at WGEF 2013. Post-plenary discussion within the group, refinements to the expert scores and the methodology for accounting for confidence will be advanced further before the results are analysed with a view to aiding future assessment and advice. However, in general, the demersal skates falling under the 'skates and rays' quota seemed to group at a more productive and more susceptible level than those demersal elasmobranchs such as *Dipturus-batis* complex, *Rostroraja alba, Squatina squatina* and *Squalus acanthias*, which all currently have a zero TAC/prohibited status.

There was agreement within WGEF that, given the large amount of potential applications and value of PSAs to the group, this should be developed collaboratively and importantly, in association with industry. Their involvement would be key, especially in discussions around potential regional management or technical measures.

18.8.3 Previous assessments

Preliminary assessments of the Celtic Sea stock of *L. naevus* were made during the DELASS project, using GLM analyses of commercial cpue and EVHOE survey data, a surplus production model and catch curve analysis. The results of these exploratory assessments did not give consistent results. *L. naevus* had demonstrated signs of an increase in number, followed by a decrease in the 1990s (Heessen, 2003). Longer term cpue data and a better knowledge of the stock are required.

A GAM analysis using Scottish Groundfish data for *R. clavata, L. naevus, R. montagui and S. canicula* in Divisions VIa, VIb and UK (English and Welsh) beam trawl survey for these species in VIIa/f was carried out by WGEF in 2007. More detailed information on the results and a description of the methods used were given in ICES (2007), with summary plots also included in ICES (2010).

18.9 Stock assessment

In the absence of formal stock assessments for the species and stocks in this ecoregion, the following provides a summary of the evaluation of stock trends, following the ICES approach to data-limited stocks. Most stocks were in category 3 of this approach.

18.9.1 Blonde ray *Raja brachyura* in Subarea VI

Raja brachyura has a patchy distribution in Subarea VI. It is not encountered in sufficient numbers in surveys to derive trends in abundance/biomass. The stock likely extends to the northwestern North Sea (IVc) and may also continue along the west coast of Ireland.

18.9.2 Blonde ray *Raja brachyura* in Divisions VIIa, f, g

Raja brachyura has a patchy distribution, and can be locally abundant in some parts of the Irish Sea and Bristol Channel, including off southeast Ireland. Mean catch rates in the Irish Sea and Bristol Channel (e.g. as observed in the UK beam trawl survey) are low and variable but are now at their highest level in the last decade of >1 ind/hr (Fig 18.33a). However, this survey does not cover the whole stock area.

If ICES is to provide more robust advice on the status of this stock, then either dedicated surveys or more intensive sampling of their main habitat in existing surveys should be considered.

18.9.3 Blonde ray *Raja brachyura* in Division VIIe

Raja brachyura has a patchy distribution in the western English Channel, and can be locally abundant on particular grounds, with the Channel Islands, Normano-Breton

Gulf and Lyme Bay serving as important sites (Figure 18.35 c). The length–frequency distribution showed a peak for juvenile fish (<25 cm LT), with no fish recorded between 24–31 cm LT and occasional records of larger specimens >70 cm LT.

Mean catch rates in a previous beam trawl survey in Great West Bay (Burt *et al.*, 2013) were low as they were caught in a relatively low proportion of tows (Figure 18.34). This may be due to *R. brachyura* favouring particular grounds, for example they are commonly encountered around sandbanks in the area.

If ICES is to provide more robust advice on the status of this stock, then either dedicated surveys or more intensive sampling of their main habitat in existing surveys should be considered.

18.9.4 Thornback ray *Raja clavata* in Subarea VI

The Irish Groundfish survey shows a steady increasing trend in catches of *R. clavata* in VIa (Figure 18.29a), with ~2 individuals per hour in 2013.

Earlier analyses of the Scottish surveys of VIa suggested stable/increasing catch trends (1985–2010; Figure 18.36b) although updated analyses were not available.

18.9.5 Thornback ray *Raja clavata* in Divisions VIIa, f, g

The French EVHOE survey indicated fluctuating catch rates at low levels in the Celtic Sea (Figure 18.28d). Nevertheless, it should also be noted that this survey tends to sample offshore grounds, whereas *R. clavata* is a more inshore species.

The UK (England and Wales) beam trawl survey in VIIa and VIIf catches reasonable numbers of *R. clavata* and they are observed regularly, although the gear used (4 m beam trawl with chain mat) may have a lower catchability for the larger individuals. This survey shows increasing catch rates in the last two years (Figure 18.33b).

The discontinued UK (England and Wales) westerly IBTS in the area caught large numbers of *R. clavata* in Liverpool Bay and the Bristol Channel, where groundgear 'A' is used, and provided samples of larger individuals (e.g. for maturity sampling). The UK (Northern Ireland) survey of the Irish Sea has also indicated low but stable catches, with the previous two years at the same level as the previous five, although this survey uses a rock-hopper trawl, and so the catchability may be low.

18.9.6 Thornback ray *Raja clavata* in Division VIIe

Analyses of data from a discontinued beam trawl survey in the western English Channel (particularly in the Great West Bay area) was provided in 2012 which suggest stable catch rates (Figure 18.34). A similar pattern of catches is seen in the current UK beam trawl survey of the western English Channel, with most *R. clavata* captured in Lyme Bay with fewer records elsewhere (Figure 18.35d). Length–frequency showed a peak in the captures of presumably 0-group fish ≤ 20 cm (Figure 18.35d).

18.9.7 Small-eyed ray *Raja microocellata* in the Bristol Channel (Division VIIf,g)

Although occasional specimens of *R. microocellata* are caught in VIIa, the main concentration of this species is in VIIf, with larger individuals occurring slightly further offshore (VIIg). The youngest size class is not often taken in surveys, as 0-group fish tend to occur in very shallow water.

The UK (England and Wales) beam trawl survey in the Bristol Channel has previously indicated stable catch rates, although the mean catches from the last two years is below the previous five year average, with the lowest catch rate in twenty years (~1 individual per hour) seen in 2013 (Figure 18.33c).

This species may also occur in some inshore areas of southern and southwestern Ireland, although data are limited for these areas.

18.9.8 Small-eyed ray *Raja microocellata* in the English Channel (Divisions VIId,e)

There are also localized concentrations of *R. microocellata* in the English Channel, including around the Channel Islands (Ellis *et al.*, 2011) and Baie of Dournanenz, Brittany (Rousset, 1990), with small numbers taken elsewhere.

Preliminary analyses of data from beam trawl surveys in the western English Channel (particularly in the Great West Bay area) were provided in 2012 (Figure 18.34). The low catch rates are probably related to the patchy distribution of the species in this area. Similarly, Silva *et al.* (2014 WD) identified only a few records of this species in the western English Channel beam trawl survey, with smaller size groups likely to occur in waters shallower than can be surveyed by the research vessel.

If ICES are to be able to provide more robust advice on the status of this stock, then either dedicated surveys or more intensive sampling of their main habitat in existing surveys should be considered.

18.9.9 Spotted ray *Raja montagui* in Subarea VI and VIIb,j

R. montagui is a widespread and small-bodied skate and is taken in reasonable numbers in a variety of surveys in the ecoregion.

Catches of *Raja montagui* in the Irish Groundfish survey in Via and VIIb,j are increasing with the mean catch rate of 2012–2013 at 1.85 individuals per hour, rising from 1.5 individuals per hour mean catch rate from 2007–2011 (Figure 18.29c).

Earlier analyses of the Scottish surveys of VIa suggested stable/increasing catch trends (Figure 18.36c), although updated analyses are not available.

18.9.10 Spotted ray *Raja montagui* in Divisions VIIa, e, f, g

The French EVHOE survey generally indicated stable catch rates at low levels in the Celtic Sea, with a slight increase in numbers seen in recent years (Figure 18.28c).

The UK (England and Wales) beam trawl survey in VIIa and VIIf catches reasonable numbers of *R. montagui* and they are observed very regularly, with mature individuals taken on the offshore stations on coarse grounds. This survey indicated a mean catch rate of 6.78 individuals per hour 2012–2013, the highest value of the time-series (Figure 18.33d).

Data from a now discontinued beam trawl survey in the western English Channel (particularly in the Great West Bay area) were provided in 2012 (Figure 18.34), which suggested that recent catches had increased in relation to the preceding five years, although catch rates were greater at the start of the time-series. A concurrent beam trawl survey of the western English Channel found this species was more commonly found in the English inshore coast strata from Lyme Bay to west of the Scilly Isles, with a peak in length for smaller individuals <22 cm L_T (Figure 18.35e).

Catches of *Raja montagui* in the Irish Groundfish survey in VIIafh are increasing with the mean catch rate of 2012–2013 at 1.89 individuals per hour, rising from 1.77 individuals per hour mean catch rate from 2007–2011 (Figure 18.29d).

18.9.11 Cuckoo ray *Leucoraja naevus* in Subarea VI and Divisions VIIa–c, e–j

L. naevus is a widespread and small-bodied skate that is taken in reasonable numbers in a variety of surveys in the ecoregion, especially on offshore grounds.

The stock structure of this species is insufficiently known, which makes the interpretation of catch rates in the various surveys more problematic. It is an offshore species that is also abundant in the Bay of Biscay (VIII) and northern North Sea (IVa), and the stock(s) may extend out of the Celtic Seas ecoregion.

The Spanish survey on the Porcupine Bank indicated recent decreases in catches (both in terms of biomass and abundance), with the 2013 level the lowest seen since the start of the time-series in 2001 (Figure 18.31 a,b).

The French EVHOE survey demonstrated peaks in relative abundance in 2001–2002 and 2007–2008, with the lowest catches in 2000. The relative abundance in the Celtic Sea/Biscay region has been stable in recent years, with catch rates similar to those seen in 2010 (Figure 18.28a).

The UK (England and Wales) beam trawl survey in VIIa catches low numbers of *L. naevus*, mostly on the offshore stations on coarse grounds. There is the indication of a decline from the start of the time-series, with the mean catch rates in the last two years (0.85 individuals per hour) lower than the average catches from the previous five years (Figure 18.33e).

The Irish Groundfish Survey mainly catches *L. naevus* in offshore areas. Trends in abundance are not very apparent, with fluctuating low annual catches. The mean catch rates in 2012–2013 were ~1 individual per hour in VIa (Figure 18.29e), and 0.46 individual per hour in VIIa,f–h (Figure 18.29f), there was a decrease in the catch rate for the latter area.

Earlier analyses of UK (Scotland) survey data for VIa suggested stable/increasing catch trends (Figure 18.36a), although more recent data were not available.

The different surveys demonstrated slightly different trends in relative abundance for this species, which further highlights the need to better understand the stock structure of this species. Whilst surveys indicated either stable or decreasing trends, no survey indicated increasing catch rates for this species in this area.

18.9.12 Sandy ray *Leucoraja circularis* in the Celtic Seas and adjacent areas

Leucoraja circularis is a large-bodied offshore species that may be distributed outside some of the areas surveyed during internationally coordinated surveys, and the distribution of what is assumed to be a Celtic Sea stock will extend into the northern North Sea (Division IVa) and parts of the Bay of Biscay (VIII).

Only the Spanish Porcupine Bank survey covers an important part of the habitat of *L. circularis* and catches this species in any quantity (Figure 18.30a). Peak catches were in 2003. Overall, the limited time-series showed low and variable catch rates, with a stable but increasing trend in recent years, with ~1.0 kg per haul noted in 2013 (Figure 18.30b).

This species is taken only infrequently in other surveys, such as the Evhoe survey (Figure 18.28e) with some nominal records considered unreliable.

18.9.13 Shagreen ray *L. fullonica* in the Celtic Seas and adjacent areas

Leucoraja fullonica is a large-bodied offshore species that may be distributed outside some of the areas surveyed during internationally coordinated surveys, and the distribution of what is assumed to be a Celtic Sea stock will extend into the northern North Sea (Division IVa) and parts of the Bay of Biscay (VIII).

Although the UK PHHT Q1 survey seemed to catch *L. fullonica* regularly, albeit in small numbers, this survey was discontinued. More recent surveys by Ireland and UK (England) (the latter now also discontinued) have only caught occasional specimens (see ICES, 2010), which may reflect insufficient sampling of the main habitat, and possibly a gear effect.

The EVHOE survey suggests an overall declining trend in the abundance and biomass over the time-series (Figure 18.28b), although this is driven by higher catch rates at the start of the time-series. Catch rates from the last two years appear on par with that of the previous five years, however the abundance estimate for 2012 showed a marked decrease from 2011.

18.9.14 Common skate *Dipturus batis*–complex (flapper skate *Dipturus batis cf. flossada* and blue skate *Dipturus cf. intermedia*) in Subarea VI and Divisions VIIa–c, e–j

Although common skate *D. batis* has long been considered depleted, on the basis of its loss from former habitat and historical decline (Brander, 1981; Rogers and Ellis, 2000), this species has recently been confirmed to comprise two species, and longer term data to determine the extents to which the two individual species have declined are lacking.

Although the nomenclature is still to be ratified, the smaller species (the form described as *D. flossada* by Iglesias *et al.*, 2010) will probably remain as *Dipturus batis* and the larger species will probably revert to *D. intermedia.*

Blue skate *Dipturus batis* (*D.* cf. *flossada*) is known to occur in parts of VIb (Rockall Bank), Celtic Sea (VIIe–k) and it likely extends into Subarea VIII. The northern limits to its distribution are unclear. Flapper skate *D.* cf. *intermedia* occurs in VIa, parts of VIb, and the northern North Sea (IVa). Smaller numbers are taken in the Celtic Sea (VIIe–k), although it's southerly and northerly limits are unknown. The bathymeric ranges of both species are poorly known, as is their western distribution ranges, although unspecified *D. batis* have been reported from the mid-Atlantic ridge. The two species overlap around the coast of Ireland.

Given that much of the data refer to the species-complex, both species are currently treated together until improved species-specific data are available. Overall, the common skate (*Dipturus batis*) complex is considered to be depleted in the Celtic Sea ecoregion.

Analyses of data from the Spanish Porcupine Bank Survey indicate low but stable catch rates of '*D. batis*' with an increased geographic distribution to the southeastern Bank (Figure 18.32a), with 15 individuals of *D. batis* found, and two specimens of *D. cf. intermedia* found in 2013 for the first time in the last three years surveys (Ruiz-Pico *et al.*, 2014 WD). There was an increase in biomass for *D. batis* to ~2kg per haul in 2013 (Figure 18.32b).

A previous examination of Scottish data (see ICES, 2010b; 2011) indicated some increase in the proportion of hauls in which *D. batis*-complex were observed (Figure 18.36d), although it should be recognized that catch rates were low and with wide confidence intervals. Updated analyses are required.

More detailed analyses of captures of '*D. batis*' from these and other surveys (e.g. the Irish western IBTS surveys are required). There are a few records from the UK western English Channel beam trawl survey, found from the western parts of the survey grid, including around the Scilly Isles (Figure 18.35a), with the observed length range representing immature fish (Silva *et al.*, 2014 WD).

18.9.15 Undulate ray *Raja undulata* in Division VIIb,j

There is thought to be a discrete stock of *R. undulata* in some of the bays of southwest Ireland, particularly Tralee Bay. Due to the shallow depth of these bays, existing surveys are unable to quantify the abundance or local distribution of this species.

It should also be noted that tagging information from 1051 individuals tagged (1972–2014; 50 recaptures) in this area (Wögerbauer *et al.*, 2014) indicate that this species largely remained resident in their original locations, leaving them at risk of localised depletion (Figure 18.37). A downward trend in numbers tagged suggests the population may be subject to overexploitation.

18.9.16 Undulate ray *Raja undulata* in Divisions VIId, e (English Channel)

There is thought to be a discrete stock of *R. undulata* in the English Channel (VIId,e), with the main part of the range extending from the Isle of Wight to the Normano-Breton Gulf. This stock is surveyed, in part, by two different beam trawl surveys: the Channel beam trawl survey (see Section 15) and the western English Channel (Eng-WEC_BTS-Q1), as well as the French Channel Groundfish survey (see Section 15). The distribution and length ranges of *R. undulata* caught in the western English Channel survey are provided in Figure 18.35f. Catch rates are generally low and variable, partly due to the patchy distribution of this species.

Since ICES (2013) commented "If ICES are to be able to provide more robust advice on the status of this stock, then either dedicated surveys or more intensive sampling of their main habitat in existing surveys should be considered" there has been a lot of dedicated surveys by French laboratories under the Raimouest project.

LeBlanc *et al.* (2014 WD) summarized the project so far, and show that *R. undulata* is the main skate species caught in the Norman-Breton Gulf and is highly dominant in coastal waters (Figures 18.38 and 18.39); although it occurs in almost all the English Channel its distribution appears to be concentrated in the central region of the English Channel (Figure 18.38). Tagging studies indicate high site fidelity (Stéphan *et al.*, 2014 WD; Figure 18.40). In the Normano-Breton Gulf, 1488 *R. undulata* were tagged (656 females (29–103 cm L_T) and 832 males (28–99 cm L_T), with a 5% (n=77) recapture rate. All the skates tagged in a region were recaptured in the same region, and distance travelled was short (<80 km). Given that the prohibited listing of the species deterred reporting of tags in some fisheries, the degree of exchange between the Normano-Breton Gulf and the south coast of England remains unclear. In the western English Channel 58.4% of the recaptured skates were taken at the release location (less than 5 km apart) and 75.3% in the western English Channel were recaptured less than 20 km from the release location. Complementary work will also be undertaken by the UK in 2014 on the English side of the Channel, which will assist in stock ID and to further our understanding of potential movements and exchange of this species in the English Channel.

Based on the decrease in the total skate landings from 2007–2008 to 2009–2010, the annual French landings of *R. undulata* were estimated as 300 t in the Western English Channel (VIIe) and as 160 t in the Normano-Breton Gulf. Furthermore, the estimated discards from the French fishing fleet in VIIe in 2013 was ~890 t (LeBlanc *et al.*, 2014 WD).

18.9.17 Other demersal elasmobranchs

Both long-nose skate *Dipturus oxyrinchus* and Norwegian skate *Dipturus nidarosiensis* also occur in the ecoregion, although the main habitats of these species are along the continental slope, at Rockall and around the Porcupine Bank (e.g. Fernández-Zapico *et al.*, 2013 WD), and so only a part of the distribution may be sampled in some of surveys conducted within the ecoregion. The abundance and biomass of *D. nidarosiensis* decreased down to around 1 kg per haul in the 2013 Porcupine Bank survey (Ruiz-Pico *et al.*, 2014 WD).

18.10 Quality of assessments

Commercial data are insufficient for a full stock assessment, although data are improving.

Several updated analyses of temporal changes in relative abundance in fishery-independent surveys were carried out between 2012 and 2014. These surveys provide the most comprehensive time-series of species-specific information. For example the French and Scottish IBTS surveys and the UK (England and Wales) beam trawl surveys have been undertaken for 10–20 years. Several other surveys now operate in the area, but over a shorter time frame. There is also a wide spatial coverage of most parts of the ecoregion with otter trawl and/or beam trawl. Hence, fishery-independent trawl data are considered the most appropriate data for evaluating the general status of the more common demersal elasmobranchs.

However, it must be stressed that not all skates and rays are well sampled by these surveys, and even the most common species (*R. montagui*, *R. clavata*, *L. naevus*) may only occur in about 30% of hauls. There is also uncertainty regarding the mean catch rates, due to the large confidence intervals.

There are several other issues that influence the evaluation of stock status:

1) The stock identity for many species is not accurately known (although there have been some tagging studies and genetic studies to inform on some species, and the stocks of species with patchy distributions can be inferred from the spatial distributions observed from surveys). For inshore, oviparous species, assessments by ICES division or adjacent divisions may be appropriate, although for species occurring offshore, including *L. naevus*, a better delineation of stock boundaries is required;

2) Age and growth studies have only been undertaken for the more common skate species, although IBTS and beam trawl surveys continue to collect maturity information. Other aspects of their biology, including reproductive output, egg-case hatching success, and natural mortality (including predation on egg-cases) are poorly known;

3) The identification of skate species is considered to be reliable for recent surveys, although there are suspected to be occasional misidentifications;

4) Although fishery-independent surveys are informative for commonly occurring species on the inner continental shelf, these surveys are not well suited for species with localized, coastal distributions (e.g. *R. undulata*, angel shark), patchy distributions (e.g. *R. brachyura*) or outer shelf distributions (e.g. *L. fullonica*).

18.11 Reference points

No reference points have been adopted. Methods for establishing precautionary reference points from using the catch-curve method described above (Section 18.8.1; Figure 18.45.

18.12 Conservation considerations

IUCN list "*Dipturus batis*" (NE Atlantic) as Critically Endangered, *Raja undulata* as listed as Endangered and *Leucoraja circularis* as Vulnerable.

Species listed by the IUCN as Near Threatened include *Dipturus oxyrinchus*, *Leucoraja fullonica*, *Raja brachyura*, *Raja clavata*, and *Raja microocellata*.

Leucoraja naevus, *Raja montagui* and *Rajella fyllae* are all listed as Least Concern (Gibson *et al.*, 2008).

18.13 Management considerations

A TAC was only introduced in 2009 for the main skate species in this region. Reported landings may be slightly lower than the TAC, but this can be influenced by issues such as quota allocation and, for 2013, the poor weather in the last two months of the year. Nevertheless, reported landings and TAC are now coming into alignment.

It has been difficult for WGEF to deal with some of the elasmobranchs in this region adequately. This is as a result of the long history of aggregated species landings, limited knowledge of the species composition of skates in commercial landings (including taxonomic confusion in some datasets), and a poor knowledge of stock structure.

Currently, fishery-independent trawl survey data provide the best time-series of species-specific information. Technical interactions for fisheries in this ecoregion are shown in Table 18.10.

Main commercial species

Thornback ray *Raja clavata* is one of the most important commercial species in the inshore fishing grounds of the Celtic Seas (e.g. eastern Irish Sea, Bristol Channel). It is thought to have been more abundant in the past, and more accurate longer term assessments of the status of this species are required. Preliminary analyses of recent survey data indicate that the relative abundance of this species in VIa and VIIa,f suggest it has been stable or increasing in recent years.

Cuckoo ray *Leucoraja naevus* is an important commercial species on offshore grounds in the Celtic Sea. Survey catch rates have decreased in some areas, but have shown more stability in other areas. Further studies to better define the stock structure are required to better interpret these contrasting abundance trends.

The relative abundance of spotted ray *Raja montagui* in this ecoregion appear to be increasing in recent years.

The main stock of small-eyed ray *Raja microocellata* occurs in the Bristol Channel, and catch rates have declined in the last two years.

The patchy distribution of blonde ray *Raja brachyura* means that existing surveys have low and variable catch rates. More detailed investigations of this species are required.

Other species

Council Regulations (EC) No 43/2009 of 16 January 2009 and (EU) No 23/2010 of 14 January 2010 banned the retention on board of three species of skate and this has been a controversial issue for some fisheries with regards *R. undulata* (in VIIe) and *D. batis (D. cf. flossada)* in some offshore areas.

Currently, interpretation of the prohibited species list may not allow commercial vessels to land fish for scientific purposes (including tagged fish), which has impacted on some recent scientific research programmes on these species.

Contemporary surveys occasionally record other skate species, although catch rates of these species are highly variable.

Historically, species such as *L. circularis, L. fullonica* and *D. oxyrinchus* may have been more widely distributed on the outer continental shelf seas. These species are now encountered only infrequently in some surveys on the continental shelf, though they are still present in deeper waters along the edge of the continental shelf. Hence studies to better examine the current status of these species in Subareas VI and VII should be undertaken. Future analyses should examine the long-term distribution and relative abundance of these species. In the first instance, data on the occurrences of these species should be collated from all surveys.

18.14 References

Bendall, V. A., Hetherington, S. J., Ellis, J. R., Smith, S. F., Ives, M. J., Gregson, J. and Riley, A. A. 2012. Spurdog, porbeagle and common skate bycatch and discard reduction. Fisheries Science Partnership 2011–2012, Final Report. 88 pp.

Brander, K. 1981. Disappearance of common skate *Raia batis* from the Irish Sea. Nature, 290: 48–49.

Burt G. J., Ellis J. R., Harley B. F. and Kupschus S. 2013. The FV Carhelmar beam trawl survey of the western English Channel (1989–2011): History of the survey, data availability and the distribution and relative abundance of fish and commercial shellfish. Science Series Technical Report, CEFAS Lowestoft, 151: 139 pp.

Chevolot, M., Ellis J. R., Hoarau, G., Rijnsdorp, A. D., Stamm W. T. and Olsenm J. L. 2006. Population structure of the thornback ray (*Raja clavata*) in British waters. Journal of Sea Research, 56: 305–316.

Coelho, R. and Erzini, K. 2002. Age and growth of the undulate ray, *Raja undulata*, in the Algarve (southern Portugal). Journal of the Marine Biological Association of the UK, 82: 987–990.

Davie, S. 2013. The Drivers and dynamics of fisher behaviour in Irish fisheries. PhD Thesis. Galway-Mayo Institute of Technology, Ireland.

Davie, S. 2014. Irish ray LPUE trends and spatial distributions. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF) 2014. 20 pp.

Davie, S., and Lordan, C. 2011. Definition, dynamics and stability of métiers in the Irish otter trawl fleet. Fisheries Research, 111: 145–158.

Dorel, D. 1986. Poissons de l'Atlantique nord-est relations taille-poids. Ifremer, Nantes. 165 pp.

Du Buit, M. H. 1976. Age et croissance de *Raja batis* et de *Raja naevus* en Mer Celtique. Journal du Conseil international pour l'Exploration del la Mer, 37: 261–265.

EC. 2009. Communication from the Commission to the European Parliament and the council on a European Community action plan for the conservation and management of sharks. Com. 2009 (40). 5th February 2009. 16 pp.

Ellis, J. R., McCully, S. R. and Poisson, F. 2014. A global review of elasmobranch discard survival studies and implications in relation to the EU 'discard ban'. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF), Lisbon, Portugal, 17–26 June 2014.

Ellis, J. R., Bendall, V. J. and McCully, S. R. 2012. Notes on common skate (*Dipturus batis*-complex) in the Celtic Sea. Working Document presented to the Working Group on Elasmobranch Fishes, 13 pp.

Ellis, J. R., Burt, G. J., Cox, L. P. N., Kulka, D. W. and Payne, A. I. L. 2008. The status and management of thornback ray *Raja clavata* in the southwestern North Sea. ICES CM 2008/K:13, 45 pp.

Ellis, J. R., Dulvy, N. K., Jennings, S., Parker-Humphreys, M. and Rogers, S. I. 2005. Assessing the status of demersal elasmobranchs in UK waters: A review. Journal of the Marine Biological Association of the United Kingdom, 85: 1025–1047.

Ellis, J. R., McCully, S. R. and Brown, M. J. 2012b. An overview of the biology and status of undulate ray *Raja undulata*. Journal of Fish Biology, 80: 1057–1074.

Ellis, J. R., Morel, G., Burt, G. and Bossy, S. 2011. Preliminary observations on the life history and movements of skates (Rajidae) around the Island of Jersey, western English Channel. Journal of the Marine Biological Association of the UK, 91: 1185–1192.

Ellis, J. R., Silva, J. F., McCully, S. R., Evans, M. and Catchpole, T. 2010. UK fisheries for skates (Rajidae): History and development of the fishery, recent management actions and survivorship of discards. ICES CM 2010/E:10, 38 pp.

Enever, R., Catchpole, T. L., Ellis, J. R. and Grant, A. 2009. The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters. Fisheries Research, 97: 72–76.

Fahy, E. 1989. Growth parameters of rays (Batoidei) in Irish waters, from material examined in commercial catches. ICES CM 1989/G:59, 11 pp.

Fernández-Zapico, O., Velasco, F., Baldó, F., Rodríguez-Cabello, C. and Ruiz-Pico, S. 2013. Results on main elasmobranch species captured during the 2001–2012 Porcupine Bank (NE Atlantic) bottom trawl surveys. Working Document presented to the Working Group on Elasmobranch Fishes, 26 pp.

Fraser, H. M., Greenstreet, S. P., and Piet, G. J. 2007. Taking account of catchability in groundfish survey trawls: implications for estimating demersal fish biomass. ICES Journal of Marine Science, 64: 1800–1819.

Gallagher, M. J. 2000. The fisheries biology of commercial ray species from two geographically distinct regions. PhD. Thesis. Trinity College, University of Dublin. 240 pp.

Gallagher, M. J., Nolan, C. P. and Jeal, F. 2005. Age, growth and maturity of the commercial ray species from the Irish Sea. Journal of Northwest Atlantic Fishery Science, 35: 47–66.

Gerritsen, H. and Lordan, C. 2011. Integrating vessel monitoring systems (VMS) data with daily catch data from logbooks to explore the spatial distribution of catch and effort at high resolution. ICES J. Mar. Sci. 68, 245–252.

Gibson, C., Valenti, S.V., Fordham, S.V. and Fowler, S.L. 2008. The Conservation of Northeast Atlantic Chondrichthyans: Report of the IUCN Shark Specialist Group Northeast Atlantic Red List Workshop. viii + 76 pp.

Heessen, H. J. L. (Ed). 2003. Development of Elasmobranch Assessments – DELASS: DG Fish Study Contract 99/055.

ICES. 2003. Report of the Study Group on the Development of Fishery-based Forecasts. Boulogne, France. ICES CM 2003/ACFM:08. 37pp.

ICES. 2004. Report of the Working Group on Elasmobranch Fishes. ICES CM 2004/G:11.

ICES. 2007. Report of the Working Group on Elasmobranch Fisheries (WGEF). Galway, Ireland.

ICES. 2010. Report of the Working Group on Elasmobranch Fishes (WGEF), 22–29 June 2010, Horta, Portugal. ICES CM 2010/ACOM:19. 558 pp.

ICES. 2011. Report of the Working Group on Elasmobranch Fishes (WGEF), 20–24 June 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:19. 492 pp.

ICES. 2012. Report of the Working Group on Elasmobranch Fishes (WGEF), 19–26 June 2012, Lisbon, Portugal. ICES CM 2012/ACOM:19. 547 pp.

ICES. 2013a. Report of the International Bottom Trawl Survey Working Group (IBTSWG), 8–12 April 2013, Lisbon, Portugal. ICES CM 2013/SSGESST:10. 272 pp.

ICES. 2013b. Report of the Working Group on Elasmobranch Fishes (WGEF), 17–21 June 2013, Lisbon, Portugal. ICES CM 2013/ACOM:19. 649 pp.

Iglesias, S. P., Toulhaut, L. and Sellos, D. Y. 2010. Taxonomic confusion and market mislabelling of threatened skates: important consequences for their conservation status. Aquatic Conservation: Marine and Freshwater Ecosystems, 20: 319–333.

Johnston, G. and Clarke, M. 2011. A comparison of the length frequencies of two ray species in the Irish sea, 2008–2010, with the length frequencies measured in 1997. Working Document to WGEF 2011, 4 pp.

Johnston, G., Tetard, A., Santos, A.R., Kelly, E and Clarke, M. 2014. Spawning and nursery areas of selected rays and skate species in the Celtic Seas. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF 2014) 7 pp.

Leblanc, N., Tetard, A., Legrand, V., Stephan, E. and Hegron-Mace., L. 2014. RAIMOUEST: the French fishery of rays in the Western English Channel (VIIe), 2014 update. Working Document to the ICES Working Group on Elasmobranch Fishes (WGEF 2014) 29 pp.

Le Quesne, W. J., and Jennings, S. 2012. Predicting species vulnerability with minimal data to support rapid risk assessment of fishing impacts on biodiversity. Journal of Applied Ecology, 49: 20–28.

Mahé, J. C. and Poulard, J.C. 2005. Spatial distribution and abundance trends of main elasmobranch species in the Bay of Biscay and the Celtic Sea from bottom-trawl surveys. ICES CM 2005/N:04, 27 pp.

McCully, S. R., Scott, F. and Ellis, J. R. 2012. Lengths at maturity and conversion factors for skates (Rajidae) around the British Isles, with an analysis of data in the literature. ICES Journal of Marine Science, 69: 1812–1822.

McCully, S.R., Scott, F., Ellis, J.R., Pilling, G.J. 2013. Productivity Sensitivity Analysis: Application and suitability for data poor assessment of elasmobranchs in northern European Seas. Collect. Vol. Sci. Pap. ICCAT, 69(4): 1679–1698.

NIEA. 2008. Position statement on sharks, skates and rays in Northern Ireland waters. Report No. BDU 2/66, 198 pp.

Parker-Humphreys, M. 2004a. Distribution and relative abundance of demersal fishes from beam trawl surveys in the Irish Sea (ICES Division VIIa) 1993–2001. Science Series Technical Report, Cefas, Lowestoft, 120, 68 pp.

Parker-Humphreys, M. 2004b. Distribution and relative abundance of demersal fishes from beam trawl surveys in the Bristol Channel (ICES Division VIIf) 1993–2001. Science Series Technical Report, Cefas, Lowestoft, 123, 69 pp.

Pawson, M., Nichols, V. 1994. Recapture patterns of rays tagged in the Bristol Channel and Irish Sea. In Proceedings of the Second European Shark and Ray Workshop. Tag and Release

Schemes and Shark and Ray Management Plans, 15–16 February 1994 (Fowler, S.T. and Earll, R.C., Eds.), pp. 10–13.

Rogers, S. and Ellis, J. R. 2000. Changes in the demersal fish assemblages of British coastal waters during the 20th century. ICES Journal of Marine Science, 57: 866–881.

Rousset, J. 1990. Catches and geographical distribution of selachians on the western coast of Brittany. Journal of the Marine Biological Association of the United Kingdom, 70: 255–260.

Ruiz-Pico, S., Velasco, F., Baldó, F., Rodríguez-Cabello, C., and Fernández-Zapico, O. 2014. Results on main elasmobranch species captured during the 2001–2013 Porcupine Bank (NE Atlantic) bottom trawl surveys. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 26 pp.

Ryland, J. S., and Ajayi, T. O. 1984. Growth and population dynamics of three *Raja* species in Carmarthen Bay, British Isles. Journal du Conseil International pour l'Exploration de la Mer, 41: 111–120.

Shephard, S., Gerritsen, H. D., Kaiser, M. J., and Reid, D. G. 2012. Spatial heterogeneity in fishing creates *de facto* refugia for endangered Celtic Sea elasmobranchs. PLOS ONE. doi:10.1371/journal.pone.0049307.

Shephard, S., Johnston, G and Clarke, M. 2014. Estimation of mortality in rays and skates in the Celtic Seas, including a proposal on target F. Working Document to the ICES Working Group on Elasmobranch Fishes, 17–26th June 2014, Lisbon, Portugal. 5 pp.

Silva, J.F., Ellis, J.R. and Catchpole, T.L. 2012. Species composition of skates (Rajidae) in commercial fisheries around the British Isles, and their discarding patterns. Journal of Fish Biology, 80: 1678–1703.

Silva, J. F., McCully, S. R., Ellis, J. R. and Kupschus, S. 2014. Demersal elasmobranchs in the western English Channel (ICES Division VIIe). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 28 pp.

Stéphan E., Hennache, C., Delamare, A., Legrand, V. and Leblanc, N. 2013. The French RECOAM project: study of the biology and ecology of five skate (Rajidae) species present in the coastal waters of the western English Channel and central Bay of Biscay. Working Document presented to the Working Group on Elasmobranch Fishes, 8 pp.

Wearmouth, V. J. and Sims, D.W. 2009. Movement and behaviour patterns of the critically endangered common skate *Dipturus batis* revealed by electronic tagging. Journal of Experimental Marine Biology and Ecology, 380: 77–87.

Whitehead, P. J. P., Bauchot, M. L., Hureau, J. C., Nielsen, J., and Tortonese, E. 1984. Fishes of the north-eastern Atlantic and the Mediterranean.

Wögerbauer C., O'Reilly S., Green P. and Roche W. 2014. IFI Marine Sportfish Tagging Programme: Preliminary results for selected species, Inland Fisheries Ireland. Report No: IFI/2014/1-4231; 38 pp.

Zhou, S., Yin, S., Thorson, J. T., Smith, A. D., and Fuller, M. 2012. Linking fishing mortality reference points to life history traits: an empirical study. Canadian Journal of Fisheries and Aquatic Sciences, 69: 1292–1301.

Table 18.1. Skates and rays in the Celtic Seas. Preliminary identification of the occurrence of the various species in the ecoregion by ICES division (Eastern English Channel (VIId) also included). Symbols: ● = Present, ○ = absent; ⦿ = occasional vagrants reported from the area, or distribution might extend to this division; ⊗ = no recent records but occurred in the past;? = uncertain). Adapted from Whitehead *et al.* (1984); Ellis *et al.* (2005); ICES (2007; Table 1.4) and FishBase.

Scientific name	VIa	VIb	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
Skates (Rajidae) occurring on the continental shelf and upper slope												
"Dipturus batis"-complex	●	●	●	●	●	⦿	●	●	●	●	●	●
D. batis (cf. flossada)	⦿	●	●	●	●	⊗	●	⦿	●	●	●	●
D. cf.intermedia	●	⦿	⦿	⦿	?	?	?	?	⦿	⦿	⦿	⦿
D. oxyrinchus	●	●	○	●	●	○	○	○	⦿	●	●	●
D. nidarosiensis	●	●	○	●	●	○	○	○	○	○	●	●
Leucoraja circularis	●	●	○	●	●	○	○	○	⦿	●	●	●
L. fullonica	●	●	⦿	●	●	○	⦿	⦿	●	●	●	●
L.naevus	●	●	●	●	●	⦿	●	●	●	●	●	●
Raja brachyura	●	⦿	●	●	⦿	●	●	●	●	●	●	○
R. clavata	●	●	●	●	●	●	●	●	●	●	●	⦿
R. microocellata	⦿	○	⦿	●	○	●	●	●	●	⦿	●	○
R. montagui	●	●	●	●	⦿	●	●	●	●	●	●	⦿
R. undulata	○	○	⦿	●	○	●	●	⦿	⦿	⦿	●	○
Rajella fyllae	●	●	○	●	●	○	○	○	○	●	●	●
Rostroraja alba	○	○	⊗	●	?	⊗	⊗	?	?	?	?	○
Demersal rays (Torpediniformes and Myliobatiformes) occurring on the continental shelf												
Torpedo marmorata	?	?	?	?	○	⦿	●	⦿	⦿	●	?	?
Torpedo nobiliana	⦿	⦿	⦿	⦿	⦿	⦿	⦿	⦿	⦿	⦿	⦿	⦿
Dasyatis pastinaca	⦿	⦿	⦿	⦿	○	●	●	⦿	⦿	●	⦿	○
Myliobatis aquila	⦿	?	⦿	⦿	○	⦿	⦿	⦿	⦿	⦿	⦿	○
	VIa	VIb	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk

Table 18.2. Skates and rays in the Celtic Seas. Total landings of skates (Rajidae) in the Celtic Seas ecoregion (VIa).

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Belgium	13	10	3	4	.	.	.	2	1	2	.	.	2	1	3	2	3	.	2	.
Denmark	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	+	+
Faeroe Islands	107	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
France	736	907	777	918	653	839	730	583	2318	741	885	955	996	645	727	766	724	711	621	603
Germany	.	1	.	.	1	2	1	.	.	.	.	.	1	.	.	.	.	.	.	.
Ireland	281	336	458	425	342	242	268	343	474	537	806	836	574	440	367	690	630	150	200	350
Netherlands	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Norway	116	105	70	77	96	226	81	253	119	146	217	99	67	44	93	144	264	71	38	82
Poland	64	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Spain	.	.	.	.	.	.	.	.	.	19	11	8	4	12	14	8	.	.	43	.
UK - (E,W&N.I.)	264	266	264	334	338	292	209	89	93	99	104	141	47	47	54	87	67	57	77	72
UK – Scotland	1302	1142	1393	1792	1724	1660	1540	1577	1496	1617	1818	2016	2034	1802	2111	2137	2499	2007	2026	1605
Total	2883	2767	2965	3551	3154	3261	2829	2847	4501	3161	3841	4055	3726	2991	3370	3834	4187	2996	3007	2712

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	1	2	7	1	2	2	4	2	4	2	8	9	4	4	0	.		0	0	0	0
Denmark	+	+	+	+	.	+	+	.	.	.	.	.	0		.	.	.	0	0	0	
Faeroe Islands	.	.	.	.	.	.	.	.	.	.	.	.		.	.	0	.				
France	606	437	553	526	384	333	NA	321	278	212	183	149	181	174	194	245	97	65	50	97	85
Germany	.	2	.	1	4	16	7	1	1	.	3	0	.	0	.	.	.	.	0		
Ireland	331	265	504	681	596	488	388	274	238	311	364	363	186	176	119	109	81	111	88	103	94
Netherlands	.	.	.	.	.	.	.	.	.	.	.	.	.	0				0		0	0
Norway	56	9	74	29	20	50	29	49	20	25	2	2	10	4	5	11	4	11	6	2	5
Poland	.	.	.	.	.	.	.	.	.	.	.	.	.	0							
Spain	.	.	.	47	58	69	34	2	.	9	27	14	14	0	0	4				8	
Spain (Basque Country)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	0	1		
UK - (E,W&N.I.)	70	101	138	101	69	157	67	108	65	114	159	66	26	18	5	1	4	1	1	0	1

UK – Scotland	1419	1429	1980	2606	1879	1460	1324	1316	1263	1136	1307	1012	623	369	426	297	240	224	194	206	185
Total	2483	2245	3256	3992	3012	2575	1853	2073	1869	1809	2053	1615	1043	744	750	667	427	412	341	416	371

Table 18.2. (Continued). Skates and rays in the Celtic Seas. Total landings of skates (Rajidae) in the Celtic Seas ecoregion (VIb).

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Estonia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Faeroe Islands	2	95	43	43	24	15	61	44	.	23	22	18	2	6	.	.	.	.	.	.
France	125	423	39	44	10	20	1	0	4	8	10	6	6	4	1	2	0	3	13	0
Germany	.	.	.	.	.	.	.	.	.	.	.	.	.	.		1	1	.	.	.
Ireland	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Norway	.	22	123	45	60	145	217	222	117	147	332	364	164	231	200	132	279	203	248	234
Portugal	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Russian Federation	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Spain	.	.	.	.	.	.	.	.	63	.	.	12	8	48	41	36	.	.	14	.
UK - (E,W&N.I.)	11	.	.	39	62	36	56	.	4	.	8	4	18	15	12	7	4	4	11	12
UK – Scotland	562	166	307	77	160	189	152	181	152	44	9	15	58	38	59	72	70	76	67	57
Total	700	706	512	248	316	405	487	447	340	222	381	419	256	342	313	250	354	286	353	303

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Estonia	.	.	.	.	.	.	.	.	56	1	.	.	.	.	.	.	.				
Faeroe Islands	.	.	.	.	.	.	.	.	.	.	.	na	na	.	.	3					
France	4	0	0	0	0	0	0	7	5	5	2	6	15	0	17	17	12	0	0	6	2
Germany	6	25	17	49	26	36	67	76	8	1	6	22	22	6	0	.	.	3	2		
Ireland	24	23	60	68	23	15	28	20	10	1	18	7	9	24	14	15	4	3	10	8	12
Norway	170	272	176	95	101	98	59	120	80	44	61	46	39	82	81	66	91	120	56	89	93
Portugal	.	.	56	.	25	26	24	29	17	31	18	na	0	0							
Russian Federation	.	.	.	.	.	.	.	5	8	.	.	na	na								
Spain	.	.	.	328	410	483	322	347	158	36	46	1	0	0	0	0				4	
UK - (E,W&N.I.)	21	28	73	175	105	134	147	156	120	92	47	48	20	20	9	0	0	0	0	0	1
UK – Scotland	70	98	97	83	91	101	123	204	97	79	146	164	59	51	30	26	35	33	34	18	41
Total	295	446	479	798	781	893	770	964	559	290	344	294	164	183	151	127	143	159	102	125	149

Table 18.2. (Continued). Skates and rays in the Celtic Seas. Total landings of skates (Rajidae) in the Celtic Seas ecoregion (VIIa).

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Belgium	296	365	278	195	236	212	177	151	206	230	233	246	372	425	545	390	271	298	209	230
France	1516	426	337	491	827	967	560	593	1985	617	440	788	1194	1578	1318	1009	641	712	890	642
Ireland	822	916	838	936	858	796	813	725	851	803	781	1067	1946	1416	1644	1911	1808	1811	1400	1301
Netherlands	1	1	3	1	1	.	1	+	+	+	+	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Norway	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Spain																				
UK - (E,W&N.I.)	1564	1533	1430	1163	1130	906	1045	1202	1113	1307	1133	1126	1103	976	1503	1435	1373	1378	1226	1150
UK (Scotland)	62	69	53	39	47	52	58	132	82	89	87	192	219	224	321	210	171	227	163	107
Total	4265	3310	2939	2825	3099	2933	2654	2803	4237	3046	2674	3419	4834	4619	5331	4955	4264	4426	3888	3430

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	107	224	218	265	298	398	542	504	724	997	830	860	860	593	680	295	250	274	471	430	370
France	550	330	293	282	151	285	NA	163	343	349	322	183	192	114	51	14	7	9	16	5	6
Ireland	679	514	438	438	593	692	827	759	807	1032	1086	825	786	645	721	515	370	557	500	496	411
Netherlands	n.a.	n.a.	n.a.	n.a.	n.a.	4	4	6	+	+	+	+	.	0	.	.			0	0	0
Norway	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	0	0	0	0	0
Spain																4					
UK - (E,W&N.I.)	1003	748	606	789	824	1009	936	671	983	863	1184	533	1252	271	260	243	214	190	172	226	213
UK (Scotland)	96	86	42	55	80	52	33	86	80	68	67	38	30	65	13	1	2	9	1	2	3
Total	2435	1902	1597	1829	1946	2440	2342	2189	2937	3309	3489	2439	3120	1689	1724	1071	844	1038	1161	1160	1003

Table 18.2. (Continued). Skates and rays in the Celtic Seas. Total landings of skates (Rajidae) in the Celtic Seas ecoregion (VIIf).

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Belgium	182	273	280	184	106	75	127	189	167	130	139	98	177	209	129	172	268	135	155	128
Denmark	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
France	.	242	426	569	720	680	873	896	856	837	648	377	306	330	247	464	366	326	607	663
Germany	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ireland	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Netherlands	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Norway	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poland	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Spain (b)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
UK - (E,W&N.I.)	504	401	468	437	452	436	444	494	508	529	480	558	648	697	784	761	710	666	627	705
UK (Scotland)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Total	686	916	1174	1190	1278	1191	1444	1579	1531	1496	1267	1033	1131	1236	1160	1397	1344	1127	1389	1497

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	96	117	108	89	116	121	103	90	91	117	134	210	208	138	206	184	193	143	175	185	149
Denmark	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			0	0	
France	565	468	394	432	485	464	453	538	642	526	536	478	429	305	424	399	365.6	517	297	325	304
Germany	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.	.	.	0		
Ireland	.	.	.	.	.	1	.	.	.	1	1	15	8	6	2	4	3	2	1	1	1
Netherlands	.	.	.	.	.	.	.	.	.	.	.	.	.	0				0	0	0	0
Norway	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0			0	0	
Poland	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0		
Spain (b)	.	.	.	8	10	12	1	.	3	.	.	.	.	0	0	0				0	
UK - (E,W&N.I.)	638	630	589	676	664	624	560	613	691	920	766	609	631	653	620	639	546	680	682	708	598
UK (Scotland)	.	.	.	.	.	.	.	.	.	.	.	.	.			0		0	0	0	0
Total	1299	1215	1091	1205	1275	1222	1117	1241	1427	1564	1437	1312	1276	1101	1252	1226	1107	1342	1155	1219	1052

Table 18.2. (Continued). Skates and rays in the Celtic Seas. Total landings of skates (Rajidae) in the Celtic Seas ecoregion (VIIegh).

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Belgium	259	238	209	529	308	208	206	254	318	271	182	215	211	311	224	227	355	242	97	183
Denmark	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	.	1
France	5729	4095	6901	6602	6189	6095	6519	6796	7647	6765	7323	6561	6890	7771	7693	7986	7566	7734	7077	6477
Germany	18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ireland	147	158	148	241	158	143	218	399	380	291	236	303	286	251	296	315	57	100	68	.
Netherlands	.	.	1	7	13	6	.	.	.	.	2	na	na	na	na	na	na	na	na	na
Norway	.	.	.	.	.	.	.	.	.	.	12	.	.	25	.	.	12	5	.	.
Poland	24	28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Spain (b)	.	.	.	.	.	45	0	0	77	30	29	24	2	62	75	49	.	.	21	
UK - (E,W&N.I.)	432	466	572	556	566	615	564	528	606	637	700	832	936	939	1061	1307	865	1211	638	751
UK (Scotland)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Total	6609	4985	7831	7935	7234	7112	7507	7977	9028	7994	8484	7935	8325	9359	9349	9885	8857	9293	7901	7412

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	209	172	203	177	293	260	240	223	248	347	576	407	432	582	569	636	506	479	533	589	494
Denmark	+	0	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0		
France	5873	5836	6029	6425	7093	6114	6098	5710	5603	5273	5588	4261	4517	3740	3741	3302	3719	3428	3193	2894	2693
Germany	.	.	.	.	.	.	.	.	.	+	.	3	.		.	.	.	0	0		
Ireland	120	106	162	349	479	446	408	203	481	729	838	844	334	315	285	214	198	174	316	315	221
Netherlands	na	na	na	na	na	9	na	7	7	11	.	.	.	1	.	.	1	2	1	1	2
Norway	.	.	.	.	.	.	.	.	11	.	.	.	.	0	0	0			0	0	
Poland	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			0		
Spain (b)	.	.	.	312	932	1178	2647	1706	1142	653	31	15	9	1	1	3	.			109	
Spain (Basque Country)																	7	2	8		
UK - (E,W&N.I.)	735	869	997	953	1098	1167	796	932	880	775	804	811	1024	727	730	667	650	865	771	667	753
UK (Scotland)	1	.	.	.	2	.	2	.	2	.	.	149	3	1		3	3	7	7	3	1
Total	6938	6983	7391	8216	9897	9173	10191	8781	8374	7788	7837	6490	6318	5366	5326	4826	5082	4957	4830	4576	4164

Table 18.2. (Continued). Skates and rays in the Celtic Seas. Total landings of skates (Rajidae) in the Celtic Seas ecoregion (VIIbcjk).

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	907	725	292	480	239	219	188	340	1120	203	169	198	344	346	456	462	427	781	541	546
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	266	321	314	320	265	268	239	269	336	271	325	296	220	226	419	332	633	350	400	619
Netherlands																				0
Norway																			0	0
Spain (b)	0	0	0	0	0	3	0	0	47	33	24	31	1	53	64	41	0	0	124	0
UK - (E,W&N.I.)	1	+	+	0	+	0	0	+	0	+	0	4	1	3	27	28	25	5	53	71
UK (Scotland)	0	0	0	0	0	1		1	0	0	0	1	+	1	+	1	13	14	15	10
Total	1174	1046	606	800	504	491	427	610	1503	507	518	530	566	629	966	864	1098	1150	1133	1246

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	0	0	0	0	0	0	24	5	0	5	1	na	0	0	0	.		0	0	0	0
France	298	224	297	375	599	500	NA	568	362	272	192	101	257	255	391	421	262	249	139	166	185
Germany	7	18	3	4	9	17	10	21	7	+	3	15	17	0				0	1	1	
Ireland	602	625	735	757	811	741	740	653	383	354	435	511	465	473	417	384	362	285	217	246	228
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Norway	0	0	0	0	0	0	0	0	0	0	0	0	0	15	4	0			0	6	
Spain (b)	0	0	0	1341	1676	1978	2419	2573	1205	2939	1281	7	16	19	11	1		0	0	184	
UK - (E,W&N.I.)	88	201	361	469	468	376	352	597	545	373	350	364	269	176	172	83	90	94	99	72	83
UK (Scotland)	34	43	73	58	36	67	121	189	162	124	226	70	58	77	0	66	39	60	54	63	22
Total	1029	1111	1469	3004	3599	3679	3666	4606	2664	4067	2488	1068	1081	1016	995	954	753	687	510	738	518

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Spain																643	693	605	494	2	251
Spain (Basque Country)																	0.8	0.0			
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	643	693	605	494	2	251

Table 18.2. (Continued). Skates and rays in the Celtic Seas. Total landings of skates (Rajidae) in the Celtic Seas ecoregion (total landings).

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Belgium	750	886	770	912	650	495	510	596	692	633	554	559	762	946	901	791	897	675	463	541
Denmark	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	1	.	2
Estonia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Faeroe Islands	109	95	43	43	24	15	61	44	.	23	22	18	3	6	.	.	.	.	.	.
France	9013	6818	8772	9104	8638	8820	8871	9208	13930	9171	9475	8885	9736	10674	10442	10689	9724	10267	9749	8931
Germany	18	1	.	.	1	2	1	.	.	.	.	.	1	.	.	1	1	0	0	0
Ireland	1516	1731	1758	1922	1623	1449	1538	1736	2041	1902	2148	2502	3026	2333	2726	3248	3128	2411	2068	2270
Netherlands	1	1	4	9	14	6	1	+	+	+	2	na	na	na	na	na	na	na	na	na
Norway	120	127	193	122	156	371	298	475	236	293	561	463	231	300	293	276	555	279	286	316
Poland	88	28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Portugal	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Russian Federation	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Spain	.	.	.	.	.	48	0	0	187	82	64	75	15	175	194	134	0	0	202	0
UK - (E,W&N.I.)	2776	2666	2734	2529	2548	2285	2318	2313	2324	2572	2425	2665	2753	2677	3441	3625	3044	3321	2632	2761
UK – Scotland	1926	1377	1753	1908	1931	1902	1750	1891	1730	1750	1914	2224	2311	2065	2491	2420	2753	2324	2271	1779
Total	16317	13730	16027	16549	15585	15393	15348	16263	21140	16426	17165	17391	18838	19176	20489	21185	20104	19278	17671	16600

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	413	515	536	532	709	781	913	824	1067	1467	1549	1485	1503	1316	1455	1115	949	896	1179	1204	1013
Denmark	+	.	+	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.
Estonia	.	.	.	.	.	.	.	.	56	1	.	.	.	.	.	.	.	0	0	0	0
Faeroe Islands	.	.	.	.	.	.	.	.	.	.	.	.	na	.	.	4	.	.	.	.	.
France	7896	7295	7566	8040	8712	7696	6551	7307	7233	6637	6823	5178	5591	4587	4818	4398	4463	4267	3695	3493	3275
Germany	13	45	20	54	39	69	84	98	16	2	12	40	39	7	.	.	.	4	3	1	0
Ireland	1756	1533	1898	2294	2502	2382	2390	1909	1919	2428	2742	2565	1787	1640	1557.940	1240.360	1018	1132	1133	1169	966
Netherlands	na	na	na	na	na	13	4	13	7	11	na	na	0	1	.	.	1	2	1	1	2
Norway	226	281	250	124	121	148	88	169	111	69	63	48	49	101	90	77	95	131	62	97	98
Poland	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Portugal	.	.	56	.	25	26	24	29	17	31	18	na	0	.	.	.	.	.	.	.	.
Russian Federation	.	.	.	.	.	.	.	5	8	.	.	na	na	.	.	.	.	.	.	.	.
Spain	0	0	0	2036	3086	3720	5423	4628	2508	3637	1385	37	39	20	12	655	700	608	503	307	251
UK - (E,W&N.I.)	2555	2577	2764	3163	3228	3467	2858	3077	3283	3137	3310	2431	3222	1865	1796	1633	1504	1830	1725	1674	1650
UK – Scotland	1620	1656	2192	2802	2088	1680	1603	1795	1604	1407	1746	1433	773	562	469	393	319	332	290	292	252
Total	14479	13902	15282	19044	20510	19981	19938	19854	17830	18828	17648	13217	13004	10099	10198	9514	9047	9201	8591	8237	7507

Table 18.3. Skates and rays in the Celtic Seas. Species composition of skates (Rajidae), as reported in national landing statistics. Note: Belgian records of 'sandy ray' are assumed to refer to small-eyed ray; Scottish records of *Rostroraja alba* may refer to *L. fullonica*.

		FRANCE			IRELAND			SPAIN		SCOTLAND			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
VIa	*Amblyraja radiata*			3.7		0.0							0.0	0.0	
	Dipturus batis	0.1								0.6	1.2	0.1			
	Amblyraja hyperborea			0.4											
	Dipturus oxyrinchus	3.1	13.9	7.4	0.9					2.8	4.5				
	Leucoraja circularis	1.1	0.7	0.8							0.4	0.1			0.0
	Leucoraja fullonica	1.6	2.6	2.2											
	Leucoraja naevus	27.7	34.5	23.1	12.0	7.4	5.4		0.5	62.8	51.7	22.1	0.1	0.0	
	Raja brachyura				0.4	0.7	11.8			7.3	1.9		0.3	0.1	0.4
	Raja clavata	15.9	36.9	28.3	43.4	64.6	68.2		7.4	45.9	62.8	104.7	0.3	0.1	0.5
	Raja microocellata														0.1
	Raja montagui	1.1	2.6	16.1	1.9	2.0	2.5			30.5	26.2	26.1			0.0
	Rostroraja alba									4.6	8.5	4.0			
	VIa Total Speciated	**50.4**	**91.3**	**82.0**	**58.6**	**74.7**	**87.9**		**7.9**	**154.4**	**157.2**	**157.2**	**0.7**	**0.3**	**1.1**
	VIa Total landings	**50.4**	**97.5**	**85.3**	**88.5**	**102.9**	**94.0**		**7.9**	**194.3**	**205.9**	**185.2**	**0.8**	**0.5**	**1.1**
VIb	*Dipturus batis*										1.7				
	Dipturus oxyrinchus		2.1						1.7	15.2	4.0				
	Leucoraja circularis	0.1	2.3	1.8	4.1						0.3	23.4			
	Leucoraja fullonica		1.1		0.6	3.0	4.4		1.5		0.7				
	Leucoraja naevus				0.2	0.3	0.1			1.4	5.0	4.2			
	Raja brachyura									0.3			0.1	0.3	
	Raja clavata		0.5		4.2	5.0	3.2			10.8	4.5	12.4			1.3
	Raja microocellata														
	Raja montagui	0.0					4.0			0.6	0.7	0.4			
	Rostroraja alba									1.9	0.2				
	VIb Total Speciated	**0.1**	**6.0**	1.8	**9.1**	**8.3**	**11.8**		**3.2**	**30.2**	**17.1**	**40.5**	**0.1**	**0.3**	**1.3**

VIb Total landings	**0.1**	**6.0**	1.8	**9.6**	**8.3**	**11.8**	**3.6**	**33.6**	**18.0**	**41.3**	**0.1**	**0.3**	**1.3**

Table 18.3. Continued. Skates and rays in the Celtic Seas. Species composition of skates (Rajidae), as reported in national landing statistics. Note: Belgian records of 'sandy ray' are assumed to refer to small-eyed ray; Scottish records of *Rostroraja alba* may refer to *L. fullonica.*

		Belgium			France			Ireland			Spain		Scotland			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
VIIa	*Amblyraja radiata*							0.9		0.1						0.7	1.2	
	Dipturus batis							4.8								0.1	0.2	0.1
	Dipturus oxyrinchus																	
	Leucoraja circularis		5.1	1.3						0.2								0.0
	Leucoraja fullonica				0.0	0.0	0.0		0.1									
	Leucoraja naevus	36.8	35.9	35.1	1.5	0.3	0.4	9.5	12.9	4.3						5.1	7.4	1.3
	Raja brachyura	182.3	142.9	152.7	0.0	0.1	0.0	362.3	388.6	318.9						23.6	23.8	8.8
	Raja clavata	132.6	214.9	179.8	0.6	1.3	0.4	35.4	36.8	54.7			0.2		2.4	129.3	176.8	186.7
	Raja microocellata	2.2			0.0	0.0	0.0	0.1	0.0								0.0	0.2
	Raja montagui	50.0	15.3		13.5	3.7	5.0	49.3	35.0	24.1			0.0		0.0	8.1	10.7	1.2
	Rostroraja alba													0.2			0.0	
	VIIa Total Speciated	**403.9**	**414.0**	**369.0**	**15.6**	**5.3**	**5.8**	**462.3**	**473.4**	**402.2**			**0.3**	**0.2**	**2.4**	**166.8**	**220.1**	**198.3**
	VIIa Total landings	**471.3**	**430.3**	**370.2**	**15.8**	**5.3**	**5.8**	**500.5**	**496.1**	**410.7**			**1.1**	**1.7**	**3.2**	**171.9**	**226.2**	**213.0**
VIIb	*Amblyraja radiata*							0.2	0.6	0.1								
	Dipturus oxyrinchus					0.1		11.6				2.5						
	Leucoraja circularis				0.0	0.0	0.0					2.5			1.3			
	Leucoraja fullonica				0.0	0.0	0.0					0.1				2.1	4.5	2.3
	Leucoraja naevus				34.4	36.0	24.8	9.1	12.5	9.3		7.0	1.4			6.5	11.6	4.9
	Raja brachyura					0.0	1.7	36.1	32.9	38.6							0.0	
	Raja clavata				18.4	30.7	39.3	39.4	60.2	51.6			2.6	2.4	0.9	5.5	8.8	4.3
	Raja microocellata						0.0											
	Raja montagui				0.1	0.2	0.1	2.2	5.6	5.1							0.9	
	Dipturus nidarosiensis																0.0	
	VIIb Total Speciated				**52.9**	**67.1**	**65.9**	**98.5**	**111.8**	**104.6**		**12.2**	**4.0**	**2.4**	**2.2**	**14.1**	**25.9**	**11.5**

VIIb Total landings	**53.0**	**67.6**	**66.1**	**118.8**	**122.4**	**106.8**	**12.2**	**4.0**	**2.4**	**2.2**	**14.1**	**25.9**	**11.5**

Table 18.3. Continued. Skates and rays in the Celtic Seas. Species composition of skates (Rajidae), as reported in national landing statistics. Note: Belgian records of 'sandy ray' are assumed to refer to small-eyed ray; Scottish records of *Rostroraja alba* may refer to *L. fullonica*.

		Belgium			France			Ireland			Netherlands			Spain		Scotland			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
VIIc	*Dipturus batis*				0.3																
	Dipturus oxyrinchus						0.0	0.0													
	Leucoraja circularis				0.0	0.0	0.1								1.7		0.1				
	Leucoraja fullonica				0.0	0.1	0.2								0.9		0.1		0.7		0.1
	Leucoraja naevus				9.6	6.8	5.6	1.6	1.5	0.3					16.0				2.7	0.5	0.5
	Raja brachyura							0.2	0.1								9.0			0.3	
	Raja clavata				2.3	3.2	5.6	0.8	4.1						0.3	13.5	5.0	4.9		0.3	0.0
	Raja microocellata																				
	Raja montagui				0.2	0.2	0.8													0.1	
	VIIc Total Speciated				**12.5**	**10.3**	**12.2**	**2.6**	**5.6**	**0.3**				**0.0**	**18.8**	**13.5**	**14.1**	**4.9**	**3.3**	**1.2**	**0.6**
	VIIc Total landings				**12.5**	**10.3**	**12.2**	2.6	**5.6**	0.3					18.8	**13.5**	**14.1**	4.9	**3.3**	**1.2**	**0.6**
VIIe	*Amblyraja radiata*		0.0		0.0														0.2	0.5	0.8
	Dipturus batis				0.7		0.5												0.1	0.3	0.6
	Dipturus oxyrinchus				0.0	0.2	0.1													0.0	0.1
	Leucoraja circularis		0.4	1.1		1.2	1.7												0.4	0.3	0.3
	Leucoraja fullonica				2.1	2.5	1.7												3.4	1.3	1.9
	Leucoraja naevus	0.9	0.7	0.7	275.3	184.5	184.8						0.0		0.1				79.8	75.8	75.4
	Raja brachyura	3.5	4.3	5.0	210.9	144.2	192.1		0.4			0.2	0.1						204.6	175.4	222.3
	Raja clavata	3.3	4.4	4.5	96.9	107.3	186.6			0.2	0.5	0.4	1.5						98.0	127.4	151.2
	Raja microocellata	0.4			15.3	15.1	19.2												24.9	30.6	29.0
	Raja montagui	1.3	1.2	0.0	278.4	284.9	339.8				0.2		0.1		0.0				46.8	44.7	63.1
	Raja undulata				1.7		1.2													0.0	
	Rostroraja alba				12.3		3.5													0.0	0.0

Rajella fyllae					0.0															
Amblyraja hyperborea																			0.0	
VIIe Total Speciated	**9.3**	**11.1**	**11.4**	**893.7**	**739.7**	**931.3**	**0.0**	**0.4**	**0.2**	**0.7**	**0.5**	**1.7**	**0.0**	**0.1**			**0.0**	**458.2**	**456.2**	**544.7**
VIIe Total landings	**13.8**	**12.6**	**11.6**	**930.9**	**778.1**	**959.8**		**0.4**	**0.2**	**0.8**	**0.6**	**1.8**		**0.1**			**0.0**	**465.2**	**463.3**	**550.6**

Table 18.3. Continued. Skates and rays in the Celtic Seas. Species composition of skates (Rajidae), as reported in national landing statistics. Note: Belgian records of 'sandy ray' are assumed to refer to small-eyed ray; Scottish records of *Rostroraja alba* may refer to *L. fullonica*.

		Belgium			France			Ireland			Spain		Scotland			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
VIIf	*Amblyraja radiata*		0.2													2.8	12.9	
	Dipturus batis			0.2	0.2													
	Dipturus oxyrinchus				0.0	0.0	0.3										0.0	0.0
	Leucoraja circularis		36.1	28.5		0.9	0.6									0.1	0.5	
	Leucoraja fullonica				4.3	4.8	1.2									2.7	2.7	3.7
	Leucoraja naevus	19.7	16.8	17.5	71.3	71.2	62.6	0.8	0.1	0.8						19.3	22.7	26.8
	Raja brachyura	32.1	53.9	62.3	94.0	70.6	46.4	0.0	0.2				0.0			227.8	218.2	240.5
	Raja clavata	40.1	42.3	37.2	8.7	7.2	9.9	0.0	0.0							215.5	255.0	200.8
	Raja microocellata	30.7		1.1	10.1	13.3	12.9									164.2	175.4	106.8
	Raja montagui	13.2	19.2		98.3	150.9	167.5	0.1	0.0							23.1	19.3	17.7
	Rostroraja alba				0.1													
	VIIf Total Speciated	**135.9**	**168.5**	**146.9**	**286.9**	**319.1**	**301.3**	**1.0**	**0.4**	**0.8**			**0.0**			**655.6**	**706.7**	**596.3**
	VIIf Total landings	**174.6**	**185.1**	**148.6**	**296.7**	**325.3**	**303.8**	**1.5**	**0.6**	**0.8**			0.1			681.9	708.0	597.9
VIIg	*Amblyraja radiata*							0.6	1.2	0.2								
	Dipturus batis				0.0				0.1									
	Dipturus oxyrinchus				0.0	0.2	0.2		0.7			0.1				0.2	0.0	0.3
	Leucoraja circularis		79.5	70.6		11.1	13.0	0.0								0.2	0.0	0.7
	Leucoraja fullonica				16.2	13.5	10.4	1.5	0.6	0.3		0.8	0.2			8.6	10.2	12.8
	Leucoraja naevus	41.3	33.3	40.6	80.2	90.9	65.5	23.4	35.9	23.6		3.7	0.1	0.0		21.1	18.5	7.8
	Raja brachyura	101.3	208.2	191.6	43.7	13.2	6.4	20.0	32.6	47.2			0.3	0.5		19.1	17.4	11.6
	Raja clavata	128.5	183.3	173.8	92.4	85.9	79.4	84.4	101.2	102.8		0.0	0.1	0.2		30.0	33.9	21.8
	Raja microocellata	73.0			7.7	2.1	3.8	0.0								21.6	28.8	8.6
	Raja montagui	55.3	34.0	1.5	451.8	573.0	327.0	12.5	17.0	16.1						2.8	6.4	2.9
	Rostroraja alba				8.1													

Rajella fyllae								0.1									
VIIg Total Speciated	**399.5**	**538.2**	**478.1**	**700.2**	**789.9**	**505.6**	**142.4**	**189.4**	**190.2**	**0.0**	**4.6**	**0.6**	**0.8**	**0.0**	**103.6**	**115.2**	**66.5**
VIIg Total landings	**519.2**	**576.0**	**482.8**	**704.1**	**794.6**	**507.7**	**283.9**	**303.4**	**206.8**		**4.6**	**1.8**	**2.8**	**0.5**	**115.2**	**115.2**	**66.6**

Table 18.3. Continued. Skates and rays in the Celtic Seas. Species composition of skates (Rajidae), as reported in national landing statistics. Note: Belgian records of 'sandy ray' are assumed to refer to small-eyed ray; Scottish records of *Rostroraja alba* may refer to *L. fullonica*.

		Belgium			France			Ireland			Netherlands			Spain		Scotland			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
VIIh	*Amblyraja radiata*					0.8															
	Dipturus batis				0.1																
	Dipturus oxyrinchus				0.1	3.5	2.3								1.1				0.1	0.0	0.0
	Leucoraja circularis		0.0			14.1	13.1								1.6				0.0	0.1	0.4
	Leucoraja fullonica				114.7	112.7	107.3	3.6	3.1	1.4					12.2	0.1	0.0		57.3	20.1	42.9
	Leucoraja naevus	0.0	0.1		1318.4	1089.4	995.6	27.1	7.2	11.7					88.8	4.5	0.2		117.4	62.0	85.3
	Raja brachyura		0.0		7.4	20.3	27.9	0.0	0.1										3.8	1.3	0.9
	Raja clavata		0.0		16.7	8.8	6.9	0.4		1.2									2.8	1.6	1.5
	Raja microocellata				10.3	0.1	0.7												3.8	1.5	1.6
	Raja montagui				63.1	66.5	68.3	0.0							0.0				5.5	1.4	3.0
	Rostroraja alba				0.6		0.1													0.0	
	VIIh Total Speciated	**0.0**	**0.2**		**1531.4**	**1316.1**	**1222.2**	**31.1**	**10.4**	**14.3**				**0.0**	**103.8**	**4.6**	**0.2**		**190.6**	**88.1**	**135.6**
	VIIh Total landings	**0.0**	**0.2**		**1534.6**	**1321.2**	**1225.2**	**32.5**	**11.0**	**14.3**					**103.8**	**4.6**	**0.2**		**190.6**	**88.1**	**135.6**
VIIj	*Amblyraja radiata*								0.0												
	Dipturus batis				0.2		0.0														
	Dipturus oxyrinchus				3.3	2.5	10.0		0.4	0.0					1.1						
	Leucoraja circularis				6.3	8.9	10.3	0.1	0.1						3.3		0.9			0.3	0.2
	Leucoraja fullonica				3.1	5.1	4.0	2.1	2.1	1.0					14.2	3.5	3.8		11.6	15.3	18.0
	Leucoraja naevus				43.0	56.8	72.0	29.8	32.8	42.2					126.5	13.5	11.3		52.5	21.1	35.8
	Raja brachyura				0.0	1.4		8.5	11.2	14.0					0.1				0.0		0.0
	Raja clavata				10.7	6.7	9.7	38.6	48.2	46.8	0.1				2.3	18.0	28.4	13.4	14.2	6.3	
	Raja microocellata					0.0									1.9				0.1		7.9

Div	Scientific name	Belgium 2011	Belgium 2012	Belgium 2013	France 2011	France 2012	France 2013	Ireland 2011	Ireland 2012	Ireland 2013	Netherlands 2011	Netherlands 2012	Netherlands 2013	Spain 2011	Spain 2012	Scotland 2011	Scotland 2012	Scotland 2013	UK (E,W&NI) 2011	UK (E,W&NI) 2012	UK (E,W&NI) 2013
	Raja montagui				1.6	2.0	0.4	10.7	17.4						3.9		0.1		2.9	2.1	8.9
	VIIj Total Speciated				**68.3**	**83.3**	**106.3**	**89.7**	**112.2**	**104.0**	**0.1**			**0.0**	**153.3**	**35.0**	**44.6**	**13.4**	**81.3**	**45.0**	**70.8**
	VIIj Total landings				**72.1**	**85.0**	**106.4**	**94.4**	**117.8**	**119.6**	**0.1**				**155.1**	**35.0**	**44.6**	**13.4**	**81.3**	**45.0**	**70.8**

Table 18.3. Continued. Skates and rays in the Celtic Seas. Species composition of skates (Rajidae), as reported in national landing statistics. Note: Belgian records of 'sandy ray' are assumed to refer to small-eyed ray; Scottish records of *Rostroraja alba* may refer to *L. fullonica*.

		Belgium			France			Ireland			Netherlands			Spain		Scotland			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
VIIh	*Amblyraja radiata*					0.8															
	Dipturus batis				0.1																
	Dipturus oxyrinchus				0.1	3.5	2.3								1.1				0.1	0.0	0.0
	Leucoraja circularis		0.0			14.1	13.1								1.6				0.0	0.1	0.4
	Leucoraja fullonica				114.7	112.7	107.3	3.6	3.1	1.4					12.2	0.1	0.0		57.3	20.1	42.9
	Leucoraja naevus	0.0	0.1		1318.4	1089.4	995.6	27.1	7.2	11.7					88.8	4.5	0.2		117.4	62.0	85.3
	Raja brachyura		0.0		7.4	20.3	27.9	0.0	0.1										3.8	1.3	0.9
	Raja clavata		0.0		16.7	8.8	6.9	0.4		1.2									2.8	1.6	1.5
	Raja microocellata				10.3	0.1	0.7												3.8	1.5	1.6
	Raja montagui				63.1	66.5	68.3	0.0							0.0				5.5	1.4	3.0
	Rostroraja alba				0.6		0.1													0.0	
	VIIh Total Speciated	**0.0**	**0.2**		**1531.4**	**1316.1**	**1222.2**	**31.1**	**10.4**	**14.3**				**0.0**	**103.8**	**4.6**	**0.2**		**190.6**	**88.1**	**135.6**
	VIIh Total landings	**0.0**	**0.2**		**1534.6**	**1321.2**	**1225.2**	**32.5**	**11.0**	**14.3**					**103.8**	**4.6**	**0.2**		**190.6**	**88.1**	**135.6**
VIIj	*Amblyraja radiata*								0.0												
	Dipturus batis				0.2		0.0														
	Dipturus oxyrinchus				3.3	2.5	10.0		0.4	0.0					1.1						
	Leucoraja circularis				6.3	8.9	10.3	0.1	0.1						3.3		0.9			0.3	0.2
	Leucoraja fullonica				3.1	5.1	4.0	2.1	2.1	1.0					14.2	3.5	3.8		11.6	15.3	18.0
	Leucoraja naevus				43.0	56.8	72.0	29.8	32.8	42.2					126.5	13.5	11.3		52.5	21.1	35.8
	Raja brachyura				0.0	1.4		8.5	11.2	14.0					0.1				0.0		0.0
	Raja clavata				10.7	6.7	9.7	38.6	48.2	46.8	0.1				2.3	18.0	28.4	13.4	14.2	6.3	
	Raja microocellata					0.0									1.9				0.1		7.9
	Raja montagui				1.6	2.0	0.4	10.7	17.4						3.9		0.1		2.9	2.1	8.9
	VIIj Total Speciated				**68.3**	**83.3**	**106.3**	**89.7**	**112.2**	**104.0**	**0.1**			**0.0**	**153.3**	**35.0**	**44.6**	**13.4**	**81.3**	**45.0**	**70.8**

		Belgium			France			Ireland			Netherlands			Spain		Scotland			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
	VIIj Total landings				**72.1**	**85.0**	**106.4**	**94.4**	**117.8**	**119.6**	**0.1**				**155.1**	**35.0**	**44.6**	**13.4**	**81.3**	**45.0**	**70.8**
VIIk	*Dipturus batis*				0.0																
	Dipturus oxyrinchus				0.2	0.0	0.0														
	Leucoraja circularis				0.0	0.0	0.1										0.8				
	Leucoraja fullonica				0.6	0.1	0.0													0.1	
	Leucoraja naevus				0.3	1.9	0.1	0.3	0.3						0.1						
	Raja brachyura					0.2			0.3	0.2											
	Raja clavata				0.1	0.3	0.1	0.4	0.0							1.5	1.3	1.0			0.2
	Raja microocellata					0.0															
	Raja montagui				0.1	0.0	0.0														
	VIIk Total Speciated				**1.3**	**2.5**	**0.3**	**0.6**	**0.6**	**0.2**				**0.0**	**0.1**	**1.5**	**2.1**	**1.0**		**0.1**	**0.2**
	VIIk Total landings				**1.3**	**2.8**	**0.3**	**0.7**	**0.6**	**0.2**					0.1	**1.5**	**2.1**	**1.0**		**0.1**	**0.2**

Table 18.3. Continued. Skates and rays in the Celtic Seas. Percentage of skates (Rajidae) reported to species level, as reported in national landing statistics. Note: Belgian records of 'sandy ray' are assumed to refer to small-eyed ray; Scottish records of *Rostroraja alba* may refer to *L. fullonica*.

		France			Ireland			Spain		Scotland			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
VIa	*Amblyraja radiata*	0.0	0.0	4.4	0.0	0.0	0.0		0.0	0.0	0.0	0.0	6.4	3.1	0.0
	Dipturus batis	0.1	0.0	0.0	0.0	0.0	0.0		0.0	0.3	0.6	0.1	0.0	0.0	0.0
	Amblyraja hyperborea														
	Dipturus oxyrinchus	6.2	14.3	8.6	1.0	0.0	0.0		0.0	1.4	2.2	0.0	0.0	0.0	0.0
	Leucoraja circularis	2.1	0.7	0.9	0.0	0.0	0.0		0.0	0.0	0.2	0.0	0.0	0.0	0.8
	Leucoraja fullonica	3.1	2.6	2.6	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Leucoraja naevus	54.9	35.4	27.1	13.6	7.2	5.7		6.3	32.3	25.1	11.9	11.1	0.4	0.0
	Raja brachyura	0.0	0.0	0.0	0.4	0.7	12.5		0.0	3.8	0.9	0.0	33.1	25.3	40.1
	Raja clavata	31.4	37.9	33.1	49.0	62.7	72.5		94.1	23.6	30.5	56.5	45.1	25.8	44.7
	Raja microocellata	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	7.2
	Raja montagui	2.1	2.6	18.8	2.2	1.9	2.7		0.0	15.7	12.7	14.1	0.0	0.0	4.4
	Rostroraja alba	0.0	0.0	0.0	0.0	0.0	0.0		0.0	2.4	4.1	2.2	0.0	0.0	0.0
	VIa Total Speciated	**100.0**	**93.6**	**96.1**	**66.2**	**72.6**	**93.5**		**100.0**	**79.5**	**76.4**	**84.9**	**95.7**	**54.6**	**97.2**
	VIa Total landings	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
VIb	*Dipturus batis*	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	9.7	0.0	0.0	0.0	0.0
	Dipturus oxyrinchus	0.0	34.5	0.0	0.0	0.0	0.0		48.3	45.1	22.2	0.0	0.0	0.0	0.0
	Leucoraja circularis	94.0	38.1	100.0	43.1	0.0	0.0		0.0	0.0	1.5	56.6	0.0	0.0	0.0
	Leucoraja fullonica	0.0	18.5	0.0	6.3	36.5	37.6		42.8	0.0	3.7	0.0	0.0	0.0	0.0
	Leucoraja naevus	0.0	0.0	0.0	1.7	3.8	0.7		0.0	4.0	28.1	10.3	0.0	0.0	0.0
	Raja brachyura	0.0	0.0	0.0	0.0	0.0	0.0		0.0	1.0	0.0	0.0	100.0	100.0	0.0
	Raja clavata	0.0	9.0	0.0	43.9	59.7	27.5		0.0	32.0	25.2	30.1	0.0	0.0	100.0
	Raja microocellata	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Raja montagui	5.6	0.0	0.0	0.0	0.0	34.3		0.0	1.9	3.8	1.0	0.0	0.0	0.0
	Rostroraja alba	0.0	0.0	0.0	0.0	0.0	0.0		0.0	5.7	0.9	0.0	0.0	0.0	0.0
	VIb Total Speciated	**99.6**	**100.0**	**100.0**	**94.9**	**100.0**	**100.0**		**91.1**	**89.6**	**95.1**	**97.9**	**100.0**	**100.0**	**100.0**
	VIb Total landings	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 18.3. Continued. Skates and rays in the Celtic Seas. Species composition of skates (Rajidae), as reported in national landing statistics. Note: Belgian records of 'sandy ray' are assumed to refer to small-eyed ray; Scottish records of *Rostroraja alba* may refer to *L. fullonica*.

		BELGIUM			FRANCE			IRELAND			SPAIN		SCOTLAND			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
VIIa	*Amblyraja radiata*	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0			0.0	0.0	0.0	0.4	0.5	0.0
	Dipturus batis	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0			0.0	0.0	0.0	0.0	0.1	0.0
	Dipturus oxyrinchus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0
	Leucoraja circularis	0.0	1.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0
	Leucoraja fullonica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0
	Leucoraja naevus	7.8	8.3	9.5	9.8	5.9	7.4	1.9	2.6	1.1			0.0	0.0	0.0	2.9	3.3	0.6
	Raja brachyura	38.7	33.2	41.3	0.1	1.3	0.0	72.4	78.3	77.7			0.0	0.0	0.0	13.7	10.5	4.1
	Raja clavata	28.1	49.9	48.6	3.6	23.9	6.6	7.1	7.4	13.3			21.6	0.0	72.9	75.2	78.2	87.7
	Raja microocellata	0.5	0.0	0.0	0.0	0.1	0.4	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.1
	Raja montagui	10.6	3.5	0.0	85.8	68.7	85.5	9.8	7.1	5.9			2.6	0.0	1.4	4.7	4.7	0.6
	Rostroraja alba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	11.8	0.0	0.0	0.0	0.0
	VIIa Total Speciated	**85.7**	**96.2**	**99.7**	**99.3**	**99.9**	**100.0**	**92.4**	**95.4**	**98.0**			**24.3**	**11.8**	**74.3**	**97.1**	**97.3**	**93.1**
	VIIa Total landings	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**			**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
VIIb	*Amblyraja radiata*				0.0	0.0	0.0	0.1	0.5	0.1		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dipturus oxyrinchus				0.0	0.2	0.0	9.7	0.0	0.0		20.8	0.0	0.0	0.0	0.0	0.0	0.0
	Leucoraja circularis				0.1	0.1	0.0	0.0	0.0	0.0		20.8	0.0	0.0	59.6	0.0	0.0	0.0
	Leucoraja fullonica				0.0	0.0	0.0	0.0	0.0	0.0		1.1	0.0	0.0	0.0	15.1	17.3	19.6
	Leucoraja naevus				64.8	53.3	37.5	7.7	10.2	8.7		57.0	34.0	0.0	0.0	45.8	44.8	42.9
	Raja brachyura				0.0	0.0	2.5	30.4	26.9	36.1		0.0	0.0	0.0	0.0	0.0	0.2	0.0
	Raja clavata				34.8	45.4	59.4	33.2	49.2	48.3		0.0	66.0	100.0	40.4	39.1	33.9	37.4
	Raja microocellata				0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Raja montagui				0.1	0.2	0.1	1.8	4.5	4.8		0.0	0.0	0.0	0.0	0.0	3.6	0.0
	Dipturus nidarosiensis				0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.2	0.0
	VIIb Total Speciated				**99.8**	**99.2**	**99.7**	**82.9**	**91.3**	**97.9**		**99.7**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**99.9**
	VIIb Total landings				**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 18.3. Continued. Skates and rays in the Celtic Seas. Species composition of skates (Rajidae), as reported in national landing statistics. Note: Belgian records of 'sandy ray' are assumed to refer to small-eyed ray; Scottish records of *Rostroraja alba* may refer to *L. fullonica*.

		Belgium			France			Ireland			Netherlands			Spain		Scotland			UK (E,W&NI)		
Div	Scientific name	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2011	2012	2013	2011	2012	2013
VIIc	*Dipturus batis*				2.4	0.0	0.0	0.0	0.0	0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dipturus oxyrinchus				0.0	0.0	0.0	1.5	0.0	0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Leucoraja circularis				0.3	0.4	0.8	0.0	0.0	0.0					9.0	0.0	0.6	0.0	0.0	0.0	0.0
	Leucoraja fullonica				0.4	0.6	1.3	0.0	0.0	0.0					4.6	0.0	0.5	0.0	19.6	0.0	11.4
	Leucoraja naevus				77.0	66.2	45.7	60.7	26.0	100.0					85.1	0.0	0.0	0.0	80.4	37.5	87.6
	Raja brachyura				0.0	0.0	0.0	6.1	1.3	0.0					0.0	0.0	63.7	0.0	0.0	27.0	0.0
	Raja clavata				18.3	30.7	45.6	30.3	72.7	0.0					1.5	100.0	35.2	100.0	0.0	25.1	1.0
	Raja microocellata				0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Raja montagui				1.7	1.7	6.4	0.0	0.0	0.0					0.0	0.0	0.0	0.0	0.0	10.5	0.0
	Amblyraja radiata				0.0	0.2	0.0	0.0	0.0	0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
	VIIc Total Speciated				100.0	99.8	99.8	98.7	100.0	100.0					100.1	100.0	100.0	100.0	100.0	100.0	100.0
	VIIc Total landings				100.0	100.0	100.0	100.0	100.0	100.0					100.0	100.0	100.0	100.0	100.0	100.0	100.0
VIIe	*Amblyraja radiata*	0.0	0.1	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0				0.1	0.1	0.2
	Dipturus batis	0.0	0.0	0.0	0.1	0.0	0.1		0.0	0.0	0.0	0.0	0.0		0.0				0.0	0.1	0.1
	Dipturus oxyrinchus	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0				0.0	0.0	0.0
	Leucoraja circularis	0.0	3.5	9.9	0.0	0.1	0.2		0.0	0.0	0.0	0.0	0.0		0.0				0.1	0.1	0.1
	Leucoraja fullonica	0.0	0.0	0.0	0.2	0.3	0.2		0.0	0.0	0.0	0.0	0.0		0.0				0.7	0.3	0.4
	Leucoraja naevus	6.4	5.4	6.3	29.6	23.7	19.3		0.0	0.0	0.0	0.0	2.7		78.0				17.2	16.4	13.7
	Raja brachyura	25.2	34.6	43.2	22.7	18.5	20.0		100.0	0.0	0.0	25.0	3.8		0.0				44.0	37.9	40.4
	Raja clavata	23.7	34.9	38.7	10.4	13.8	19.4		0.0	100.0	65.5	57.8	87.5		0.0				21.1	27.5	27.5
	Raja microocellata	3.1	0.0	0.0	1.6	1.9	2.0		0.0	0.0	0.0	0.0	0.0		0.0				5.3	6.6	5.3
	Raja montagui	9.1	9.7	0.1	29.9	36.6	35.4		0.0	0.0	24.4	0.0	4.7		22.0				10.1	9.6	11.5
	Raja undulata	0.0	0.0	0.0	0.2	0.0	0.1		0.0	0.0	0.0	0.0	0.0		0.0				0.0	0.0	0.0
	Rostroraja alba	0.0	0.0	0.0	1.3	0.0	0.4		0.0	0.0	0.0	0.0	0.0		0.0				0.0	0.0	0.0
	Rajella fyllae	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0				0.0	0.0	0.0
	Amblyraja hyperborea	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0				0.0	0.0	0.0
	VIIe Total Speciated	67.4	88.2	98.1	96.0	95.1	97.0		100.0	100.0	89.9	82.8	98.7		100.0				98.5	98.5	98.9
	VIIe Total landings	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0	100.0	100.0	100.0		100.0				100.0	100.0	100.0

Table 18.3. Continued. Skates and rays in the Celtic Seas. Species composition of skates (Rajidae), as reported in national landing statistics. Note: Belgian records of 'sandy ray' are assumed to refer to small-eyed ray; Scottish records of *Rostroraja alba* may refer to *L. fullonica*.

		Belgium			France			Ireland			Spain		Scotland			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
VIIf	*Amblyraja radiata*	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0			0.4	1.8	0.0
	Dipturus batis	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0	0.0
	Dipturus oxyrinchus	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0			0.0			0.0	0.0	0.0
	Leucoraja circularis	0.0	19.5	19.2	0.0	0.3	0.2	0.0	0.0	0.0			0.0			0.0	0.1	0.0
	Leucoraja fullonica	0.0	0.0	0.0	1.4	1.5	0.4	0.0	0.0	0.0			0.0			0.4	0.4	0.6
	Leucoraja naevus	11.3	9.1	11.8	24.0	21.9	20.6	54.5	16.5	100.0			0.0			2.8	3.2	4.5
	Raja brachyura	18.4	29.1	41.9	31.7	21.7	15.3	2.7	32.9	0.0			38.6			33.4	30.8	40.2
	Raja clavata	23.0	22.9	25.0	2.9	2.2	3.3	2.7	8.3	0.0			0.0			31.6	36.0	33.6
	Raja microocellata	17.6	0.0	0.7	3.4	4.1	4.2	0.0	0.0	0.0			0.0			24.1	24.8	17.9
	Raja montagui	7.6	10.4	0.0	33.1	46.4	55.1	5.4	8.6	0.0			0.0			3.4	2.7	3.0
	Rostroraja alba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0			0.0	0.0	0.0
	VIIf Total Speciated	**77.8**	**91.0**	**98.8**	**96.7**	**98.1**	**99.2**	**65.4**	**66.3**	**100.0**			**38.6**			**96.1**	**99.8**	**99.7**
	VIIf Total landings	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**			**100.0**			**100.0**	**100.0**	**100.0**
VIIg	*Amblyraja radiata*																	
	Dipturus batis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dipturus oxyrinchus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0		1.2	0.0	0.0	0.0	0.1	0.0	0.5
	Leucoraja circularis	0.0	13.8	14.6	0.0	1.4	2.6	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.2	0.0	1.0
	Leucoraja fullonica	0.0	0.0	0.0	2.3	1.7	2.0	0.5	0.2	0.2		17.9	10.0	0.0	0.0	7.5	8.9	19.2
	Leucoraja naevus	8.0	5.8	8.4	11.4	11.4	12.9	8.2	11.8	11.4		80.1	5.9	1.0	0.0	18.3	16.0	11.8
	Raja brachyura	19.5	36.1	39.7	6.2	1.7	1.3	7.0	10.8	22.8		0.0	14.4	16.9	0.0	16.6	15.1	17.4
	Raja clavata	24.8	31.8	36.0	13.1	10.8	15.6	29.7	33.3	49.7		0.8	4.9	8.8	0.0	26.1	29.4	32.7
	Raja microocellata	14.1	0.0	0.0	1.1	0.3	0.7	0.0	0.0	0.0		0.0	0.0	0.0	0.0	18.8	25.0	13.0
	Raja montagui	10.7	5.9	0.3	64.2	72.1	64.4	4.4	5.6	7.8		0.0	0.0	0.0	0.0	2.4	5.6	4.4
	Rostroraja alba	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Rajella fyllae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	VIIg Total Speciated	**76.9**	**93.4**	**99.0**	**99.4**	**99.4**	**99.6**	**50.2**	**62.4**	**92.0**		**100.0**	**35.2**	**26.7**	**0.0**	**89.9**	**100.0**	**99.9**

VIIg Total landings	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 18.3. Continued. Skates and rays in the Celtic Seas. Species composition of skates (Rajidae), as reported in national landing statistics. Note: Belgian records of 'sandy ray' are assumed to refer to small-eyed ray; Scottish records of *Rostroraja alba* may refer to *L. fullonica*.

		Belgium			France			Ireland			Netherlands			Spain		Scotland			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
VIIh	*Amblyraja radiata*	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0	0.0		0.0	0.0	0.0
	Dipturus batis	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0	0.0		0.0	0.0	0.0
	Dipturus oxyrinchus	0.0	0.0		0.0	0.3	0.2	0.0	0.0	0.0					1.1	0.0	0.0		0.0	0.0	0.0
	Leucoraja circularis	0.0	10.4		0.0	1.1	1.1	0.0	0.0	0.0					1.5	0.0	0.0		0.0	0.1	0.3
	Leucoraja fullonica	0.0	0.0		7.5	8.5	8.8	11.2	27.8	9.8					11.8	2.1	19.5		30.0	22.8	31.6
	Leucoraja naevus	100.0	45.4		85.9	82.5	81.3	83.2	65.7	81.4					85.6	97.9	80.5		61.6	70.5	62.9
	Raja brachyura	0.0	17.5		0.5	1.5	2.3	0.1	0.8	0.0					0.0	0.0	0.0		2.0	1.5	0.6
	Raja clavata	0.0	20.2		1.1	0.7	0.6	1.1	0.0	8.5					0.0	0.0	0.0		1.5	1.8	1.1
	Raja microocellata	0.0	0.0		0.7	0.0	0.1	0.0	0.0	0.0					0.0	0.0	0.0		2.0	1.7	1.2
	Raja montagui	0.0	0.0		4.1	5.0	5.6	0.1	0.0	0.0					0.0	0.0	0.0		2.9	1.6	2.2
	Rostroraja alba	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0	0.0		0.0	0.0	0.0
	VIIh Total Speciated	**100.0**	**93.4**		**99.8**	**99.6**	**99.8**	**95.7**	**94.3**	**99.7**					**99.9**	**100.0**	**100.0**		**100.0**	**100.0**	**100.0**
	VIIh Total landings	**100.0**	**100.0**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**					**100.0**	**100.0**	**100.0**		**100.0**	**100.0**	**100.0**
VIIj	*Amblyraja radiata*				0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dipturus batis				0.3	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dipturus oxyrinchus				4.6	2.9	9.4	0.0	0.3	0.0	0.0				0.7	0.0	0.0	0.0	0.0	0.0	0.0
	Leucoraja circularis				8.8	10.4	9.6	0.1	0.1	0.0	0.0				2.1	0.0	2.1	0.0	0.0	0.8	0.3
	Leucoraja fullonica				4.3	6.0	3.7	2.2	1.8	0.8	0.0				9.1	9.9	8.6	0.0	14.3	34.0	25.4
	Leucoraja naevus				59.6	66.8	67.6	31.5	27.9	35.3	0.0				81.6	38.5	25.4	0.0	64.6	46.7	50.5
	Raja brachyura				0.0	1.6	0.0	9.0	9.5	11.7	0.0				0.1	0.0	0.0	0.0	0.0	0.0	0.0
	Raja clavata				14.8	7.9	9.1	40.9	40.9	39.1	100.0				1.5	51.5	63.6	100.0	17.5	13.9	0.0
	Raja microocellata				0.0	0.0	0.0	0.0	0.0	0.0	0.0				1.2	0.0	0.0	0.0	0.1	0.0	11.2
	Raja montagui				2.2	2.3	0.4	11.3	14.8	0.0	0.0				2.5	0.0	0.3	0.0	3.5	4.6	12.6
	VIIj Total Speciated				**94.7**	**97.9**	**99.9**	**95.0**	**95.3**	**87.0**	**100.0**				**98.9**	**100.0**	**100.0**	**100.0**	**99.9**	**100.0**	**100.0**
	VIIj Total landings				**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**				**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

		Belgium			France			Ireland			Netherlands			Spain		Scotland			UK (E,W&NI)		
Div	**Scientific name**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
VIIk	*Dipturus batis*				0.1	0.0	0.0	0.0	0.0	0.0					0.0	0.0	0.0	0.0		0.0	0.0
	Dipturus oxyrinchus				17.4	0.3	2.7	0.0	0.0	0.0					0.0	0.0	0.0	0.0		0.0	0.0
	Leucoraja circularis				0.1	0.2	16.3	0.0	0.0	0.0					0.0	0.0	39.3	0.0		0.0	0.0
	Leucoraja fullonica				45.7	3.9	8.9	0.0	0.0	0.0					0.0	0.0	0.0	0.0		100.0	0.0
	Leucoraja naevus				20.4	67.6	37.3	37.8	44.2	0.0					100.0	0.0	0.0	0.0		0.0	0.0
	Raja brachyura				0.0	5.4	0.0	0.0	49.8	100.0					0.0	0.0	0.0	0.0		0.0	0.0
	Raja clavata				5.2	10.9	34.0	51.0	6.0	0.0					0.0	100.0	60.7	100.0		0.0	100.0
	Raja microocellata				0.0	0.0	0.0	0.0	0.0	0.0					0.0	0.0	0.0	0.0		0.0	0.0
	Raja montagui				11.1	0.0	0.8	0.0	0.0	0.0					0.0	0.0	0.0	0.0		0.0	0.0
	VIIk Total Speciated				**100.0**	**88.4**	**100.0**	**88.8**	**100.1**	**100.0**					**100.0**	**100.0**	**100.0**	**100.0**		**100.0**	**100.0**
	VIIk Total landings				**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**					**100.0**	**100.0**	**100.0**	**100.0**		**100.0**	**100.0**

Table 18.4a. Skates and rays in the Celtic Seas. Summary details of fishery-independent surveys using otter trawls in the Celtic Seas ecoregion. Adapted from ICES (2013a and references therein).

Country	Ireland	UK (Scot)	UK (Scot)	UK (Scot)	UK (NI)	UK (NI)	UK (Eng&Wal)	UK (Eng&Wal)	France	Spain
Acronym	IGFS-WIBTS-Q4	ScoGFS-WIBTS-Q1	ScoGFS-WIBTS-Q4	Rock-IBTS-Q3	NIGFS-WIBTS-Q1	NIGFS-WIBTS-Q4	EngW-WIBTS-Q4	PHHT-Q1	EVHOE-WIBTS-Q4	SpPGFS-WIBTS-Q4
Laboratory	MI	MSS	MSS	MSS	AFBI	AFBI	Cefas	Cefas	Ifremer	IEO
Research vessel	Celtic Explorer	Scotia	Scotia	Scotia	Corystes	Corystes	Endeavour	Cirolana/Endeavour	Thalassa	Vizconde de Eza
Gear type	36/47 GOV	36/47 GOV	36/47 GOV		Rock-hopper otter trawl	Rock-hopper otter trawl	36/47 GOV [34/45 GOV]	PHHT	36/47 GOV	BACA 40/52
Depth range	20–600	20–400	20–400		20–120	20–120	20–150		30–400	150–800
Trawl speed (knots)	4	4	4	4	3	3	4	4	4	3.5
Groundrope	Groundgears A&D	Bobbins	Bobbins	Bobbins	Rubber discs	Rubber discs	Groundgears A&D	Rock-hopper	Groundgear A	Synthetic wrapped wire core (double coat)
Survey area	VIA, VII	VI	VI	VIb	VIIA	VIIA	VIIA,E–H	VII	VIIF–J, VIII	VIIC
Station grid	Semi-random depth stratified	Semi-random, 1–2 tows per rectangle	Semi-random, 1–2 tows per rectangle		Fixed stations in strata	Fixed stations in strata	Fixed stations in strata	Fixed stations	Stratified random	Random stratified across 5 strata
Quarter	4	1	4	4	1	4	4	1 (4)	4	3–4
Time coverage	2003–	1992–	1992–		1992–	1992–	2003–2011	1988–2003	1997–	2001–
Coordination	IBTSWG	IBTSWG	IBTSWG	IBTSWG	IBTSWG	IBTSWG	IBTSWG	-	IBTSWG	IBTSWG

Table 18.4b. Skates and rays in the Celtic Seas. Summary details of fishery-independent trawl surveys (WIBTS) in the Celtic Seas ecoregion.

Country	UK (Eng&Wal)	UK (Eng&Wal)	UK (Eng&Wal)
Acronym	EngW-BTS-Q3	Eng-WEC-BTS-Q4	Eng-WEC-BTS-Q1
Laboratory	Cefas	Cefas	Cefas
Research vessel	Endeavour [1]	FV Carhelmar	Endeavour
Gear type	4 m BT	4 m BT (twin)	4 m BT (twin)
Depth range	10–135		
Trawl speed (knots)	4	4	4
Survey area	VIIAF	VIIE (part)	VIIE
Station grid	Fixed	Fixed	Stratified random
Quarter	3	4	1
Time coverage	1988–present [2]	1988–2012[2]	2006–present
Coordination	WGBEAM	WGBEAM	

[1] Endeavour used in recent years only. RV *Corystes* used previously.

[2] Grid standardized since 1993.

Table 18.5. Skate and rays in the Celtic Seas. Preliminary estimates of M for skates in the Celtic Seas ecoregion.

Species	Sex	Longevity	Reference	M_longevity	Age 50	Reference	M_maturity
Dipturis batis complex	both	50	Du Buit, 1976	0.09	11.00	Du Buit 1976	0.11
Leucoraja naevus	m	12		0.38	4.17		0.38
Leucoraja naevus	f	12	Du Buit, 1976	0.38	4.25	Gallagher, 2000	0.38
Raja brachyura	m	12		0.38	5.50		0.29
Raja brachyura	f	12	Ryland and Ajayi, 1984	0.38	4.63	Gallagher, 2000	0.34
Raja clavata	m	12		0.38	6.13		0.25
Raja clavata	f	12	Ryland and Ajayi, 1984	0.38	6.13	Gallagher, 2000	0.25
Raja microocellata	m	7		0.66			
Raja microocellata	f	9	Ryland and Ajayi, 1984	0.51			
Raja montagui	m	8		0.58	3.41		0.47
Raja montagui	f	8	Ryland and Ajayi, 1984	0.58	4.14	Gallagher, 2000	0.39
Raja undulata	m	12	.	0.38	7.66		0.19
Raja undulata	f	13	Coelho and Erzini, 2002	0.35	8.98	Coelho and Erzini, 2006	0.15

Table 18.6. Skate and rays in the Celtic Seas. Preliminary catch curve estimates of HR-converted (HR = 1-exp (-F)) fishing mortality (F=Z-M) for four skate species. Missing values are due to insufficient data.

IGFS Celtic Sea VIIg: Survey data	Catch curve	Summed	Female	Male	2011	2012	2013
Spotted Ray	*Raja montagui*	0.23	0.22	0.40	0.43	0.15	0.19
Thornback ray	*Raja clavata*	0.01	0.02	0.04			
Cuckoo ray	*Leucoraja naevus*	0.54	0.58	0.32			
Blonde ray	*Raja brachyura*	0.11					

NIGFS Irish Sea VIIa: Survey data	Catch curve	Summed	Female	Male
Spotted Ray	*Raja montagui*	0.71	0.17	0.11
Thornback ray	*Raja clavata*			
Cuckoo ray	*Leucoraja naevus*			
Blonde ray	*Raja brachyura*			

Irish Sea (VIIa): Observer data	Catch curve	Summed	Female	Male	2011	2012
Spotted Ray	*Raja montagui*	0.67	0.19	0.18	0.20	0.53
Thornback ray	*Raja clavata*					
Cuckoo ray	*Leucoraja naevus*	0.40				
Blonde ray	*Raja brachyura*	0.40	0.37	0.32	0.27	0.22

Table 18.7. Skate and rays in the Celtic Seas. Preliminary survey estimates of TSB and HR for four tested skate species. HR values coloured red are ≥ than precautionary reference levels, green are <reference levels.

Irish Sea (VIIa)	Survey method	2011		2012	
Common name	Latin name	TSB	*HR*	TSB	*HR*
Spotted Ray	*Raja montagui*	12982	0.03	8826	0.02
Thornback ray	*Raja clavata*	25976	0.01	24680	0.02
Cuckoo ray	*Leucoraja naevus*	2363	0.26	4629	0.10
Blonde ray	*Raja brachyura*	8037	0.09	7589	0.08
IGFS Celtic Sea VIIg	**Survey method**				
Spotted Ray	*Raja montagui*	2542	0.17	2317	0.22
Thornback ray	*Raja clavata*	255	0.65	368	0.55
Cuckoo ray	*Leucoraja naevus*	1704	0.27	313	0.67
Blonde ray	*Raja brachyura*	1237	0.27	58	0.82
VIIa and VIIg	**Survey method**				
Spotted Ray	*Raja montagui*	15524	0.05	11143	0.07
Thornback ray	*Raja clavata*	26231	0.03	25048	0.04
Cuckoo ray	*Leucoraja naevus*	4067	0.26	4942	0.19
Blonde ray	*Raja brachyura*	9274	0.12	7647	0.11

Table 18.8. Skate and rays in the Celtic Seas. Potential precautionary HR reference points for four skate species in ICES VIIa and VIIg.

	HR_{msy}	HR_{40}
Latin name	Zhou 2012	Le Quesne 2012
Raja montagui	**0.21**	**0.10**
Raja clavata	**0.14**	**0.09**
Leucoraja naevus	**0.14**	**0.11**
Raja brachyura	**0.14**	**0.08**

Table 18.9. Skates and rays in the Celtic Seas. Potential reference points and harvest ratios for skates, as calculated using different methodologies.

Irish Sea (VIIa)	Survey method			2011		2012		HR_{MSY}	HR_{40}
Common name	Latin name		*M*	TSB	*HR*	TSB	*HR*	Zhou 2012	Le Quesne & Jennings 2012
Spotted ray	*R. montagui*		0.58	12982	0.03	8826	0.02	0.21	0.10
Thornback ray	*R .clavata*		0.38	25976	0.01	24680	0.02	0.14	0.09
Cuckoo ray	*L. naevus*		0.38	2363	0.26	4629	0.10	0.14	0.11
Blonde ray	*R. brachyura*		0.38	8037	0.09	7589	0.08	0.14	0.08
VIIa and VIIg	Survey method								
Spotted ray	*R. montagui*			22828	0.04			0.21	0.10
Thornback ray	*R. clavata*			28084	0.03			0.14	0.09
Cuckoo ray	*L. naevus*			7422	0.16			0.14	0.11
Blonde ray	*R. brachyura*			11488	0.10			0.14	0.08
IGFS Celtic Sea VIIg	Catch curve	Summed	Female	Male	2011	2012	2013		
Spotted ray	*R. montagui*	0.32	0.22	0.40	0.30	0.19	0.21	0.21	0.10
Thornback ray	*R. clavata*	0.01	0.02	0.04				0.14	0.09
Cuckoo ray	*L. naevus*	0.49	0.38	0.58				0.14	0.11
Blonde ray	*R. brachyura*	0.25						0.14	0.08
NIGFS Irish Sea VIIa	Catch curve	Summed	Female	Male					
Spotted ray	*R. montagui*	0.71	0.24	0.24				0.21	0.10
Thornback ray	*R. clavata*							0.14	0.09
Cuckoo ray	*L. naevus*							0.14	0.11
Blonde ray	*R. brachyura*							0.14	0.08
irish Sea (VIIa)	Observer catch curves	Summed	Female	Male	2011	2012			
Spotted ray	*R. montagui*	0.67	0.19	0.18	0.20	0.53		0.21	0.10
Thornback ray	*R.clavata*							0.14	0.09
Cuckoo ray	*L. naevus*							0.14	0.11
Blonde ray	*R. brachyura*	0.39	0.37	0.32	0.27	0.22		0.14	0.08

Table 18.10. Skates and rays in the Celtic Seas. Technical interactions.

Stock interaction table	Anglerfish budegassa VIIb-k, VIIIabd	Anglerfish piscatorius VIIb-k, VIIIabd	Cod VIIe-k	Haddock VIIb-k	Hake Northern	Herring Celtic Sea and Division VIIj	Herring VIa(S) and VIIbc	Horse Mackerel Western	Mackerel North East Atlantic	Megrim VII	Nephrops Area L: VIIbcjk	Nephrops Area M: VIIfgh+VIIa	Nephrops VIIIa,b	Plaice VIIbc	Plaice VIIe	Plaice VIIfg	Plaice VIIhjk	Sole VIIbc	Sole VIIe	Sole VIIfg	Sole VIIhjk	Sprat VIIde	Whiting VIIe-k	Seabass	Skates and rays	Pelagic and migratory sharks	Demersal sharks
Anglerfish budegassa VIIb-k, VIIIabd		H	L	L	M	0	0	0	0	M	M	L	M	L	L	L	L	L	L	L	L		L		H	L	H
Anglerfish piscatorius VIIb-k, VIIIabd	T		L	L	M	0	0	0	0	M	M	M	M	L	L	L	L	L	L	L	L		L		H	L	H
Cod VIIe-k	T	T		H	L	0	0	0	0	L	L	M	0	0	L	M	L	0	L	L	L	0	H/M		H	L	H
Haddock VIIb-k	T	T	T		L	0	0	0	0	L	M	M	0	L	L	L	L	L	L	L	L	0	H	0	H	L	H
Hake Northern	T	T	T			0	0	0	0	M	M	L	M	L		0	L	L		0	L		L		H	L	H
Herring Celtic Sea and Division VIIj	N	N	N	N	N		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	I	0
Herring VIa(S) and VIIbc	N	N	N	N	N	N		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	L	0
Horse Mackerel Western	N	N	N	N	N	N	N		H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	L	0
Mackerel North East Atlantic	N	N	N	N	N	N	N			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	L	0
Megrim VII	T, BT	T, BT	T		T	N	N	N	N		H	M	M	L			L	L		L	L		L		H	0	H
Nephrops Area L: VIIbcjk	NT	NT	NT	NT	NT	N	N	N	N	NT		0	0	L	0	0	L	L	0	0	L	0	M		M	0	M
Nephrops Area M: VIIfgh+VIIa	NT	NT	NT	NT	NT	N	N	N	N	NT	N		0	0	0	0	L	0	0	L	L	0	M		M	0	M
Nephrops VIIIa,b	NT	NT	N	N	NT	N	N	N	N	NT	N	N		0	0	0	0	0	0	0	0	0	0		L	0	M
Plaice VIIbc			N			N	N	N	N		NT	N	N		0	0	0	L	0	0	0	0	L	0	H	0	M
Plaice VIIe	OT, BT	OT, BT	OT, BT	N		N	N	N	N		N	N	N	N		0	0	0	H	0	0	0	L		H	0	M
Plaice VIIfg	OT, BT	OT, BT	OT, BT	OT, BT	N	N	N	N	N		N	N	N	N	N		0	0	0	H	0	0	L		H	0	M
Plaice VIIhjk			BT, OT			N	N	N	N		NT	N	N	N	N	N		0	0	0	L	0	L	0	H	0	M
Sole VIIbc			N			N	N	N	N		N	N	N		N	N	N		0	0	0	0	L	0	H	0	M
Sole VIIe	BT, OT	BT, OT	BT, OT	N		N	N	N	N		N	N	N	N	BT, OT	N	N	N		0	0	0	L		H	0	M
Sole VIIfg	BT, OT	BT, OT	BT, OT	BT, OT	N	N	N	N	N	BT	N	NT	N	N	N	BT, OT	N	N	N		0	0	L		H	0	M
Sole VIIhjk			BT, OT			N	N	N	N		N	N	N	N	N	N	T, BT	N	N	N		0	L	0	H	0	M
Sprat VIIde	N	N	N	N				N	N		N	N	N	N	N	N	N	N	N	N	N		0				
Whiting VIIe-k	T	T	T	T		N	N	N	N		NT	NT	N	N	N	BT, OT		N	N	BT, OT				0	H	L	H
Seabass						N	N	N	N														0		L	L	L
Skates and rays	BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	N	N	N	N	BT, OT	NT	NT	NT	BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	N	BT,OT	GN		L	H
Pelagic and migratory sharks	BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	N	N	N	N	BT, OT				BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	N	BT, OT	BT, OT	N	BT,OT	T, GN	GN, BT		0
Demersal sharks	BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	N	N	N	N	BT, OT	NT	NT	NT	BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	BT, OT	N	BT,OT	GN	BT,OT	N	

H; the stocks are taken together in most fisheries where they are taken and their fisheries linkage is therefore high; M: the stocks are taken together in some but not all important fisheries and their fisheries linkage is therefore medium; L: the stocks

T: Trawl; BT: Beam trawl; OT: Otter trawl; NT: Nephrops trawl; GN: Gillnet; N: none

Figure 18.1a. Skates and rays in the Celtic Seas. Total landings (tonnes) of skates (Rajidae) in the Celtic Seas (ICES Subareas VI and VII (including VIId)), from 1903–2013 (Source: ICES).

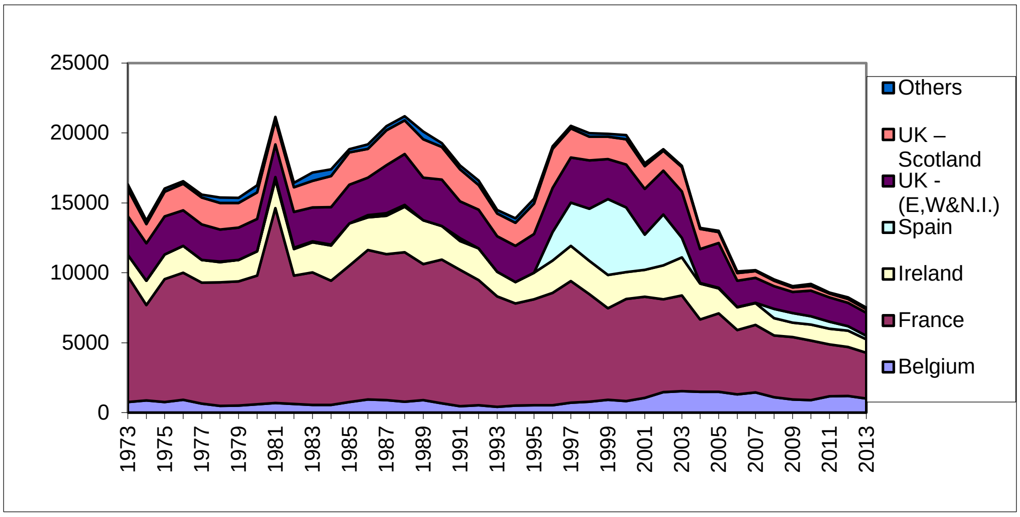


Figure 18.1b. Skates and rays in the Celtic Seas. Total landings (tonnes) of skates (Rajidae) by nation in the Celtic Seas from 1973–2013 (Source: ICES).

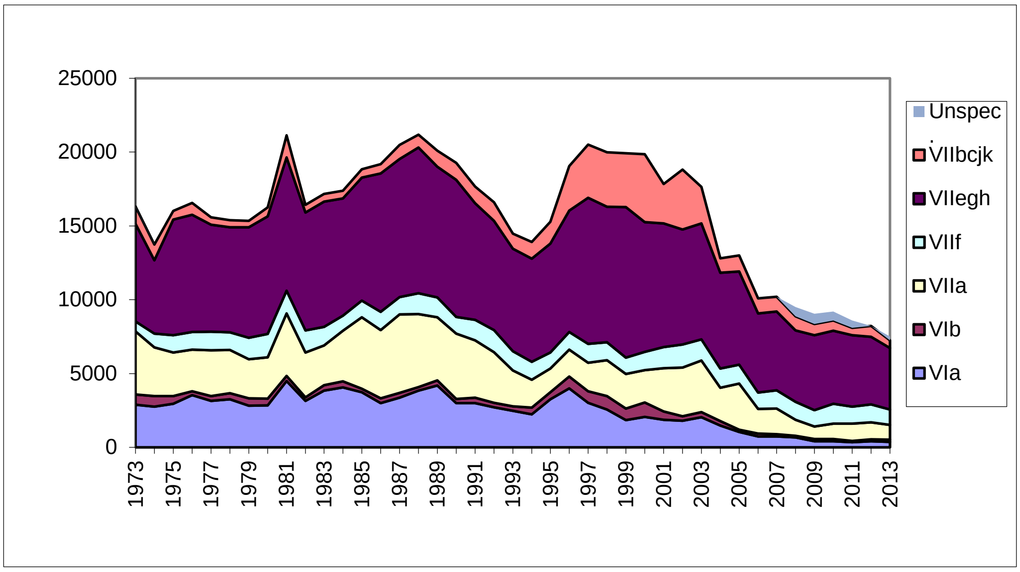


Figure 18.1c. Skates and rays in the Celtic Seas. Total landings (tonnes) of skates (Rajidae) by ICES Division in the Celtic Seas from 1973–2013 (Source: ICES).

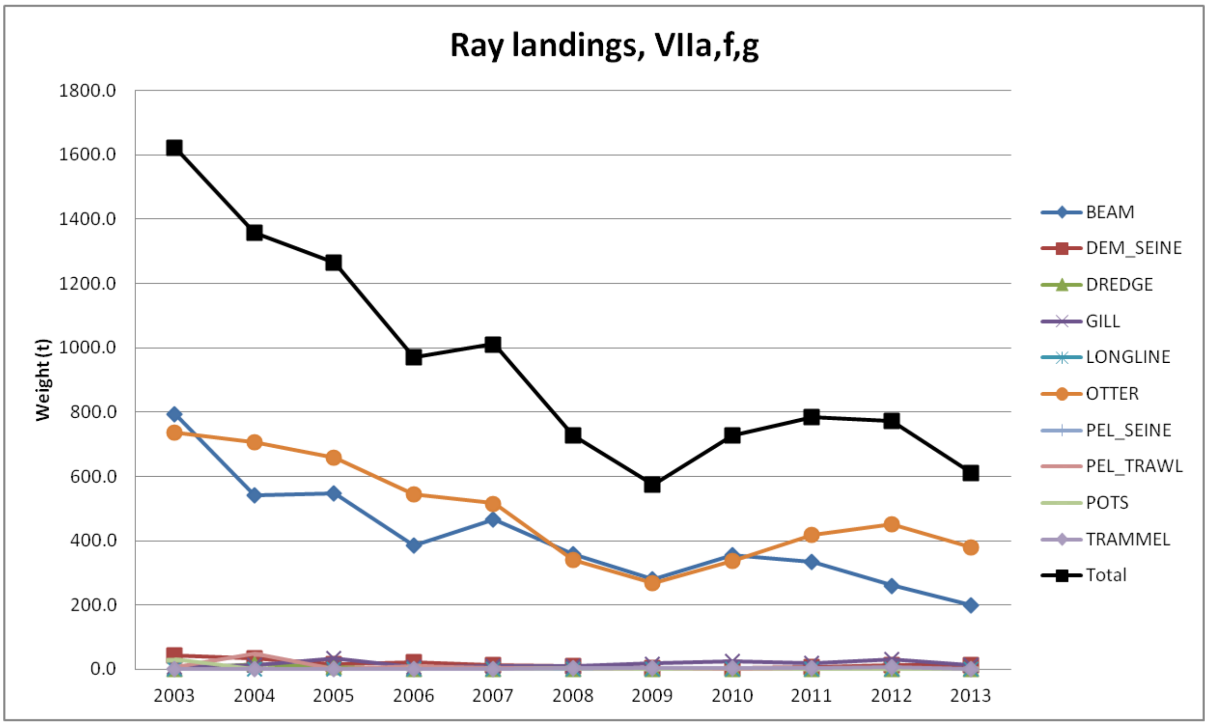


Figure 18.2. Skates and rays in the Celtic Seas. Landings by gear type of combined skate species within Divisions VIIa, VIIf, and VIIg, 2003–2013.

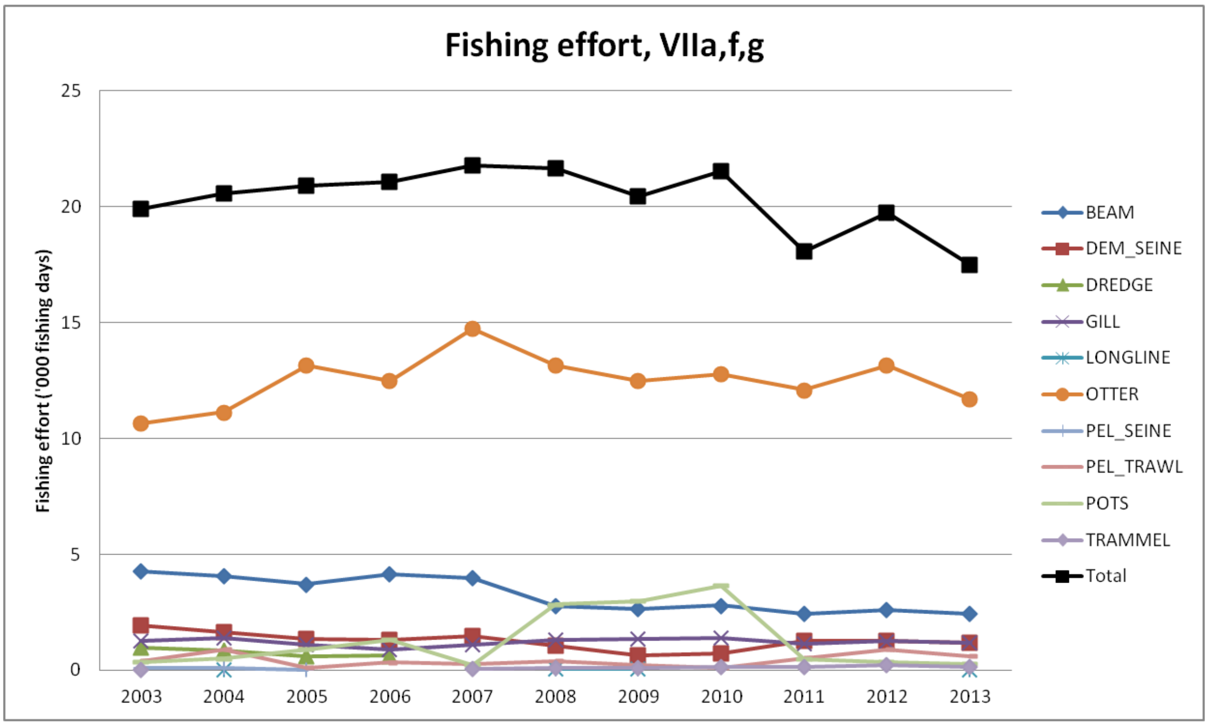


Figure 18.3. Skates and rays in the Celtic Seas. Fishing effort (in fishing days) by gear type within Divisions VIIa, VIIf, and VIIg, 2003–2013.

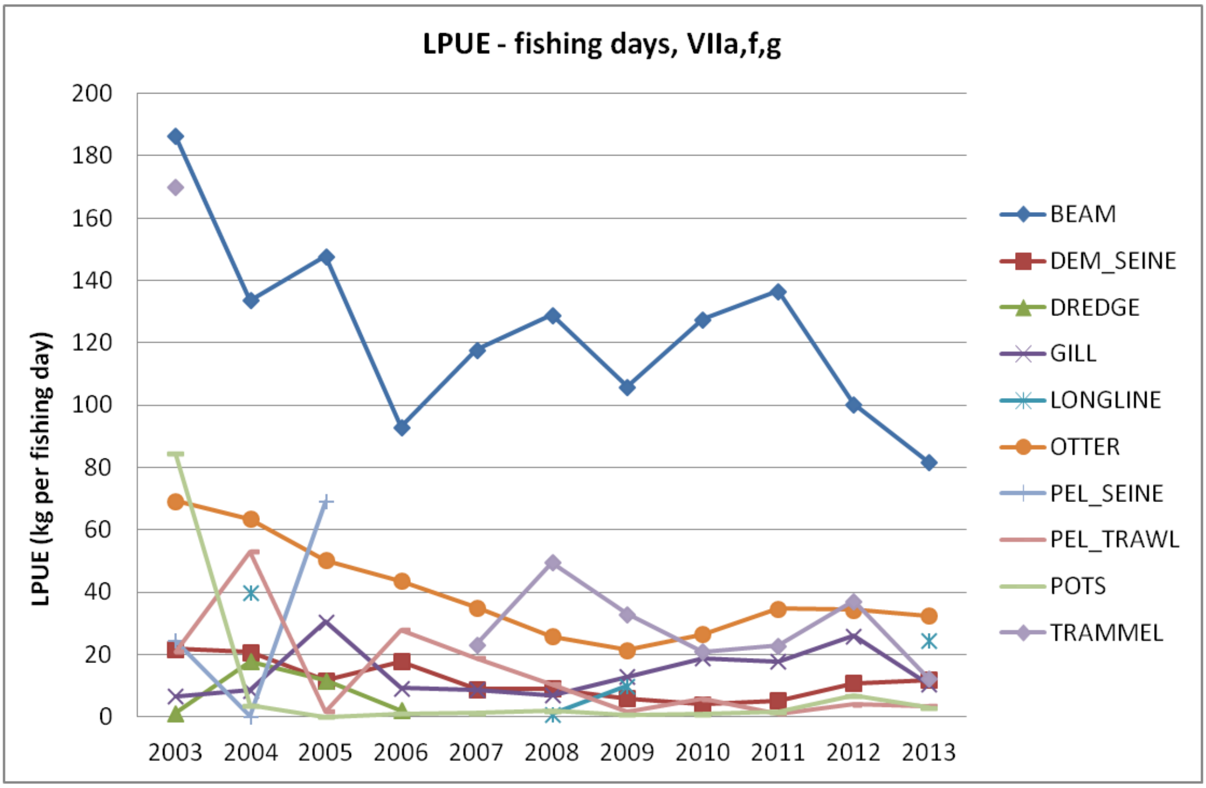


Figure 18.4. Skates and rays in the Celtic Seas. Irish lpue (in fishing days per kg) of combined skate species by gear types in Divisions VIIa, VIIf, and VIIg, 2003–2013.

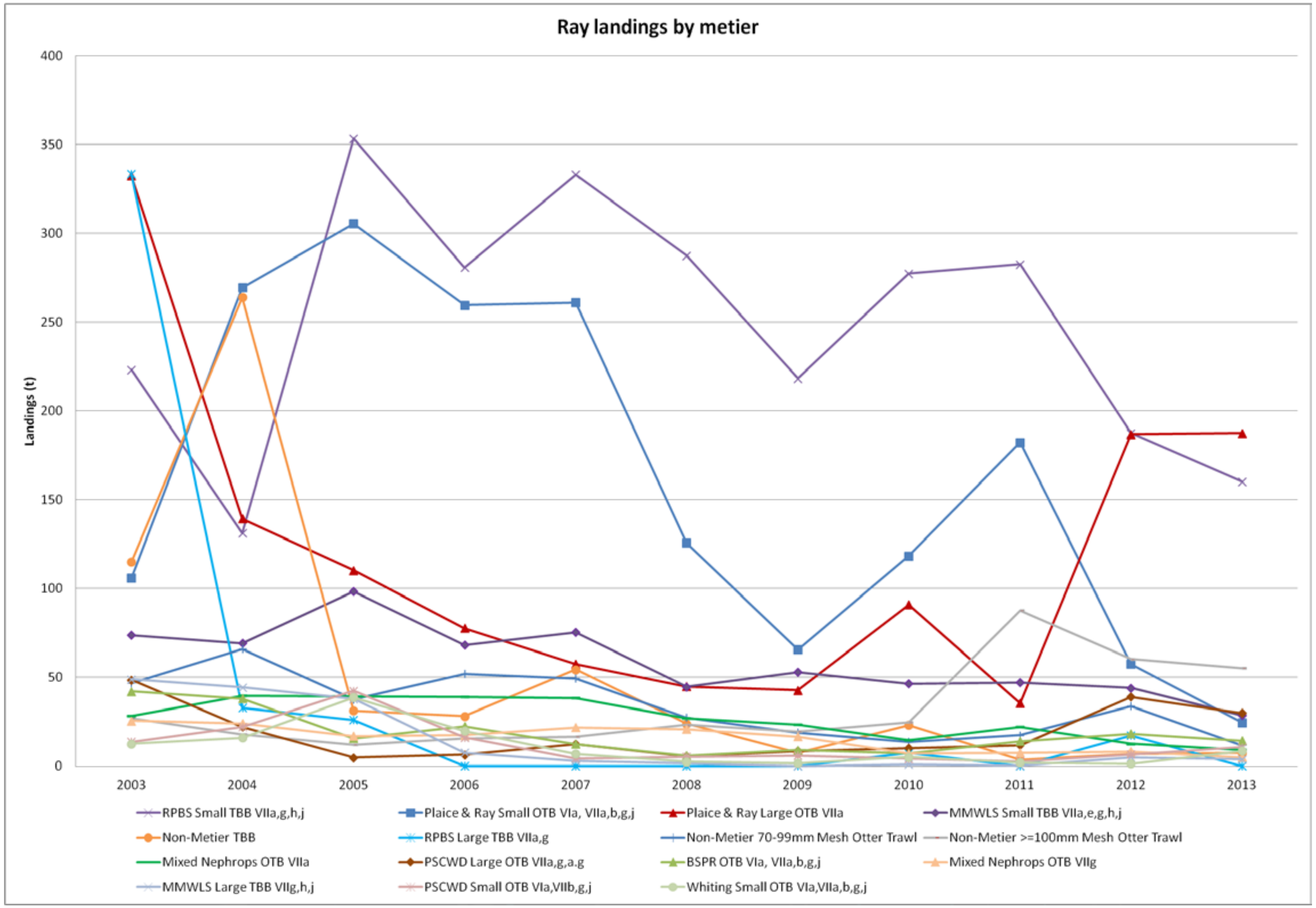


Figure 18.5. Skates and rays in the Celtic Seas. Landings of combined skate species by métier grouping (Davie and Lordan, 2011; Davie, 2014) in Divisions VIIa, VIIf, VIIg, 2003–2013.

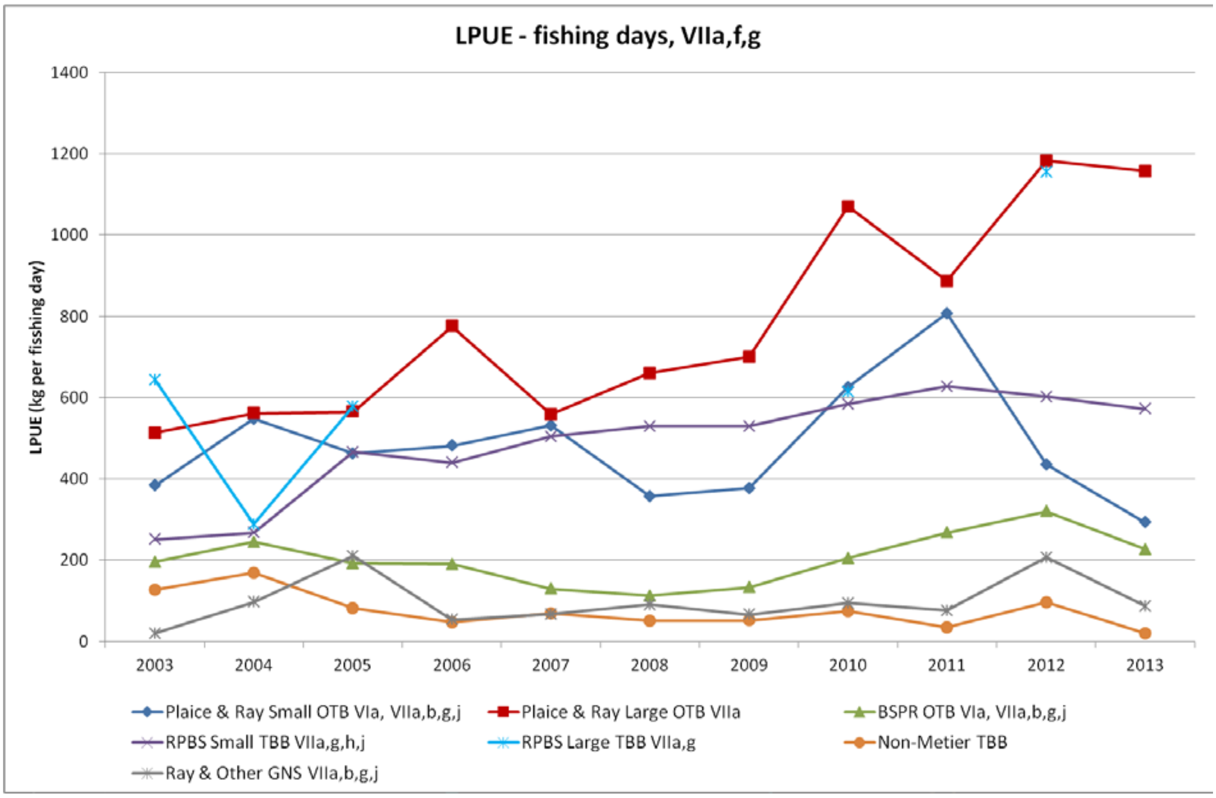


Figure 18.6. Skates and rays in the Celtic Seas. Irish lpue (in fishing days per kg) of combined skate species in Divisions VIIa, VIIf, and VIIg by targeting métiers (Table 1), 2003–2013.

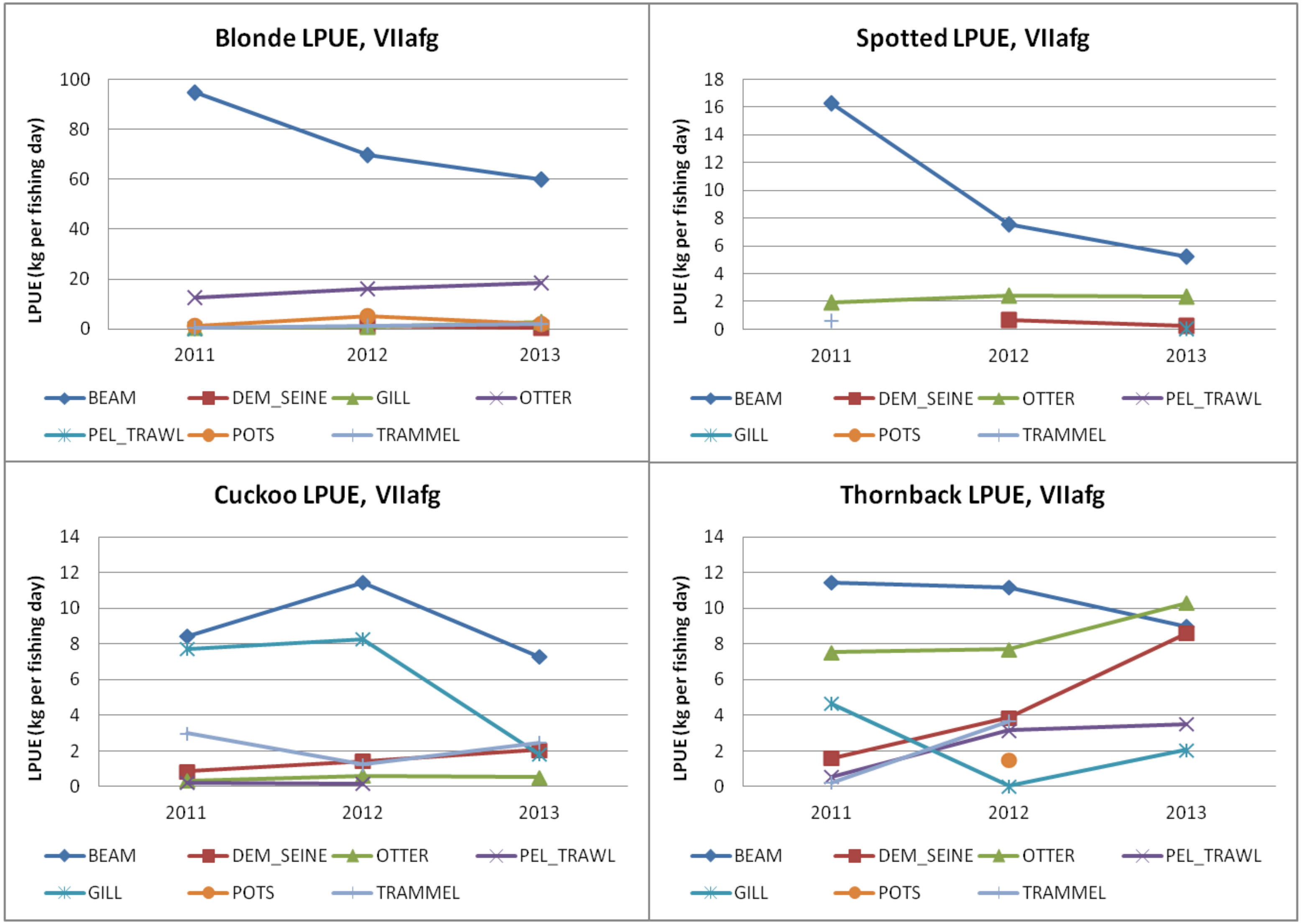


Figure 18.7. Skates and rays in the Celtic Seas. Irish lpue (in fishing days per kg) of the four skate species (blonde ray *R. brachyura,* thornback ray *R. clavata,* spotted ray *R. montagui* and cuckoo ray *L. naevus*) by gear type in Divisions VIIa, VIIf, VIIg, 2011–2013.

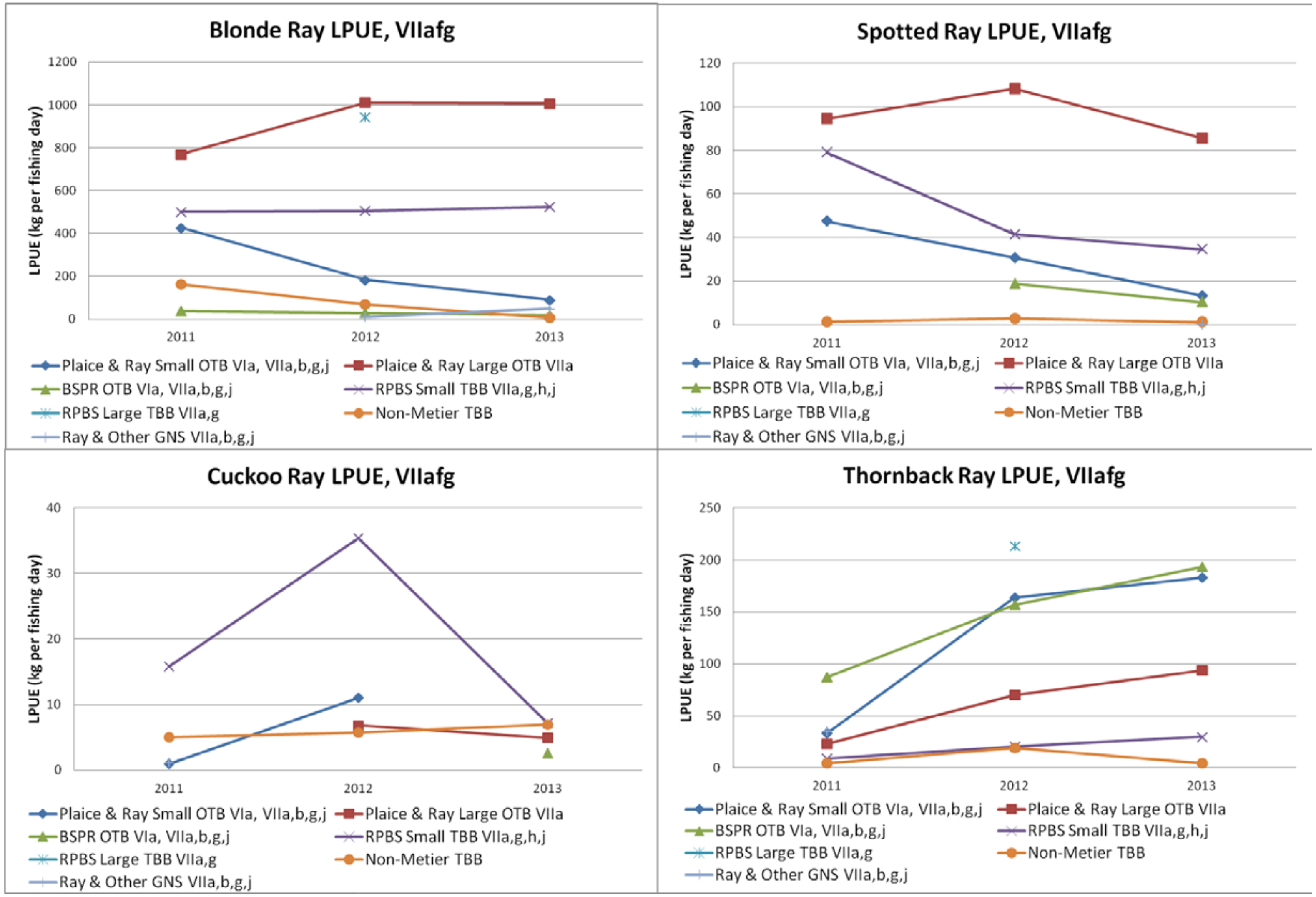


Figure 18.8. Skates and rays in the Celtic Seas. Irish lpue (in fishing days per kg) of the four skate species (blonde ray *R. brachyura,* thornback ray *R. clavata,* spotted ray *R. montagui* and cuckoo ray *L. naevus*) by targeting métiers in Divisions VIIa, VIIf, VIIg, 2011–2013.

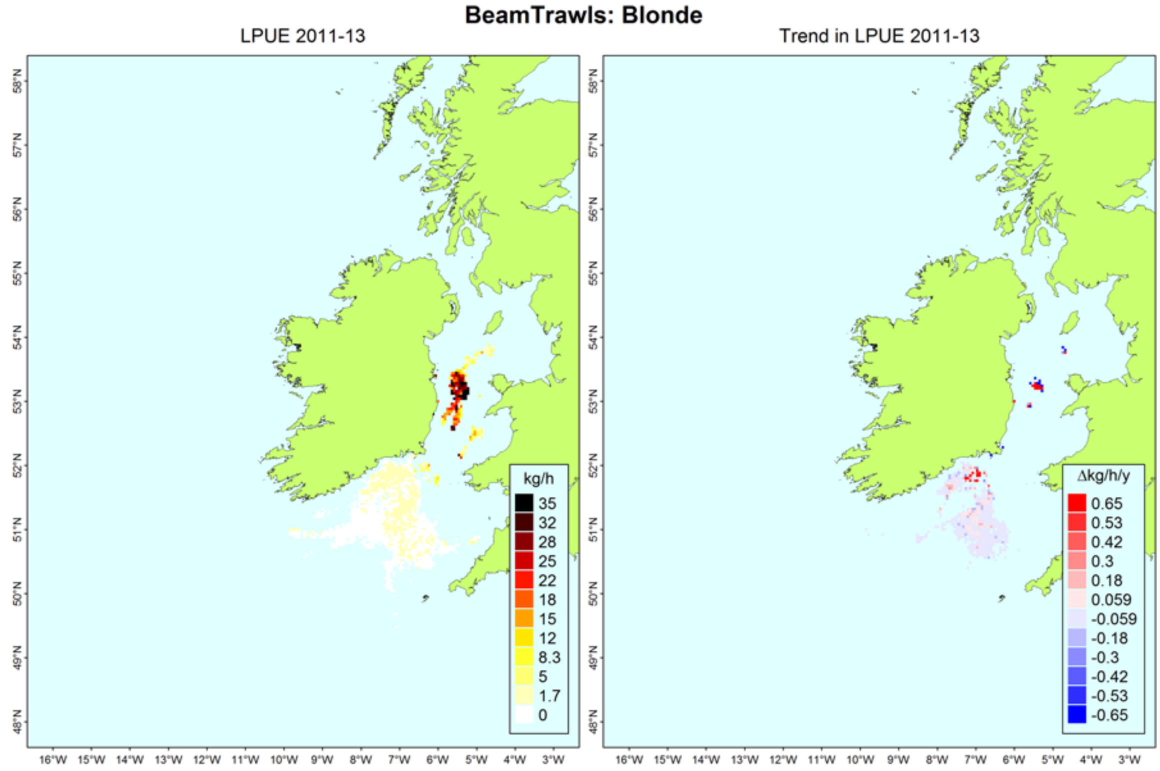


Figure 18.9. Skates and rays in the Celtic Seas. Lpue (kg/h) distribution and trend plots of *R. brachyura* landed by beam trawls, 2011–2013.

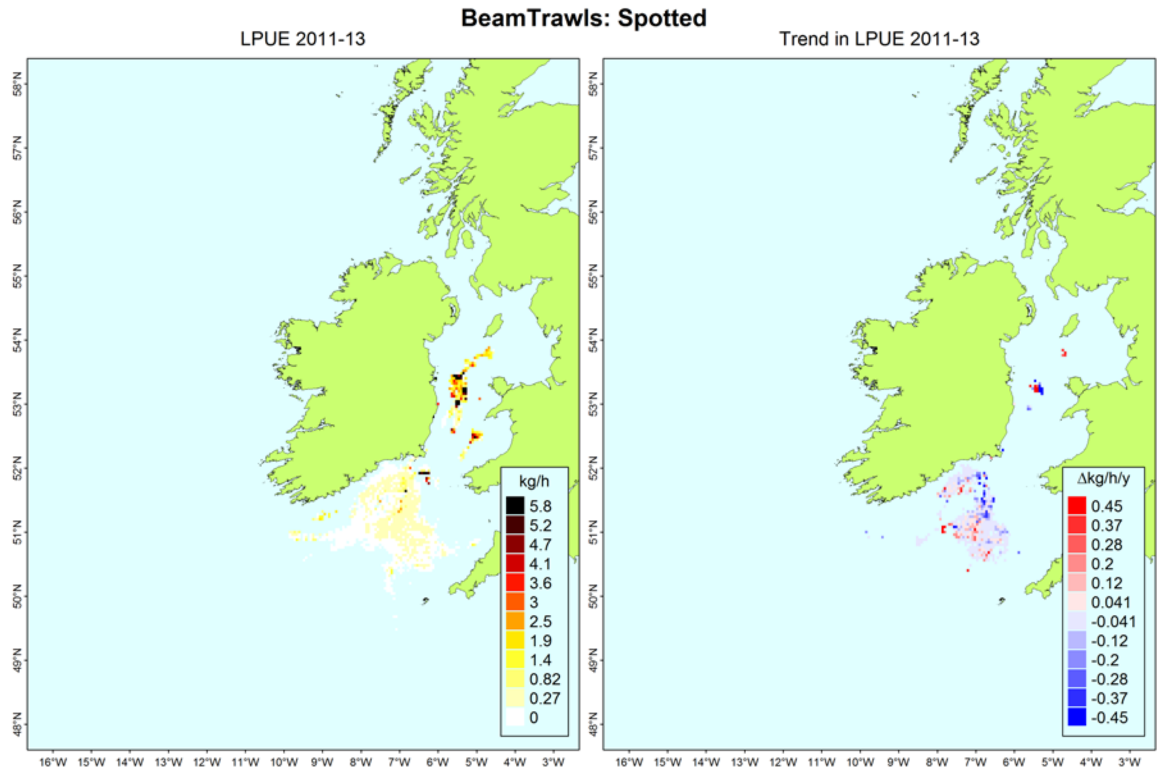


Figure 18.10. Skates and rays in the Celtic Seas. Lpue (kg/h) distribution and trend plots of *R. montagui* landed by beam trawls, 2011–2013.

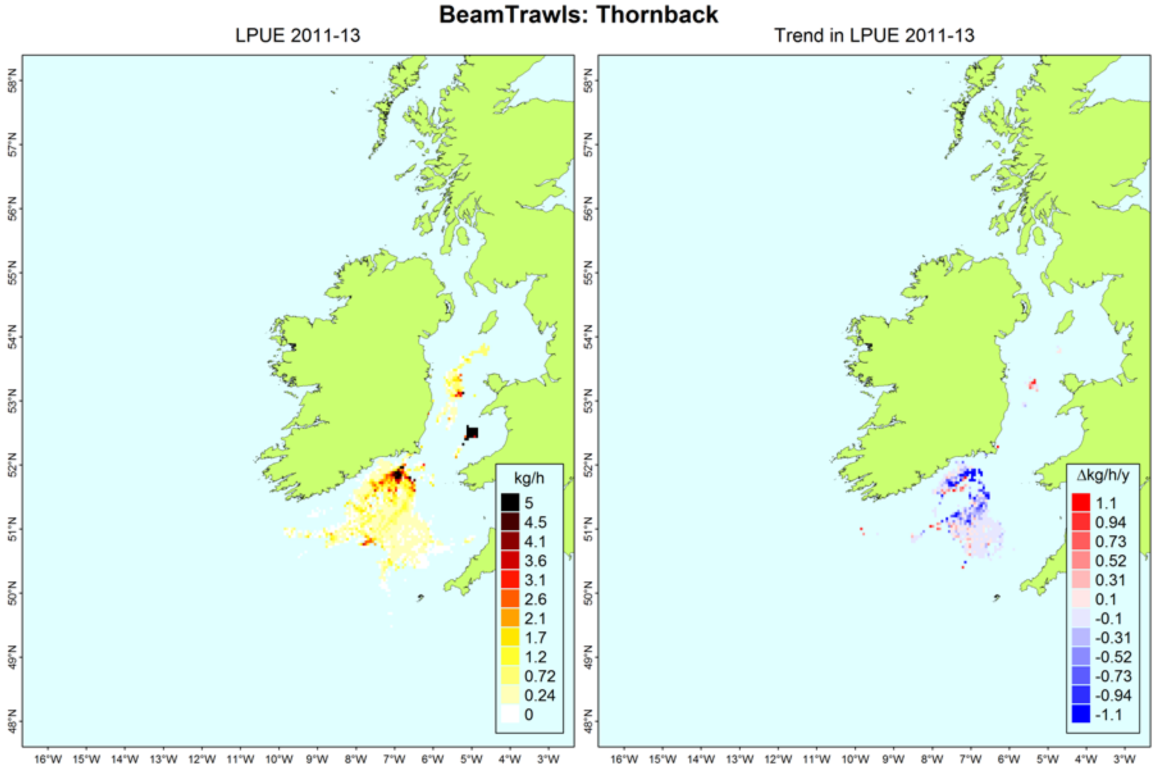


Figure 18.11. Skates and rays in the Celtic Seas. Lpue (kg/h) distribution and trend plots of *R. clavata* landed by beam trawls, 2011–2013.

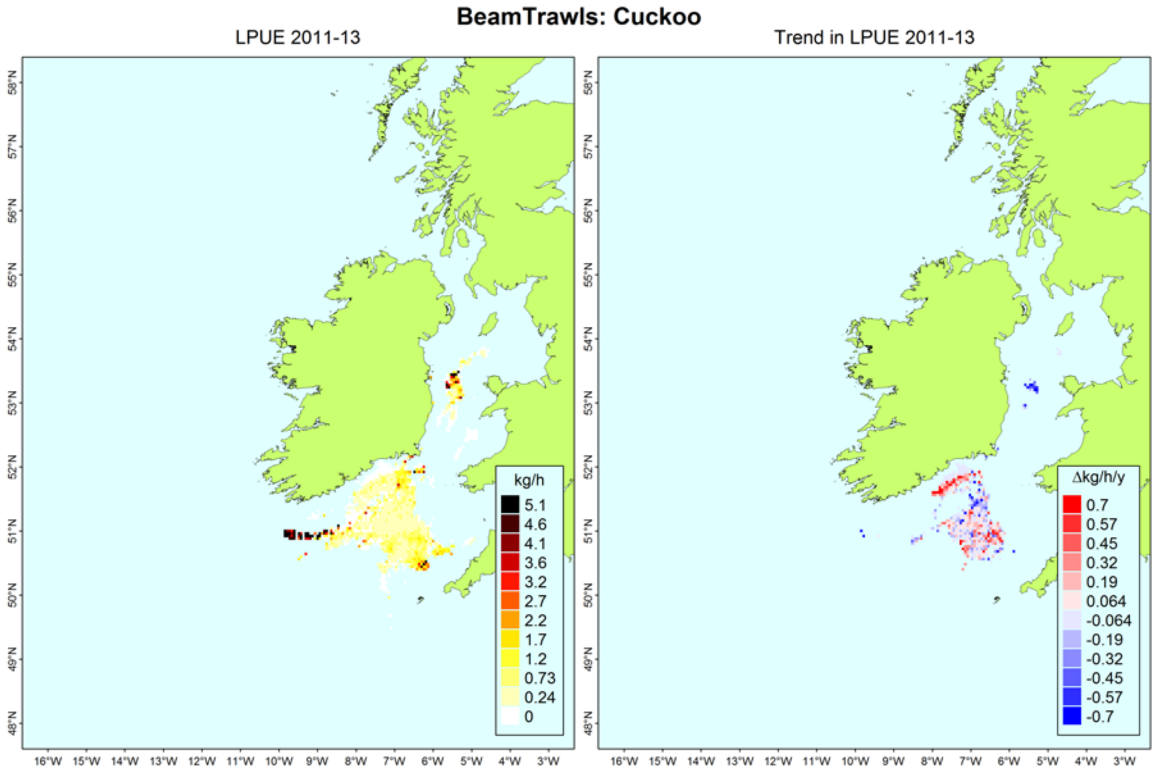


Figure 18.12. Skates and rays in the Celtic Seas. Lpue (kg/h) distribution and trend plots of *L. naevus* landed by beam trawls, 2011–2013.

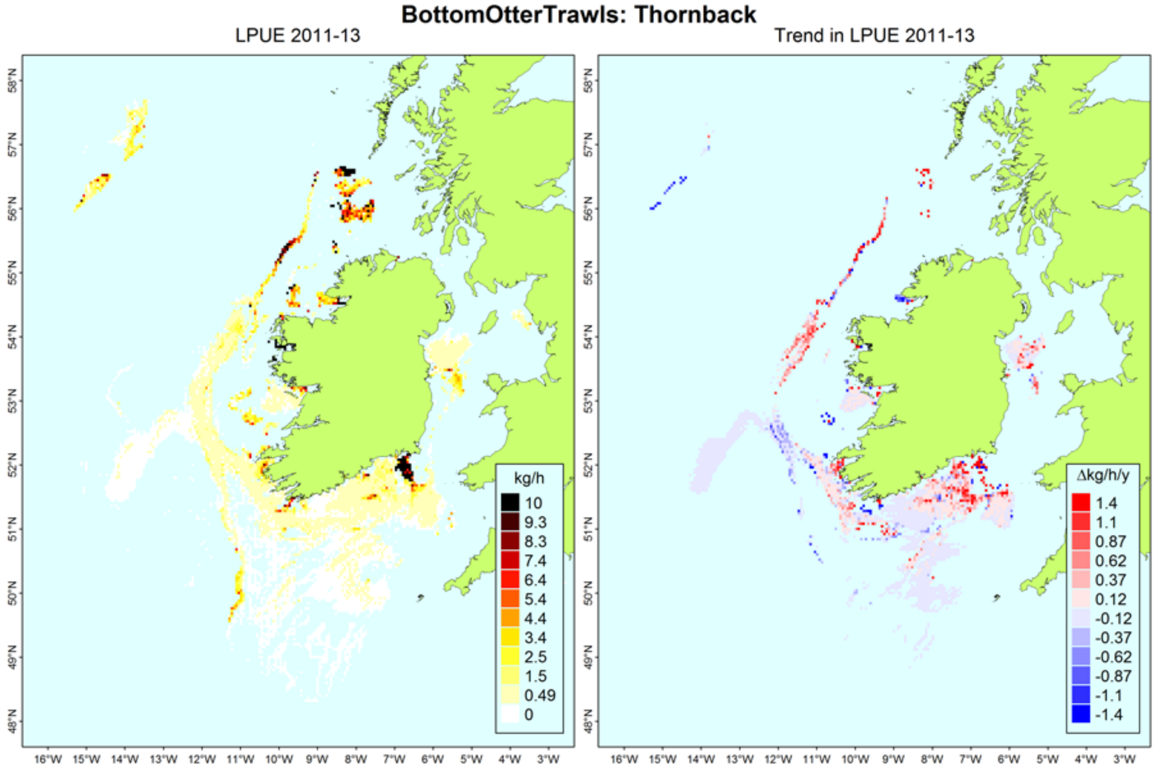


Figure 18.13. Skates and rays in the Celtic Seas. Lpue (kg/h) distribution and trend plots of *R. clavata* landed by otter trawls, 2011–2013.

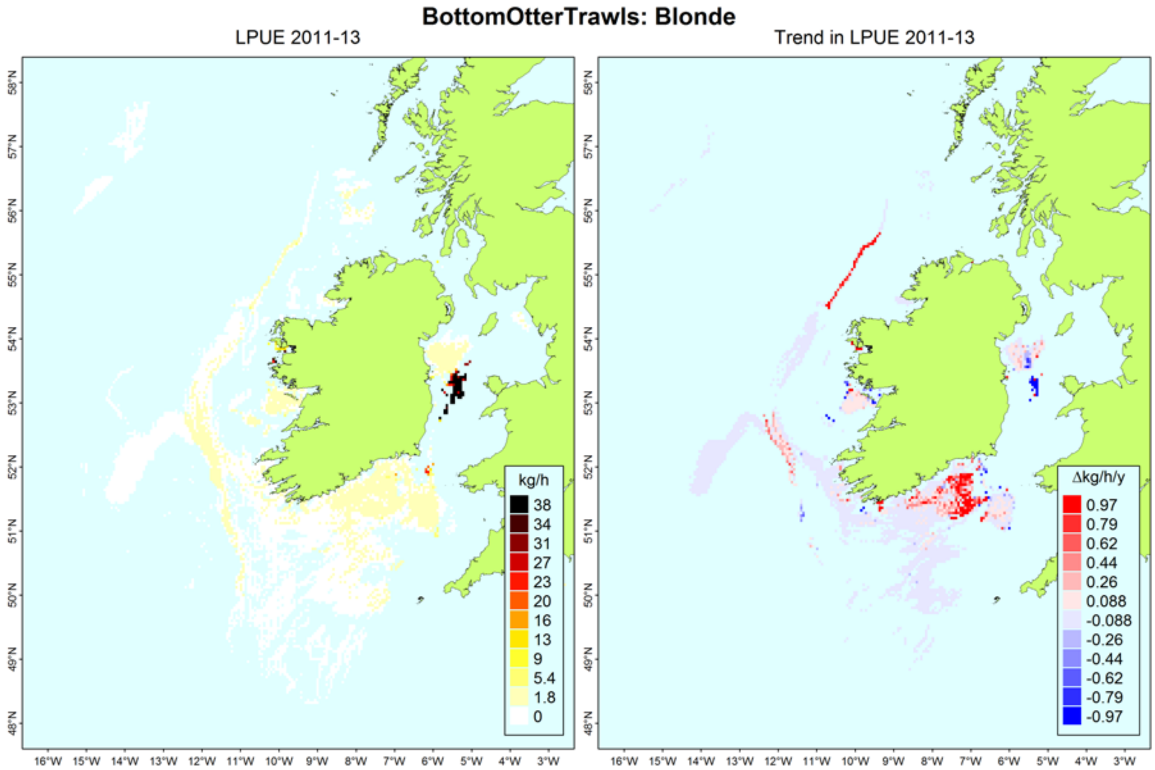


Figure 18.14. Skates and rays in the Celtic Seas. Lpue (kg/h) distribution and trend plots of *R. brachyura* landed by otter trawls, 2011–2013.

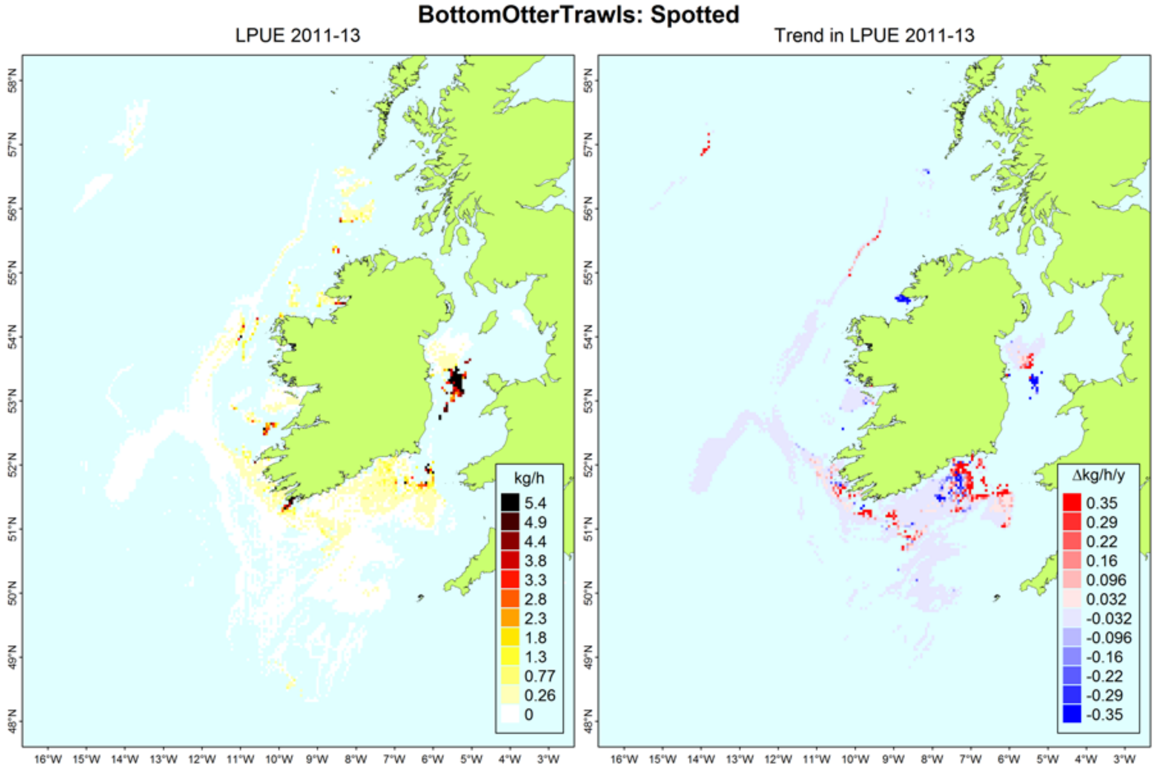


Figure 18.15. Skates and rays in the Celtic Seas. Lpue (kg/h) distribution and trend plots of *R. montagui* landed by otter trawls, 2011–2013.

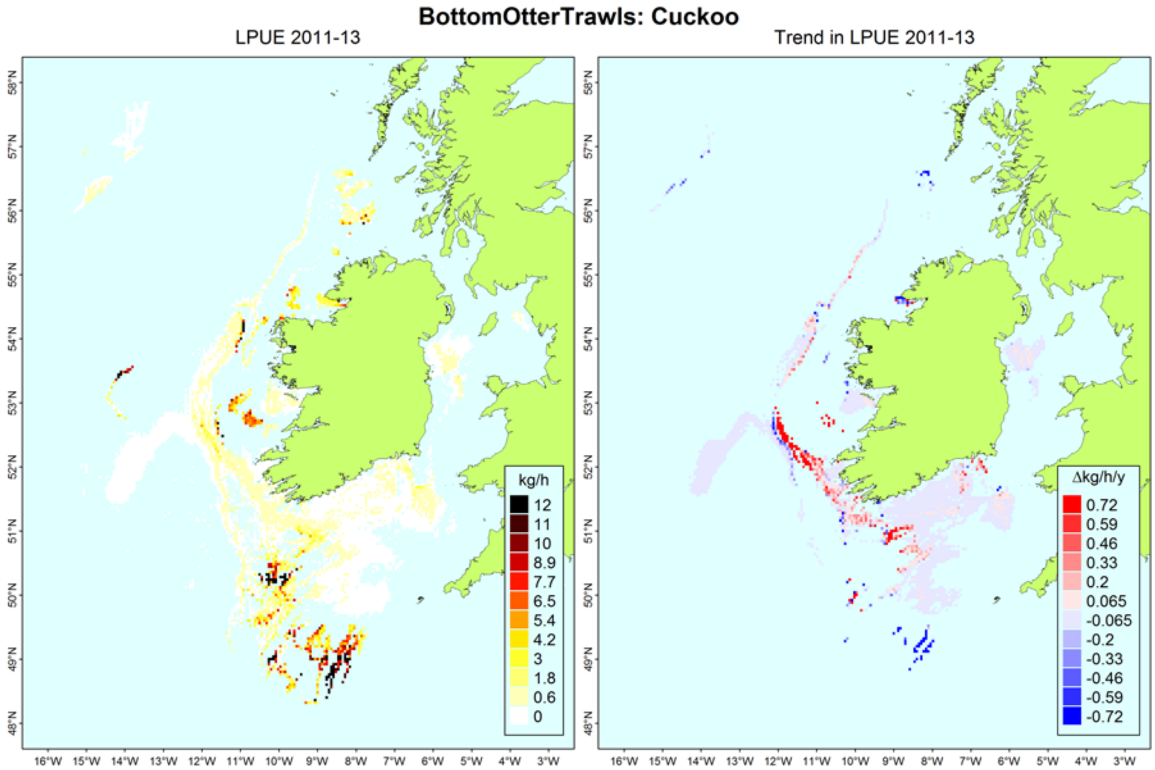


Figure 18.16. Skates and rays in the Celtic Seas. Lpue (kg/h) distribution and trend plots of *L. naevus* landed by otter trawls, 2011–2013.

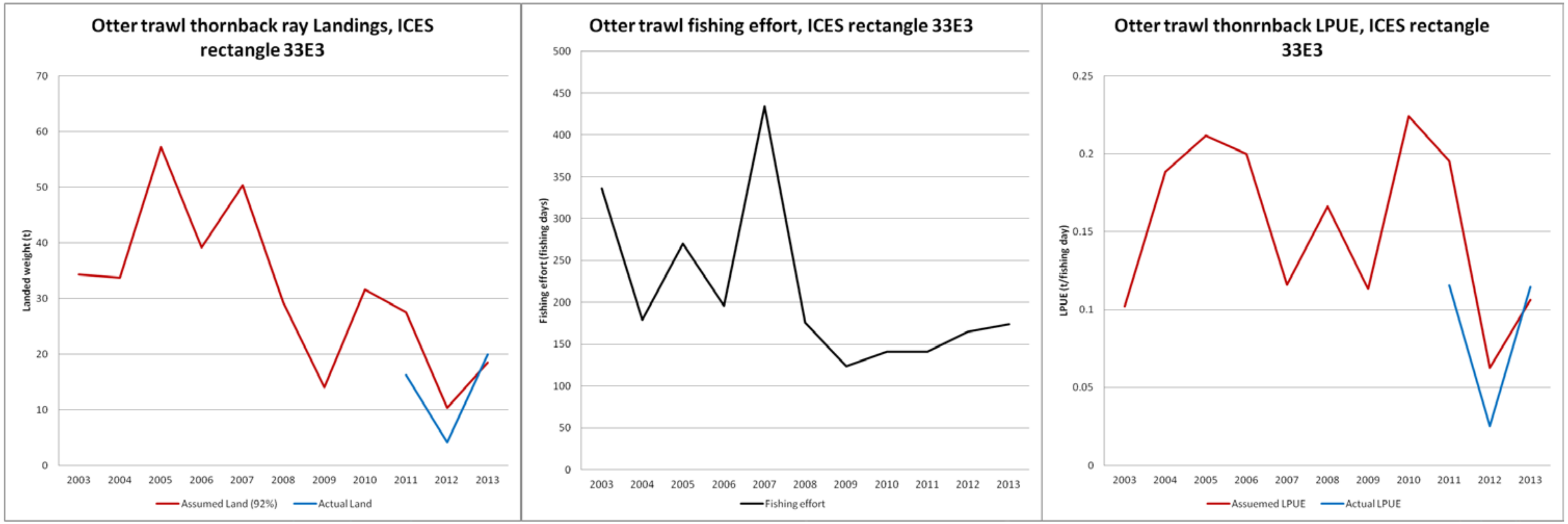


Figure 18.17. Skates and rays in the Celtic Seas. Otter trawl fishing effort, *Raja clavata* landings and lpue from ICES rectangle 33E3. Assumed landings and lpue values generated from average thornback contribution to skate composition from 2011–2013 (92%) applied back to 2003.

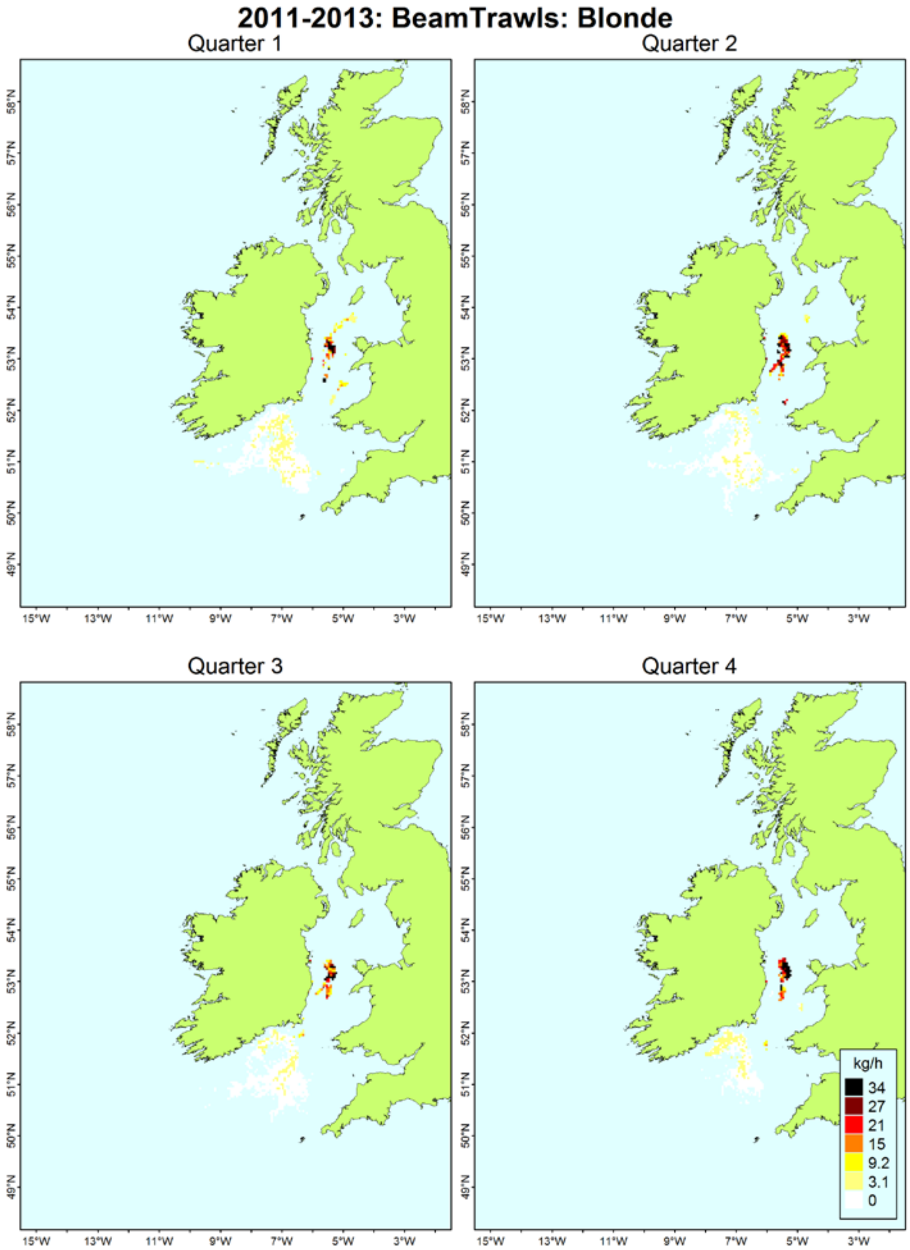


Figure 18.18. Skates and rays in the Celtic Seas. Quarterly lpue (kg/h) distribution plots of *R. brachyura* landed beam trawls, 2011–2013.

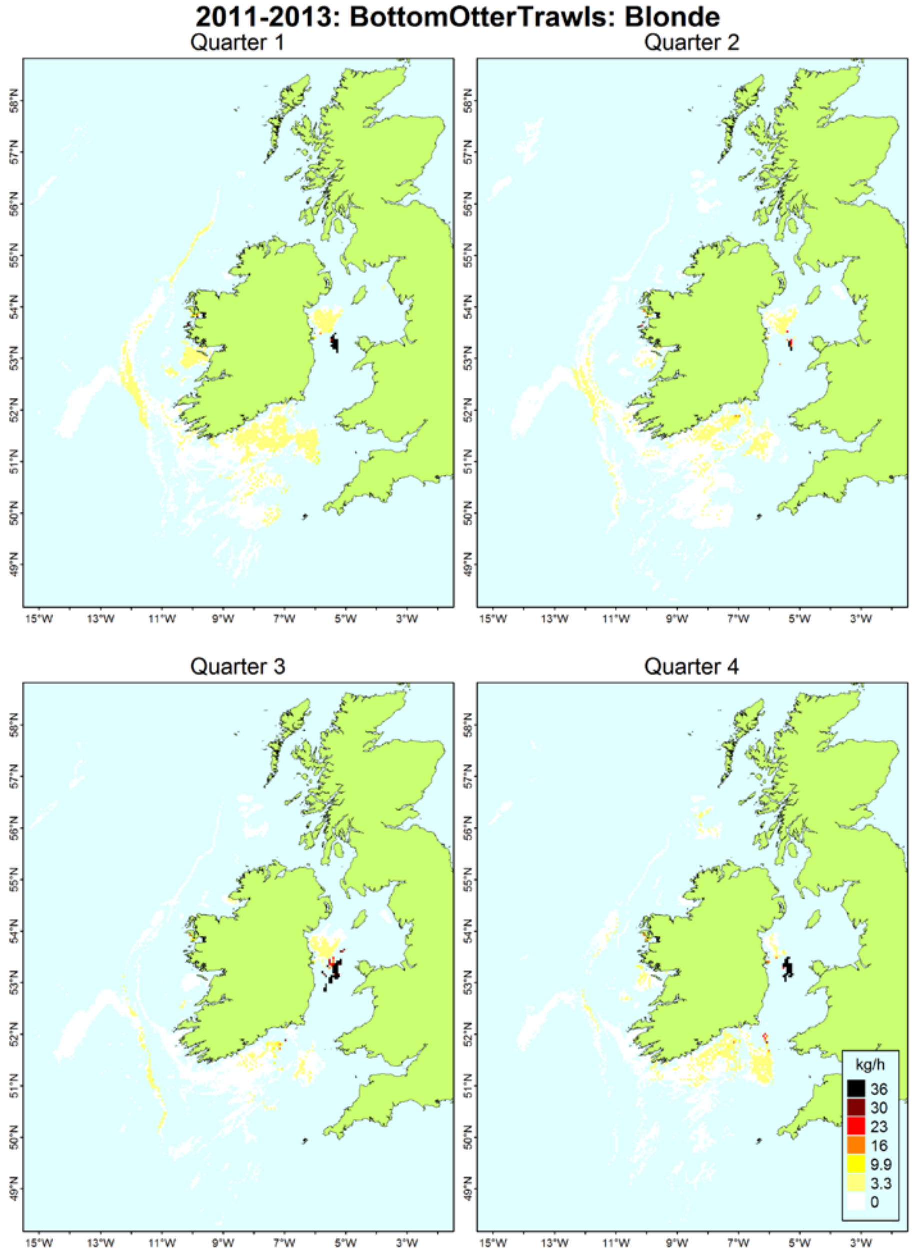


Figure 18.19. Skates and rays in the Celtic Seas. Quarterly lpue (kg/h) distribution plots of *R. brachyura* landed otter trawls, 2011–2013.

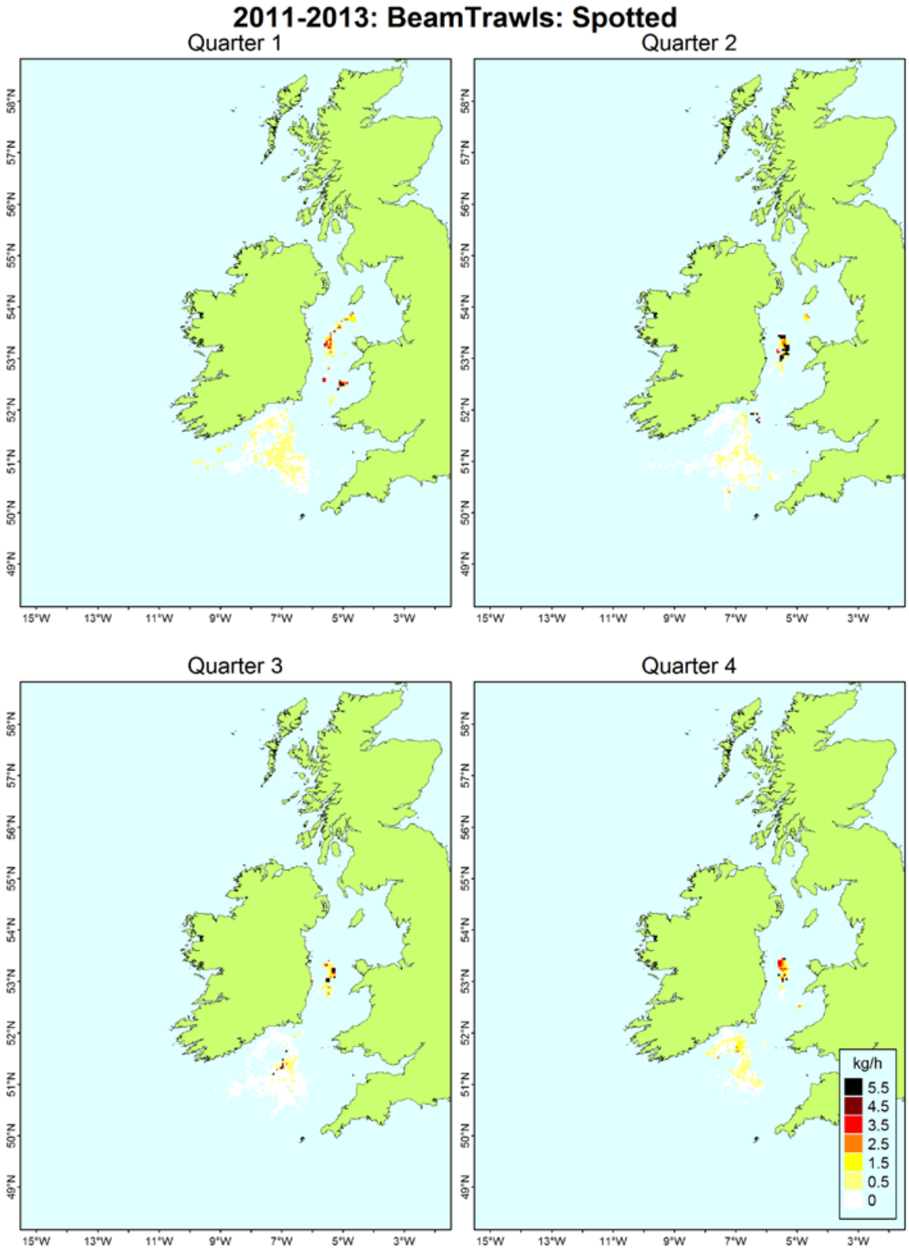


Figure 18.20. Skates and rays in the Celtic Seas. Quarterly lpue (kg/h) distribution plots of *R. montagui* landed beam trawls, 2011–2013.

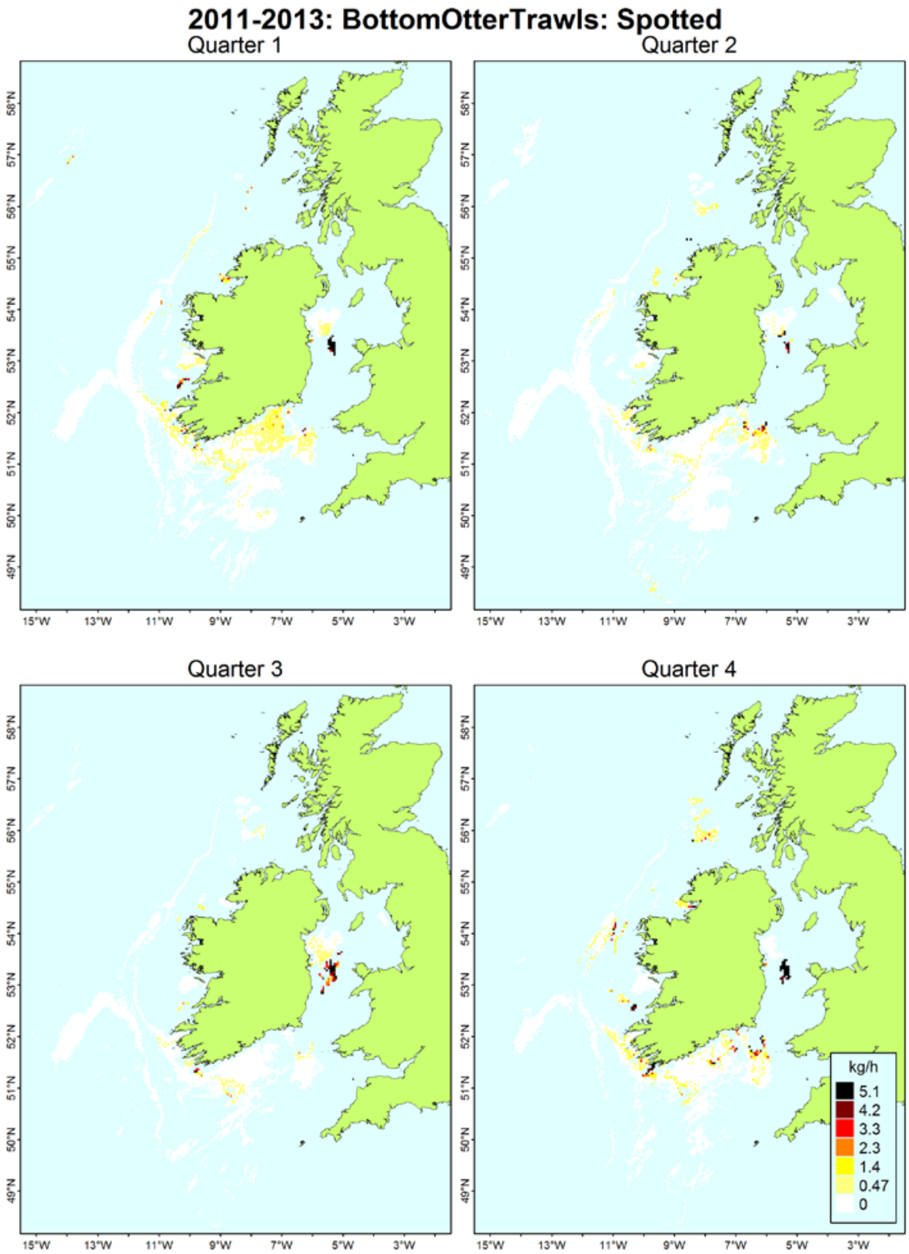


Figure 18.21. Skates and rays in the Celtic Seas. Quarterly lpue (kg/h) distribution plots of *R. montagui* landed otter trawls, 2011–2013.

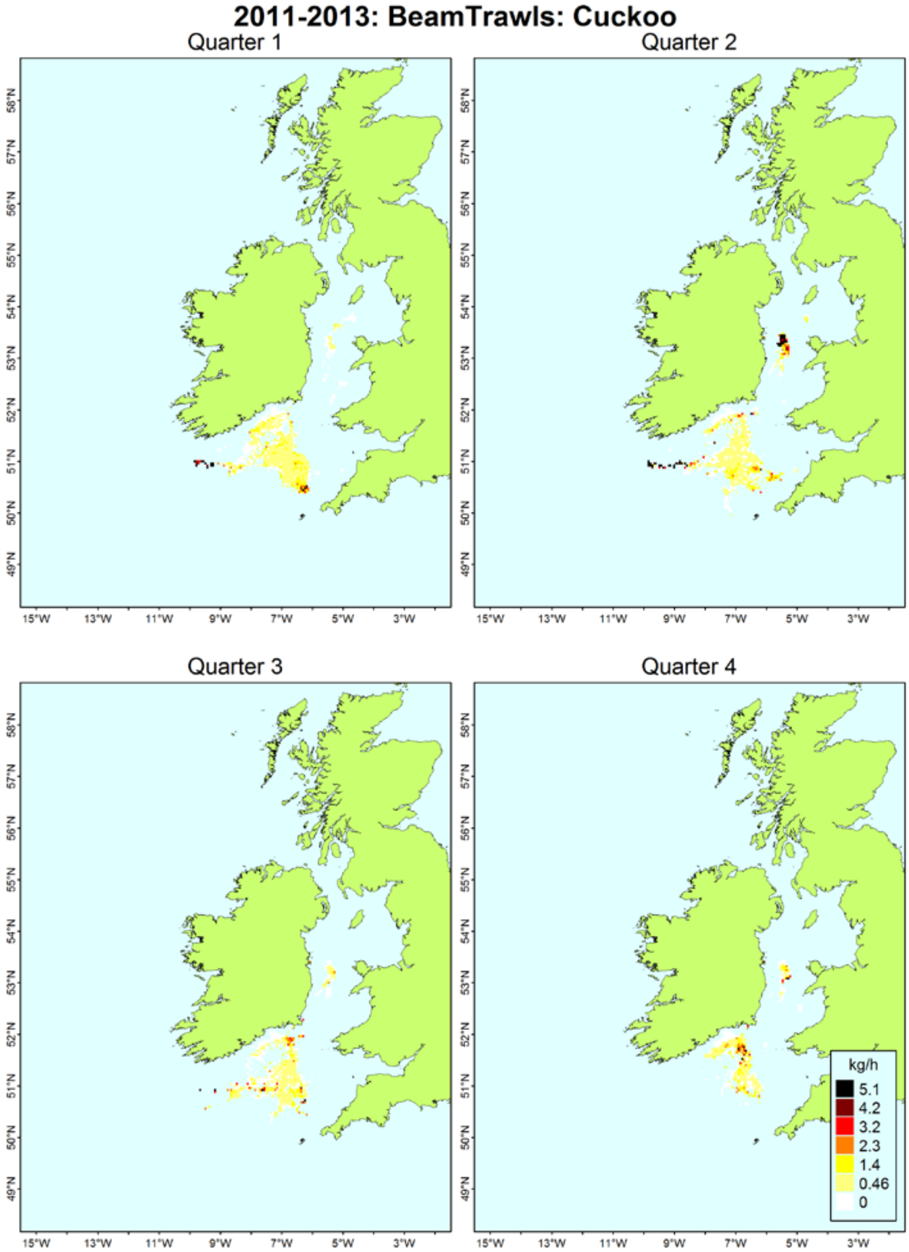


Figure 18.22. Skates and rays in the Celtic Seas. Quarterly lpue (kg/h) distribution plots of *L. naevus* landed beam trawls, 2011–2013.

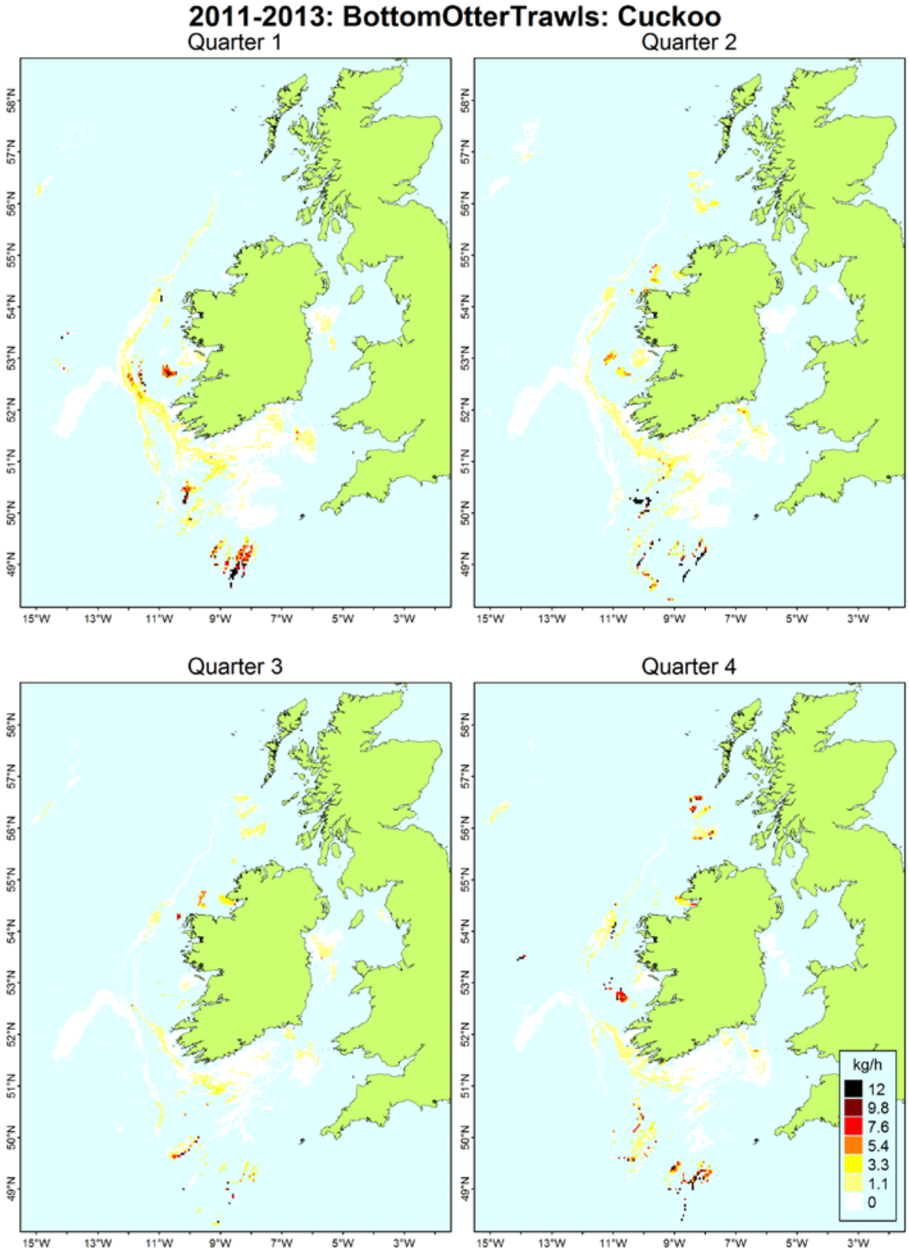


Figure 18.23. Skates and rays in the Celtic Seas. Quarterly lpue (kg/h) distribution plots of *L. naevus* landed otter trawls, 2011–2013.

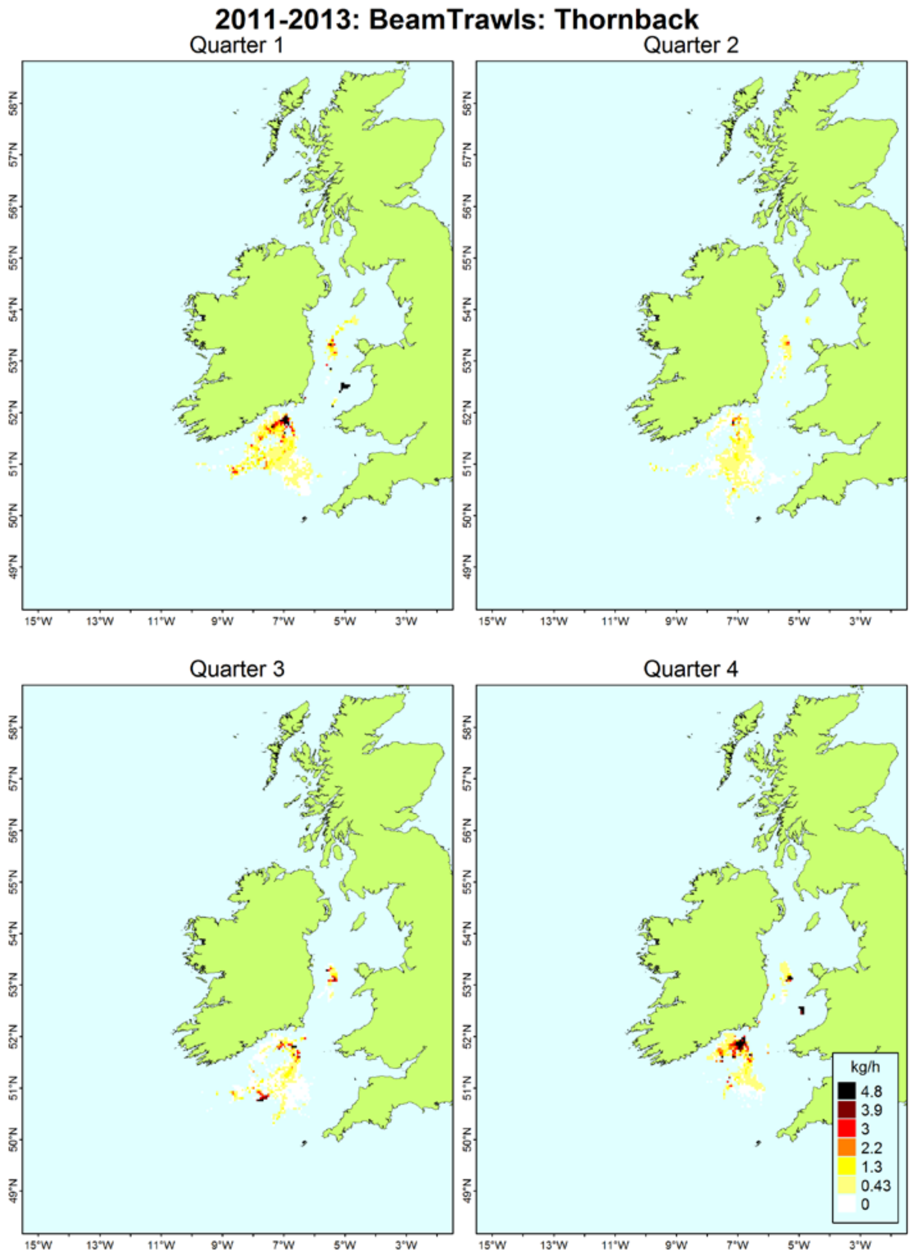


Figure 18.24. Skates and rays in the Celtic Seas. Quarterly lpue (kg/h) distribution plots of *R. clavata* landed beam trawls, 2011–2013.

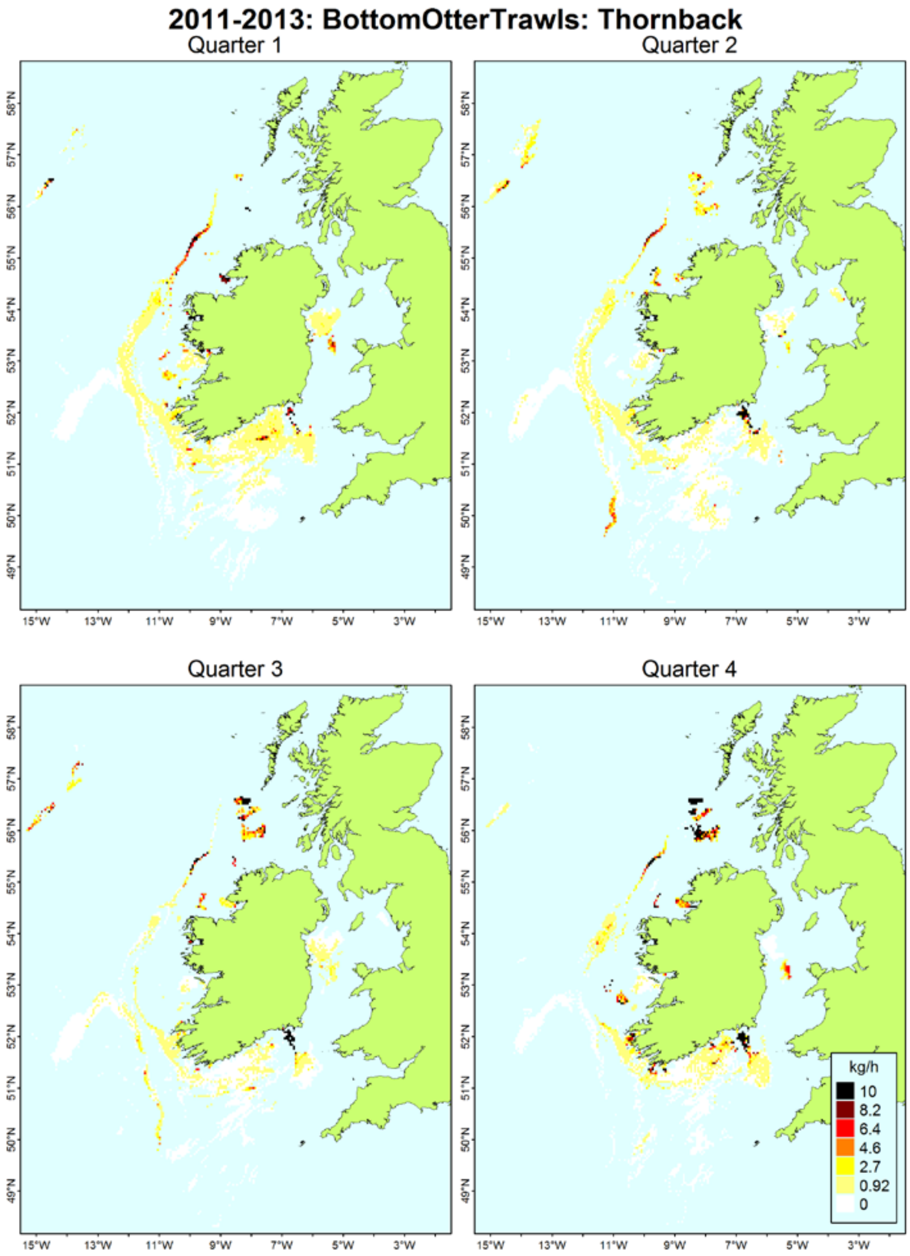


Figure 18.25. Skates and rays in the Celtic Seas. Quarterly lpue (kg/h) distribution plots of *R. clavata* otter trawls, 2011–2013.

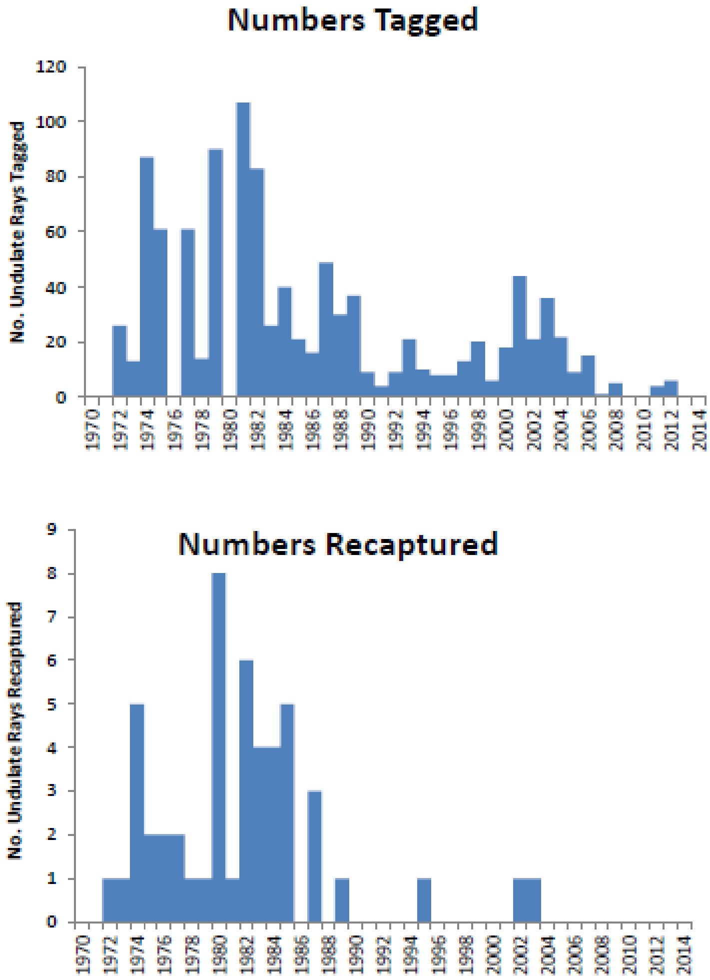


Figure 18.26. Skates in the Celtic Seas. Numbers of *Raja undulata* tagged (top) and recaptured (bottom) in Tralee Bay and surroundings, 1970–2014. Source: Wogerbauer *et al*, 2014 WD.

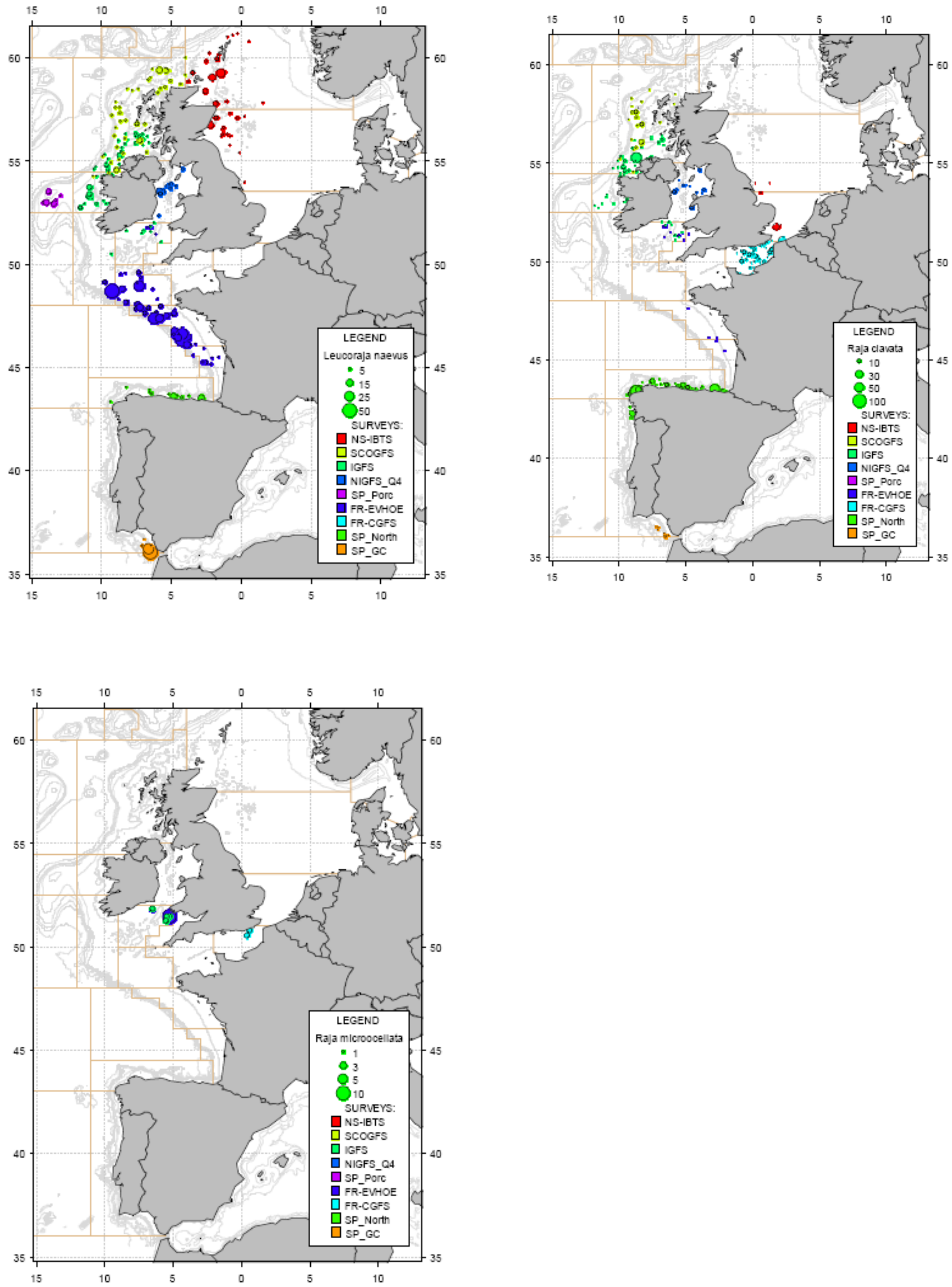


Figure 18.27. Skates and rays in the Celtic Seas. Catches, in numbers per hour, of cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata*, small-eyed ray *Raja microocellata* in Q4 IBTS surveys in the southern and western areas in 2011. The catchability of the different gears used in these surveys is not constant; therefore these maps do not reflect proportional abundance in all the areas but within each survey (see ICES, 2013a for further details).

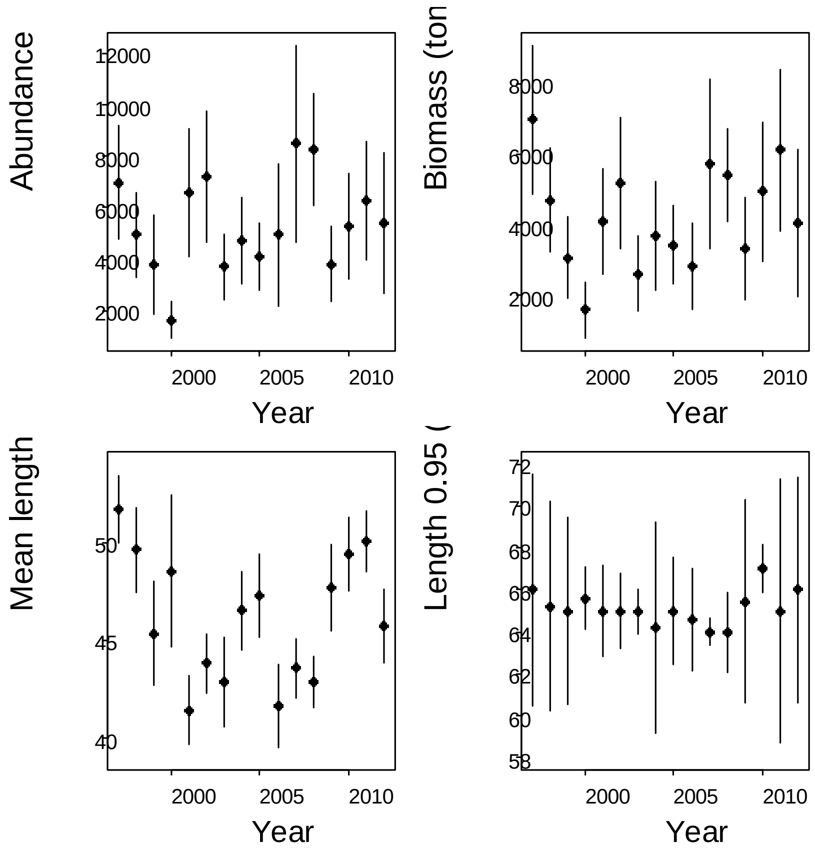


Figure 18.28. Skates and rays in the Celtic Seas. a) Temporal trends in relative abundance (numbers), biomass, and mean length of *Leucoraja naevus* in the French Evhoe Q4 survey of VIIg–k.

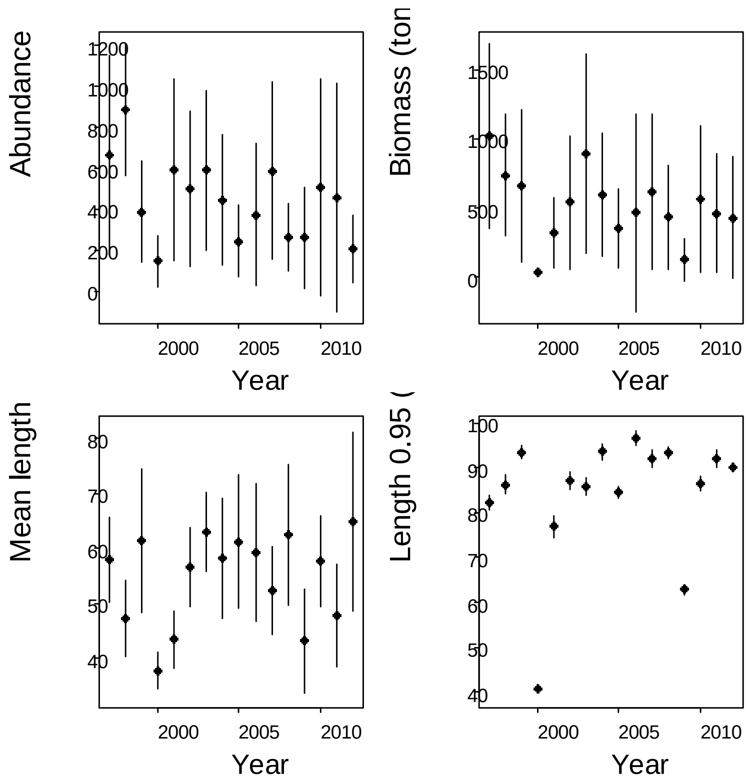


Figure 18.28.b) Skates and rays in the Celtic Seas. Temporal trends in relative abundance (numbers), biomass, and mean length of *Leucoraja fullonica* in the French Evhoe Q4 survey of VIIg–k.

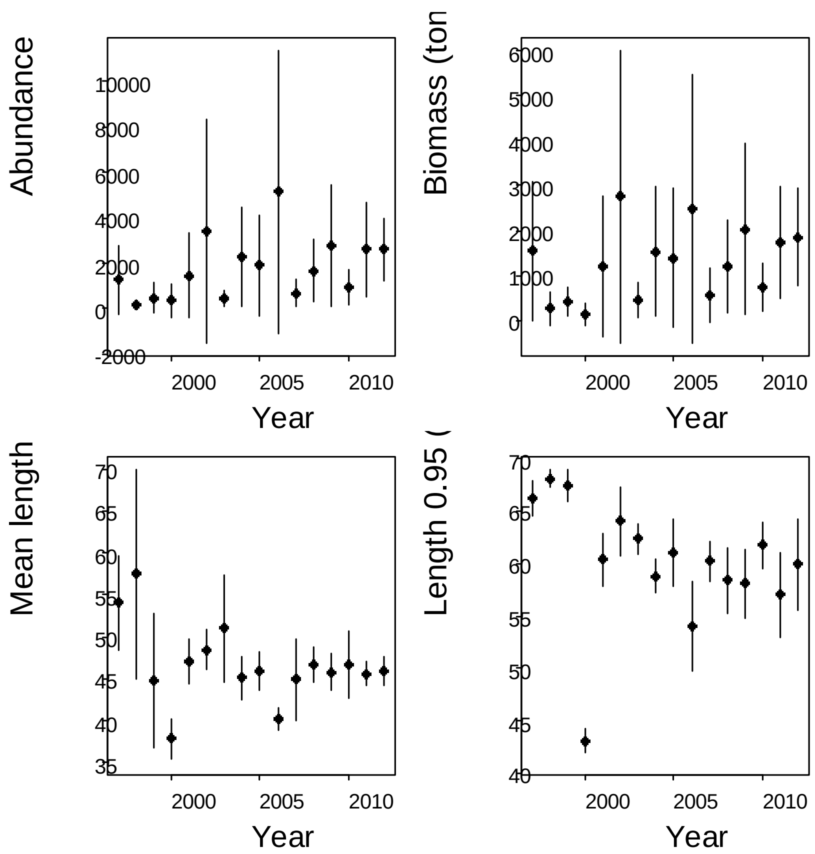


Figure 18.28.c) Skates and rays in the Celtic Seas. Temporal trends in relative abundance (numbers), biomass, and mean length of *Raja montagui* in the French Evhoe Q4 survey of VIIg–k.

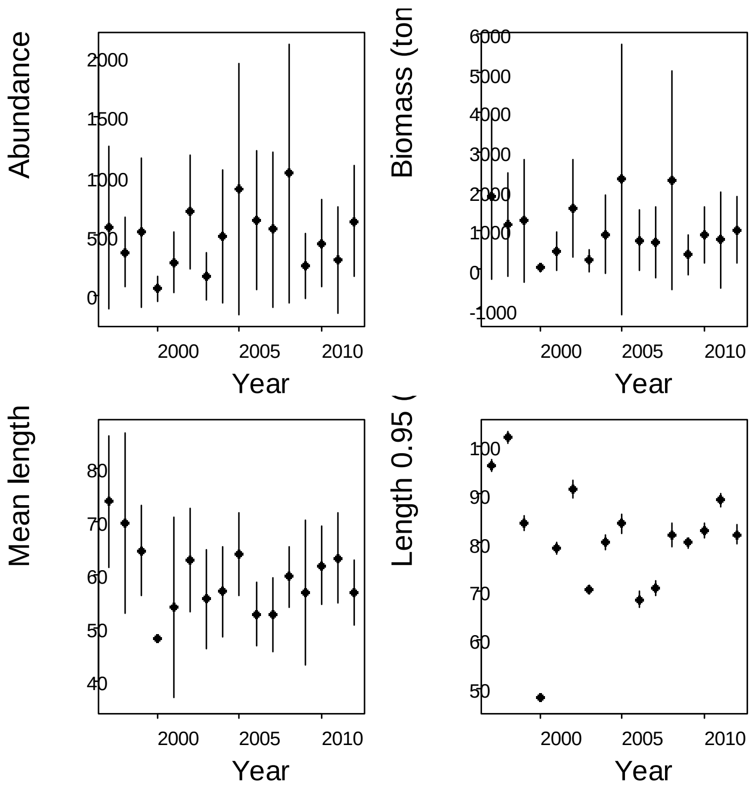


Figure 18.28.d) Skates and rays in the Celtic Seas. Temporal trends in relative abundance (numbers), biomass, and mean length of *Raja clavata* in the French Evhoe Q4 survey of VIIg–k.

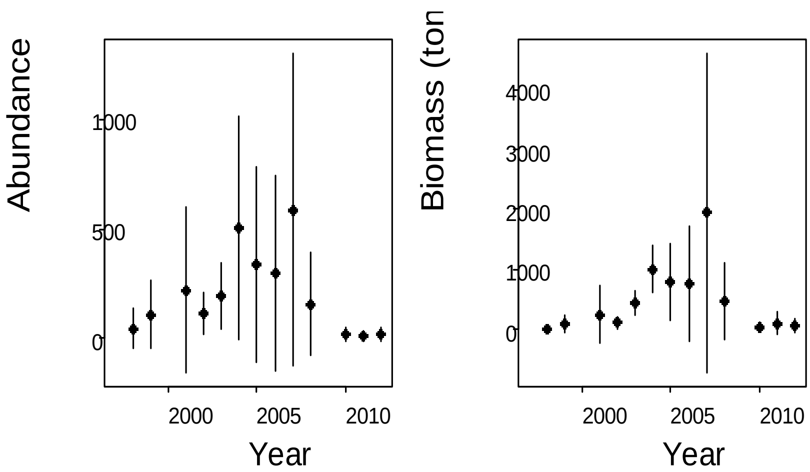


Figure 18.28.e) Skates and rays in the Celtic Seas. Temporal trends in relative abundance (numbers), biomass, and mean length of *Leucoraja circularis* in the French Evhoe Q4 survey of VIIg–k.

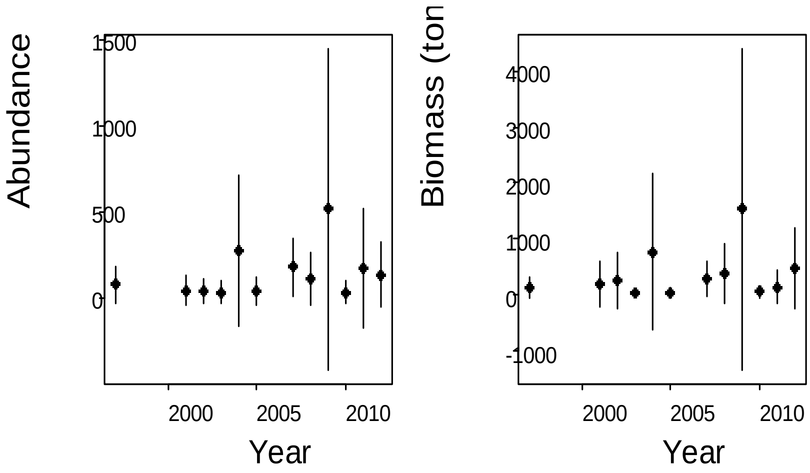


Figure 18.28.f) Skates and rays in the Celtic Seas. Temporal trends in relative abundance (numbers), biomass, and mean length of *Raja brachyura* in the French Evhoe Q4 survey of VIIg–k.

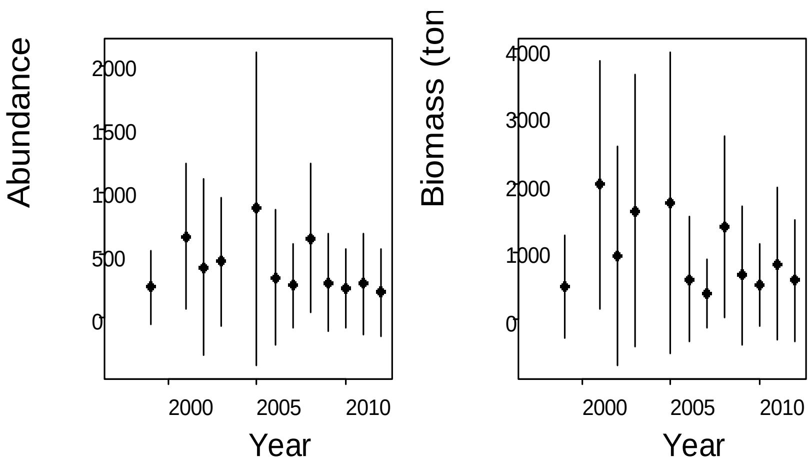


Figure 18.28.g) Skates and rays in the Celtic Seas. Temporal trends in relative abundance (numbers), biomass, and mean length of *Raja microocellata* in the French Evhoe Q4 survey of VIIg–k.

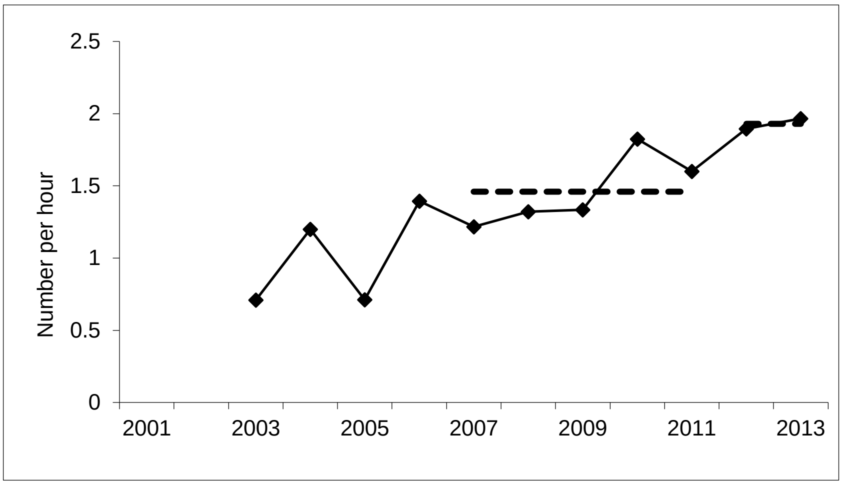


Figure 18.29.a) Skates and rays in the Celtic Seas. Irish Groundfish Survey mean cpue of VIa *Raja clavata*. Dashed lines give mean annual cpue for 2007–2011 and mean annual cpue for 2012–2013.

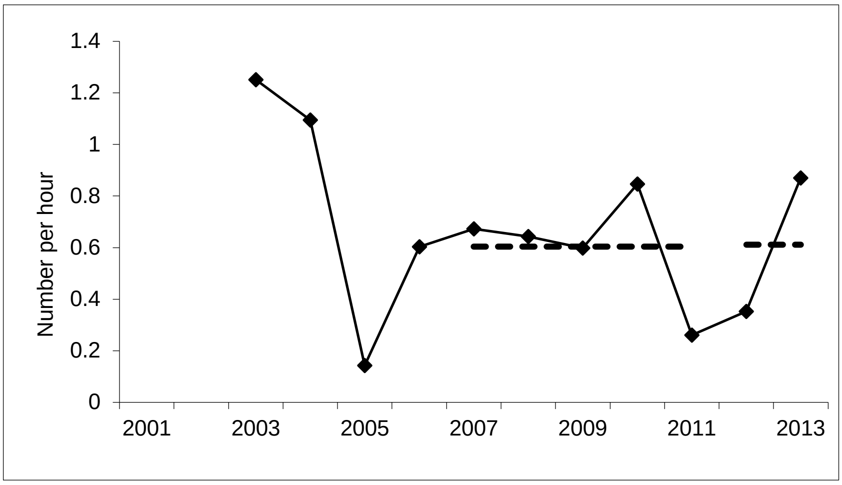


Figure 18.29.b) Skates and rays in the Celtic Seas. Irish Groundfish Survey mean cpue of VIIafh *Raja clavata*. Dashed lines give mean annual cpue for 2007–2011 and mean annual cpue for 2012–2013.

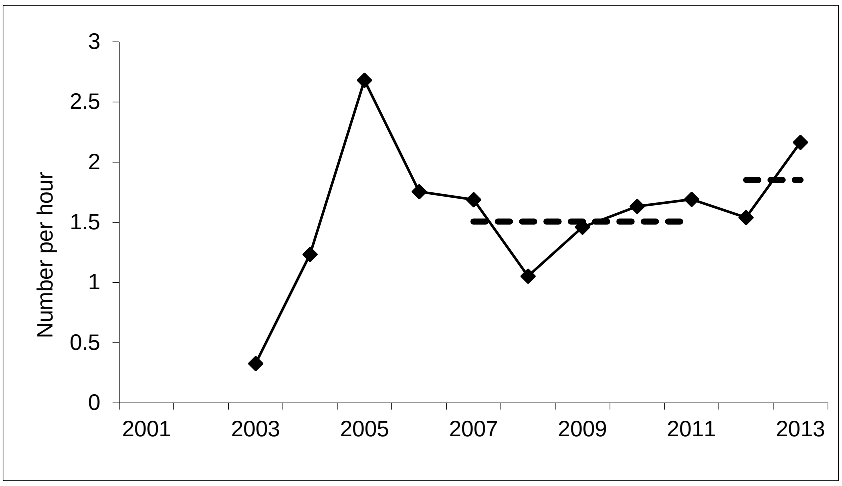


Figure 18.29.c) Skates and rays in the Celtic Seas. Irish Groundfish Survey mean cpue of VIa *Raja montagui*. Dashed lines give mean annual cpue for 2007–2011 and mean annual cpue for 2012–2013.

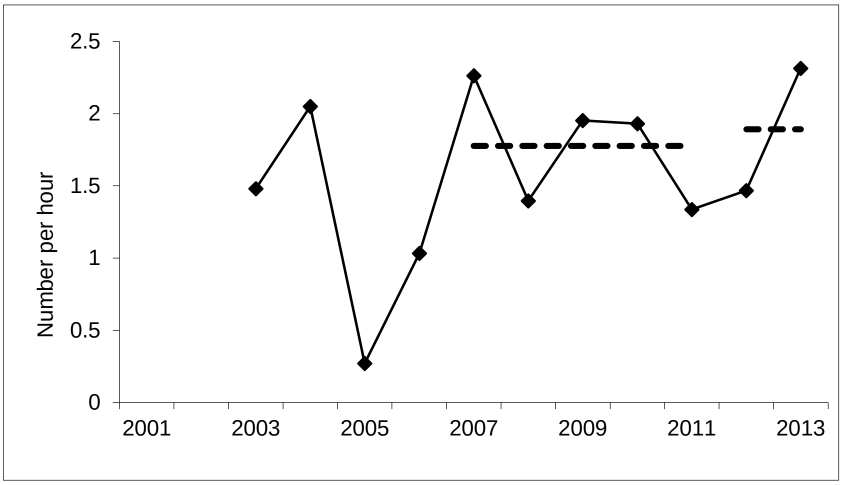


Figure 18.29.d) Skates and rays in the Celtic Seas. Irish Groundfish Survey mean cpue of VIIafh *Raja montagui*. Dashed lines give mean annual cpue for 2007–2011 and mean annual cpue for 2012–2013.

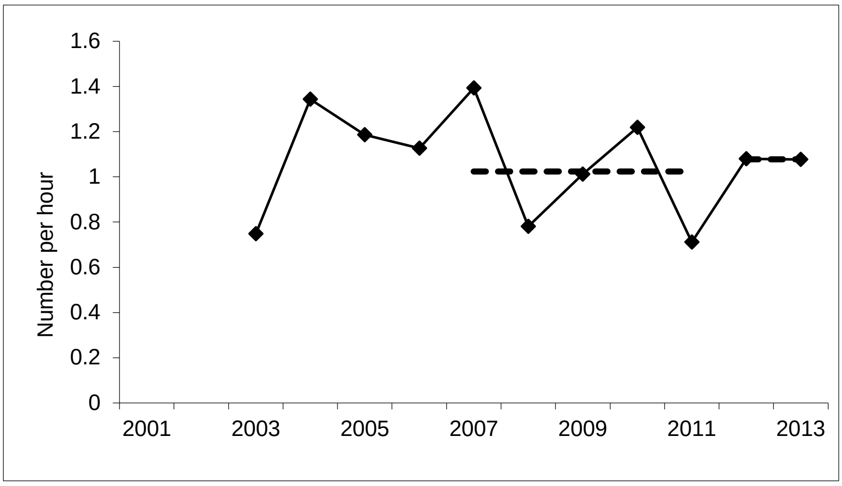


Figure 18.29.e) Skates and rays in the Celtic Seas. Irish Groundfish Survey mean cpue of VIa *Leucoraja naevus*. Dashed lines give mean annual cpue for 2007–2011 and mean annual cpue for 2012–2013.

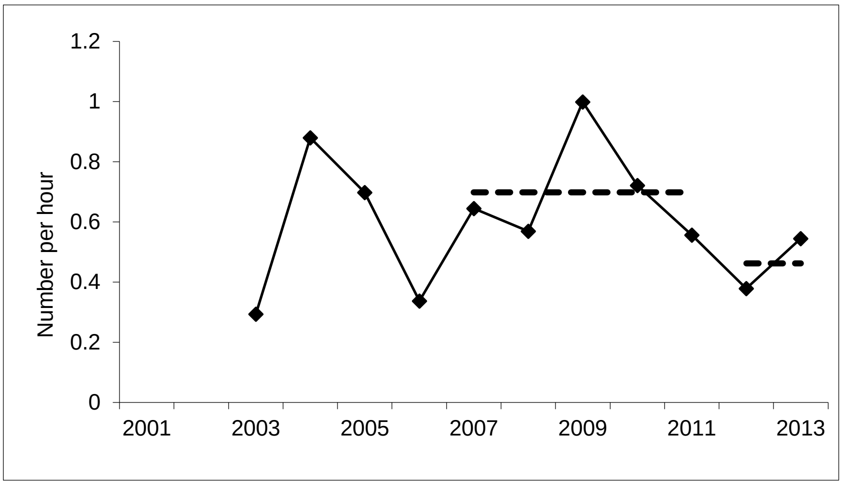


Figure 18.29.f) Skates and rays in the Celtic Seas. Irish Groundfish Survey mean cpue of VIIafh *Leucoraja naevus*. Dashed lines give mean annual cpue for 2007–2011 and mean annual cpue for 2012–2013.

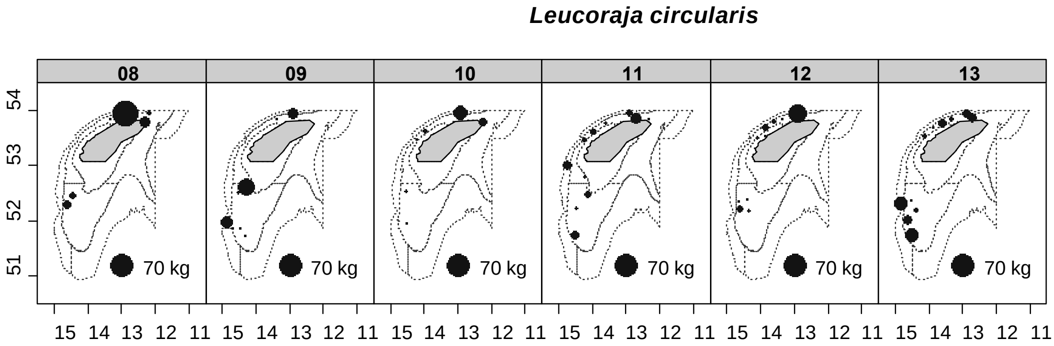


Figure 18.30.a) Skates and rays in the Celtic Seas. Geographical distribution of sandy ray *Leucoraja circularis* catches (kg·haul-1) in Porcupine survey time-series (2008–2013) (Ruiz-Pico *et al.*, 2014 WD).

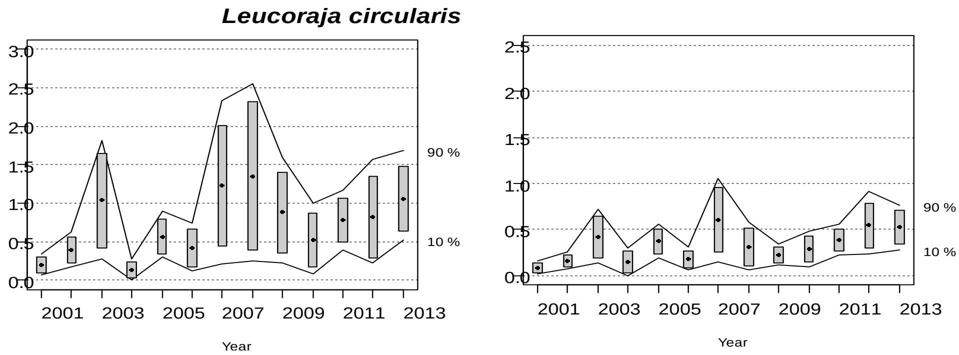


Figure 18.30.b) Skates and rays in the Celtic Seas. Temporal changes sandy ray *Leucoraja circularis* biomass index (kg·haul-1) during Porcupine survey time series (2001–2013). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000) (Ruiz-Pico *et al.*, 2014 WD).

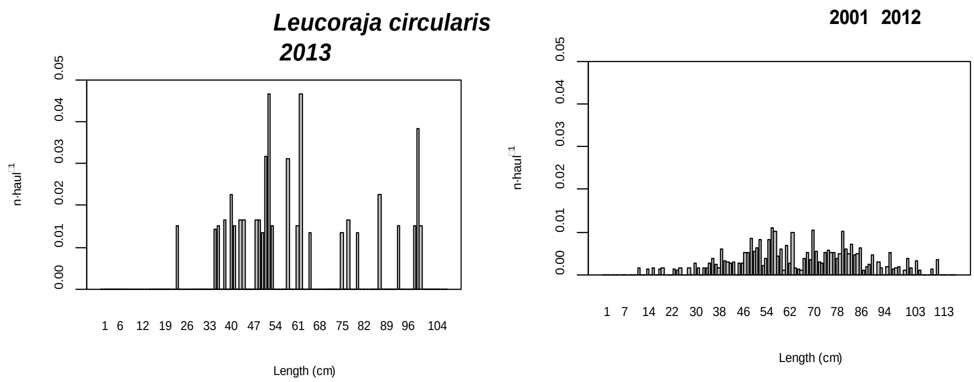


Figure 18.30.c) Skates and rays in the Celtic Seas. Stratified length distributions of sandy ray *Leucoraja circularis* in 2013 Porcupine survey, and mean values during Porcupine survey time-series (2001–2012) (Ruiz-Pico *et al.*, 2014 WD).

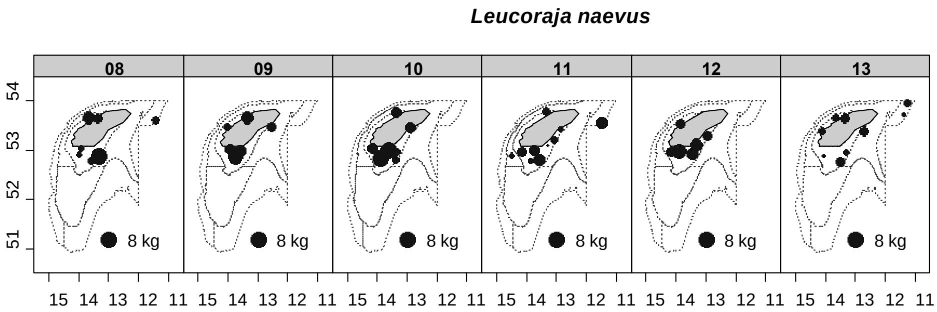


Figure 18.31.a) Skates and rays in the Celtic Seas. Geographical distribution of cuckoo ray *Leucoraja naevus* catches (kg·haul-1) in Porcupine survey time-series (2008–2013) (Ruiz-Pico *et al.*, 2014 WD).

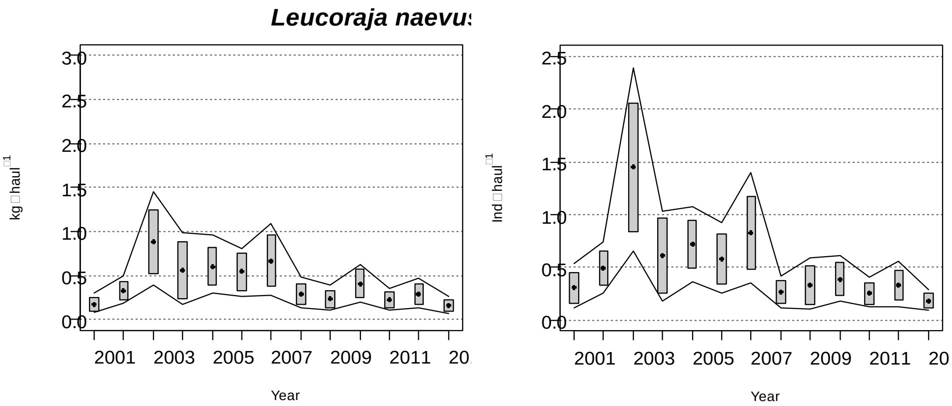


Figure 18.31.b) Skates and rays in the Celtic Seas. Temporal changes in cuckoo ray *Leucoraja naevus* biomass index (kg.haul-1) during Porcupine survey time-series (2001–2013). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000) (Ruiz-Pico *et al.*, 2014 WD).

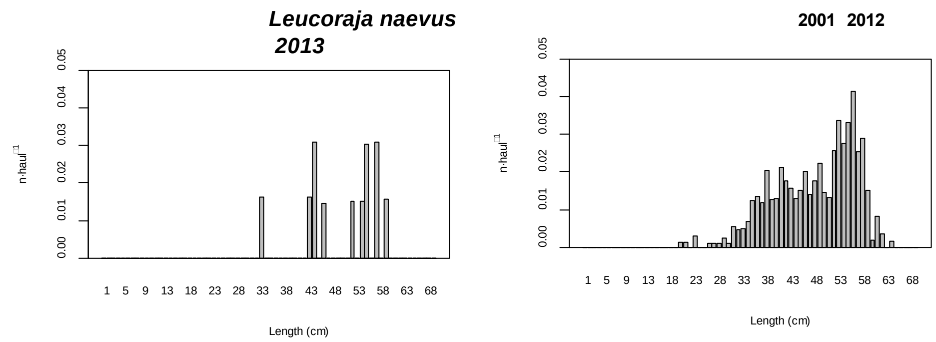


Figure 18.31.c) Skates and rays in the Celtic Seas. Stratified length distributions of cuckoo ray *Leucoraja naevus* in 2013 in Porcupine survey, and mean values during Porcupine survey time-series (2001–2012) (Ruiz-Pico *et al.*, 2014 WD).

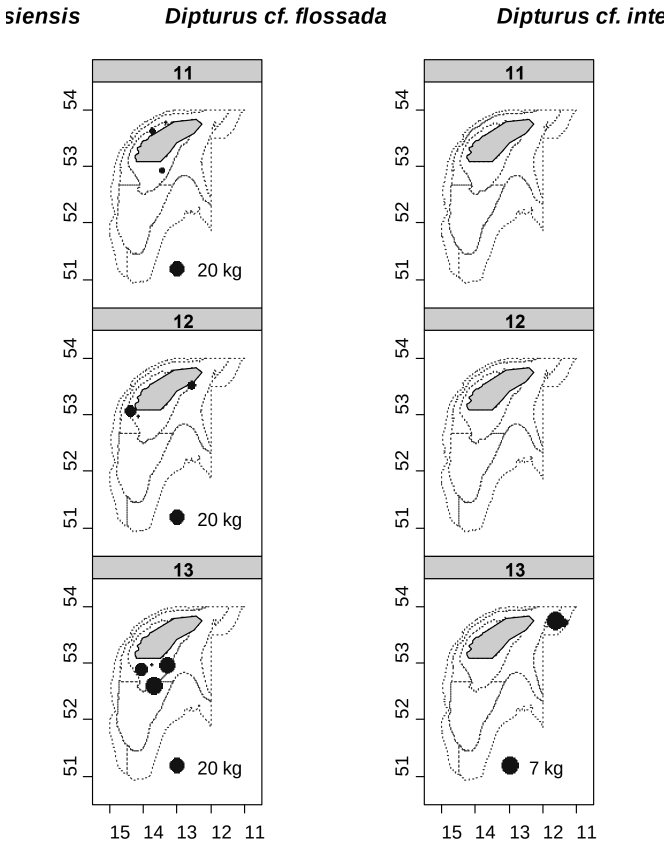


Figure 18.32.a) Skates and rays in the Celtic Seas. Geographical distribution of *Dipturus* cf. *flossada* and *D.* cf. *intermedia* spp. (kg·haul-1) in Porcupine survey time-series (2011–2013) (Ruiz-Pico *et al.*, 2014 WD).

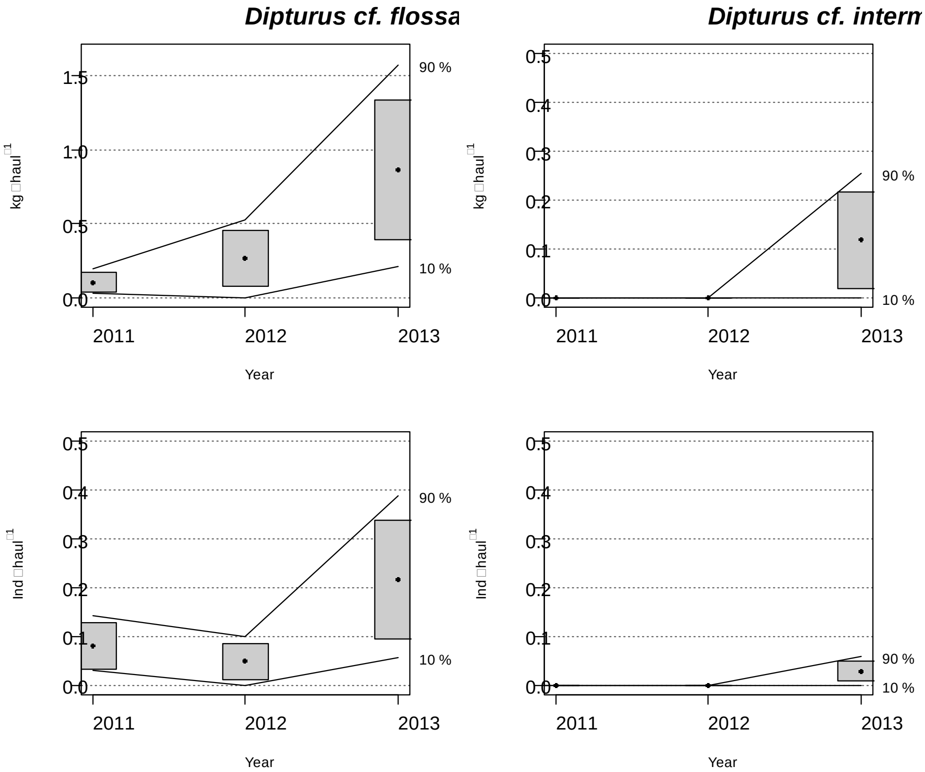


Figure 18.32.b) Skates and rays in the Celtic Seas. Changes in *Dipturus* cf. *flossada* and *Dipturus* cf. *intermedia*. Biomass index (kg·haul-1) during Porcupine survey time-series (2011–2013). Boxes mark parametric standard error of the stratified index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000) (Ruiz-Pico *et al.*, 2014 WD).

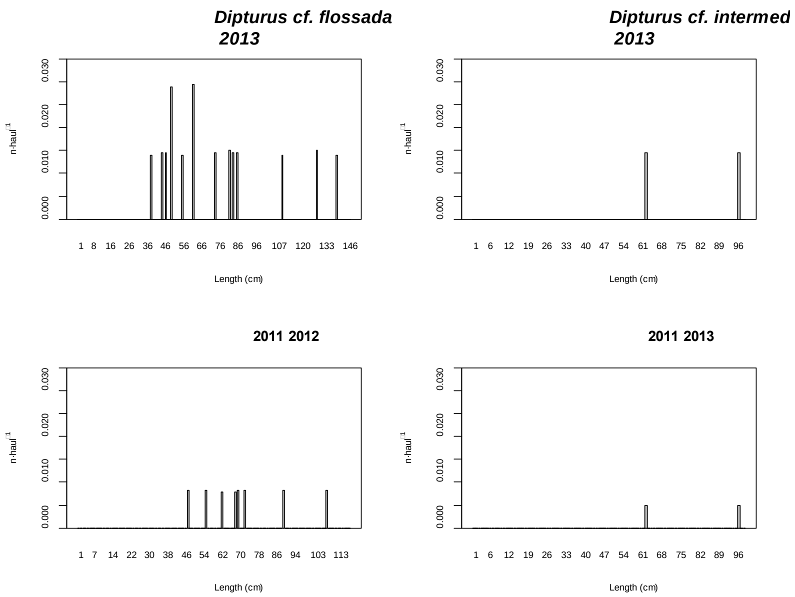


Figure 18.32.c) Skates and rays in the Celtic Seas. Stratified length distributions of *Dipturus* cf. *flossada* and *Dipturus* cf. *intermedia* in 2013 Porcupine survey, and mean values during survey time-series (2011–2012) (Ruiz-Pico *et al.*, 2014 WD).

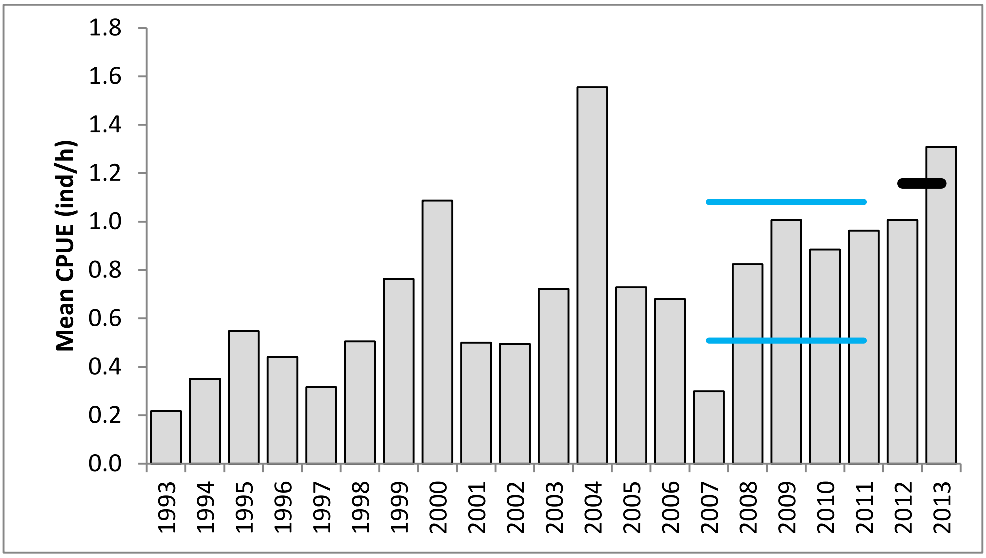


Figure 18.33.a) Skates and rays in the Celtic Seas. Mean cpue of *Raja brachyura* in the UK VIIaf beam trawl survey. Blue lines give mean annual cpue 2007–2011; black line mean annual cpue 2012–2013.

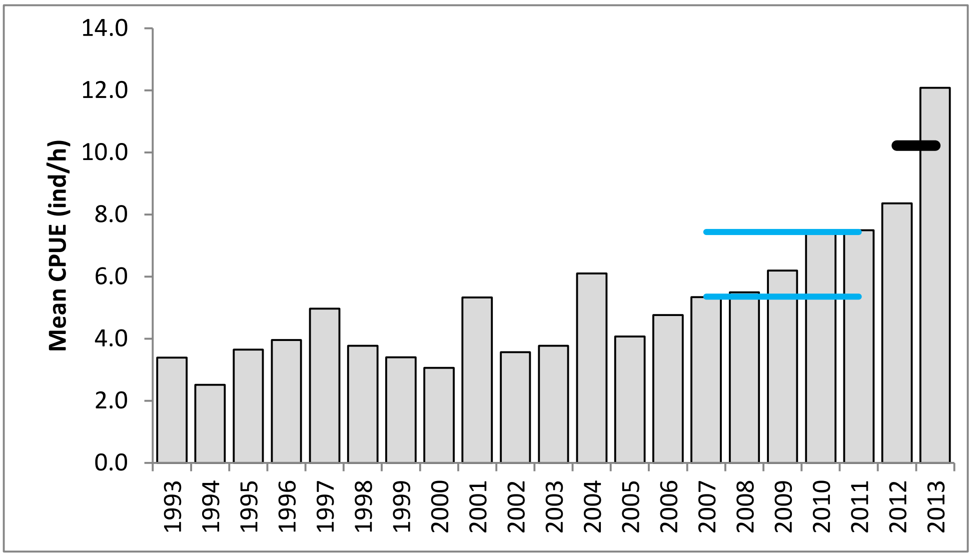


Figure 18.33.b) Skates and rays in the Celtic Seas. Mean cpue of VIIaf *Raja clavata* in the UK VIIaf beam trawl survey. Blue lines give mean annual cpue 2007–2011; black line mean annual cpue 2012–2013.

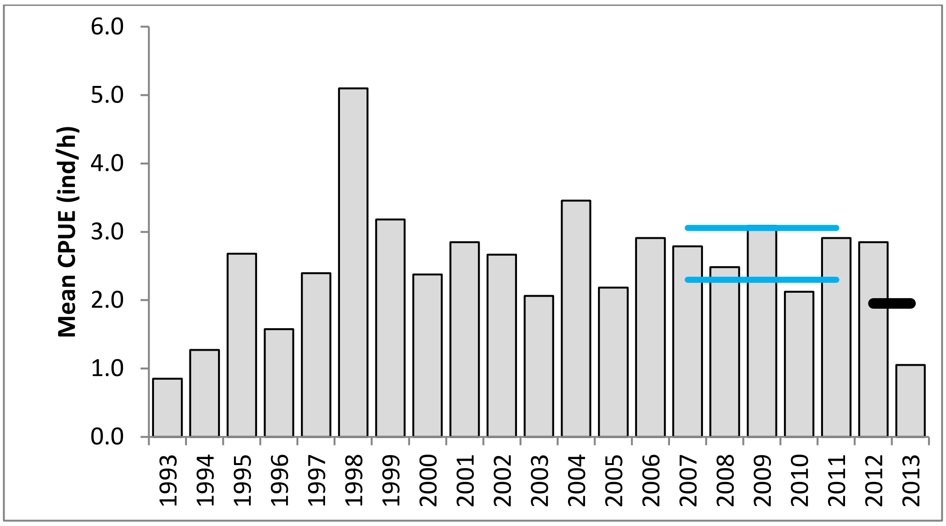


Figure 18.33.c) Skates and rays in the Celtic Seas. Mean cpue of VIIf *Raja microocellata* in the UK VIIaf beam trawl survey. Blue lines give mean annual cpue 2007–2011; black line mean annual cpue 2012–2013.

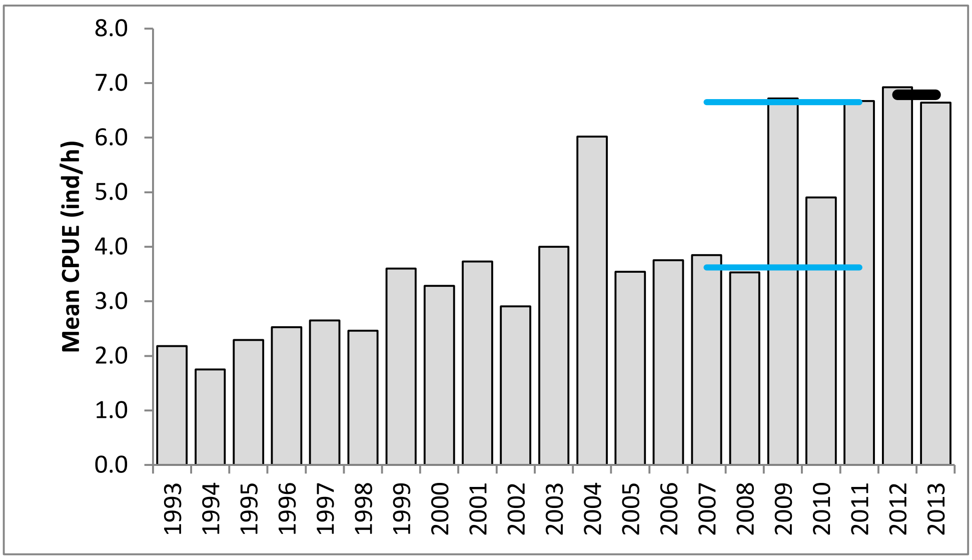


Figure 18.33.d) Skates and rays in the Celtic Seas. Mean cpue of VIIaf *Raja montagui* in the UK VIIaf beam trawl survey. Blue lines give mean annual cpue 2007–2011; black line mean annual cpue 2012–2013.

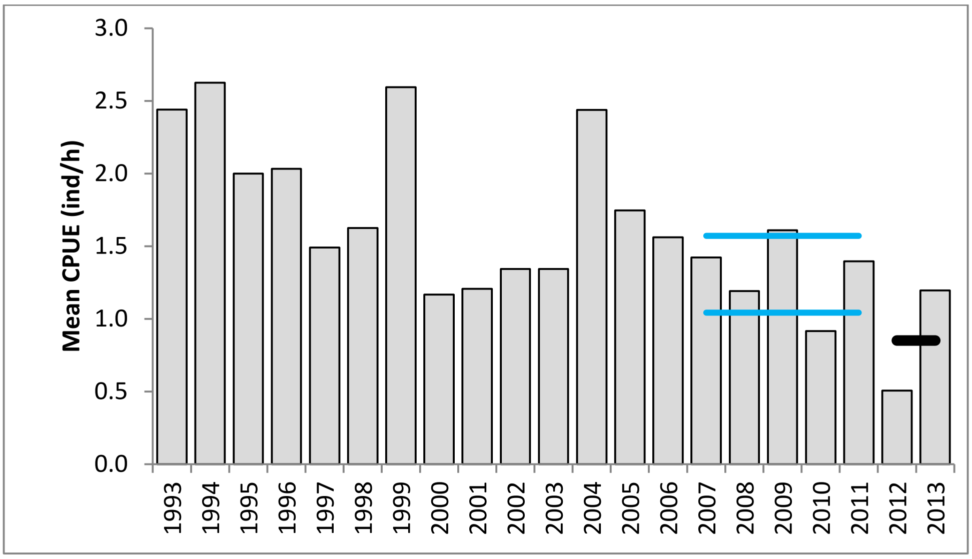


Figure 18.33.e) Skates and rays in the Celtic Seas. Mean cpue of VIIa *Leucoraja naevus* in the UK VIIaf beam trawl survey. Blue lines give mean annual cpue 2007–2011; black line mean annual cpue 2012–2013.

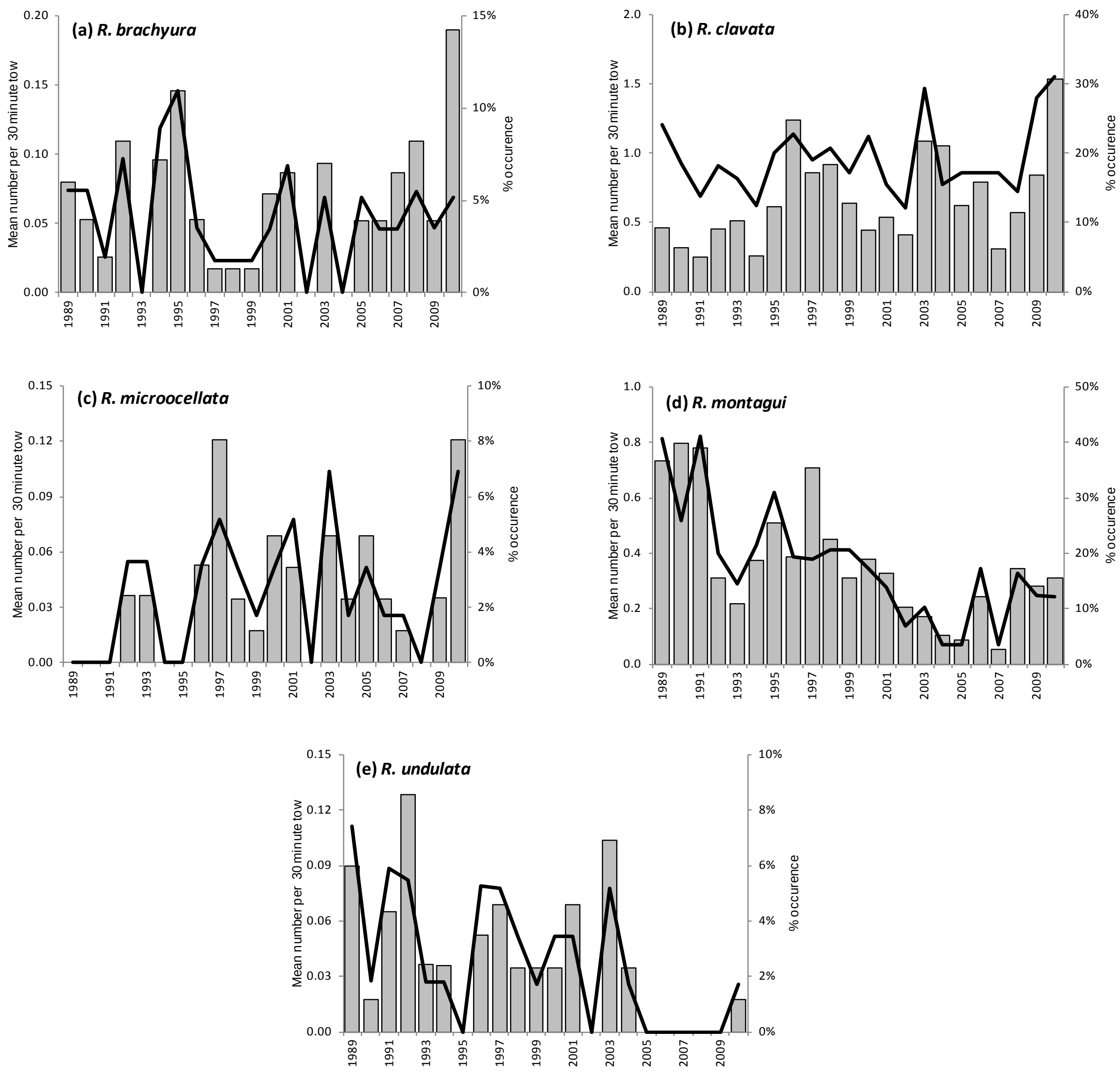


Figure 18.34. Skates and rays in the Celtic Seas. Trends in the mean relative abundance (numbers per 30 minute tow, grey columns) and frequency of occurrence (solid line) for five skate species caught in the Great West Bay (western English Channel) during the *Carhelmar* survey (1989–2010). Adapted from Burt *et al.* (2012).

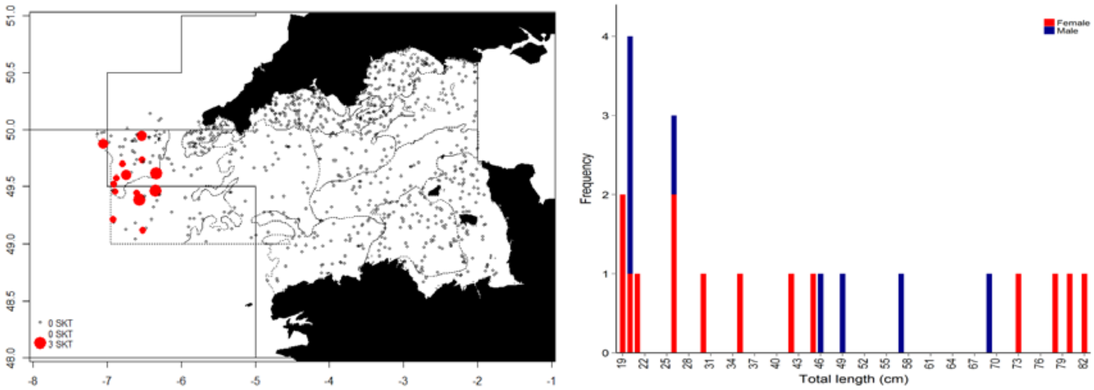


Figure 18.35a. Skates and rays in the Celtic Seas.: The distribution and relative abundance, and length-frequency by sex of common skate *Dipturus batis* complex in the western English Channel Q1 beam trawl survey (Silva *et al.*, 2014 WD).

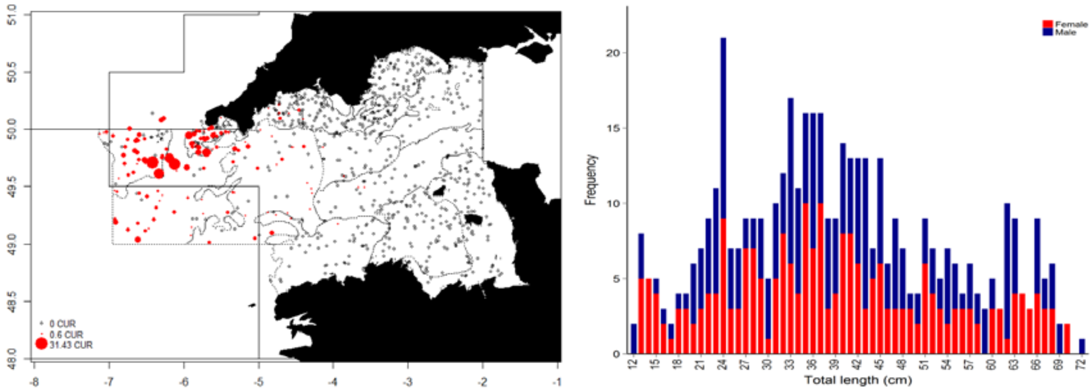


Figure 18.35b. Skates and rays in the Celtic Seas.: The distribution and relative abundance, and length-frequency by sex of cuckoo ray *Leucoraja naevus* in the western English Channel Q1 beam trawl survey (Silva *et al.*, 2014 WD).

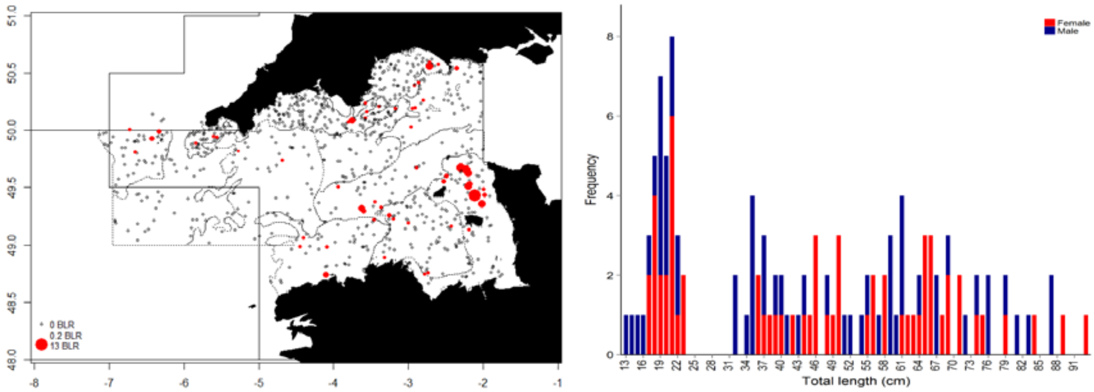


Figure 18.35c. Skates and rays in the Celtic Seas.: The distribution and relative abundance, and length-frequency by sex of blonde ray *Raja brachyura* in the western English Channel Q1 beam trawl survey (Silva *et al.*, 2014 WD).

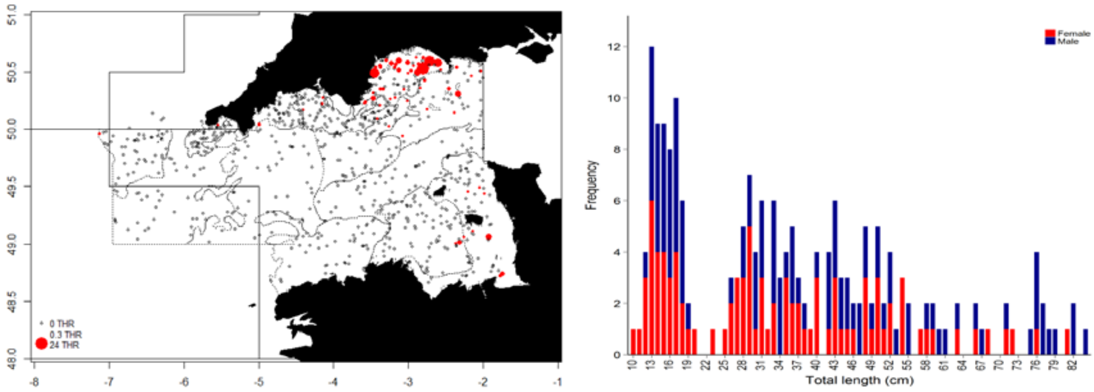


Figure 18.35d. Skates and rays in the Celtic Seas: The distribution and relative abundance, and length-frequency by sex of thornback ray *Raja clavata* in the western English Channel Q1 beam trawl survey (Silva *et al.*, 2014 WD).

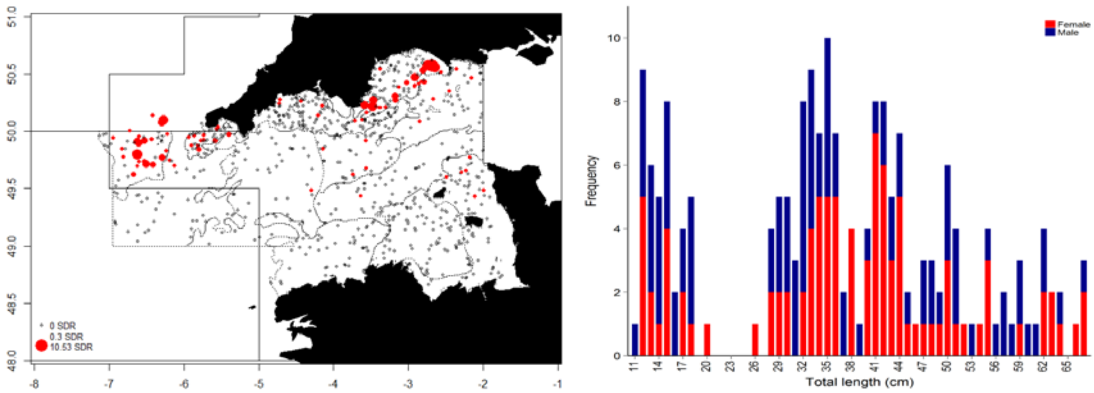


Figure 18.35e. Skates and rays in the Celtic Seas. The distribution and relative abundance, and length-frequency by sex of spotted ray *Raja montagui* in the western English Channel Q1 beam trawl survey (Silva *et al.*, 2014 WD).

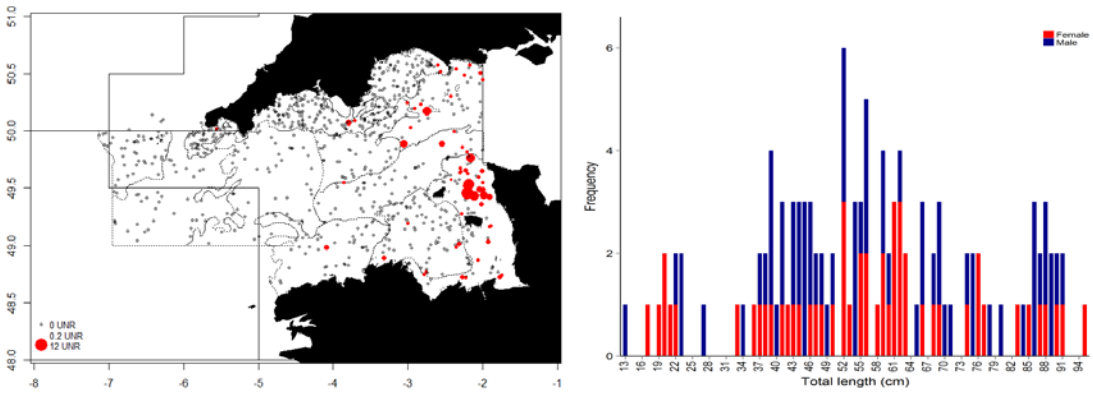


Figure 18.35f. Skates and rays in the Celtic Seas. The distribution and relative abundance, and length-frequency by sex of undulate ray *Raja undulata* in the western English Channel Q1 beam trawl survey (Silva *et al.*, 2014 WD).

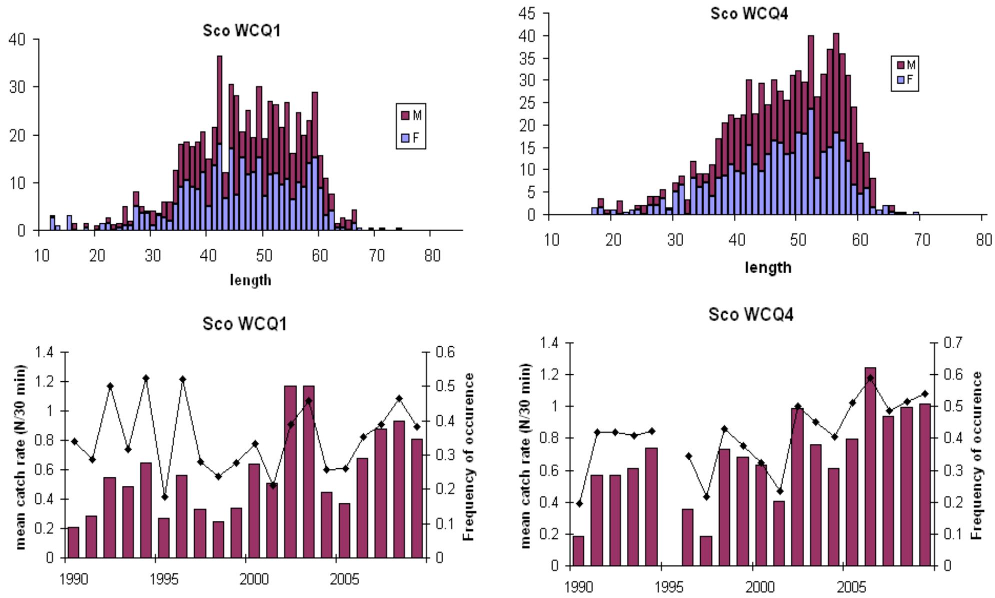


Figure 18.36a. Skates and rays in the Celtic Seas. Length–frequency distributions of *L. naevus* from the Scottish west coast surveys in Q 1 and Q4 (upper plots). Lower plots show frequency of occurrence (line) and average catch rate (bars) in number 30 min^{-1}.

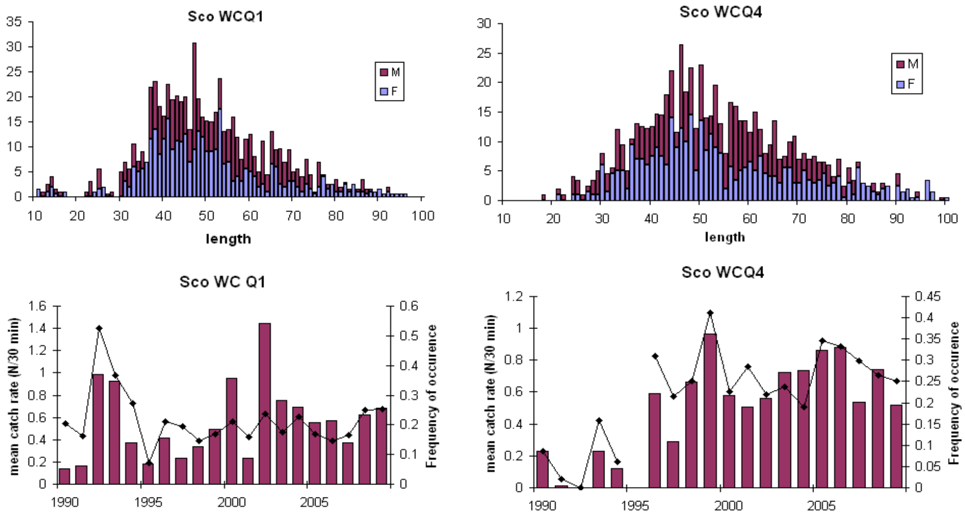


Figure 18.36b. Skates and rays in the Celtic Seas. Length–frequency distributions of *R. clavata* from the Scottish west coast surveys in Q 1 and Q4 (upper plots). Lower plots show frequency of occurrence (line) and average catch rate (bars) in number 30 min^{-1}.

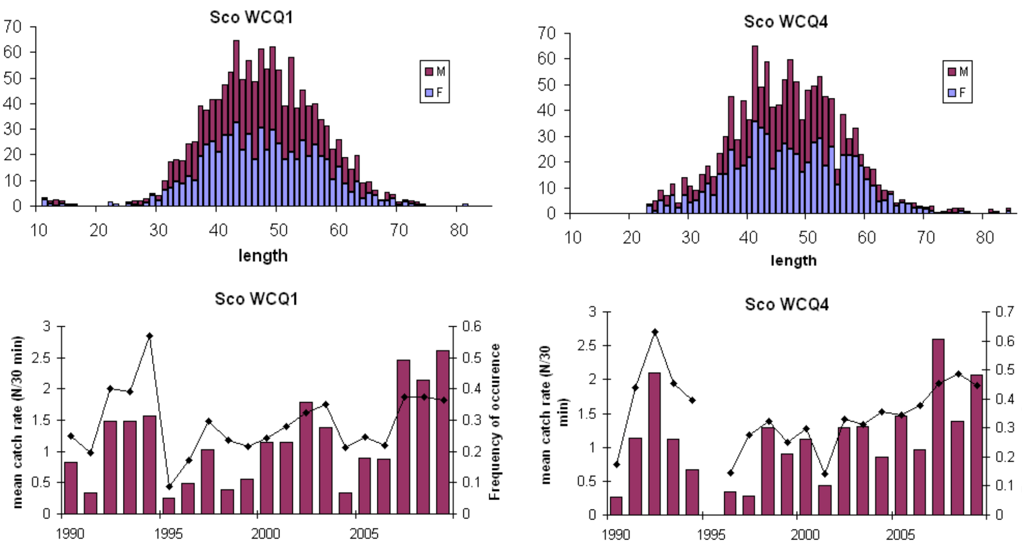


Figure 18.36c. Skates and rays in the Celtic Seas. Length–frequency distributions of *R. montagui* from the Scottish west coast surveys in Q 1 and Q4 (upper plots). Lower plots show frequency of occurrence (line) and average catch rate (bars) in number 30 min^{-1}.

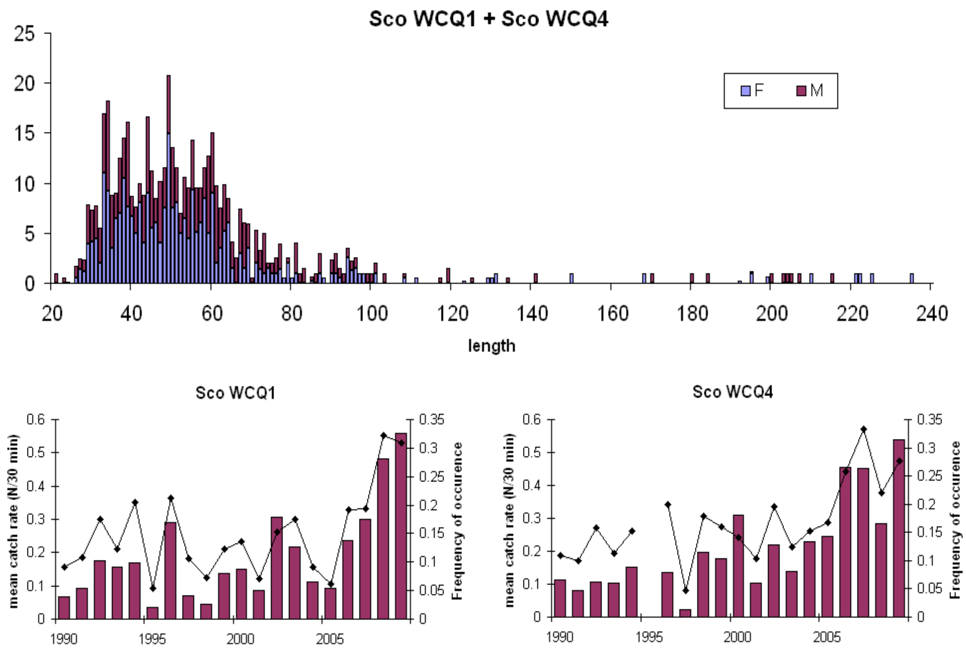
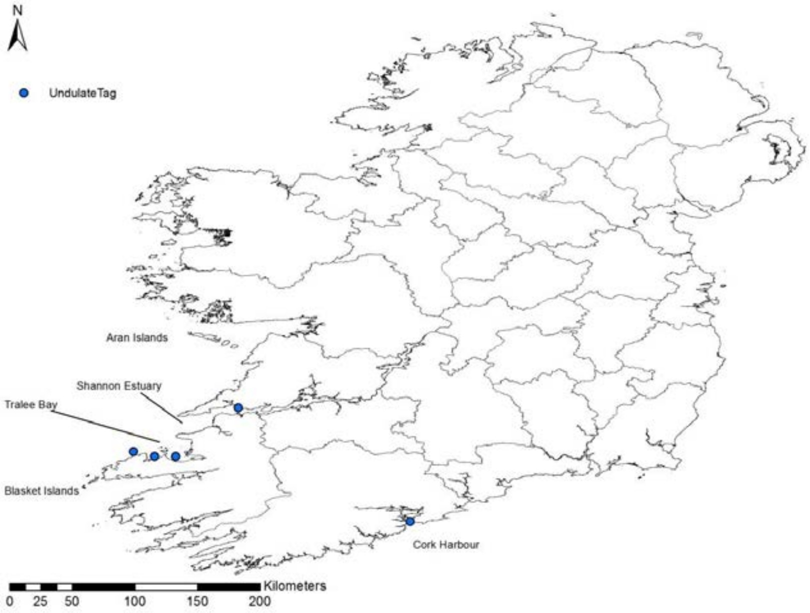


Figure 18.36d. Skates and rays in the Celtic Seas. Combined length–frequency distributions of *'D. batis'* from the Scottish west coast surveys in Q1 and Q4 (upper plot). Lower plots show frequency of occurrence (line) and average catch rate (bars) in number 30 min^{-1}.



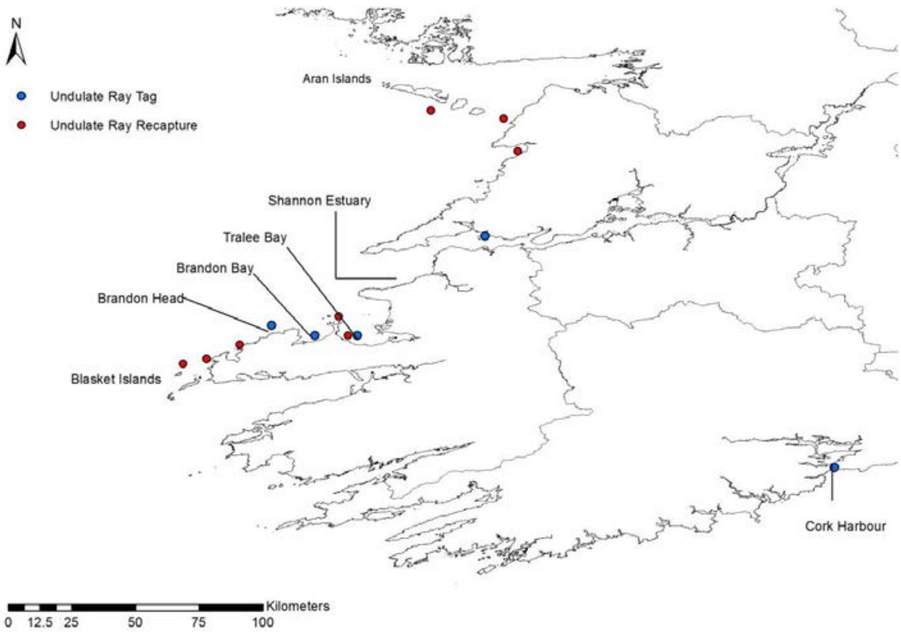


Figure 18.37. Skates and rays in the Celtic Seas. Undulate ray tagging locations (top) and recapture positions (bottom) 1972–2014 from IFI Marine Sportfish Tagging Programme (Wögerbauer *et al.*, 2014 WD).

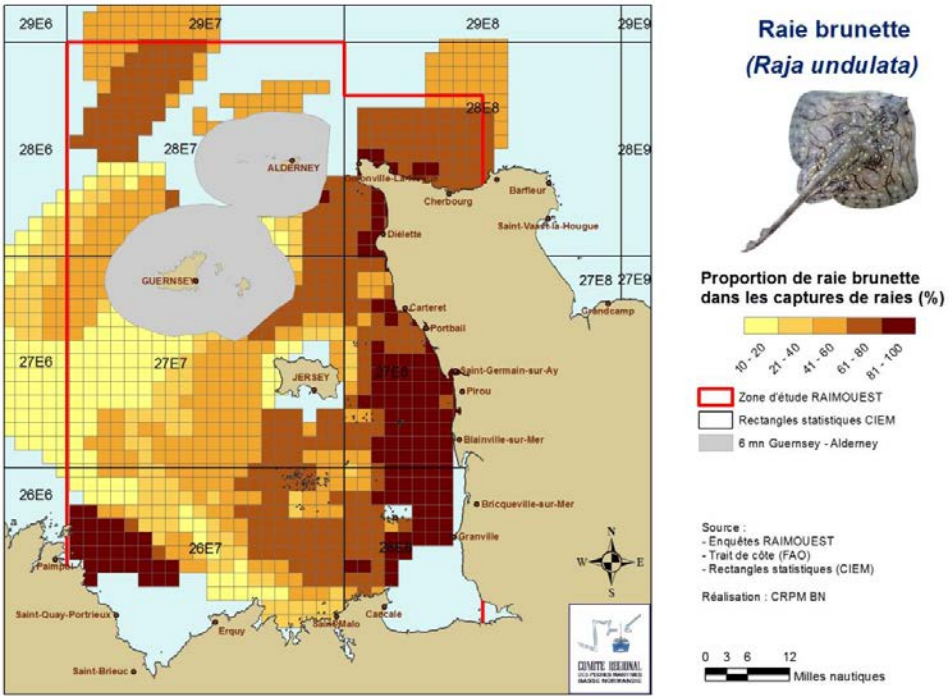


Figure 18.38. Skates and rays in the Celtic Seas.: Proportion of *R. undulata* in the total catch of rays in the Normand-Breton Gulf from enquiries with fishermen under the Raimouest project (LeBlanc *et al.*, 2014 WD).

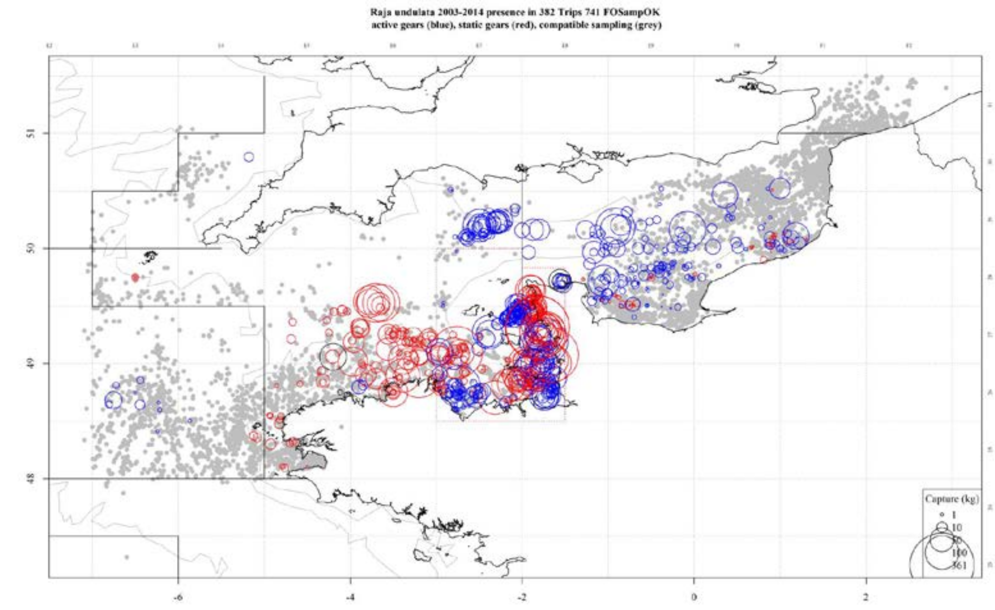


Figure 18.39. Skates and rays in the Celtic Seas. *R. undulata* catches (Kg) in samplings at sea in the English Channel from 2003 to the first quarter 2014 (grey = compatible sampling, blue = active gears, red = passive gears). Collated under the Raimouest project (LeBlanc *et al.*, 2014 WD).

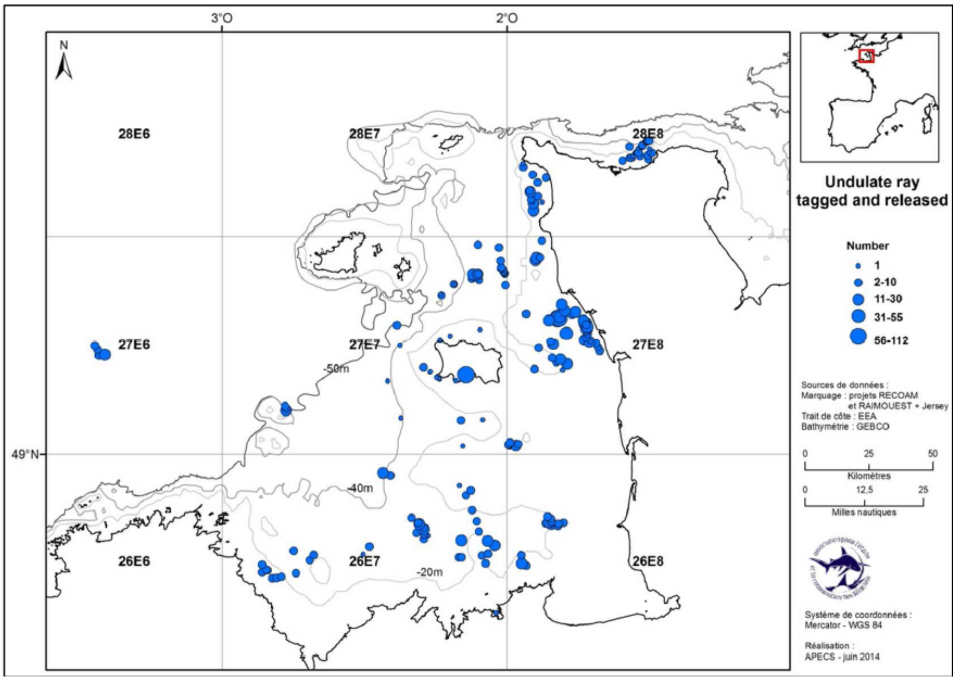
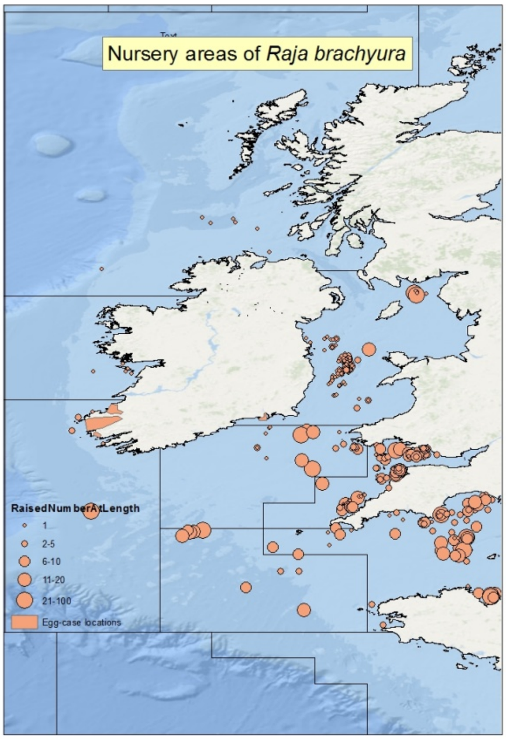


Figure 18.40. Skates and rays in the Celtic Seas.: Release positions and number (n=1488) of undulate rays tagged in the Normano-Breton Gulf under the Raimouest project (Stephan *et al.,* 2014 WD).



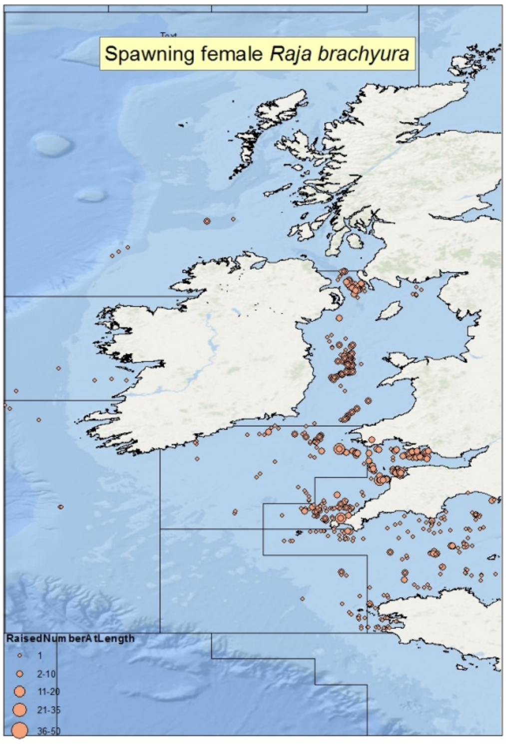


Figure 18.41a. Skates and Rays in the Celtic Seas. Nominal locations of potential nursery areas and areas with adult females during Q2 of *Raja brachyura*. Source: Irish, UK and French discard observer programmes. Subareas VI and VII only. Note: some of these data may be confounded with that of *R.montagui*.

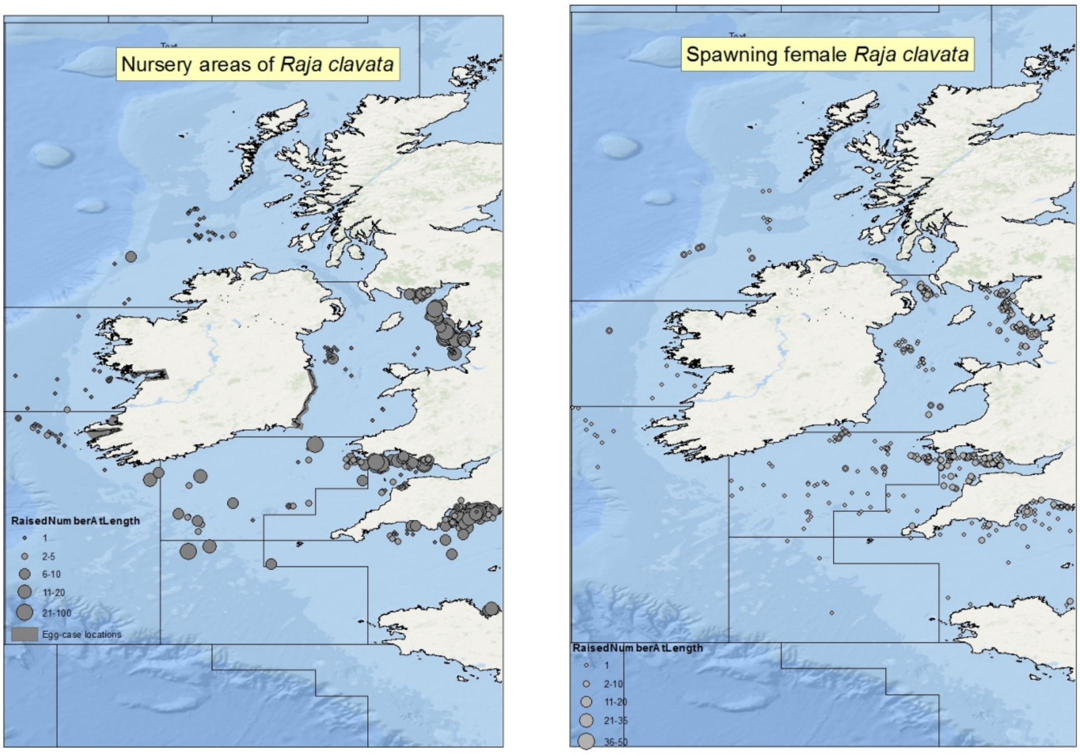


Figure 18.41b. Skates and Rays in the Celtic Seas. Nominal locations of potential nursery areas and areas with adult females during Q2 of *Raja clavata*. Source: Irish, UK and French discard observer programmes. Subareas VI and VII only.

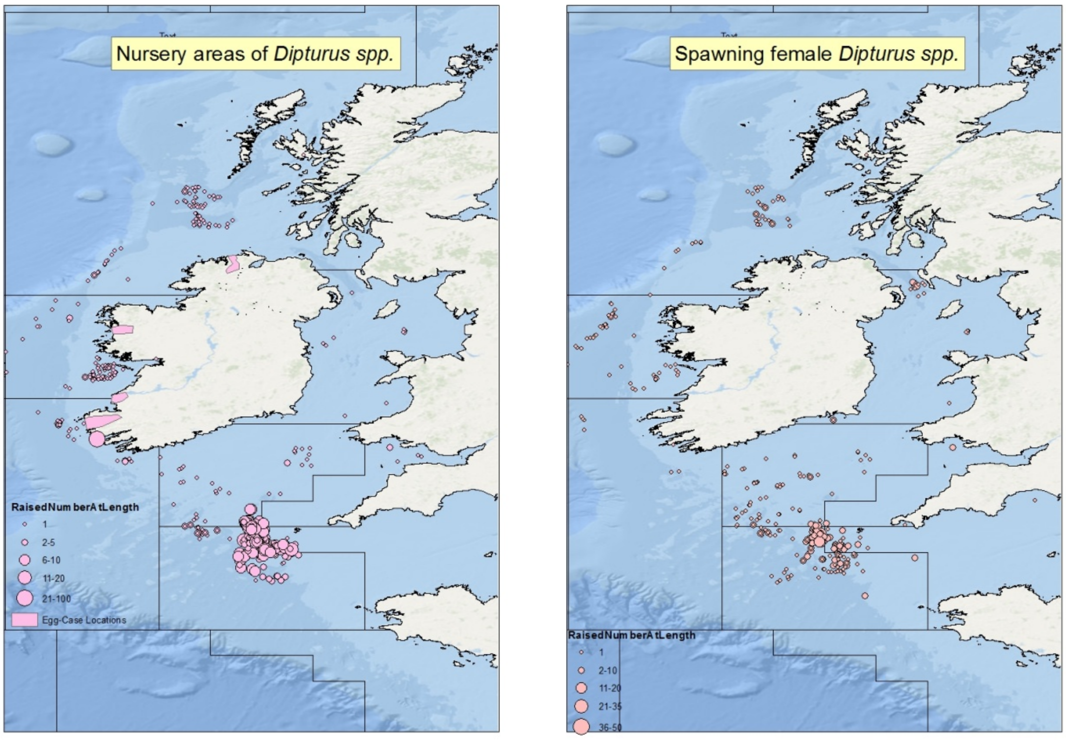


Figure 18.41c. Skates and Rays in the Celtic Seas. Nominal locations of potential nursery areas and areas with adult females during Q2 of *Dipturus batis* complex. Source: Irish, UK and French discard observer programmes. Subareas VI and VII only.

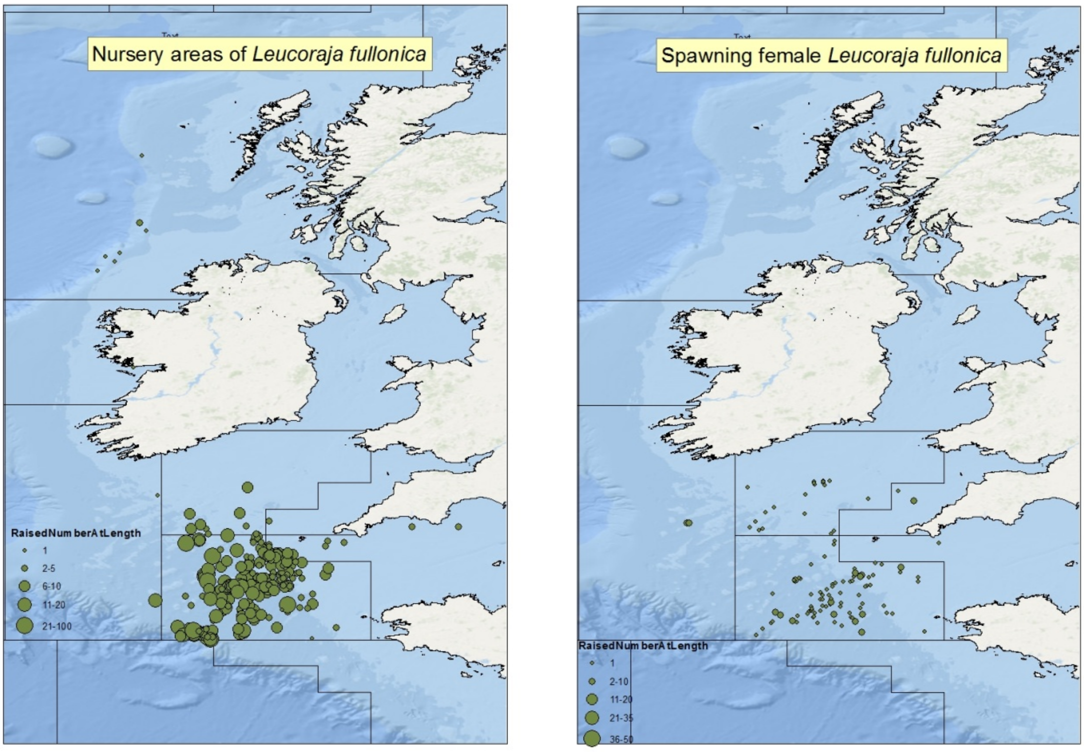


Figure 18.41d. Skates and Rays in the Celtic Seas. Nominal locations of potential nursery areas and areas with adult females during Q2 of *Leucoraja fullonica*. Source: Irish, UK and French discard observer programmes. Subareas VI and VII only.

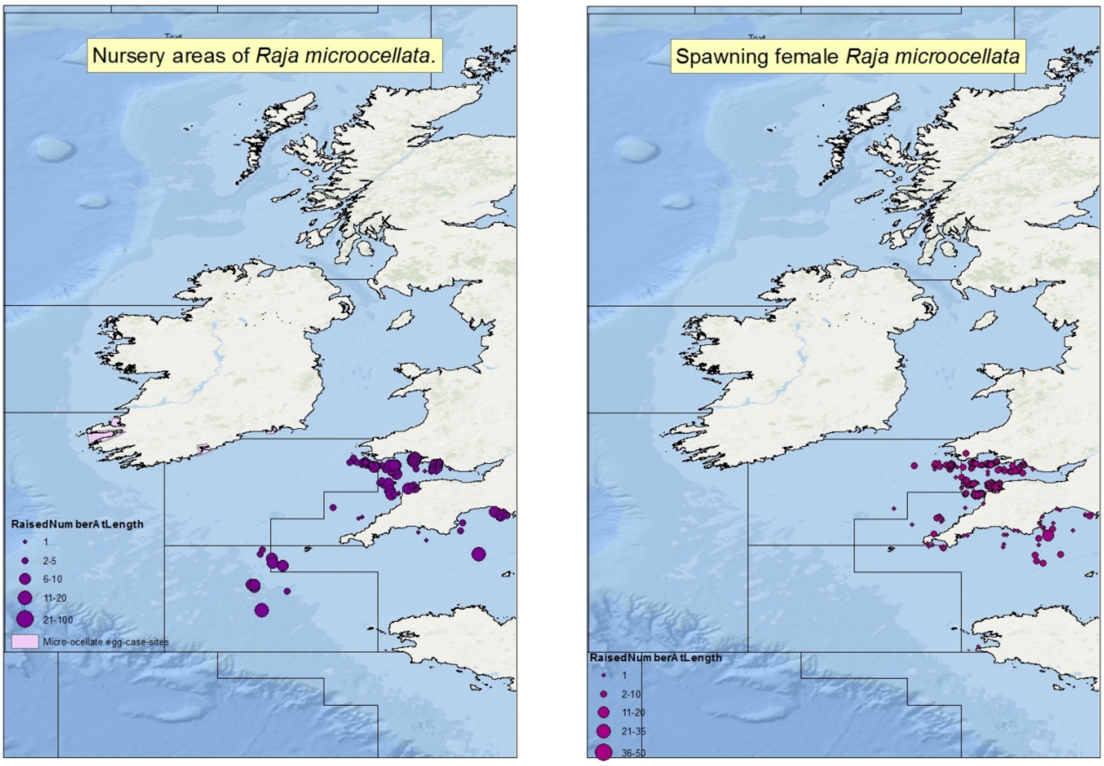
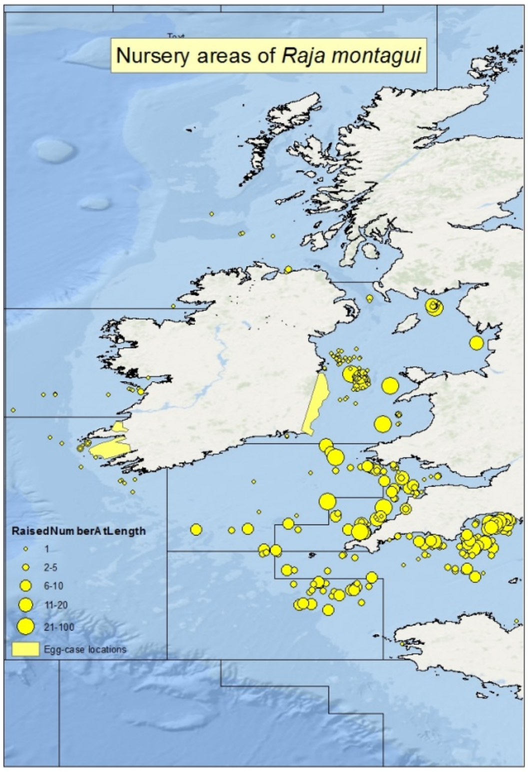


Figure 18.41e. Skates and Rays in the Celtic Seas. Nominal locations of potential nursery areas and areas with adult females during Q2 of *Raja microocellata*. Source: Irish, UK and French discard observer programmes. Subareas VI and VII only. Note: Offshore records of this species may represent misidentifications.



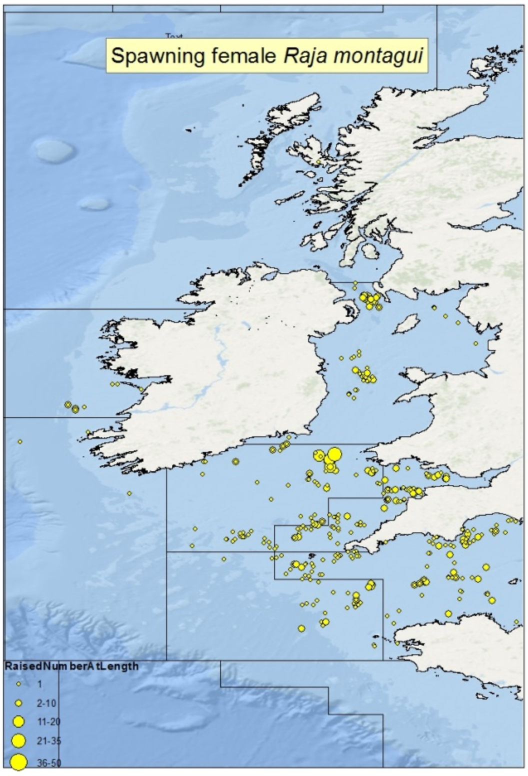


Figure 18.41f. Skates and Rays in the Celtic Seas. Nominal locations of potential nursery areas and areas with adult females during Q2 of *Raja montagui*. Source: Irish, UK and French discard observer programmes. Subareas VI and VII only.

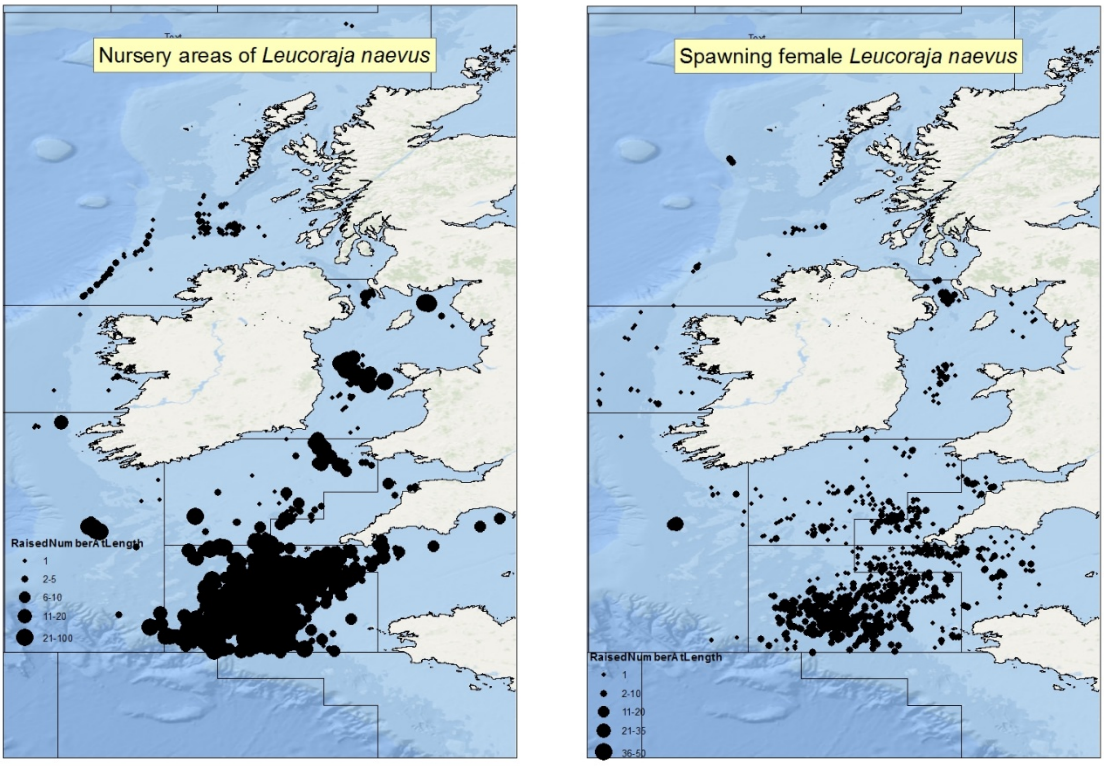


Figure 18.41g. Skates and Rays in the Celtic Seas. Nominal locations of potential nursery areas and areas with adult females during Q2 of *Leucoraja naevus*. Source: Irish, UK and French discard observer programmes, Subareas VI and VII only.

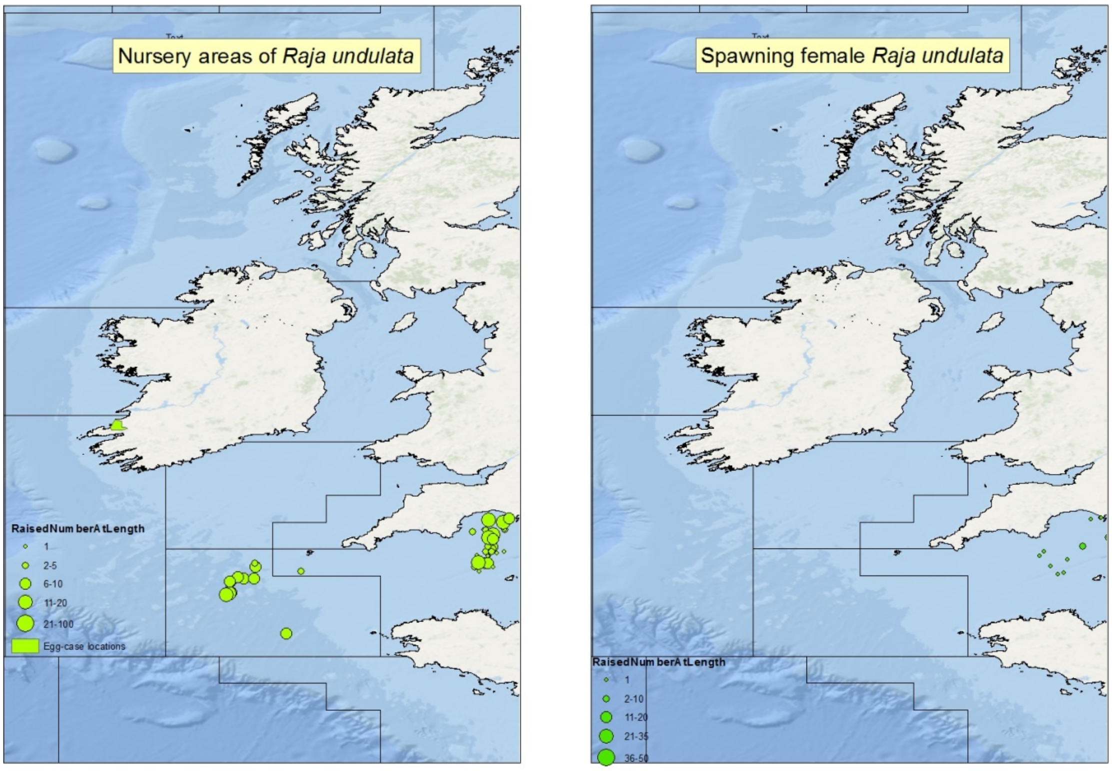


Figure 18.41h. Skates and Rays in the Celtic Seas. Nominal locations of potential nursery areas and areas with adult females during Q2 of *Raja undulata*. Source: Irish, UK and French discard observer programmes. Subareas VI and VII only. Note: Offshore records of this species may represent misidentifications and require validation.

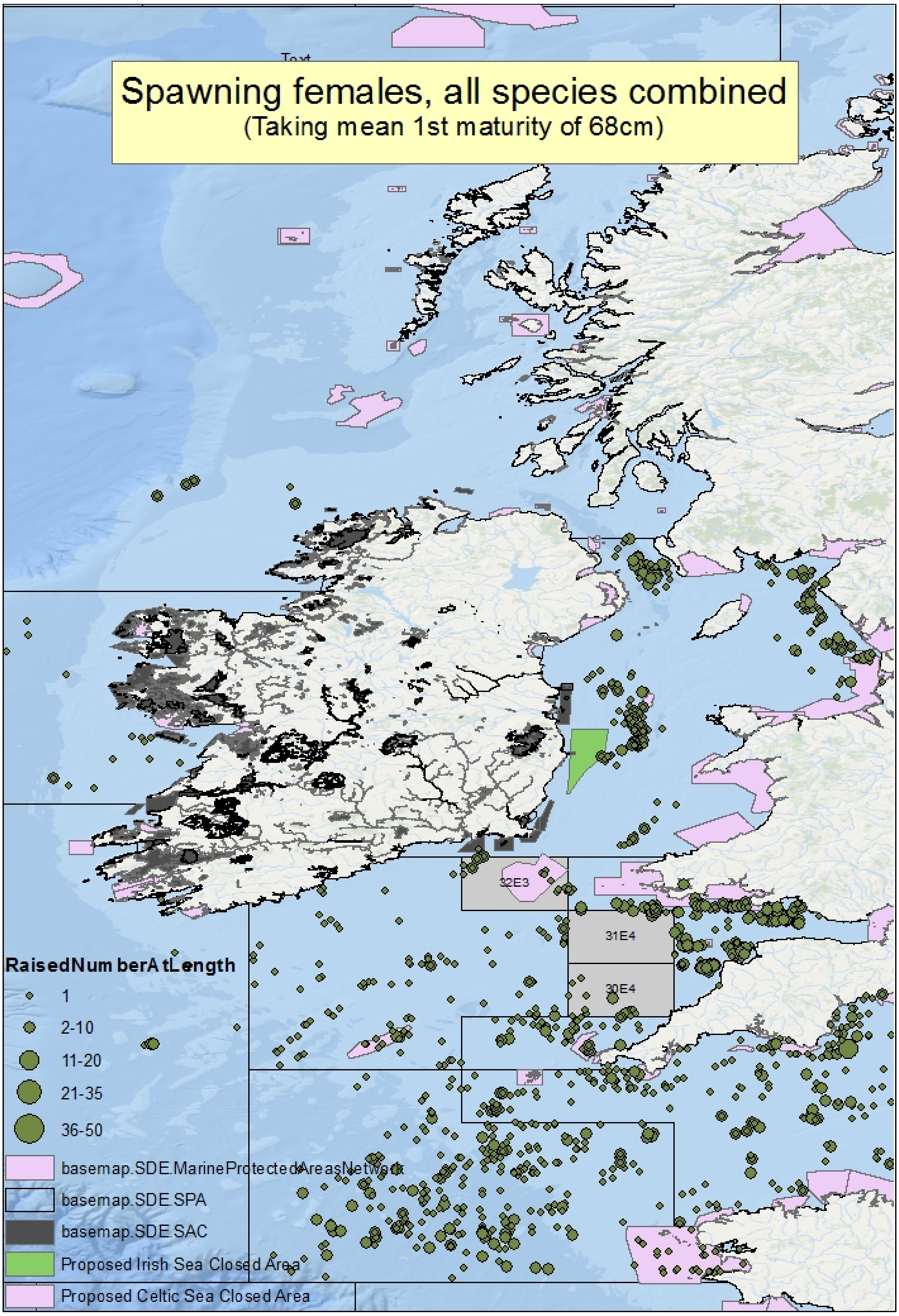


Figure 18.42. Skates and Rays in the Celtic Seas. Location of adult females, Q2, all species combined, with locations of existing and proposed conservation areas in VI and VII. Conservation areas includes MPAs, SPAs, SACs, and cod protection areas.

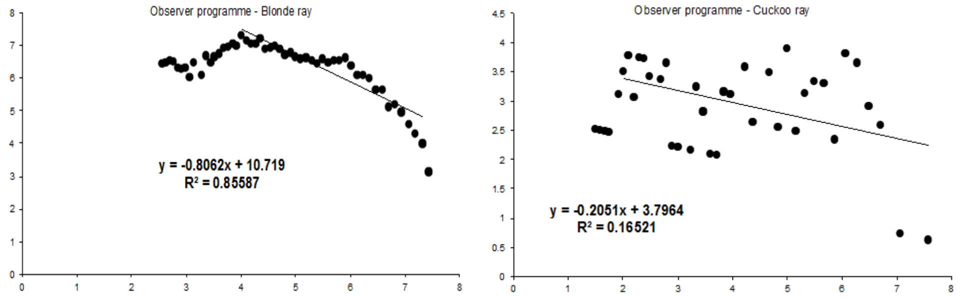


Figure 18.43. Skates and rays in the Celtic Seas. Catch curves from the Irish VIIa discard observer programme, and from combined NIGFS (VIIa) and IGFS (VIIg) survey data. The observer programme recorded insufficient data for thornback ray to fit a curve.

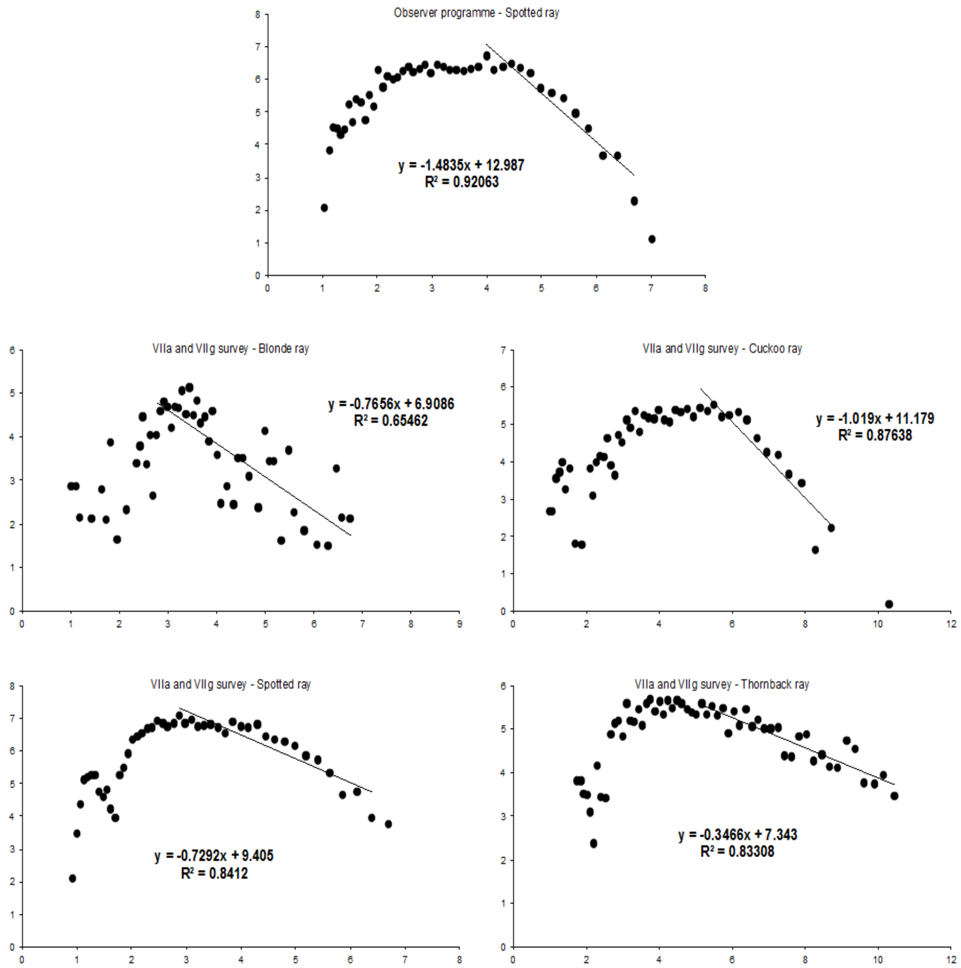


Figure 18.44. Skates and rays in the Celtic Seas. Catch curves from the Irish VIIa discard observer programme, and from combined NIGFS (VIIa) and IGFS (VIIg) survey data. The observer programme recorded insufficient data for thornback ray to fit a curve.

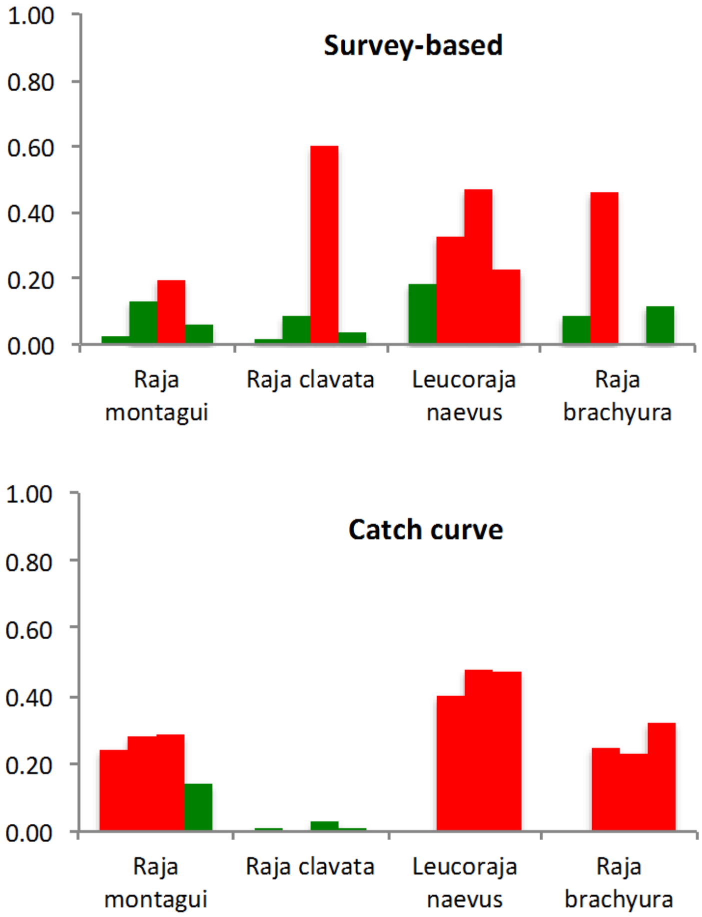


Figure 18.45. Skates and rays in the Celtic Seas. Survey- and catch curve-based estimates of HR (averaged for 2011–2012) for four skate species in the Celtic Seas (ICES VIIa and VIIg). Bars are coloured coded to indicate whether HR estimates are ≥ (red) or < (green) the mean of precautionary reference values (HR_{MSY} Mean, see Table 18.1.8).

19 Skates and rays in the Bay of Biscay and Iberian Waters (ICES Subarea VIII and Division IXa)

19.1 Ecoregion and stock boundaries

The Bay of Biscay and Iberian Waters ecoregion covers the Bay of Biscay (ICES Divisions VIIIa, b, d), including the Cantabrian Sea (ICES Divisions VIIIc), and the Spanish and Portuguese Atlantic coast (ICES Division IXa). This ecoregion broadly equates with the area covered by the Southern Waters AC (SWAC).

In contrast to the more northerly Bay of Biscay, which has a wider continental shelf with flat and soft bottoms more suitable for trawlers, the Cantabrian Sea has a narrow continental shelf with some remarkable bathymetric features (canyons, marginal shelves, etc.). The Portuguese continental shelf (ICES Division IXa) is also generally narrow, except for the area located between the Minho River and the Nazaré Canyon, and in the Gulf of Cadiz, where it is about 50 km wide, particularly to the east. The slope is mainly steep with a rough bottom, with canyons and cliffs.

Rajidae are widespread throughout this region but there are some important regional differences in their distribution as described in earlier reports (ICES, 2010). This is particularly evident for some skates and rays, which have a well-defined patchy distribution and limited dispersal (Carrier *et al*., 2004).

Skates and rays in this ecoregion include thornback ray (*Raja clavata*) and cuckoo ray (*Leucoraja naevus*) and the less common blonde ray (*Raja brachyura*), small-eyed ray (*R. microocellata*), brown ray (*R. miraletus*), spotted ray (*R. montagui*), undulate ray (*R. undulata*), shagreen ray (*Leucoraja fullonica*), common skate (*Dipturus batis* complex), long-nose skate (*D. oxyrinchus*), sandy ray (*Leucoraja circularis*) and white skate (*Rostroraja alba*).

Studies held in the centre off Portugal (IXa), and in VIIIc East indicate some spatial overlap between *R. clavata* and *L. naevus*. Both occur in areas deeper than 100 m depth, on grounds composed of soft sediment, between mud and fine sand (Serra-Pereira, *et al*., 2014). *R. clavata* also occurs on other sediments, from rocky to sandy bottoms while *L. naevus*, according to the historical landings in the Bay of Biscay, is more abundant on the offshore trawlable fishing grounds. *R. clavata* and *R. brachyura* co-occur in areas with rocks surrounded by sand, at depths deeper than 100 m. Juveniles of *R. brachyura*, *R. montagui* and *R. clavata* are also known to co-occur at depths shallower than 100 m depth (Serra-Pereira, *et al*., 2014). *R. undulata* and *R. microocellata* co-occur in the same areas, preferably shallower than 40 m depth and over sandy bottoms.

Whilst the geographical distributions of the main skates and rays species in the ecoregion are fairly well known, the stock structures for most are still to be defined.

A tagging survey of *R. undulata* carried out in the Bay of Biscay (2012–2013) shows that migrations are mostly limited to 30 km, independent of time at liberty (Delamare *et al*., 2013 WD; Biais *et al*., 2014 WD). This result confirms that several local stocks are likely to exist in western European waters giving support to three separate units for stock assessment in the ecoregion (Divisions VIIIa–b; VIIIc and IXa).

For other skate species WGEF decided to consider two stock units in this ecoregion: Subarea VIII (Bay of Biscay) and Division IXa (Iberian waters). However, further studies to better understand stock structure of these species are required, which could make use of both tagging studies and molecular techniques.

19.2 The fishery

19.2.1 History of the fishery

In order to facilitate the reading of this section, the structure adopted for describing the history of the fishery is divided according to the three main countries fishing in this ecoregion: France, Spain and mainland Portugal.

France

Skates and rays are traditional food resources in France, where directed fisheries were known to occur since the 1800s. In the 1960s, skates and rays were primarily taken as bycatch of bottom trawl fisheries operating off the northern part of the Bay of Biscay, the southern Celtic Sea and the English Channel. By this time *R. clavata* was seasonally targeted by fisheries, being the dominant skate species landed in France. After the 1980s, *L. naevus* became the dominant species. However, the landings of the two species have declined since 1986.

Other skates and rays are also landed, including *L. circularis*, *L. fullonica*, *R. microocellata, D. batis* complex and *D. oxyrinchus*. There is no evidence of large catches of *Rostroraja alba* in the past three decades by the French fleets.

Spain

The Spanish demersal fishery along the Cantabrian Sea (VIIIc) and Bay of Biscay (VIIIa,b,d) takes several skate species using different gears. Most landings are bycatch from trawl fisheries targeting other demersal species (hake, anglerfish and megrim). Several skates occur in landings, but the most common are *L. naevus* and *R. clavata*. Most of these species are landed together in the same commercial category, especially those derived from artisanal gillnetters, due to their low commercial value. Along the Cantabrian Sea and Galician coast (VIIIc and IXa) there are also artisanal fisheries (gillnetters) operating in bays or shallow waters. The importance of these fleets in the Spanish skate landings is not fully known.

Mainland Portugal

Off mainland Portugal (IXa), skates are captured by trawlers, but mainly by the artisanal polyvalent fleet, which accounts for the highest reported landings. The artisanal fleet mostly operates with trammel nets but other types of fishing gears (e.g. longlines and gillnets) are also be used. The landing composition of skate species varies between areas. The main species landed is *R. clavata*, but *R. brachyura*, *L. Naevus* and *R. montagui* are also common. Before its prohibited listing, *R. undulata* was landed frequently, particularly at the northern landing ports. Other species, such as *R. microocellata*, *R. miraletus*, *D. oxyrinchus*, *R. alba* and *L. circularis*, are also caught but less frequently (particularly the latter two species). Further details on fisheries in the IXa are reported in the Stock Annex.

19.2.2 The fishery in 2013

France

No new information is available.

Spain

The preliminary results from the DCF pilot study in the Basque Country waters (VIIIc) conducted from 2011 to 2013, which aims to describe and characterise the coastal artisanal fishery (trammel nets targeting mainly hake, monkfish and mackerel), shows that several skates and rays species are caught as bycatch, particularly *R. clavata*, *R. montagui*, *L. naevus*, *L. fullonica, L. circularis, R. brachyura* and *R. undulata*. The coastal artisanal fleet consists of 55 small vessels using gillnets and trammel nets in different periods of the year. Vessels have a mean average length of 12.7 m and 82.4 kW average engine power. The proportion of rays in the total of sampled trips was 30% in 2011, 35% in 2012 and 16% en 2013. The skates and rays landings estimates of this fleet were 19.3 t in 2012 and 26.9 t in 2012 (Diez *et al.*, 2014 WD).

In the Cantabrian Sea (VIIIc) most of skates and rays landings are bycatch from otter trawl (47%) and gillnet gears (43%), and the remaining are derived from longlines and other gears.

Mainland Portugal

Information on the fishery was mainly derived from the DCF funded pilot study focused on skate catches in the Portuguese continental fisheries (IXa) carried out from 2011 to 2013. Skates are mainly a bycatch in mixed fisheries, particularly from the polyvalent segment (between 70–76%) (Portuguese Directorate General for Natural Resources-DGRM). Polyvalent trawl vessels, depending on the fishing port, represent up to 9% of the landed weight of skates. Nets or a combination of nets and traps account for the majority of the landed weight of skates within the polyvalent segment representing between 65 and 78%, followed by longline that represents between 19 and 24% (Maia *et al.*, 2013 WD). Further details are described in the Stock Annex.

19.2.3 ICES Advice applicable

In 2012, ICES provided advice for 2013 and 2014 for several species/stocks in this region as summarized below:

Skates and rays in Subareas VIII and IX

ICES provides advice on the overall exploitation (landings and discards) of the skate and rays species assemblage, and also individual species. ICES does not advise that general or species-specific TACs be established for each species, at present. This is because a TAC is not considered the most effective means to regulate fishing mortality in these bycatch species.

ICES advises that a suite of species- and fishery-specific measures be developed to manage the commercial fisheries and achieve recovery of the depleted species. Such measures should be developed by management authorities involving all stakeholders; ICES could assist in this process. Management measures should be framed in a mixed-fisheries context, considering the overall behaviour of demersal fleets, and the drivers for such behaviour. When the TAC is exhausted, catches may continue to take place, but are discarded. In order to achieve optimal harvesting of the commercial species, and to assist recovery of the depleted species, a suite of measures should be put in place.

Closure to fishing of spawning and/or nursery grounds, and measures to protect the spawning component of the population (e.g. maximum landing size) are powerful tools to manage skates and rays. In some cases, single-species TACs may be appropriate, especially for easily identified species and/or discrete stocks in limited distribution areas.

Given that the European Community intends to introduce a ban on discards, minimum or maximum landing sizes should be carefully considered before they are introduced, because they could lead to increased discards. Size limits may best be applied in target fisheries, if discard (escape) survival can be shown to be high.

Species-specific advice was provided for the following stocks:

- Thornback ray (*Raja clavata*) in Subarea VIII (Bay of Biscay and Cantabrian Sea);
- Cuckoo ray (*Leucoraja naevus*) in Subarea VIII (Bay of Biscay and Cantabrian Sea);
- Spotted ray (*Raja montagui*) in Subarea VIII (Bay of Biscay and Cantabrian Sea);
- Spotted ray (*Raja montagui*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz);
- Cuckoo ray (*Leucoraja naevus*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz);
- Thornback ray (*Raja clavata*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz);
- Blonde ray (*Raja brachyura*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz);
- Common skate (*Dipturus batis*) complex (flapper skate *Dipturus* cf. *flossada* and blue skate *Dipturus* cf. *intermedia*) in Subarea VIII and Division IXa (Bay of Biscay and Atlantic Iberian waters);
- Other skates and rays in Subarea VIII and Division IXa (Bay of Biscay and Atlantic Iberian waters).

As species-specific landings data are not complete, it is not possible to quantify the current catch and so ICES did not advise that an individual TAC be set for individual stocks, at present. ICES recommended landings of skates and rays to be less than 4200 t for the main species and no target fishery on *R. undulata* and *Dipturus batis* complex. ICES also advise that white skate (*R. alba*) should remain on the Prohibited species list, as it appears to be depleted in this area.

Additionally, it was noted that, based on the ICES approach to data-limited stocks, catches of *L. naevus* (VIII) should increase by at least 6%, *R. clavata* (VIII) should not increase, and *R. montagui* (VIII and IXa), *L. naevus* (IXa), *R. clavata* (IXa), *R. brachyura* (IXa), and other Rajidae (VIII and IXa) should be decreased by at least 20%, compared to the last three years' average.

In 2010, ICES was asked to comment on the listings of common skate and undulate ray as 'prohibited species' on EC TAC and quota regulations.

For *R. undulata*, ICES advised "There is no basis in the current or previous ICES advice for the listing of undulate ray as a prohibited species. Therefore it should not appear on the prohibited species list in either the Celtic Seas or the Biscay/Iberia ecoregion fisheries legislation … In view of the poor knowledge and patchy distribution of these populations, ICES recommends a precautionary approach to the exploitation of these populations of undulate ray".

For common skate ICES advised "There is no basis in the current or previous ICES advice for the listing of the common skate (*Dipturus batis*) as a prohibited species. Therefore it should not appear on the prohibited species list in either the Celtic Seas or the Biscay/Iberia ecoregion fisheries legislation. In the Celtic Seas ecoregion, ICES considers that stocks of the common skate complex is depleted, and that protective management measures are required. There should be no target fishing on the common skate, and there should be a TAC set at 0.

19.2.4 Management applicable

EC Council Regulation 43/2014 established a TAC of 3420 t in 2014 for Rajidae in Subareas VIII and IX.

RAJIDAE	TAC	LANDINGS	TAC	LANDINGS
Divisions VIII & IX	2013	2013	2014	2014
Belgium	8	0	7	0
France	1441	1279	1298	1279
Portugal	1168	1114	1051	1061
Spain	1175	1168	1057	1168*
UK	8	0	7	0
UE	3800	3560	3420	3507

This Regulation indicates that catches of *L. naevus*, *R. brachyura*, and *R. clavata* shall be reported separately. Council Regulation (EC) No 43/2009 also states that *angel shark in all EC waters may not be retained on board* and that catches *shall be promptly released unharmed to the extent practicable*. This is also applied to *R. undulata*, *D. batis* complex and *R. alba*. Catches of these species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

19.2.4.1 Regional management measures

On 29–12–2011 the Portuguese Administration adopted a national legislation (Portaria no 315/2011) that prohibits, along the whole continental Portuguese EEZ, during the May the catch, the maintenance on board and the landing of any skate species belonging to the Rajidae family in each fishing trip, unless those represent less than 5% bycatch, in weight.

19.3 Catch data

19.3.1 Landings

Rajidae landing data for the period 1996–2012 are given in Tables 19.1a–e and in Figures 19.1a–b. Landings reported by Spain for 2013 are considered preliminary and will be revised in the 2015 WG. Tables 19.2 and 19.3 present species specific-landings (see Section 19.10).

Skates and rays in ICES Subarea VIII

Historically the 59.6% of landings in this area were assigned to France while 38.9% are from Spain and Basque Country fisheries combined. Since 1973, landings of skates and rays show no clear pattern, although there was a remarkable peak at the earlier years of the time-series (1973–1974) and also from 1982–1991.

From 2003 to 2013, landings in Subarea VIII have been between 2000–2800 t.y^{-1}. In 2013 the Divisions with the highest landings were VIIIa–b (72%), mostly from France (1220 t), which was similar to 2012. In Division VIIIc (25%) landings, mainly from Spain and Basque Country, reached 507 t in 2013. The Division VIIId represented the 3%) reached 59 t in 2013.

Skates and rays in ICES division IXa

In 2012 and 2013, the total landings in this subarea are the lowest recorded since 1996, probably reflecting the Portuguese legislation adopted (see 19.2.4.1.) Reported landings from this area are from Portugal (82%) and from Spain (18%). In 2013, the most important species in official landings, by decreasing order, are *R. clavata, R. brachyura, L. naevus* and *R. montagui* (see Section 19.4.2 for more detailed information).

The Spanish mean annual landings since 1999 were 324 t with a maximum of 549 t in 2011.

From the 1990s until 2010 the Portuguese mean annual landings were ~1500 tonnes. In 2012 and 2013 landings decreased to 1131 and 1114 t respectively, being in line with the quota assigned to Portugal. This decrease is also likely to reflect the Portuguese regulation measure to reduce fishing effort on skates (see 19.2.4.1.).

19.3.2 Discards

Discard information is available for Basque OTB (Bottom Otter Trawler) fleet in Divisions VIIIa, b, c, d (Table 19.4a and b), Spanish fisheries in VIII and IXa (Table 19.4c) and from Portuguese OTB and Polyvalent fleets (Tables 19.4d to 19.4g). Although there may be a widespread discarding of skates across fisheries, a proportion of these are likely to survive.

Basque OTB fleet in VIII

In Subarea VIIIa,b,d, small specimens are commonly discarded. Since 2009, there is species-specific information of skate discards. This information indicates that *L. naevus* was the most discarded species with a peak of 22.7 t in 2013.

The analysis of discard estimates for the period 2009 to 2013 indicates that depending on the year this fleet discarded 4–23% of *L. naevus* catches and 0–11% of *R. clavata* (Table 19.4b).

Spanish fleet in IXa and VIIIc

Information on results of the Spanish discard sampling programme for the main elasmobranch species in VIIIc and IXa were updated. *L. naevus* and *R. brachyura* were the most frequently discarded species in some years (Table 19.4c).

In 2013, preliminary discard estimates for the Spanish and Basque OTB fleet in VIII were 52 t of *L. naevus* (4% of total landings) and 55 t of *R. clavata* (18% of total landings).

Portuguese OTB fleet in IXa

Information on discards of elasmobranchs produced by the Portuguese bottom otter trawl fleet operating in the ICES Division IXa has been collected by the Portuguese on-board sampling programme (EU DCR/NP) between 2004 and 2013. Methodologies to estimate the probability of the species being caught in a haul and a specimen being discarded, as well as, the expected number of discarded specimens per haul are described in stock annexes.

Two fisheries were analyzed: i) the crustacean bottom otter trawl fishery (OTB_CRU) and ii) the demersal bottom otter trawl fish fishery (OTB_DEF). In both fleets, the probability of the species being caught in a haul and of a specimen being discarded, as well as the expected number of discarded specimens per haul, were both very low (Tables 19.4d–g). The annual frequency of occurrence of rajids ranged from 0% to 9% in the crustacean fishery (Prista *et al.*, 2014WD). In the demersal bottom otter trawl fish fishery, rajids occurred in 0 to 51% of the total number of sampled hauls, with *R. clavata* occurred in up to 21%. The frequency of occurrence of rajids in discards was low, with *R. clavata* occurring at maximum of 12% (Prista *et al.*, 2014WD).

Polyvalent Portuguese fleet

Information on discards of Rajidae species produced by the Portuguese polyvalent fleet operating in the ICES Division IXa was obtained from the DCF skate pilot study and from the DCF Portuguese trammel nets fishery pilot study. The addressed fisheries include: i) the net fisheries (trammel or gillnets) targeting a multi-species complex and ii) the trammelnets fishery targeting anglerfish. For analysis purposes the considered fisheries were categorized as operating shallower than 150 m in the case of multi-species net fishery and deeper than 150 m regarding the anglerfish trammelnets fishery. Results show that the frequency of occurrence of rajids was higher in nets operating shallower than 150 m, presumably due to a higher spatial overlap with the species' distributions. The probability of the species being caught in a haul and a specimen being discarded and the expected number of discarded specimens per haul were very low for all the species considered in the analysis (Tables 19.4c and 19.4f). Methods are described in the Stock Annex.

19.3.3 Discard survival

Table 19.4h shows survivorship estimates for *R. clavata*, *L. naevus*, *R. montagui,* and *R. brachyura* based on onboard sampling observations collected under the Portuguese DCF skate pilot study. Results indicate that the survivorship of all the species addressed after capture is high. Both mesh size and soak time affected survivorship. Methods for estimating survivorship are described in the Stock Annex.

In the case of *R. undulata*, from a total of 100 individuals sampled onboard fishing vessels, 91% were found with "good" health status, 6% found with "moderate" health status and only 3% found in "poor" health status (Table 19.4i). These results indicate that the survivorship of *R. undulata* after capture is high. The size of the specimens influences the survivorship of this species. For the two size groups considered groups (<50 cm and > 50 cm) the percentage of individuals in "good" health status is high (83% and 92%, respectively). However, smaller individuals (< 50 cm) showed a lower percentage of "good" health condition. In general, for different soaking times and mesh sizes the survivorship of *R. undulata* is always very high (>82%). The method used to estimate the survivorship of this species is described in the stock annex.

19.4 Commercial catch compositions

19.4.1 Species and size composition

Subarea VIII

Length–frequency distributions of *R. clavata* and *L. naevus* from commercial Basque trawlers in VIIIa,b,d are presented in Figures 19.2a–b.

Divison IXa

Length data information is collected from Spanish commercial fleets under the EU/DCF. The length–frequency distribution of *R. clavata* from the Spanish commercial fleet (mainly trawl fleet) in IXa ranged from 24 cm to 98 cm, with a mean length of 55.5 cm (Figure 19.3a). The length–frequency distribution of *L. naevus* from the Spanish commercial trawl fleet operating in Galicia and Cantabrian Sea ranged from 31 to 65 cm, with a mean length of 49.5 cm (Figure 19.3b) whereas length–frequency distribution from artisanal fleet (mainly gillnets) operating in Galicia coastal waters (IXaN) ranged from 54 to 77 cm, with a mean length of 64 ± 4 cm.

Length–frequency distributions of *R. clavata, R. brachyura, R. montagui, R. microocellata* and *L. naevus* from the Portuguese commercial polyvalent and trawl fleet are present in Figures 19.3c–g. Length–frequency distributions were built by extrapolating to the total estimated landed weight of each species. Both length distributions and ranges are stable among years for both fleets. However, there are differences in length distributions between the two fleets for some species: landings from the trawl segment tend to be composed by a higher density of smaller length classes than the polyvalent fleet as in the case of *R. brachyura* and *R. microocellata*.

Length–frequency distribution of *R. undulata* collected on board of polyvalent vessels is presented in Figure 19.3h. In recent years the length structure of the population caught shifted to larger individuals.

19.4.2 Quality of the catch data

Species composition of landings in Subarea VIII and Division IXa are presented in Tables 19.3 and 19.5. Only a small proportion of landings are reported as Rajidae or *Raja* spp.

From 2011 to 2013 there was a DCF pilot study (coordinated between AZTI-Tecnalia and IPMA). The main objective of the Basque Country pilot study was to characterize the main fishing parameters of the trammelnet fishery (fishing gear, métier, effort and lpue) and to identify the skates and rays species present in the landings as well as the biometric relationships as "wing weight/total weight" and total length/wing width" in order to precise the live weight of the landed skates and rays.

In the Portuguese official landings statistics only four commercial designations are adopted: thornback ray, blonde ray, spotted ray and cuckoo ray. Thus skate species misreporting in landing ports persist. To circumvent this deficiency an extra effort in data collection was made under the DCF skate pilot study and robust estimators were developed to estimate landings per species (for more detail on methodology see stock annexes) for the period from 2008 to 2013. Table 19.5 presents the updated landings proportion of each Rajidae species.

19.5 Commercial catch-effort data

19.5.1 Spanish data (VIII)

Only limited new data were provided.

A revised nominal lpue-series for the Basque Country's OTB DEF>=70 in Subarea VIII from 2001 to 2013 is presented in Table 19.6 and Figure 19.4 and refers to the main ray species landed by the fleets: *L. naevus* and *R. clavata*.

The *L. naevus* lpue has been above 100 kg/day except in 2002, 2009, 2010 and 2013.The lowest peak was observed in 2010 with 44 kg/day and the highest in 2007 with 169 kg/day. Landings per effort of *R. clavata* in this area are smaller than those recorded for *L. naevus*, oscillating between 14 and 29 kg/day.

19.5.2 Portuguese data (IXa)

Fishery data collected under the Portuguese Pilot Sampling Programme on skates in ICES Subarea IXa (EU DCR/NP) was used to develop a standardized lpue ($Kg.trip^{-1}$) time-series for the period 2008–2013. Standardized lpue time-series were developed for the most representative skate species; *R. clavata, R. montagui*, *R. brachyura* and *L. naevus* (Figure 19.5a). With exception of *L. naevus*, lpue standardisation was applied to the polyvalent fleet, which is the most representative fleet in terms of Rajidae landed weight. For *L. naevus*, lpue was standardized for both polyvalent and trawl fleets, since the two contribute with ~50% each for the species annual landings. The lpue time-series *R. clavata* and *R. montagui* show an increase trend, while for *R. brachyura* and, *L. naevus* lpue follows a stable trend along the entire considered period.

The index of abundance of *Raja undulata* was estimated from the Portuguese polyvalent segment as the catch weight of the species per trip (fishing effort unit) using data collected on board of commercial vessels. Cpue standardisation was constrained to the polyvalent fleet, since this species is not frequently caught by the trawl segment. Despite the short range of the time-series, cpue has a stable trend (Figure 19.5b).

Methodological procedures are described in the Stock Annex.

19.5.3 Quality of the catch data

Under DCF pilot study on rays and skates that last from 2009–2013, the quality of catch and effort data by species has greatly improved. Nevertheless since rays are caught in a high diversity of mixed fisheries there is a need to maintain the monitoring programme of the catches.

A project on *R. undulata* in Portuguese waters (Division IXa) started in June 2014 with the aim to improve the knowledge on the stock structure, abundance and the dynamics of the species.

19.6 Fishery-independent surveys

Groundfish surveys provide information on the spatial and temporal patterns in the species composition, biological aspects and relative abundance and biomass of several Rajidae species. Fishery-independent surveys operating in the Bay of Biscay and Iberian Waters are briefly discussed below (further details for Iberian waters are presented in the Stock Annexes). It should be noted that existing survey data are limited for some skate species (e.g. *R. undulata, R. brachyura* and *R. microocellata*) as a result of their more coastal distribution and habitat specificity. More detailed studies of existing data are required to better inform on their status. In some instances, it may be required to have dedicated inshore surveys using an appropriate gear and census method in order to better evaluate these stocks.

19.6.1 French survey data (VIII)

For the 1987 to 1996 period, the Survey EVHOE has been conducted in the Bay of Biscay on an annual basis with the exception of the years 1993 and 1996. It has been conducted in the third or fourth quarter except in 1991 where it took place in May. In 1988 two surveys were conducted, one in May the other in October. Since 1997 the main objectives have been: i) the construction of time-series of abundance indices for all the commercial species in the Bay of Biscay and the Celtic Sea with an emphasis on the yearly assessed species where abundance indices at-age are computed; ii) to describe the spatial distribution of the species and to study their interannual variations; and iii) to estimate and/or update biological parameters (e.g. growth, sexual maturity, sex ratio).

Population indices from the French EVHOE survey were calculated for all elasmobranchs caught Indices of abundance and biomass per year are only reliable for *L. naevus*. For other species, small number with occasional hauls with high catch and some years without catch at all did not allow using the indices. A presence-absence indicator and maps of catches by sets of three years were presented and may be a useful approach to detect changes in habitats occupied by elasmobranchs.

19.6.2 Spanish survey data (VIIIc and IXa)

The aim of the ITSASTEKA survey carried out in the coastal waters of the Basque Country by AZTI-Tecnalia (ICES Division VIIIc) is the characterization of the demersal ecosystem, to obtain reliable data on the distribution and abundance of commercial fish, cephalopods and benthic invertebrates in this area. The ITSASTEKA survey covers a total of 7.21 km^2 in 23 fishing hauls. Results of biomass index and length frequencies of the main elasmobranchs sampled in the third year of the ITSASTE KA survey carried out in summer of 2013 is presented in Section 19.6.4.

The Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters has covered this area annually since 1983 (except in 1987), obtaining abundance indices and length distributions for the main commercial species and elasmobranch. Survey design is randomly stratified with number of hauls allocated proportionally to strata area. An update of the results on four of the most important elasmobranch species sampled in the IEO Q4-IBTS survey on the Northern Iberian shelf (VIIIc and IXa North) is presented in a Working Document (Fernández-Zapico *et al*., 2014 WD).The Galician IXa area covered by the survey is reduced. Catches are low and the survey cannot be used to estimate abundance or biomass indexes. More information on the Spanish IEO Q4-IBTS survey in the Cantabrian Sea and Galician waters is reported in the stock annexes.

The Spanish bottom trawl survey IBTS-GC-Q1-Q4 (ARSA) in the Gulf of Cadiz has been carried out in the spring and autumn from 1993 to 2013. The surveyed area corresponds to the continental shelf and upper-middle slope from the latitude 6º20’W to 7º20’W and from 15 m to 800 m depth covering an area of 7224 km^2.

19.6.3 Portuguese survey data (IXa)

The Portuguese Autumn Groundfish Survey (PT-GFS) has been conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, ex-IPIMAR) and has the main objective to monitor the abundance and distribution of hake (*Merluccius merluccius*) and horse mackerel (*Trachurus trachurus*) recruitment (Cardador *et al*., 1997). In these surveys, *R. clavata* is the most frequent skate species caught (88% of the total weight of skates).

The Portuguese crustacean surveys/ *Nephrops* TV Surveys (PT-CTS (UWTV (FU 28–29)) have also been conducted by IPMA and the main objective is to monitor the abundance and distribution of the main commercial crustaceans (*Nephrops norvegicus,* rose shrimp *Parapenaeus longirostris* and red shrimp *Aristeus antennatus*).

19.6.4 Temporal trends

French EVHOE Survey (VIII)

The abundance of *R. clavata* shows no clear trend in the series but two important peaks can be observed in 2001 and 2008 to 56 and 16 individuals per hour respectively (Figure 19.6a). The abundance of *L. naevus* in almost all years of the series higher than *R. clavata*, and strongly fluctuates over the period with highest values in 2002, 2007, 2008 and 2011.

Figure 19.6bc shows the geographical distribution (occupancy) of several skate species recorded in the French EVHOE survey in the Bay of Biscay (VIIIa, b) since 1987. The occupancy data are grouped each three years of the series since 1987.

L. naevus is mainly distributed in the northern area (Division VIIIa) of the Bay of Biscay near the continental slope, and less abundant in the survey record in the period from 1987 to 1994.

R. brachyura is only found in very few hauls in the north of the VIIIa Division and always in waters near the coast. This species was absent in the survey records from 1991 to 2010.

R clavata, as in the case of *R. Brachyuran,* is found in few hauls but is distributed mainly in the northern and centre areas of Bay of Biscay, near the coast and but also in waters placed in the middle areas of the continental platform.

R. montagui is mainly found in northern waters of Division VIIIa and less frequently in the north areas of Division VIIIb. As with *R. clavata,* it is distributed near the coast and but is also found in the middle areas of the continental platform.

R. undulata is only found in a few hauls, always in shallower waters and near the coast, but its distribution goes from the northern parts of VIIIa to the southern parts of VIIIb. This species was absent in several periods of the historical series (1987, 2002–2004).

Basque Country (Spain) ITSASTEKA survey (VIIIc)

In 2013 the ITSASTEKA survey, identified 76 different species of fish and cephalopods in 27 sampling stations, of which only three were demersal sharks (*G. melastomus, Mustelus* spp. and *S. canicula)* and four skates (*L. naevus, R. clavata, R. undulata* and *R. montagui*). In 2013, despite the small number of shark and skate species caught, catch rates (kg/km^2) reached 24% of total biomass of fish and cephalopods (4% in 2011 and 12.9% in 2012) due to the high abundance of *S. canicula*.

R. clavata was found in 18 trawling stations, at depths <200 m but mainly to 0–100 m in sand and muddy grounds (Table 19.7). In one station, biomass indices reached 200 kg/30 min. In 2011 the proportion of larger individuals was higher than in the rest of the years (Figure 19.7).

L. naevus was less abundant, only found in four trawl stations always at depths <135 m and with much lower biomass indices than *R. clavata*.

Spanish IEO Q4-IBTS survey in VIIIc and IXa

In 2013 in Division VIIIc the main species in biomass terms in this survey, in decreasing order of abundance, are *R. clavata*, *R. montagui* and *L. naevus*. All species have shown an increase in biomass with regard to previous years in Division VIIIc, some (as *R. clavata*) reaching peaks in the time-series (Fernández-Zapico *et al*., 2014 WD). Stratified length distributions, biomass indices and geographic distribution of the catches are presented for *R. clavata* (Figures 19.8a–c) and *L. naevus* (Figure 19.9a–c).

Raja clavata is the most abundant skate in the area, and in 2013 showed the highest value of the time-series in VIIIc, around 7 kg·haul^{-1} almost twice compared to the previous year. In IXa, this species registered a decrease in relation to 2012 but the index values were similar to those registered along the time-series available. This survey is not considered to provide an adequate index of abundance for the species.

In Division VIIIc *Leucoraja naevus* displayed a sharp increase in the catch rate (three times the value of the previous year in the stratified biomass), with the index value being similar to the value observed in 2001, the highest one of the time-series. No records of *L. naevus* were found in Galician waters (Division IXa).

Portuguese surveys (IXa)

Raja clavata biomass index estimates from the Portuguese Autumn Groundfish Surveys (PT-GFS) show at the end of the time-series the levels of biomass are at high levels compared for instance with the late 1990s early 2000s (Figures 19.10).

Leucoraja naevus biomass index estimates have been stable since 1998 apart from a high value registered in 2011 which showed a very level of variability (Figure 19.11).

Raja montagui biomass index estimates from the Portuguese Autumn Groundfish Surveys (PT-GFS) show a stable trend along the whole time-series, particularly since 2008 (Figures 19.12).

Spanish (IBTS-GC-Q1-Q4 (ARSA) bottom trawl survey in the Gulf of Cadiz (IXa South)

In ARSA surveys, 21 different skates and rays species were caught. The most abundant were *L. naevus* and *R. clavata,* both species presenting similar catch rate values (kg/hour) in the autumn survey along the time-series available. L*eucoraja naevus* shows an increasing trend since 1993 with the highest values in 2001, 2005 and in 2013, when the maximum is reached (1.2 kg/hour). *Raja clavata* showed the highest indices in the last years of the series, reaching 1.4 kg/h in 2013 (Figure 19.13a).

The abundance trend (no/hour) shows some variability along the years but, for both species, the abundance has been increasing since 1993 with the highest values observed in 2013 for *R. clavata* and in 2006 and 2013 for *L. naevus* (Figure 19.13b).

19.7 Life-history information

Studies on biological aspects, e.g. age and growth, reproduction, diet and morphometry, of the most frequently landed species, such as *Raja clavata*, *R. brachyura*, *R. undulata*, *L. naevus* and *R. montagui* caught in Portuguese Iberian waters are available (ICES Division IXa). Table 19.8 compiles the main biological information collected. More information, including diet and trophodynamic modelling for the northern part of IXa, is available in the Stock Annex.

19.7.1 Ecologically important habitats

Recent studies have provided information on ecologically important habitats for *R. clavata*, *R. brachyura*, *R. montagui*, *R. microocellata*, *R. undulata* and *L. naevus* in Portuguese continental waters (Serra-Pereira *et al.*, 2014). Sites with similar geomorphology were associated with the occurrence of juveniles and/or adults of the same group of species. For example, adult *R. clavata* were mainly found in sites deeper than 100 m with soft sediment. Those were also referred as habitat for egg deposition of this species. *Raja undulata* and *R. microocellata* are more coastal species, occurring preferentially on sand or gravel habitats. *Raja brachyura*, *R. montagui* and *R. clavata* potential nursery areas were located in coastal areas with rocks and sand seabed (Serra-Pereira *et al.*, 2014). More information is available in the Stock Annex.

Information from trawl surveys on catches of (viable) skate egg-cases is considered valuable for evaluate ecologically important habitats. Further information could be collected in trawl surveys.

19.8 Exploratory assessments

Previous analyses of the skates in this ecoregion have focused on commercial lpue data and survey data. Updated analyses were conducted in 2014 (see below).

19.9 Stock assessment

Given the limited time-series of species-specific landings, and that commercial and biological data are often limited, the status of the main skate stocks is based primarily on survey data. Further analyses of survey data (see Section 19.6) and catch rates were undertaken. In this section, data and analyses are summarised by stock units for which ICES provides advice are detailed.

19.9.1.1 Thornback ray (*Raja clavata*) in Subarea VIII (Bay of Biscay and Cantabrian Sea) (rjc-bisc)

The Spanish IEO Q4-IBTS survey in VIIIc provides information on the stock status of *R. clavata* in Subarea VIII. The highest catch rate of the time-series was observed in 2013, being almost twice the value from the previous year. Catches in the EVHOE survey are low and are not considered suitable for abundance or biomass trend analyses, for the whole time-series only occasional high catch values were registered. A presence-absence indicator was calculated (see Stock Annex) and did not show trend in the area occupancy of *R. clavata* in the Bay of Biscay since the late 1980s (Table 19.9).

19.9.1.2 Thornback ray (*Raja clavata*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz) (rjc-pore)

The status of this stock is evaluated based on survey data derived from the Portuguese Autumn Groundfish Surveys (PT-GFS) and the Spanish ARSA survey in Gulf of Cadiz (Q1 SP-GCGFS and Q4 SP-GCGFS). The biomass index from the Portuguese Autumn Groundfish Survey (PT-GFS) is stable along the overall series. Both ARSA surveys series indicate a long-term increasing trend (from 1997 to 2013). Combined survey data suggest a stability of the series until 2005 and an increasing trend since then with a distinct maximum in 2013. Following ICES DLS approach for category 3 stocks, the annual trend on the combined surveys (each survey scaled to average for the overall period) is consistently increasing for the overall period. The ratio between the average biomass index for the last two years (2012–2013) and the average of the biomass index for the reference period (2007–2013) is 1.74.

Annual standardized lpue estimates determined for Portuguese polyvalent fleet for the period 2008–2013 show an increasing trend, consistent with the combined surveys trend (Figure 19.5a).

Annual mean length of the specimens caught during the Portuguese Groundfish Surveys is equal or above the mean of the series since 2008 (Figure 19.14).

19.9.1.3 Cuckoo ray (*Leucoraja naevus*) in Subarea VIII (Bay of Biscay and Cantabrian Sea) (rjn-bisc)

Survey indicators suggest an increase in biomass over the past two decades in Subarea VIII (Figure 19.15) and a more stable situation for the potential whole stock in VIIjk and VIIIabd (Figure 19.16). EVHOE survey information on abundance, biomass and mean length was used to assess the stock status of this species. The spatial distribution of the survey catches suggest that one single population occurs in VIIIa,b,d and VIIj,k (Figure 19.17). The Spanish IEO Q4-IBTS survey recorded an important increase of the cuckoo ray catches in 2013 (three times the value of the previous year in the stratified biomass).

19.9.1.4 Cuckoo ray (*Leucoraja naevus*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz) (rjn-pore)

The status of this stock is evaluated based on survey data derived from Portuguese Crustacean Surveys/ *Nephrops* TV Surveys (PT-CTS (UWTV (FU 28-29)) and Spanish ARSA surveys in Gulf of Cadiz (Q1 SP-GCGFS and Q4 SP-GCGFS). Both ARSA surveys series indicate a long-term increasing trend (1993 and 1997 to 2013). The Portuguese Crustacean Surveys show cpue stability since the beginning of the series in 1997. Following ICES DLS approach for category 3 stocks, the annual trend on the combined surveys (each survey scaled to average for the overall period) is consistently increasing for the overall period. The ratio between the average biomass index for the last two years (2012–2013) and the average biomass index for the reference period (2007–2013) is 2.22.

Annual standardized lpue estimates determined for Portuguese trawl and polyvalent fleets for the period 2008–2013 show a stable trend for both segments, with a distinct maximum obtained in 2013 for the polyvalent Portuguese fleet (Figure 19.5a).

Annual mean length of the specimens caught during the Portuguese Crustacean Surveys /*Nephrops* TV Surveys (PT-CTS (UWTV (FU 28–29)) are stable since 2006 (Figure 19.18).

19.9.1.5 Spotted ray (*Raja montagui*) in Subarea VIII (Bay of Biscay and Cantabrian Sea) (rjm-bisc)

Spotted ray is sporadically present in the EVHOE catches (see Stock Annex). The occurrence of this ray in the EVHOE catches does not suggest any recent change in abundance.

19.9.1.6 Spotted ray (*Raja montagui*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz) (rjm-pore)

The status of this stock is evaluated based on survey data derived from the Portuguese Autumn Groundfish Surveys (PT-GFS). Survey data suggest a stability of the whole series, with the last years' estimates above the average for the entire series. Lpue time-series display some variability, with an increasing trend since 2011. Following ICES DLS approach for category 3 stocks, the biomass index increased: the ratio between the average biomass index for the last two years (2012–2013) and the average biomass index for the reference period (2007–2013) is 1.

Annual standardized lpue estimates determined for Portuguese polyvalent fleet for the period 2008–2013 show a stable trend with a distinct maximum in 2013 (Figure 19.5a).

Annual mean length of the specimens caught during the Portuguese Groundfish Surveys is equal or above the mean since 2008 (Figure 19.19).

19.9.1.7 Undulate ray (*Raja undulata*) in Divisions VIIIa,b (Bay of Biscay) (rju 8ab)

The abundance indices time-series from the EVHOE survey are not informative for this stock because the distribution of undulate ray is mostly shallower than the area surveyed. It includes years with no catch and the number caught per years is very low.

A mark–recapture survey has provided a biomass estimate in the Bay of Biscay, particularly for the Gironde Estuary and for the part of the stock formed by the larger fish (>65 cm length) (Biais *et al*., 2014 WD). The habitat surface (Figure 19.20) and density indices estimates (Table 19.10), were used to determine the biomass of fish larger than 65 cm, which ranged between 87 and 120 t in the whole central part of the Bay of Biscay.

The tagging survey also provided catch at age ratios, using the length distribution to get number-at-age using age slicing based on the von Bertalanffy growth curve parameters estimated by Moura *et al*. (2007) in the central Portugal (script in R from Kell and Kell, 2011). Ages between 9 and 10 are considered not affected either by the gear selectivity or by a possible decrease in vulnerability to the longline of the larger fish, at least in November-December (Table 19.11). The ratio obtained provided an estimate of the total mortality-at-age 4 in 2008, before the landing ban, and of the fishing mortality (0.17) using the natural mortality estimate as 0.27 in the central Portugal (Serra-Pereira *et al*., 2013 WD), assuming that the fishing mortality is negligible since the ban implemented in 2009.

Abundances-at-ages 4 and 5 in 2008 may also be estimated using the mark–recapture abundance estimates at ages 10 and 11 at the beginning of 2014 (ages 9 and 10 at the end of 2013) and considering that fishing mortality-at-age 5 is similar to age 4 in 2008 and that natural mortality is only acting over the population from 2009 onwards.

Based on these estimates, the catch and spawning biomass may be estimated in 2008 and in following years, making assumptions on the fishing mortality pattern in 2008. The aim was to investigate the biomass trend since the 2009 landing ban and the consistency of the mark–recapture estimates regarding in particular the 2008 catch for which a second estimate is available (Hennache, 2013; cited by Delamare *et al*., 2013 WD). The simulations were carried out for the low and the high abundance estimates which are provided by the mark–recapture survey (Table 19.12).

A flat fishing pattern was adopted above age 7, considering that when fish length is above 73 cm, the fishing effort is likely the same on all age groups and that the catchability fluctuations are negligible compared to other uncertainties. Fishing mortality-at-age 6 was fixed to the mean of fishing mortalities-at-ages 5 and 7 to smooth the transition between this two ages.

Fishing mortalities-at-ages 3 and younger ages are considered null. This latter assumption supposes that the fish are all discarded at these ages and that their survivorship is high. It is questionable as is the constant mortalities above age 7, but a fishing pattern with low fishing mortalities at younger ages is likely realistic. The general shape of the fishing pattern is then considered to be depicted.

Assuming this fishing pattern, fishing mortality-at-age 7 is the only missing value to estimate the stock numbers at all ages in 2008 from stock numbers-at-ages 5 and 6.

To estimate this fishing mortality-at-age 7, the constraint was set to have recruitment at age 0 lower than the estimate of egg number released by the females, calculated using sex ratio of tagging survey catch and fecundity estimates from Portuguese waters (Figueiredo *et al*., 2014 WD). This constraint requires that the fishing mortality-at-age 7 is less than 0.76 for the low as well as the high abundances-at-ages 5 and 6 provided by the mark–recapture survey.

The corresponding catches are 43 t and 60 t in 2008, depending on whether the low or the high abundances-at-ages 5 and 6 are used. Catch in 2008 was estimated between 60 and 100 t by Hennache (2013), using action hall information (cited by Delamare *et al*., 2013 WD). This latter catch is consequently estimated too high and/or the abundances are underestimated by the mark–recapture survey.

To estimate stock numbers in 2015, constant recruitments and numbers-at-ages being reduced only by natural mortalities were assumed. The spawning–stock biomass was estimated by adopting a knife edge ogive and age-at-maturity available (Stephan *et al*., 2014 WD). Note that the constant recruitment assumption has no effect on the spawning biomass trend from 2008 to 2015 as maturity is estimated to occur at age 8.

Higher is the fishing mortality in 2008, lower is the spawning biomass in 2009 (at the beginning of the year) and consequently higher is the increase from 2009 to 2015 because the 2015 spawning biomass will be composed largely by year classes which were slightly or not exploited in 2008, according to the assumed fishing pattern. At half of the higher fishing mortality-at-age 7, according to the constraint on the egg number released by the females, the spawning biomass is estimated to have been multiplied by 4. According to the set of assumptions, the spawning biomass increases consequently largely from 2009 to 2015 and to values which are only slightly changed when the fishing mortality varies (about 190 t or 270 t when respectively low or high abundance estimate are used). Regarding the possibility that the abundances are underestimated by the mark–recapture survey, these values may be changed proportionally to any increase of the mark–recapture abundances, but the increasing spawning biomass trend is unchanged.

However, it must be underlined these results must be considered with caution, given that the numerous assumptions were made and particularly the complete effectiveness of the ban on landing associated with a high survivorship of discards (no fishing mortality from 2009 to 2015).

19.9.1.8 Undulate ray (*Raja undulata*) in Division VIIIc (Cantabrian Sea) (rju 8c)

Scientific studies carried out in the eastern VIIIc area have been conducted to characterize the specific composition of the landed skates and rays, the species-specific cpue and the geographical distribution of the catches (Diez *et al.*, 2014). During the period 2011–2013, up to 118 trip/hauls of 21 vessels of the trammel net fleet belonged to the nine main ports of the Basque Country were sampled. *Raja undulata* was the fifth most important species caught (5% of the total). The total estimated catches of this species in 2011 and 2012 were 1.3 t and 1.0 t respectively. The short time period does not allow inferring if the population levels are low or have declined. According to fishing interviews this species is locally frequent and widely distributed in the coastal waters of the VIIIc, although not very abundant in catches. This situation may not have changed over the years.

19.9.1.9 Undulate ray (*Raja undulata*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz) (rju 9a)

The compiled data on this species (Pilot Study on Skates included in DCF) for the period 2011–2013 showed that the species has a patchy distribution along the Portuguese continental coast being concentrated in specific coastal areas. Along the Portuguese continental waters, the species is more abundant between 30 and 40 m deep.

The stability on the length–frequency distribution and on the index of abundance from on-board observations along years suggests that the stock in Division IXa has not been severely impaired by previous exploitation.

Biological data and the relative high discard survivorship indicate that the resilience of the species to exploitation when than other Rajidae species is at relative high level.

Given that patchy distribution of the species, the adoption of local management measures e.g. no fisheries on the hotspot of species concentration, will allow the monitoring of the stock.

19.9.1.10 Blonde ray (*Raja brachyura*) in Division IXa (west of Galicia, Portugal, and Gulf of Cadiz) (rjh-pore)

Surveys indexes are considered not to be indicative of the stock status since this is a coastal species with a patchy distribution, and thus not recorded during groundfish surveys. Landing and effort data from Portuguese polyvalent fleet constituted the input data for evaluating the stock status.

Annual standardized lpue estimates determined for Portuguese polyvalent fleet for the period 2008–2013 show a stable trend (Figure 19.5a).

The yield per recruit (Y/R and potential spawning ratio (%SPR)) curves at long term for different levels of fishing mortality and age of first capture (TC) were estimated using the polyvalent fishing data as described in stock annex. The actual F (F_{CURR}=0.14) is at a level correspondent of about 30% of the virgin exploitable spawning biomass ($F_{30\%SPR}$=0.15) indicating that the stock have been exploited at a sustainable fishing rate (Figure 19.21).

19.9.1.11 Common skate (*Dipturus batis*-complex) in Subarea VIII and Division IXa (Bay of Biscay and Atlantic Iberian waters) rjb-89a

These species are only caught occasionally in the Subarea VIII and are inexistent in Division IXa.

Despite common skate (*Dipturus batis*) complex being a prohibited species in EU some individuals were occasionally landed in French fish markets in 2014, in Division VIIIa. Sampled specimens in fish markets included an adult female of *Dipturus* cf. *intermedia* (2 m total length) - a southerly record of the species in recent years; and small individuals of *Dipturus batis* (cf. *Flossada*) caught at the Glénan archipelago (southern Brittany). As these species are now mostly extirpated from the shelf seas of this area, fishermen generally are unable to accurately identify them. Available information does not change the perception of the stock status of these species that occur at low levels in this ecoregion.

19.9.1.12 Other skates and rays in Subarea VIII and Division IXa (Bay of Biscay and Atlantic Iberian waters) rja 89a

The sandy ray, *Leucoraja circularis,* occurs on the deeper shelf and along the slope of the Bay of Biscay and has a minor expression on the Portuguese landings. Minor occurrences of the shagreen ray (*Leucoraja fullonica*) are observed to the North of ICES Division VIIIa, being absent from Division IXa. Owing to higher abundance in the Celtic Sea these are most probably part of the stock of the Celtic sea.

In Subarea VIII, occasional catches of the blonde ray (*Raja brachyura*) and the small-eyed ray (*Raja microocellata*) are found at the coast. These four species are caught in small numbers in the EVHOE survey to calculate population indices.

In Division IXa *Raja microocellata*, *Raja miraletus* and *D. oxyrhincus* have low expression in landings. The two latter species are caught in low numbers in Portuguese surveys.

19.9.2 Stock status

The following table provides a summary of stock status for the main species using ICES DLS approach.

SPECIES	NOMINAL STOCK AREA	PERCEIVED STATUS
Thornback ray *Raja clavata*	VIII	Survey catch rates increasing in VIIIc but no trends in surveys in VIIIabd.
	IXa	Survey catch rates stable/increasing
Cuckoo ray *Leucoraja naevus*	VIII	Survey catch rates increasing
	IXa	Survey catch rates stable/increasing
Spotted ray *Raja montagui*	VIII	Uncertain. No trends are apparent from surveys.
	IXa	Survey catch rates stable/increasing
Undulate ray *Raja undulata*	VIII	Uncertain. Surveys available data are not informative for this stock
	IXa	Abundance index indicate stable trend. Species patchy distributed along IXa
Blonde ray *Raja brachyura*	IXa	Uncertain. Survey data are not informative for this stock. Lpue estimates show a stable trend from 2008–2013
Common skate *Dipturus batis* complex	VIII and IXa	Uncertain. Available information does not change the perception of the stock status, that is only caught occasionally in the Subarea VIII and are inexistent in Division IXa.
Other skates and rays	VIII and IXa	Uncertain. These species are cuagth in small numbers in surveys and commercial fisheries

19.10 Quality of assessments

No full analytic stock assessments have been conducted either for Divisions VIIIa–b, VIIIc or IXa, but an exploratory assessment is presented for *R. Undulate* in the Bay of Biscay (VIIIa,b).

Lpue data for *L. naevus and R. clavata* are available for Divisions VIIIa, b, d since 2001. Since 2008 lpue were available for *R. clavata*, *R. microocellata*, *R. montagui*, *R. undulata* and *R. brachyura* in Division IXa.

In the last four years, a lot of effort has been made by the countries involved in the demersal elasmobranch fisheries on this ecoregion to provide species-specific landings of skates and rays. As a result of this improvement in the data, 19 different species have been identified (plus a general category "Rajidae.") from catches of Subareas VIII and IX. A summary of the information available of the species-specific landings of skates and rays by country is shown in Tables 19.2 and 19.3.

Like surveys in other ecoregions, surveys in VIII and IXa were not specifically designed for elasmobranchs, producing a high frequency of zero-catch data. The fishing gear used in surveys is not the most appropriate to catch elasmobranchs, especially for species with patchy distributions. The survey effort in coastal areas is very scarce and does not cover a wide range of depths. Nevertheless, for some species, it is possible to estimate some valuable abundance data and by that get trends on abundance. An effort has been done to overcome these data limitations in order to standardize the fishery-independent abundance indexes, using as an example the estimates for *R. clavata* data from the autumn survey (PT-GFS) in IXa (Figueiredo and Serra-Pereira, 2013 WD). To deal with the large amount of zero-catches a generalized linear mixed model (GLMM) was fitted to the data, assuming a Tweedie distribution for the observations. One of the main purposes of applying a GLMM was to incorporate, in the model, variables that could account for the differences between years, namely the difference between stations, depths, survey methodology, etc. Some decisions/assumptions had to be taken in order to proceed with the analysis of the data, including the determination of a subset of the available data which is better represents the geographical distribution of the species. Since, this methodology was proven to be adequate to model the abundance series of *R. clavata*, for 2014, standardized fishery-independent abundance indexes will be presented for the remaining species, in this division.

Undulate ray tagging has shown that the distribution of this species is discontinuous, confirming the 2013 tagging results and the need to assess the state of the stocks of this species for areas that fit with the limited moves that this species may make. This behaviour may be a benefit for obtaining mark–recapture stock estimate as the one provided for central part of the Bay of Biscay. Its results allow an exploratory analysis including a lot of assumptions. Consequently, it must be regarded as only indicative of the biomass trend.

19.11 Reference points

No reference points have been proposed for the stocks in this ecoregion.

19.12 Conservation considerations

IUCN lists angel shark, *D. batis* complex and *R. alb*a (NE Atlantic) as Critically Endangered, *R. undulata* and the guitarfish *Rhinobatos cemiculus* and *Rhinobatos rhinobatos* are listed as Endangered, and *L. circularis* as Vulnerable. Sawfish (*Pristis pectinata* and *P. pristis*) are also listed as Critically Endangered, and although the southernmost part of IXa is the northernmost part of the purported range of these species, the occurrence of these species in European Atlantic seas is questionable.

Species listed by the IUCN as Near Threatened include *D. oxyrinchus*, *L. fullonica*, *R. brachyura*, *R. clavata*, *R. microocellata* and *S. stellaris*. *L. naevus*, *R. miraletus*, and *R. montagui* are all listed as Least Concern (Gibson *et al*., 2008).

19.13 Management considerations

EC Council Regulation 39/2013 established a TAC of 3800 t in 2013 for Rajidae in Subareas VIII and IX. EC Council Regulation 43/2014 established a TAC of 3420 t in 2014.

The Council Regulation (EC) No 43/2009 of 16 January 2009 which bans the retention on board of three species of skates (see 19.2.4 Management applicable) has been a controversial issue in the affected countries. Despite an official answer from the EU Commission confirming this position, the fishing industry asked this measure to be reconsidered and other scientific studies to be conducted in order to assess the English Channel and Bay of Biscay and Iberia stock(s).

Spanish artisanal fishers operating in coastal waters of VIIIc and IXa and the French fisheries Ministry expressed surprise at this measure in 2009, as there is not enough information or evidence of declines in the populations of *R. undulata* in these subareas. In this sense, due to the coastal and shallow distribution of this species, there are not enough data from catches. Most of the catches of this species came from small artisanal vessels operating in bays or shallow waters. Although Spanish trawler fleets historically land the largest proportion of skates from the Cantabrian Sea and Bay of Biscay waters, they do not catch *R. undulata*, because trawling is banned in waters shallower than 100 m.

In order to answer this controversial management decision, in 2011 Portugal and Spain (Basque Country) developed a triennial pilot project, funded by the DCF, to study the fisheries catching skates and rays in the areas of the continental coast in ICES Subarea VIII and Division IXa (Diez *et al.*, 2014 WD). The main objective of the study was to improve the quality of knowledge of the fisheries landing skates, filling the gaps in existing basic issues, such as fishery information, biology and economic importance. The data being collected will contribute to the future stock assessment of skates and rays from the Iberian ecoregion, and ensure the sustainability of the fisheries involved. The pilot study shares the same concept, goal, work plan and data analysis but is adapted to the particular "*modus operandi*" of the different fleets existing in the Subarea VIII and Division IXa.

On 29–12–2011 the Portuguese Administration adopted a national legislation (Portaria no 315/2011) that prohibits, along the whole continental Portuguese EEZ, during the whole month of May the catch, the maintenance on board and the landing of any skate species belonging to the Rajidae family. In addition, in each fishing trip a maximum of 5% bycatch, in weight, of those species is allowed to be maintained on board and to be landed.

19.14 References

Biais G., C. Hennache, É. Stéphan, A. Delamare. 2014. Mark–recapture abundance estimate of undulate ray in the Bay of Biscay. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, Lisbon, 17–26 June, 2014.

Cardador, F., Sanchéz, F., Pereiro, F.J., Borges, M.F., Caramelo, A.M., Azevedo, M., Silva, A., Pérez, N., Martins, M.M., Olaso, I., Pestana, G., Trujillo, V. and Fernandez A. 1997. Groundfish surveys in the Atlantic Iberian waters (ICES Divisions VIIIc and IXa): history and perspectives. ICES CM 1997/Y:8.

Carrier JC, Musick JA, Heithaus M.R. 2004. Biology of sharks and their relatives. CRC Press, Florida, USA.

Coelho, R. and Erzini, K. 2002. Age and growth of the undulate ray, *Raja undulata*, in the Algarve (southern Portugal). Journal of the Marine Biological Association of the United Kingdom, 82: 987–990.

Coelho, R. and Erzini, K. 2006. Reproductive aspects of the undulate ray, *Raja undulata*, from the south coast of Portugal. Fisheries Research, 81:80–85.

Delamare, A., Hennache, C., Éric, S., and Biais, G. 2013. Bay of Biscay undulate ray (*Raja undulata*) abundance assessment by mark-recapture method. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013.

Diez, G., Mugerza, E. Iriondo, A., and Santurtun, M. 2014. Characterization of the ray catches of the Basque trammel net fleet in the Bay of Biscay (VIIIc East). Working Document for the ICES Working Group on Elasmobrach Fishes (WGEF) Lisbon, 17 to 26 June 2014, 11 pp.

Farias I. 2005. Estudo da Biologia de *Leucoraja naevus* (Müller and Heule, 1841) e *Raja brachyura* Lafont, 1873, na Costa Portuguesa. Tese de Licenciatura. Faculdade de Ciências da Universidade de Lisboa, Janeiro 2005.

Fernández-Zapico, O., F. Velasco, C. Rodríguez-Cabello, A. Punzón, A. Serrano, S. Ruiz-Pico, M. Blanco. 2014. Results on main elasmobranch species captured in the bottom trawl surveys on the Northern Spanish Shelf. Working Document for the Working Group on Elasmobranch Fishes (WGEF), Lisbon, 17–26 June 2014, 20 pp.

Figueiredo, I. and Serra-Pereira, B. 2013. Modelling *Raja clavata* abundance from Portuguese IBTS data (1990–2011) using GLMM with Tweedie distribution. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013.

Figueiredo, I., Maia, C., and Serra-Pereira, B. 2014. Overview of the information available on *Raja undulata* from Portuguese mainland waters (ICES Division IXa). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26th June, 2014.

Gibson, C., Valenti, S.V., Fordham, S.V. and Fowler, S.L. 2008. The Conservation of Northeast Atlantic Chondrichthyans: Report of the IUCN Shark Specialist Group Northeast Atlantic Red List Workshop. viii + 76 pp.

Hennache, C. 2013. Etude du taux de survie de raies brunettes marquée à l'aide de disque de Petersen. 7p.

ICES. 2010. Report of the Working Group on Elasmobranch Fishes (WGEF), 22–29 June 2010, Horta, Portugal. ICES CM 2010/ACOM:19. 558 pp.

Kell, L.T., and Kell, A. 2011. A comparison of age slicing and statistical age estimation for Mediterranean swordfish (*Xiphias gladius*). Collect. Vol. Sci. Pap. ICCAT, 66(4): 1522–1534.

Maia, C., Erzini, K., Serra-Pereira, B. and Figueiredo, I. 2012. Reproductive biology of cuckoo ray *Leucoraja naevus*. Journal of Fish Biology 81:1285–1296.

Maia, C., Serra-Pereira, B. and Figueiredo, I. 2013. Skates and rays estimates of landings by species from the Portuguese vessels operating in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013.

Moura, T., Figueiredo, I., Farias, I., Serra-Pereira, B., Coelho, R., Erzini, K., Neves, A., and Gordo, L. S. 2007. The use of caudal thorns for ageing *Raja undulata* from the Portuguese continental shelf, with comments on its reproductive cycle. Marine and Freshwater Research 58: 983–992. Available at http://www.publish.csiro.au/?paper=MF07042.

Moura, T., Figueiredo, I., Farias, I., Serra-Pereira, B., Neves, A., Borges, M. d. F. and Gordo, L. S. 2008. Ontogenetic dietary shift and feeding strategy of *Raja undulata* Lacepède, 1802 (Chondrichthyes: Rajidae) on the Portuguese continental shelf. Scientia Marina, 72:311–318.

Pina-Rodrigues, M.T. 2012. Age, growth and maturity of two skate species (*Raja brachyura* and *Raja montagui*) from the continental Portuguese coast. (Master thesis) Gent University. 49pp.

Prista, N., Fernandes, A.C., Maia, C., Moura, T., and Figueiredo, I. 2014. Discards of elasmobranchs in the Portuguese Fisheries operating in ICES Division IXa: Bottom otter trawl, deepwater set longlines, set gillnet and trammel net fisheries (2004–2013). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26th June, 2014.

Serra-Pereira B. 2005. Aspectos da Biologia de *Raja clavata* Linnaeus, 1758 e *Raja montagui* Fowler, 1910, na Costa Portuguesa. Tese de Licenciatura. Faculdade de Ciências da Universidade de Lisboa, Janeiro 2005.

Serra-Pereira, B., Figueiredo, I., Farias, I., Moura, T. and Gordo, L. S. 2008. Description of dermal denticles from the caudal region of *Raja clavata* and their use for the estimation of age and growth. ICES Journal of Marine Science, 65: 1701–1709.

Serra-Pereira, B., Figueiredo, I. and Gordo, L. 2011. Maturation, fecundity, and spawning strategy of the thornback ray, *Raja clavata*: do reproductive characteristics vary regionally? Marine Biology, 158: 2187–2197.

Serra-Pereira, B., Maia, C. and Figueiredo, I. 2013. Remarks on the reproduction strategy of *Raja undulata* from mainland Portugal. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013.

Serra-Pereira, B., Erzini, K., Maia, C. and Figueiredo, I. 2014. Identification of potential Essential Fish Habitats for skates based on fisher's knowledge. Environmental Management, 53:985–98.

Stéphan E., C. Hennache, A. Delamare, N. Leblanc, V. Legrand, G. Morel, E. Meheust, JL. Jung. 2014. Length at maturity, conversion factors, movement patterns and population genetic structure of undulate ray (*Raja undulata*) along the French Atlantic and English Channel coasts: preliminary results. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26th June, 2014.

Table 19.1a. Skates and rays in the Bay of Biscay and Iberian Waters. Nominal landings (tonnes) of skates and rays by division and country (Source: ICES). Total landings (t) of Rajidae in Divisions VIIIab.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	12	6	11	11	6	11	14	11	8	12	14			11	4	7	4	
France	1535	1733	1503	1479	1206	1091	1106	1037	1170	1797	1296	1505	1395	1615	1393	1147	1228	1220
Netherlands						1							0	0		0		
Spain	872	906	724	677	146	76	323	27	20	9	12	15	17	16	26	24	168	239**
Spain (Basque Country)	*	*	*	*	297	337	*	252	242	278	218	199	283	224	100	154	*	
UK (E&W)	22	76	13	7	2	3	4	4		8	40			0	0	0	5	0
UK (Scotland)										1		3	2	0		0		
Total	2442	2721	2251	2174	1657	1518	1447	1331	1440	2106	1581	1722	1697	1867	1524	1332	1405	1459

*** Included in Spanish landings; * * Preliminary landings**

Table 19.1b. Total landings (t) of Rajidae in Division VIIId.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium																0		
France	46	50	60	52	43	66	64	73	63	97	61	58	89	68	70	57	76	59
Spain	89	92	74	2	1	1	9	5	40	21	23	20	17	16	32	0	3	* * *
Spain (Basque Country)	*	*	*	*		2	*		1		1	2	0		0		*	
UK (E&W)											3			0	0	0	0	0
UK (Scotland)												1	0	0				
Total	135	143	134	54	44	69	73	78	104	118	87	81	107	84	102	57	80	59

*** Included in Spanish landings; ** Included in Area VIIIab; * * * Preliminary landings**

Table 19.1c. Total landings (t) of Rajidae in Division VIIIc.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium																		
France	0	0	1	1	1	0		0	0	0	0	1	0	1	0	0	1	0
Netherlands																		
Portugal	11	7	10	4	4	5			264									
Spain	0	321	345	226	424	978	352	1004	511	546	430	862	488	489	514	628	543	507* *
Spain (Basque Country)	*	*	*	*	5	16	*	21	21	20	14	9	23	22	21	25	*	
UK (E&W)																		
UK (Scotland)																		
Total	11	328	356	231	434	999	352	1025	796	567	444	872	511	512	536	653	544	508

*** Included in Spanish landings; * * Preliminary landings**

Table 19.1d. Total landings (t) of Rajidae in Division IXa.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
France																		
Portugal	1534	1512	1485	1420	1528	1591	1521	1598	1614	1303	1544	1443	1580	1473	1469	1490	1131	1061
Spain	58	143	197	276	285	416	339	342	325	300	364	354	376	342	457	549	303	421* *
Total	1592	1655	1682	1696	1813	2007	1860	1940	1939	1602	1908	1797	1956	1815	1926	2039	1434	1535

Table 19.1e. Combined Landings (t) of Rajidae in Biscay and Iberian Waters.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	12	6	11	11	6	11	14	11	8	12	14	0	0	11	4	7	4	0
France	1581	1784	1564	1532	1250	1157	1170	1110	1233	1894	1357	1564	1484	1684	1464	1204	1306	1279
Netherlands						1								0			0	0
Portugal	1545	1519	1495	1424	1532	1596	1521	1598	1878	1303	1544	1443	1580	1473	1469	1490	1131	1061
Spain	1019	1462	1340	1181	855	1471	1022	1378	895	876	829	1250	897	864	1029	1201	1017	1168* *
Spain (Basque Country)					302	354		273	264	298	233	210	306	246	121	178	*	*
UK (E&W)	22	76	13	7	2	3	4	4		8	43			0	0	0	5	0
UK (Scotland)										1	0	4	2	0			0	0
Total	4179	4846	4423	4155	3947	4593	3732	4374	4279	4393	4020	4471	4270	4279	4087	4081	3462	3507

*** Included in Spanish landings.**

*** * Preliminary landings**

Table 19.2. Skates and Rays in the Bay of Biscay and Iberian Waters. Species-specific landings (skates and rays in t) by country in Subarea VIII, and Division XIa, all gears combined. These data are included in the Tables 19.1a to 19.1c. * (Data could include landings of *R. brachyura*). **consider by WGEF to be misidentified.

COUNTRY	YEAR	SUBAREA	*L. NAEVUS*	*R. CLAVATA*	*R. MONTAGUI**	*D. BATIS*	*T. MARMORATA*	*D. OXYRINCHUS*	*L. CIRCULARIS*	*L. FULLONICA*	*R. MICROOCELLATA*	*R. UNDULATA*	*D. PASTINACA*	*M. AQUILA*	*R. ASTERIAS**	*R. BRACHYURA*	R. MIRALETUS	*R. ALBA*	*A. RADIATA**	*RAJA SPP.*
France	1999	VIII	319	75	46	1	24	0	17	0	0	0	0	2						0
France	2000	VIII	749	68	53	5	9	1	55	3	0	1	1	0						1
France	2001	VIII	637	37	62	4	3	0	47	7	1	2	1	0						1
France	2002	VIII	614	39	47	13	5	16	51	5	1	0	0	0						0
France	2003	VIII	654	49	58	4		1	44	4	2	0			0					
France	2004	VIII	749	97	67	4		0	46	4	0	0			0					201
France	2005	VIII	946	104	54	4		1	61	5	0	0			0					598
France	2006	VIII	668	139	61	4		2	36	4	0	0	2	1	0			0		607
France	2007	VIII	582	74	30	2		1	30	3			1							841
France	2008	VIII	775	82	41	5		3	56	5		0	2	0						502
France	2009	VIII	1096	177	64	1	26	1	20	45	3	2	3	1	0	3		4	0	237
France	2010	VIII	975	165	81	0	22	0	26	36	2			1		2		0	1	173
France	2011	VIII	875	107	65				16	32		0				20				69
France	2012	VIII	861	178	88	0	19	0	19	30	13	3	2	1	0	7		1	0	84
France	2013	VIII	754	203	112	0		0	19	30	20	0	3	1	1	28		0	0	86
Belgium	2002	VIII	15	6	0															
Belgium	2009	VIII	7	2	0											0				2
Belgium	2010	VIII	3		0						1					0				1
Belgium	2011	VIII	4		0				0							0				0
Belgium	2012	VIII	2	2	0				0							0				0
Belgium	2013	VIII	3	3					0											
Spain (Basque Country)	2000	VIII	250	39	2	6				4		0								

Country	year	Subarea	L. naevus	R. clavata	R. montagui*	D. batis	T. marmorata	D. oxyrinchus	L. circularis	L. fullonica	R. microocelli	R. undulata	D. pastinaca	M. aquila	R. asterias*	R. brachyura	R. miraletus	R. alba	A. radiata*	Raja spp.
Spain (Basque Country)	2001	VIII	230	85	5	8		0		26					0					
Spain (Basque Country)	2002	VIII	243	54	18															
Spain (Basque Country)	2003	VIII	230	38	4					12		0								
Spain (Basque Country)*	2004	VIII	202	46	6	3		0		7	0	0			0					
Spain (Basque Country)*	2005	VIII	229	52	7	3		0		8	0	0			0					
Spain (Basque Country)*	2006	VIII	179	41	5	3		0		6		0			0					
Spain (Basque Country)*	2007	VIII	161	37	5	2		0		5		0			0					
Spain (Basque Country)*	2008	VIII	236	52	7	4		0		8		0			0					
Spain (Basque Country)	2009	VIII	194	48						0										
Spain (Basque Country)	2010	VIII	88	33																
Spain (Basque Country)	2011	VIII	135	36																
Spain	2011	VIII	2		4															516
Spain	2012	VIII	160	269	21		0	0	6	0	0		0			0				268
Spain	2013	VIII	593	93	60															
UK (E & W)	2008	VIII	1								1					2				175
UK (E & W)	2009	VIII		0	0					0						0				0
UK (E & W)	2010	VIII	0		0					0	0									0
UK (E & W)	2011	VIII	0		0															
UK (E & W)	2012	VIII		2					0	0										
UK (Scotland)	2008	VIII			1															
UK (Scotland)	2009	VIII			0.3															
Spain	2011	IXa										0								526
Spain	2012	IXa	12	193	3		1	0	0	0	0		0			0				94

Country	year	Subarea	L. naevus	R. clavata	R. montagui*	D. batis	T. marmorata	D. oxyrinchus	L. circularis	L. fullonica	R. microocellata	R. undulata	D. pastinaca	M. aquila	R. asterias*	R. brachyura	R. miraletus	R. alba	A. radiata*	Raja spp.
Spain	2013	IXa	11	7	144										194					
Portugal	2002	IXa	13	2																1505
Portugal	2003	IXa	18	351	56						78	126				578	2			
Portugal	2004	IXa	113	516	82						95	108				532	17	5		
Portugal**	2005	IXa	43	480	76						88	100				495	16	5		
Portugal**	2006	IXa	51	569	90						105	119				586	19	6		
Portugal**	2007	IXa	79	472	119						35	277				459				3
Portugal**	2008	IXa	50	745	144			72	1		19					193	4			
Portugal	2009	IXa	50	739	184			75	2		45					163	2			
Portugal***	2010	IXa	55	611	275			20	11		43					221	6			
Portugal***	2011	IXa	56	811	121			68	1		29					161	5			
Portugal***	2012	IXa	39	570	108			24	0		36					165	5			
Portugal***	2013	IXa	26	631	111			67	0		40					185	1			

*** landings from 2004 to 2007 are based on the average species proportion of 2000–2003 ** landings from 2005 to 2008 are based in the species proportion of 2004; ***Based on official landings.**

Table 19.3. Skates and Rays in the Bay of Biscay and Iberian Waters. 2013 Species-specific landings as a percent of total landings in each ICES subdivision.

	VIII	IXa
L. naevus	67.2%	1.9%
R. clavata	14.9%	45.3%
*R. montagui**	8.6%	18.1%
D. batis	0.0%	0.0%
T. marmorata	0.0%	0.0%
D. oxyrinchus	0.0%	4.8%
L. circularis	1.0%	0.0%
L. fullonica	1.5%	0.0%
R. microocellata	1.0%	2.8%
R. undulata	0.0%	0.0%
D. pastinaca	0.2%	0.0%
M. aquila	0.1%	0.0%
*R. asterias**	0.0%	13.8%
R. brachyura	1.4%	13.2%
R. miraletus	0.0%	0.1%
Rostroraja alba	0.0%	0.0%
*A. radiata**	0.0%	0.0%
Raja spp.	4.3%	0.0%

*** Questionable species records that are in official landings.**

Table 19.4a. Skates and Rays in the Bay of Biscay and Iberian Waters. Elasmobranch discard estimates (t) of the Basque OTB (Bottom otter trawl) in Subarea VIII.

Subarea VIII	*S. canicula*	*G. melastomus*	Rajidae	*L. naevus*	*R. clavata*
2003	348	0	76		
2004	654	227	64		
2005	275	5	13		
2006	173	1	10		
2007	417	n.a	n.a.		
2008	641	23	24		
2009	1092	0		6	
2010	688	34	0	7	1
2011	1054	7	0	18	3
2012	905		1	8	0
2013	65			23	3

Table 19.4b. Skates and Rays in the Bay of Biscay and Iberian Waters. Estimate of the percentage of the elasmobranch discarded by the Basque OTB (Bottom otter trawl) in Divisions VIIIa,b,d.

	L. naevus	*R. clavata*	*S. canicula*
2009	4%	0%	252%
2010	12%	5%	219%
2011	17%	10%	288%
2012	10%	0%	321%
2013	23%	11%	23%

Table 19.4c. Skates and Rays in the Bay of Biscay and Iberian Waters. Discard estimations from the Spanish discard sampling programme in VIII and IXa Divisions. Weight discarded (tons) of demersal elasmobranchs (Bold) and CV of estimations (Italics) by fishing ground.

Divisions (VIIIc-IXa)											
Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Galeus melastomus	589	244	527	553	1063	226	904	1272	730.7	1433	749.0
CV	*31.4*	*54.8*	*36.0*	*60.7*	*36.7*	*28.5*	*62.8*	*51.1*	*34.8*	*40.5*	31.8
Leucoraja naevus	73.0	188	6.5	63.5	19.7	2.7	14.5	9.6	2.2	5.6	29.3
CV	*56.4*	*57.6*	*69.3*	*51.7*	*63.9*	*52.0*	*79.3*	*70.2*	*40.3*	*40.5*	38.5
Mustelus asterias	0.0	28.1	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
CV	-	*99.7*	*95.7*	-	-	-	-	-	-	*99.5*	-
Raja brachyura	0.1	90.8	1.2	11.6	31.6	2.1	10.4	6.0	34.1	5.5	7.7
CV	*99.8*	*50.6*	*63.9*	*92.7*	*59.2*	*47.8*	*43.8*	*54.8*	*68.5*	*65.1*	49.1
Raja clavata	0.0	1.0	9.9	54.5	10.9	5.5	36.0	32.4	50.6	29.6	54.6
CV	-	*57.7*	*54.6*	*75.6*	*45.5*	*76.2*	*47.9*	*43.1*	*50.7*	*28.9*	39.0
Raja montagui	26.0	1.3	0.2	0.7	0.4	1.2	1.6	0.0	1.4	4.1	5.2
CV	*66.1*	*69.8*	*99.6*	*75.8*	*99.8*	*94.0*	*70.3*	-	*47.5*	*63.8*	89.8
Scyliorhinus canicula	1933	799	397	1723	954	300	954	635	720.8	753.3	1136.7
CV	*36.9*	*38.6*	*34.2*	*63.8*	*23.3*	*32.7*	*40.1*	*21.5*	*26.5*	*26.3*	23.2

Table 19.4d. Skates and Rays in the Bay of Biscay and Iberian Waters. *Raja clavata* number of sampled hauls, number of hauls where the species occurred, probability of the species be caught in a haul and a specimen be discarded (pCD) and expected number of discarded specimens per haul in the Portuguese polyvalent and trawl segments. Polyvalent segment: i) nets operating at depths shallower than 150 m (i.e. trammel and gillnets) and ii) trammelnets operating deeper than 150 m. Trawl segment: i) Crustacean Fishery and ii) Demersal Fish Fishery.

	Polyvalent Segment		Trawl Segment	
	Nets <150 m deep	**Trammelnets >150 m deep**	**Crustacean Fishery**	**Demersal Fish Fishery**
nº of sampled hauls	41	57	665	1162
nº of hauls in which the species occurred	21	21	13	100
pCD	0.08	0.17	0.02	0.09
Expected number of discarded specimens per haul	2	3	3	1

Table 19.4e. Skates and Rays in the Bay of Biscay and Iberian Waters. *Raja montagui* number of sampled hauls, number of hauls where the species occurred, probability of the species be caught in a haul and a specimen be discarded (pCD) and expected number of discarded specimens per haul in the Portuguese polyvalent and trawl segments. Polyvalent segment: i) nets operating at depths shallower than 150 m (i.e. trammel and gillnets) and ii) trammelnets operating deeper than 150 m. Trawl segment: i) Crustacean Fishery and ii) Demersal Fish Fishery.

	POLYVALENT SEGMENT		TRAWL SEGMENT	
	Nets <150 m deep	**Trammel nets >150 m deep**	**Crustacean Fishery**	**Demersal Fish Fishery**
nº of sampled hauls	41	57	665	1162
nº of hauls in which the species occurred	17	13	2	22
pCD	0.10	0.08	0.003	0.01
Expected number of discarded specimens per haul	3	3	2	1

Table 19.4f. Skates and Rays in the Bay of Biscay and Iberian Waters. *Raja brachyura* number of sampled hauls, number of hauls where the species occurred, probability of the species be caught in a haul and a specimen be discarded (pCD) and expected number of discarded specimens per haul in the Portuguese polyvalent and trawl segments. Polyvalent segment includes nets operating at depths shallower than 150 m (i.e. trammel and gillnets). Trawl segment: i) Crustacean Fishery and ii) Demersal Fish Fishery.

	POLYVALENT SEGMENT	TRAWL SEGMENT	
	Nets <150 m deep	Crustacean Fishery	Demersal Fish Fishery
nº of sampled hauls	41	665	1162
nº of hauls in which the species occurred	15	3	17
pCD	0.04	0.005	0.01
Expected number of discarded specimens per haul	4	3	1

Table 19.4g. Skates and Rays in the Bay of Biscay and Iberian Waters. *Leucoraja naevus* number of sampled hauls, number of hauls where the species occurred, probability of the species be caught in a haul and a specimen be discarded (pCD) and expected number of discarded specimens per haul in the Portuguese polyvalent and trawl segments. Polyvalent segment: i) nets operating at depths shallower than 150 m (i.e. trammel and gillnets) and ii) trammelnets operating deeper than 150 m. Trawl segment: i) Crustacean Fishery and ii) Demersal Fish Fishery.

	Polyvalent Segment		Trawl Segment	
	Nets <150 m deep	Trammelnets >150 m deep	Crustacean Fishery	Demersal Fish Fishery
nº of sampled hauls	41	57	665	1162
nº of hauls in which the species occurred	4	22	4	16
pCD	0.02	0.17	0.006	0.02
Expected number of discarded specimens per haul	3	12	2	1

Table 19.4h. Skates and Rays in the Bay of Biscay and Iberian Waters. *Raja clavata*, *Raja montagui*, *Raja brachyura* and *Leucoraja naevus* percentage of individuals by health status (1=Good; 2=Moderate; 3=Poor) in relation to mesh size and soaking time in the Portuguese polyvalent fleet. Total length range is indicated.

	Mesh Size (mm)	Soaking Time (h)	Health Status			n	TL range (cm)
			1	2	3		
Raja clavata	**<180**	**<24**	100%	0%	0%	17	23–72
		>24	72%	12%	16%	25	39–80
	>180	**<24**	92%	4%	4%	26	48–88
		>24	52%	23%	24%	103	40–96
Raja montagui	**<180**	**<24**	100%	0%	0%	18	21–64
		>24	67%	21%	12%	42	10–60
	>180	**<24**	40%	30%	30%	20	46–62
		>24	37%	33%	30%	43	37–68
Raja brachyura	**<180**	**<24**	67%	22%	11%	9	39–66
		>24	92%	4%	4%	24	27–75
	>180	**<24**	57%	19%	24%	21	49–95
		>24	70%	20%	10%	143	18–106
Leucoraja naevus	**<180**	**<24**	100%	0%	0%	1	53–53
	>180	**<24**	100%	0%	0%	1	61–61
		>24	58%	21%	21%	24	46–62

Table 19.4i. Skates and Rays in the Bay of Biscay and Iberian Waters. Percentage of individuals of *Raja undulata* by health status according length class (cm), soaking time (h) and mesh size (mm) in the Portuguese polyvalent fleet. Number of sampled individuals = 100; TL range= 36–88 cm.

		Length class (cm)		Soaking Time (h)		Mesh Size (mm)	
Health Status	**Total**	**<50**	**>50**	**<24**	**>24**	**<180**	**>180**
1	91%	83%	92%	86%	92%	82%	93%
2	6%	0%	8%	7%	8%	9%	7%
3	3%	17%	0%	7%	0%	9%	0%

Table 19.5. Skates and Rays in the Bay of Biscay and Iberian Waters. Relative landed weight (%) for skate species (*Raja miraletus*, *Rostroraja alba*, *Raja clavata*, *Raja microocellata*, *Raja brachyura*, *Leucoraja circularis*, *Raja montagui*, *Leucoraja naevus* and *Dipturus oxyrinchus*), per fishing fleet (Portuguese polyvalent and trawl fleets) for 2008–2013.

	Polyvalent						Trawl					
	2008	2009	2010	2011	2012	2013	2008	2009	2010	2011	2012	2013
Raja miraletus	0%	0%	0%	0%	0%	0%	1%	0%	1%	0%	1%	0%
Raja clavata	48%	48%	40%	55%	44%	55%	64%	60%	48%	66%	72%	66%
Raja microocellata	2%	4%	3%	3%	4%	5%	0%	0%	2%	0%	0%	0%
Raja brachyura	15%	11%	16%	13%	18%	20%	8%	12%	13%	5%	6%	8%
Leucoraja circularis	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Raja montagui	10%	14%	19%	9%	9%	10%	10%	11%	18%	8%	11%	12%
Leucoraja naevus	2%	3%	3%	3%	3%	2%	7%	6%	8%	8%	6%	4%
Dipturus oxyrinchus	6%	5%	1%	4%	3%	5%	3%	6%	3%	8%	1%	8%
Raja spp.	17%	15%	17%	13%	19%	3%	7%	5%	7%	5%	3%	2%

Table 19.6. Skates and rays in the Bay of Biscay and Iberian Waters. Lpue (kg/day) of main elasmo-branchs caught by the Basque Country OTB DEF >= 70 (Bottom otter trawl) in Subarea VIII.

	Lpue (kg/day)	
	L. naevus	*R. clavata*
2001	112	27
2002	91	16
2003	136	19
2004	120	21
2005	134	23
2006	140	24
2007	169	29
2008	137	24
2009	84	18
2010	44	14
2011	115	25
2012	102	21
2013	80	21

Table 19.7. Skates and rays in the Bay of Biscay and Iberian Waters. Distribution of elasmobranch biomass (kg/30 min) by depth and type of substratum in the ITSASTEKA survey (VIIIc East) in 2013.

Depth (m)	Substrate	*L. naevus*	*R. clavata*	*R. montagui*	*R. undulata*	*T. marmorata*
26	**fine sand**	4	26		14	
32	**fine sand**		62	26		
38	**medium sand**		22	21		
49	**fine sand**		12	13		
52	**fine sand**	2	87			
53	**coarse sand**			14		2
70	**fine sand**		22	4		
71	**fine sand**		200	86		
90	**fine sand**		34	38		
93	**mud**		69			
94	**coarse sand**		22			
99	**mud**		15	71		
102	**mud**		7	3		
118	**mud**			2		
125	**mud**	0				
127	**mud**		57			
131	**mud**		6			
132	**mud**		17			
134	**fine sand**	3	24			
157	**fine sand**					
173	**medium sand**					
175	**medium sand**					
181	**fine sand**		16			
200	**fine sand**		20			
233	**fine sand**					
267	**mud**					
367	**mud**					

Table 19.8. Skates and rays in the Bay of Biscay and Iberian Waters. Life-history information): Table 2. Biological parameter estimates available for skate species inhabiting Portuguese Iberian waters. Growth models: VBR – von Bertalanffy Growth Model; GG – Gompertz Growth Model.

Species	TL range (cm)	L50 (cm) F	L50 (cm) M	I50 (years) F	I50 (years) M	Fecundity	Reproductive period	Growth model	Growth parameters estimates						Period	Region	Source
									L∞ (cm)	k (y^{-1})	t0 (years)	Lmax (cm)	Imax (years)	I∞ longevity (years)			
R. undulata	19.4–88.2	76.2	73.6	8.98	7.66	-	-	VBG	110.2	0.11	–1.58	88.2	13	-	1999–2001	Algarve	[1,2]
	23.7–90.5	83.8	78.1	9	8	-	Feb–May	VBG	113.7	0.15	–0.01	90.5	12	23.6	2003–2006	Centre	[3]
	32.0–83.2	-	-	-	-	-	-	VBG	119.3	0.12	–0.41	83.2	9	28.9	1999–2001	Algarve	[3]
	23.5–95.9	86.2 ±2.6	76.8 ±2.4	8.7 ±0.3	8.7 ±0.3	69.8 ± 3.4	Dec–Jun	-	-	-	-	-	-	-	2003–2013	North /Centre	[4]
R. clavata	14.3–91.3	-	-	-	-		-	VBG	128.0	0.112	–0.62	91.3	10	-	2003–2007	All	[5]
	12.5–105.0	78.4	67.6	7.5	5.8	136	May–Jan		-	-	-	-	-	-	2003–2008	All	[6]
R. brachyura	37.4–106.1	97.9	88.8	-	-	-	Mar–jul	VBG	110.51	0.12	0.26	106.1	-	-	2003–2004	All	[7]
	37.6–108.8	96.6	88.6	-	-		Mar–Jul		-	-	-	-	-	-	2003–2012	North /Centre	[10]
R. montagui	25.2–76.1	59.4	50.4	-	-	-	Apr–Jun	VBG	75.9	0.23	0.16	76.1	7	-	2003–2004	All	[8]
	36.8–70.2	56.7	48.0	-	-		Apr-Jul	-	-	-	-	-	-	-	2003–2012	All	[10]
L. naevus	12.7–71.8	55.6	56.5	-	-		-	VBG	79.2	0.24	0.12	71.8	-	-	2003–2004	All	[7]
	13.3–71.8	56.5	56.0	-	-	63	Jan-May		-	-	-	-	-	-	2003–2010	All	[9]

[1] Coelho and Erzini, 2002; [2] Coelho and Erzini, 2006; [3] Moura *et al.*, 2008; [4] Serra-Pereira *et al.*, 2013 WD; [5] Serra-Pereira *et al.*, 2008; [6] Serra-Pereira *et al.*, 2011; [7] Farias, 2005; [8] Serra-Pereira, 2005; [9] Maia *et al.*, 2012; [10] Pina Rodrigues, 2012).

Table 19.9. Skates and rays in the Bay of Biscay and Iberian Waters. Presence-absence indicator derived the EVHOE survey in the Bay of Biscay.

YEAR	TOTAL NUMBER OF HAULS	NUMBER OF HAUL WITH CATCH OF *R. CLAVATA*	PROPORTION OF HAUL WITH CATCH
1987	105	11	0.1
1988–1990	443	31	0.07
1991, 1992, 1994	286	19	0.07
1995, 1997, 1998	229	30	0.13
1999–2000	192	19	0.1
2002–2004	205	17	0.08
2005–2007	199	23	0.12
2008–2010	205	24	0.12
2011–2013	203	16	0.08

Table 19.10. Skates and Rays in the Bay of Biscay and Iberian Waters. Undulate ray in the Bay of Biscay - Abundance estimate of the stock potentially exploitable by the long-liners in the central part of the Bay of Biscay according to the low (A1) and high (A2) estimates by mark–recapture in the Gironde estuary area.

Abundance in other areas are derived from these estimate by the following formula:

$$A\ (\text{area } x) = \frac{DI\ (\text{area } x)}{DI\ (GE)} \cdot \frac{S\ (\text{area } x)}{S\ (GE)} \cdot Ai\ (GE)$$

Where Ai is one of the two interval limits of the abundance estimated by mark–recapture in the Gironde Estuary (GE), Density index (DI) are area coefficients obtained by a variance analysis of standardized cpue and, Surface (S) is habitat area shown by the catch and tagging data.

AREA	SURFACE (S IN NM²)	DENSITY INDEX (DI)	ABUNDANCE (A1)	ABUNDANCE (A2)
Gironde Estuary (GE)	560	1.45	10214	14 188
West Oléron (WO)	300	1.42	5348	7429
Pertuis d'Antioche (PA)	65	0.62	507	704
Pertuis Breton (PB)	180	0.78	1763	2449
Total	1105	-	17 832	24 770
Biomass(t)	-	-	87	120

Table 19.11. Skates and rays in the Bay of Biscay and Iberian Waters. Undulate ray in the Bay of Biscay – Mean length-at-age and estimation of longline catch-at-age in November 2013 (chartered trip) with their log ratios.

Age	Mean length (Nov.)	Catch at age	Log catch ratio
5	66.1	7	–1.95
6	72.6	37	–1.67
7	78.2	95	–0.94
8	83.1	138	–0.37
9	87.3	215	–0.44
10	90.9	139	0.44
11	94.0	24	1.76
12	96.7	13	0.61
13	99.0	4	1.18

Table 19.12. Skates and rays in the Bay of Biscay and Iberian Waters. Undulate ray in the Bay of Biscay-Stock number in 2008 derived from the 2014 mark–recapture abundance estimates (lower estimates in the upper table and higher estimates in the lower table), assuming no fishing mortality below age 4 and a flat fishing pattern above age 6 in 2008, no fishing from 2009 to 2015 (example given for half of the highest possible fishing mortality-at-age 7 and above in 2008 according to a recruitment constraint based on the number of eggs released). Biomass in 2009 and 2015 assuming constant recruitments.

YEAR	2008	2008	2008	2009	2014	2015	2015
Age	Stock Number	F	Catch (t)	Biomass (t)	Mark–recapture estimate	Stock Number	Biomass (t)
0	100 621	0.00	0	0		100 621	0
1	76 812	0.00	0	5		76 812	5
2	58 637	0.00	0	17		58 637	17
3	44 762	0.00	0	30		44 762	30
4	34 171	0.17	6	42		34 171	42
5	22 092	0.17	6	41		26 085	49
6	14 228	0.27	8	37		19 913	52
7	8254	0.38	8	28		15 201	52
8	4313	0.38	5	18	Lower	11 604	49
9	2253	0.38	3	11	estimates	8858	44
10	1177	0.38	2	7	5705	6762	39
11	615	0.38	1	4	3688	4355	28
12	321	0.38	1	2		2816	20
13	168	0.38	0	1		1633	13
Total	267 803		39	245		412 232	441
Spawning	8848		12	44		36 029	194

Year	2008	2008	2008	2009	2014	2015	2015
Age	Stock Number	F	Catch (t)	Biomass (t)	Mark–recapture estimate	Stock Number	Biomass (t)
0	139 771	0.00	0	0		139 771	0
1	106 698	0.00	0	7		106 698	7
2	81 451	0.00	0	23		81 451	23
3	62 178	0.00	0	42		62 178	42
4	47 465	0.17	8	58		47 465	58
5	30 687	0.17	8	58		36 234	68
6	19 764	0.27	11	52		27 660	73
7	11 465	0.38	11	39		21 115	72
8	5991	0.38	7	25	Higher	16 119	68
9	3130	0.38	4	16	estimates	12 305	62
10	1636	0.38	3	9	7925	9393	54
11	855	0.38	2	6	5124	6050	39
12	447	0.38	1	3		3911	28
13	233	0.38	1	2		2269	18
Total	371 999		55	340		572 620	613
Spawning	12 291		17	61		50 047	269

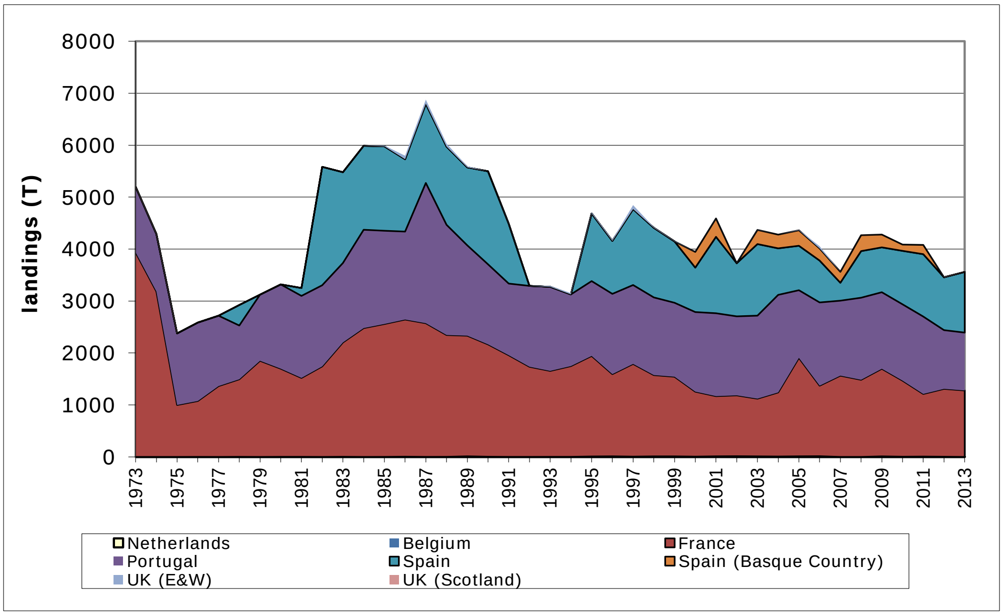
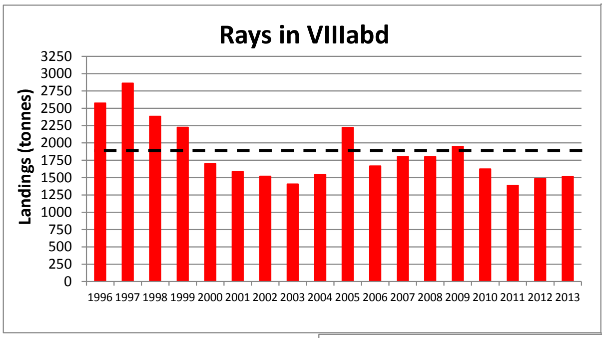
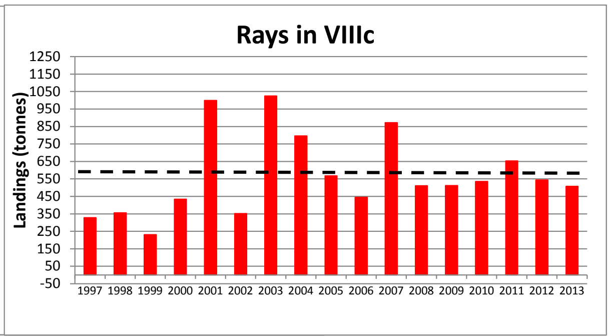


Figure 19.1a. Skates and rays in the Bay of Biscay and Iberian Waters. Historical trend landings of Rajidae in Subarea VIII and Division IXa.





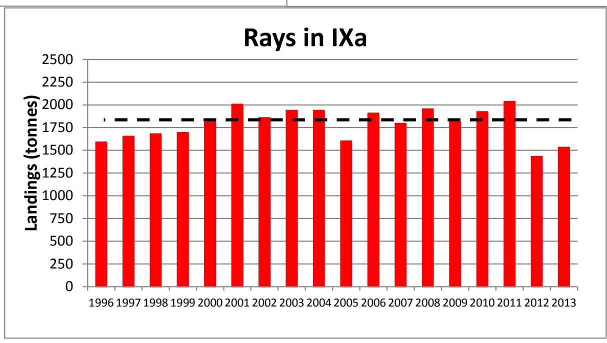


Figure 19.1b. Skates and rays in the Bay of Biscay and Iberian Waters. Historical trend landings of Rajidae in the ICES Divisions VIIIabd, VIIIc and IXa. Dashed line indicates the average of landings in the period.

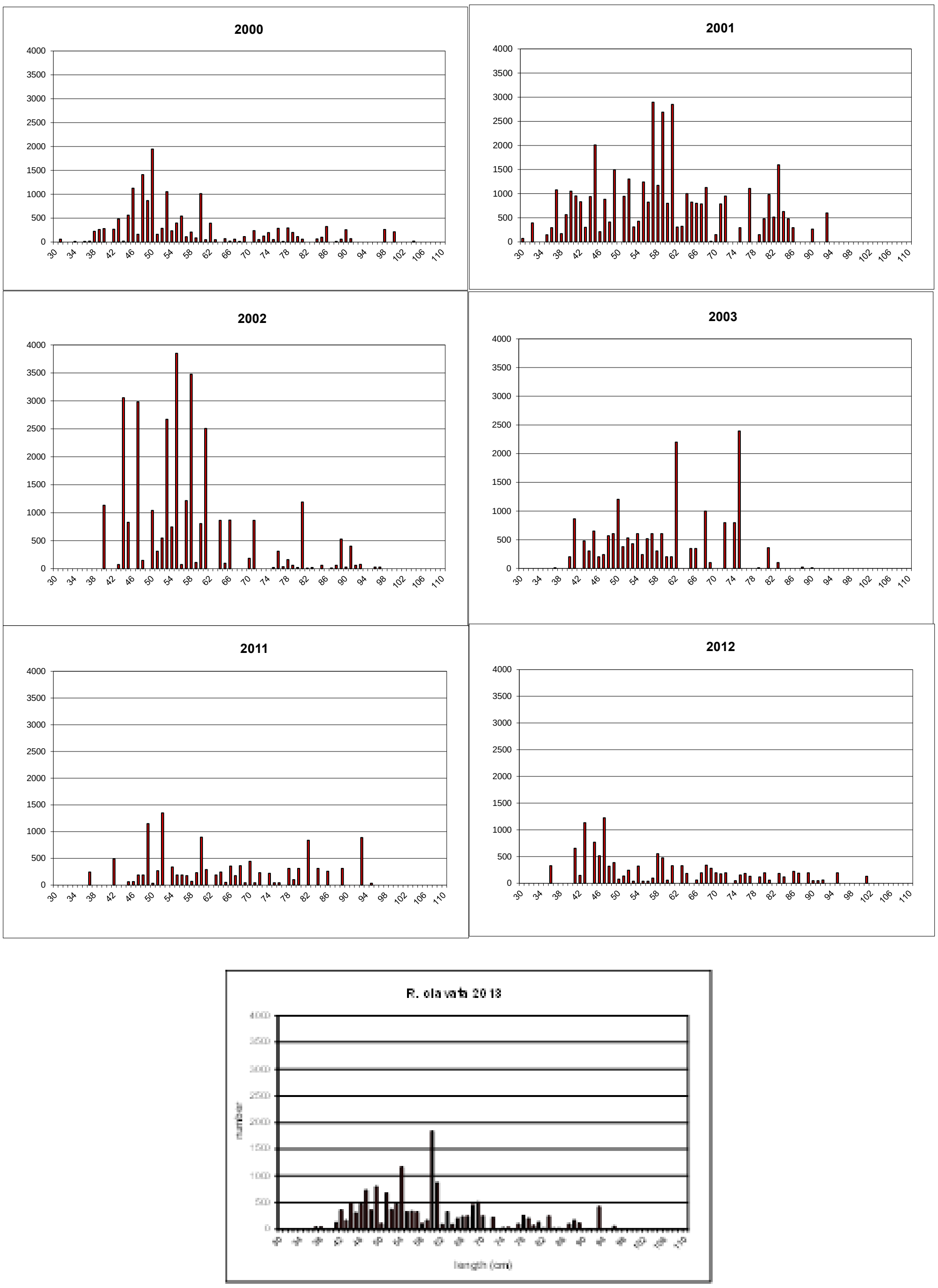


Figure 19.2a. Skates and rays in the Bay of Biscay and Iberian Waters. Length frequencies of *R. clavata* of the OTB Basque fleet in Subarea VIII from the period 2000–2003 and 2011–2013.

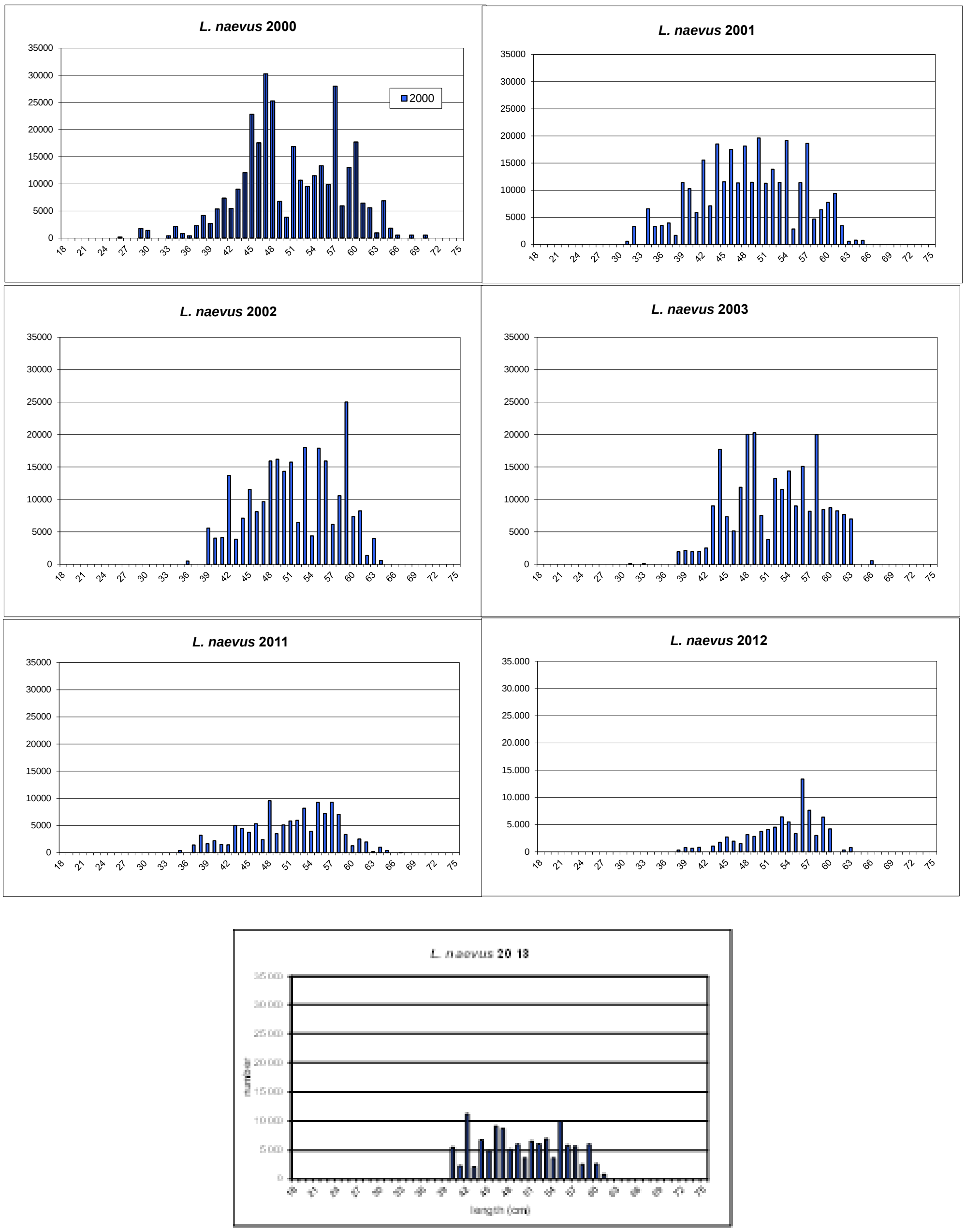


Figure 19.2b. Skates and rays in the Bay of Biscay and Iberian Waters. Length frequencies of *L. naevus* of the OTB Basque fleet in Subarea VIII from the period 2000–2003 and 2011–2013.

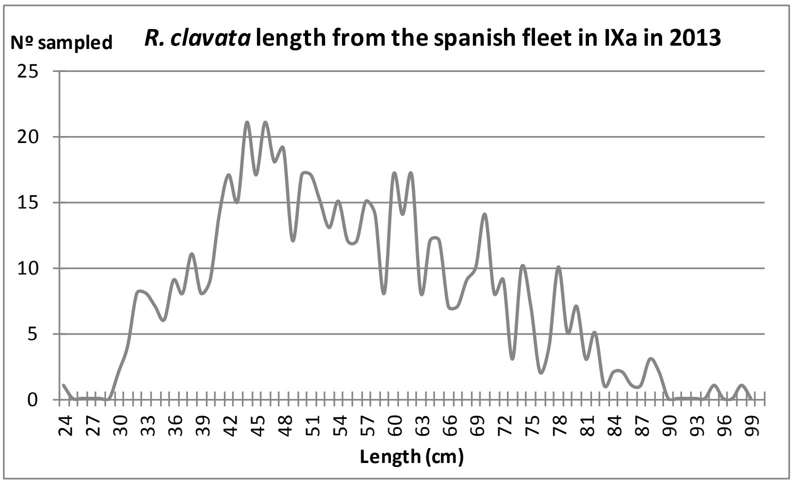


Figure 19.3a. Skates and rays in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja clavata* samples from the Spanish fleet in Division IXa in 2013.

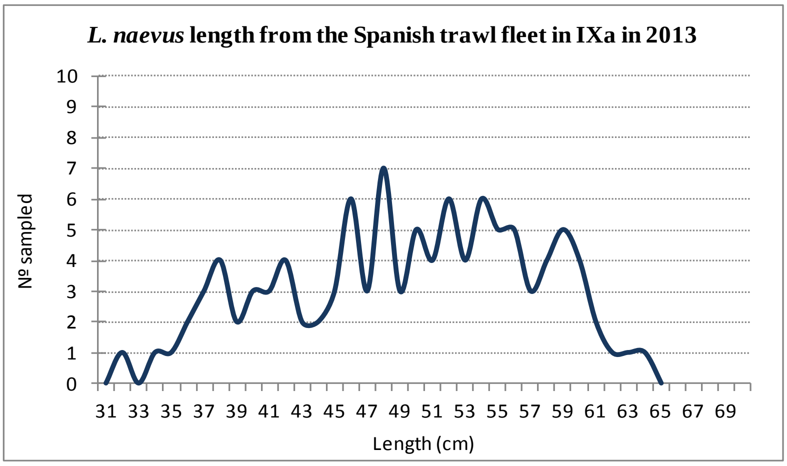


Figure 19.3b. Skates and rays in the Bay of Biscay and Iberian Waters. Lengthrequency distribution of *Leucoraja naevus* samples from the Spanish trawl fleet in Division IXa in 2013.

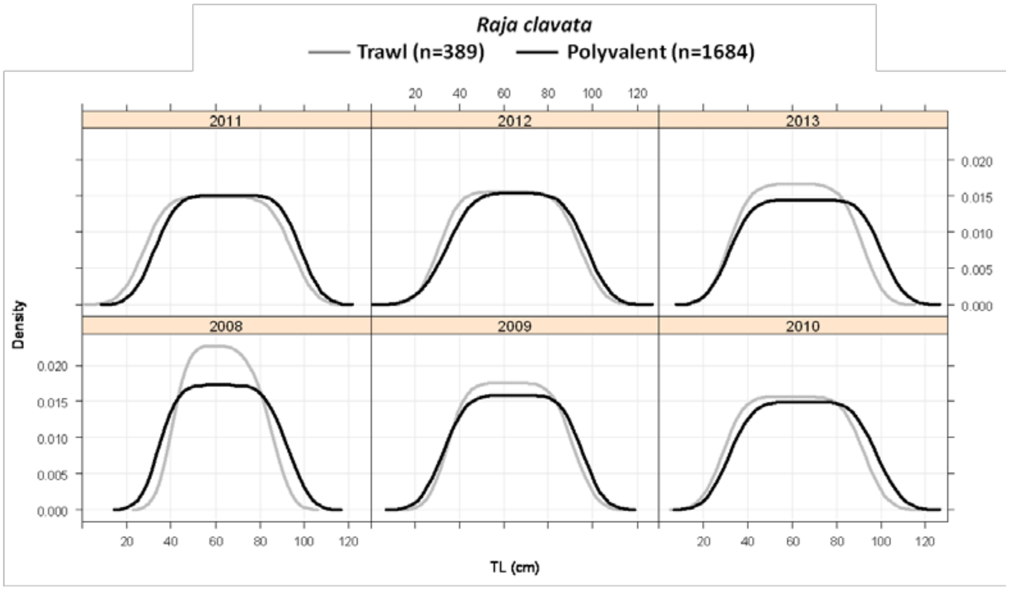


Figure 19.3c. Skates and rays in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja clavata* for the period from 2008–2013 in mainland Portugal (IXa). Total number of sampled trips for each segment is indicated.

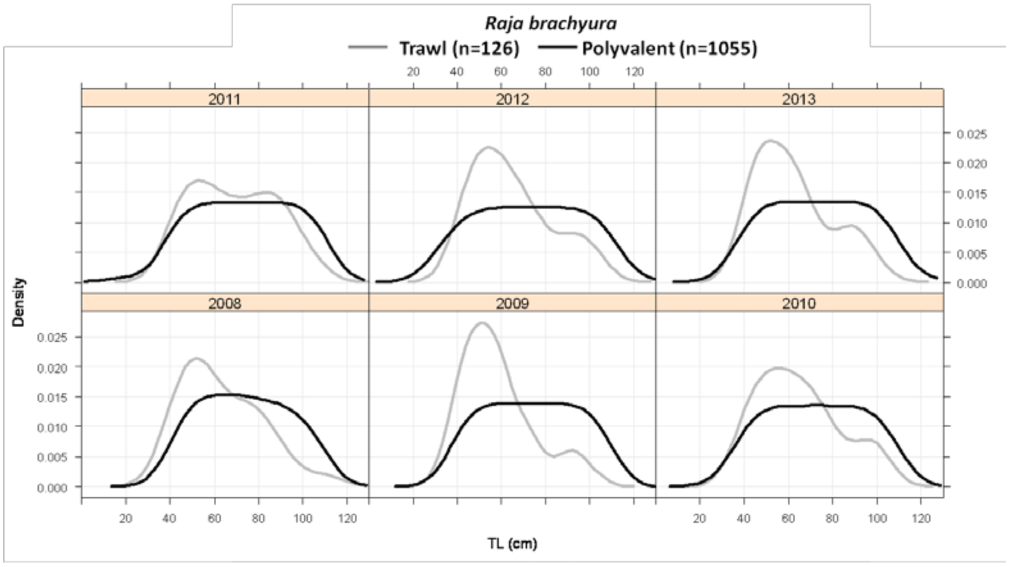


Figure 19.3d. Skates and rays in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja brachyura* for the period from 2008–2013 in mainland Portugal (IXa). Total number of sampled trips for each segment is indicated.

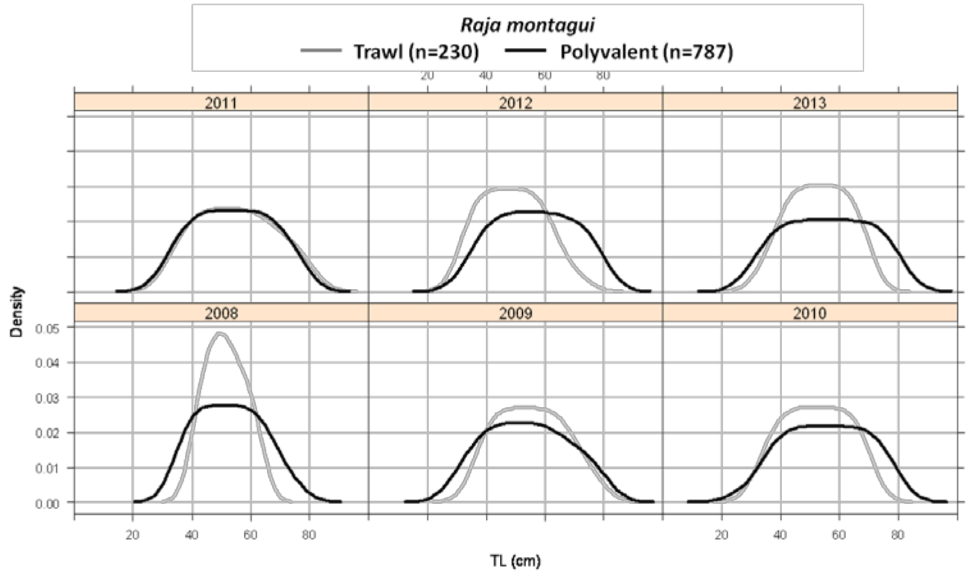


Figure 19.3e. Skates and rays in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja montagui* for the period from 2008–2013 in mainland Portugal (IXa). Total number of sampled trips for each segment is indicated.

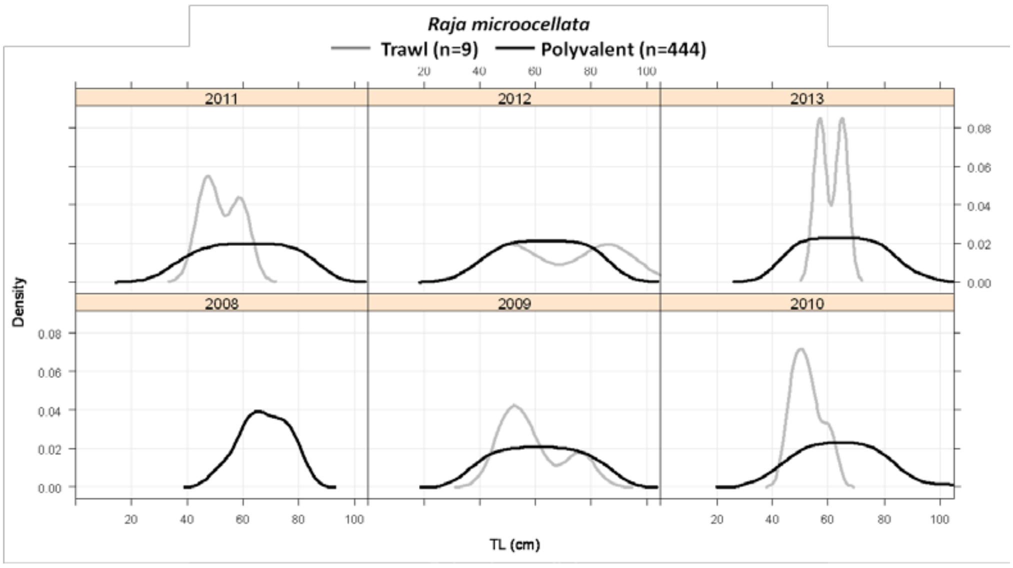


Figure 19.3f. Skates and rays in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja microocellata* for the period from 2008–2013 in mainland Portugal (IXa). Total number of sampled trips for each segment is indicated.

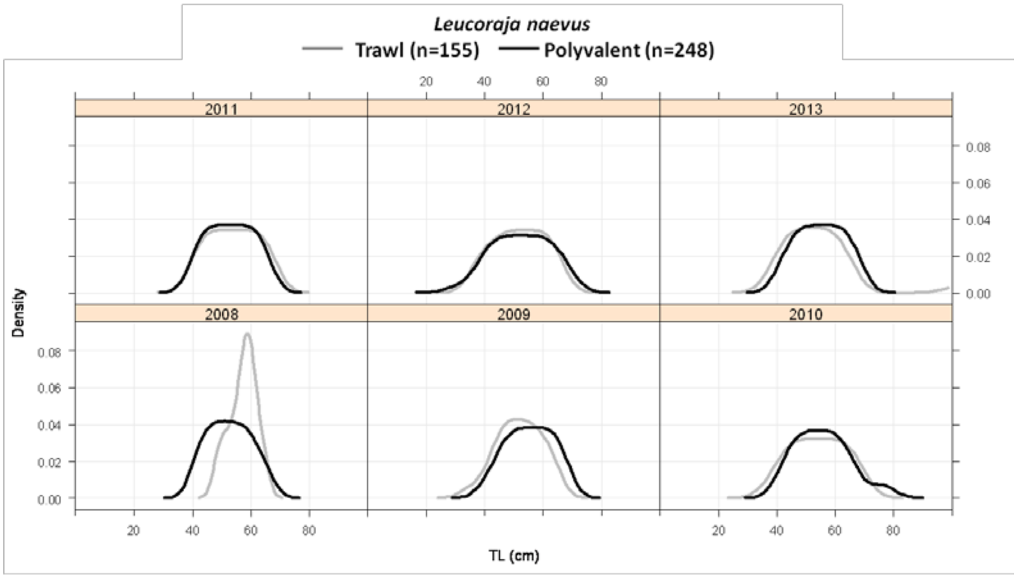


Figure 19.3g. Skates and rays in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Leucoraja naevus* for the period from 2008–2013 in mainland Portugal (IXa). Total number of sampled trips for each segment is indicated.

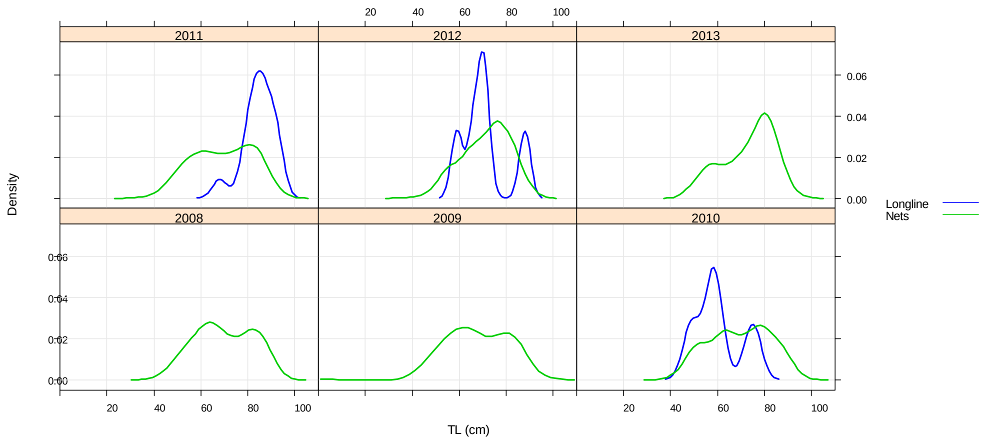


Figure 19.3h. Skates and rays in the Bay of Biscay and Iberian Waters. Length–frequency distribution of *Raja undulata* by fishing gear (longline and nets) for the period 2008–2013.

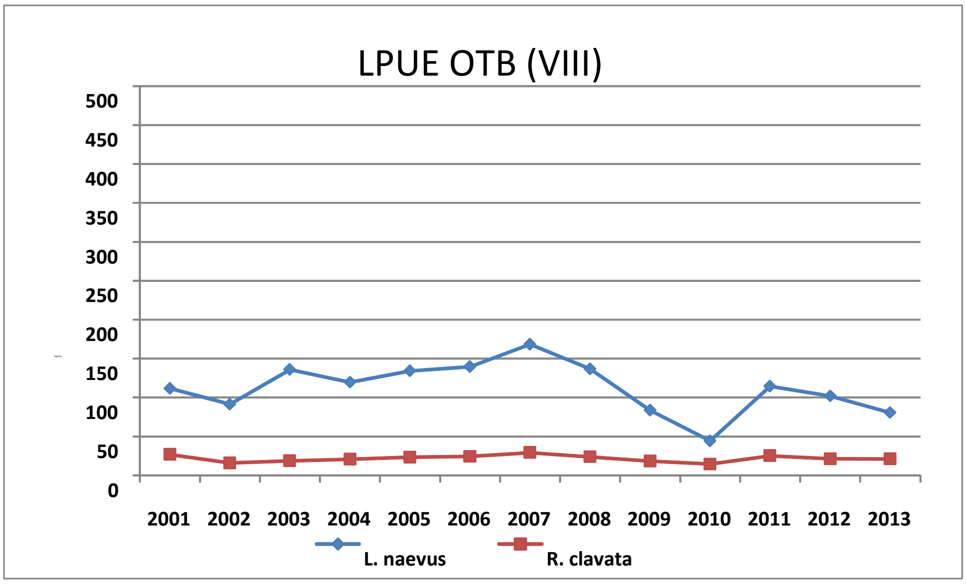


Figure 19.4. Skates and rays in the Bay of Biscay and Iberian Waters. *Leucoraja naevus* and *Raja clavata* nominal lpue (kg/day) of OTB Basque fleet in Subarea VIII from 2001 to 2013.

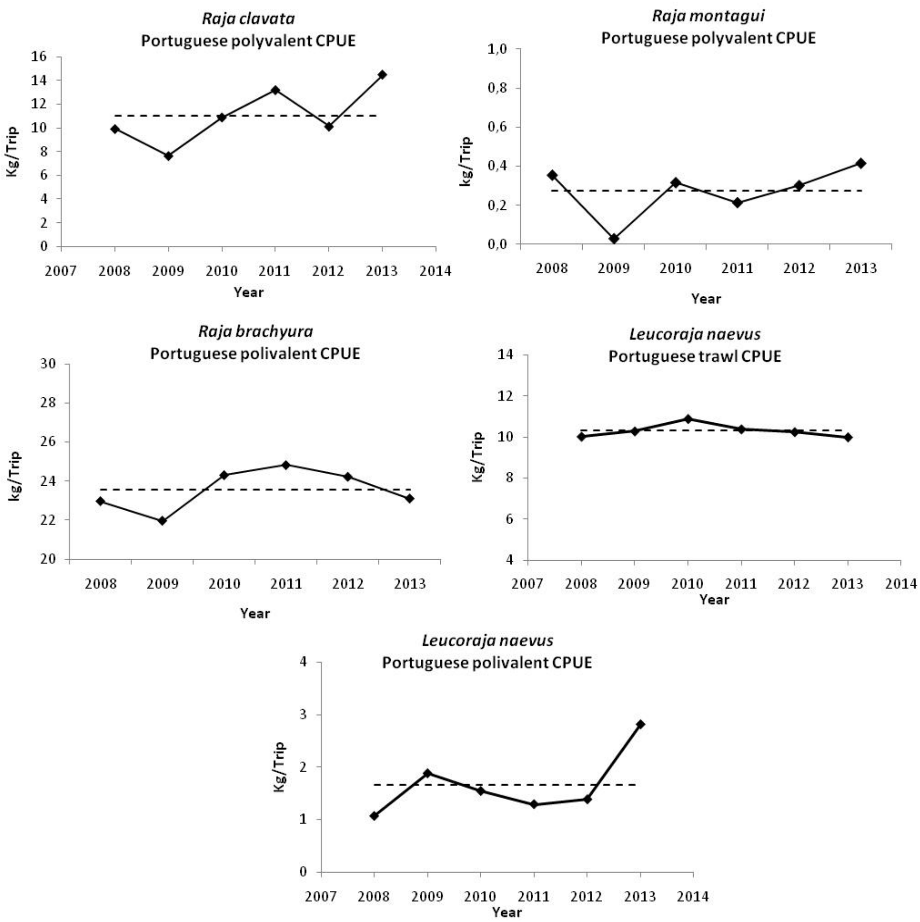


Figure 19.5a. Skates and rays in the Bay of Biscay and Iberian Waters. Standardized cpue (kg.trip^{-1}) by species for the period 2008–2013: *Raja clavata, Raja montagui, Raja brachyura* and *Leucoraja naevus*. The considered reference fleet is indicated. Dashed line: average of the entire time-series.

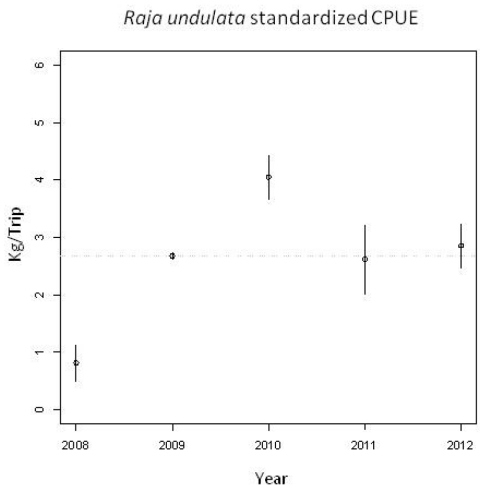
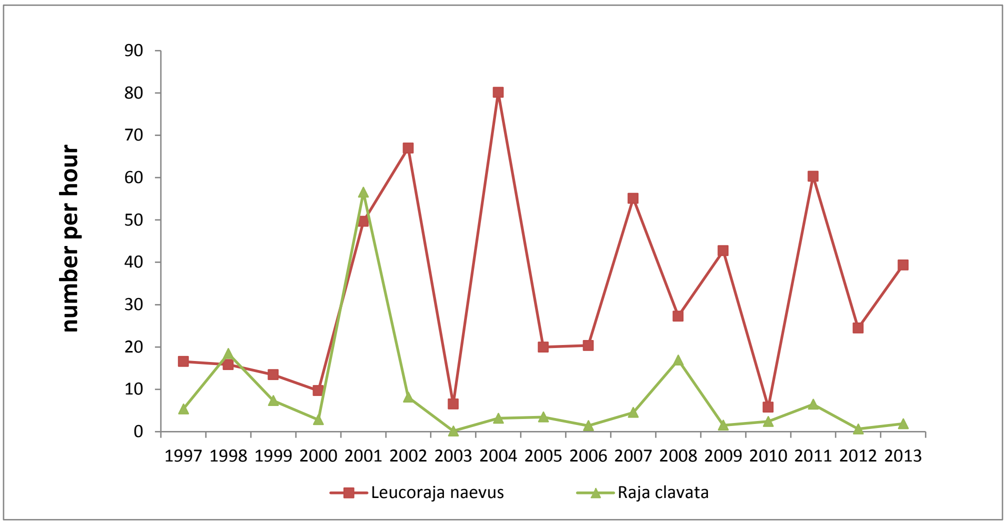
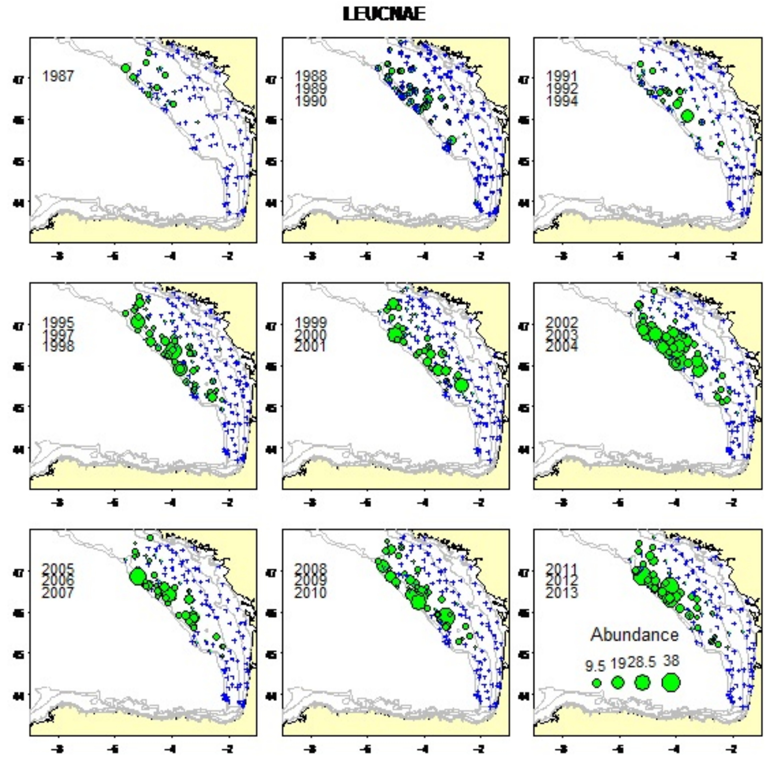


Figure 19.5b. Skates and rays in the Bay of Biscay and Iberian Waters. Standardized cpue (kg.trip⁻¹) of *Raja undulata* for the period 2008–2013. Dashed line: average of the entire time-series.



Figures 19.6a. Skates and rays in the Bay of Biscay and Iberian Waters. French EVHOE Survey indices (number per hour) of *L. neavus* and *R. clavata* in VIIIabd 1997–2013.



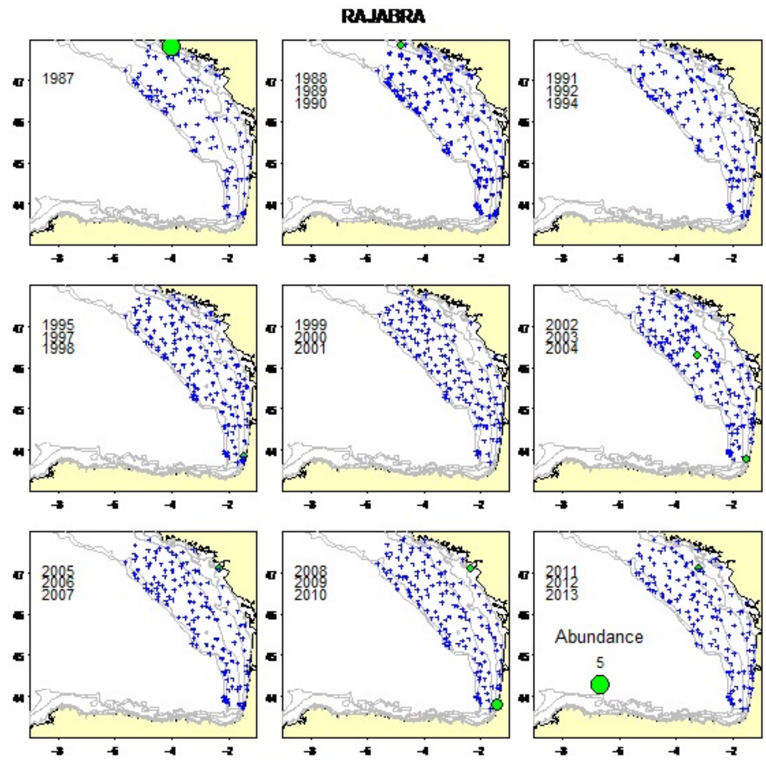


Figure 19.6b. Skates and rays in the Bay of Biscay and Iberian Waters. Geographical distribution of the abundance of ray species in the French EVHOE survey in Bay of Biscay (Divisions VIIIa, b) since 1987, showing *L. naevus* (top) and *R. brachyura* (bottom).

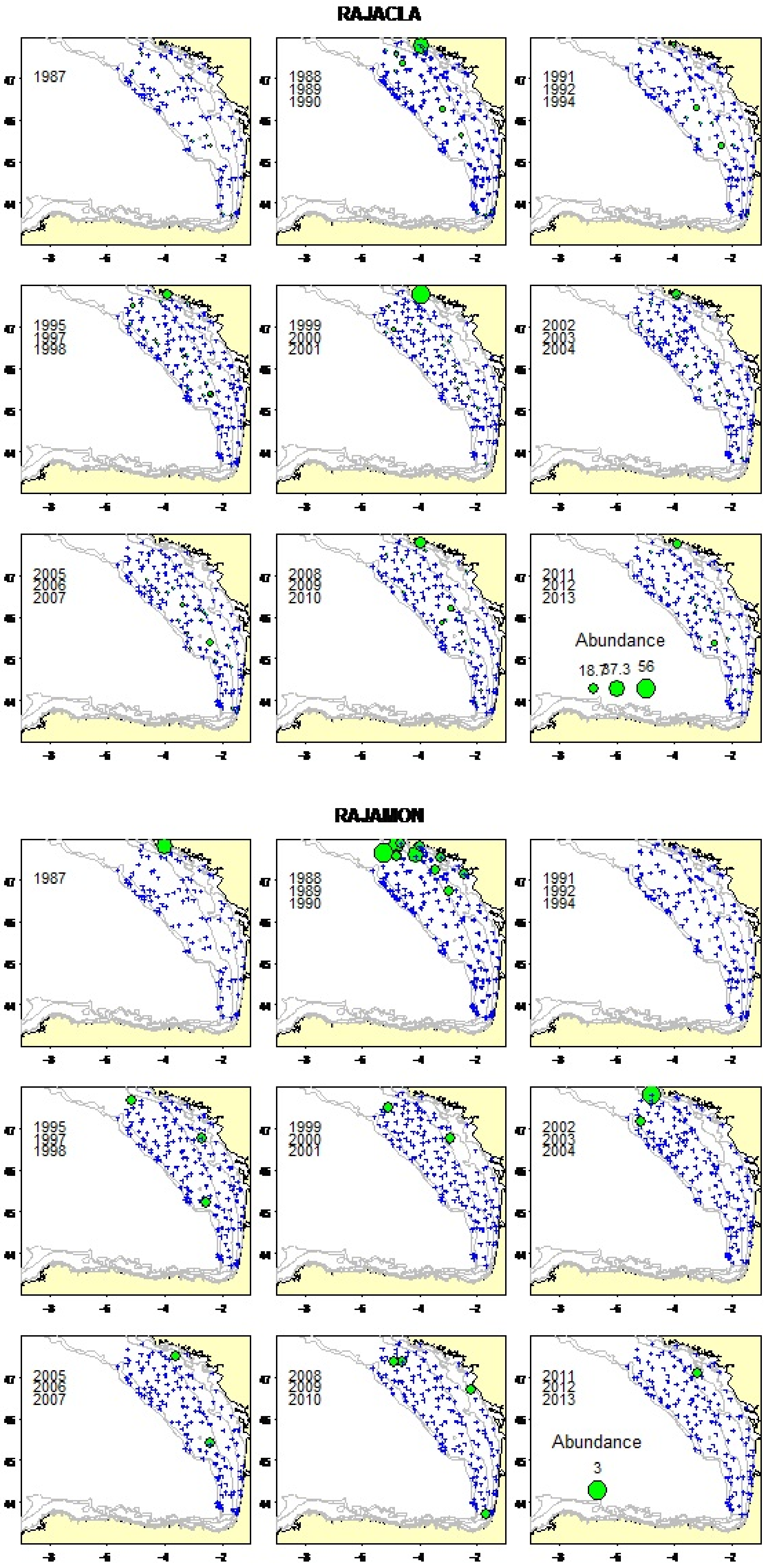


Figure 19.6b. (Cont.) Skates and rays in the Bay of Biscay and Iberian Waters. Geographical distribution of the abundance of ray species in the French EVHOE survey in Bay of Biscay (Divisions VIIIa, b) since 1987, showing *R. clavata* (top) and *R. montagui* (bottom).

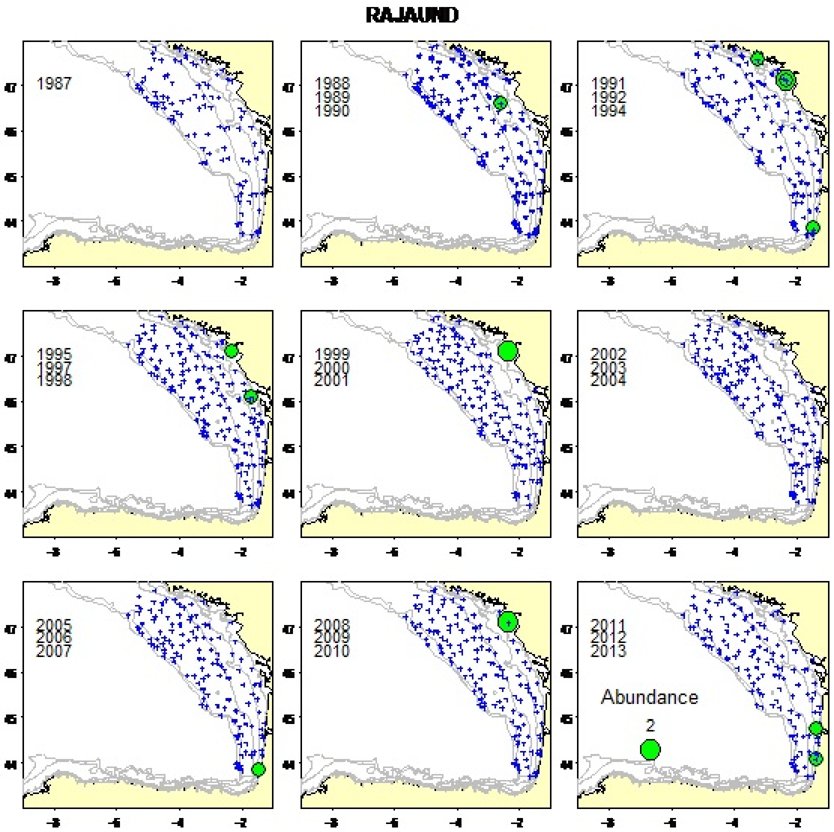


Figure 19.6b. (Cont.) Skates and rays in the Bay of Biscay and Iberian Waters. Geographical distribution of the abundance of ray species in the French EVHOE survey in Bay of Biscay (Divisions VIIIa, b) since 1987, showing *R. undulata*.

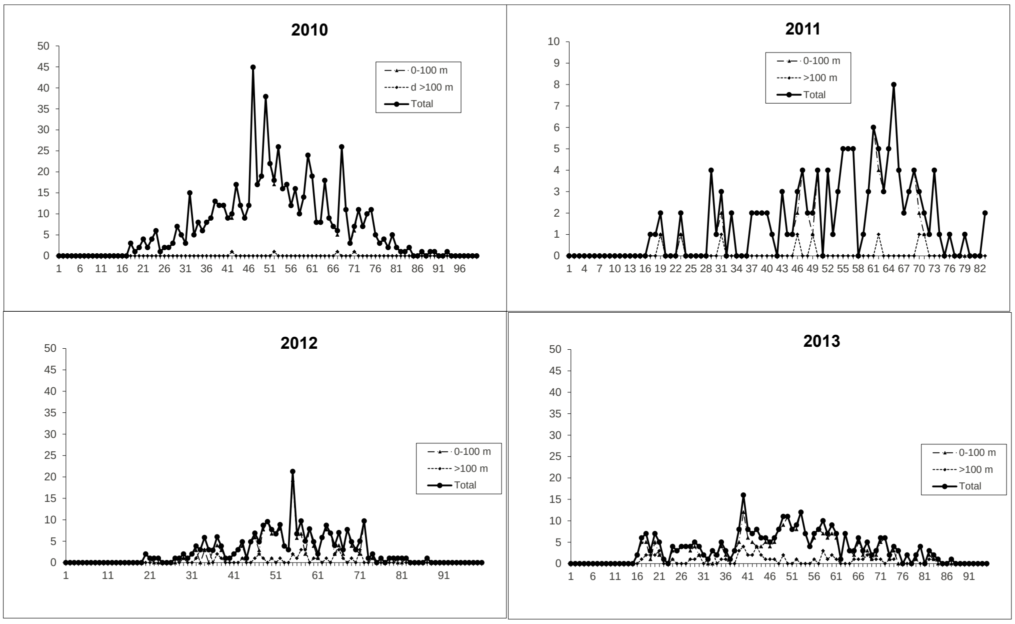


Figure 19.7. Skates and rays in the Bay of Biscay and Iberian Waters. Length distribution of *R. clavata* by depth strata in the ITSASTEKA survey (Eastern VIIIc) from 2010 to 2013.

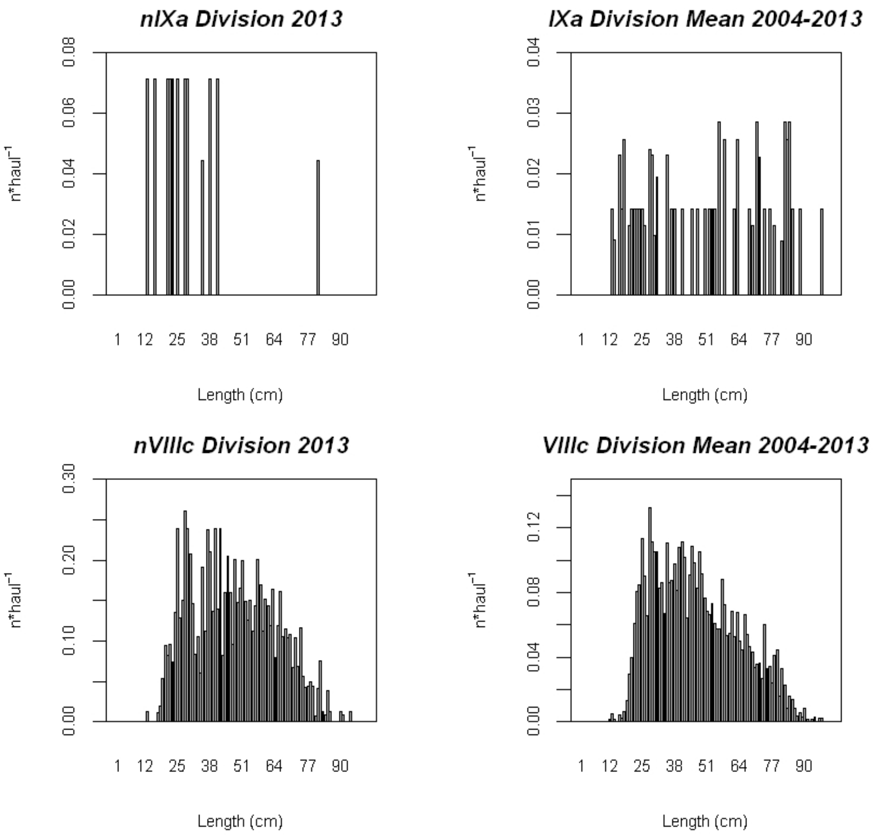


Figure 19.8a. Skates and rays in the Bay of Biscay and Iberian Waters. Stratified length distribution of thorny ray (*R. clavata*), in ICES Divisions IXa and VIIIc, during 2013 and mean values during the period 2004–2013.

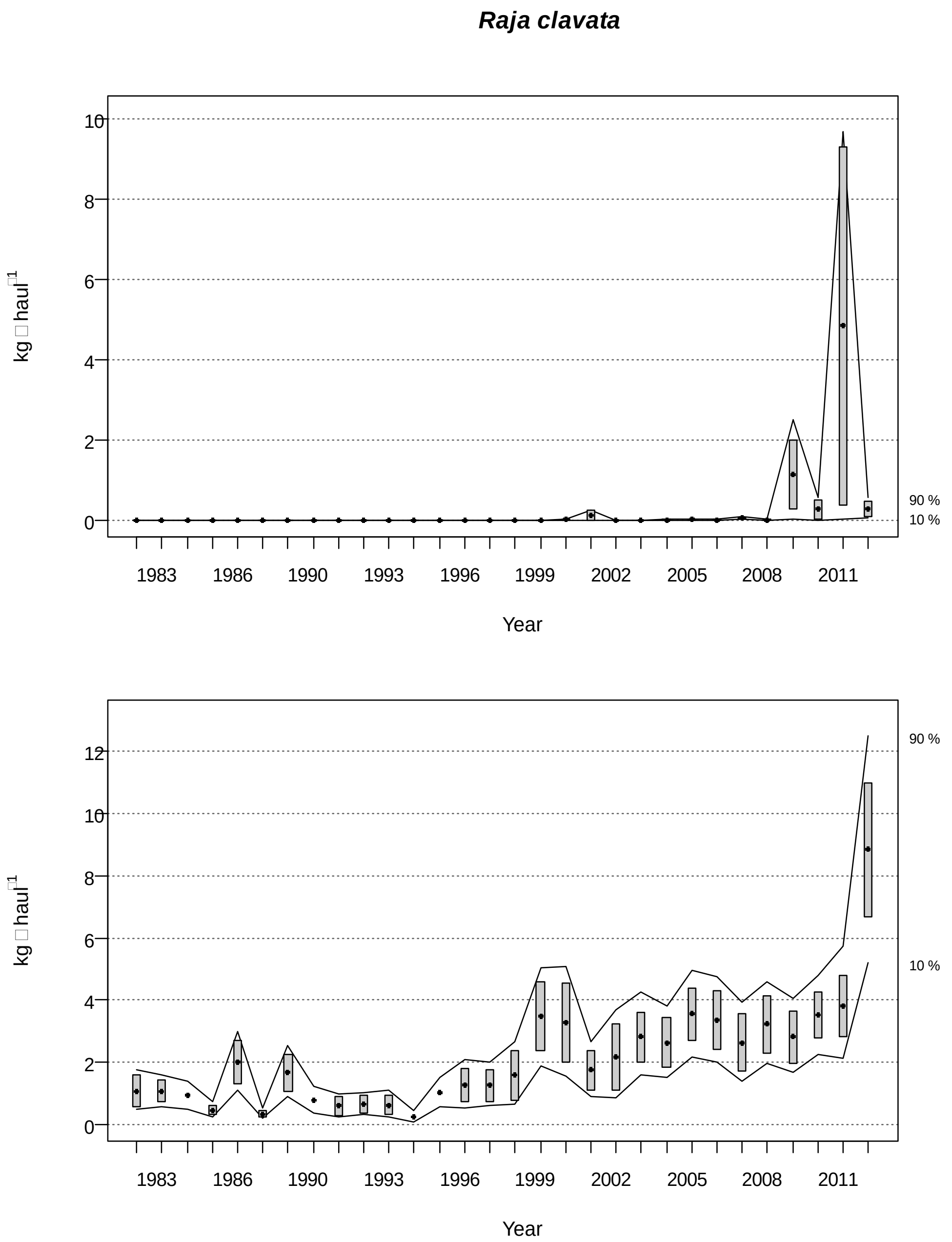


Figure 19.8b. Skates and rays in the Bay of Biscay and Iberian Waters. Changes in thorny ray (*Raja clavata*) biomass indices, in ICES Division IXa and VIIIc, during North Spanish Coast Survey time-series (1983–2013). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

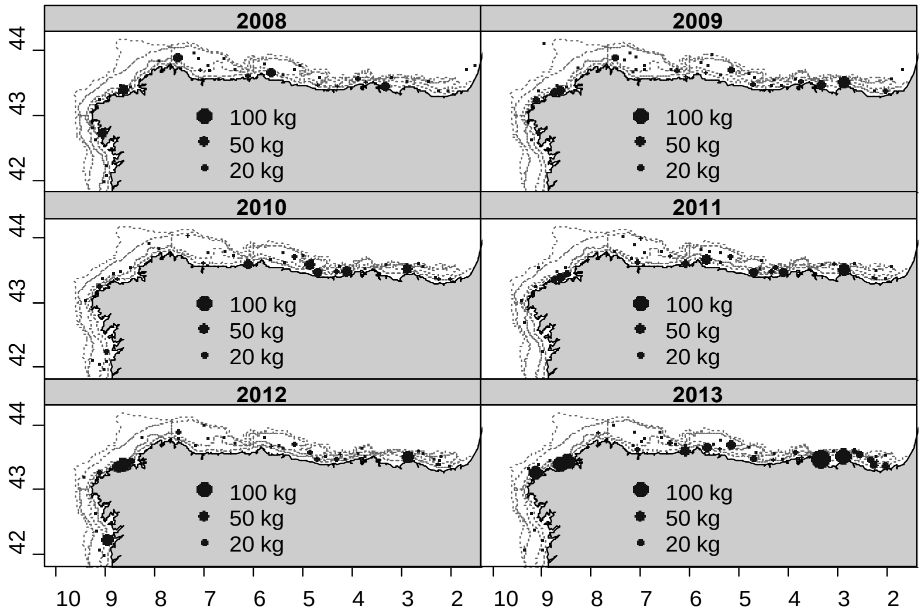


Figure 19.8c. Demersal elasmobranchs in the Bay of Biscay and Iberian Waters. Geographic distribution of thornback ray (*R. clavata*) catches (kg/30 min haul) in North Spanish Shelf groundfish surveys (2008–2013).

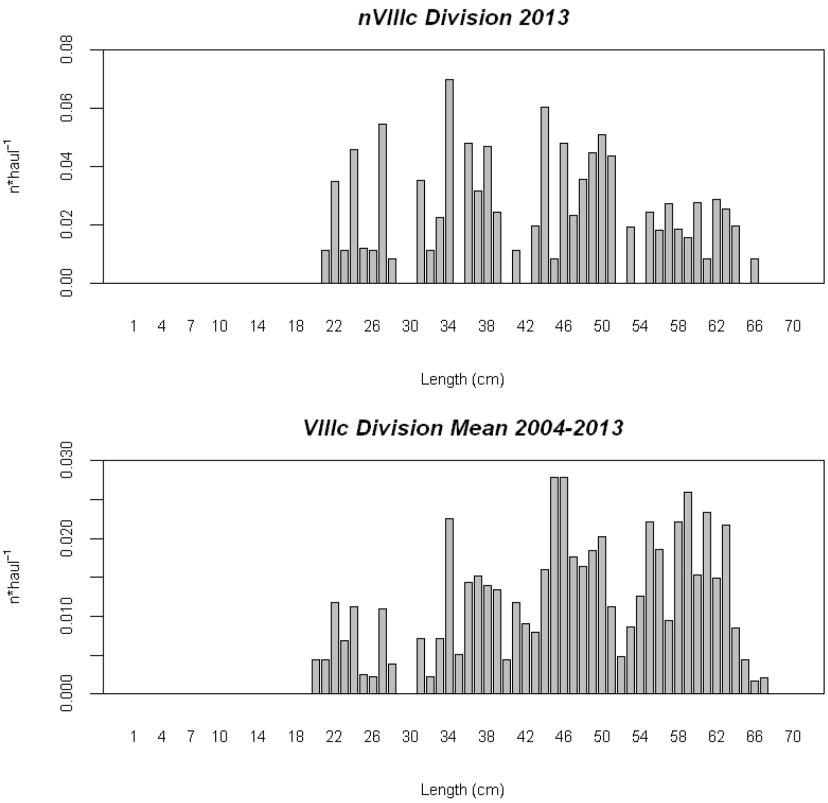


Figure 19.9a. Skates and rays in the Bay of Biscay and Iberian Waters. Stratified length distributions of *L. naevus* in 2013 in VIIIc ICES Division covered by North Spanish shelf bottom trawl survey, and mean values for the period 2004–2013.

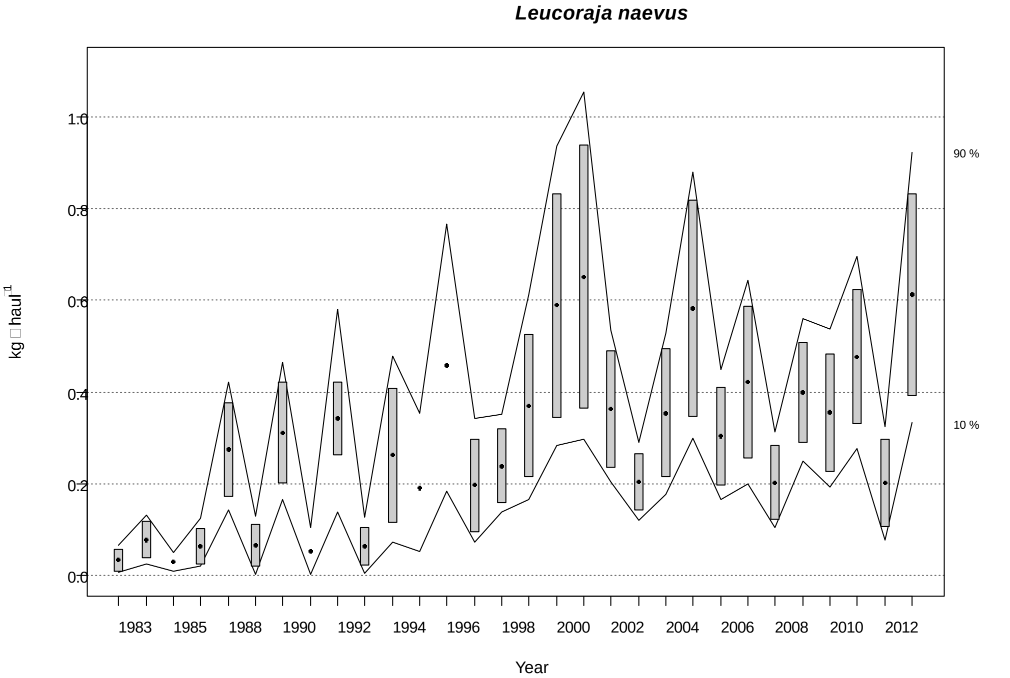


Figure 19.9b. Skates and rays in the Bay of Biscay and Iberian Waters. Changes in *Leucoraja naevus* biomass index during North Spanish shelf bottom trawl survey time-series (1983–2013) in the two ICES divisions covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

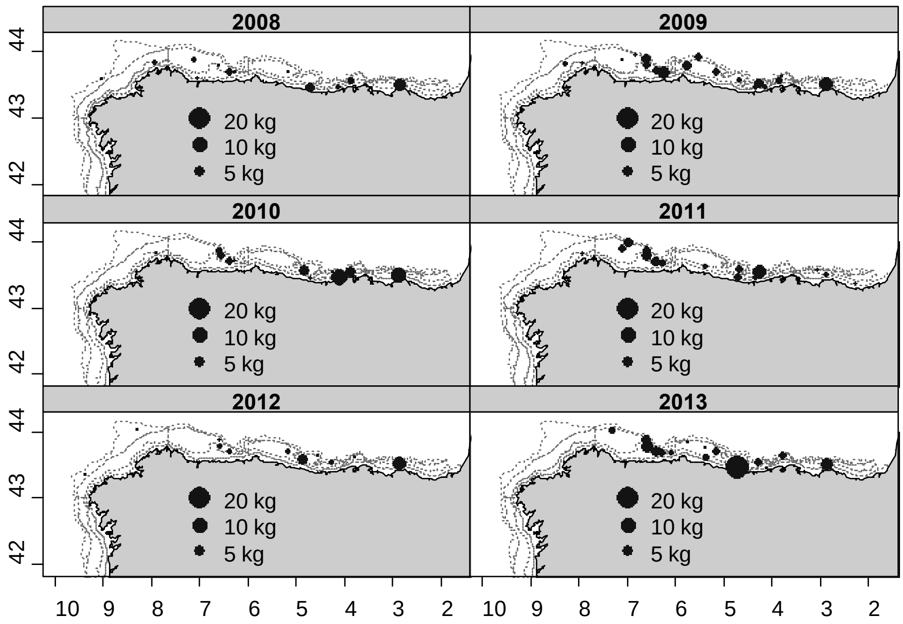


Figure 19.9c. Skates and rays in the Bay of Biscay and Iberian Waters. Geographic distribution of cuckoo ray (*L. naevus*) catches (kg/30 min haul) in North Spanish Shelf groundfish surveys (2008–2013).

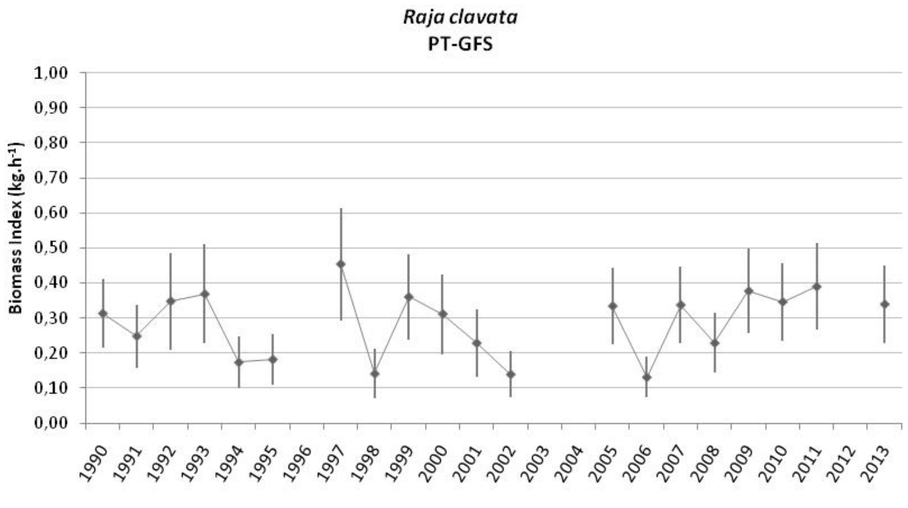


Figure 19.10. Skates and rays in the Bay of Biscay and Iberian Waters. *Raja clavata* biomass indices (kg/h) on PT-GFS, during 1990–2013.

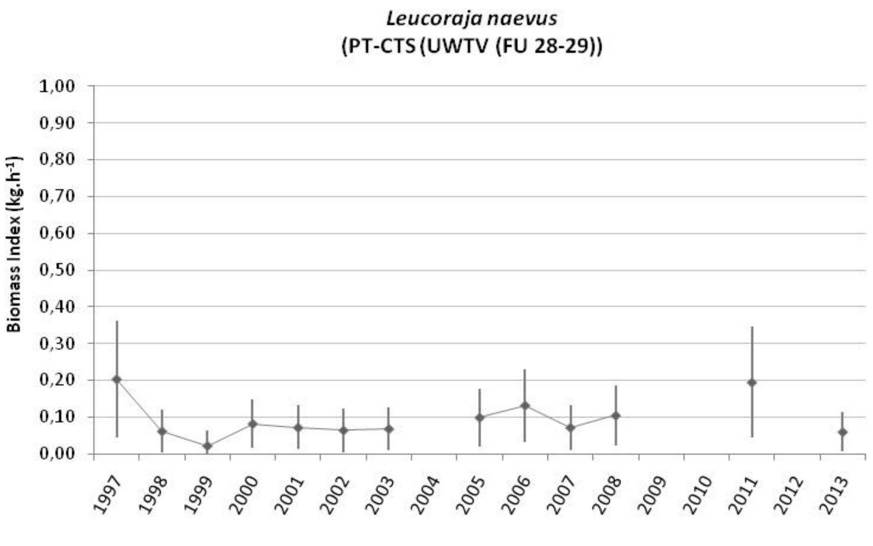


Figure 19.11. Skates and rays in the Bay of Biscay and Iberian Waters. *Leucoraja naevus* biomass indices (kg/h) on PT-CTS (UWTV (FU 28–29)) surveys, during 1997–2013.

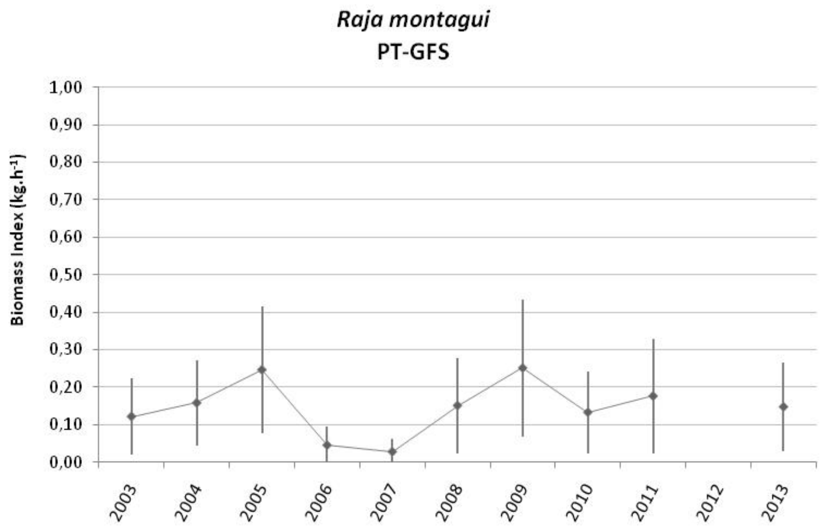


Figure 19.12. Skates and rays in the Bay of Biscay and Iberian Waters. *Raja montagui* biomass indices (kg/h) on PT-GFS surveys, during 2003–2013.

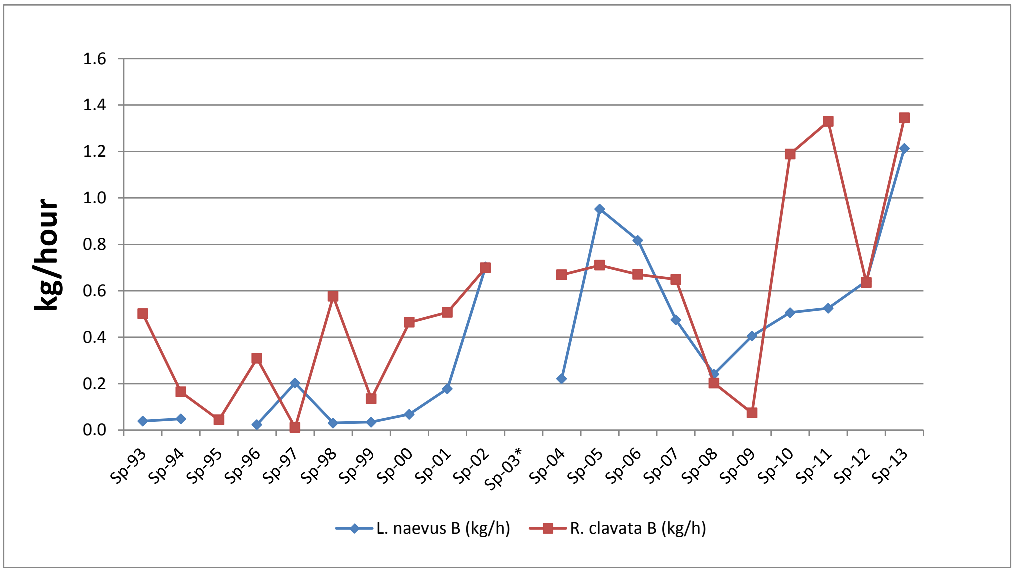


Figure 19.13a. Skates and rays in the Bay of Biscay and Iberian Waters. Trend of the yield of *R. clavata* and *L. naevus* expressed as kg/hour in the ARSA survey (IXa South) since 1993.

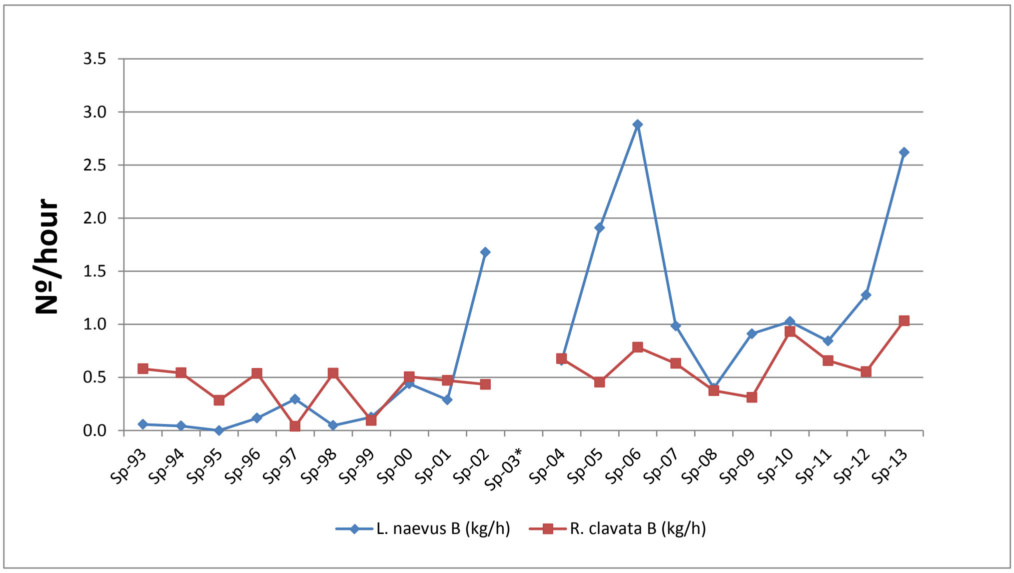


Figure 19.13b. Skates and rays in the Bay of Biscay and Iberian Waters. Trend of the yield of *R. clavata* and *L. naevus* expressed as Nº/hour in the ARSA survey (IXa South) since 1993.

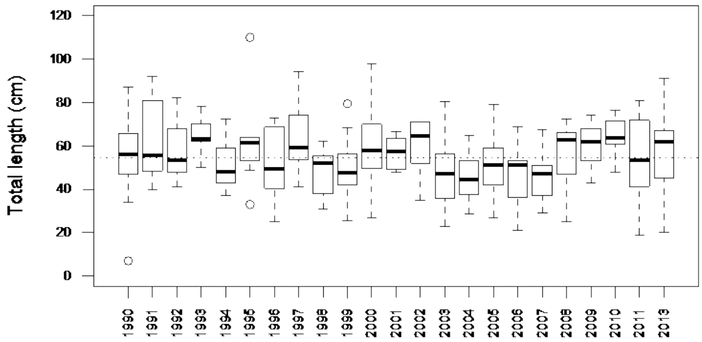


Figure 19.14. Skates and rays in the Bay of Biscay and Iberian Waters. *Raja clavata* total length variation on PT-GFS surveys, during 1990–2013.

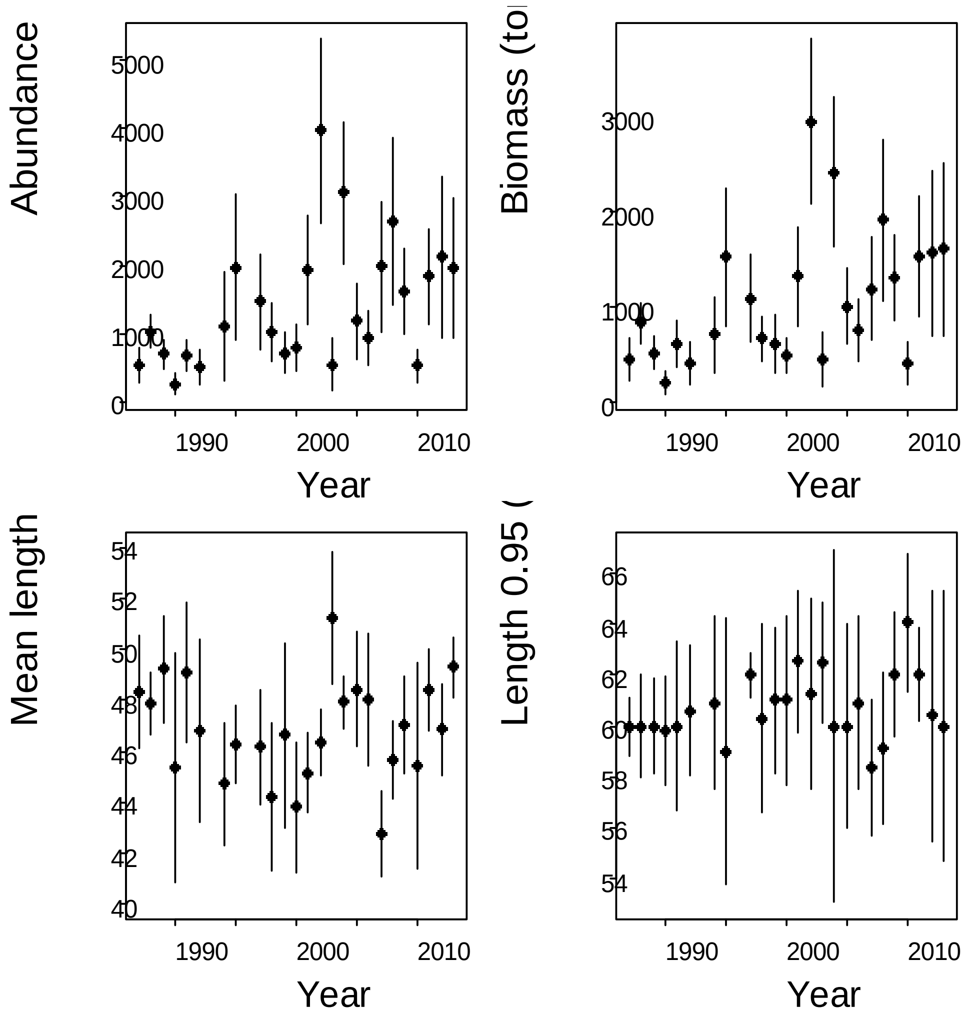


Figure 19.15. Skates and rays in the Bay of Biscay and Iberian Waters. EVHOE survey indices 1987–2013 of the cuckoo ray in the Bay of Biscay (VIIIa,b,c). Abundance and biomass are raised to the total area surveyed (swept area method) but should be considered relative and not absolute estimates.

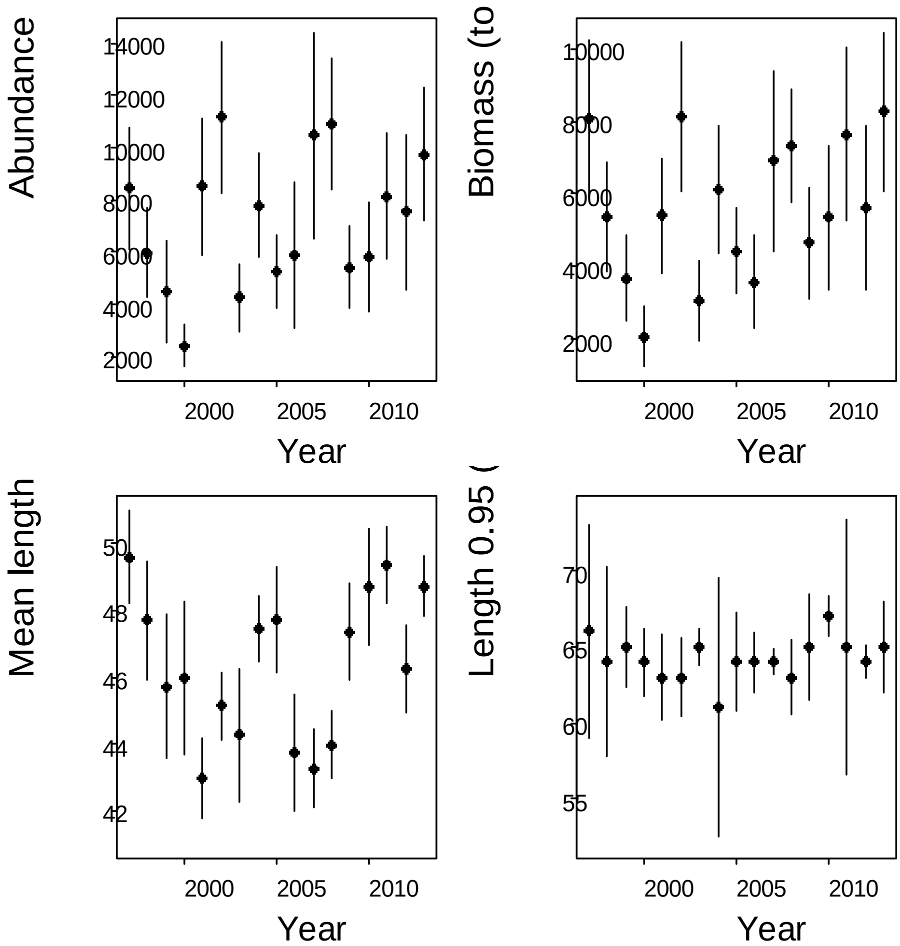


Figure 19.16. Skates and rays in the Bay of Biscay and Iberian Waters. EVHOE survey indices 1987–2013 of the cuckoo ray in the Celtic Sea and Bay of Biscay (VIIj,k and VIIIa,b,c). Abundance and biomass are raised to the total area surveyed (swept area method) but should be considered relative and not absolute estimates.

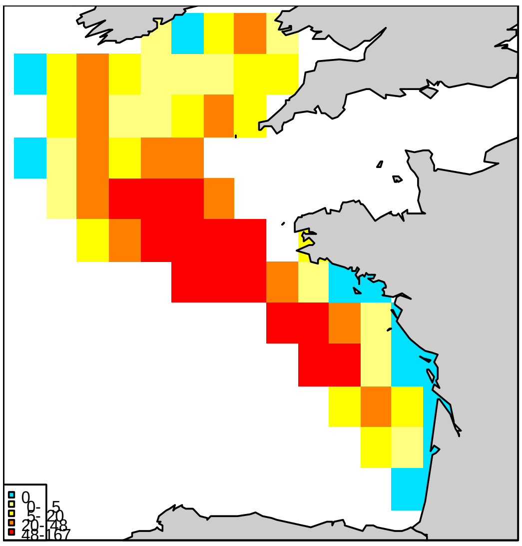


Figure 19.17. Skates and rays in the Bay of Biscay and Iberian Waters. Spatial distribution of the cuckoo ray (*Leucoraja naevus*) in ICES Divisions VIIIabc and VIIgk, based on catch in the EVHOE survey.

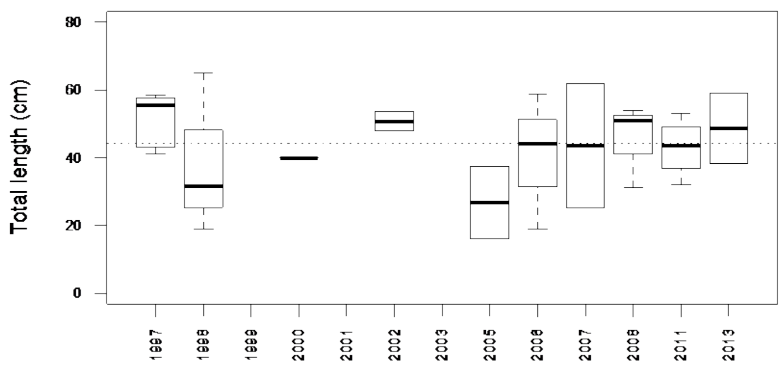


Figure 19.18. Skates and rays in the Bay of Biscay and Iberian Waters. *Leucoraja naevus* total length variation on PT-CTS (UWTV (FU 28-29)) surveys, during 1997–2013.

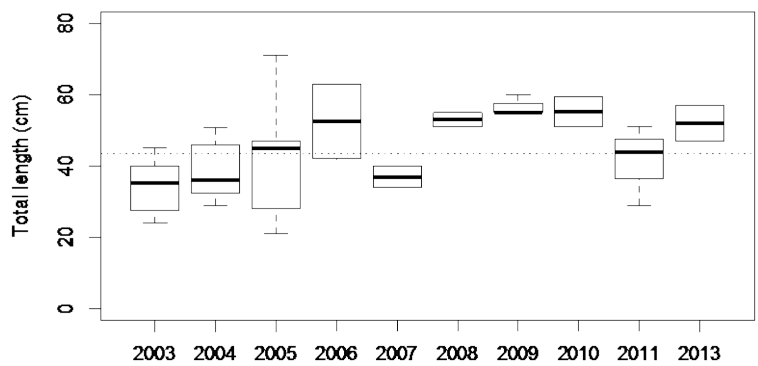


Figure 19.19. Skates and rays in the Bay of Biscay and Iberian Waters. *Raja montagui* total length variation on PT-GFS surveys, during 2003–2013.

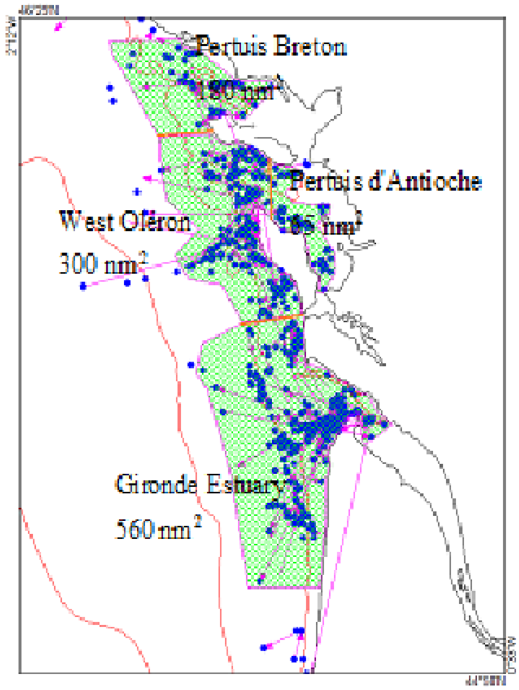


Figure 19.20. Skates and rays in the Bay of Biscay and Iberian Waters. Undulate ray habitat areas in the centre of the Bay of Biscay from 2011–2014 tagging and recapture positions.

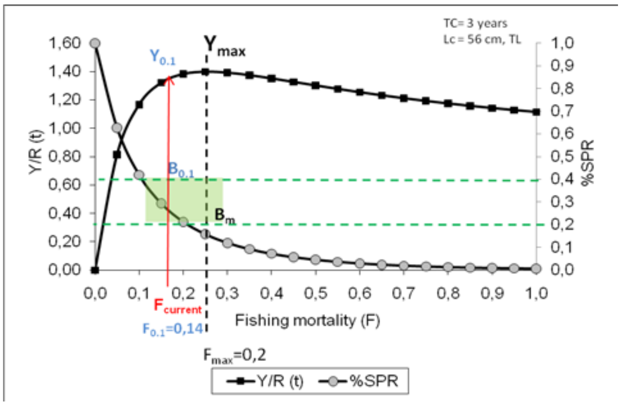


Figure 19.21. Skates and rays in the Bay of Biscay and Iberian Waters. ***Raja brachyura*** **yield per recruit (Y/R and potential spawning ratio (%SPR) curves for different levels of fishing mortality and an age of first capture = 3 years (TC).Red line shows $F_{current}$.** ***Raja brachyuran.***

20 Demersal elasmobranchs in the Azores and Mid-Atlantic Ridge

20.1 Ecoregion and stock boundaries

The Mid-Atlantic Ridge (MAR; ICES Subareas X, XII, XIV) is an extensive and diverse area, which includes several types of ecosystem, including abyssal plains, seamounts, active underwater volcanoes, chemosynthetic ecosystems and islands.

The main species of elasmobranch observed in this ecoregion are deep-water species (Centrophorus spp., Centroscymnus spp., Deania spp., Etmopterus spp., Hexanchus griseus, Galeus murinus, Somniosus microcephalus, Pseudotriakis microdon, Scymnodon obscurus, Centroscyllium fabricii and various deep-water skates; see Sections 3 and 5), particularly whenever the gear fishes deeper than 600 m. Many of these are discarded as a consequence of their low commercial value (ICES, 2005; Pinho and Canha, 2011). In the Azores area, kitefin shark Dalatias licha and tope Galeorhinus galeus are the most important commercial elasmobranchs (see Sections 4 and 10, respectively).

This section focuses on the skates taken in Azorean waters. Of these, the most abundant in Subarea X is thornback ray *Raja clavata*. Other species also observed include *Dipturus batis* complex, *D. oxyrinchus*, *Leucoraja fullonica*, *Rajella bathyphila*, *Raja brachyura*, and *Rostroraja alba* (Pinho, 2005; 2014b). Other species of batoid, such as Bigelow's ray *Rajella bigelowi*, stingray *Dasyatis pastinaca*, marbled electric ray *Torpedo marmorata* and electric ray *T. nobiliana* are also observed in this ecoregion (e.g. Santos *et al.*, 1997; Menezes *et al.*, 2006). These species are generally discarded if caught in commercial fisheries (Pinho and Canha, 2011). Some of the scarcer elasmobranchs observed on MAR include *Bathyraja pallida* and *Bathyraja richardsoni* (ICES, 2005).

Stock boundaries are not known for most of the species in this area, neither are the potential movements of species that also occur on the continental shelf of mainland Europe. In terms of *Raja clavata*, genetic studies have indicated important differences between Azorean and the eastern Atlantic sea board (Chevolot *et al.*, 2006), indicating that mixing is limited. Further investigations are necessary to determine potential migrations or interactions of elasmobranch populations within this ecoregion and neighbouring areas.

20.2 The fishery

20.2.1 History the fishery

In the context of this report, this area is mainly a natural deep-water environment exploited by small-scale fisheries in the Azorean islands EEZ and industrial deep-sea fisheries in international waters. The fisheries from these areas were described in earlier reports (ICES, 2005). Landings from the Azorean fleets have been reported to ICES. Landings from MAR remain very small and variable, or even absent, and few vessels find the MAR fisheries profitable at present.

Demersal elasmobranchs are caught in the Azores EEZ by a multispecies demersal fishery, using handlines and bottom longlines, and by the black scabbard fish fishery using bottom longlines (ICES, 2005). The most commercially important elasmobranchs caught and landed from these fisheries are *Raja clavata* and tope (Pinho, 2005; 2014a; ICES, 2005).

20.2.2 The fishery in 2012 and 2013

An expansion of the Azorean longline fishery to the more offshore seamounts has been observed in recent years as a result of intensive fishing or overexploitation of important commercial demersal/deep-water stocks. A shift from this fishery to the new black scabbard fish has been observed during the last four years.

The landings of demersal/deep-water sharks were very low due to the quota restrictions (Pinho, 2014a WD). There are no target fisheries, but discards of these species are expected to increase, particularly from the longliners, because of quota and local area restrictions to fishing being introduced in Subdivision Xa2 (Azores EEZ).

20.2.3 ICES advice applicable

ICES first provided advice for this ecoregion in 2012, stating "*As thornback ray is the dominant ray species at Azores and the Mid-Atlantic Ridge, the advice for skates and rays is based on the status of this species. Based on ICES approach to data-limited stocks, ICES advises that catches should be decreased by 36%. Because the data for catches are not fully documented and not reliable, ICES is not in a position to quantify the result*".

20.2.4 Management applicable

NEAFC has adopted management measures for the MAR areas under its regulatory area. These include effort limitations, area and gear restrictions (http://www.neafc.org/measures). Those recommendations that are relevant to elasmobranchs in this region include:

- Recommendation III (2006): Since 2006 NEAFC has prohibited fisheries with gillnets, entangling nets and trammel nets in depths below 200 m and introduced measures to remove and dispose of unmarked or illegal fixed gear and retrieve lost gear to minimize ghost fishing;
- Recommendations IX (2007) and IX (2008): Bottom fishing (Bottom trawling and fishing with static gear, including bottom-set gillnets and longlines) was forbidden in some areas of Hatton Bank and Rockall Bank;
- Recommendation XVI (2008): The access to the new bottom fishing areas (considered as other areas not mapped as actual existing bottom fishing areas) was limited;
- Recommendation VII (2009) and REC VI (2010): Since 2009 effort was limited and set at 65% of the highest level put into deep-sea fishing in previous years for the relevant species;
- Recommendation XIV (2009): During 2009 five areas (including three seamounts), on the Mid-Atlantic Ridge in the high seas in the Northeast Atlantic, were closed temporarily to bottom fisheries (fishing gears which is likely to contact the seabed) under its policy for area management;
- Recommendation VI (2011): As an interim measure, no directed fishery for basking shark shall be undertaken in the Convention Area in 2011;
- Recommendation VII (2010). Directed fishing of spurdog (*Squalus acanthias*) is prohibited in the Regulatory Area by vessels flying its flag. Any incidental catches of this stock shall be promptly released unharmed to the extent possible.

Deep-water sharks are subject to management in Community waters and in certain non-Community waters for stocks of deep-sea species (EC no 2270/2004 article 1).

In 1998, the Azorean government implemented local management actions in order to reduce effort on shallow areas of the islands, including a licence threshold based on the requirement of the minimum value of sales and the creation of a box of three miles around island areas, with fishing restrictions by gear (only handlines are permitted) and vessel type. During 2009 additional measures were implemented, including area restriction (temporary closure of the Condor Bank) and gear restriction by vessel type (licence and gear configuration).

Portugal introduced a new regulation banning the use of bottom trawling and bottom gillnetting on the high seas in the area covered by Portugal's extended continental shelf under the UN Law of the Sea (Portaria n.º 114/2014 de 28 de Maio). The new regulation expands the EU regulation adopted in 2005 to ban bottom trawling in the Azores and Madeiran waters and has the objective to protect deep-sea ecosystems (such as cold-water corals and seamounts) from the impact of bottom trawling and gillnet fishing.

Under the Common Fisheries Policy of the EU a box of 100 miles was created around the Azorean EEZ where only the Azorean fleets are permitted to line fish for deep-sea species (Regulation EC 1954/2003). TACs for deep-water sharks are in place for ICES Areas V, VI, VII, VIII, IX, X and XII (EC Reg. no 1539/2008).

20.3 Catch data

20.3.1 Landings

The landings reported by each country and subarea are given in Tables 20.1–20.3. Historical total landings of skates reported for Areas X and XII are presented in Figure 20.1.

Landings data from this ecoregion are also collated by NEAFC, and further studies to ensure that these data are consistent with ICES estimates are required.

20.3.2 Discards

Information on the discarding of skates is not currently available.

Information on discards from observers in the longline fishery from 2004 to 2010, as reported to the WGDEEP (Pinho and Canha, 2011) shows that for some species, such as deep-water sharks, the discards may be important. For species such as *Etmopterus* spp. and *Centrophorus* spp., all fish are discarded. Other species frequently caught and discarded include *Dalatias licha*, *Deania* spp. and *Hexanchus griseus*. These changes are probably due to the management measures introduced, particularly the TAC/quotas, minimum size and fishing area restrictions that changed the fleet behaviour on targeting, expanding the fishing areas to more offshore seamounts and deeper strata. Fisheries occurring outside the ICES area to the south of the Azores EEZ may exploit the same stocks considered here.

20.3.3 Quality of catch data

Species-specific landings data are not currently available for skates landed in this ecoregion. For demersal sharks, misidentifications are known to occur. Misidentified species, grouped as not specified elasmobranchs in the landings increased during the last two years.

20.3.4 Discard survival

Information on the discard survival of elasmobranchs in these fisheries is not currently available.

20.3.5 Species composition

In the Azores there is no systematic fishery/landing sampling programme for these species because they have very low priority on the port sampling programme. Landings statistics on rays and skates from Azorean fisheries are reported under generic categories. Accurate data on the composition of skates landed are not currently available.

20.4 Commercial catch composition

20.4.1 Length composition of landings

Since 2004, length samples of *Raja clavata* have been collected, however few individuals were sampled.

20.4.2 Length composition of discards

No information available.

20.4.3 Sex ratio of landings

No information available.

20.4.4 Quality of data

Only limited data are available. Improved data collation and quality checks (including for species identification) are required.

20.5 Commercial catch and effort data

No information available.

20.6 Fishery-independent surveys

Since 1995 the Department of Oceanography and Fisheries (DOP) has carried out an annual spring demersal bottom longline survey (ARQDACO(P)-Q1) around the Azores. An overview of the elasmobranch species occurring in the Azores (ICES Subarea X), their fisheries and available information on species distributions by depth were described by Pinho (2005; 2014a,b WD). This survey is not specifically designed to catch elasmobranchs, and so does not provide quantitative information for most species.

Raja clavata is one of the most commonly reported elasmobranch species in this survey (ICES, 2006). Relevant biological information available from surveys on this species were updated, including the annual abundance index (Figure 20.2) and length–frequency distribution (Figure 20.3). The absence of records of the youngest size classes in this survey can be attributed to a gear effect. Catches of other skates are insufficient to be informative of stock trends.

Information on elasmobranchs recorded on MAR is available from the literature (Hareide and Garnes, 2001) and was summarized in ICES (2005).

20.7 Life-history information

No new information.

20.8 Exploratory assessment methods

No assessments have been conducted, as a consequence of insufficient data.

20.9 Quality of assessments

No assessments have been conducted, as a consequence of insufficient data. Analyses of survey trends may be informative for *Raja clavata* but do not allow the status of other skates to be evaluated.

20.10 Reference points

No reference points have been proposed for any of these species.

20.11 Management considerations

WGEF considers that the elasmobranch fauna of Mid-Atlantic Ridge in ICES Subareas X and XII is poorly understood. The species of demersal elasmobranchs are probably little exploited compared with continental Europe. The ecoregion is considered to be a sensitive area. Consequently, commercial fisheries taking demersal elasmobranchs in this area should not be allowed to proceed unless studies are conducted that can demonstrate what sustainable exploitation levels should be.

20.12 References

Chevolot, M., Hoarau, G., Rijnsdorp, A. D., Stam, W. T., and Olsen, J. L. 2006. Phylogeography and population structure of thornback rays (*Raja clavata* L., Rajidae). *Molecular Ecology*, 15: 3693–3705.

Hareide, N. R. and Garnes, G. 2001. The distribution and catch rates of deep water fish along the Mid-Atlantic Ridge from 43 to 61 N. *Fisheries Research*, 519: 297–310.

ICES. 2005. Report of the Study Group on Elasmobranch Fishes. ICES CM 2006/ACFM:03, 224 pp.

ICES. 2006. Report of the Working Group on Elasmobranch Fishes (WGEF). 14–21 June 2006, ICES Headquarters. ICES CM 2006/ACFM:31. 291 pp.

Menezes, G. M., Sigler, M. F., Silva, H. M., and Pinho, M. R. 2006. Structure and zonation of demersal fish assemblages off the Azores Archipelago (Mid-Atlantic). *Marine Ecology Progress Series*, 324: 241–260.

Pinho, M. R. 2005. Elasmobranchs of the Azores. ICES Working Document WGEF 2005.

Pinho, M. R. 2014a. Elasmobranchs from the Azorean fisheries (ICES Area X). ICES Working Document WGEF 2014.

Pinho, M. R. 2014b. Resuming elasmobranchs survey data from the Azores (ICES X).ICES Working Document WGEF 2014.

Pinho, M. R. And Canha, A. 2011. Elasmobranch discards from the Azores longline fishery (ICES Subdivision Xa2). ICES Working Document WGDEEP 2011.

Santos, R. S., Porteiro, F. M. and Barreiros, J. P. 1997. Marine fishes of the Azores: An annotated checklist and bibliography. *Arquipélago*. Life and Marine Sciences, Supplement 1: xxiii + 242 pp.

Table 20.1. Demersal elasmobranchs in the Azores and Mid-Atlantic Ridge. Landings of demersal elasmobranchs (t) from ICES Subarea X.

ICES SUBAREA X													
Country	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1996
Azores	Rajidae	48	29	35	52	43	32	55	62	71	99	117	71
France	Rajidae							1					
Spain	Rajidae							.					
Azores	Bluntnose six-gill shark	+	1	1	1	+	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Azores	Sharks	+	+	4	12	+	n.a.	138	256	328	n.a.	n.a.	328
Total		48	30	40	65	43	32	194	318	399	99	117	399

ICES SUBAREA X													
Country	Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Azores	Rajidae	99	117	103	83	68	70	89	72	47	62	71	72
France	Rajidae					2	.	.	.	.	-	-	.
Spain	Rajidae				24	29	-	-	-	.	-	-	
Azores	Bluntnose six-gill shark	n.a.	n.a.	n.a.	n.a.	n.a.	7	2	1	1	1	1	.
Azores	Sharks	n.a.	n.a.	6	18	22	n.a.	n.a.	n.a.	3		11	18
Total		99	117	109	125	121	77	91	73	51	63	82	91

ICES SUBAREA X						
Country	Species	2009	2010	2011	2012	2013
Azores	Rajidae	60	68	90.7	103	46
France	Rajidae	.	.	.	.	.
Spain	Rajidae			.	.	.
Azores	Bluntnose six-gill shark	.	0.6	.	0	0
Azores	Sharks	10	6.3	1.6	31	70
Total		71	75	92	134	116

Table 20.2. Demersal elasmobranchs in the Azores and Mid-Atlantic Ridge. Landings of demersal elasmobranchs (t) from ICES Subarea XII.

ICES SUBAREA XII										
Country	Species	2001	2002	2003	2004	2005	2006	2007	2008	2009
UK	Rays and skates	1	1	6	1	.			0	0
UK	Sharks	-	6.7	-	-	113			0	0
Total		1	7	6	0.8	113	0	0	0	0

ICES SUBAREA XII					
Country	Species	2010	2011	2012	2013
UK	Rays and skates	.	.	.	.
Norway	Rajidae	.	.	.	.
Total		0	0	0	0

Table 20.3. Demersal elasmobranchs in the Azores and Mid-Atlantic Ridge. Landings of demersal elasmobranchs (t) from ICES Subarea XIV.

ICES SUBAREA XIV										
Country	Species	2001	2002	2003	2004	2005	2006	2007	2008	2009
UK	Rays and skates	+	+	-	-	-			0	0
Norway	Rajidae						6	0	1	0
Total		0.3	0.4	-	-	-	6	0	1	0

ICES SUBAREA XIV					
Country	Species	2010	2011	2012	2013
France	Rays and skates			0,484	.
Germany	Rays and skates	0.02	0	0	0,047
UK	Rays and skates	+	.		.
Norway	Rajidae		.		.
Total		0.02	0	0,484	0

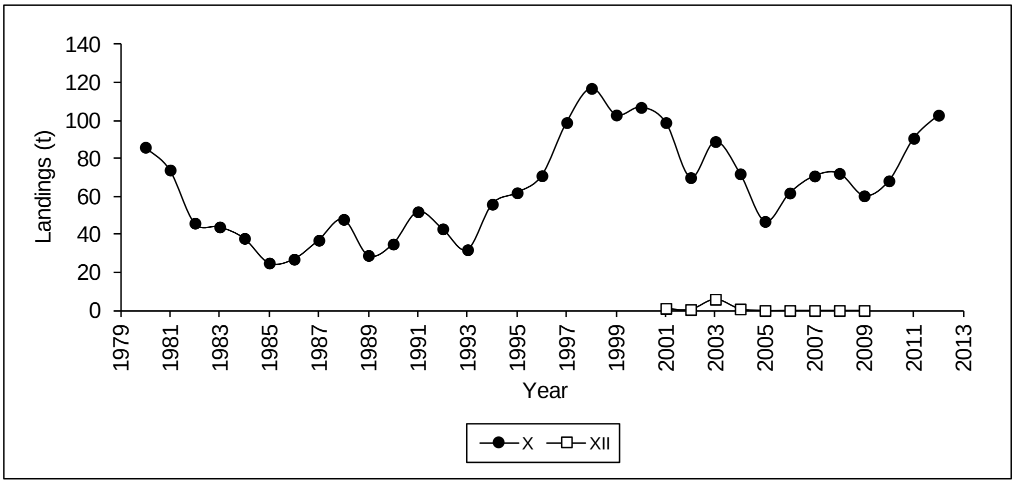


Figure 20.1. Demersal elasmobranchs in the Azores and Mid-Atlantic Ridge. Historical landings of rays from Azores (Ices Subarea X) and MAR (ICES Subarea XII).

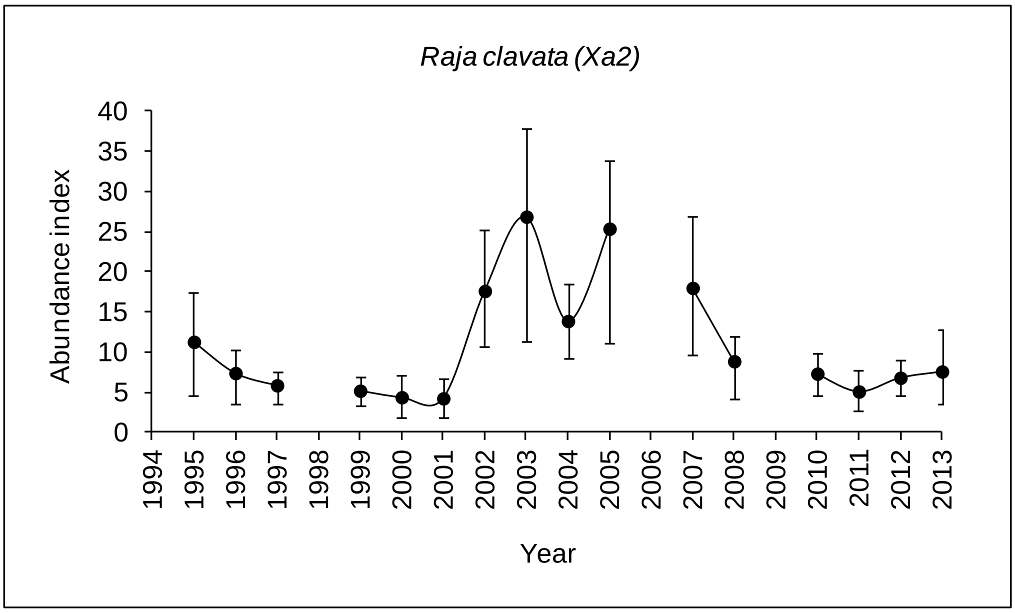


Figure 20.2. Demersal elasmobranchs in the Azores and Mid-Atlantic Ridge. Annual abundance, in numbers, of *Raja clavata* from the Azores (ICES X) from the Azorean demersal spring bottom longline survey (1995–2013).

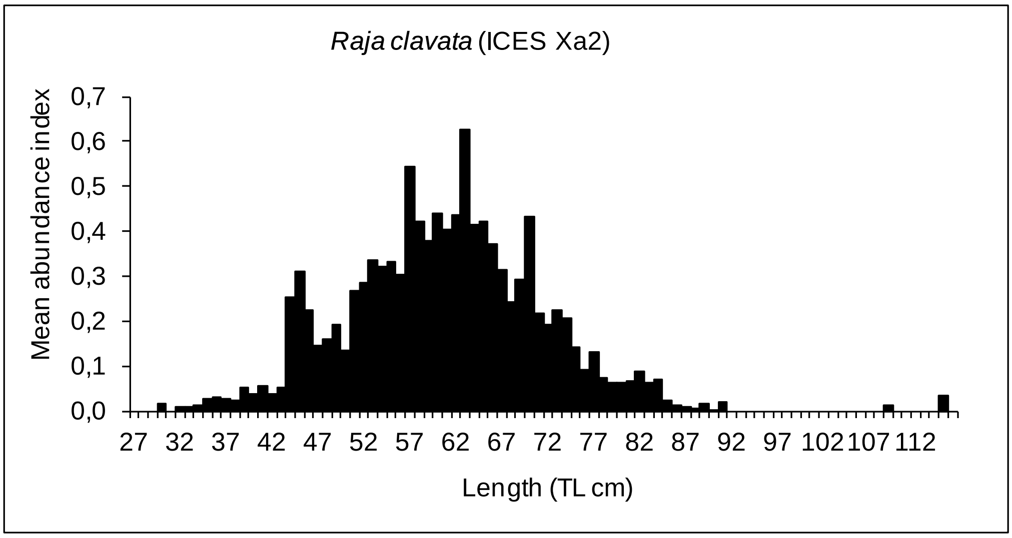


Figure 20.3. Demersal elasmobranchs in the Azores and Mid-Atlantic Ridge. Length frequency of *Raja clavata* caught in the Azorean demersal spring bottom longline survey for the period 1995–2012.

21 Smooth-hounds in the Northeast Atlantic

21.1 Stock distribution

Three species of smooth-hound (Triakidae) occur in the ICES area. The most frequent species in the northern part of the area is starry smooth-hound *Mustelus asterias.* Common smooth-hound *Mustelus mustelus* may also occur in northern European seas, although no confirmed specimens have been found in recent years and historical records may be unreliable. Separating these two species on the presence or absence of spots is unreliable (Compagno, 1984; Farrell *et al*., 2009), and information and data from northern Europe referring to *M. mustelus* likely refers to *M. asterias*.

A third species, black-spotted smooth-hound *Mustelus punctulatus,* occurs in the Mediterranean Sea (Quignard, 1972) and off NW Africa and may occur in the southernmost part of ICES Division IXa.

M. asterias is the dominant smooth-hound in northern European waters. The development of a molecular genetic identification technique has allowed the reliable identification and discrimination of north-east Atlantic *Mustelus* species (Farrell *et al*., 2009). Subsequent studies involving the collection of 231 *Mustelus* from the Irish Sea, Bristol Channel, Celtic Sea and west of Ireland, identified all to be *M. asterias* (Farrell *et al*., 2010a, b). A further study from the North Sea and English Channel (McCully and Ellis, 2014 WD) that sampled 210 *Mustelus*, also found no specimens of *Mustelus mustelus*.

Given the problems in separating *M. asterias* and *M. mustelus* and that data for these two species are confounded, data in this chapter are generally combined at genus level. Whilst assessments conducted by WGEF will be based on *Mustelus asterias,* management advice should be at the genus level, so as to avoid identification problems associated with management and enforcement.

In the absence of dedicated scientific studies on stock units, WGEF considers there to be a single management unit of *Mustelus asterias* in the continental shelf waters of the ICES area, comprising ICES Subareas IV, VI–IX. This stock may extend to the northern part of the CECAF area and possibly the Mediterranean Sea.

Improved studies to better understand the stock unit(s) are required. There are several programmes that tag and release *M. asterias* in the North Sea and Celtic Seas ecoregions (e.g. Burt *et al*., 2013 WD), and cooperative large-scale analyses of these data are required. Additionally, tagging studies from the more southern parts of the distribution range could be usefully undertaken.

21.2 The fishery

21.2.1 History of the fishery

Smooth-hounds are taken as a seasonal bycatch in trawl, gillnet and longline fisheries. Though they are discarded in some fisheries, other fisheries land this bycatch, depending on market demands. Some may also be landed to supply bait for pot fisheries.

Smooth-hounds are also a relatively important species for recreational sea anglers and charter boat fishing in several areas, with anglers and angling clubs often having catch-and-release protocols, particularly in the Celtic and North Seas.

21.2.2 The fishery in 2013

There were no major changes to the fishery noted in 2013. Information from the fishing industry suggests that the increased landings of smooth-hounds are partly to supply market demand for 'dogfish' given the current restrictions on spurdog.

21.2.3 ICES Advice applicable

ICES first provided advice for this stock in 2012, stating that "*Based on ICES approach to data-limited stocks, ICES advises that catches should be reduced by 4%. Because the data for catches of smooth-hounds are not fully documented and considered highly unreliable (due to the historical use of generic landings categories), ICES is not in a position to quantify the result*".

21.2.4 Management applicable

EC Council Regulations 850/98 for the `conservation of fishery resources through technical measures for the protection of juveniles of marine organisms' details the minimum mesh sizes that can be used to target fish. Although other dogfish (*Squalus acanthias* and *Scyliorhinus* spp.) could be targeted in fixed nets of 120–219 mm and >220 mm mesh size (in regions 1 and 2), *Mustelus* spp. would be classed under 'all other marine organisms', and so can only be targeted in fixed nets of >220 mm. This has been queried by some fishermen.

21.3 Catch data

21.3.1 Landings

No accurate estimates of catch are available, as many nations that land smooth-hounds report an unknown proportion of landings in aggregated landings categories (e.g. dogfish and hounds). Preliminary values of landings are given in Table 21.1 and Figure 21.1. Declared landings are increasing. The main nations exploiting smooth-hounds are France and England, and the English Channel and southern North Sea are important fishing grounds.

21.3.2 Discards

Although some discards data are available from various nations, data are limited for most nations and fisheries. Preliminary analyses have indicated that juveniles are typically discarded (Figure 21.2), although the survival of these discards has not yet been evaluated (Silva *et al*., 2013 WD).

Smooth-hounds taken by beam trawl and *Nephrops* trawl were composed primarily of juveniles and subadults (<70 cm), and most these were nearly all discarded. Gillnet catches were comprised primarily of fish in the 60–110 cm length range, with fish <55 cm usually discarded. Otter trawl catches covered a broad length range, and smooth-hounds <50 cm were typically discarded. The absence of full retention at length in these gears may be due to various factors, such as catch quality and local market value, influencing the discarding behaviour of fishers.

Silva *et al.* (2013 WD) also noted that a greater proportion of smooth-hounds were retained since landings opportunities for spurdog had become restrictive. Over the time period 2002–2005, the retention of *Mustelus* spp. ≥70 cm L_T was 1% and 39% in gillnet and otter trawl fisheries, respectively. In the period 2006–2011, however, retention increased to 73% (gillnets) and 49% (otter trawl).

21.3.3 Quality of catch data

Landings data are of poor quality, as much of the landings data have been reported under generic landings categories, especially historically. Most nations have made efforts to improve the recording of species in recent years. The availability and quality of catch data for off NW Africa and from the Mediterranean Sea needs to be investigated.

Better estimates of discarding are required, with information on discard survival also needed, as a proportion of discarded smooth-hounds may survive.

Biological data are not collected under the Data Collection Regulations.

21.3.4 Discard survival

Survival appears to be quite variable across this family (Ellis *et al*., 2014 WD). Whilst quantitative data are limited in European waters, Fennessy (1994) reported at-vessel mortality of 29% for Arabian smooth-hound *Mustelus mosis* taken in a prawn trawl fishery. Mortality ranged from 57–93% for three triakid sharks taken in an Australian gillnet fishery, despite the soak times being <24 h (Braccini *et al*., 2012). High survival of triakids has been reported in longline fisheries (Frick *et al*., 2010a; Coelho *et al*., 2012).

21.4 Commercial catch composition

Studies to better understand the composition by size and sex (and species where there is overlap) are required. Given the potential for sexual and sex-based segregation of *Mustelus* spp., appropriate levels of monitoring would be required to fully understand the catch composition over appropriate spatial and temporal scales.

21.4.1 Length Composition of landings

To date, 210 starry smooth-hound samples (113 female, 97 male, Figure 21.3) were examined in a UK study (McCully and Ellis, 2014). Of these 138 comprised of commercially landed specimens, with length ranges 52–124 cm total length.

21.4.2 Length composition of discards

Silva *et al*. (2013 WD) analysed the discard and retention patterns of *Mustelus* spp. taken as bycatch in UK commercial fisheries. Beam trawlers caught proportionally more juveniles (most records were for fish of about 35–70 cm L_T), consequently, discarding was quite high (95–99%). High rates of discarding (of smaller fish, <65 cm L_T) were also apparent in otter trawls, where about 75–80% of the total catches were discarded in the Celtic Seas and North Sea, respectively. Gillnets were more selective for larger fish (with the majority of fish 60–100 cm L_T), where typically only the larger fish (>70 cm L_T) were retained.

21.4.3 Sex ratio of landings

Of 138 commercially landed samples from the southern North Sea in May–November, 78 were female and 60 were male (McCully and Ellis, 2014). Due to smooth-hounds aggregating by sex and size, the sex ratio (and length–frequency) may vary over the year and area.

21.4.4 Quality of data

Mustelus length measurements may be collected as part of the concurrent sampling of the DCF. These data should be made available for future analysis.

21.5 Commercial catch and effort data

There are no data available on commercial cpue.

21.6 Fishery-independent information

21.6.1 Availability of survey data

Several fishery-independent surveys operate in the stock area. Analyses of survey data need to be undertaken with care, as smooth-hounds are relatively large-bodied species (maximum size of *M. asterias* is about 150 cm total length) and adults are strong swimmers. Hence, larger individuals may not be sampled effectively in IBTS surveys. Given their aggregating nature, some surveys may have a large number of zero hauls and a few hauls with relatively large numbers.

They are often caught in GOV trawl and other otter trawl surveys in the area. For further details of trawl surveys in the stock area, see Section 15 (North Sea ecoregion), Section 18 (Celtic Seas) and Section 19 (Biscay-Iberia). Summary details from IBTS 2011 are shown in Figure 21.4.

Larger individuals are not sampled effectively in beam trawl surveys (because of low gear selectivity). For example, the UK western English Channel beam trawl survey only occasionally records fish greater than 100 cm in length (Silva *et al.*, 2014 WD; Figure 21.5).

Although two species of smooth-hound have previously been reported in most surveys, the discrimination of these species has usually been based on the presence or absence of spots, which is not a reliable characteristic. WGEF consider that survey data for these two species should be combined in any analyses, and that starry smooth-hound *Mustelus asterias* is likely to be the only species in the Celtic Seas and North Sea ecoregions.

21.6.2 Survey trends

Trends in many of the fisheries-independent surveys have been increasing in recent years.

The UK (England and Wales) beam trawl survey of the Irish Sea catches reasonable numbers of smooth-hounds (Figure 21.6; ICES, 2010c, S21.1). The trend in abundance is derived from the catch rates from fixed stations (n=97) fished regularly (at least 18 years out of the 21 year time-series), and is currently at its highest level (since 1993) of 3.23 individuals per hour (2012–2013), increasing from 2.33 individuals per hour (2007–2011).

The UK (England and Wales) beam trawl survey of the southern North Sea and eastern English Channel catches lower numbers. The trend in abundance of smooth-hounds (derived from the catch rates from 76 fixed stations fished at least 17 years out of the 21 year time-series) was increasing, and they were also being observed in an increasing proportion of hauls until 2011 (ICES, 2011; S21.2). However, in the last two years, the trend in abundance has dropped slightly from 0.84 (2007–2011) to 0.5

individuals per hour, this is still stable at the level seen prior to the 2008–2011 peak (Figure 21.7).

A further UK (England and Wales) beam trawl survey of the western English Channel also encounters smooth-hounds in good numbers. Across the survey time-series (2006–2014), a total of 658 have been caught, accounting for 7.6% of the elasmobranch catch by numbers; the observed length range was 31–115 cm L_T (Silva *et al*., 2014 WD).

Previous analyses also indicated an increase in mean catch rates in the UK (Northern Ireland) western IBTS Q4 survey of the Irish Sea (ICES, 2010c), but recent data were not available to WGEF.

Although smooth-hounds are not subject to routine biological sampling in any of the surveys, all UK (England and Wales) surveys tag and release starry smooth-hounds, and the individual weights and maturity (of male fish) are recorded prior to release (See Section 21.7.5).

21.7 Life-history information

There have been several biological investigations of *Mustelus* spp. in European seas, including from the NE Atlantic and Mediterranean Sea.

21.7.1 Habitat

The distribution of *Mustelus* spp. around the British Isles has been described, with more detailed studies on the habitat utilization only examined in the English Channel (Martin *et al*., 2010; 2012).

21.7.2 Spawning, parturition and nursery grounds

Pups of *M. mustelus* are born at a size of 34–42 cm in the Mediterranean (Saidi *et al*., 2008) and 36 to 45 cm off Senegal (Capapé *et al*., 2006). Pups are taken in trawl surveys, and such data might be able to assist in the preliminary identification of general pupping and/or nursery areas.

Most of the records for *M. asterias* pups recorded in UK beam trawl surveys are from the southern North Sea (IVc), parts of the English Channel and Bristol Channel (VIIf) (Ellis *et al*., 2005). The total length of full-term pups ranged from 21–31 and was directly related to maternal length (McCully and Ellis, 2014 WD).

The lack of more precise data on the timing of parturition and the locations of pupping and nursery grounds and their importance to the stock, precludes spatial-temporal management for this species at the present time.

Studies on other species of smooth-hound have shown high site fidelity of immature individuals on nursery grounds (Espinoza *et al*., 2011).

21.7.3 Age and growth

Farrell *et al*. (2010a) studied the age and growth of *M. asterias* in the Celtic Seas ecoregion. Growth parameters for males (n = 106) were L_∞ = 103.7 cm total length, L_0 = 38.1 cm STL, k = 0.195 year^{-1}). Growth parameters for females (n = 114) were (L_∞= 123.5 cm STL, L_0= 34.9 cm STL, k = 0.146 year^{-1}). Estimates of longevity were 13 years (males) and 18.3 years (females).

Age and growth of *M. mustelus* has been studied in South African waters, with males and females estimated to mature at 6–9 and 12–15 years, respectively (Goosen and Smale, 1997). The maximum age reported in this study was 24 years.

The length–weight relationship of *Mustelus* spp. caught during the Cefas tagging programme, 2000–2010 is illustrated in Figure 21.8.

21.7.4 Reproductive biology

Studies in the Celtic Seas ecoregion had indicated that the total length (and age) at 50% maturity for male and female *M. asterias* are 78 cm (4–5 years) and 87 cm (six years), respectively (Farrell *et al*., 2010b).

Estimates of fecundity range from 8–27 (ovarian fecundity) and 6–18 (embryonic fecundity), with a gestation period of about twelve months (Farrell *et al*., 2010b), and there may also be a resting period of a year between pregnancies, giving a 2-year reproductive period. However, within mature female fish sampled by McCully and Ellis (2014 WD), twelve late gravid females with term pups (uterine fecundity 6–20) were also found to have numerous mature follicles (n = 6–22; follicle diameters 6–10 mm). This could indicate a possible annual reproductive cycle, but further studies are required to confirm or reject this hypothesis, including more samples of fish from winter and spring.

The smallest mature female that Farrell *et al*. (2010a) reported was 83 cm; slightly larger than the smallest females (two fish at 80 cm; summarised below) recorded by McCully and Ellis. This is interesting, as the two studies use slightly different maturity keys, with Farrell *et al*. (2010a) assigning a female to be mature when oocytes were present, yellow, and countable at >3 mm in diameter, whereas Cefas maturity keys (Appendix II of McCully and Ellis, 2014 WD), which are comparable to those keys developed within ICES, assign a female as mature when the oocytes are slightly larger (>5 mm).

Length (cm) at maturity estimates for starry smooth-hound (McCully and Ellis, 2014):

	FEMALE	MALE
Smallest mature	80	71
Largest immature	87	72
100% maturity	88	73

The number of mature follicles ranged from 1–28 in the mature females. These will not all necessarily develop into embryos, however, and estimates of ovarian fecundity are known to exceed estimates of uterine fecundity. The size spectra of the mature follicles (within mature females) ranged from 4.1 mm (mid-term gravid female) to 20.7 mm (mature female).

The uterine fecundity ranged from 4–20, which exceeds the maximum uterine fecundity (18) found by Farrell *et al*. (2010a), however they stated that their values may be underestimated due to females aborting pups on capture. The female identified with a fecundity of 20, was found with full-term pups. Uterine fecundity increased with length (Figure 21.9). Furthermore there were also positive linear relationships identified between maternal length and average pup length and weight (Figure 21.10).

In the Mediterranean Sea, *Mustelus asterias* reach maturity at about 75 cm (males) and 96 cm (females), with estimates of fecundity ranging from 10–45 (ovarian fecundity) and 10–35 (uterine fecundity), with fecundity increasing with length (Capapé, 1983).

Studies on *Mustelus mustelus* in the Mediterranean have found that females matured at 107.5–123 cm total length (50% maturity at 117.2 cm) and that males matured at 88–

112 cm (50% maturity at 97.1 cm) (Saidi *et al*., 2008). This study also found that embryonic fecundity ranged from 4–18 embryos, with fecundity increasing with length. Further south, off Senegal, the lengths at first (and 100%) maturity for *M. mustelus* were found to be 82 cm (95 cm), for males, and 95 cm (104 cm) for females (Capapé *et al*., 2006). This study reported litters of 4–21.

21.7.5 Movements and migrations

Although the movements and migrations of smooth-hounds are not fully known, there have been relatively high numbers of *Mustelus* spp. tagged and released during various other elasmobranch research programmes in the UK (Burt *et al*., 2013 WD), Figure 21.11. A Dutch angler-led programme has tagged 746 smooth-hounds since 2011, with 15 returns so far (Figure 21.12). Further analyses of these and other data are still required.

21.7.6 Diet and role in ecosystem

Mustelus spp. are primarily carcinophagous, predating on a variety of crustaceans, including hermit crabs (Paguridae), stomatopods, brachyuran crabs, squat lobsters and shrimps, with teleosts also consumed by larger individuals (McCully and Ellis, 2014; Ellis *et al*., 1996; Morte *et al*., 1997; Jardas *et al*., 2007; Santic *et al*., 2007; Saidi *et al*., 2009; Lipej *et al*., 2011). They can be important predators of commercial crustaceans, feeding on small edible crab *Cancer pagurus* in rocky areas, and they also feed on velvet swimming crab *Necora puber*.

21.7.7 Conversion factors

The relationship between total length and weight in the smooth-hounds sampled by sex and maturity stage are summarised below and in Figures 21.13 and 21.14 (McCully and Ellis, 2014). The relationship for males differs slightly to that of females, largely driven by the larger maximum length of females and the weights of females about to give birth. Of note is the 119 cm outlier, which related to a post-partum female with a very low body mass. Samples of the smaller size classes were obtained from scientific trawl surveys, while the larger individuals were from commercially landed specimens. Smooth-hounds are traditionally landed for the market gutted, and so conversion factors to length is also a useful parameter to augment data collected during market sampling programmes.

Relationship	Sex/Stage	Equation	R^2
Total weight to Total length	Immature Female	$y = 0.0027x^{3.0587}$	0.990
	Immature Male	$y = 0.0018x^{3.1494}$	0.991
	Mature Female	$y = 0.0041x^{3.0007}$	0.894
	Mature Male	$y = 0.0163x^{2.642}$	0.920
	Mid/late term Gravid Females	$y = 0.0003x^{3.5817}$	0.921
Gutted weight to Total Length	Sexes combined	$y = 0.0017x^{3.1273}$	0.993
	Female	$y = 0.0018x^{3.1163}$	0.991
	Male	$y = 0.0017x^{3.1149}$	0.995

21.8 Exploratory assessment models

21.8.1 Previous studies

No previous assessments of NE Atlantic smooth-hounds have been made. However, there have been assessment methods developed for the Australian species *Mustelus antarcticus* (e.g. Xiao and Walker, 2000; Pribac *et al*., 2005) which may be applied to European species when relevant data are available.

21.8.2 Data exploration and preliminary assessments

Although no modelling or quantitative stock assessments have been undertaken, trends in relative abundance have been used to inform on current status (see Section 21.6).

21.9 Stock assessment

No assessment was undertaken.

21.10 Quality of the assessment

No assessment was undertaken.

Scientific trawl surveys provide the longest time-series of species-specific data.

21.11 Reference points

No reference points have been proposed for this stock.

21.12 Conservation considerations

The IUCN Red List Assessments do not identify smooth-hounds as high conservation importance, listing them as Least Concern (*M. asterias* and *M. mustelus*) and Data Deficient (*M. punctulatus*).

21.13 Management considerations

Smooth-hounds appear to be increasing in relative abundance in trawl surveys, and also in commercial landings data. Given the potential expansion in fisheries for smooth-hounds (which may reflect an increased abundance and that fishing opportunities for *S. acanthias* are limited), further work to understand the dynamics of this stock is required.

It should be noted that smooth-hounds taken by beam trawl and *Nephrops* trawl were composed primarily of juveniles and subadults (<70 cm), and these were nearly all discarded, as were smooth-hounds <50 cm in the otter trawl fishery (Figure 21.2). Discard mortality is not known, and nor is the proportion of recruits that may survive to maturity and marketable size. However, discard survivability within this family is quite variable (Ellis *et al*., 2014 WD). Further study on the mortality and survival rates of juveniles in these fisheries are needed to evaluate impacts on recruitment.

Smooth-hounds are also an important target species in some areas for recreational fisheries; though there are insufficient data to examine the relative economic importance of these fisheries, or the degree of mortality.

Other species of smooth-hound are targeted elsewhere in the world, including Australia/New Zealand and South America. Although smooth-hounds are generally quite productive stocks (at least for elasmobranchs), evidence from these fisheries suggests that various management controls can be used for their appropriate management.

21.14 References

Braccini, M., Van Rijn, J., and Frick, L. 2012. High post-capture survival for sharks, rays and chimaeras discarded in the main shark fishery of Australia? *PloS One*, 7(2), e32547, 1–9.

Burt, G. J., Silva, J. F., McCully, S. R., Bendall, V.A. and Ellis, J. R. 2013. Summary results from opportunistic tagging programmes for smooth-hound *Mustelus* spp., greater-spotted dogfish *Scyliorhinus stellaris* and tope *Galeorhinus galeus* around the British Isles. Working Document to the Working Group on Elasmobranch Fishes, Lisbon, Portugal, 17–21 June 2013. 12 pp.

Capapé, C. 1983. New data on the biological of the reproduction of *Mustelus asterias* Cloquet, 1821 (Pisces, Pleurotremata, Triakidae) from Tunisian coasts. *Vie et Milieu*, 33: 143–152.

Capapé, C., Diatta, Y., Diop, M., Vergne, Y. and Guelorget, O. 2006. Reproductive biology of the smoothhound, *Mustelus mustelus* (Chondrichthyes: Triakidae) from the coast of Senegal (eastern tropical Atlantic). *Cybium*, 30: 273–282.

Coelho, R., Fernandez-Carvalho, J., Lino, P.G., and Santos, M.N. 2012. An overview of the hooking mortality of elasmobranchs caught in a swordfish pelagic longline fishery in the Atlantic Ocean. *Aquatic Living Resources*, 25: 311–319.

Compagno, L., Dando, M. and Fowler, S. 2005. Sharks of the World. Collins Field Guide. Harper Collins Publishers, London.

Espinoza, M., Farrugia, T. J. and Lowe, C. G. 2011. Habitat use, movements and site fidelity of the gray smooth-hound shark (*Mustelus californicus* Gill 1863) in a newly restored southern California estuary. *Journal of Experimental Marine Biology and Ecology*, 401: 63–74.

Ellis, J.R.., McCully, S.R. and Poisson, F. 2014. A global review of elasmobranch discard survival studies and implications in relation to the EU 'discard ban'. Working Document to the ICES Working Group on Elasmobranch Fishes, Lisbon, June 2014. 48 pp.

Ellis, J.R., Cruz-Martinez, A., Rackham, B.D. and Rogers, S.I. 2005. The distribution of chondrichthyan fishes around the British Isles and implications for conservation. *Journal of Northwest Atlantic Fishery Science*, 35: 195–213.

Farrell, E. D., Clarke, M. W. and Mariani, S. 2009. A simple genetic identification method for northeast Atlantic smoothhound sharks (*Mustelus* spp.). *ICES Journal of Marine Science*, 66: 561–565.

Farrell, E. D., Mariani, S. and Clarke, M. W. 2010a. Age and growth estimates for the starry smoothhound (*Mustelus asterias*) in the northeast Atlantic Ocean. *ICES Journal of Marine Science*, 67: 931–939.

Farrell, E. D., Mariani, S. and Clarke, M. W. 2010b. Reproductive biology of the starry smoothhound shark *Mustelus asterias*: Geographic variation and implications for sustainable exploitation. *Journal of Fish Biology*, 77: 1505–1525.

Fennessy, S.T. 1994. Incidental capture of elasmobranchs by commercial prawn trawlers in the Tugela Bank, Natal, South Africa. *South African Journal of Marine Science*, 14: 287–296

Frick, L.H., Reina, R.D. and Walker, T.I. 2010. Stress related changes and post-release survival of Port Jackson sharks (*Heterodontus portusjacksoni)* and gummy sharks (*Mustelus anarcticus)* following gill-net and longline capture in captivity. *Journal of Experimental Marine Biology and Ecology*, 385: 29–37.

Gibson, C., Valenti, S.V., Fordham, S.V. and Fowler, S.L. 2008. The Conservation of Northeast Atlantic Chondrichthyans. Report of the IUCN Shark Specialist Group Northeast Atlantic Red List Workshop. viii + 76pp.

Goosen, A. and Smale, M. J. 1997. A preliminary study of age and growth of the smoothhound shark *Mustelus mustelus* (Triakidae). *South African Journal of Marine Science*, 18: 85–91.

Jardas, I., Santic, M., Nerlovic, V. and Pallaoro, A. 2007. Diet of the smooth-hound, *Mustelus mustelus* (chondrichthyes: Triakidae), in the eastern Adriatic Sea. *Cybium*, 31: 459–464.

Lipej, L., Mavric, B., Resek, S., Chérif, M. and Capapé, C. 2011. Food and feeding habits of the blackspotted smooth-hound, *Mustelus punctulatus* (Elasmobranchii: Carcharhiniformes: Triakidae), from the northern Adriatic. *Acta Ichthyologica et Piscatoria*, 41: 171–177.

Martin C.S., Vaz, S., Ellis, J.R., Coppin, F., Le Roy, D. and Carpentier, A. 2010. Spatio-temporal patterns of demersal elasmobranchs in trawl surveys in the eastern English Channel (1988–2008). *Marine Ecology Progress Series*, 417: 211–228.

Martin, C.S., Vaz, S., Ellis, J.R., Lauria, V., Coppin, F., and Carpentier, A. 2012. Modelled distributions of ten demersal elasmobranchs of the eastern English Channel in relation to the environment. *Journal of Experimental Marine Biology and Ecology*, 418/419: 91–103.

McCully, S and Ellis, J.E. 2014. Biological studies to inform management of smooth-hounds (*Mustelus* spp.) in the North-east Atlantic. Working Document to ICES Working Group on Elasmobranch Fishes. Lisbon, Portugal. 16pp.

Morte, S., Redon, M. J. and Sanz-Brau, A. 1997. Feeding habits of juvenile *Mustelus mustelus* (Carcharhiniformes, Triakidae) in the western Mediterranean. *Cahiers de Biologie Marine*, 38: 103–107.

Pribac, F., Punt, A. E. Taylor, B. L. and Walker, T. I. 2005. Using length, age and tagging data in a stock assessment of a length selective fishery for gummy shark (*Mustelus antarcticus*). *Journal of Northwest Atlantic Fishery Science*, 35: 267–290.

Quignard, J. P. 1972. Note sur les especes mediterraneenes du genre *Mustelus* (Selachii, Galeoidea, Triakidae). *Rev. Trav. Inst. Peches Marit*., Nantes, 36(1): 15–29.

Saidi, B., Bradai, M. N. and Bouain, A. 2008. Reproductive biology of the smooth-hound shark *Mustelus mustelus* (L.) in the Gulf of Gabes (south-central Mediterranean Sea). *Journal of Fish Biology*, 72: 1343–1354.

Saidi, B., Enajjar, S., Bradai, M. N. and Bouain, A. 2009. Diet composition of smooth-hound shark, *Mustelus mustelus* (Linnaeus, 1758), in the Gulf of Gabes, southern Tunisia. *Journal of Applied Ichthyology*, 25: 113–118.

Santic, M., Nerlovic, V. and Pallaoro, A. 2007. Diet composition of blackspotted smooth-hound, *Mustelus punctulatus* (Risso, 1826), in the eastern Adriatic Sea. *Journal of Applied ichthyology*, 23: 279–281.

Silva, J.F., McCully, S.R., Ellis, J.R. and Kuoshus, S. 2014. Demersal elasmobranchs in the English Channel. Working Document to the ICES Working Group on Elasmobranch Fishes. 28pp.

Silva, J. F., Ellis, J. R., Catchpole, T. L. and Righton, D. 2013. Bycatch and discarding patterns of dogfish and sharks taken in commercial fisheries around the British Isles. Working Document to the Working Group on Elasmobranch Fishes, Lisbon, Portugal. 17–21 June 2013. 31 pp.

Xiao, Y. and Walker, T. I. 2000. Demographic analysis of gummy shark (*Mustelus antarcticus*) and school shark (*Galeorhinus galeus*) off southern Australia by applying a generalized Lotka equation and its dual equation. *Canadian Journal of Fisheries and Aquatic Sciences*, 57: 214–222.

Table 21.1. Smooth-hounds in the Northeast Atlantic. Reported species-specific landings (tonnes) for the period 1973–2013. These data are considered underestimates as some smooth-hounds are landed under generic landings categories. Species-specific landings data are not available for the Mediterranean Sea and are limited for northwestern African waters.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Belgium	.	.	.	.	.	.	.	.	.	.	.	.	.
France	0	0	0	0	0	0	32	0	0	222	218	66	143
Netherlands	.	.	.	.	.	.	.	.	.	.	.	.	.
Portugal	.	.	.	.	.	.	.	.	.	.	.	.	
UK -E, W & NI	.	.	.	.	.	.	.	.	.	.	.	.	.
UK - Scotland	.	.	.	.	.	.	.	.	.	.	.	.	.
	0	0	0	0	0	0	32	0	0	222	218	66	143

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Belgium													
France	64	117	126	93	90	102	138	145	228	187	197	64	117
Netherlands	.	.	.	.	.	.	.	.	.	.	.	.	.
Portugal	.	.	.	.	.	.	.	.	.	.	.	.	.
UK -E, W & NI	.	.	.	.	.	.	.	.	.	.	.	.	.
UK - Scotland	.	.	.	.	.	.	.	.	.	.	.	.	.
	64	117	126	93	90	102	138	145	228	187	197	64	117

Table 21.1 (continued). Smooth-hounds in the Northeast Atlantic. Reported species-specific landings (tonnes) for the period 1973–2013. These data are considered underestimates as some smooth-hounds are landed under generic landings categories. Species-specific landings data are not available for the Mediterranean Sea and are limited for northwestern African waters.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	.	.	.	.	.	.	.	.	.	.	.	.	.	8	10
France	.	306	377	585	589	682	767	714	908	522	926	969	706	2695	2955
Netherlands	.	.	.	.	.	.	.	.	.	.	.	8	3	11	20
Portugal	.	.	.	.	.	.	.	.	.	.	.	.	35	42	41
Spain	.	.	.	.	.	.	.	.	.	.	.	34	48	9	83
UK -E, W & NI	.	14	0	0	0	0	0	0	0	115	132	161	919	337	323
UK - Scotland	.	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	0	320	377	585	589	682	767	714	908	637	1059	1172	1712	3101	3433

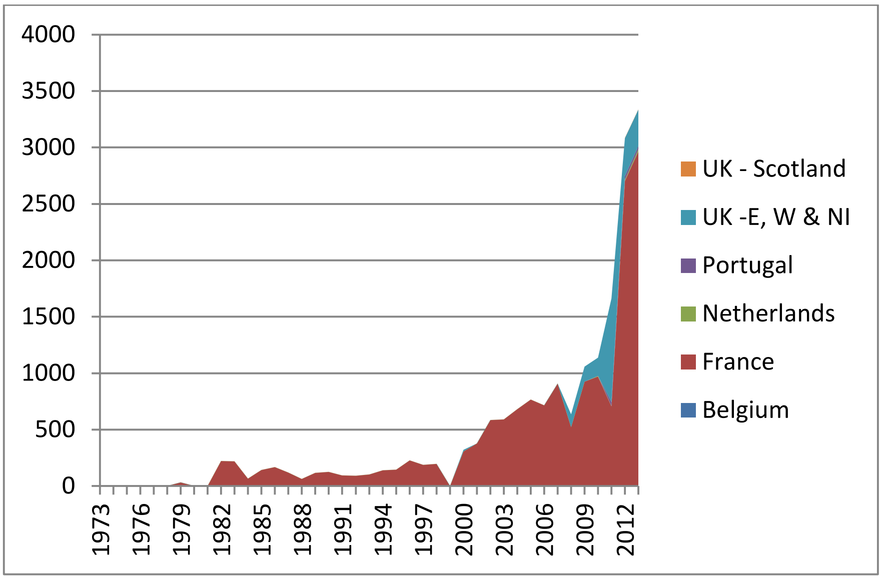
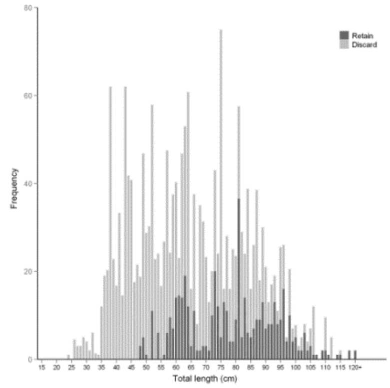
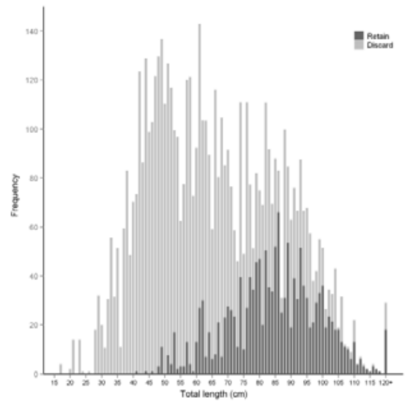


Figure 21.1. Smooth-hounds in the Northeast Atlantic. Working Group estimates of *Mustelus* spp. landings by country, 1973–2013. Data are considered underestimates.

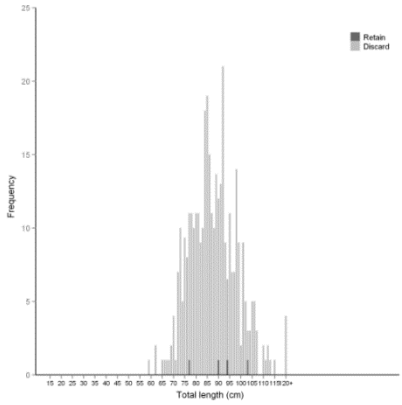
A



B



C



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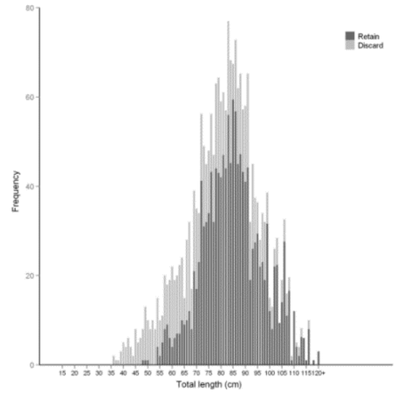
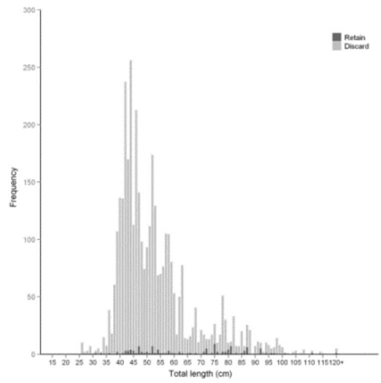


E



F

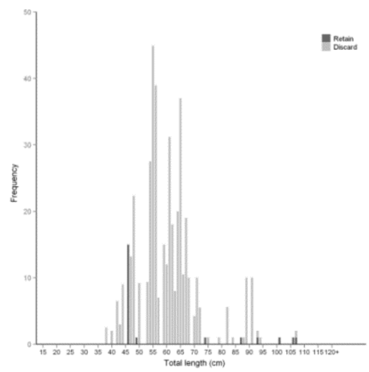


Figure 21.2. Smooth-hounds in the Northeast Atlantic. Length–frequency of discarded and retained smooth-hounds *Mustelus* spp. by (a) otter trawl (2002–2005), (b) otter trawl (2006–2011), (c) gillnet (2002–2005), (d) gillnet (2006–2011), (e) beam trawl (2002–2011) and (f) *Nephrops* trawl (2002–2011), as recorded in the Cefas observer programme. Data aggregated across ecoregions (Source: Silva *et al.*, 2013 WD).

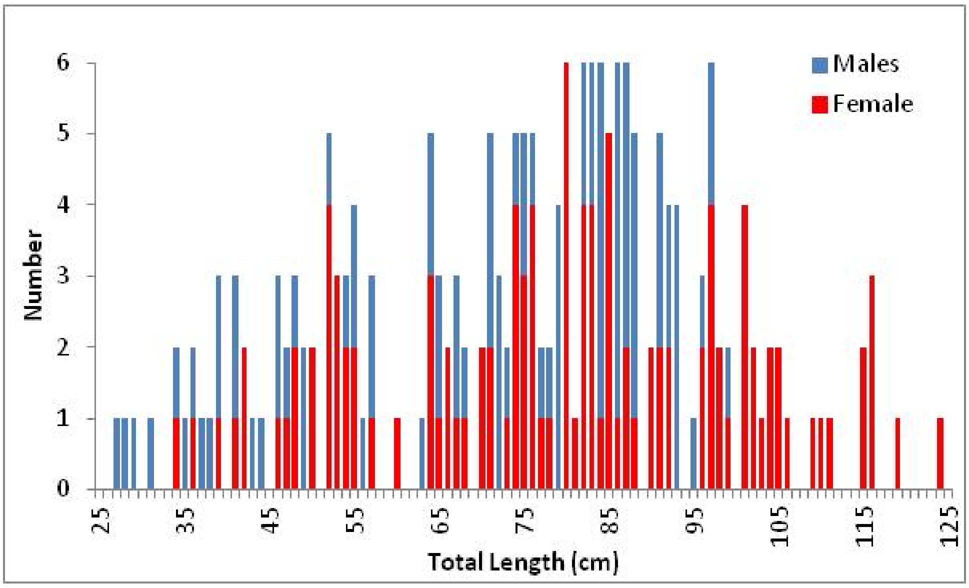


Figure 21.3. Smooth-hounds in the Northeast Atlantic. Number of starry smooth-hounds biologically sampled by length and sex. Source: McCully and Ellis (2014).

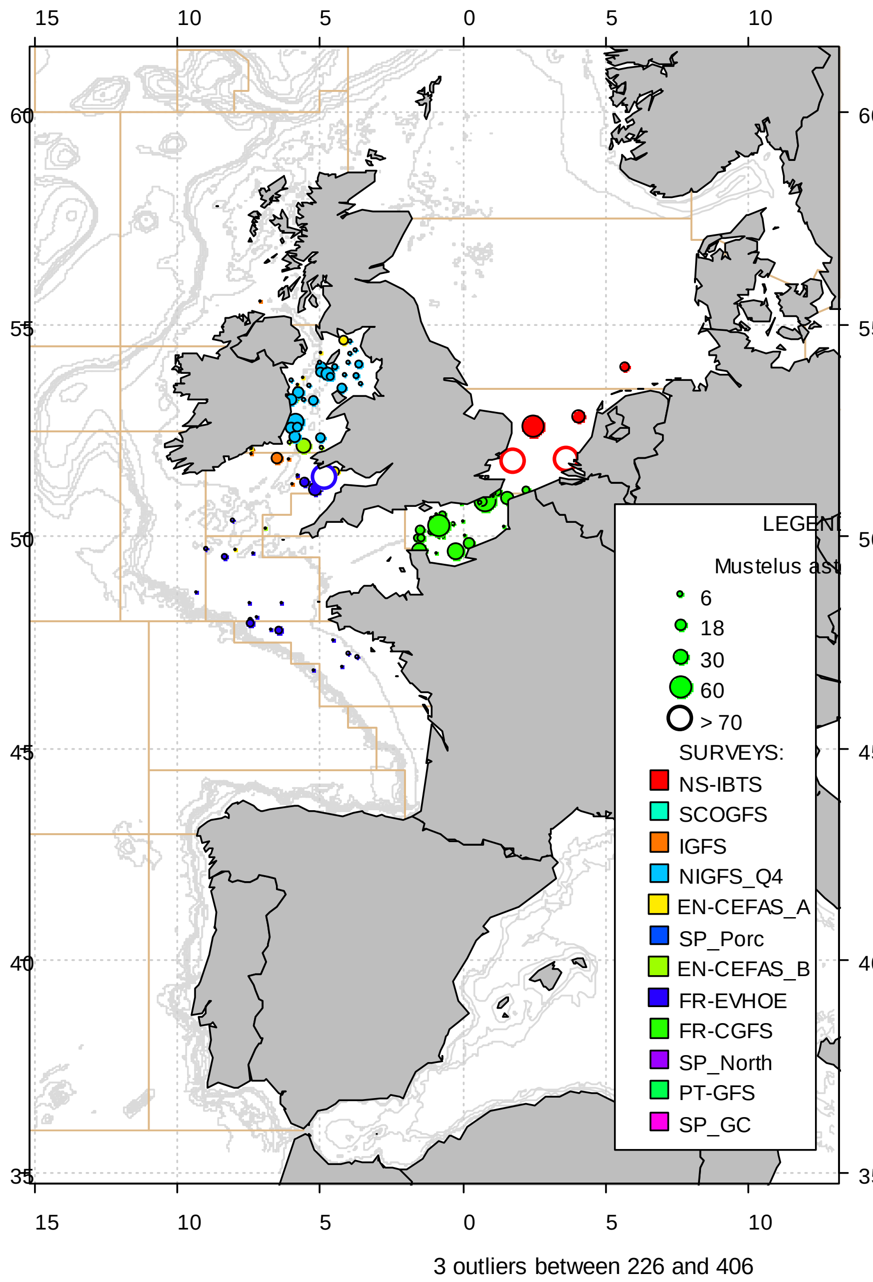


Figure 21.4a. Smooth-hounds in the Northeast Atlantic. Captures of *Mustelus asterias* as reported in the 2011 IBTS. The catchability of the different gears used in the NE Atlantic surveys is not constant; therefore the map does not reflect proportional abundance in all the areas but within each survey. Source: ICES (2012).

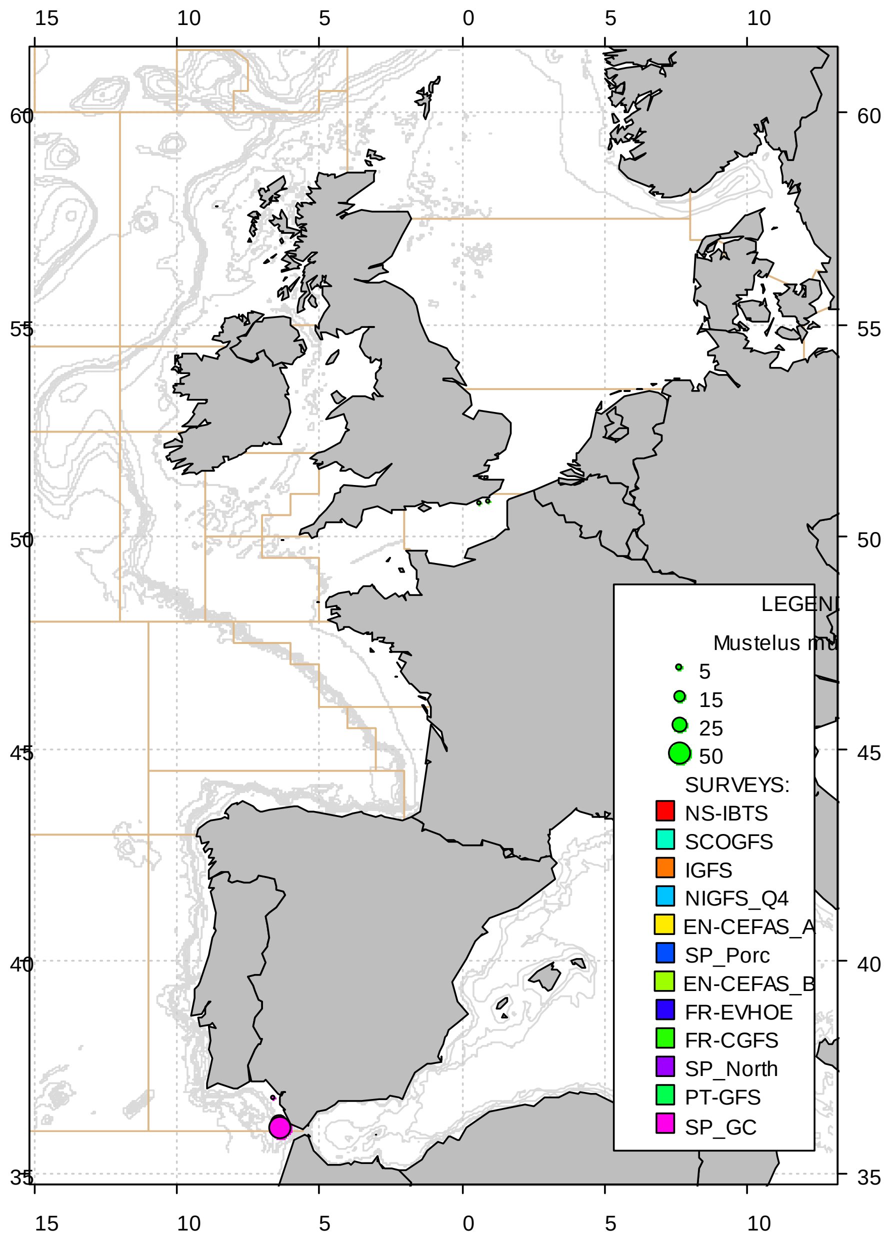


Figure 21.4b. Smooth-hounds in the Northeast Atlantic. Captures of *Mustelus mustelus* as reported in the 2011 IBTS. The catchability of the different gears used in the NE Atlantic surveys is not constant; therefore the map does not reflect proportional abundance in all the areas but within each survey. Source: ICES (2012).

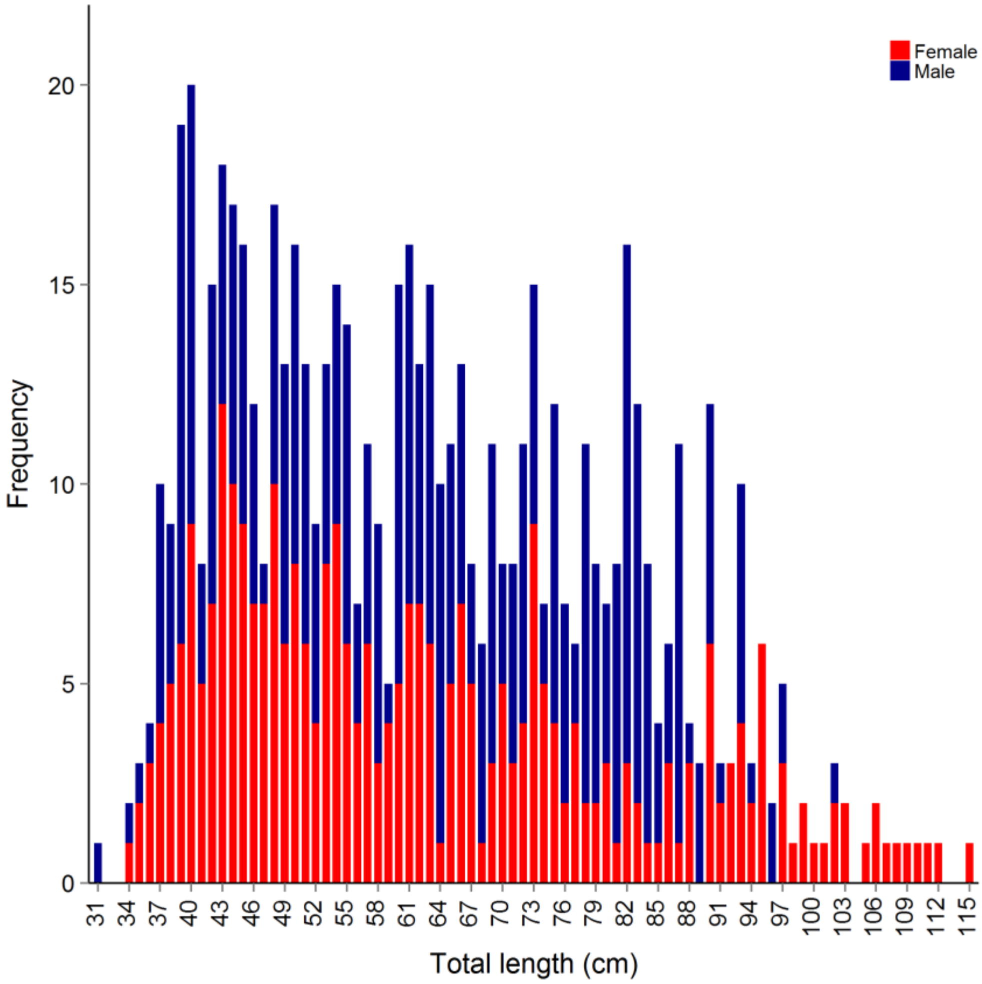


Figure 21.5. Smooth-hounds in the Northeast Atlantic. Length–frequency by sex of smooth-hounds *Mustelus* spp. From the UK Western Channel Q1 Beam-trawl survey. Source: Silva *et al.* (2014 WD).

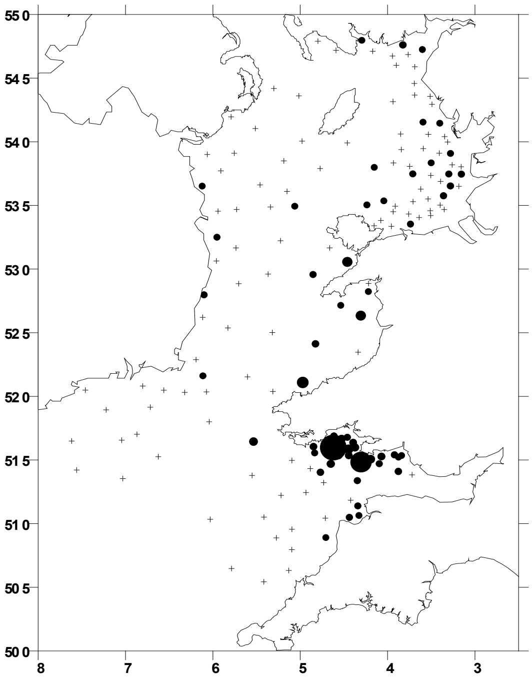


Figure 21.6a. Distribution and relative abundance of smooth-hounds in the UK (E&W) VIIa,f 4 m beam trawl survey area. Source: Ellis (2010 WD).

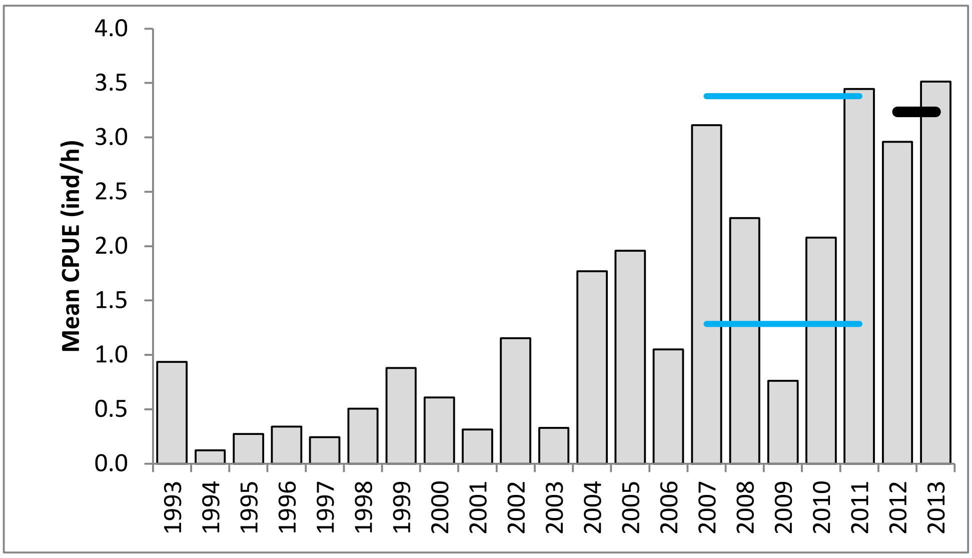


Figure 21.6b. Mean cpue of VIIa,f smooth-hounds from the UK (E&W) 4 m beam trawl survey. Blue lines give mean ± 1SD annual cpue for 2007–2011, black line shows mean annual cpue for 2012–2013.

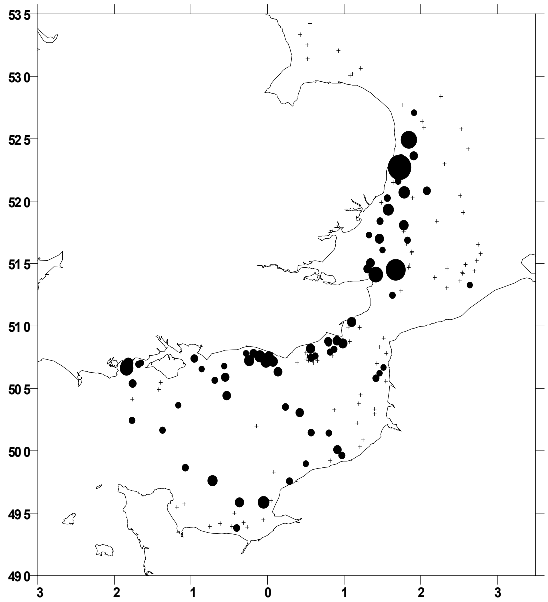


Figure 21.7a. Distribution and relative abundance of smooth-hounds in the UK (BTS-Q3) IVc, VIId 4 m beam trawl survey area. Source: Ellis (2010 WD).

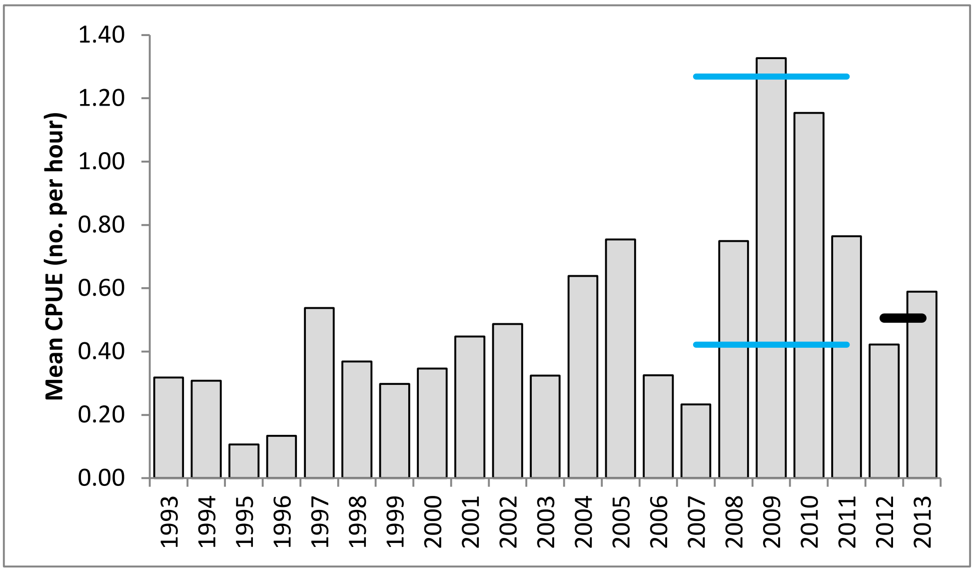


Figure 21.7b. Mean cpue of IVc–VIId smooth-hounds from the UK (BTS-Q3) 4 m beam trawl survey. Blue lines give mean ± 1SD annual cpue for 2007–2011, black line shows mean annual cpue for 2012–2013.

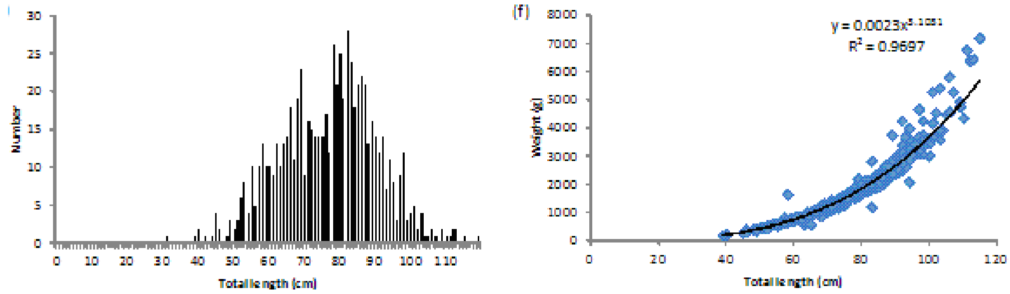


Figure 21.8. Smooth-hounds in the Northeast Atlantic. Length–frequency distributions of *Mustelus* spp. (n = 715), and the length–weight relationships for (*Mustelus* spp. (n = 508) tagged during the Cefas programme. Source: Burt *et al.* (2013 WD.)

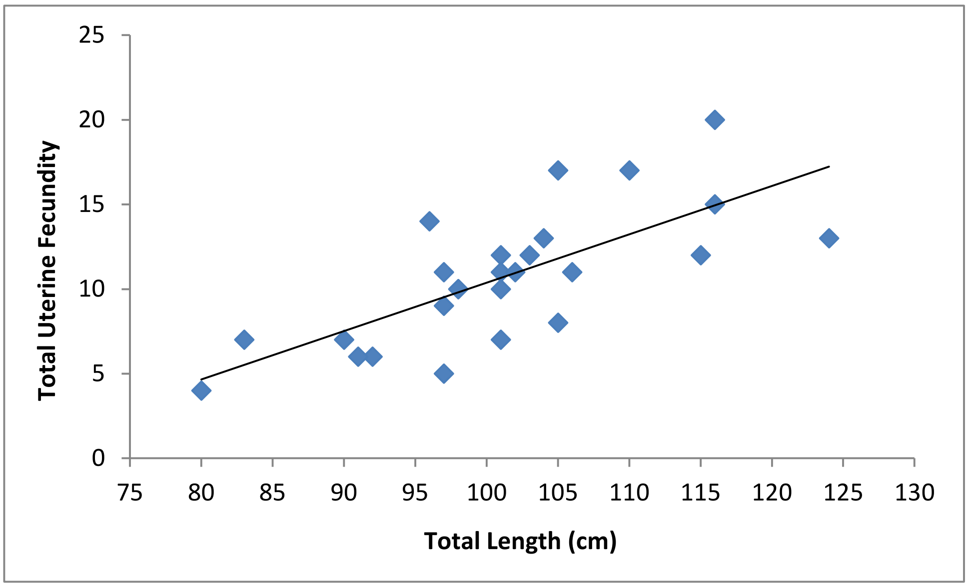


Figure 21.9. Smooth-hounds in the Northeast Atlantic. Relationship between maternal total length and number of term pups produced. Source: McCully and Ellis (2014).

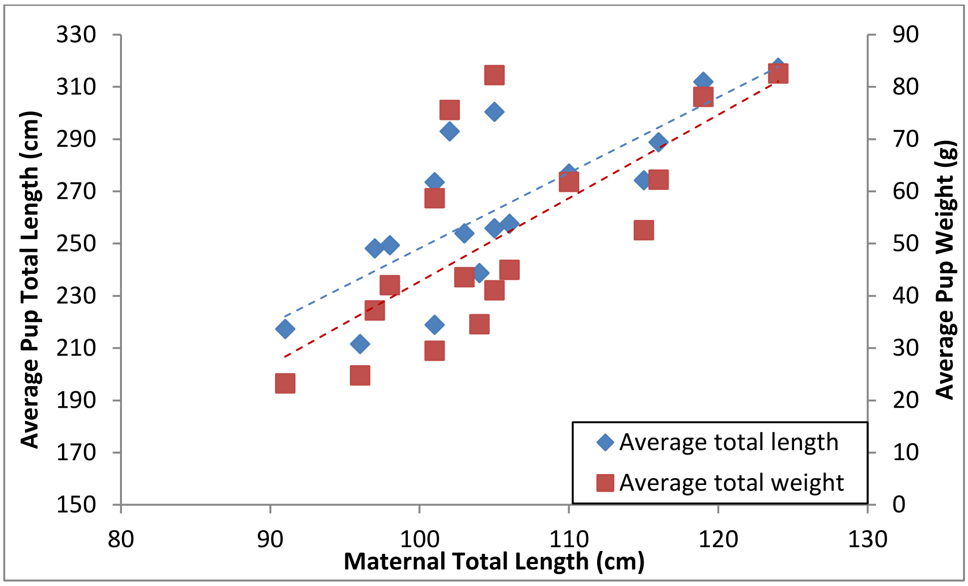


Figure 21.10. Smooth-hounds in the Northeast Atlantic. Relationship between maternal total length and average length and weight of term pups. Source: McCully and Ellis (2014).

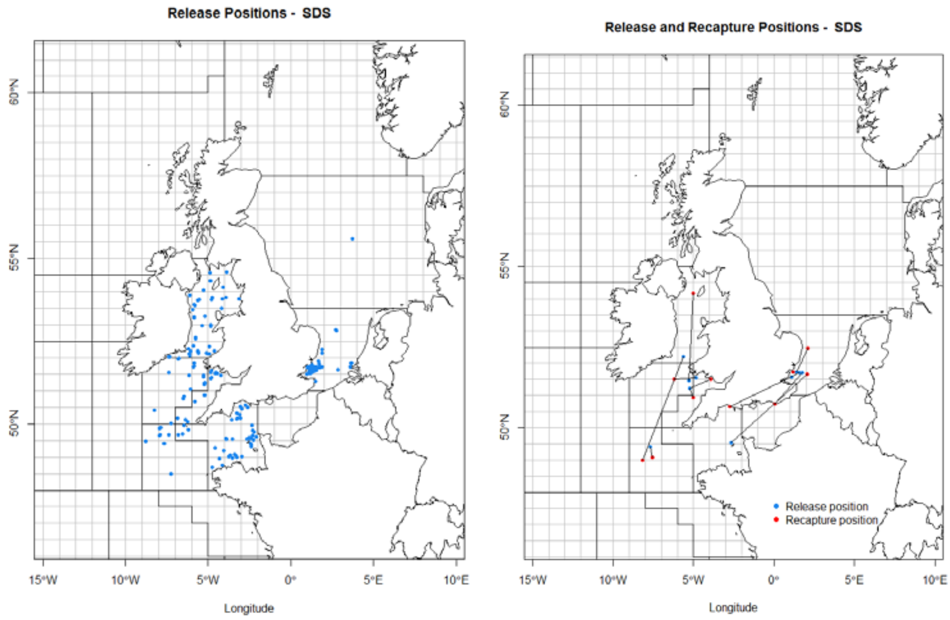


Figure 21.11. Smooth-hounds in the Northeast Atlantic. Locations of smooth-hound, *Mustelus* spp. (i) released and (ii) release and recapture positions for recaptured fish (2000–2013). Source: Burt *et al.*, WD 2013.

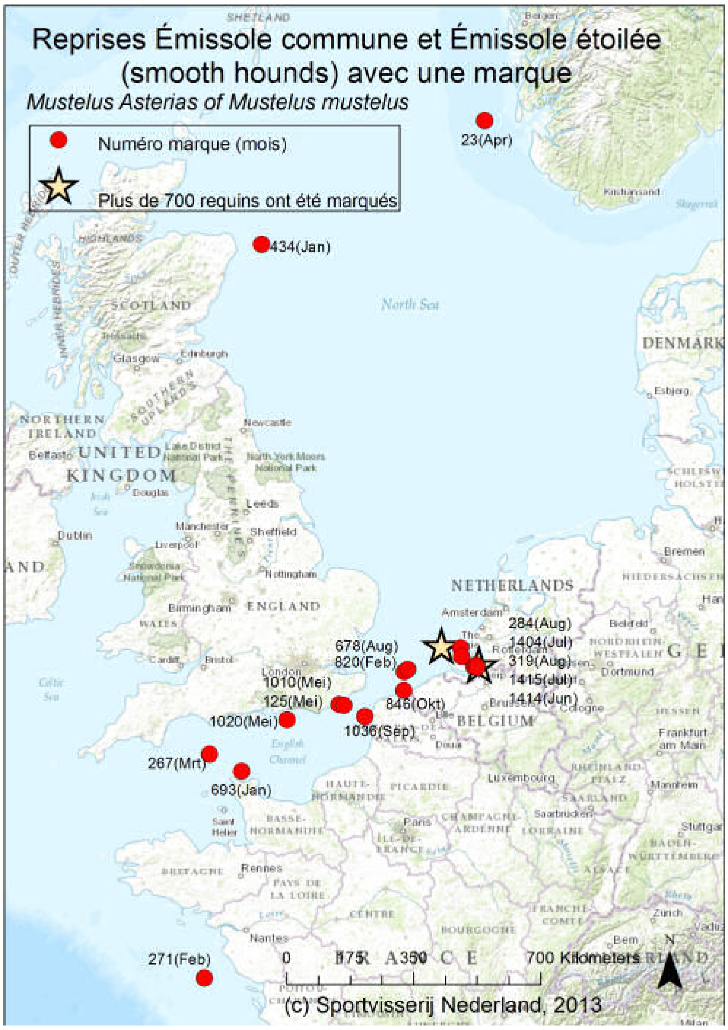


Figure 21.12. Smooth-hounds in the Northeast Atlantic. Recapture positions of smooth-hounds from Dutch sport fishing tagging programme. Source: Niels Breve, Sportvisserij Nederland.

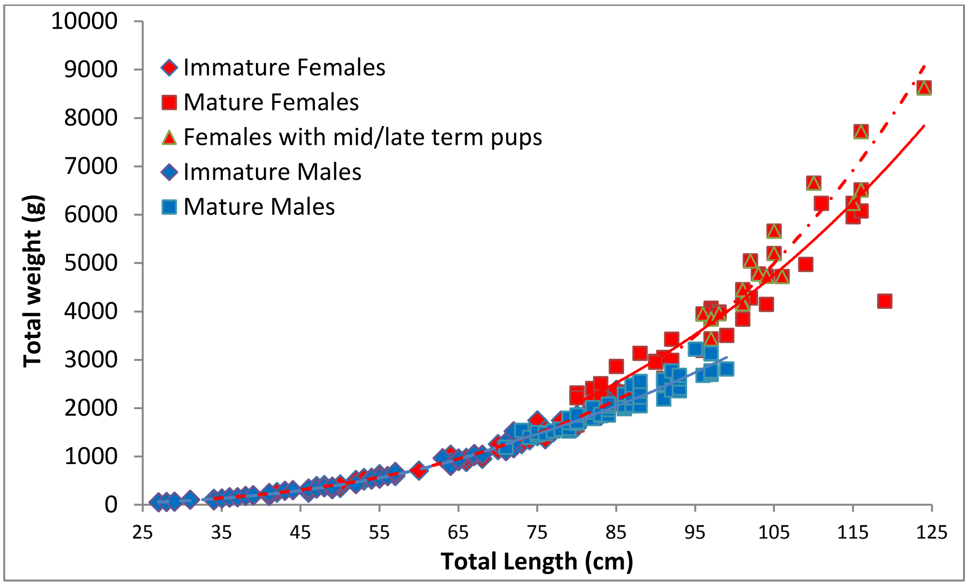


Figure 21.13. Smooth-hounds in the Northeast Atlantic Relationship between total weight and total length by sex and maturity stage. Source: McCully and Ellis (2014).

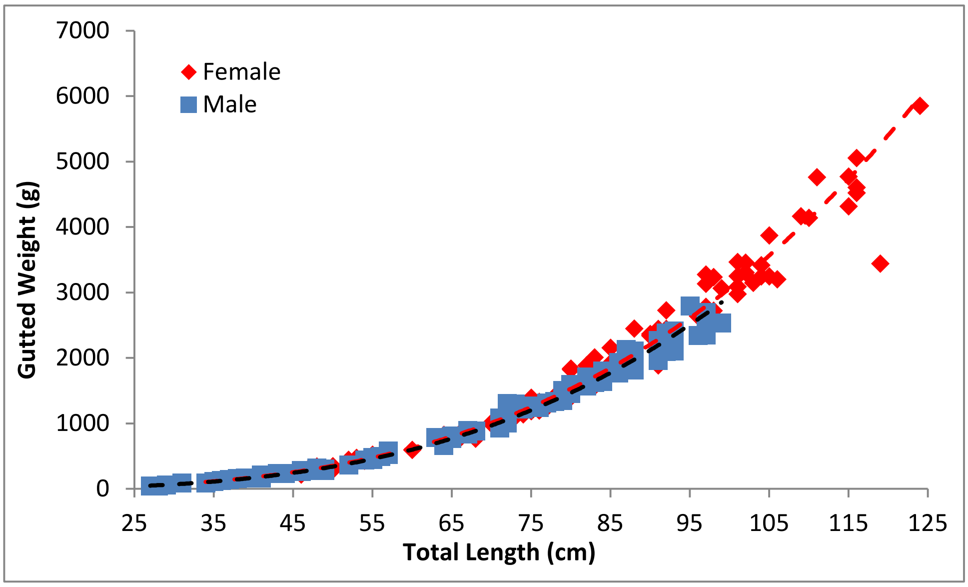


Figure 21.14. Smooth-hounds in the Northeast Atlantic.: Total length to gutted weight relationship. Source: McCully and Ellis (2014).

22 Angel shark *Squatina squatina* in the Northeast Atlantic

22.1 Stock distribution

Angel shark *Squatina squatina* was historically distributed from the British Isles southwards to western Africa and the Mediterranean Sea. As such the species distribution covers parts of ICES Subareas IV and VI–IX. The stock structure is not known, but available data for this and other species of angel sharks indicate high site-specificity and possibly localised stocks. STECF (2003) noted that angel sharks "*should be managed on smallest possible spatial scale*". However, Given that this species is perceived as highly threatened throughout the ICES area (and elsewhere in European waters), ICES advice is given at the species level.

22.2 The fishery

22.2.1 History of the fishery

Angel shark is thought to have been the subject of exploitation for much of the 19th century and parts of the 20th century, and was traditionally called 'monkfish' before the anglerfish *Lophius piscatorius* was considered marketable. It was exploited for meat, liver and skin. Given the coastal nature of the species, it was also subject to fishing pressure from recreational fishing in parts of its range. As catches declined, it was still landed occasionally as a 'curio' for fish stalls. The species has been extirpated from parts of its former range, with only occasional bycatch in certain areas.

22.2.2 The fishery in 2013

No target fisheries for angel shark, although they can be expected to be a very occasional bycatch in some trawl and gillnet fisheries. Nevertheless these captures should be released.

22.2.3 ICES Advice applicable

In 2008, ICES advised that angel shark in the North Sea eco-region was "extirpated in the North Sea. It may still occur in Division VIId". For the Celtic Seas, ICES advised that it "has a localized and patchy distribution, and is extirpated from parts of its former range. It should receive the highest possible protection. Any incidental bycatch should not be landed, but returned, to the sea, as they are likely to have a high survival rate".

In 2010 and 2012, ICES advised that it should remain on the list of Prohibited Species.

22.2.4 Management applicable

Council Regulation (EC) 43/2009 stated that "*Angel shark in all EC waters may not be retained on board. Catches of these species shall be promptly released unharmed to the extent practicable*". It has subsequently been included on the list of Prohibited Species and it is prohibited for EU vessels to fish for, to retain on board, to tranship and to land angel shark in EU waters (Council Regulations (EC) 23/2010, 57/2011, 43/2012, 39/2013 and 43/2014).

Angel shark is also protected in UK waters as it is listed on the Wildlife and Countryside Act.

22.3 Catch data

22.3.1 Landings

Angel shark (historically termed monkfish) became increasingly rare in landings data over the available time period, and was only reported rarely prior to it being listed as a prohibited species (Table 22.1; Figure 22.1). It is believed that the peak in UK landings in 1997 from VIIj–k were either misreported anglerfish (also called monkfish) or hake, as angel shark is a more coastal species. These figures have been removed from the landings data. French landings declined from >20 t in 1978 to less than 1 t per year prior to the prohibition on landings.

Whilst some nominal records were available in French national landings data for 2012 and 2013, the reliability of these data is uncertain, due to the areas and quantities reported, and catch gears. Further analyses and clarification of these data are required, and as such they are not included in the tables below.

22.3.2 Discards

Limited data are available. Analyses of the discard observer programme for the English and Welsh fleets did not note any angel sharks (Silva *et al.*, 2013). Examination of data collected under the French discard observer programme (2003–2013) indicated that only two individuals were observed (both in 2012) in the ICES area. According to observations from French fish markets and catches reported by fishermen, four additional individuals (two in 2007 and two in 2010) were also caught (Iglésias, pers. comm.). All these six individuals were collected off Pembrokeshire (Wales) at the entrance to St George's Channel.

22.3.3 Quality of catch data

Some concerns over some of the landings data (see above), and the prohibited species listing implies that commercial landings data will be near zero. Further studies of various national observer programmes are needed to better estimate commercial catch.

Given the low abundance of this species and its high conservation interest, WGEF recommend that (i) any data on angel shark collected from national observer programmes be reported to WGEF next year and (ii) that ongoing DCF observer programmes collect information on health state (e.g. lively, sluggish, dead) of discards of this species.

22.3.4 Discard survival

No data on the discard survival of angel shark caught in European fisheries, although other species have been studied elsewhere in the world. Fennessy (1994) reported at-vessel mortality of 60% for African angel shark *Squatina africana* caught in South African prawn trawlers, and Braccini *et al.* (2012) reported at-vessel mortality of 25% for Australian angel shark *Squatina australis* captured in a gillnet fishery (soak times <24 h).

22.4 Commercial catch composition

No data available.

22.5 Commercial catch and effort data

No data available for commercial fleets.

22.5.1 Recreational catch and effort data

Information from the Irish Central Fisheries Board has been used by WGEF to inform on the status of angel shark (see ICES 2010 for further information).

Updated information from the Inland Fisheries Ireland (IRI) National Marine Sport Fish Tagging Programme confirms the scarcity of angel shark. Tagging of angel sharks has declined markedly in the last 25 years. A total of 1029 individuals were tagged since 1970, but only a single individual tagged since 2006 (Roche and O'Reilly, 2013 WD; Wögerbauer *et al.*, 2014 WD, with this fish tagged on the east coast by a commercial fisherman in 2011. Only occasional specimens (estimated at <3 per year) caught by anglers in Tralee Bay. Effort data were, however, not available. Since 2004 there have been no recaptures of tagged angel shark.

22.6 Fishery-independent data

22.6.1 Availability of survey data

Angel sharks are encountered very rarely in trawl surveys, which may reflect the low abundance of the species, poor spatial overlap between surveys and refuge populations and their preferred habitats, and low catchability in some survey gears.

Occasional individuals have been captured in the UK beam trawl survey in Cardigan Bay, but the gear used (4 m beam trawl with chain mat) is not thought to be suitable for catching larger angel sharks.

22.6.2 Temporal trends in relative abundance

Existing surveys are not considered appropriate for monitoring the status of this species. Dedicated, non-destructive inshore surveys in areas of known or suspected presence could usefully be initiated.

22.7 Life-history information

There have been limited biological investigations of angel shark in European seas, including from the Northeast Atlantic and Mediterranean Sea.

22.7.1 Habitat

Angel shark is a coastal species that has often been reported from sand bank habitats and other such topographic features. This ambush predator buries into the sand for camouflage. In terms of recent information on their habitats, a potential overwintering area may occur off Pembrokeshire (51°30' to 52°00'N and 5°03' to 6°03'W; Figure 22.2), small specimens have been reported in Cardigan Bay (summer) and the western coast of Ireland (particularly Tralee Bay) may be important "summer areas" for the species (Wögerbauer *et al.*, 2014 WD).

22.7.2 Spawning, parturition and nursery grounds

No specific information. Angel sharks giving birth have been reported from parts of the North Sea (e.g. Patterson, 1905) and small specimens have been found in the inshore waters or Cardigan Bay. Information from other angel shark species elsewhere in the world suggests that there may be an inshore migration in early sum, with parturition occurring during the summer.

22.7.3 Age and growth

No information available.

22.7.4 Reproductive biology

Angel sharks give birth to live young. Patterson (1905) reported that female (ca. 124 cm long) gave birth to 22 young. Capapé *et al.* (1990) reported a fecundity of 8–18 (ovarian) and 7–18 (uterine) for specimens from the Mediterranean. Embryonic development takes one year, but the reproductive cycle may be two years.

22.7.5 Movements and migrations

Tagging studies indicated high site fidelity (Capapé *et al.*, 1990; Quigley, 2006; ICES, 2013). More than half of tagged angel sharks moved less than 10 km from their original location, but individuals are capable of travelling longer distances within a relatively short window (Wögerbauer *et al.*, 2014 WD). Occasional longer distance movements have also been reported, with fish tagged off Ireland recaptured off the south coast of England and Bay of Biscay (Quigley, 2006).

Seasonal migrations are suspected, with fish moving to deeper waters in the winter before returning to inshore waters for the summer. Other species of angel shark have also been shown to move into coastal waters in the summer, typically to give birth (Vögler *et al.*, 2008).

The uncommon landing of about ten large individuals observed in 2000 from a French trawler fishing off southern Ireland, provide further evidence for localised aggregation of the species (Iglésias, pers. comm.).

22.7.6 Diet and role in ecosystem

Angel shark is an ambush predator that predates on a variety of fish (especially flatfish) and various invertebrates (Ellis *et al.*, 1996).

22.8 Exploratory assessment models

An exploratory stock assessment of the Tralee Bay (ICES Division VIIj) population was presented in Bal *et al.* (2014 WD). This used the data from the IFI Marine Sportfish Tagging Programme (see Section 22.5.1). The aim of this study was to get first estimates of the size of the population of angel shark in Tralee Bay using estimates of capture efficiency so as to raise catch numbers (new catch plus recaptures) accordingly. To reach this it was necessary to i) give the data a discrete structure and ii) to limit dataset to one fishing method only.

22.8.1 Data used

The capture–mark–recapture database used was based on 1007 Angel sharks caught and released year round by recreational fisheries over the period 1970–2011. There were 188 individual recapture records, and some fish were recaptured several times.

Captures and recaptures that occurred in June, July and August were therefore considered. This period roughly agrees with their seasonal occurrence and is long enough to ensure having data to complete the analyses. As capture data used were from recreational anglers only, recapture data were filtered using this method only.

The final dataset used was limited to 728 captures and 42 corresponding angling recaptures (Figure 22.3).

22.8.2 Methodology

To estimate population size, a Cormack-Jolly-Seber (CJS) model was applied to the capture–recapture data, which allowed the authors to disentangle probability of capture from survival probability. The state–space model and data structures used are summarized in Figure 22.4. State–space models are hierarchical models that decompose an observed time-series of observed response into a process (here, survival rate) and an observation error component (here, capture probability) (Kéry and Schaub, 2012).

According to the model, the latent variable $z_{i,y}$ which takes the value 1 if an individual *i* is alive and value 0 if an individual is dead year *y*.

Conditionally on being alive at occasion *y*, individual *i* may survive until occasion *y+1* with probability $\Phi_{i,y}(y = 1, ..., Y)$. The following equation defines the state process:

$$z_{i,y+1} \mid z_{i,y} \sim \text{Bernouilli}(z_{i,y} * \Phi_{i,y}) \quad (1)$$

The Bernoulli success is composed of the product of the survival and the state variable *z*.

Furthermore if individual *i* is alive at occasion *y*, it may be recapture with probability $p_{i,y}(y = 2, ..., Y)$. This is modelled as a Bernoulli trial with success probability $p_{i,y}$:

$$y_{i,y} \mid z_{i,y} \sim \text{Bernouilli}(z_{i,y} * p_{i,y}) \quad (2)$$

In both cases the inclusion of the latent variable *z* insures that an individual dead cannot be modelled again afterwards.

From this basic framework explained above, the following was modelled:

> survival vary per year using a fully hierarchical structure on mean(μ) and standard deviation (sd) thanks to the logit link function. This structure, more flexible than modelling yearly survival as a random effect, also allow borrowing and exchanging information between data-poor and data-rich years thanks to hyper-parameters. Principles are described in Figure 22.4 and equation (2) is changed for the following equation:

$$z_{i,y+1} \mid z_{i,y} \sim \text{Bernouilli}(z_{i,y} * \Phi_y)$$
$$\text{logit}(\Phi_y) \sim \text{Normal}(\mu, sd) \quad (3)$$

The capture probability of individuals as a fixed, equation (1) thus change into the following equation:

$$y_{i,y} \mid z_{i,y} \sim \text{Bernouilli}(z_{i,y} * p) \quad (4)$$

Yearly population sizes were then derived in the Bayesian approach using parameter *p* and the total number of sharks captured at the corresponding year.

22.8.3 Computation details

Bayesian fitting, forecasting and the derivations were implemented using Markov Chain Monte Carlo algorithms in JAGS (Just Another Gibbs Sampler, Plummer, 2003; http://mcmc-jags.sourceforge.net) through the R software (R Development Core Team, 2013). Two parallel MCMC chains were run and 20 000 iterations from each were retained after an initial burn-in of 20 000 iterations. Convergence of chains was assessed using the Brooks-Gelman-Rubin diagnostic (Brooks and Gelman, 1998).

22.8.4 Results

Results were composed of the following figures showing posterior density function of capture rate (Figure 22.6), yearly survival (Figure 22.7) and population size estimates (Figure 22.8).

The current population of angel shark in Tralee Bay is at very low numbers (Figure 22.8), but the actual population size remains uncertain.

22.8.5 Quality of the assessment

WGEF considers that further work needs to be done and more details need to be provided for a fuller understanding of model options, particularly in what concerns as to how the state–space model estimates the number of elements of the population in each year and on how individuals that initiate or remain in the process are followed. Estimates can be impeded by the fact that no sharks in the subset of data analysed were observed as dead.

Although size and/or weight of sharks were originally available, they were not considered in the study because they appeared unreliable. Priors used to model survival need to be refined to get better posteriors. Expert opinion could be valuable.

The model was unsuccessful in making capture probability varying by year. Covariates could be included for both capture and survival probabilities modelling. It would help developing model with annual variations in both survival and capture probabilities.

Sensitivity analyses are recommended to perceive the influence of prior distributions on the posterior distributions given the data available. It is also recommended that the observational process should be restricted to the time-series for which data were available.

22.9 Stock assessment

No formal stock assessment has been undertaken.

Historically, coastal trawl surveys around the British Isles often reported angel shark, especially in the western English Channel (Garstang, 1903; Rogers and Ellis, 2000) and Bay of Biscay (Quéro and Cendrero, 1996).

WGEF considers that the comparisons of historical data with the near-absence in recent data (landings, surveys, observer programmes, angling data) is sufficient to consider the species to be severely depleted in the Celtic Seas ecoregion and possibly extirpated from the North Sea ecoregion. Whilst its status in the Bay of Biscay and Iberian coastal waters is unknown, it is considered very rare, with only occasional individuals reported.

22.10 Quality of the assessment

No formal stock assessment has been undertaken.

22.11 Reference points

No reference points have been proposed for this stock.

22.12 Conservation considerations

Angel shark is listed as Critically Endangered on the IUCN Red List (Gibson *et al.*, 2008). It is listed on the OSPAR List of Threatened and Declining Species (OSPAR Commission, 2010). It is protected on the UK's Wildlife and Countryside Act.

22.13 Management considerations

Angel shark catches have declined dramatically in the northern parts of the ICES area and Mediterranean Sea, as evidenced from landings data, survey information and the decline in the numbers tagged in Irish waters. The status and magnitude of any decline in the southern parts of the ICES area and northwest Africa remain uncertain.

Since ICES advised that this species should receive the highest protection possible, it has been listed as a prohibited species on EC fishery regulations.

Dedicated, non-destructive surveys of areas of former local abundance would be needed to inform on current habitat and range, and to assess the possibilities of spatial management.

Given the perceived low productivity of this species, any population recovery would take a decadal time frame.

Improved communication with the fishing industry to ensure that any specimens captured are released is also required.

22.14 References

Bal, G., White, J., Johnston, G., Roche, W., O'Reilly, S., Green, P. and Fitzmaurice, P. 2014. Estimates of yearly population size of Angel Sharks from Tralee Bay. Working Document to the ICES Working Group on Elasmobranch Fishes. 8 pp.

Braccini, M., Van Rijn, J., and Frick, L. 2012. High post-capture survival for sharks, rays and chimaeras discarded in the main shark fishery of Australia? *PloS One*, 7(2), e32547, 1–9.

Brooks, S. P. and Gelaman A. 1998. General methods for monitoring convergence of iterative simulations. *Journal of Computational and Graphical Statistics*, 7: 434–455.

Capapé, C., Quignard, J. P., and Mellinger, J. 1990. Reproduction and development of two angel sharks, *Squatina squatina* and *S. oculata* (Pisces: Squatinidae), off Tunisian coasts: semi-delayed vitellogenesis, lack of egg capsules, and lecithotrophy. *Journal of Fish Biology*, 37: 347–356.

Ellis, J. R., Pawson, M. G., and Shackley, S. E. 1996. The comparative feeding ecology of six species of shark and four species of ray (Elasmobranchii) in the north-east Atlantic. *Journal of the Marine Biological Association of the United Kingdom*, 76: 89–106.

Fennessy, S. T. 1994. Incidental capture of elasmobranchs by commercial prawn trawlers on the Tugela Bank, Natal, South Africa. *South African Journal of Marine Science*, 14: 287–296.

Garstang, W. 1903. Report on trawling and other investigations carried out in the bays on the south-east coast of Devon during 1901 and 1902. *Journal of the Marine Biological Association of the United Kingdom*, 6: 435–527.

Gibson, C., Valenti, S.V., Fordham, S.V. and Fowler, S.L. 2008. The Conservation of Northeast Atlantic Chondrichthyans. Report of the IUCN Shark Specialist Group Northeast Atlantic Red List Workshop. viii + 76 pp.

ICES. 2010. Report of the Working Group on Elasmobranch Fishes (WGEF). 22–29 June 2010, Horta Portugal. ICES CM 2010/ACOM 19, 560 pp.

ICES. 2013. Report of the Working Group on Elasmobranch Fishes (WGEF), 17–21 June 2013, Lisbon, Portugal. ICES CM 2013/ACOM:19, 649 pp.

Kéry, M. and Schaub, M. 2012. Bayesian population analysis using winbugs: a hierarchical perspective. Elsevier Academic Press.

OSPAR Commission. 2010. Background Document for Angel shark *Squatina squatina*. OSPAR Biodiversity Series, Publication Number 471/2010, 20 pp.

Patterson, A. H. 1905. Nature in eastern Norfolk. Methuen & Co., London.

Plummer, M. 2003. JAGS: A program for analysis of Bayesian graphical models using Gibbs sampling. Proceedings of the 3rd International Workshop on Distributed Statistical Computing (DSC 2003). March 2003; 20–22.

Quéro, J. C., and Cendrero, O. 1996. Incidence de la pêche sur la biodiversité ichtyologique marine: le bassin d'Arcachon et le plateau continental sud Gascogne. *Cybium*, 20: 323–356.

Quigley, D. T. 2006. Angelshark (*Squatina squatina*) in Irish Waters. *Sherkin Comment*, 41: 5.

Roche, W. and O'Reilly, S. 2013. Note on recent Angel shark (*Squatina squatina*) angling and tagging activity in Ireland- 1970–2011. Working Document presented to the Working Group on Elasmobranch Fishes, 2 pp.

Rogers, S. I., and Ellis, J. R. 2000. Changes in the demersal fish assemblages of British coastal waters during the 20th century. *ICES Journal of Marine Science*, 57: 866–881.

Silva, J. F., Ellis, J. R., Catchpole, T. L. and Righton, D. 2013. Bycatch and discarding patterns of dogfish and sharks taken in commercial fisheries around the British Isles. Working Document presented to the Working Group on Elasmobranch Fishes, 31 pp.

STECF. 2003. Report of the Subgroup on Resource Status (SGRST) of the Scientific, Technical and Economic Committee for Fisheries (STECF): Elasmobranch Fisheries. Brussels, 22–25 July 2003. Commission Staff Working Paper SEC (2003) 1427; 207 pp.

Vögler, R., Milessi, A. C., and Quiñones, R. A. 2008. Influence of environmental variables on the distribution of *Squatina guggenheim* (Chondrichthyes, Squatinidae) in the Argentine–Uruguayan Common Fishing Zone. *Fisheries Research*, 91: 212–221.

Wögerbauer C., O'Reilly S., Green P. and Roche W. 2014. IFI Marine Sportfish Tagging Programme: Preliminary results for selected species, Inland Fisheries Ireland. Report No: IFI/2014/1-4231; 38 pp.

Table 22.1. Angel shark in the Northeast Atlantic. Reported landings (tonnes) for the period 1978–2013. French landings from ICES and Bulletin de Statistiques des Peches Maritimes. UK data from ICES and DEFRA. Belgian data from ICES. UK landings for 1997 considered to be misreported fish.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Belgium	.	.	.	.	.	.	.	.	.	.
France	8	3	32	26	29	24	19	18.7	19.5	18
UK (E,W &N.I.)	.	.	.	.	.	.	.	.	.	.
Total	8	3	32	26	29	24	19	18.7	19.5	18

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Belgium	.	.	.	.	.	.	.	.	.	.
France	13	9	13	14	12	11	2	2	1	1
UK (E,W &N.I.)	.	.	.	.	.	.	2	1	1	.
Total	13	9	13	14	12	11	4	3	2	1

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Belgium	.	.	.	.	.	.	.	.	.	.
France	1	1	2	1	2	+	1	+	+	+
UK (E,W &N.I.)	.	.	.	.	(47)	.	.	.	.	.
Total	1	1	2	1	2	0	1	0	0	0

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	.	.	.	.	.	.	.	.	.	.	.
France	+	+	2	+	1	+	1	2	.	.	+
UK (E,W &N.I.)	.	.	.	+	+	.		+	+	.	.
Total	0	0	2	0	1	0	1	2	0	0	0

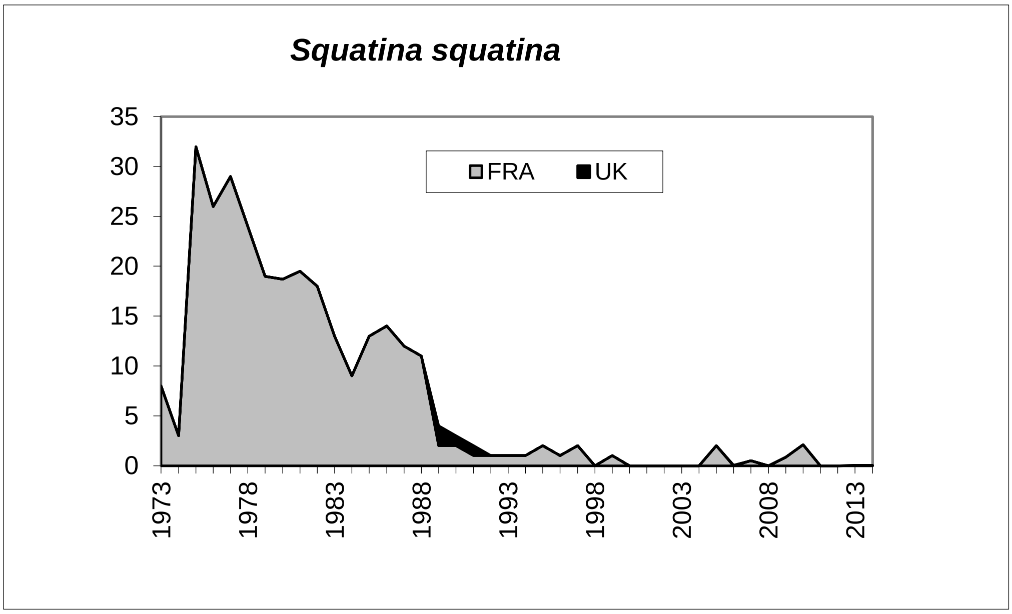


Figure 22.1. Angel shark in the Northeast Atlantic. Total landings of *Squatina squatina* (1973–2012). Angel shark is now on a prohibited species list and only nominal landings are reported.

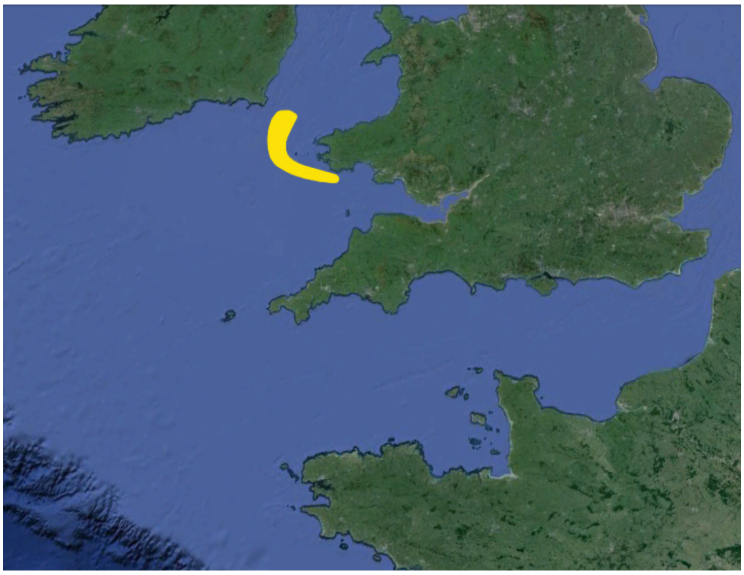


Figure 22.2. Angel shark in the Northeast Atlantic. The suspected over-wintering area off Pembrokeshire, where occasional individuals have been reported by French vessels.

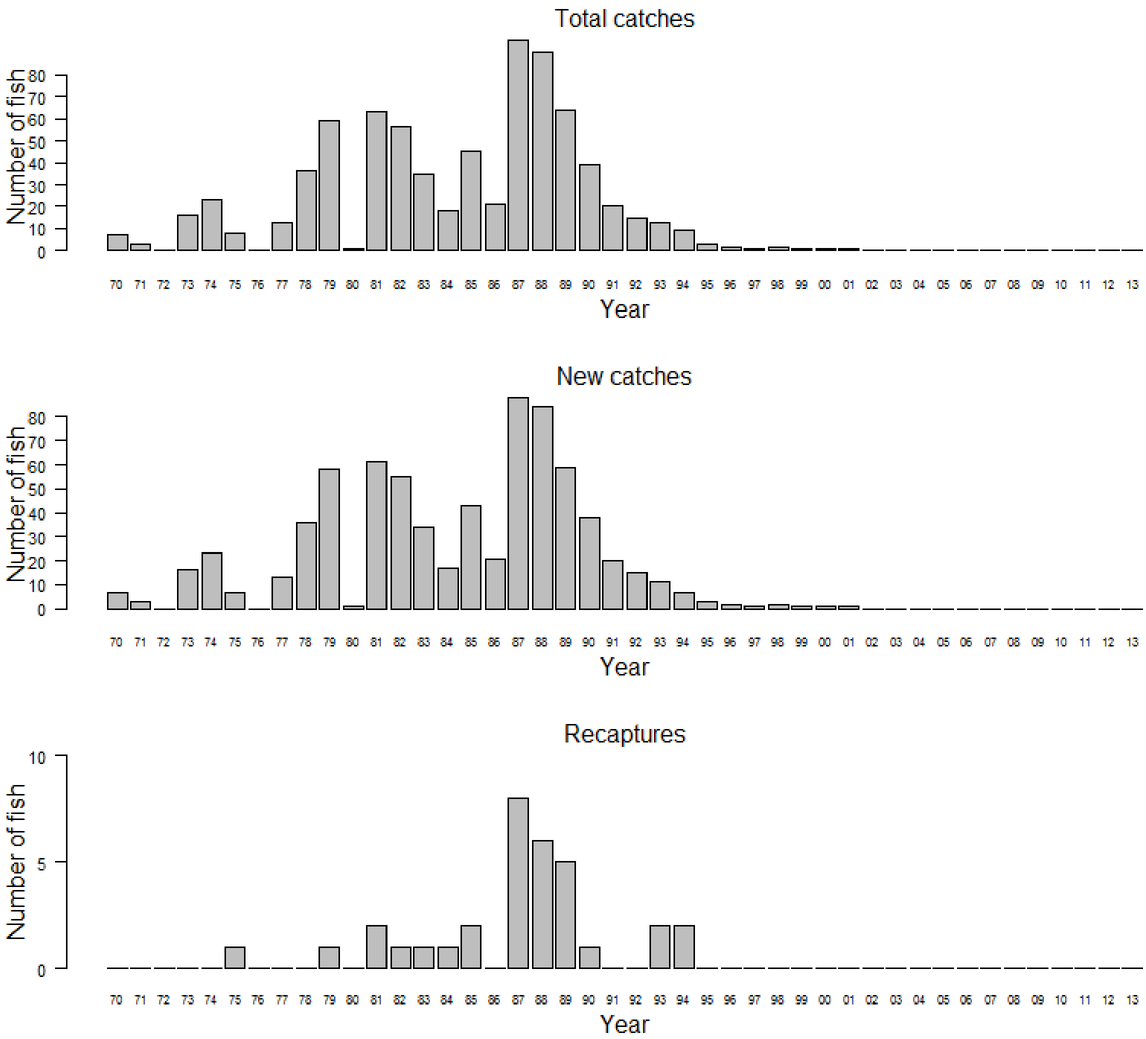


Figure 22.3. Angel Shark in the Northeast Atlantic. Number of sharks captured, recaptured and newly captured per year, Tralee Bay; Source Bal *et al.*, 2014 WD.

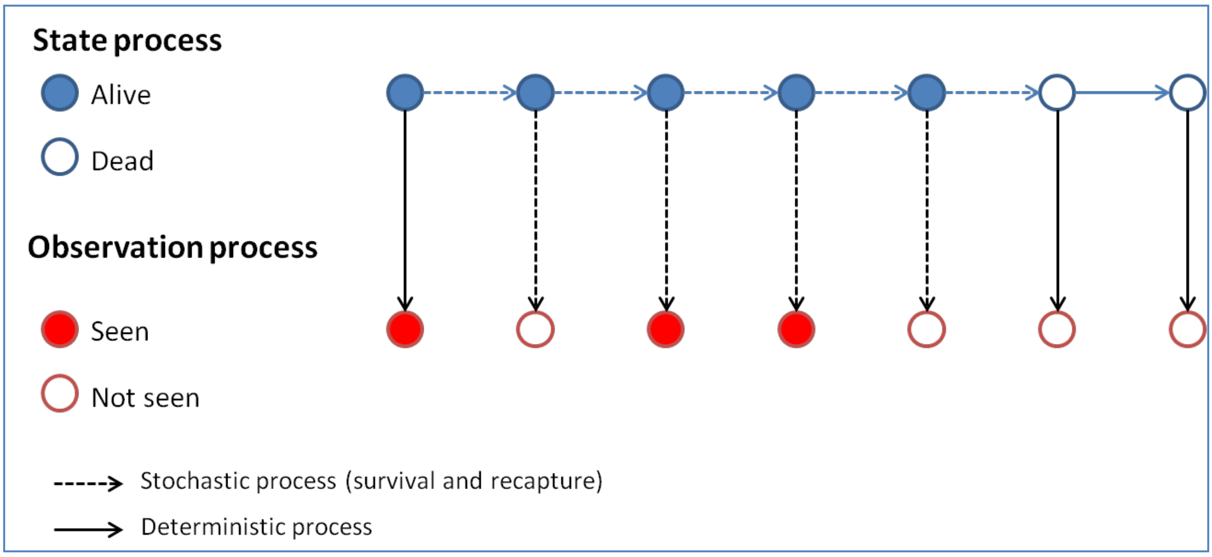


Figure 12.4. Angel shark in the Northeast Atlantic. Example of the state and observation process of a marked individual over time for the CJS model. The sequence of true states in this individual is z = [1, 1, 1, 1, 1, 0, 0] and the observed capture history is y = [1, 0, 1, 1, 0, 0, 0]. Souce: Bal *et al.*, 2014 WD.

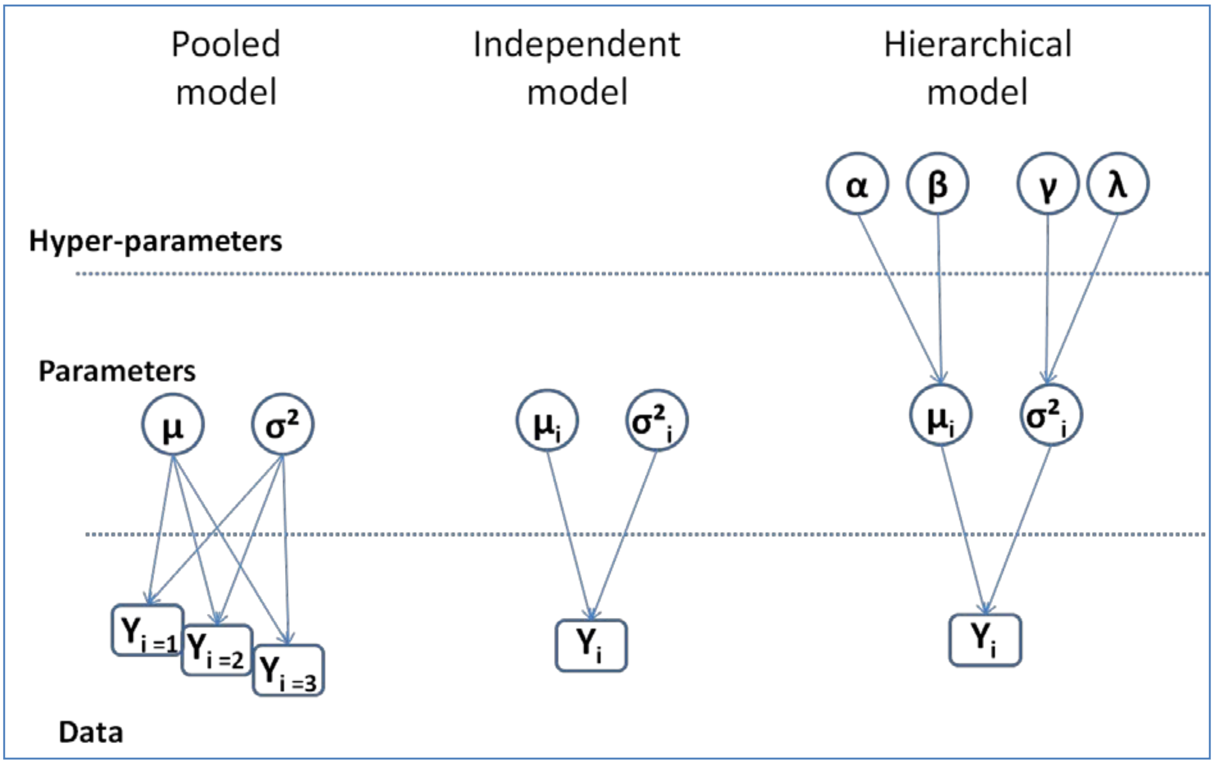


Figure 22.5. Angel shark in the Northeast Atlantic. Pooled, independent and hierarchical models. Souce: Bal *et al.*, 2014 WD.

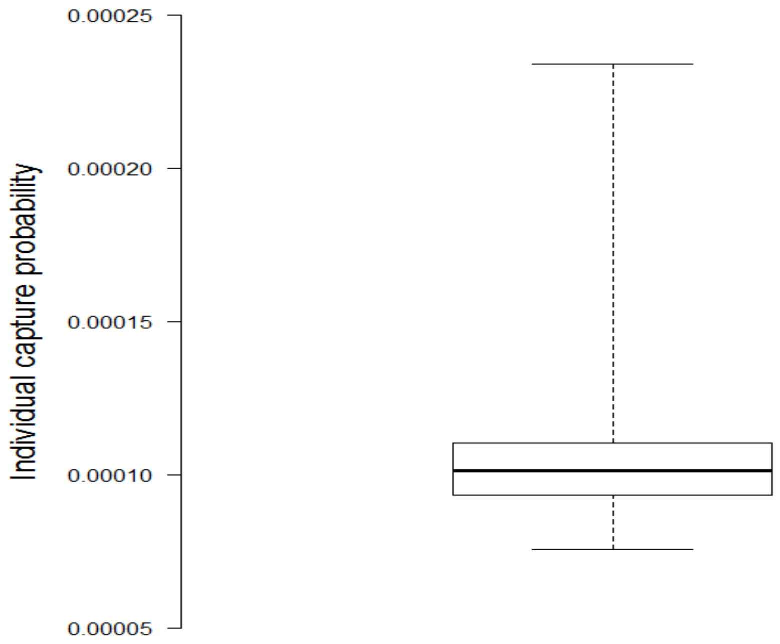


Figure 22.6. Angel shark in the Northeast Atlantic. Boxplot of the individual capture probability posterior. Source: Bal *et al.*, 2014 WD.

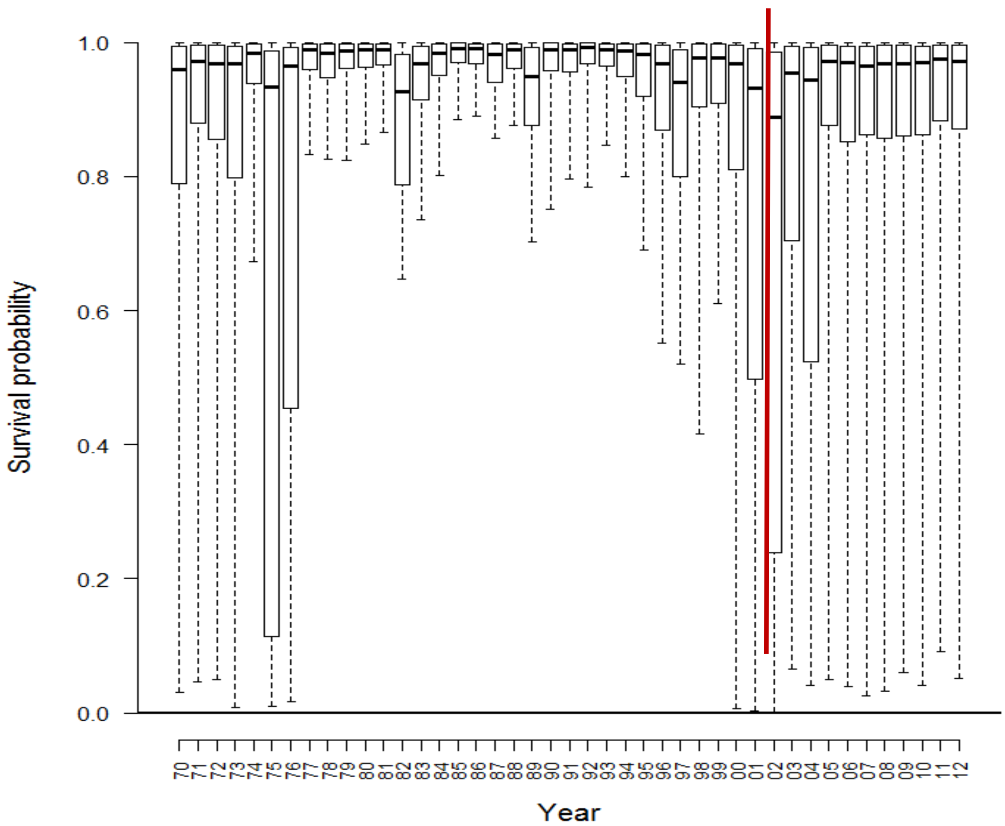


Figure 22.7. Angel shark in the Northeast Atlantic. Boxplot of annual survival probabilities posteriors. The model estimated catch rather than using observations after the red line. Source: Bal *et al.*, 2014 WD.

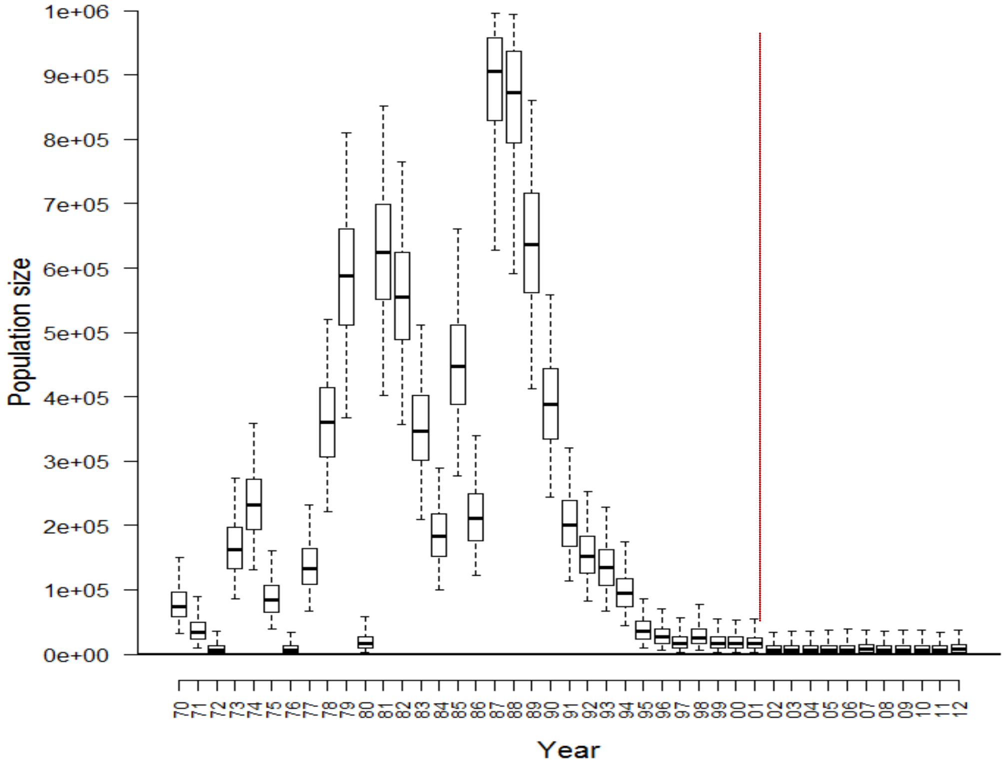


Figure 22.8. Angel shark in the Northeast Atlantic. Boxplot annual population sizes posteriors. The model estimated catch rather than using observations after the red line. Source: Bal *et al.*, 2014 WD.

23 White skate *Rostroraja alba* in the Northeast Atlantic

23.1 Stock distribution

White skate *Rostroraja alba* is distributed from the British Isles southwards to southern Africa, including the Mediterranean Sea. As such, the species distribution covers parts of ICES Subareas VII–IX, and may have extended into the southern parts of Subareas IV and VI. The stock structure across this area is unknown. Given that this species is perceived as highly threatened throughout the ICES area (and elsewhere in European waters), ICES advice is given at the species level.

23.2 The fishery

23.2.1 History of the fishery

White skate is thought to have been the subject of targeted exploitation for much of the 19th century and early parts of the 20th century, with targeted fisheries in the English Channel, Brittany and possibly the Isle of Man (Irish Sea). It was viewed as a highly marketable skate due to its large size and thickness of the wings (see Ellis *et al.*, 2010).

In 1964, 58.94 t of white skate were landed in the port of Douarnenez (Brittany), when this species was targeted by a longline fishery (Du Buit, pers. comm.). When this population collapsed over the next few years, so too did the fishery. The use of the landing name 'Raie blanche' (white skate) is now discontinued in French fish markets and it is now only known by the oldest fishermen and fish-market workers. Up to 2009, only occasional individuals were landed in France, often under the name '*Dipturus batis*'. It was estimated that only 13 ± 10 individuals (117 ± 89 kg) were landed in 2005 in France under the names '*D. batis*'. During a 2006–2007 survey of large skates (*Dipturus* and *Rostroraja*) in French ports, during which 4110 skates were sampled, only one specimen of white skate was identified (Iglésias *et al.*, 2010).

23.2.2 The fishery in 2013

White skate may be a very occasional bycatch in some trawl and gillnet fisheries, although as a prohibited species the caught individuals should be released. There have been records of individual fish in the English Channel and Iberian waters. As the species is largely unknown by fishermen and it does not have highly conspicuous morphological characters for its identification, individuals might occasionally be mixed with other skates.

23.2.3 ICES Advice applicable

In 2008, ICES advised that white skate in the Celtic Seas ecoregion was "*extirpated from most parts of the Celtic Seas ecoregion. It should receive the highest possible protection. Any incidental bycatch should not be landed, but returned, to the sea, as they are likely to have a high survival rate*". In both 2010 and 2012, ICES advised that it should remain on the list of Prohibited Species.

23.2.4 Management applicable

Council Regulation (EC) 43/2009 stated that white skate in EC waters of VI, VII, VIII, IX and X "*may not be retained on board. Catches of these species shall be promptly released unharmed to the extent practicable*". It has subsequently been included on the list of

Prohibited Species and it is prohibited for EU vessels to fish for, to retain on board, to tranship and to land white skate in Union waters of Subareas VI–X (Council Regulations (EC) 23/2010, 57/2011, 43/2012, 39/2013 and 43/2014).

White skate is also protected in UK waters as it is listed on the Wildlife and Countryside Act.

23.3 Catch data

23.3.1 Landings

Nominal landings of white skate are contained within the relevant ecosystem chapters. White skate became increasingly rare in landings prior to the requirements for species-specific recording, and so there is great uncertainty on the historical levels of exploitation. Some of the reported landings of white skate are thought to refer to either other large-bodied skates (*Dipturus* spp.) or shagreen ray *Leucoraja fullonica*, as all these species have a pointed snout.

23.3.2 Discards

Limited data are available. Analyses of the discard observer programme for the English and Welsh fleets did not note any white skate (Silva *et al.*, 2012). There is uncertainty in the reliability of some nominal records of white skate recorded in other national observer programmes.

23.3.3 Quality of catch data

Both landings and discards data for white skate are very limited and may be confounded with other species.

Given the low abundance of this species and its high conservation interest, WGEF recommend that (i) any data on white skate collected from national observer programmes be verified whenever possible (e.g. photographed) and (ii) that ongoing DCF observer programmes collect information on health state (e.g. lively, sluggish, dead) of discards of this species.

23.3.4 Discard survival

No data on the discard survival of white skate. Discard survival of skates has been examined for a range of other skate species, with survival potentially high (Ellis *et al.*, 2014 WD).

23.4 Commercial catch composition

No data available.

23.5 Commercial catch-effort data

No data available for commercial fleets.

23.6 Fishery-independent information

White skate is very rarely encountered in trawl surveys, which may reflect the low abundance of the species and/or poor spatial overlap between surveys and refuge populations and/or their favoured habitats. Although not taken in English trawl surveys (Ellis *et al.*, 2005), occasional individuals have been captured in the Irish

Groundfish survey along the west coast of Ireland, up to at least 2011. Existing surveys are not considered appropriate for monitoring the status of this species at the present time.

23.7 Life-history information

Although taken periodically along the west coast of Ireland (Quigley, 1984), the biology of this species in northern European seas is largely unknown. It has been better studied in the Mediterranean Sea (Capapé, 1976; 1977). More recently, Kadri *et al.* (2014) examined specimens from the Mediterranean Sea, where the smallest mature fish were 110 cm (male) and 120 cm (female). The youngest mature female in this study was reported as 17 years old and the oldest fish was thought to be 35 years old.

The species was known by fishermen to live preferentially on hard bottoms and so it may be caught more frequently by nets and longline fisheries (Iglésias, pers. comm).

23.8 Exploratory assessment models

No quantitative assessments have been undertaken. The perceived stock status is based primarily on comparisons between recent and historical data on catches in trawl surveys. Historically, coastal trawl surveys around the British Isles reported white skate (Rogers and Ellis, 2000), and such longer term declines were also reported for the Bay of Biscay (Quéro and Cendrero, 1996).

WGEF consider that the comparison of historical data with the near-absence in recent data sources (landings, surveys, observer programmes) is sufficient to consider the species to be severely depleted and near-extirpated from various parts of the Celtic Seas ecoregion.

23.9 Stock assessment

No formal stock assessment has been undertaken.

23.10 Quality of the assessment

No formal stock assessment has been undertaken.

23.11 Reference points

No reference points have been proposed for this stock.

23.12 Conservation considerations

White skate is listed as Critically Endangered on the IUCN Red List (Gibson *et al.*, 2008). It is listed on the OSPAR List of Threatened and Declining Species (OSPAR Commission 2010). It is protected on the UK's Wildlife and Countryside Act.

23.13 Management considerations

Since ICES advised that this species should receive the highest protection possible, it has been listed as a prohibited species on EC fishery regulations.

Dedicated, non-destructive surveys of areas of former abundance would be needed to inform on current habitat and range.

Given the perceived low productivity of this species, any population recovery would take a decadal time frame.

As this species could be overlooked in catches of mixed skates, improved identification material could usefully be developed.

23.14 References

Capapé, C. 1976. Contribution à la biologie des Rajidæ des côtes tunisiennes. *Raja alba* Lacépède, 1801: Répartition géographique et bathymétrique, sexualité, reproduction, fécondité. *Annales de l'Institut Michel Pacha*, 9: 23–47.

Capapé, C. 1977. Contribution a la biologie des Rajidae des cotes tunisiennes. 8. *Raja alba* Lacepede, 1803: Regime alimentaire. *Archives de l'Institut Pasteur de Tunis*, 54.

Ellis, J. R., Cruz-Martinez, A., Rackham, B. D. and Rogers, S. I. 2005. The distribution of chondrichthyan fishes around the British Isles and implications for conservation. *Journal of Northwest Atlantic Fishery Science*, 35: 195–213.

Ellis, J. R., McCully, S. R. and Poisson, F. 2014. A global review of elasmobranch discard survival studies and implications in relation to the EU 'discard ban'. Working Document to ICES Working Group on Elasmobranch Fishes.

Ellis, J. R., Silva, J. F., McCully, S. R., Evans, M. and Catchpole, T. 2010. UK fisheries for skates (Rajidae): History and development of the fishery, recent management actions and survivorship of discards. ICES CM 2010/E:10, 38 pp.

Gibson, C., Valenti, S. V., Fordham, S. and Fowler, S. L. 2008. The Conservation of Northeast Atlantic Chondrichthyans. Report of the IUCN Shark Specialist Group Northeast Atlantic Red List Workshop. viii + 76pp.

Iglésias, S. P., Toulhoat, L. and Sellos, D. Y. 2010. Taxonomic confusion and market mislabelling of threatened skates: Important consequences for their conservation status. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 20: 319–333.

Kadri, H., Marouani, S., Bradai, M. N., Bouaïn, A. and Morize, E. 2014. Age, growth, mortality, longevity and reproductive biology of the white skate, *Rostroraja alba* (Chondrichthyes: Rajidae) of the Gulf of Gabès (Southern Tunisia, Central Mediterranean). *Turkish Journal of Fisheries and Aquatic Sciences*, 14: 193–204.

OSPAR Commission. 2010. Background document for white skate *Rostroraja alba*. OSPAR Biodiversity Series, Publication Number 476/2010, 17 pp.

Quéro, J.C. and Cendrero, O. 1996. Incidence de la pêche sur la biodiversité ichtyologique marine: le bassin d'Arcachon et le plateau continental sud Gascogne. *Cybium*, 20: 323–356.

Quigley, D. T. G. 1984. White Skate, *Raja alba* Lacépède, 1803 (*R. marginata*, Lacép.) in Irish waters: A further record and review of Irish records. *Irish Naturalists' Journal*, 21: 217–220.

Rogers, S. I. and Ellis, J. R. 2000. Changes in the demersal fish assemblages of British coastal waters during the 20th century. *ICES Journal of Marine Science*, 57: 866–881.

Silva, J. F., Ellis, J. R. and Catchpole, T. L. 2012. Species composition of skates (Rajidae) in commercial fisheries around the British Isles, and their discarding patterns. *Journal of Fish Biology*, 80: 1678–1703.

24 Greenland shark *Somniosus microcephalus* in the Northeast Atlantic

24.1 Stock distribution

The known distribution range of Greenland shark *Somniosus microcephalus*, which has been defined primarily by observations of specimens caught in cold-water commercial fisheries, extends from the temperate North Atlantic to the Arctic Ocean (MacNeil *et al.*, 2012). It ranges from Georgia (USA) to Greenland, Iceland, Spitzbergen and the Arctic coasts of Russia and Norway to the North Sea and Ireland, with occasional individuals recorded further south (Ebert and Stehmann, 2013). Due to their known tolerance for extreme cold water and their ability to inhabit abyssal depths, Greenland shark may be more widespread, but the known distribution is also compromised by taxonomic problems in this genus (MacNeil *et al.*, 2012). The stock unit(s) are unknown.

24.2 The fishery

24.2.1 History of the fishery

Fishing for Greenland shark has been a part of Scandinavian, Icelandic and Inuit cultures for centuries, and earliest catch records date back to the 13th and 14th century in Norway and Iceland, respectively. In the early and mid-20th century, Greenland sharks were caught in large quantities as a source for liver oil. In that time, peak annual catches e.g. in Norway summed up to 58 000 individuals (Ebert and Stehmann, 2013; MacNeil *et al.*, 2012). After the invention of synthetic oil in the late 1940s demand for shark oil diminished and no large-scale catches of Greenland sharks have been reported since (Nielsen *et al.*, 2014). Greenland shark is still targeted in small scale directed artisanal fisheries in Iceland and Greenland. Artisanal fisheries mostly target Greenland shark with hook and line, longline gear or gaffs, but it is also often taken in seal nets and cod traps (Ebert and Stehmann, 2013). Although the meat of Greenland shark can be toxic when fresh (e.g. Anthoni *et al.*, 1991; McAllister, 1968), it is eaten in some countries after curing.

24.2.2 The fishery in 2013

National landings data are available from Iceland, where 6 t were landed in 2013. No data from other countries were declared, although Greenland shark can be expected to be a regular bycatch in longline, trawl and gillnet fisheries (see below).

24.2.3 ICES Advice applicable

No species-specific advice is given for Greenland shark.

24.2.4 Management applicable

Greenland shark is listed as a deep-water shark on EC regulations. As such, it is included under the zero TACs that have been in place for such fish (see Section 5).

24.3 Catch data

24.3.1 Landings

Limited data are available on landings. Most comprehensive landings data are available from Iceland (www.hagstova.is and Marine Research Institute databases). Reported annual landings from Iceland in ICES areas Va and XIV since 1993 fluctuate around 37 tons and range between 2 (2007) and 66 (2004) tons (see Table 24.1).

24.3.2 Discards

Limited information is available. Most Greenland shark bycatch is thought to be from trawl fisheries (e.g. for Greenland halibut *Reinhardtius hippoglossus* and shrimp *Pandalus borealis*), as well as with gillnets and longlines (MacNeil *et al.*, 2012; Nielsen *et al.*, 2014).

In the Barents Sea, bycatch of Greenland shark in bottom trawls were related to water temperature, with more bycatch in lower temperatures (Rusyaev and Orlov, 2013). Despite scarce information on bycatch of Greenland shark in the commercial trawl fishery, Rusyaev and Orlov (2013), based on present fishing activities and effort, suggested an annual catch of 140–150 t in the Barents Sea. In local fishing communities in Greenland, this shark accounts for 50% of the total waste produced by the fishing industry with estimated annual amounts of waste products of Greenland shark from fishing and hunting in specific counties summing up to roughly 1000 t (Gunnarsdóttir and Jørgensen, 2008).

24.3.3 Quality of catch data

As observers are not mandatory in the fisheries that may possibly have a bycatch of Greenland shark, levels of such bycatch are uncertain. In some areas there may be confusion with other members of the genus or even basking shark (MacNeil *et al.*, 2012).

24.3.4 Discard survival

No estimates on discard survival available. According to on-board observers, some Greenland sharks caught in offshore trawl and longline fisheries are released alive (MacNeil *et al.*, 2012).

24.4 Commercial catch composition

No information available.

24.5 Commercial catch and effort data

No information available.

24.5.1 Recreational cpue data

There are recreational catch and release fisheries for Greenland sharks in Norway (year-round) and Greenland (in March) (MacNeil *et al.*, 2012). No data on cpue available.

24.6 Fishery-independent information

Greenland sharks are caught regularly during gillnet and bottom trawl surveys around Greenland, such as the Greenland Institute of National Resources Annual bottom trawl survey (Nielsen *et al.*, 2014). Catches are also reported from the annual German Greenland groundfish survey (59 individuals between 1981 and 2011). Trawl surveys conducted in the Barents Sea also encounter Greenland sharks. Occasional catches are also reported in various Icelandic surveys, but with a total of just 68 observations over the period 1936–2012.

Existing scientific surveys are not appropriate for monitoring the abundance of Greenland sharks in their distribution area.

24.7 Life-history information

24.7.1 Habitat

Greenland sharks show a marked preference for cold water with observation and catch temperatures ranging from -1.8°C to 10.0°C and a majority of records having been from water temperatures <5°C (Skomal and Benz, 2004; Stokesbury *et al.*, 2005; Fisk *et al.*, 2012; MacNeil *et al.*, 2012). It occurs on continental and insular shelves and upper slopes (Ebert and Stehmann, 2013). Confirmed observations cover a broad depth range from abyssal depths of at least 1560 m (Fisk *et al.*, 2012) to shallow water (Yano *et al.*, 2007; MacNeil *et al.*, 2012). Though primarily considered a demersal species, it may be caught both at the surface and in the pelagic zone (e.g. Stokesbury *et al.*, 2005; MacNeil *et al.*, 2012). They often associate with fjordal habitats (MacNeil *et al.*, 2012).

24.7.2 Spawning, parturition and nursery grounds

No detailed information is available. Based on observations on two specimens captured in a midwater trawl off Jan Mayen Island and classified as neonates, Kondyurin and Myagkov (1983) concluded that parturition may occur in the Norwegian Sea in July and August. The only captures of Greenland sharks with near-term embryos originated near fjords in the Faroe Islands and specimens of what is assumed neonatal size have been reported from Canadian, Norwegian and Greenland fjords (Bjerkan and Koefoed, 1957).

24.7.3 Age and growth

Greenland shark is the second largest shark in the ICES area and is the largest fish inhabiting Arctic Ocean waters (Ebert and Stehmann, 2013). Bigelow and Schroeder (1948) report a maximum total length of 640 cm and a total mass of 1023 kg with females generally larger than males. The growth rate of Greenland sharks is not known, but observations from tagging experiments indicated growth rates of 0.5–1 cm yr^{-1} (Hansen, 1963). Conventional ageing techniques (vertebral ageing methods) are not applicable to Greenland sharks (MacNeil *et al.*, 2012).

24.7.4 Reproductive biology

Greenland sharks are viviparous with yolk-sac (Carrier *et al.*, 2004; Ebert and Stehmann, 2013). The exact size at birth as well as the gestation period remain unknown, but based on different observations of Greenland sharks identified as neonates, size at birth is probably 40–100 cm (MacNeil *et al.*, 2012). Size-at-maturity is difficult to determine. The onset of maturity in male Greenland sharks probably occurs at ca.

260 cm but is highly variable, and males are suggested to approach maturity at ca. 300 cm (Yano *et al.*, 2007). More variability has been observed in females, with specimens from Iceland mature at 355–480 cm (MacNeil *et al.*, 2012). Based on a change in ovary mass, Yano *et al.* (2007) suggested that female Greenland sharks approach the onset of maturity at >400 cm. Fecundity is uncertain, but may be in the region of ten (Bjerkan and Koefoed, 1957; Ebert and Stehmann, 2013).

24.7.5 Movements and migrations

Studies have used conventional and electronic (satellite and acoustic) tagging to study horizontal and vertical movements and migrations. Fisk *et al.* (2012) deployed 20 archival pop-off tags on Greenland sharks in Svalbard, Norway. The sharks displayed a broad vertical distribution (from 6 to more than 1500 m) but no obvious diel movements were noted. Average daily distances travelled also varied and most tags popped off less than 500 km from tagging sites. Two sharks travelled 725 and 980 km, respectively. Previous studies have also examined the behaviour of Greenland shark in the Northwest Atlantic (Skomal and Benz, 2004; Stokesbury *et al.*, 2005). All such studies have found examples of localized movements and site fidelity, as well as some larger scale movements.

24.7.6 Diet and role in ecosystem

Greenland shark feed on a wide variety of invertebrates, fishes and marine mammals, indicating they are generalist feeders on both benthic and pelagic organisms (MacNeil *et al.*, 2012; Nielsen *et al.*, 2014). As well as serving as important scavengers, including of whales (Leclerc *et al.*, 2011), they also predate on live organisms (including marine mammals) and are regarded as important predators in Arctic foodwebs (Leclerc *et al.*, 2012).

24.8 Exploratory assessment models

No exploratory stock assessments have been undertaken.

24.9 Stock assessment

No stock assessment has been undertaken.

24.10 Quality of the assessment

No stock assessment has been undertaken.

24.11 Reference points

No reference points have been proposed for this stock.

24.12 Conservation considerations

On the basis of possible population declines and limiting life-history characteristics, Greenland shark is listed as Near Threatened in the IUCN Red List (Kyne *et al.*, 2006). It is listed vulnerable in the Swedish Red List of endangered species (Svensson *et al.*, 2010).

24.13 Management considerations

The stock status and many aspects of the biology are unknown. Given the large body size of this species and perceived low population productivity, further studies to better understand population dynamics and sources of mortality are required.

24.14 References

Anthoni, U., Christophersen, C., Gram, L., Nielsen, N.H. and Nielsen, P. 1991. Poisonings from flesh of the Greenland shark *Somniosus microcephalus* may be due to trimethylamine. *Toxicon*, 29: 1205–1212.

Bigelow, H.B. and Schroeder, W.C. 1948. Sharks. In Tee-Van, J., Breder, C.M., Hildebrand, S.F., Parr, A.E. and Schroeder, W.C. (eds.) Fishes of the Western North Atlantic, Part 1. Yale, CT: Yale University, Sears Foundation for Marine Research: 59–546.

Bjerkan, P. and Koefoed, E. 1957. Notes on the Greenland Shark *Acanthorhinus carcharias* (Gunn). Report on Norwegian Fishery and Marine Investigations, 11: 1–12.

Carrier, J.C., Pratt, H.L. Jr. and Castro, J.I. 2004. Reproductive biology of elasmobranchs. In Carrier J.C., Musick, J.A. and Heithaus, M.R. (eds.) Biology of Sharks and their Relatives, Boca Raton, FL, CRC Press: 269–286.

Ebert, D.A. and Stehmann, M.F. 2013. Sharks, batoids, and chimaeras of the North Atlantic, Food and Agriculture Organization of the United Nations: 537 pp.

Fisk, A.T., Lydersen, C. and Kovacs, K.M. 2012. Archival pop-off tag tracking of Greenland sharks *Somniosus microcephalus* in the High Arctic waters of Svalbard, Norway. *Marine Ecology Progress Series*, 468: 255–265.

Gunnarsdóttir, R. and Jørgensen, M.W. 2008, Utilization possibilities of waste products from fishing and hunting to biogas and bio-oil production in Uummannaq County. In Sustainable Energy Supply in the Arctic - sun, wind, water etc.: ARTEK Event. Arctic Technology Centre, Department of Civil Engineering, Copenhagen: 52–58.

Hansen, P.M. 1963. Tagging Experiments with the Greenland shark (*Somniosus microcephalus* (Block and Schneider)) in Subarea 1. International Commission for the Northwest Atlantic Fisheries. Special Publication, 4: 172–175.

Kondyurin, V.V. and Myagkov, N.A. 1983. Catches of newborn Greenland shark, *Somniosus microcephalus* (Bloch and Schneider) (Dalatiidae). *Journal of Ichthyology* 23: 140–141.

Kyne, P.M., Sherrill-Mix, S.A. and Burgess, G.H. 2006. *Somniosus microcephalus*. In: IUCN 2014. IUCN Red List of Threatened Species. Version 2014.1. <www.iucnredlist.org>. Downloaded on 18 June 2014.

Leclerc, L.-M., Lydersen, C., Haug, T., Bachmann, L., Fisk, A. and Kovacs, K. 2012. A missing piece in the Arctic food web puzzle? Stomach contents of Greenland sharks sampled in Svalbard, Norway. *Polar Biology*, 35: 1197–1208.

Leclerc, L.-M., Lydersen, C., Haug, T., Glover, K. A., Fisk, A. T. and Kovacs, K. M. 2011. Greenland sharks (*Somniosus microcephalus*) scavenge offal from minke (*Balaenoptera acutorostrata*) whaling operations in Svalbard (Norway). *Polar Research*, 30: 4 pp.

McAllister, D.E. 1968. Poisonous and venomous fishes of Canada. National Museum of Canada Natural History Papers, 42: 2–3.

MacNeil, M.A., McMeans, B.C., Hussey, N. E., Vecsei, P., Svavarsson, J., Kovacs, K.M., Lydersen, C., *et al*. 2012. Biology of the Greenland shark *Somniosus microcephalus. Journal of Fish Biology*, 80: 991–1018.

Nielsen, J., Hedeholm, R.B., Simon, M.J., Steffensen, J.F., Nielsen, J., Hedeholm, R.B., Simon, M.J., *et al*. 2014. Distribution and feeding ecology of the Greenland shark (*Somniosus microcephalus*) in Greenland waters. *Polar Biology*, 37: 37–46.

Rusyaev, S. and Orlov, A. 2013. Bycatches of the Greenland shark *Somniosus microcephalus* (Squaliformes, Chondrichthyes) in the Barents Sea and adjacent waters under bottom trawling data. *Journal of Ichthyology*, 53: 111–115.

Skomal, G.B. and Benz, G.W. 2004. Ultrasonic tracking of Greenland sharks, *Somniosus microcephalus*, under Arctic ice. *Marine Biology*, 145: 489–498.

Stokesbury, M.J.W., Harvey-Clark, C., Gallant, J., Block, B.A. and Myers, R.A. 2005. Movement and environmental preferences of Greenland sharks (*Somniosus microcephalus*) electronically tagged in the St. Lawrence Estuary, Canada. *Marine Biology*, 148: 159–165.

Svensson, M., Degerman, E., Florin, A.-B., Hagberg, J., Kullander, S.O., Nathanson, J.E. and Stenberg, C. 2010. Fiskar–Fish. Pisces. In Gärdenfors, U. (ed.) Rödlistade arter i Sverige 2010 –The 2010 Red List of Swedish Species. ArtDatabanken, SLU, Uppsala: 323–332.

Yano, K., Stevens, J.D. and Compagno, L.J.V. 2007. Distribution, reproduction and feeding of the Greenland shark *Somniosus* (*Somniosus*) *microcephalus*, with notes on two other sleeper sharks, *Somniosus* (*Somniosus*) *pacificus* and *Somniosus* (*Somniosus*) *antarcticus*. *Journal of Fish Biology*, 70: 374–390.

Table 24.1. Greenland shark *Somniosus microcephalus*. Preliminary landings (tonnes) for the period 1993–2013. Data sources: National Icelandic database (www.hagstova.is) and Marine Research Institute database. Greenland and Portuguese landings since 2006 from ICES database.

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Iceland	43	26	32	32	62	56	52	37	36	47
Greenland										
Portugal										
Total	43	26	32	32	62	56	52	37	36	47

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Iceland	62	66	54	29	2	42	26	43	18	19
Greenland					17					
Portugal				1	1	1				
Total	62	66	54	30	20	43	26	43	18	19

	2013
Iceland	6
Greenland	
Portugal	
Total	6

25 Catsharks (Scyliorhinidae) in the Northeast Atlantic

25.1 Stock distribution

This section addresses four species of catshark that occur on the continental shelf and upper slope of the ICES area: Lesser-spotted dogfish or small-spotted catshark *Scyliorhinus canicula*, greater-spotted dogfish *Scyliorhinus stellaris*, black-mouth dogfish (or black-mouth catshark *Galeus melastomus* and Atlantic catshark *Galeus atlanticus.* Other catsharks that occur in deeper waters (*Apristurus* spp., *Galeus murinus*) are not included here (see Section 5). All catsharks are demersal and oviparous (egg-laying) species. The stock units are not known, but tagging data indicate that movements are generally quite limited.

Lesser-spotted dogfish: *S. canicula* is an abundant species occurring on a range of substrates (from mud to rock) on the European continental shelves and upper slopes, but is most abundant on the shelf. Its distribution ranges from Norway and the British Isles to the Mediterranean Sea and to Northwest Africa (Ebert and Stehmann, 2013). In relation to lesser-spotted dogfish, STECF (2003) assumed that "*separate stocks reside in separate ICES Divisions and that immigration and emigration from adjacent populations are either insignificant or on a par*" and that such species would best be managed as local populations (e.g. on the level of an ICES division or adjacent divisions). According to tagging surveys carried out in the Cantabrian Sea since 1993, lesser-spotted dogfish is a philopatric species, with the maximum distance reecorded for recaptured fishes <20 km (Rodriguez-Cabello *et al*., 2004, 2007).

Greater-spotted dogfish: *S. stellaris* is a common inshore shark of the Northeast Atlantic continental shelf found from shallow water to depths of about 125 m on rough or rocky bottoms, including areas with algal cover (e.g. kelp forests) (Ebert and Stehmann, 2013). It is a larger-bodied catshark, growing to at least 130 cm.

Black-mouth catshark*: G. melastomus* is a small-sized shark (< 90 cm), found in the Mediterranean Sea and from northern Norway along the continental shelf, including the Faroes, south to Senegal (Ebert and Stehmann, 2013).

Atlantic catshark: *G. atlanticus* is a small catshark on the continental slopes living in depths of 330–790 m. Its distribution in the Eastern Atlantic ranges from Spain (off Galicia) to Portugal into the Mediterranean and further south to Morocco and possibly to Mauritania. Northern range limits are unknown (Ebert and Stehmann, 2013), as there is confusion between this species and *G. melastomus* (see Rey *et al.*, 2006 for distinguishing characters).

25.2 The fishery

25.2.1 History of the fishery

Catsharks are a bycatch species of demersal trawl, gillnet and longline fisheries in the ICES area, and, with the exception of seasonal, small-scale directed fisheries in some coastal areas, are not subject to target fisheries.

The retention patterns of catsharks in the North Sea and Celtic Seas ecoregions are highly variable, with varying proportions retained/discarded (Silva *et al*., 2013 WD). Some are landed for human consumption (but not as much as in the southern parts of the ICES area) and they are also landed in some areas as bait for pot fisheries, especially in fisheries for whelk *Buccinum undatum* around the British Isles.

In the Bay of Biscay and in Iberian Waters (ICES Areas VIIIc, IXa), *Scyliorhinus canicula* is caught by both coastal trawlers and an artisanal fishing fleet, which operates with different fishing gears. This species is landed in the major ports of Division IXa. The greater-spotted dogfish (*S. stellaris)* is rarely caught by the Portuguese fishing fleets.

25.2.2 The fishery in 2013

No new information.

25.2.3 ICES Advice applicable

ICES advice for catsharks was included in the regional demersal elasmobranch advice (2006–2010).

Based on ICES approach to data-limited stocks, ICES (2012) advised that "catches could be increased by a maximum of 20%. Because the data for catches of lesser-spotted dogfish are not fully documented, ICES is not in a position to quantify the result. ICES does not advise that an individual TAC be set for this stock, at present".

This advice applied to lesser-spotted dogfish in (a) Division IIIa (Skagerrak and Kattegat), Subarea IV (North Sea), and Division VIId (eastern Channel); (b) in Subarea VI and Divisions VIIa–c, e–j (Celtic Sea and west of Scotland); and (c) Divisions VIIIa,b,d (Bay of Biscay).

For Divisions VIIIc and IXa (Atlantic Iberian waters), based on ICES approach to data-limited stocks, ICES (2012) advised that "*catches should be decreased by 9%. Because the data for catches of lesser-spotted dogfish are not fully documented (due to the historical use of generic landings categories), ICES is not in a position to quantify the result. ICES does not advise that an individual TAC be set for this stock.*

A special advice request to ICES was drafted by the European Union in 2013 that concerned a revision of the list of species of deep-sea sharks in EU Council Regulation No. 1262/2012 Annex. In particular, the request questioned the listing of black-mouth catshark (*G. melastomus*). Based on the different life-history traits from other species on the list, its assumed lower vulnerability towards fishing pressure as well as its main distribution extending to upper slope and outer shelf habitats, that are not considered deep-water habitat, ICES recommended removing *G. melastomus* from the list of deep-water sharks.

25.2.4 Management applicable

Council Regulation (EC) 1262/2012 included both *G.melastomus* and *G. murinus* in the list of deep-sea sharks, for which EU vessels were subject to a zero TAC for EU and international waters in Subareas V–X. Council Regulation (EC) 1182/2013 removed *G. melastomus* from this list of deep-water sharks.

25.3 Catch data

25.3.1 Landings

Landings of catsharks were traditionally reported under a range of generic landing categories; although species-specific reporting has improved in recent years. As such, historic landings data are lacking and even recent data highly uncertain. All data shown here must be considered as preliminary, and further collation of landings data for these species will be undertaken by WGEF next year.

Landing data of lesser-spotted dogfish in the North Sea ecoregion are shown in Table 25.1a. It should be noted that in 2012 and 2103, France and the UK also landed unspecified Scyliorhinidae. For France, the 2012 landings of all Scyliorhinidae was 2225 tonnes, and in 2013 it was 2146 tons. For the UK (England, Wales and Northern Ireland) the total landings of Scyliorhinidae was 188 tons.

Landings data from the Celtic Seas (ICES Areas VI, VIIa–c,e–j) for both lesser-spotted dogfish and greater-spotted dogfish are underestimated, as it has not been possible to disaggregate these species from the generic categories under which they are often declared, and the lack of consistency by which it is categorized. As a consequence of the lack of species-specific landings data for demersal sharks, and the absence of market sampling, it is not currently possible to differentiate the landings of demersal shark species in most areas. Data for this ecoregion are not shown here and will be presented next year.

In ICES Areas VII and VIII *S. canicula* and *S. stellaris* are mostly landed by the French fisheries mixed together under the single landing name "*Scyliorhinus canicula*" (code SYC). In 2012–2014 only four of 32 French fish markets used the landing name "*Scyliorhinus stellaris*" (code SYT) whereas specimens of *S. stellaris* were observed in 17 fish-markets during market surveys. In coastal fisheries, small volumes of *S. canicula* are often mixed and sold together with other bony fishes of similar price.

Landings of *S. canicula* from the Biscay-Iberia ecoregion reported to the WG are shown in Table 25.1b–d and Figure 25.1. France and Spain landings originate mainly from Divisions VIIIa, b. In 2012, Spanish fleet landed 804 t in Subarea VIII and only 396 t in 2013, mainly due to the lack of reported landings in the Divisions VIIIa,b. In Divisions VIIIa,b landings of the French fleet declined from a maximum of 1168 t in 2004 to 894 t in 2013. In Division VIIIc (Table 25.2c) only Spanish landings are significant, showing an increase since 2012. In contrast, due to the reduced effort of the trawler fleet in VIIId compared to other Divisions, landings are historically not significant.

Most of the landings of *S. canicula* in IXa are from the Portuguese fleet (Table 25.1e). From 1996 to 2004, Portuguese landings ranged between 600 and 700 $t.y^{-1}$. After a period of low landings (from 2005 to 2008) Portuguese and Spanish landings have increased again in recent years to 696 t in 2013.

Preliminary landings data for *Galeus melastomus* (black-mouth catshark) are given in Table 25.2a. In Subarea VIII only Spain reported landings and total landings have been historically very low and <8 $t.y^{-1}$ (Table 25.2b). In Division IXa, landings of *G. melastomus* are mainly from the Portuguese fleet. Before 2009, landings were around 30 t but after they decreased significantly (Table 25.2c).

25.3.2 Discards

Lesser-spotted dogfish and other catsharks are often discarded from continental shelf fisheries (Silva *et al.*, 2013). Although these data have not been collated and raised to fleet level, the high discard survival of species in this family, at least for continental shelf fisheries, means that landing data are likely to be more reflective of dead removals. Discard data for black-mouth catshark and lesser-spotted dogfish from the Iberian and Celtic Sea are available from Spanish surveys (Santos *et al*., 2010 WD).

Discard information is also available from the Basque OTB fleet in VIII. The analysis of discard estimates for the period 2009 to 2013 indicates that depending on the year this fleet discarded 23–32% of *S. canicula* (Table 25.3a). Although this species is the most important elasmobranch species landed by the Basque fleets in VIII, estimated discards have been historically much higher than landings except in 2013 when only 65 t were discarded. *Galeus melastomus* is landed in "small" amounts, however discards exceeded landings in 2004, 2005, 2009 and 2010 with exceptionally high discards of 226 t in 2004. However, this number seems to be unreliable and might be due to an overestimation of subsamples as this species is very scarce in the catches.

In 2013, *S. canicula* and *G. melastomus* were the most important discarded species by the Spanish fleet in ICES Divisions VIIIc and IXa, accounting for 1137 t and 749 t, respectively. Data on *G. melastomus* in VIIIc and IXa indicate that all the individuals are discarded because there are not reported in landings in these subdivisions.

In the Portuguese crustacean bottom otter trawl fishery operating in ICES Division IXa the most frequent discarded demersal species were *G. melastomus* and *S. canicula*. For this fishery, the estimated total discarded weight for *G. melastomus* was from 263 t (CV=39%) in 2004 and 45 t (CV=93%) in 2012, and for *S. canicula* was from 30 t (CV=29%) in 2012 and 49 t (CV=40%) in 2012 (Prista and Fernandes, 2013 WD). The discarded *G. melastomus* measured, on average, 23.5 ± 10.6 cm and had a sex ratio of 1.1:1, and *S. canicula* measured, on average, 28.5 ± 11.7 cm, and had a sex ratio of 1.4:1. Information on *G. melastomus* discards in the deep-water longline Portuguese fleet targeting black scabbardfish in the ICES Division IXa has also been collected under the Portuguese on board sampling programme (EU DCR/NP), between 2005 and 2012. In 2012 its frequency in the discards was 56%.

25.3.3 Discard survival

Lesser-spotted dogfish have been shown to have a high discard survival (Revill *et al*., 2005; Rodriguez-Cabello *et al*., 2005).

25.3.4 Quality of catch data

Accurate species-specific landings data are not currently available. The 2012–2014 French programme "Mislabelling of Chondrichthyans in French landings" aims to better evaluate the relative proportion of species mixed under a single landing name, as it is for *S. canicula*/*S. stellaris* (see above).

25.4 Commercial catch composition

Data from national observer programmes have provided information on the size distribution of the retained proportions of the catch. It is generally larger fish that are landed (Silva *et al*., 2013 WD). Example length-frequency distribution data are shown for *S. canicula* caught by the Dutch beam trawl fleet in 2012–2013 (Figure 25.2a), French landings of *S. canicula* and *S. stellaris* from sub-areas VII and VIII (Figures 25.2b and 25.2c) and from the OTB Basque fleet in Division VIIIc (Figure 25.2d).

25.5 Commercial catch-effort data

According to available data for commercial landings per unit effort (lpue) series, the abundance of *S. canicula* in the Bay of Biscay (Divisons VIIIa, b, d) has been increasing since 1994. Updated information of lpue from trawler fleets indicate that the lpue for *S. canicula* in Subarea VIII has been increasing from 1994 to 2011. The high levels of discards in 2011 could suggest a high abundance of small individuals in Subarea VIII. Despite misreporting, historical Spanish landings data indicates a stable trend since 1996 (2000–2500 $t.y^{-1}$).

Lpue data from the Basque Country OTB fleet (Division VIIIc; Figure 25.3) show an increasing trend over the time-series (2001–2013), with a peak in 2011 and more recent decreased in 2011 and 2012.

25.6 Fishery-independent information

25.6.1 Availability of survey data

Catsharks are a common component of many fishery-independent trawl surveys, including both IBTS and beam trawl surveys, and for further information see Section 15 (North Sea), Section 18 (Celtic Seas) and Section 19 (Biscay-Iberia).

25.6.2 Abundance trends for *S. canicula* in the North Sea ecoregion

The abundance of *S. canicula* is increasing in IV and Division VIId, and the area occupied in IV is increasing.

This increasing trend in seen in both the Q1 and Q3 IBTS in the North Sea (Figures 25.4a–b), and the length range has been relatively stable (Figure 25.5).

Within the English Channel, Martin *et al.*, 2005 analysed data from the French Channel Groundfish Survey (CGFS) and the Eastern Channel Beam Trawl Survey (UK (BTS-Q3)) for the years 1989–2004. An apparent trend for lesser-spotted dogfish distribution to be increasing towards the Straits of Dover and into the North Sea was noted. Increasing trends in survey catch rates are evident in both the French CGFS (Figure 25.6) and the UK beam trawl survey (Figure 25.7).

Within this ecoregion, *S. caniucla* is most abundant in the English Channel, southern North Sea and northwestern North Sea, with fewer specimens found in the eastern North Sea (Figure 25.8).

25.6.3 Abundance trends for *S. canicula* in the Celtic Seas ecoregion

<u>Spanish Porcupine Bank survey</u>: This survey demonstrates an increasing trend for *Scyliorhinus canicula* to the west of Ireland), with the highest catch levels in the time-series occurring during the 2007 survey (Figure 25.9).

<u>The UK (England and Wales) beam trawl survey in VIIa and VIIf</u>: Large numbers of lesser-spotted dogfish are caught, and they are abundant throughout the survey grid, suggesting they occur over a range of habitats. This survey also indicates increasing catches (Figure 25.10).

<u>Other surveys</u>: Earlier analyses of the Scottish surveys of VIa suggested increasing catch trends, although updated analyses were not available. Similarly, previous analyses of the UK (Northern Ireland) survey of the Irish Sea and the Irish Groundfish Survey also indicate increasing catch trends (see ICES, 2010).

25.6.4 Abundance trends for *S. canicula* in the Biscay-Iberia ecoregion

<u>French EVHOE survey</u>: In the Biscay area, the abundance of *S. canicula* increased from 1997 to 2011 but slightly decreased afterwards although maintaining values higher than those at the mid-period of the time-series (Figure 25.11).

<u>Basque ITSASTEKA survey</u>: Among the 89 different species of fish and cephalopods caught, only two demersal sharks (*G. melastomus* and *S. canicula)* were identified. In 2012, despite the small number of shark and skate species caught, catch rates (kg/km^2) reached 12.9% of total biomass of fish and cephalopods (4% in 2011). *S. canicula* was

the second species by abundance in the survey and was found in almost all trawling stations except in shallower areas, being less abundant below 250 m. Younger and larger individuals were found at similar depths (Figure 25.12, Table 25.4).

Spanish IEO Q4 survey: This survey of northern Iberian waters in ICES Divisions (VIIIc and IXa) has noted differences in biomass between the two Divisions from 2006 to 2012 (Figure 25.13). The percentage of *S. canicula* in the total fish catch ranged from 1.7% (2.15 kg·haul^{-1}) in 1983 to 6.6% in 2011 (6.58 kg·haul^{-1}).

Portuguese surveys: Along the Portuguese continental shelf (Division IXa) the species is evenly distributed (Figure 25.14a) and shows a stable trends in both abundance (Figure 25.14b) and length composition (Figure 25.14c).

25.6.5 Abundance trends for *S. stellaris*

Greater-spotted dogfish is larger than lesser-spotted dogfish and also tends to have a more restricted, inshore distribution than lesser-spotted dogfish. The preferred habitats for this species include rocky, inshore grounds. Hence, most surveys will not sample effectively the main parts of their range, resulting in low catch rates. Most data are available for the Celtic Seas ecoregion.

The stock structure is little-known at the moment, although preliminary tagging studies have not observed any movements between the western English Channel and Irish Sea (Burt *et al.*, 2013 WD).

The UK (England and Wales) beam trawl survey in VIIa and VIIf catches small numbers of greater-spotted dogfish (although the catchability for the larger individuals may be low), and they are captured regularly around Anglesey, Lleyn Peninsula and in Cardigan Bay. This survey indicates that the most recent catches are above average (Figure 25.10).

The recently-ceased UK (England and Wales) Q4 westerly IBTS also had stations along the west coast of Wales. Although they were captured regularly in this survey, catches comprised few individuals.

All UK surveys have tagged and released a number of greater-spotted dogfish in recent years, which will hopefully provide further information to aid in stock identification.

25.6.6 Abundance trends for *G. melastomus*

Black-mouth catshark occur on the outer continental shelf and upper slope, and so are typically taken in those surveys operating in waters 300–700 m deep.

Spanish surveys on the Porcupine Bank (SpPGFS-WIBTS-Q4) in ICES Subarea VII (VIIc and VIIk) presented abundance indexes for black-mouth catshark (*Galeus melastomus*) which was the most abundant species in the survey in terms of biomass. For more detailed information, see Fernández-Zapico *et al.*, 2013. In 2013, black-mouth catshark had catch values around 44 kg and 90.2 individuals per haul, thus representing about 74% and 88% of the elasmobranch mean stratified biomass and abundance per haul. The stratified biomass and abundance trends were similar. Although a slightly lower capture was found in 2011, black-mouth catshark showed an increasing trend during the last five years after the remark able drop from 2005 to 2006 (Figure 25.15).

Changes in *Galeus* spp. (*G. melastomus* and *G. atlanticus*) biomass index during the North Spanish shelf bottom trawl survey are shown in Figure 25.16.

25.7 Life-history information

Catsharks can have protracted spawning periods, with lesser-spotted dogfish bearing egg cases observed for much of the year. This protracted egg-laying season may result in no apparent age classes in survey data. Age and growth parameters are uncertain for all the species considered here.

The reproductive biology of *Scyliorhinus canicula* has been studied for the Bristol Channel (Ellis and Shackley, 1997). Males mature al lengths of 49–54 cm ($L_{50\%}$ at 52 cm) and female at 52–64 cm ($L_{50\%}$ at 55 cm). The egg-laying season lasts at least ten months with a peak in June and July, and fecundity increases with fish length. The egg cases are often laid on erect, sessile invertebrates (e.g. bryozoans, poriferans and hydroids).

25.8 Exploratory assessment models

25.8.1 Lesser-spotted dogfish

The lesser-spotted dogfish (*S. canicula*) is considered to be best assessed as local populations within individual or neighbouring ICES divisions.

The status of these species has mostly been evaluated through catch rates in scientific trawl surveys. Catch rates have increased in all surveys analysed (see above).

Updated information of lpue from trawler fleets operating in ICES Divisions VIIIa, b, d indicate that the lpue for *S. canicula* in Subarea VIII has been increasing from 1994 to 2011 but a decrease is observed from 2012 to 2013. The high levels of historical discards could suggest high abundance of small individuals in Subarea VIII. The historical landings series indicates a stable trend since 1996 although the preliminary reported landings in 2013 (902 t) are below the average of the series (1217 t.y-1). The French EVHOE survey indicates a clear increase in total biomass until 2011, however as the trend landings indicate a decrease in the last two years is observed.

In Division IXa, *S. canicula* is essentially a bycatch from other fisheries, so the landings could be related mainly to changes in effort along the Portuguese coast. Landings, which might not reflect the actual catches, were reduced from 2005 until 2008, but since this year onwards a strong recovery is observed. Surveys from Portugal mostly reveal a constant cpue and size of caught individuals over the past ten years.

The IEO Q4-IBTS survey in northern IXa showed an increase in the abundance index since 2006, and similarly the Portuguese Winter Groundfish Survey (PtGFS-WIBTS-Q1) in Southern IXa indicates that *S. canicula* is relatively abundant, being present in all the years of the series.

25.8.1.1 GAM analyses of survey trends

A GAM analysis (see Section 15 for further information) focused on *S. canicula* in the CGFS, UK-BTS, IBTS-Q1 and IBTS-Q3 surveys. The length-based cpues per haul for the period 1977–Q1 2014 were used as input data. This dataset contains information on the survey, geographic position of the haul, depth, length of each individual measured to the nearest centimetre, year of haul, and survey quarter. These variables were used to predict cpue in a GAM analysis (Wood, 2006). The cpue in is given as n/hr. Given the nature of the data, we assumed a negative binomial error distribution with a log link. Results in terms of predicted mean cpue per year and length (at a given location with corresponding depth) and the spatial distribution of the catches are given in Figure 25.17. The name of the survey was taken into account as a nuisance variable that describes the difference in catchability among the surveys. Future work on these analyses could include converting the cpue indices to numbers per unit area (density estimates). Once the cpue estimates are analysed in terms of numbers per unit area, total biomass estimates can be further determined.

25.8.2 Black-mouth catshark

In the work developed by IPMA (ex-IPIMAR), under the Marine Strategy Framework Descriptor 1, the conservation status of *G. melastomus* was evaluated. For this, data from the PtGFS-WIBTS-Q1 collected between 2005 and 2009 were compared with the period considered of reference, 2000–2002. The mean abundance by haul of each year was divided by the mean abundance of the reference period. Results show that the variations observed are not significant and that the conservation status was maintained along the years (Figure 25.18).

25.9 Stock assessment

No stock assessments have been undertaken.

25.10 Quality of the assessment

No formal stock assessments have been undertaken.

25.11 Reference points

No reference points have been proposed for these species and stocks.

25.12 Conservation considerations

Lesser-spotted dogfish and black-mouth catshark are both listed as Least Concern, and greater-spotted dogfish and Atlantic catshark both listed as Near Threatened on the IUCN Red List (Coelho *et al*., 2007; Ellis *et al*., 2009; Serena *et al*., 2009).

25.13 Management considerations

Catch data are highly uncertain, and further efforts are required to construct a meaningful series of landings data.

Discard survival of *Scyliorhinus* spp. is considered to be high, but estimates for discard survival for *Galeus* spp. are not currently available.

Catch rates of lesser-spotted dogfish are increasing in all surveys analysed. As one of the more productive demersal elasmobranchs that is often discarded (with a high discard survival) and is known to scavenge on discards, it is unclear as to whether or not the increasing catch rates observed are a sign of a healthy ecosystem.

25.14 References

Burt, G. J., Silva, J. F., McCully, S. R., Bendall, V.A. and Ellis, J. R. 2013. Summary results from opportunistic tagging programmes for smooth-hound Mustelus spp., greater-spotted dogfish Scyliorhinus stellaris and tope Galeorhinus galeus around the British Isles. Working Doc-ument presented to the Working Group on Elasmobranch Fishes, 12 pp.

Coelho, R., Rey, J., Serena, F., and Mancusi, C. 2007. *Galeus atlanticus*. In: IUCN 2014. IUCN Red List of Threatened Species. Version 2014.1. <www.iucnredlist.org>. Downloaded on **24 June 2014**.

Ebert, D.A. and Stehmann, M.F.V. 2013. Sharks, batoids,and chimaeras of the North Atlantic. FAO Species catalogue for fishery purposes. No 7. Rome, FAO, 523 pp.

Ellis, J., Serena, F., Mancusi, C., Haka, F., Morey, G., Guallart, J., and Schembri, T. 2009. *Scyliorhinus stellaris*. In: IUCN 2014. IUCN Red List of Threatened Species. Version 2014.1. <www.iucnredlist.org>. Downloaded on **24 June 2014**.

Ellis, J.R., and Shackley, S.E. 1997. The reproductive biology of *Scyliorhinus canicula* in the Bristol Channel, UK. Journal of Fish Biology 51: 361–372.

Fernández-Zapico, O., Velasco, F., Baldó, F., Rodríguez-Cabello, C. and Ruiz-Pico, S. 2013. Results on main elasmobranch species captured during the 2001–2012 Porcupine Bank (NE Atlantic) bottom trawl surveys. Working Document presented to the Working Group on Elasmobranch Fishes, 26 pp.

ICES. 2010. Report of the Working Group on Elasmobranch Fishes (WGEF), 22–29 June 2010, Horta, Portugal. ICES CM 2010/ACOM:19. 558 pp.

Martin, C.S., Vaz, S., Ernande, B., Ellis, J.R., Eastwood, P.D., Coppin, F., Harrop, S., Meaden, G.J., and Carpentier, A. 2005. Spatial distributions (1989–2004) and preferential habitats of thornback ray and lesser-spotted dogfish in the eastern English Channel. ICES CM 2005/N:23, 27 pp.

Revill, A.S, Dulvy, N.K., and Holst, R. 2005. The survival of discarded lesser-spotted dogfish (*Scyliorhinus canicula*) in the Western English Channel beam trawl fishery. Fisheries Research 71: 121–124.

Rey, J., Séret, B., Lloris, D., Coelho, R., and Gil de Sola, L. 2006. A new redescription of *Galeus atlanticus* (Vaillant, 1888) (Chondrichthyes: Scyliorhinidae) based on field marks. *Cybium*, 30: 7–14.

Rodríguez-Cabello, C., Fernández, A., Olaso, I. and Sánchez, F. 2005. Survival of small-spotted catshark (*Scyliorhinus canicula*, L.) discarded by trawlers in the Cantabrian Sea. Journal of the Marine Biological Association of the United Kingdom, 85: 1145–1150.

Rodríguez-Cabello, C., Sánchez, F., Fernández, A., and Olaso, I. 2004. Is the lesser spotted dogfish (*Scyliorhinus canicula*) from the Cantabrian Sea a unique stock? Fisheries Research 69: 57–71.

Rodríguez-Cabello, C., Sánchez, F., Olaso, I. 2007. Distribution patterns and sexual segregations of *Scyliorhinus canicula* (L.) in the Cantabrian Sea. Journal of Fish Biology 70: 1568–1586.

Santos, J., Araújo, H., Salinas, I., and Pérez, N. 2010. Elasmobranches Results from Spanish Discard Sampling Programme. Working Document WGEF 2010.

Serena, F., Mancusi, C., Ungaro, N., Hareide, N.R., Guallart, J.,Coelho, R., and Crozier, P. 2009. *Galeus melastomus*. In: IUCN 2014. IUCN Red List of Threatened Species. Version 2014.1. <www.iucnredlist.org>. Downloaded on 24 June 2014.

Silva, J.F., Ellis, J.R., Catchpole, T.L., and Righton, D. 2013. Bycatch and discarding patterns of dogfish and sharks taken in commercial fisheries around the British Isles. Working Document presented to the Working Group on Elasmobranch Fishes, 31 pp.

STECF. 2003. Report of the Subgroup on Resource Status (SGRST) of the Scientific, Technical and Economic Committee for Fisheries (STECF): Elasmobranch Fisheries. Brussels, 22–25 July 2003. Commission Staff Working Paper SEC (2003) 1427; 207 pp.

Wood, S. N. 2006. Generalized Additive Models: an Introduction with R. Boca Raton: Chapman and Hall. CRC.

Table 25.1a. Demersal elasmobranchs in the North Sea, Skagerrak, Kattegat and eastern Channel. Preliminary estimates of landings of *Scyliorhinus canicula* in IIIa, IV and VIId (in tonnes). "n.a." indicates not available.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	186	330	235	244	225	238	262	266	336	313	291	309	310	220
France	1633	1811	1899	1777	1472	1614	1492	1459	1406	1751	1999	2013	2053	2034
Netherlands	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	32	29	37	37	47	35	36
UK (E,W, NI)	n.a.	n.a.	n.a.	13	57	92	118	94	102	116	128	176	179	185
UK (Scotland)	.	.	1	5	3	22	6	3	2	3	3	.	10[1)]	.
Total	1819	2141	2135	2039	1757	1966	1878	1854	1875	2220	2458	2545	2577	2474

[1)] Registered as spotted dogfish.

Table 25.1b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of lesser-Spotted Dogfish (*Scyliorhinus canicula*) landings (t) in Divisions VIIIab.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	.	3	8	7	9	11	10	8	9	10	13	13	18	24	28	28	32	
France	606	691	811	405	768	839	748	1030	1168	1024	1112	1198	743	1115	1075	781	920	894
Spain	0	0	63	0	7	7	28	1	0	0	2	1	1	0	35	57	443	* *
Spain (Basque Country)	223	270	336	254	247	277	353	318	254	335	318	247	383	415	270	285	*	
UK (E&W)								2		3							4.8	.
Total	829	964	1218	667	1032	1135	1139	1359	1431	1373	1444	1458	1145	1554	1408	1151	1401	895

*** Included in Spanish landings.**

*** * Preliminary landings**

Table 25.1c. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of lesser-Spotted Dogfish (*Scyliorhinus canicula*) landings (t) in Division VIIId.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
France	4	3	5	2	5	7	5	7	6	13	6	8	3	10	11	7	8	7
Spain			97		78							1	2				11	**
Spain (Basque Country)						0	1		1		2	2	0		0	0	*	
UK (E&W)																	0	
Total	4	3	102	2	83	7	6	7	7	13	8	11	5	10	11	7	19	7

*** Included in Spanish landings.**

*** * Preliminary landings.**

Table 25.1d. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of lesser-spotted dogfish (*Scyliorhinus canicula*) landings (t) in Area VIIIc.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
France	0	0	1	1	1	4	3	4	5	1	0	1	1	1		0	0	0
Spain	417	458	375,6	448	167	187,6	65	114	88	143	168	150	149	132	181	180	350	395* *
Spain (Basque Country)	11	8	8	9	5	10	52	65	63	66	73	59	47	30	56	121	*	
Total	428	466	385	458	173	201	120	183	157	211	241	210	198	162	237	301	350	395

*** Included in Spanish landings.**

*** * Preliminary landings**

Table 25.1e. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of lesser-spotted dogfish (*Scyliorhinus canicula*) landings (t) in Division IXa.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Spain	3	6	19	34	30	39	39	69	86	88	92	118	76	67	99	130	143	176**
Portugal	667	691	689	882	757	734	673	658	677	385	185	157	120	450	444	551	544	520
Total	670	697	708	916	787	773	712	727	763	472	276	275	196	518	543	681	687	696

*** * Preliminary landings**

Table 25.2a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of landings of black-mouth catshark *Galeus melastomus*.

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Ireland	.	.	.	.	.	.	.	.	.	.	.	.
Spain (Basque c.)	.	.	.	.	.	.	.	.	+	.	+	.
Spain	.	.	.	.	.	.	4	3	6	2	4	1
France												
Portugal	17	17	16	20	37	29	35	29	22	23	39	36
Norway												
Total	17	17	16	20	37	29	39	32	28	25	43	37

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Ireland	.	+	1	.	.		0					
Spain (Basque c.)	.	.	+	.	4		4	4	3			
Spain	35	1	.	4			28			+		5
France										3	2	4
Portugal	52	29	57	38	29	26	15	12	7		2	1
Norway										18	25	13
Total	87	30	58	41	32	26	47	16	10	21	29	23

Table 25.2b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of landings (tonnes) of black-mouth catshark *Galeus melastomus* - ICES Subarea VIII.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Portugal												1	2					
Spain							4	3	6	2	3	1	1	1	1	4	6	1* *
Spain (Basque Country)	4	3	6	2	3	1	1	1	1	4	4	6	4	4	3	0	*	
France																	0	0
Total	4	3	6	2	3	1	5	4	7	6	7	8	7	5	4	4	6	1

*** Included in Spanish landings.**

*** * Preliminary landings**

Table 25.2c. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Preliminary estimates of landings of black-mouth catshark *Galeus melastomus* - ICES Subdivision IXa.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Portugal	17	17	16	20	37	29	35	29	57	38	35	24	26	15	7	2	2	1
Spain													25				2	4* *
Total	17	17	16	20	37	29	35	29	57	38	35	24	51	15	7	2	4	5

*** * Preliminary landings.**

Table 25.3a. Catsharks in the Bay of Biscay and Iberian Waters. Discard estimates (t) of the Basque OTB (Bottom otter trawl) in Subarea VIII.

Subarea VIII	*S. canicula*	*G. melastomus*
2003	348	0
2004	654	227
2005	275	5
2006	173	1
2007	417	n.a
2008	641	23
2009	1092	0
2010	688	34
2011	1054	7
2012	905	
2013	65	

Table 25.3b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Lpue (kg/day) of main elasmobranchs caught by the Basque Country OTB DEF >= 70 (Bottom otter trawl) in Subarea VIII.

	Lpue (kg/day)
	S. canicula
2001	133
2002	163
2003	248
2004	210
2005	254
2006	340
2007	340
2008	255
2009	250
2010	364
2011	465
2012	205
2013	189

Table 25.4. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Distribution of elasmobranch biomass (kg/ 30 min) by depth and type of substratum in the ITSASTEKA survey (VIIIc East) in 2013.

Depth (m)	Substrate	*G. melastomus*	*S. canicula*
26	**fine sand**		
32	**fine sand**		4
38	**medium sand**		4
49	**fine sand**		8
52	**fine sand**		29
53	**coarse sand**		102
70	**fine sand**		5
71	**fine sand**		88
90	**fine sand**		40
93	**mud**		115
94	**coarse sand**		14
99	**mud**		45
102	**mud**		90
118	**mud**		137
125	**mud**		23
127	**mud**		278
131	**mud**		41
132	**mud**		81
134	**fine sand**		63
157	**fine sand**		338
173	**medium sand**		62
175	**medium sand**	2	53
181	**fine sand**		180
200	**fine sand**		103
233	**fine sand**	18	359
267	**mud**	12	114
367	**mud**	47	81

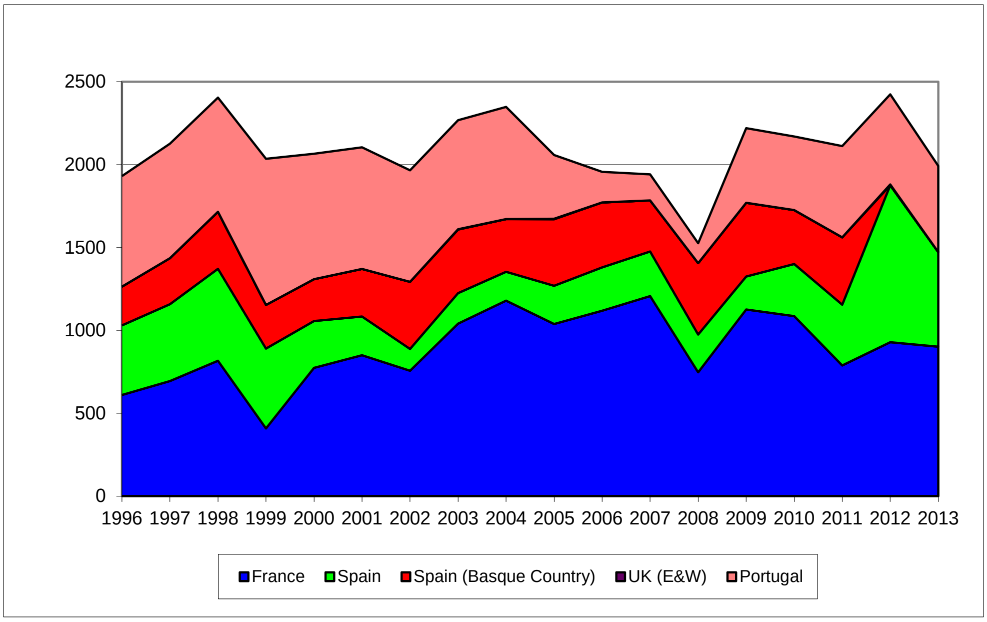
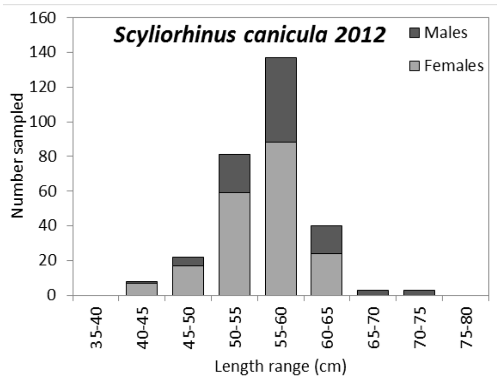


Figure 25.1. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Historical trend landings of lesser-spotted dogfish *Scyliorhinus canicula* in Subarea VIII and Division IXa. (Spanish landings data in 2007 and 2008 come from FishStat).



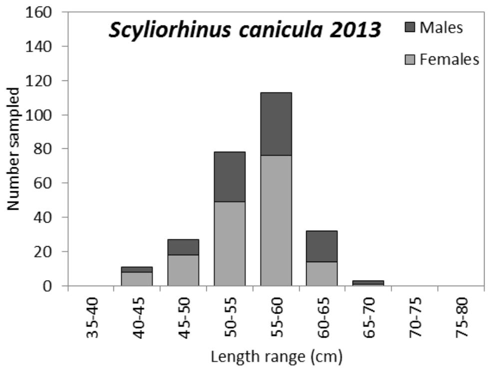


Figure 25.2a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length–frequency distribution of *Scyliorhinus canicula* measured during a pilot market sampling programme of the Dutch beam trawl fleet in 2012 and 2013.

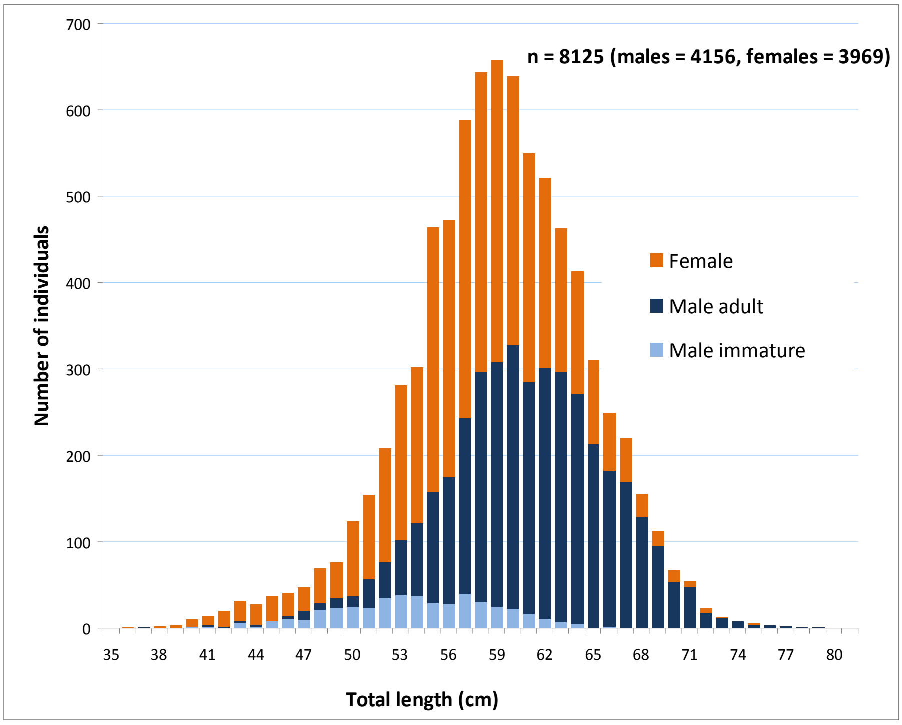


Figure 25.2b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length–frequency distribution of *Scyliorhinus canicula* from French landings (2012–2014), including samples from ICES Sub-areas VII and VIII.

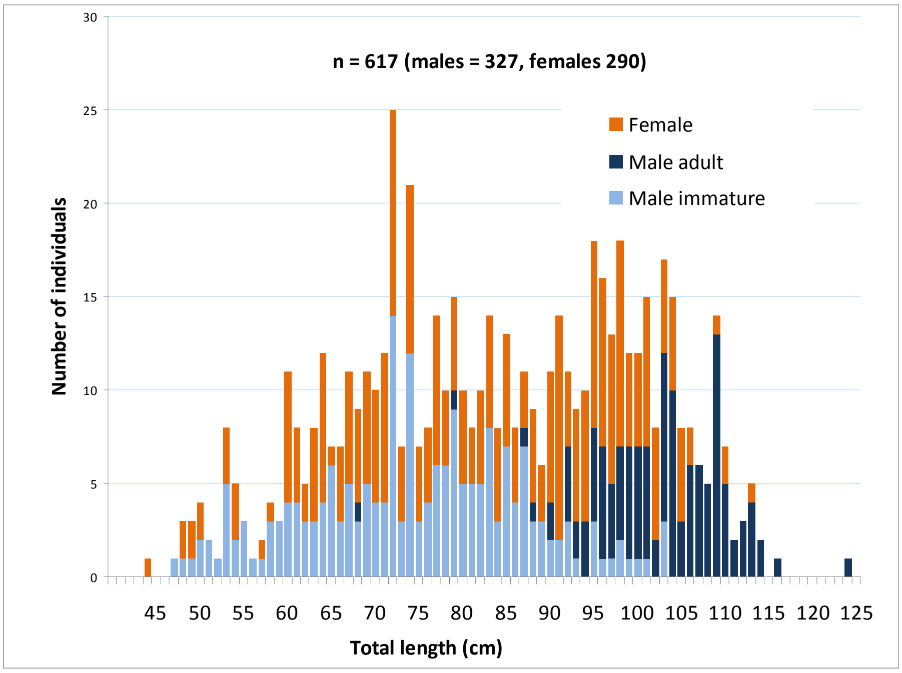


Figure 25.2c. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length–frequency distribution of *Scyliorhinus stellaris* from French landings (2012–2014), including samples from ICES Subareas VII and VIII.

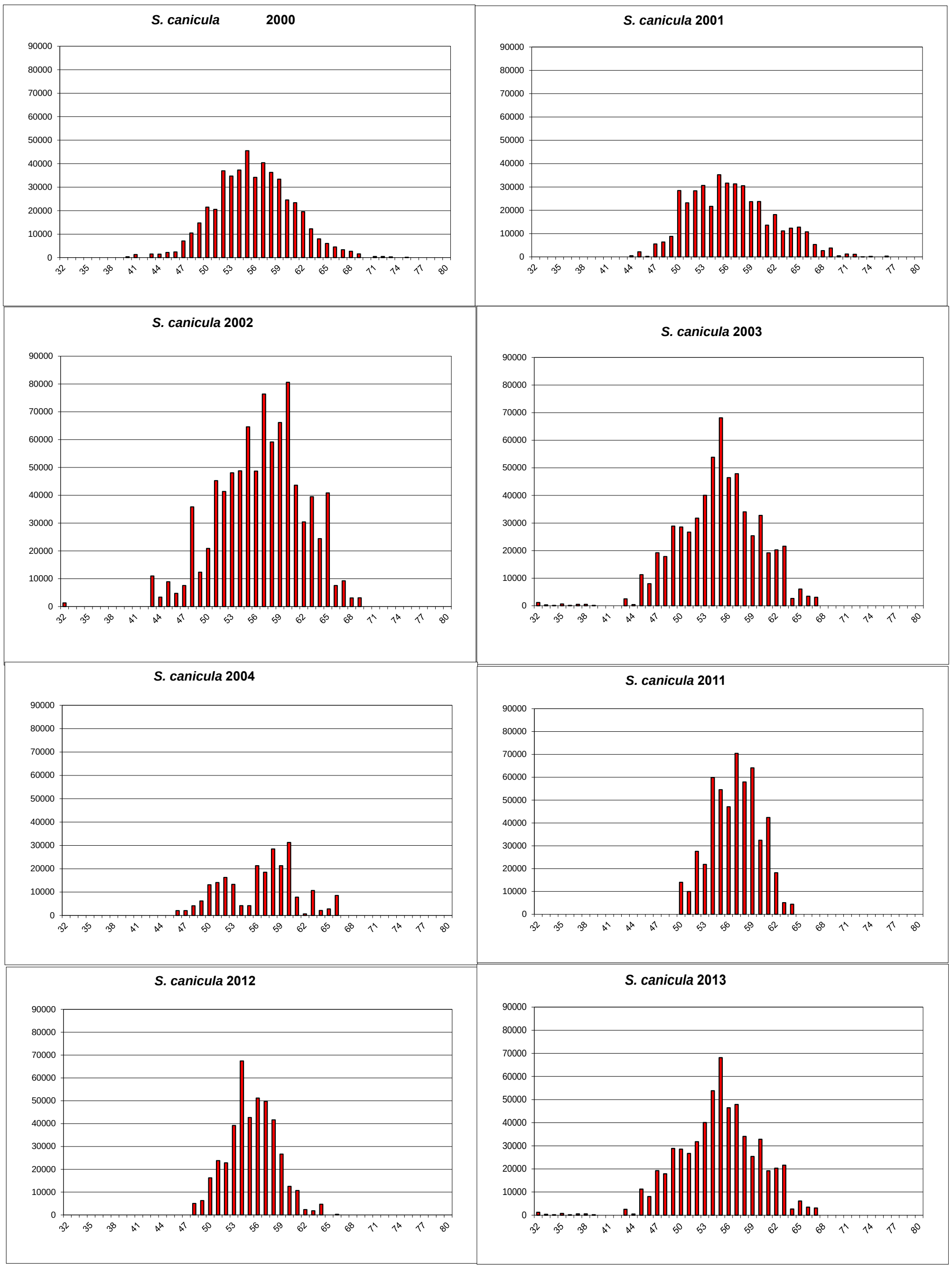


Figure 25.2d. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length–frequency distributions of *Scyliorhinus canicula* in the OTB Basque fleet in Subarea VIII (2000–2004 and 2011–2013).

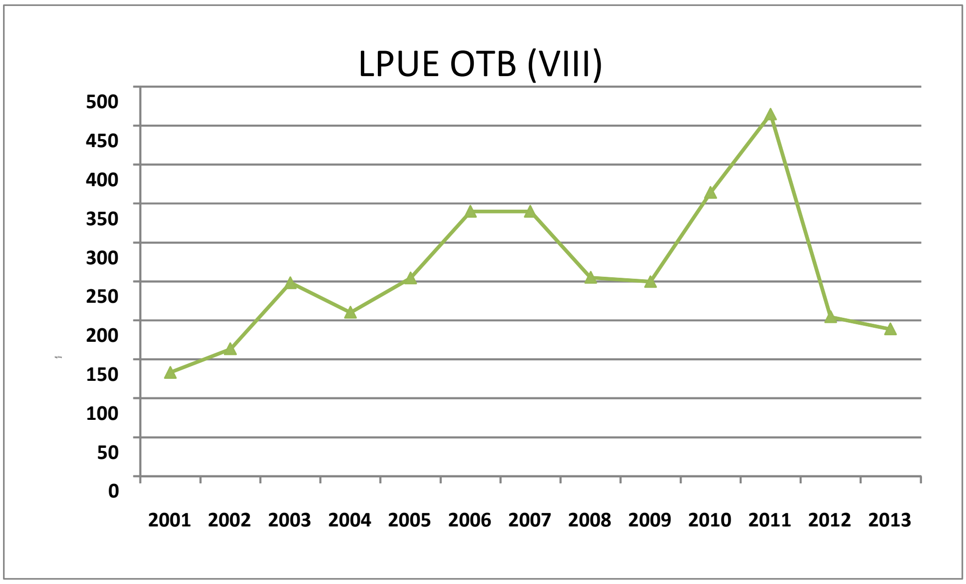


Figure 25.3. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Nominal lpue (kg/day) of *S. canicula* by the OTB Basque fleet in Subarea VIII from 2001 to 2013.

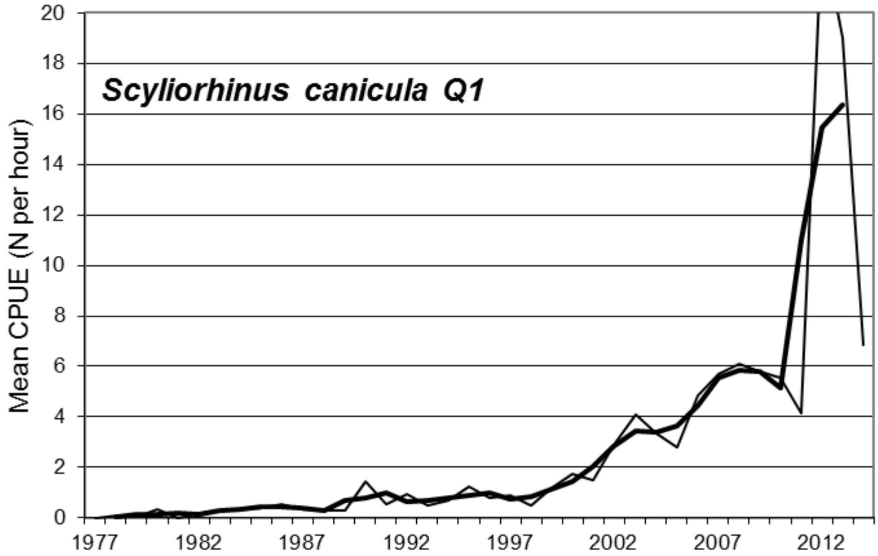


Figure 25.4a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Average catch of *Scyliorhinus canicula* (N per hour) and three year running mean during the North Sea IBTS-Q1 in the years 1977–2014 in roundfish Areas 1–7. Data extracted from the DATRAS database (selected for cpue per length per statrec) on 19th June 2014.

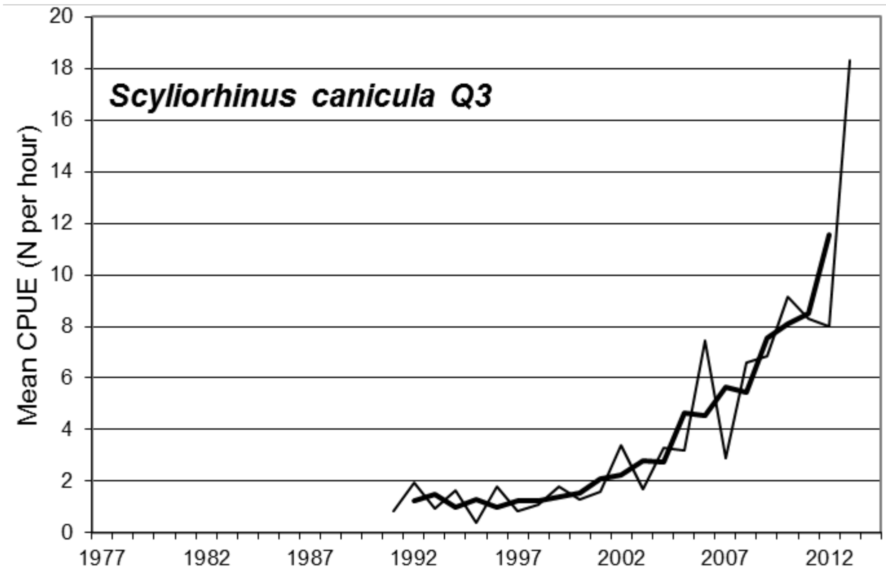


Figure 25.4b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Average catch of *Scyliorhinus canicula* (N per hour) and three year running mean during the North Sea IBTS-Q3 in roundfish Areas 1–7. Data extracted from the DATRAS database (selected for cpue per length per statrec) on 19th June 2014.

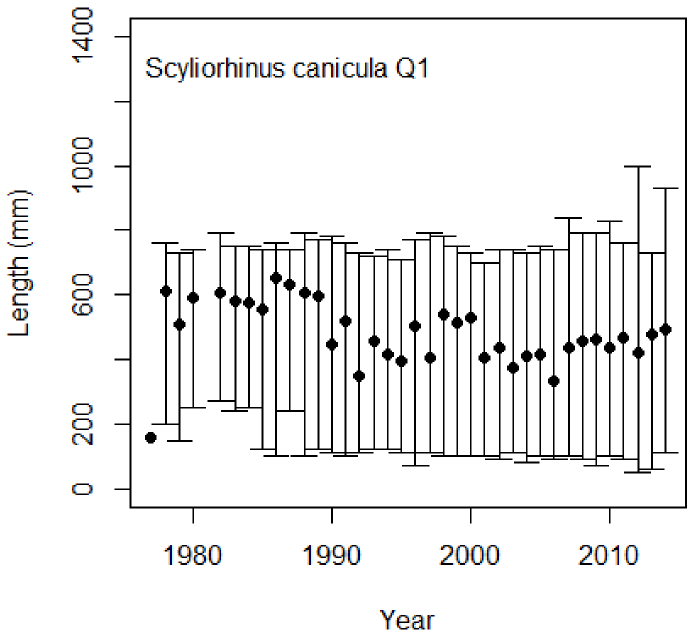


Figure 25.5a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Average length (dots) and length range of *Scyliorhinus canicula* during the North Sea IBTS-Q1 in roundfish Areas 1–7. Data extracted from the DATRAS database (selected for cpue per length per statrec) on 19th June 2014.

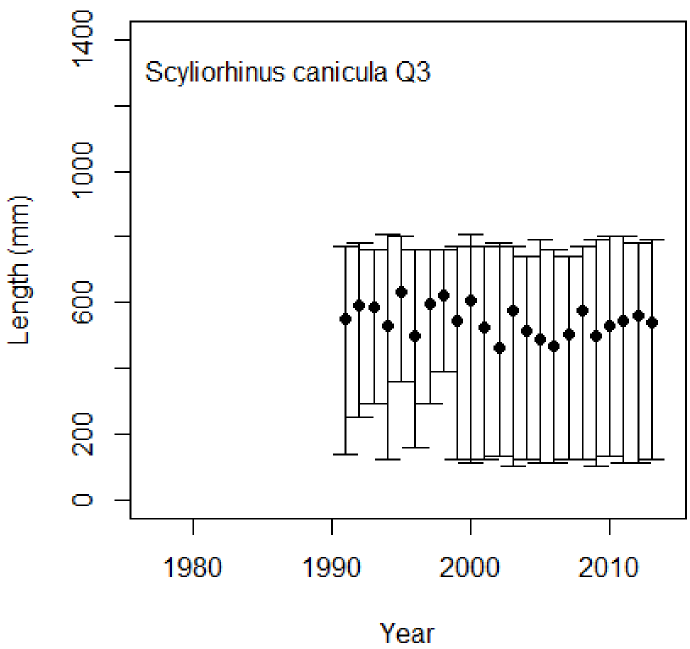


Figure 25.5b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Average length (dots) and length range of *Scyliorhinus canicula* during the North Sea IBTS-Q3 in roundfish Areas 1–7. Data extracted from the DATRAS database (selected for cpue per length per statrec) on 19th June 2014.

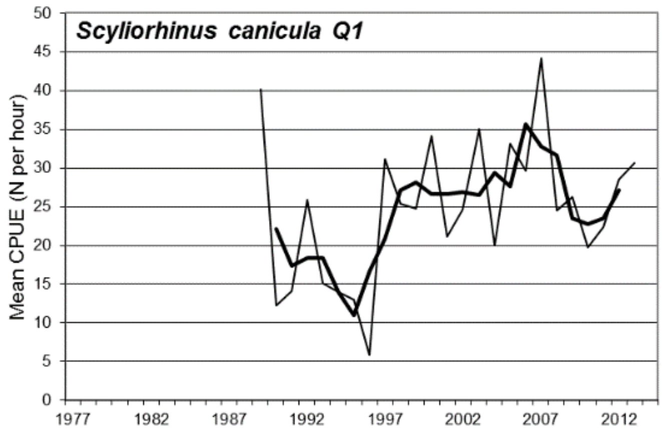


Figure 25.6. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Average catch of *Scyliorhinus canicula* (N per hour) and three year running mean during the Eastern Channel CGFS-Q4 Survey. Data extracted from the DATRAS database (selected for exchange data that were converted to cpue per length per statrec) on 20th June 2014.

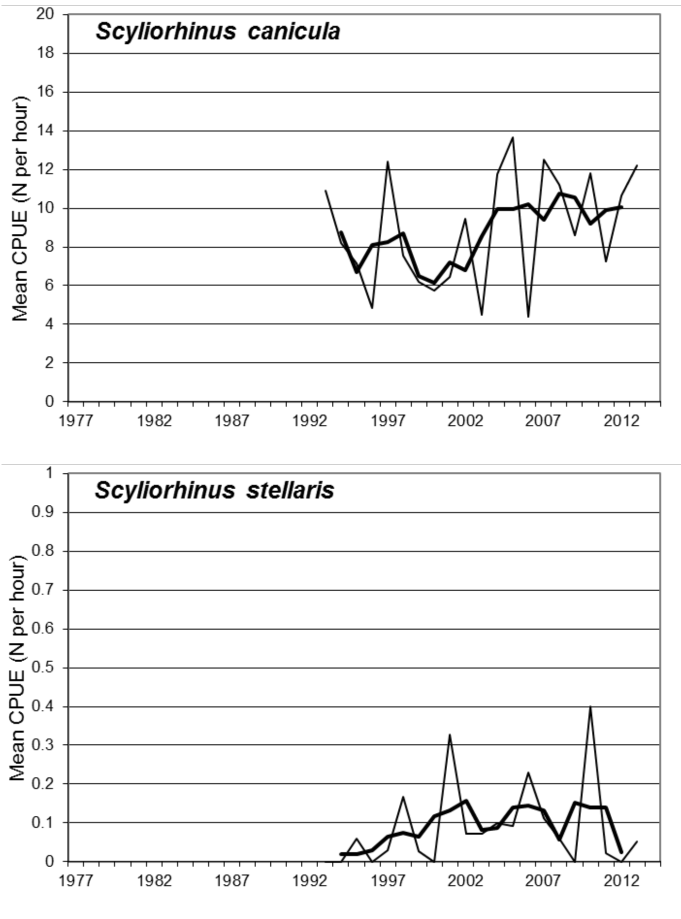


Figure 25.7. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Average catches of *Scyliorhinus canicula* and *S. stellaris* (N per hour) and three year running mean during the UK BTS survey of the English Channel. Data obtained from CEFAS on 20th June 2014.

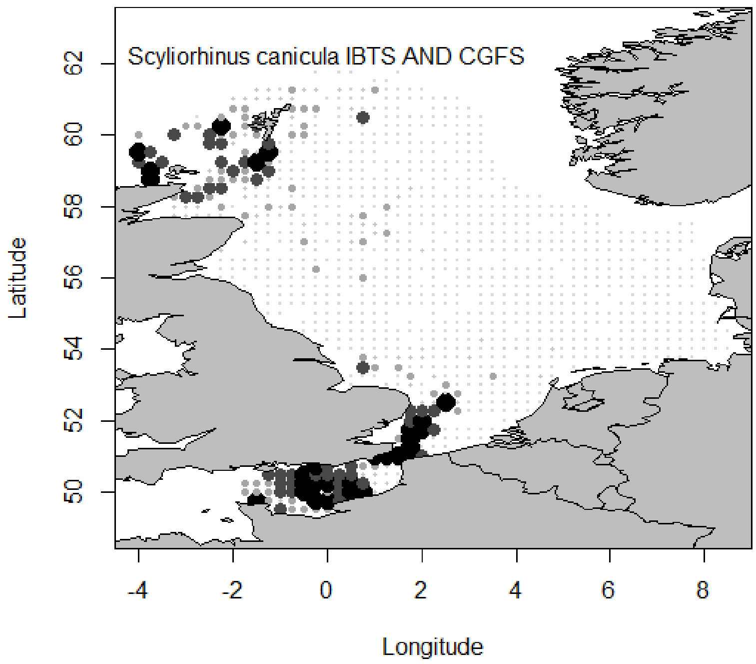


Figure 25.8. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Distribution plot of *Scyliorhinus canicula* based on IBTS Q1, IBTS Q3 (roundfish Areas 1–7), and eastern Channel CGFS Q4 data in the period 1989–2014. All data are abstracted from DATRAS. Data for IBTS were extracted as cpue per length per statistical rectangle) on 19th June 2014, while data for CGFS are extracted as exchange data.

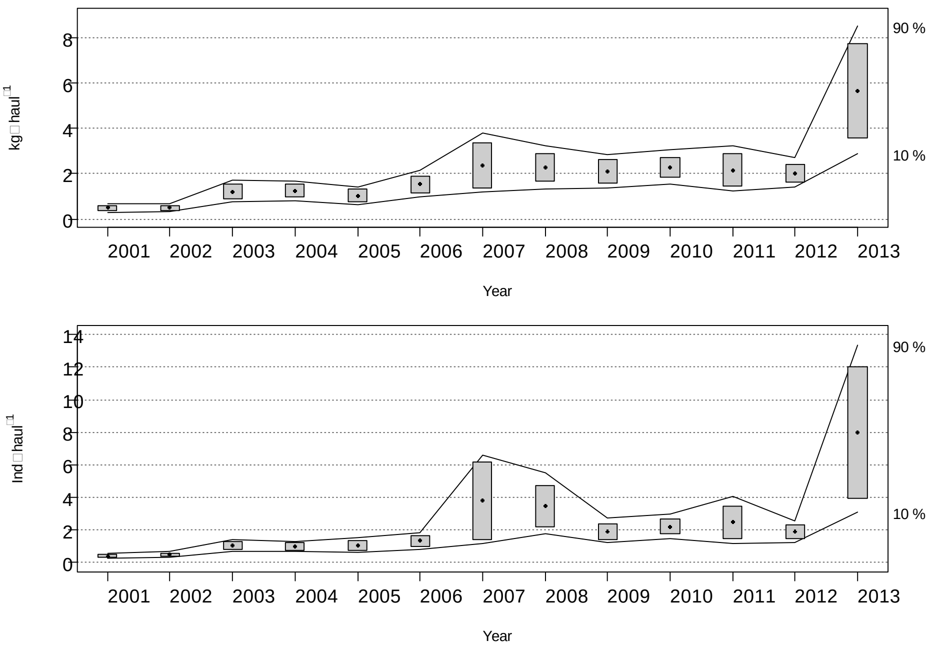
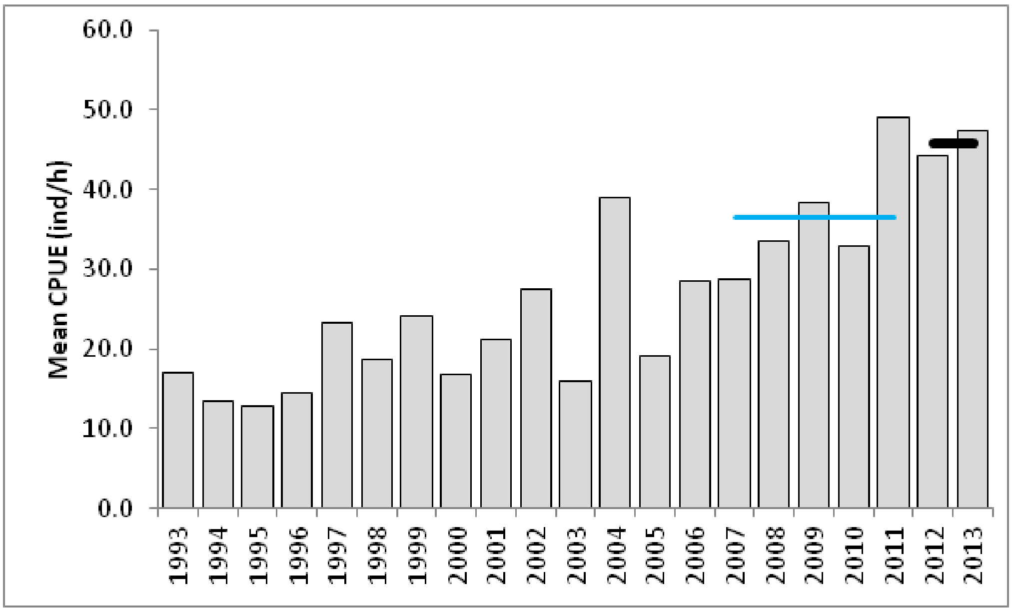


Figure 25.9. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Changes in *Scyliorhinus canicula* biomass index (kg·haul-1) during Porcupine survey time-series (2001–2013). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).



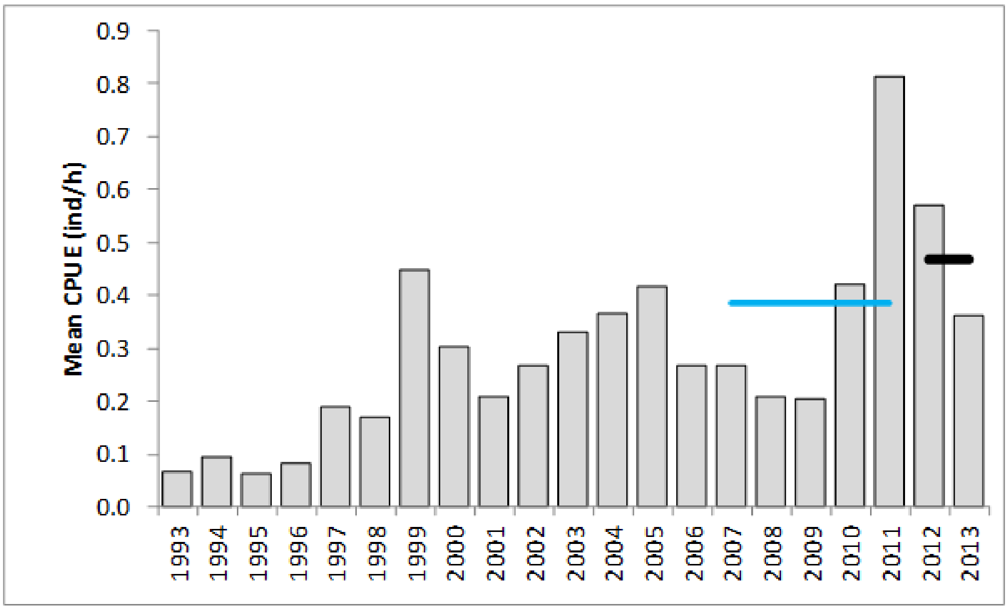


Figure 25.10. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Average catches (N per hour) of *Scyliorhinus canicula* (top) and *S. stellaris* (bottom) in the UK beam trawl survey of the Bristol Channel and Irish Sea (VIIa,f). Black line indicates average of the last two years and the blue line indicates the average catch for the preceding five years.

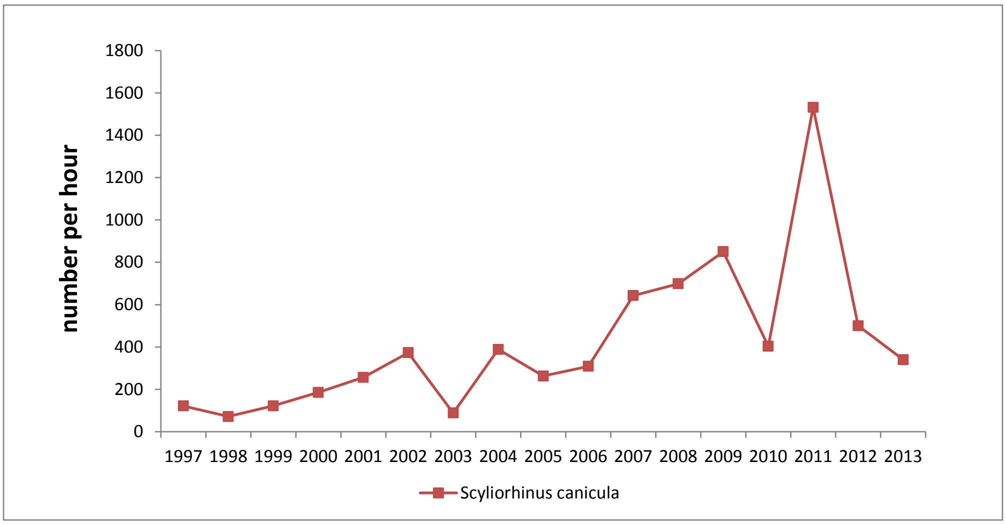


Figure 25.11. Catsharks (Scyliorhinidae) in the Northeast Atlantic. French EVHOE survey indices (number per hour) of *S. canicula* in VIIIabd 1997–2013.

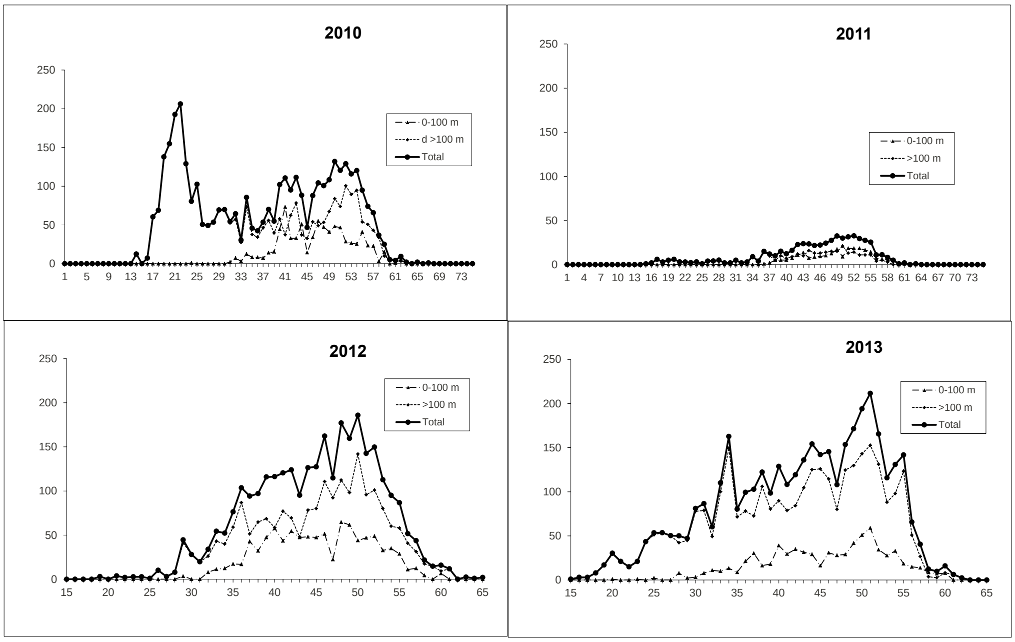


Figure 25.12. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Length distribution of *S. canicula* by depth strata in the ITSASTEKA survey (Eastern VIIIc) from 2010 to 2013.

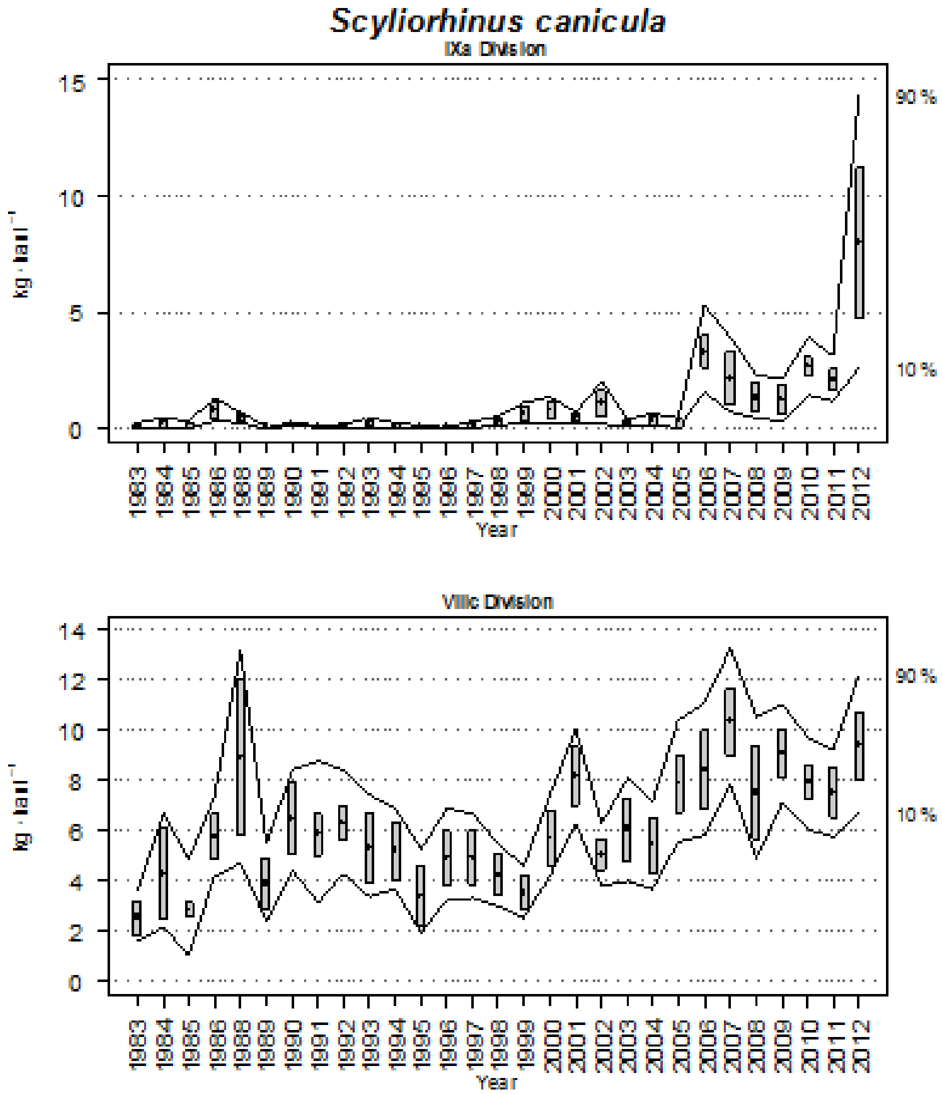


Figure 25.13a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Changes in *Scyliorhinus canicula* biomass index during the North Spanish shelf bottom trawl survey time-series (1983–2011 but in 1987) in the two ICES divisions covered by the survey. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

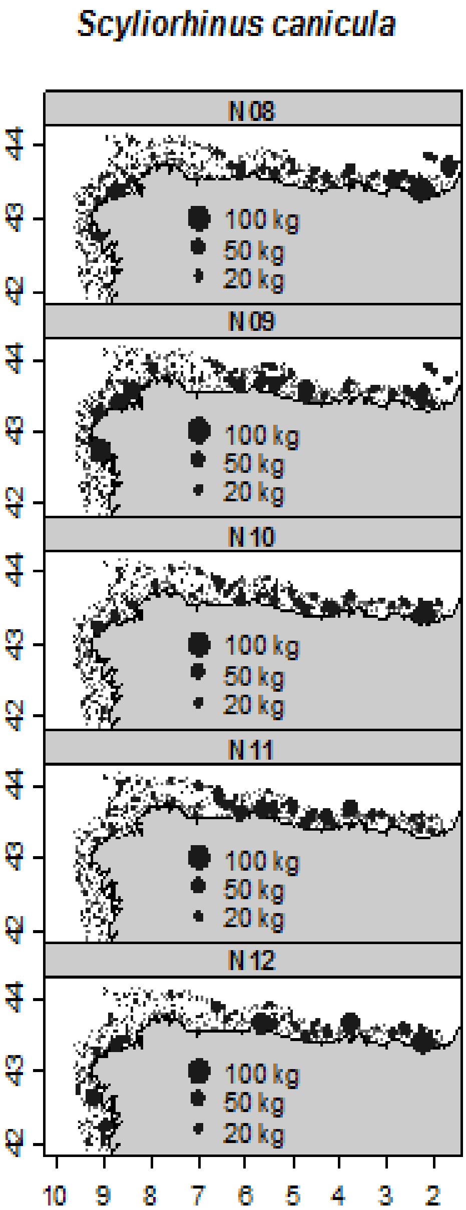


Figure 25.13b. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Geographic distribution of lesser-spotted dogfish (*Scyliorhinus canicula*), catches (kg/30 min haul) in North Spanish Shelf groundfish surveys (2004–2011).

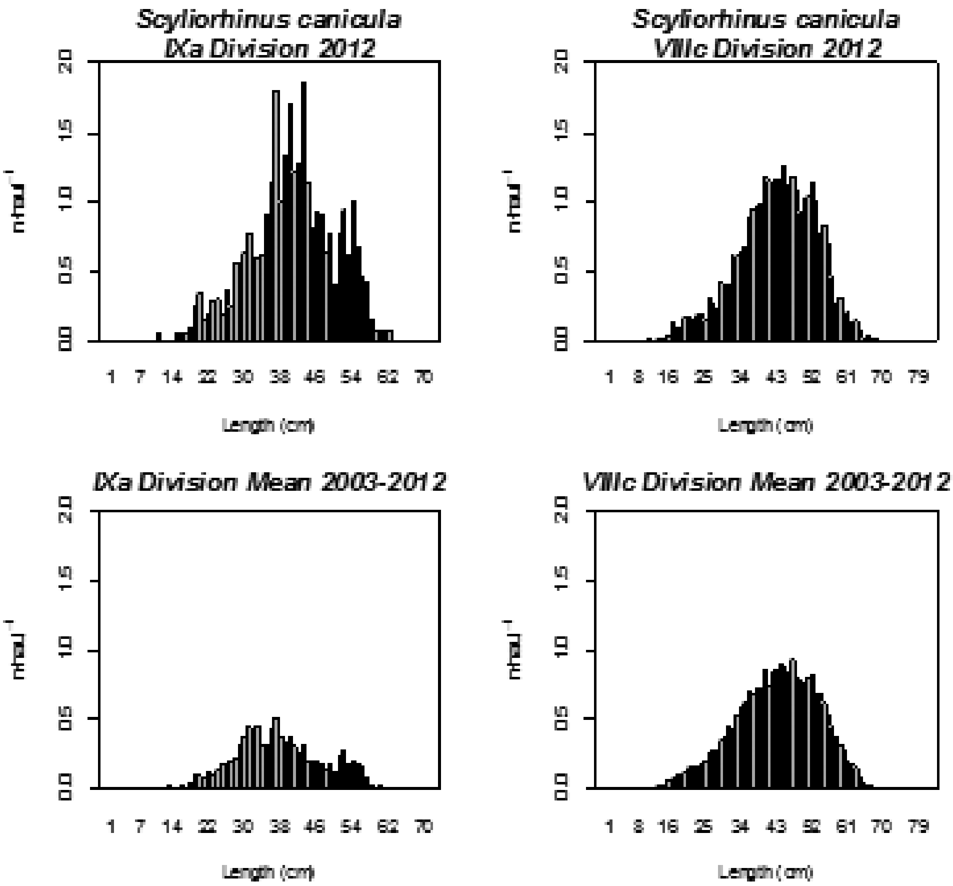


Figure 25.13c. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Stratified length distributions of *Scyliorhinus canicula* in 2011 in the two ICES divisions covered by the North Spanish Shelf bottom trawl survey, and mean values for the last decade in both areas (2000–2010).

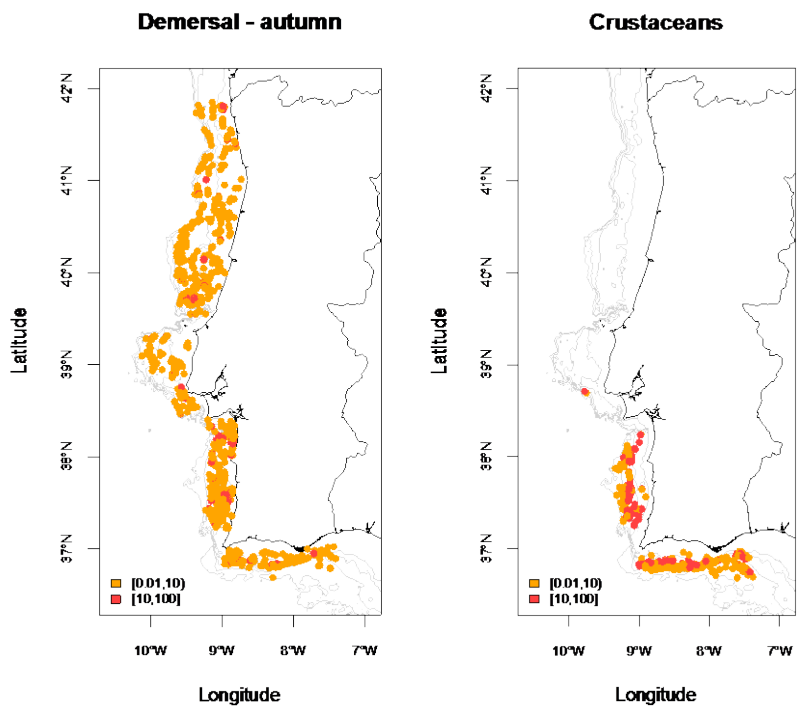


Figure 25.14a. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Total length variation by year (cm) for *Scyliorhinus canicula* in ICES Subarea IXa. Dashed line represents the mean annual length for 1990–2013.

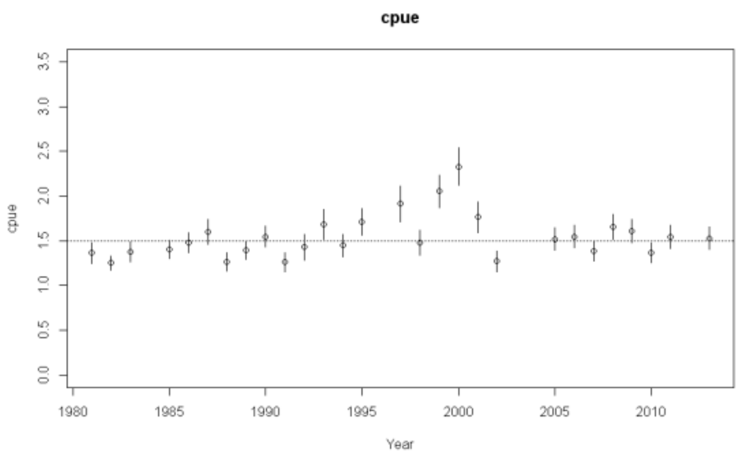


Figure 25.14b. Catsharks (Scyliorhinidae) in the Northeast Atlantic Mean cpue (kg.hour-1) for *Scyliorhinus canicula* in ICES Subarea IXa. Dashed line represents the mean annual abundance for 1981–2013.

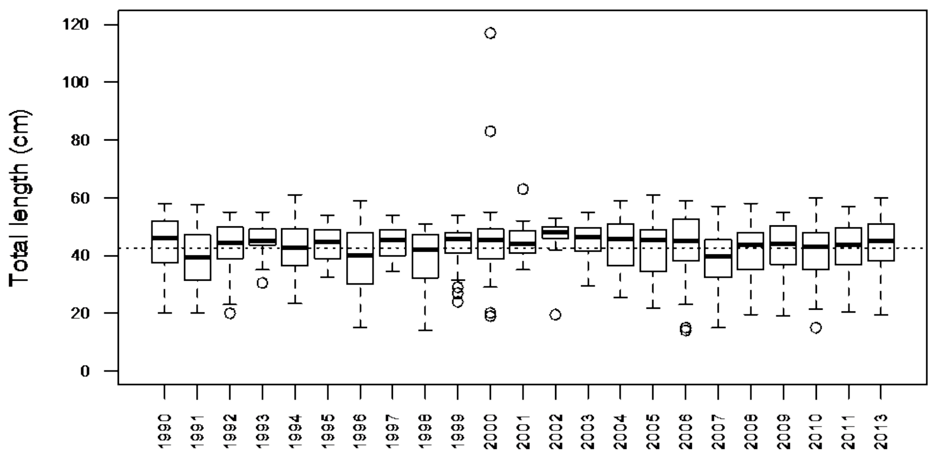


Figure 25.14c. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Total length variation by year (cm) for *Scyliorhinus canicula* in ICES Subarea IXa. Dashed line represents the mean annual length for 1990–2013. Note: There are some erroneous datapoints in the year 2000 that need to be investigated.

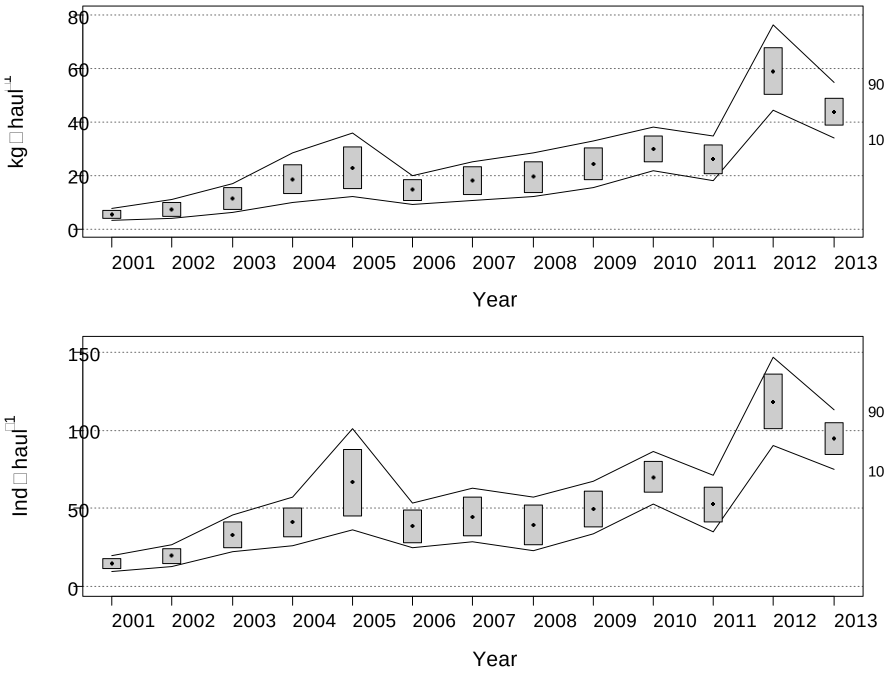


Figure 25.15. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Changes in *Galeus melastomus* biomass index and abundance during Porcupine survey time-series (2001–2013). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

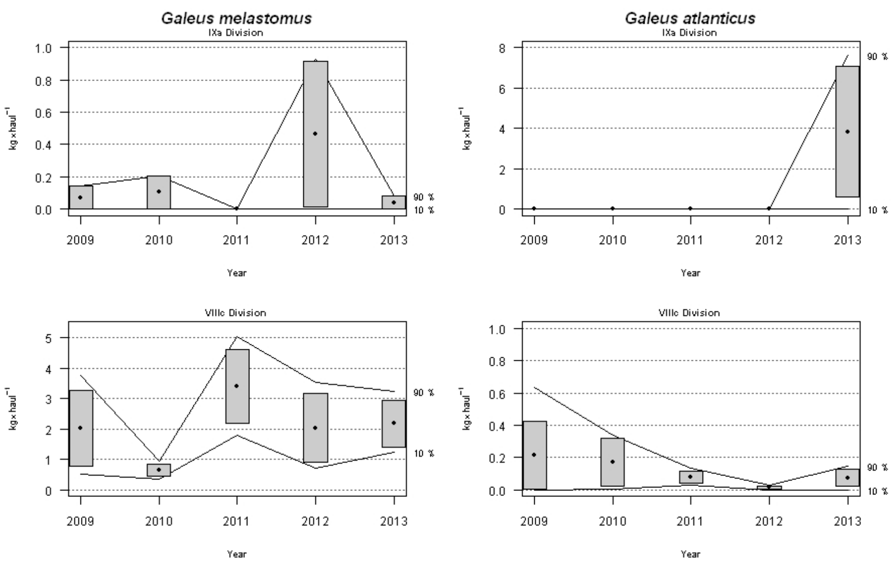


Figure 25.16. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Changes in *Galeus melastomus* and *Galeus atlanticus* stratified biomass index (covering standard hauls between 70 and 500 m) during the North Spanish shelf bottom trawl survey between 2009 and 2013 in the two ICES divisions. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80 bootstrap iterations = 1000).

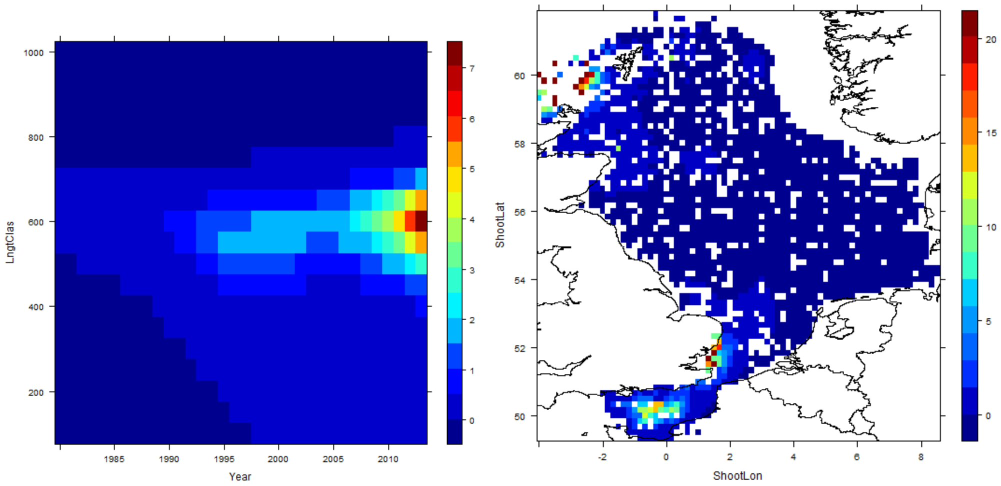


Figure 25.17. Catsharks (Scyliorhinidae) in the Northeast Atlantic. *Scyliorhinus canicula* in the North Sea. Results of GAM analysis of the CGFS, UK BTS, IBTS-Q1, and IBTS Q3 data.

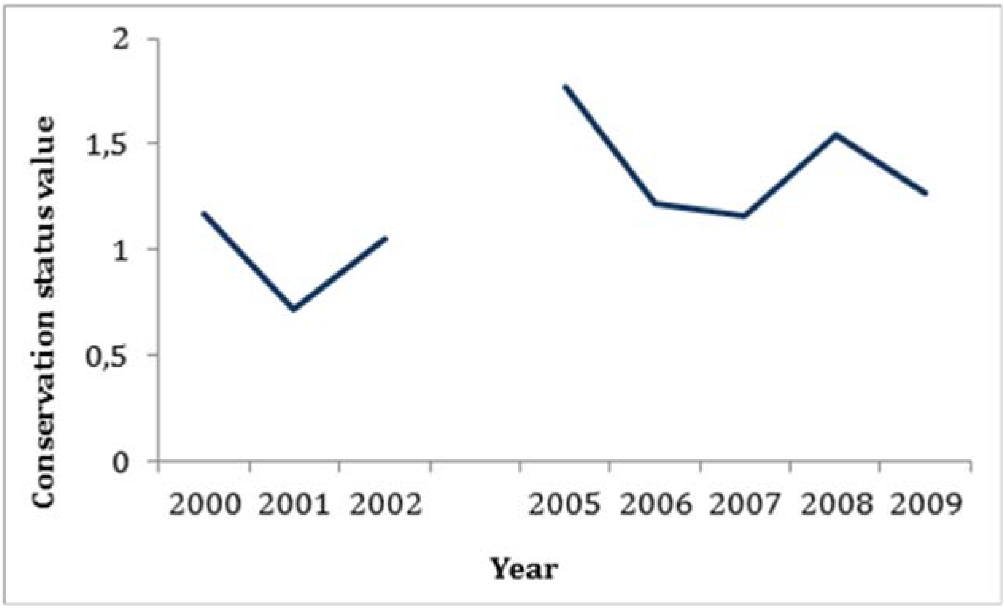


Figure 25.7. Catsharks (Scyliorhinidae) in the Northeast Atlantic. Conservation status of *G. melastomus* in PT-CTS (UWTV (FU 28–29) (IXa).

26 Other issues

26.1 PSA approaches

WGEF also had a term of reference relating to Productivity Susceptibility Analysis (ToR i), which was to: Continue the necessary planning for a future PSA for elasmobranches in the ICES area by i) Reviewing existing approaches; and ii) Intersessionally, compiling the input parameters required for a regional PSA.

The intention of this section is not to review all existing PSA approaches and reiterate the well documented caveats and limitations of the method. This was summarised for data-limited stocks by WKLIFE III (see Section 4.7 of ICES, 2013a), with limitations also discussed by Watling *et al*. (2011) and Devin *et al*. (2012). Issues and limitations for elasmobranchs in the ICES area have also been discussed in McCully *et al.* (2013a, 2013b, Submitted) and Moura *et al.* (2013).

Despite the documented limitations associated with this method, its value lies with using it as a tool for highlighting relative species vulnerabilities, prioritising species of concern in data-limited situations as to which species should be further investigated. The approaches may also be used to evaluate alternative management measures which may influence the 'susceptibility' parameters (e.g. in relation to technical measures, such as changes in mesh size, spatial-temporal management, size restrictions). At a regional level, PSA analyses have to be conducted for all the fisheries operating in the region, as the susceptibilities of the fish will differ. PSA analyses will mainly identify the most vulnerable species for which management is required, which is especially important where several species are managed together as a complex (e.g. skates).

This ToR would be best addressed when the utility of this method, in terms of management within the ICES area, has been identified and a standard, appropriate approach has been established and validated. In the short term, until an evaluation as to how this approach can be used in the ICES advisory process is fulfilled, there seems limited utility in assessing further regions and fisheries in such time consuming, collaborative exercises.

WGEF recommends that before PSA analyses are applied to other areas and fisheries, a case study in which one approach/area/fishery is agreed and the procedures are standardized. A list of potential attributes applied to PSAs on elasmobranch are available (McCully *et al.,* 2013a; 2013b, submitted; Moura *et al.,* 2013).

The group does not advocate PSA as a method to set precautionary buffers, as the merits of what the limits should be set at, and what actually defines a species as 'high', 'medium' or 'low' risk are not clearly defined.

The appropriate scale of PSA was also discussed. Whilst regional PSA of generic fisheries (e.g. beam trawl) operating over broad areas (e.g. Celtic Seas or Greater North Seas ecoregions) can help identify the more vulnerable members of the species complex, such a broad scale means that it is not realistic to critically examine the effects of potential management measures. In practise, the latter will be most appropriate for specific fisheries (métiers) for which the spatial scale and species that may be encountered (target and non-target) are better defined (e.g. some artisanal fisheries).

It was beyond the scope of the working group to determine and evaluate appropriate management measures during the meeting, although these can be advised upon (ICES 2013b, Annex 3). The PSA does not have the power to evaluate all different management options available, as it cannot account for any subsequent changes in fisher behaviour, such as effort displacement. Should management representatives and policy makers ask 'what is the best method to protect the most vulnerable species', potential options could be suggested and scientists and fishers could gauge the possible impacts on the susceptibilities of the relevant species (target and non-target).

WGEF requests feedback from WKLIFE IV and ACOM regarding their perceptions of the utility of this for future applications and how guidelines as to how specific methods, approaches and input parameters can be rationalised or standardised.

26.2 References

Devine, J. A., Watling, L., Cailliet, G., Drazen, J., Durán Muñoz, P., Orlov, A. M. and Bezaury, J. 2012. Evaluation of potential sustainability of deep-sea fisheries for grenadiers (Macrouridae). Journal of Ichthyology, 52: 709–721.

ICES. 2013a. Report of the Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other key parameters for Data-limited Stocks (WKLIFE III), 28 October–1 November 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:35. 98 pp.

ICES. 2013b. Report of the Working Group on Elasmobranch Fishes (WGEF), 17–21 June 2013, Lisbon, Portugal. ICES CM 2013/ACOM:19. 649 pp.

McCully, S.R., Scott, F., Ellis, J.R., Pilling, G.M. 2013a. Productivity and Susceptibility Analysis: Application and suitability for data poor assessment of elasmobranchs in Northern European seas. Collective Volume of Scientific Papers ICCAT, 69: 1679–1698.

McCully, S.R., Scott, F., and Ellis, J.R. 2013b. Productivity Susceptibility Analyses: A method for Producing Skate Advice in ICES? Working Document to ICES Workshop WKLIFE III, Copenhagen, October 28 to November 1, 2013.

McCully, S.R., Scott, F., and Ellis, J.R. Submitted. Having Confidence in Productivity Susceptibility Analyses: A method for Underpinning Scientific Advice on Skate Stocks? Fisheries Research.

Moura, T, Prista, N., and Figueiredo, I. 2013. Productivity-susceptibility analysis of the by-catch species taken in the deepwater longline fishery from Portugal mainland. Working Document for the ICES Working Group on Elasmobranch Fishes. Lisbon, 17–21 June 2013.

Watling, L., Haedrich, R. L., Devine, J., Drazen, J., Dunn, M. R., Gianni, M., Baker, K., *et al.* 2011. Can ecosystem-based deep-sea fishing be sustained? Report of a Workshop held 31 August–3 September 2010. Neuville-Bosc, France (available at http://digitalcommons.library.umaine.edu/sms_facpub/145/).

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Annex 2: WGEF Stock Annexes

The following stock annexes are included in the WGEF report 2014.

STOCK ID	STOCK NAME
dgs-nea	Spurdog in the Northeast Atlantic
por-nea	Porbeagle in the Northeast Atlantic (Subareas I–XIV)
rjb-89a	Common skate (*Dipturus batis*-complex) in Subarea VIII and Division IXa (Bay of Biscay and Atlantic Iberian waters)
rjc-bisc	Thornback ray (*Raja Clavata*) in the Bay of Biscay VIIIa–c
rjc-echw	Thornback ray (*Raja clavata*) in Division VIIe
rjc-pore	*Raja clavata* in Western Iberian Waters (west of Galicia, Portugal, and
Gulf of Cadiz) (ICES Division IXa)	June 2014
rje-ech	Small-eyed ray (*Raja microocellata*) in Divisions VIId,e (English Channel)
rjh-pore	*Raja brachyura* in Western Iberian Waters (west of Galicia, Portugal, and Gulf of Cadiz) (ICES Division IXa)
rjm-bisc	Spotted ray (*Raya montagui*) in the Bay of Biscay
rjm-pore	*Raja montagui* in Western Iberian Waters (west of Galicia, Portugal, and Gulf of Cadiz) (ICES Division IXa)
rjn-bisc	Cuckoo ray (*Leucoraja naevus*) in Subarea VIII (Bay of Biscay and Cantabrian Sea)
rjn-pore	*Leucoraja naevus* in Western Iberian Waters (west of Galicia, Portugal and Gulf of Cadiz) (ICES Division IXa)
rju-9a	*Raja undulata* in Western Iberian Waters (west of Galicia, Portugal, and Gulf of Cadiz) (ICES Division IXa)
rju-ech	Undulate ray (*Raja undulata*) in Divisions VIId,e (English Channel)

Spurdog in the Northeast Atlantic

Stock distribution

Spurdog, *Squalus acanthias*, has a worldwide distribution in temperate and boreal waters, and occurs mainly in depths of 10–200 m. In the NE Atlantic this species is found from Iceland and the Barents Sea southwards to the coast of Northwest Africa (McEachran and Branstetter, 1984).

WGEF considers that there is a single NE Atlantic stock ranging from the Barents Sea (Subarea I) to the Bay of Biscay (Subarea VIII), and that this is the most appropriate unit for assessment and management within ICES.

Spurdog in Subarea IX may be part of the NE Atlantic stock, but catches from this area are likely to consist of a mixture of *Squalus* species, with increasing numbers of *Squalus blainville* further south. The relationships between the main NE Atlantic stock and populations in the Mediterranean are unclear.

In the ICES area, this species exhibits a complex migratory pattern. Norwegian and British tagging programmes conducted in the 1950s and 1960s focused on individuals captured in the northern North Sea. These were regularly recaptured off the coast of Norway, indicating a winter migration from Scotland, returning in summer (Aasen, 1960; 1962). Other tagging studies in the English Channel indicated summer movement into the southern North Sea (Holden, 1965). Few individuals tagged in this more southerly region were recaptured in the north and vice-versa and therefore at this time, distinct Scottish-Norwegian and Channel stocks were believed to exist. A tagging study initiated in the Irish and Celtic Seas in 1966 yielded recaptures over 20 years from all round the British Isles and suggests that a single NE Atlantic stock is more likely (Vince, 1991). Transatlantic migrations have occurred (e.g. Templeman, 1976), but only occasionally, and therefore it is assumed that there are two separate North Atlantic stocks.

No studies have been conducted using parasitic markers and only preliminary studies on population genetics, to identify spurdog stocks. Data on morphometrics/meristics are inadequate for stock identification. The conclusions drawn about stock identity are therefore based solely on the tagging studies described above.

The fishery

Historically, spurdog was a low-value species and in the 1800s was considered as a nuisance to pelagic herring fisheries, both as a predator and through damage to fishing nets. However, during the first half of the 20th century, this small shark became highly valued, both for liver oil and for human consumption, and NE Atlantic spurdog was increasingly targeted. By the 1950s, targeted spurdog fisheries were operating in the Norwegian Sea, North Sea and Celtic Seas. Landings peaked at a total of over 60 000 tonnes in the 1960s (See Figure 2.1; Table 2.1 in 2010 Report) and since then have declined, except for a brief period during the 1980s when targeted gillnet and longline fisheries along the west coasts of Ireland and in the Irish Sea developed.

In more recent years, an increasing proportion of the total spurdog landings are taken as bycatch in mixed demersal trawl fisheries. The larger, offshore longline vessels that targeted spurdog around the coasts of the British Isles have stopped, although there are landings from gillnet and longline fisheries, which are often undertaken in seasonal, inshore fisheries.

The main exploiters of spurdog have historically been France, Ireland, Norway and the UK (see Figure 2.2 and Table 2.21 in 2010 Report). The main fishing grounds for the NE Atlantic stock of spurdog are the North Sea (IV), West of Scotland (VIa) and the Celtic Seas (VII) and, during the decade spanning the late 1980s to 1990s, the Norwegian Sea (II) (see Figure 2.3 and Table 2.3 in 2010 Report). Outside these areas, landings have generally been low.

In the UK (E&W), more than 70% of spurdog landings were taken in line and gillnet fisheries in 2005, with most landings coming from Subarea VII and in particular the Irish Sea. Such fisheries are likely to be closer inshore and may be targeting aggregations of mature female spurdog. The introduction of a bycatch quota deterred such target fisheries in both Subareas IV and VII in 2008 and 2009.

Scottish landings of spurdog in 2009 mainly came from the mixed demersal trawl and seine fisheries in the North Sea and to the West of Scotland. Less than 1% of landings were taken by other gears , compared with more than 20% taken by longliners in 2007. It seems likely that this reduction has been due to the extension of the 5% bycatch regulation to the West of Scotland region in 2008 and potentially due to the implementation of limits on the maximum landings size (100 cm) in 2009 to deter target fisheries.

The Irish fishery for spurdog consists mainly of bottom otter trawlers, and less than 30% of landings coming from longline and gillnet fisheries. Most landings are reported from Division VIa and Division VIIg. From April 2008 there has been no directed spurdog fishery in Irish waters.

Over 70% of Norwegian spurdog landings in 2009 were taken in gillnet fisheries operating in Subareas IIa, IIIa and IVa. In Subarea IIIa, a significant component of the landings (> 40%) was taken as bycatch by shrimp trawlers. The remainder of the landings are taken in line fisheries and to a lesser extent, other trawl fisheries.

Catch data

Landings

Total annual landings (over a 60 year time period), as estimated by the WG for the NE Atlantic stock of spurdog are given in the WGEF Report 2010.

A number of generic categories are used in the logbooks which may include some spurdog. The estimates of total landings made by the WG (and used in the Stock Assessment) are therefore based on expert judgement and the process for obtaining these estimates is described below:

> 1903–1960: Landings data from the *Bulletin Statistique* for the category “Dogfish, etc.” have been assumed to be comprised entirely of spurdog. Landings of other dogfishes (e.g. tope and smooth hound) are assumed to be a negligible component of these catches, as these species are typically discarded in the stock area.
>
> 1961–1972: Landings data from the *Bulletin Statistique* for the categories “Picked dogfish” and “Dogfishes and hounds” have been used, and assumed to be comprised almost entirely of spurdog. Landings of other dogfishes (e.g. tope and smooth hound) are assumed to be a negligible component of these catches, as these species are typically discarded in the stock area. No country

consistently reported both of these dogfish categories in proportions that would be consistent with the nature of the fisheries. Fisheries for deep-water sharks were not well established in the stock area in this period.

1973–present: Landings data from the ICES database were used, and these data included species-specific data for spurdog and some of the data from the appropriate generic categories (i.e. *Squalus* spp, Squalidae, Dogfishes and hounds, and Squalidae and Scyliorhinidae). National species-specific data for Iceland (1980–2002), Germany (1995–2002) and Ireland (1995–2002) were used to update data from the ICES database (ICES, 2003). The following assumptions were made regarding generic categories, based on the judgement of WG members.

Belgian landings of *Squalus* spp. were assumed to be spurdog.

Landings of Squalidae from ICES Subareas I–V and VII (except French landings) were assumed to be spurdog on the basis that fisheries for other squaloids (i.e. deep-water species) were not well developed in these areas over the period of reported landings. Landings of Squalidae from ICES Subarea VI were assumed to be spurdog for early period and for nations landings low quantities. The increase in French and German landings of Squalidae in this area after 1991 and 1995 respectively were assumed to be comprised of deep-water squaloid sharks. Similarly, French landings from ICES Divisions VIIb–c (all years), VIIg–k (1991 onwards) and VIII (all years) were assumed to be deep-water sharks. Landings of Squalidae from areas further south were excluded as they were out of the stock area and were likely comprised of deep-water species.

Landings of "dogfishes and hounds" from Areas VIIa and VIII were assumed to be spurdog. Landings of this category from other areas were generally low and excluded, with the assumption that spurdog contained in this category would be negligible.

French data were lacking from the ICES database and Bulletin Statistique for the years (1966–1967 and 1969–1977 inclusive), and these data were estimated from "Statistique des Peches Maritimes". As only aggregated shark landings were available for these years, spurdog landings were assumed to comprise 53% of the total shark landings, as spurdog comprised 50–57% of shark landings in subsequent years.

Discards

Estimates of total amount of spurdog discarded are not routinely provided although some discard sampling does take place.

Some preliminary elasmobranch discard estimates from the Basque fleets operating in Subareas VI, VII and VIII were presented in Diez *et al*., (2006, WD). Initial studies found no discarding of spurdog by the Baka trawler fleets.

A recent study on the estimated short-term discard mortality of otter trawl captured spurdog in the NW Atlantic demonstrated that mortality 72 h after capture was in some cases well below the currently estimated 50% for trawling (Mandelman and Farrington, 2006). When catch-weights exceeded 200 kg, there were increases in 72 h mortality that more closely approached prior estimates, indicating that as tows become more heavily packed, there was a greater potential for fatal damage to be inflicted. It should be noted that tow duration in this study was only 45–60 minutes, and additional studies on the discard survivorship in various commercial gears are required, under various deployment times.

Discard survival from liners is unknown, and may depend on hook type, where the fish is hooked and also whether there is a bait stripper. Spurdog with broken jaws (i.e. possibly have gone through a bait stripper) have been observed (Ellis, pers. obs.) with healed wounds, although quantitative data are lacking.

Quality of catch data

In addition to the problems associated with obtaining estimates of the historical total landings of spurdog due to the use of generic dogfish landings categories, anecdotal information suggests that widespread misreporting by species may have contributed significantly to the uncertainties in the overall level of spurdog landings.

Under-reporting may have occurred in certain ICES areas when vessels were trying to build up a track record of other species, for example deep-water species. It has also been suggested that over-reporting may have occurred where stocks with highly restrictive quotas have been recorded as spurdog. However, it is not possible to quantify the amount of under and over-reporting that has occurred. The introduction of UK and Irish legislation requiring registration of all fish buyers and sellers may mean that these misreporting problems have greatly declined since 2006.

It is not known whether the 5% bycatch ratio has lead to any misreporting or reporting under generic landings categories, although the buyers and sellers legislation should deter this and so the bycatch ratio may have resulted in more discarding.

Commercial catch composition

Length compositions

Sex disaggregated length frequency samples are available from UK (E&W) for the years 1983–2001 and UK (Scotland) for 1991–2004 for all gears combined. Scottish data are available for the North Sea and West of Scotland separately while the English data are all areas combined. The two sets of Scottish length frequency distributions (IV and VIa) are very similar and these have therefore been combined to give a 'total' Scottish length frequency distribution. Typically these appear to be quite different from the length frequency distributions obtained from the UK (E&W) landings, with a much larger proportion of small females being landed by the Scottish fleets. The length distributions of the male landings appear to be relatively similar. Figure 1 shows landings length frequency distributions averaged over five year intervals. The Scottish data have been raised to total Scottish reported landings of spurdog while the UK (E&W) data have only been raised to the landings from the sampled boats.

Raw market sampling data were also provided by Scotland for the years 2005–2008. However, sampled numbers have been low in recent years (due to low landings) and use of these data was not pursued.

Discard length compositions

There are no international estimates of discard length frequencies.

Discard length frequencies have previously been provided by UK (E & W) for fisheries operating in the Celtic Seas (Subareas VI–VII) and North Sea (Subarea IV), as observed for the years 1999–2006 (Figure 2). The data for beam trawl, demersal trawl and drift/fixed net fisheries indicate that most spurdog are retained, although juveniles (e.g. individuals <45–50 cm) tend to be discarded, which agrees with data from market sampling. Data were limited for seine and longline fisheries.

Quality of data

Length frequency samples are only available for UK landings and these are aggregated into broader length categories and have been used in the previously presented assessments. No data were available from Norway, France or Ireland who are the other main exploiters of this stock. Over the past 20 years, UK landings have on average accounted for approximately 45% of the total. However, there has been a systematic decline in this proportion since 2005 and the UK landings in 2008 represented less than 20% of the total. It is not known to what extent the available commercial length–frequency samples are representative of the catches by these other nations.

Commercial catch-effort data

No studies of commercial cpue data have been undertaken.

Fishery-independent information

Availability of survey data

Fishery-independent survey data are available for most regions within the stock area. The following survey data are available to this group:

UK (England & Wales) Q1 Celtic Sea groundfish survey: years 1982–2002.

UK (England & Wales) Q4 Celtic Sea groundfish survey: years 1983–1988.

UK (England & Wales) Q3 North Sea groundfish survey 1977–2009.

UK (England & Wales) Q4 SWIBTS survey 2004–2009 in the Irish and Celtic Seas.

UK (NI) Q1 Irish Sea groundfish survey 1992–2009.

UK (NI) Q4 Irish Sea groundfish survey 1992–2009.

Scottish Q1 west coast groundfish survey: years 1990–2009.

Scottish Q4 west coast groundfish survey: years 1990–2009.

Scottish Q1 North Sea groundfish survey: years 1990–2009.

Scottish Q3 North Sea groundfish survey: years 1990–2009.

Irish Q3 Celtic Seas groundfish survey: years 2003–2009.

Both Ireland and UK (England and Wales) now participate in the fourth quarter westerly IBTS surveys, and further studies of these data will be undertaken in 2010.

Cpue

The overall trends in the various surveys examined in previous meetings have indicated a trend of decreasing occurrence and decreasing frequency of large catches (Figures 3 and 4), with catch rates also decreasing, although catch rates are highly variable (ICES, 2006).

Length distributions

Length distributions were analysed from survey data made available to the group in 2009. The UK (E&W) Q4 SWIBTS exhibits annual differences in length frequency distributions of spurdog caught. In 2005 the mean length frequency of females and males was higher than previous and preceding years. In 2008 relatively larger numbers of juveniles <55 cm were caught in the survey (Figure 5).

The length frequency distributions obtained from the UK(NI) Q4 GFS survey demonstrate a large proportion of larger fish (>85 cm) which are likely to be mature females (males are smaller) (Figure 6), although sex disaggregated data are only available since 2006 (Figure 7–8). A large haul of predominantly large females was caught in 2008 which has influenced the pattern of the length frequencies from this survey (Figure 8).

Length frequencies generated from the Irish Q3 GFS survey suggest spatial as well as temporal variation in the size distributions (Figure 9). Catches in the southern region of the survey area (VIIg) tended to consist of smaller individuals, while larger individuals were the dominant component in the remaining areas.

Presence of Pups

Pups of spurdog (individuals ≤25 cm) are caught in many of the surveys, although generally in very small numbers. Although catches of pups tend to be low and may not be accurate indicators of recruitment, the location of catches may indicate possible pupping grounds or nursery areas. The location of survey hauls were spurdog pups (individuals ≤25 cm) were present was plotted for data from the North Sea (Figure 10).

Seasonal distributions of spurdog catches in VIIa(N) and VIA(S) by biomass and numbers have been plotted from survey data in the area (Figure 11).

Biological parameters

Life-history information

Although there have been several studies in the North Atlantic and elsewhere describing the age and growth of spurdog (Holden and Meadows, 1962; Sosinski, 1977; Hendersen *et al*., 2001), routine ageing of individual from commercial catches or surveys is not carried out.

WGEF assumes the following sex-specific parameters in the length–weight relationship ($W=aL^b$) for NE Atlantic spurdog (Coull *et al*., 1989):

	A	B
Female	0.00108	3.301
Male	0.00576	2.89

where length is measured in cm and weight in grammes.

The proportion mature-at-length was assumed to follow a logistic ogive with 50% maturity at 80 cm for females and 64 cm for males. Values of female length at 50% maturity from the literature include 74 cm (Fahy, 1989), 81cm (Jones and Ugland, 2001) and 83 cm (Gauld, 1979).

The WG has assumed a linear relationship between fecundity (F) and total length (L):

F = 0.344.L–23.876 (Gauld, 1979).

More recent information on the fecundity length relationship of spurdog caught in the Irish Sea indicates:

F = 0.428.L–31.87 (n=179; Ellis and Keable, 2008).

Natural mortality

Not known, though estimates ranging from 0.1–0.3 have been described in the scientific literature (Aasen, 1964; Holden, 1968). WGEF has assumed a length dependent natural mortality with a value of 0.1 for a large range of ages, but higher values for both very small (young) and large (old) fish.

Recruitment

Ellis and Keable, 2008, reported a maximum uterine fecundity of 21 pups, which was greater than previously reported for NE Atlantic spurdog. It is unclear as to whether this increase is a density-dependent effect or sampling artefact.

Exploratory assessment models

Previous studies

Exploratory assessments undertaken in 2006 included the use of a delta-lognormal GLM-standardized index of abundance and a population dynamic model. This has been updated at subsequent meetings. The results from these assessments indicate that spurdog abundance has declined, and that the decline is driven by high exploitation levels in the past, coupled with biological characteristics that make this species particularly vulnerable to such intense exploitation (ICES, 2006).

Earlier demographic studies on elasmobranchs indicate that low fishing mortality on mature females may be beneficial to population growth rates (Cortés, 1999; Simpfendorfer, 1999). Hence, measures that afford protection to mature females may be an important element of a management plan for the species. As with many elasmobranchs, female spurdog attain a larger size than males, and larger females are more fecund.

Preliminary simulation studies of various Maximum Landing Length (MLL) scenarios were undertaken by ICES, 2006 and suggested that there are strong potential benefits to the stock by protecting mature females. However, improved estimates of discard survivorship from various commercial gears are required to better examine the efficacy of such measures.

Data exploration and preliminary modelling

At the 2006 WG meeting, an analysis of Scottish survey data was presented which investigated methods of standardizing the survey catch rate to obtain an appropriate index of abundance. Following on from this, and the subsequent comments of the most recent Review Group, further analysis was conducted in 2009. The major concern was that given the large differences in size for this species, an index of abundance in Nhr^{-1} was less informative than an index of biomass catch rates. The analysis was updated at the WG in 2009 to address these concerns.

Data from four Scottish surveys listed above (1990–2009) were considered in the analysis (Rockall was not included due to the very low numbers of individuals caught in this survey). The dataset consists of length frequency distributions at each trawl station, together with the associated information on gear type, haul time, depth, duration and location. Each survey dataset used in this analysis contains over 1000 hauls and the North Sea Q3 contains over 1500. For each haul station, catch-rate was calculated: total weight caught divided by the haul duration to obtain a measure of catch-per-unit effort in terms of g/30 min.

The objective of the analysis was to obtain standardized annual indices of cpue (on which an index of relative abundance can be based) by identifying explanatory variables which help explain the variation in catch-rate which is not a consequence of changes in population size. Due to the highly skewed distribution of catch rates and the presence of the large number of zeros, a 'delta' distribution approach was taken to the statistical modelling. Lo *et al*., 1992 and Stefansson, 1996 describe this method which combines two generalized linear models (GLM): one which models the probability of a positive observation (binomial model) and the second which models the catch rate conditioned on it being positive assuming a lognormal distribution. The overall year effect (annual index) can then be calculated by multiplying the year effects estimated by the two models.

The analysis was conducted in stages: initially each survey was considered separately then the model fitted to all survey data combined. Because the aim was to obtain an index of temporal changes in the cpue, year was always included as a covariate (factor) in the model. Other explanatory variables included were area (Scottish demersal sampling area, see Dobby *et al*., 2005 for further details) and month and interactions terms were also investigated. Variables which explained greater than 5% of the deviance were retained in the model. All variables were included as categorical variables.

Stock assessment

Introduction

The exploratory assessment for spurdog presented in 2006 (ICES, 2006) has been extended to account for further years of landings data, updated statistical analyses of survey data, a split of the largest length category into two to avoid too many animals being recorded in this category, and fecundity data sets from two periods (1960 and 2005). The statistical analysis of survey data provides a delta-lognormal GLM-standardised index of abundance (with associated CVs), based on Scottish groundfish surveys. The exploratory assessment assumes two "fleets", with landings data split to reflect a fleet with Scottish selectivity (non-target), and one with England & Wales selectivity (target). The non-target and target selectivities were estimated by fitting to proportions-by-length-category data derived from Scottish and England & Wales commercial landings data bases.

The assessment is based on an approach developed by Punt and Walker (1998) for school shark (*Galeorhinus galeus*) off southern Australia (De Oliveira et al., 2013). The approach is essentially age- and sex-structured, but is based on processes that are length-based, such as maturity, pup-production, growth (in terms of weight) and gear selectivity, with a length–age relationship to define the conversion from length to age. Pup-production (recruitment) is closely linked to the numbers of mature females, but the model allows deviations from this relationship to be estimated (subject to a constraint on the amount of deviation).

The implementation for spurdog was coded in AD Model Builder (Otter Research).

The approach is similar to Punt and Walker (1998), but uses fecundity data from two periods (1960 and 2005) in an attempt to estimate the extent of density-dependence in pup-production (a new feature compared to ICES, 2006) and fits to the Scottish groundfish surveys index of abundance, and proportion-by-length-category data from both the survey and commercial catches (aggregated across gears) (De Oliveira et al., 2013). Five categories were considered for the survey proportion-by-length-category data, namely length-groups 16–31 cm (pups); 32–54 cm (juveniles); 55–69 cm (sub-adults); and 70–84 cm (maturing fish) and 85+ cm (mature fish). The first two categories were combined for the commercial catch data to avoid zero values.

A closer inspection of the survey proportions-by-length-category data showed a greater proportion of males than females in the largest two length categories. This could indicate a lower degree of overlap between the distribution of females and the survey area compared to males, and requires both a separate selectivity parameter to be fitted for the largest two length categories, and the survey proportion-by-length-category data to be fitted separately for females and males. However, the low numbers of animals in the largest length category (85+) resulted in the occurrence of zeros in this length category, so the approach since 2011 has been to combine the two largest length categories (resulting in a total of four length categories: 16–31 cm, 32–54 cm, 55–69 cm, and 70+) when fitting to survey proportions-by-length-category data for females and males separately.

The only estimable parameters considered are the total number of pregnant females in the virgin population ($N_0^{f,preg}$), Scottish survey selectivity-by-length-category (4 parameters), commercial selectivity-by-length-category for the two fleets (6 parameters, three reflecting non-target selectivity, and three target selectivity), extent of density-dependence in pup production (Q_{fec}), and constrained recruitment deviations (1960–2009). Although two fecundity parameters could in principle be estimated from the fit to the fecundity data, these were found to be confounded with Q_{fec}, making estimation difficult, so instead of estimating them, values were selected on the basis of a scan over the likelihood surface. The model also assumes two commercial catch exploitation patterns that have remained constant since 1905, which is an oversimplification given the number of gears taking spurdog, and the change in the relative contribution of these gears in directed and mixed fisheries over time, but sensitivity tests are included to show the sensitivity to this assumption. Growth is considered invariant, as in the Punt and Walker (1998) approach, but growth variation could be included (Punt *et al.*, 2001).

Population dynamics model

The model is presented in De Oliveira et al. (2013), and is largely based on Punt and Walker (1998) and Punt *et al.* (2001).

Basic Dynamics

The population dynamics for spurdog are assumed to be governed by:

$$N^s_{y+1,a} = \begin{cases} \Phi^s R_{y+1} & a=0 \\ (N^s_{y,a-1}e^{-M_{a-1}/2} - \sum_j C^s_{j,y,a-1})e^{-M_{a-1}/2} & 0 < a \le A-1 \\ (N^s_{y,A-1}e^{-M_{A-1}/2} - \sum_j C^s_{j,y,A-1})e^{-M_{A-1}/2} + (N^s_{y,A}e^{-M_A/2} - \sum_j C^s_{j,y,A})e^{-M_A/2} & a=A \end{cases} \quad \text{1a}$$

where $s=f$ or m, Φ^s is the sex ratio (assumed to be 0.5), R_y the recruitment of pups to the population, $N^s_{y,a}$ the number of animals of sex s and age a at the start of year y, M_a the instantaneous rate of natural mortality-at-age a, $C^s_{j,y,a}$ the number of animals caught of sex s and age a in year y by fleet j, and A the plus group (60). Total biomass is then calculated as:

$$B_y = \sum_s \sum_a w^s_a N^s_{y,a} \quad \text{1b}$$

where w^s_a is the begin-year mean weight of animals of sex s and age a.

Recruitment

The number of pups born each year depends on the number of pregnant females in the population as follows:

$$N_{pup,y} = \sum_{a=1}^{A} P'_a P''_a N^f_{y,a} \quad \text{2a}$$

where P'_a is the number of pups per pregnant female of age a, and P''_a the proportion females of age a that become pregnant each year. Q_y, the density-dependence factor that multiplies the number of births in year y, is calculated as follows:

$$Q_y = 1 + (Q_{fec} - 1)(1 - N_{pup,y} / R_0) \quad \text{2b}$$

where Q_{fec} is the parameter that determines the extent of density dependence, and R_0 the virgin recruitment level (see “Initial conditions” below). Recruitment in year y is the product of these two equations, and in order to allow for interannual variation in pup survival rate, “process error” is introduced to give the following:

$$R_y = Q_y N_{pup,y}\, e^{\varepsilon_{r,y}} \quad \text{2c}$$

where the recruitment residuals $\varepsilon_{r,y}$ are estimated (see equation 9a below).

Fecundity

Fecundity, expressed as number of pups per pregnant female of age a, is modelled as follows:

$$P'_a = \begin{cases} 0 & l^f_a < l^f_{mat00} \\ b_{fec}\left(l^f_a + \sqrt{(l^f_a + a_{fec}/b_{fec})^2 + \gamma^2} - \sqrt{(a_{fec}/b_{fec})^2 + \gamma^2}\right)/2 & l^f_a \ge l^f_{mat00} \end{cases} \quad \text{3}$$

where l^f_{mat00} is the female length-at-first maturity (Table 1), and γ is set at 0.001. The bent hyperbola formulation (Mesnil and Rochet, 2010) given in the bottom line of equation 2.3, is to ensure that if parameters a_{fec} and b_{fec} are estimated, P'_a remains non-negative and the function is differentiable for $l_a^f \geq l_{mat00}^f$.

Estimated fishing proportion and catch-at-age

Catches are assumed to be taken in a pulse in the middle of the year, with the fully selected fishing proportion $F_{j,y}$ being estimated from the observed annual catch (in weight) by fleet $C_{j,y}$ as follows:

$$F_{j,y} = \frac{C_{j,y}}{\sum_a e^{-M_a/2} \sum_s w^s_{a+\frac{1}{2}} S^s_{com,j,a} N^s_{y,a}} \qquad \text{4a}$$

where $w^s_{a+\frac{1}{2}}$ is the mid-year mean weight of animals of sex *s* and age *a*, and $S^s_{com,j,a}$ the selectivity-at-age of animals of sex *s* and age *a* caught by fleet *j*. For the purposes of estimating a mean fishing proportion trajectory, the mean effective fishing proportion over ages 5–30 is calculated as follows:

$$F_{prop5-30,y} = \sum_j \frac{1}{26} \sum_{a=5}^{30} \left[\frac{\sum_s S^s_{com,j,a} N^s_{y,a} (F_{j,y} S^s_{com,j,a})}{\sum_s S^s_{com,j,a} N^s_{y,a}} \right] \qquad \text{4b}$$

Catch-at-age (in numbers) is estimated as follows:

$$C^s_{j,y,a} = F_{j,y} S^s_{com,j,a} N^s_{y,a} e^{-M_a/2} \qquad \text{4c}$$

Commercial selectivity

Commercial selectivity-at-age is calculated from commercial selectivity-by-length category parameters as follows:

$$S^{s*}_{com,j,a} = \begin{cases} S_{c2,j} & 16 \leq l^s_a < 55 \\ S_{c3,j} & 55 \leq l^s_a < 70 \\ S_{c4,j} & 70 \leq l^s_a < 85 \\ 1 & l^s_a \geq 85 \end{cases} \qquad \text{5a}$$

so that:

$$S^s_{com,j,a} = S^{s*}_{com,j,a} / \max_j (S^{s*}_{com,j,a}) \qquad \text{5b}$$

where l^s_a is the length-at-age for animals of sex *s*. Selectivity-by-length category parameters $S_{c2,j}$, $S_{c3,j}$ and $S_{c4,j}$ (*j=non-tgt* or *tgt*) are estimated in the model.

Survey selectivity

Survey selectivity-at-age $S^s_{sur,a}$ for animals of sex *s* is calculated in the same manner as commercial selectivity, except that there is only one survey abundance-series (the index *j* is dropped from the above equations) and different length categories (the 16–54 cm category is split into 16–31 and 32–54, and the 70-84 and 85+ categories are combined into a single 70+ category), leading to four selectivity parameters to be estimated (S_{s1}, S_{s2}, S_{s3} and S_{s4}), the first three applying to the smallest length categories (16-31, 32-54 and 55-69), regardless of sex, and the fourth (S_{s4}) to the 70+ category for females only (assuming 1 for males in this length category).

Initial conditions

The model assumes virgin conditions in 1905, the earliest year for which continuous landings data are available, with the total number of pregnant females in the virgin population, $N_0^{f,preg}$, treated as an estimable parameter in the model. Taking the model back to 1905 ensures that the assumption of virgin conditions is more appropriate, although it also implies that exploitation patterns estimated for the most recent period (1980+) are taken back to the early 1900s. Taking the model back also allows early fecundity data to be fitted. Virgin conditions are estimated by assuming constant recruitment and taking the basic dynamics equations forward under the assumption of no commercial exploitation. Virgin recruitment (R_0) is then calculated as follows [note: $\sum_{i=0}^{-1}()$ is defined as 0]:

$$R_0 = \frac{N_0^{f,preg}}{\Phi^f \left[\sum_{a=0}^{A-1} P''_a e^{-\sum_{i=0}^{a-1} M_i} + P''_A \frac{e^{-\sum_{i=0}^{A-1} M_i}}{1-e^{-M_A}} \right]} \quad 6$$

Natural mortality for pups (M_{pup})

With the possibility of estimating the fecundity parameters a_{fec} and b_{fec} (equation 2.3), the natural mortality parameter M_{pup} (Table 1) needs to be calculated so that, in the absence of harvesting, the following balance equation is satisfied:

$$\frac{1}{\Phi^f} = \sum_{a=0}^{A-1} P'_a P''_a e^{-\sum_{i=0}^{a-1} M_i} + P'_A P''_A \frac{e^{-\sum_{i=0}^{A-1} M_i}}{1-e^{-M_A}} \quad 7$$

Estimating MSY parameters

Two approaches were used to derive MSY parameters. In order to derive MSYR, the ratio of maximum sustainable yield, MSY, to the mature biomass (assumed to be the biomass of all animals $\geq l^f_{mat00}$) at which MSY is achieved (MSY/B_{MSY}) is calculated. This follows the same procedure for calculating MSYR as Punt and Walker (1998), and ensures that MSYR is comparable among different stocks/species, which would then allow MSYR estimates for other stocks/species to be used to inform on the likely range for spurdog. The selectivity for this first approach is therefore simply:

$$S^{s,mat}_{MSY,a} = \begin{cases} 0 & l^s_a < l^f_{mat00} \\ 1 & l^s_a \geq l^f_{mat00} \end{cases} \quad 8a$$

However, an estimate of $F_{prop,MSY}$ is needed from the assessment, which should correspond to the selection patterns of the fleets currently exploiting spurdog. The second approach was therefore to use selection patterns estimated for the non-target and target fleets (average over most recent five years; equations 4a-b) to estimate

$F_{prop,MSY}$. The selectivity for the second approach is therefore calculated as follows:

$$S^{s,cur}_{MSY,j,a} = \bar{f}_{rat,j}\, S^{s}_{com,j,a} \qquad \text{8b}$$

where $S^{s}_{com,j,a}$ is from equation 2.5b, and $\bar{f}_{rat,j}$ is a five-year average as follows:

$$\bar{f}_{rat,j} = \frac{1}{5}\sum_{y=yend-4}^{yend} \frac{F_{j,y}}{\sum_j F_{j,y}} \qquad \text{8c}$$

where $F_{j,y}$ is from equation 4a, and *yend* is the most recent year of data used in the assessment. In order to calculate MSY parameters, the first step is to express population dynamics on a per-recruit basis. Therefore, taking equations 1a and 4c, the equivalent per-recruit equations (dropping the *y* subscript) are given as:

$$N^{s}_{pr,a} = \begin{cases} \Phi^{s} & a = 0 \\ \Phi^{s}\prod_{i=0}^{a-1}\left(1-\sum_j F_{mult} S^{s}_{MSY,j,i}\right)e^{-M_i} & 0 < a \le A-1 \\ \Phi^{s}\dfrac{\prod_{i=0}^{A-1}\left(1-\sum_j F_{mult} S^{s}_{MSY,j,i}\right)e^{-M_i}}{\left(1-\sum_j F_{mult} S^{s}_{MSY,j,A}\right)(1-e^{-M_A})} & a = A \end{cases} \qquad \text{8d}$$

where *s* represents sex, F_{mult} replaces $F_{j,y}$ as the multiplier that is used to search for MSY, and the selection pattern $S^{s}_{MSY,j,a}$ reflects either the first approach (equation 8a, defined in terms of animals all animals $\ge l^{f}_{mat00}$ only, so subscript *j* and the summation over *j* is dropped) or the second approach (equation 8b, reflecting exploitation by current fleets, so subscript *j* and the summation over *j* is kept). Equation 2a therefore becomes:

$$N_{pup,pr} = \sum_{a=1}^{A} P'_a P''_a N^{f}_{pr,a} \qquad \text{8e}$$

Recruitment can be expressed in terms of $N_{pup,pr}$ by re-arranging equations 2b–c (omitting the process error term) as follows:

$$R = \frac{R_0}{N_{pup,pr}}\left[1 - \frac{(1/N_{pup,pr} - 1)}{Q_{fec} - 1}\right] \qquad \text{8f}$$

Yield can then be calculated as follows for the first (Y^{mat}) and second (Y^{cur}) approaches:

$$Y^{mat} = R\sum_{s}\sum_{a=0}^{A}\left(F_{mult} S^{s,mat}_{MSY,a} w^{s}_{a} N^{s}_{pr,a}\right) \qquad \text{8g}$$

and

$$Y^{cur} = R\sum_{s}\sum_{a=0}^{A}\sum_{j}\left(F_{mult}S^{s,cur}_{MSY,j,a}w^{s}_{a+\frac{1}{2}}N^{s}_{pr,a}e^{-M_a/2}\right) \quad \text{8h}$$

MSY is found by solving for the F_{mult} value that maximises equation 8g or 8h, and the corresponding $F_{prop,MSY}$ is calculated using equation 4b (replacing $F_{j,y}$ with F_{mult}, $S^{s}_{com,j,a}$ with $S^{s}_{MSY,j,a}$, and $N^{s}_{y,a}$ with $N^{s}_{pr,a}$). Here, equation 8g has been used for the purposes of calculating MSYR, and equation 8h for estimating $F_{prop,MSY}$.

Likelihood function

Survey abundance index

The contribution of the Scottish survey abundance index to the negative log-likelihood function assumes that the index $I_{sur,y}$ is lognormally distributed about its expected value, and is calculated as follows:

$$-\ln L_{sur} = \tfrac{1}{2}\sum_{y}[\ln(2\pi\sigma^{2}_{sur,y}) + \varepsilon^{2}_{sur,y}] \quad \text{9a}$$

where $\sigma_{sur,y}$ is the CV of the untransformed data, q_{sur} the survey catchability (estimated by closed-form solution), and $\varepsilon_{sur,y}$ the normalised residual:

$$\varepsilon_{sur,y} = [\ln(I_{sur,y}) - \ln(q_{sur}B_{sur,y})]/\sigma_{sur,y} \quad \text{9b}$$

$B_{sur,y}$ is the "available" mid-year abundance corresponding to $I_{sur,y}$, and is calculated as follows:

$$B_{sur,y} = \sum_{s}\sum_{a}S^{s}_{sur,a}w^{s}_{a+\frac{1}{2}}[N^{s}_{y,a}e^{-M_a/2} - \sum_{j}C^{s}_{j,y,a}/2] \quad \text{9c}$$

Commercial proportion-by-length-category

The contribution of the commercial proportion-by-length-category data to the negative log-likelihood function assumes that these proportions $p_{j,y,L}$ for fleet j and length category L (combined sex) are multinomially distributed about their expected value, and is calculated as follows (Punt *et al.*, 2001):

$$-\ln L_{pcom,j} = k_{pcom,j}\sum_{y}\sum_{L}\varepsilon_{pcom,j,y,L} \quad \text{10a}$$

where $k_{pcom,j}$ is the effective sample size, and the multinomial residual $\varepsilon_{pcom,j,y,L}$ is:

$$\varepsilon_{pcom,j,y,L} = -\frac{n_{pcom,j,y}}{\bar{n}_{pcom,j}}p_{j,y,L}[\ln(\hat{p}_{j,y,L}) - \ln(p_{j,y,L})] \quad \text{10b}$$

with $n_{pcom,j,y}$ representing the number of samples on which estimates of proportions by length category are based, and $\bar{n}_{pcom,j}$ the corresponding average (over y). Because actual sample sizes were not available for the commercial data (only raised sample sizes), all model runs assumed $n_{pcom,j,y} = \bar{n}_{pcom,j}$, ICES (2010) concluded that model results were not sensitive to this assumption. Four length categories are considered for the commercial proportions-by-length (16–54 cm; 55–69 cm; 70–84 cm; and 70+ cm), and the model estimates $\hat{p}_{j,L,y}$ are obtained by summing the estimated numbers caught in the relevant length category L and dividing by the total across all the length categories. The effective sample size $k_{pcom,j}$ is assumed to be 20 for all j (but a sensitivity test explores alternative assumptions).

Survey proportion-by-length-category

The negative log-likelihood contributions (-lnL_{psur}) for the Scottish survey proportions-by-length category are as for the commercial proportions, except that there is only one survey abundance series (the j index is dropped in the above equations), and different length categories (the 16–54 cm category is split into 16–31 and 32–54, and the 70-84 and 85+ categories are combined into a single 70+ category). The effective sample size k_{psur} is assumed to be 10, and reflects the lower sample sizes for surveys relative to commercial catch data (Punt *et al.*, 2001).

Fecundity

The contribution of the fecundity data from two periods to the negative log-likelihood function assumes that the data are normally distributed about their expected value, and is calculated as follows:

$$-\ln L_{fec} = \tfrac{1}{2} \sum_{y=1960;2005} \sum_{k=1}^{K_y} [\ln(2\pi\sigma_{fec}^2) + \varepsilon_{fec,k,y}^2] \qquad \text{11a}$$

where K_y represents the sample sizes for each of the periods (K_{1960}=783, K_{2005}=179), k the individual samples, and $\varepsilon_{fec,k,y}$ is:

$$\varepsilon_{fec,k,y} = [P'_{k,y} - \hat{P}'_{k,y}] / \sigma_{fec} \qquad \text{11b}$$

where $P'_{k,y}$ represents the data and $\hat{P}'_{k,y}$ the corresponding model estimate calculated by multiplying equation 3 with Q_y in equation 2b and substituting the length of the sample in equation 3 (where the age subscript a is replaced by the sample subscript k). A closed-form solution for σ_{fec} exists as follows:

$$\sigma_{fec} = \sqrt{\frac{\sum_{y=1960;2005} \sum_{k=1}^{K_y} (P'_{k,y} - \hat{P}'_{k,y})^2}{(K_{1960} + K_{2005})}} \qquad \text{11c}$$

Recruitment

Recruitment (pups) is assumed to be lognormally distributed about its expected value, with the following contribution to the negative log-likelihood function:

$$-\ln L_r = \tfrac{1}{2} \sum_y [\ln(2\pi\sigma_r^2) + (\varepsilon_{r,y} / \sigma_r)^2] \qquad \text{12}$$

where $\varepsilon_{r,y}$ are estimable parameters in the model, and σ_r is a fixed input (0.2 for the base case).

Total likelihood

The total negative log-likelihood is the sum of the individual components:

$$-\ln L_{tot} = -\ln L_{sur} - \sum_j \ln L_{pcom,j} - \ln L_{psur} - \ln L_{fec} - \ln L_r \qquad \text{13}$$

Life-history parameters and input data

Calculation of the life-history parameters M_a (instantaneous natural mortality rate), l_a^s (mean length-at-age for animals of sex *s*), w_a^s (mean weight-at-age for animals of sex *s*), and P_a'' (proportion females of age *a* that become pregnant each year) are summarised in Table 1.

Quality of assessments

WGEF has attempted various analytic assessments of NE Atlantic spurdog using a number of different approaches (see Section 2.8 and ICES, 2006). Although these models have not proved entirely satisfactory (as a consequence of the quality of the assessment input data), these exploratory assessments and survey data all indicate a decline in spurdog.

Catch data

The WG has provided estimates of total landings of NE Atlantic spurdog and has used these, together with UK length frequency distributions in the assessment of this stock. However, there are still concerns over the quality of these data as a consequence of:

- uncertainty in the historical level of catches because of landings being reported by generic dogfish categories;
- uncertainty over the accuracy of the landings data because of species misreporting;
- lack of commercial length frequency information for countries other than the UK (UK landings are a decreasing proportion of the total and therefore the length frequencies may not be representative of those from the fishery as a whole);
- low levels of sampling of UK landings and lack of length frequency data in recent years when the selection pattern may have changed due to the implementation of a maximum landings length (100 cm);
- lack of discard information.

There are occasional slight (0–1%) inconsistencies in the total landings when measured by country and when measured by ICES Division. This is the result of some national revision of historical landing and the assigning of proportions of catches from generic *nei* categories as “spurdog”. It is intended that these be completely reconciled before the next meeting.

Survey data

Survey data are particularly important indicators of abundance trends in stocks such as this where an analytical assessment is not available. However, it should be highlighted that

- the survey data examined by WGEF cover only part of the stock distribution and analyses should be extended to other parts of the stock distribution.
- spurdog survey data are difficult to interpret because of the typically highly skewed distribution of catch-per-unit effort.

- annual survey length frequency distribution data (aggregated over all hauls) may be dominated by data from single large haul.

Biological information

As well as good commercial and survey data, the analytical assessments require good information on the biology of NE Atlantic spurdog. In particular, the WG would like to highlight the need for:

- updated and validated growth parameters, in particular for larger individuals;
- better estimates of natural mortality.

Exploratory assessment

As with any stock assessment model, the exploratory assessment relies heavily on the underlying assumptions, particularly with regard to life-history parameters (e.g. natural mortality and growth), and on the quality and appropriateness of input data. The inclusion of two periods of fecundity data has provided valuable information that allows estimation of Q_{fec}, and projecting the model back in time is needed to allow the 1960 fecundity data set to be fitted. Nevertheless, the likelihood surface does not have a well-defined optimum, and additional information, such as on appropriate values of MSYR for a species such as spurdog, would help with this problem. Further refinements of the model are possible, such as including variation in growth. Selectivity curves also cover a range of gears over the entire catch history, and more appropriate assumptions (depending on available data) could be considered.

In summary, the model may be appropriate for providing an assessment of spurdog, though it could be further developed if the following data were available:

Selectivity parameters disaggregated by gear for the main fisheries (i.e. for various trawl, long line and gillnets);

Appropriate indices of relative abundance from fishery-independent surveys, with corresponding estimates of variance;

Improved estimates for biological data (e.g. growth parameters, reproductive biology and natural mortality);

Information on likely values of MSYR for a species such as spurdog.

Reference points

$F_{prop,\mathrm{MSY}}$=0.029, as estimated by the current assessment, assuming average selection over the most recent 5 years of data (2006-2010 for this estimate).

Management considerations

Stock distribution

Spurdog in the ICES area are considered to be a single-stock, ranging from Subarea I to Subarea IX, although landings from the southern end of its range are likely also to include other *Squalus* species.

There should be a single TAC area. Although a new TAC has been established for other areas, given that northern Scotland is an important area for spurdog, separate TACs for the waters of VIa and IVa could result in area misreporting should the TAC for one area be more restrictive than the other.

Biological considerations

Spurdogs are long-lived, slow growing, have a high age-at-maturity, and are particularly vulnerable to high levels of fishing mortality. Population productivity is low, with low fecundity and a protracted gestation period. In addition, they form size- and sex-specific shoals and therefore aggregations of large fish (i.e. mature females) are easily exploited by target longline and gillnet fisheries.

Fishery and technical considerations

Those fixed gear fisheries that capture spurdog should be reviewed to examine the catch composition, and those taking a large proportion of mature females should be strictly regulated.

Since 2009, there has been a maximum landing length (MLL) to deter targeting of mature females (see Section 2.10 of ICES, 2006 for simulations on MLL). Discard survival of such fish needs to be evaluated. Those fisheries taking spurdog that are lively may have problems measuring fish accurately, and investigations to determine an alternative measurement (e.g. pre-oral length) that has a high correlation with total length and is more easily measured on live fish are required. Dead dogfish may also be more easily stretched on measuring, and understanding such post-mortem changes is required to inform on any levels of tolerance.

North Sea fisheries were regulated by a bycatch quota (2007–2008), whereby spurdog should not have comprised more than 5% by live weight of the catch retained on board. This was extended to western areas in 2008. The bycatch quota was removed in 2009, when the maximum landing length was brought in.

Spurdog were historically subject to large targeted fisheries, but are increasingly now taken as a bycatch in mixed trawl fisheries. In these fisheries, measures to reduce overall demersal fishing effort should also benefit spurdog. However, a restrictive TAC in this case would likely result in increased discards of spurdog and so may not have the desired effect on fishing mortality if discard survivorship is low.

There is limited information on the distribution of spurdog pups, though they have been reported to occur in Scottish waters, in the Celtic Sea and off Ireland. The lack of accurate data on the location of pupping and nursery grounds, and their importance to the stock precludes spatial management for this species at the present time.

Although there is no EU minimum landing size for spurdog, there is some discarding of smaller fish, and it is likely that spurdog of <40 or 45 cm are discarded in most fisheries. The survivorship of discards of juvenile spurdog is not known.

References

Aasen, O. 1960. Norwegian dogfish tagging. Ann. Biol., Copenhagen, 15, 76.

Aasen, O. 1962. Norwegian dogfish tagging. Ann. Biol., Copenhagen, 17, 106–107.

Aasen, O. 1964. The exploitation of the spiny dogfish (*Squalus acanthias* L.) in European waters. Fiskeridir. Skr. Ser. Havunders., 13(7): 5–16.

Bedford, B.C., Woolner, L.E, and Jones, B.W. 1986. Length-weight relationships for commercial fish species and conversion factors for various presentations. Data Report, MAFF Directorate of Fisheries Research Lowestoft, 10: 41pp.

Cortés, E. 1999. A stochastic stage-based population model of the sandbar shark in the Western North Atlantic. In Life in the slow lane: Ecology and conservation of long-lived marine animals. Ed. by J.A. Musick. American Fisheries Society Symposium, 22: 115–136.

Coull, K. A., Jermyn, A. S., Newton, A. W., Henderson, G. I and W. B. Hall. 1989. Length-weight relationships for 88 species of fish encountered in the North East Atlantic. Scottish Fisheries Research Report Number 43.

De Oliveira, J. A. A., Ellis, J. R., and Dobby, H. 2013. Incorporating density dependence in pup production in a stock assessment of NE Atlantic spurdog *Squalus acanthias*. ICES Journal of Marine Science, 70: 1341–1353.

Diez, G., Iriondo, A., Ruiz, J., Quincoces, I., González, I., Santurtun, M. and Artetxe, I. 2006. Lesser spotted dogfish, rays and spurdog Landings Per Unit Effort and preliminary discards data of Basque fleets operating in Subareas VI, VII and VIII in the period 1994–2005. Working Document presented at the 2006 WGEF.

Dobby, H., Beare, D, Jones, E.and MacKenzie, K. 2005. Comparison of trends in long term survey data for Squalus acanthias with a preliminary stock assessment for this species. ICES CM 2005/N:01.

Ellis, J.R. and Keable, J. 2008. The fecundity of Northeast Atlantic spurdog (*Squalus acanthias* L., 1758). ICES Journal of Marine Science, 65: 979–981.

Ellis, J.R., Doran, S., Dunlin, G., Hetherington, S., Keable, J., and Skea, N. 2010. Spurdog in the Irish Sea. Cefas, Lowestoft, Fisheries Science Partnership; 2009; Programme 9, Final Report, 28 pp. (available electronically at http://www.cefas.co.uk/data/fisheries-science-partnership-(fsp)/20082009-programme.aspx).

Fahy, E. 1989. The spurdog *Squalus acanthias* (L.) fishery in south-west Ireland. Ir. Fish. Invest. Part B: March, 32: 22 pp.

Gauld, J. A. 1979. Reproduction and fecundity of the Scottish Norwegian stock of Spurdogs, Squalus acanthias (L.). ICES CM 1979/H:54, 15 pp.

Henderson, A.C., Flannery, K., Dunne, J. 2001. Growth and reproduction in spiny dogfish *Squalus acanthias* L. (*Elasmobranchii*: *Squalidae*), from the west coast of Ireland. Sarsia, 87(5): 350–261.

Holden, M. J. 1965. The stocks of spurdogs (*Squalus acanthias* L.) in British waters and their migrations. Fish. Invest., Ser. II, 24(4), MAFF, London, 20 p.

Holden, M. J. 1968. The rational exploitation of the Scottish-Norwegian stock of spurdogs (*Squalus acanthias* L.). Fishery Investigations, Series II, 25(8), MAFF, London, 27 pp.

Holden, M. and Meadws, P. S. 1962. The structure of the spine of the spurdog fish (*Squalus acanthias* L.) and its use for age determination. Journal of the Marine Biological Association of the United Kingdom, 42: 179–197.

ICES. 2006. Report of the Working Group on Elasmobranch Fishes (WGEF), 14–21 June 2006, ICES Headquarters. ICES CM 2006/ACFM:31. 291 pp.

ICES. 2009a. Report of the Working Group on the Assessment of Demersal Stocks in the North

Sea and Skagerrak. Combined Spring and Autumn (WGNSSK), 6–12 May 2009, ICES Headquarters, Copenhagen. ICES CM 2009/ACOM:10. 1028 pp.

ICES. 2009b. Report of the Working Group on the Celtic Seas Ecoregion (WGCSE), 13 –19 May 2009, ICES Headquarters, Copenhagen.

ICES. 2010. Report of the Working Group on Elasmobranch Fishes (WGEF), 22–29 June 2010, Horta, Portuga. ICES CM 2010/ACOM:19. 558 pp.

Jones, T. S. and Ugland, K. I. 2001. Reproduction of female spiny dogfish, *Squalus acanthias*, in the Oslofjord. Fish. Bull., 99: 685–690.

Lo, N. C., Jacobson, L. D. and Squire, J. L. 1992. Indices of relative abundance for fish spotter data based on delta-lognormal models. Canadian Journal of Fisheries and Aquatic Sciences, 49: 2515–2526.

Mandelman, J. W., and Farrington, M. A. 2006. The estimated short-term discard mortality of a trawled elasmobranch, the spiny dogfish (*Squalus acanthias*). Fisheries Research 83: 238–245.

McEachran, J. D., and Branstetter, S. 1984. Squalidae. In Fishes of the Northeastern Atlantic and the Mediterranean Vol. 1, pp 128–147. Ed. by P. J. P.Whitehead, M.-L.Bauchot, J.-C.Hureau, J. Nielsen, and E. Tortonese. UNESCO, Paris.

Mesnil, B. and Rochet, M.-J. 2010. A continuous hockey stick stock-recruit model for estimating MSY reference points. ICES Journal of Marine Science, 67: 000-000. [doi:10.1093/icesjms/fsq055].

NIEA. 2008. Position statement on sharks, skates and rays in Northern Ireland waters BDU2/66. 198 pp.

Punt, A. E. and Walker, T. I. 1998. Stock assessment and risk analysis for the school shark (*Galeorhinus galeus*) off southern Australia. Marine and Freshwater Research 48, 719–31.

Punt, A. E., Pribac, F., Walker T. I. and B.L. Taylor. 2001. Population modelling and harvest strategy evaluation for school and gummy shark, Report of FRDC 99/102. CSIRO Marine Research, Hobart.

Simpfendorfer, C. A. 1999. Demographic analysis of the dusky shark fishery in Southwestern Australia. In Life in the slow lane: Ecology and conservation of long-lived marine animals, pp 149–160. Ed. by J. A.Musick. American Fisheries Society Symposium, 22.

Sosinski, J. 1977. Polish investigations on the Scottish Norwegian spurdog (*Squalus acanthias*) in 1974. Ann. Biol., Copenhagen, 32: 178–179.

STECF. 2009. STECF Report of the SGMOS-09-05 Working Group on Fishing Effort Regimes Regarding Annex IIA of TAC & Quota Regulations and Celtic Sea.

Stefansson, G. 1996. Analysis of groundfish survey abundance data: combining the GLM and delta approaches. ICES Journal of Marine Science, 53: 577–588.

Templeman, W. 1976. Transatlantic migrations of spiny dogfish (*Squalus acanthias*). J. Fish. Res. Bd. Can., 33: 2605–2609.

Vince, M. R. 1991. Stock identity in spurdog (*Squalus acanthias* L.) around the British Isles. Fisheries Research, 12: 341–354.

Zuur, A., Fryer, R. and Newton, A. W. 2001. The comparative fishing trial between Scotia II and Scotia III. FRS Marine Lab. Internal Report No 03/01.

Table 1. Northeast Atlantic spurdog. Description of life-history equations and parameters.

Parameters	Description/values	Sources
M_a	Instantaneous natural mortality at age *a*: $M_a = \begin{cases} M_{pup} e^{-a \ln(M_{pup}/M_{adult})/a_{M1}} & a < a_{M1} \\ M_{adult} & a_{M1} \le a \le a_{M2} \\ M_{til} / [1 + e^{-M_{gam}(a-(A+a_{M2})/2)}] & a > a_{M2} \end{cases}$	
a_{M1}, a_{M2}	4, 30	expert opinion
M_{adult}, M_{til}, M_{gam}	0.1, 0.3, 0.04621	expert opinion
M_{pup}	Calculated to satisfy balance equation 2.7	
l_a^s	Mean length-at-age a for animals of sex *s* $l_a^s = L_\infty^s (1 - e^{-\kappa^s (a - t_0^s)})$	
L_∞^f, L_∞^m	110.66, 81.36	average from literature
κ^f, κ^m	0.086, 0.17	average from literature
t_0^f, t_0^m	-3.306, -2.166	average from literature
w_a^s	Mean weight at age *a* for animals of sex *s* $w_a^s = a^s (l_a^s)^{b^s}$	
a^f, b^f	0.00108, 3.301	Bedford *et al.*, 1986
a^m, b^m	0.00576, 2.89	Coull *et al.*, 1989
l_{mat00}^f	Female length at first maturity 70 cm	average from literature
P_a''	Proportion females of age a that become pregnant each year $P_a'' = \dfrac{P_{max}''}{1 + \exp\left[-\ln(19)\dfrac{l_a^f - l_{mat50}^f}{l_{mat95}^f - l_{mat50}^f}\right]}$ where P_{max}'' is the proportion very large females pregnant each year, and l_{matx}^f the length at which *x*% of the maximum proportion of females are pregnant each year	
P_{max}''	0.5	average from literature
l_{mat50}^f, l_{mat95}^f	80 cm, 87 cm	average from literature

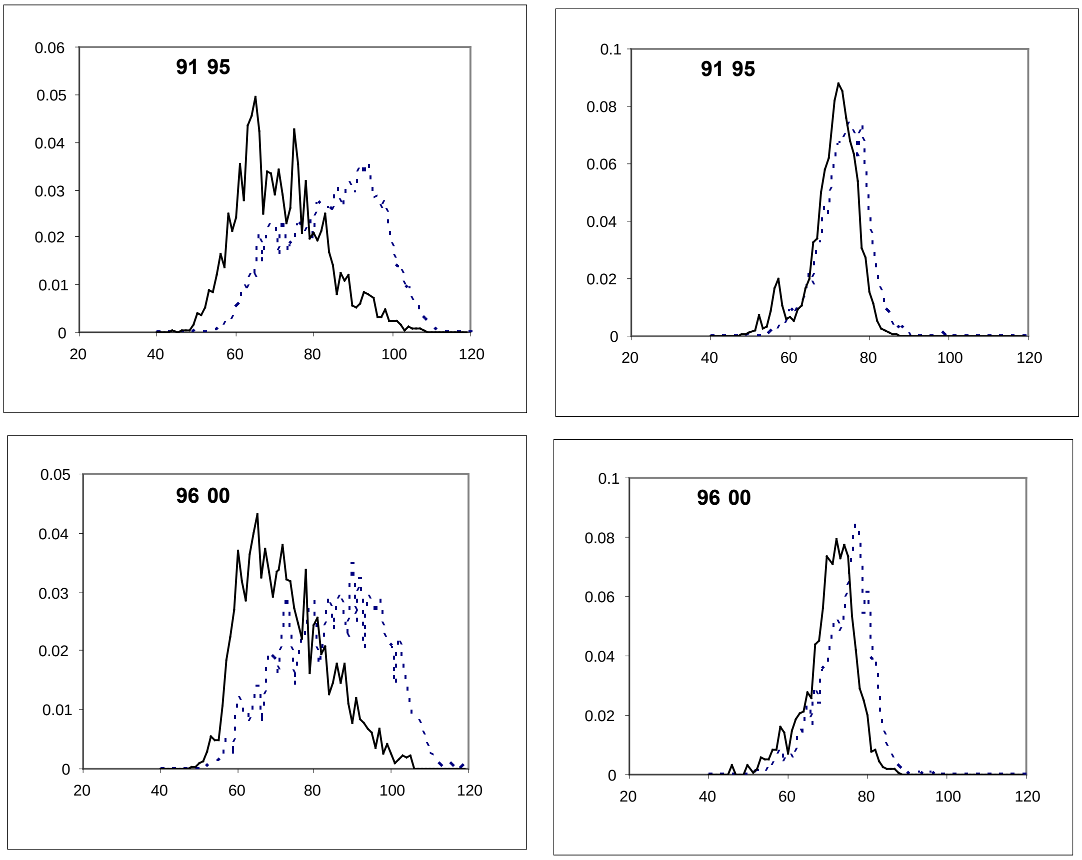


Figure 1. Northeast Atlantic spurdog. Comparison of length frequency distributions (proportions) obtained from market sampling of Scottish (solid line) and UK (E&W) (dashed line) landings data. Data are sex-disaggregated, but averaged over five year intervals.

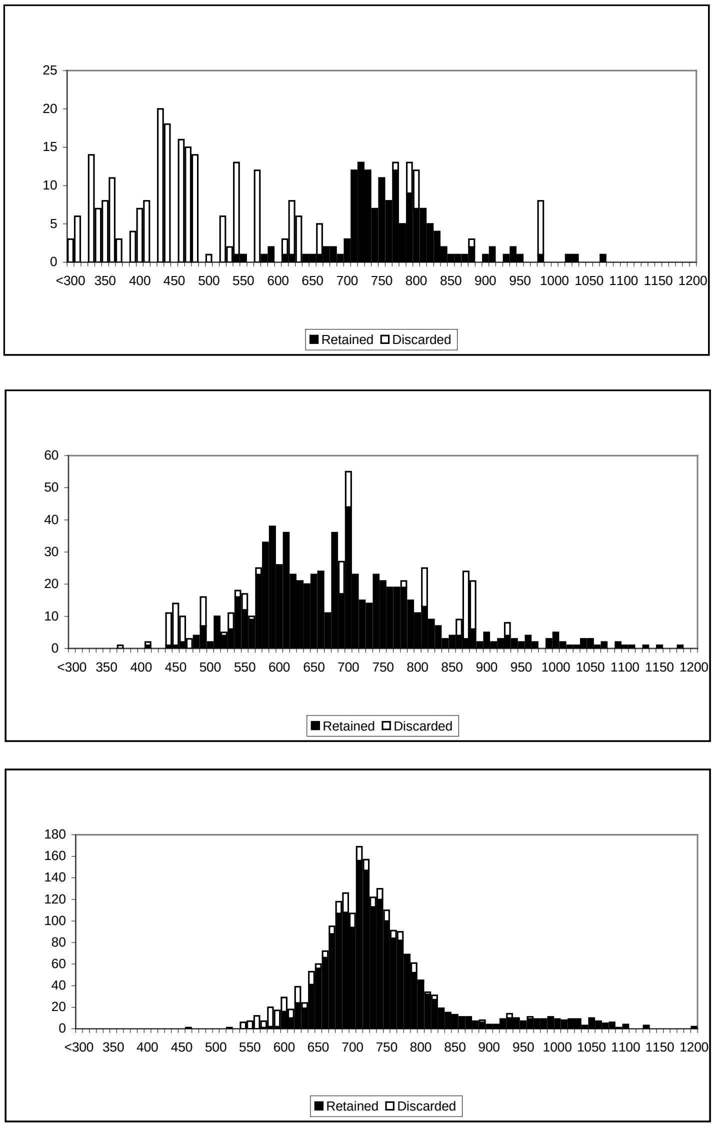
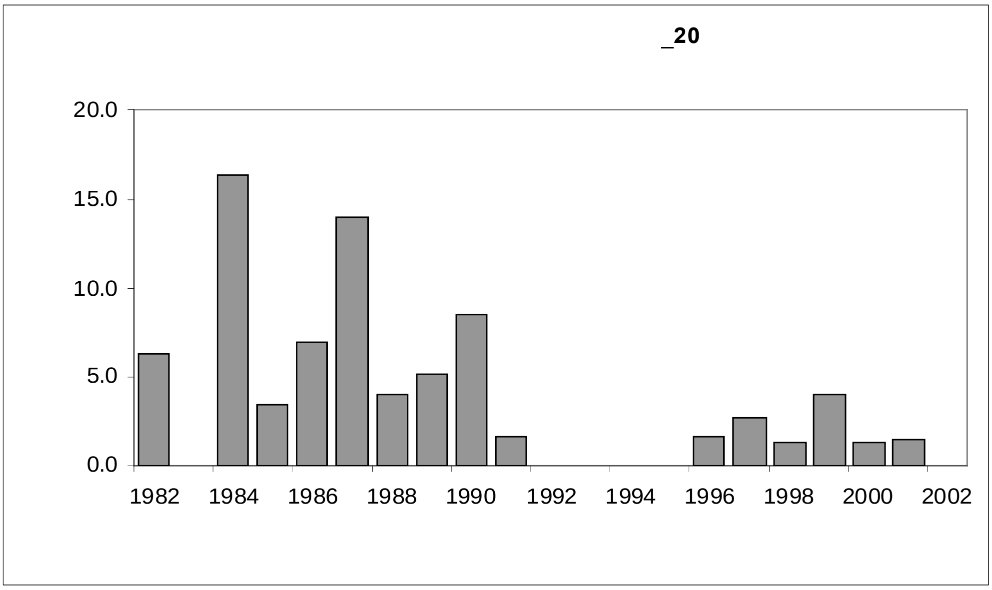


Figure 2. Northeast Atlantic spurdog. Length distribution of discarded and retained in fisheries in the North Sea and Celtic Seas ecoregions for (a) beam trawl, (b) demersal trawl and (c) drift and gillnets. These data (1999–2006) are aggregated across individual catch samples (Source: UK (E&W) Discards surveys).



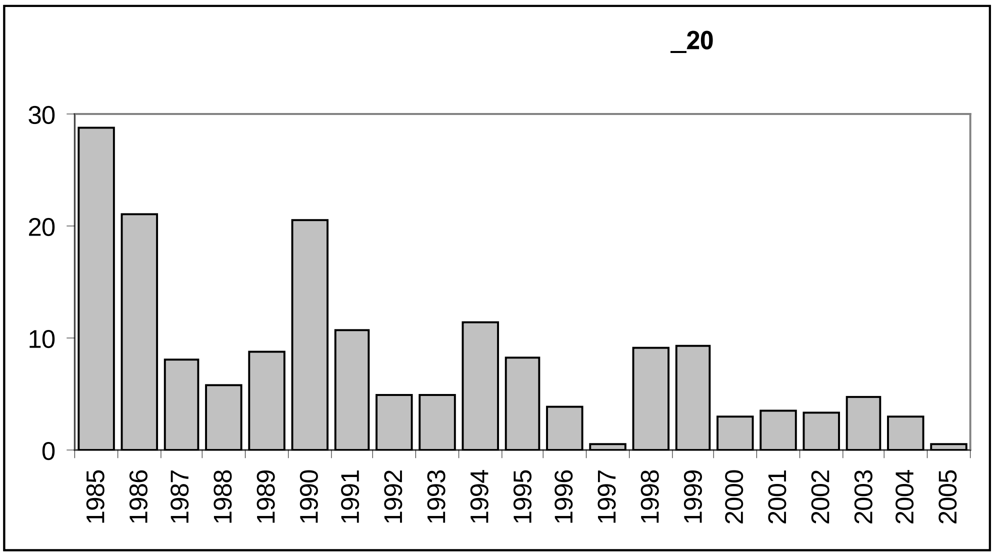
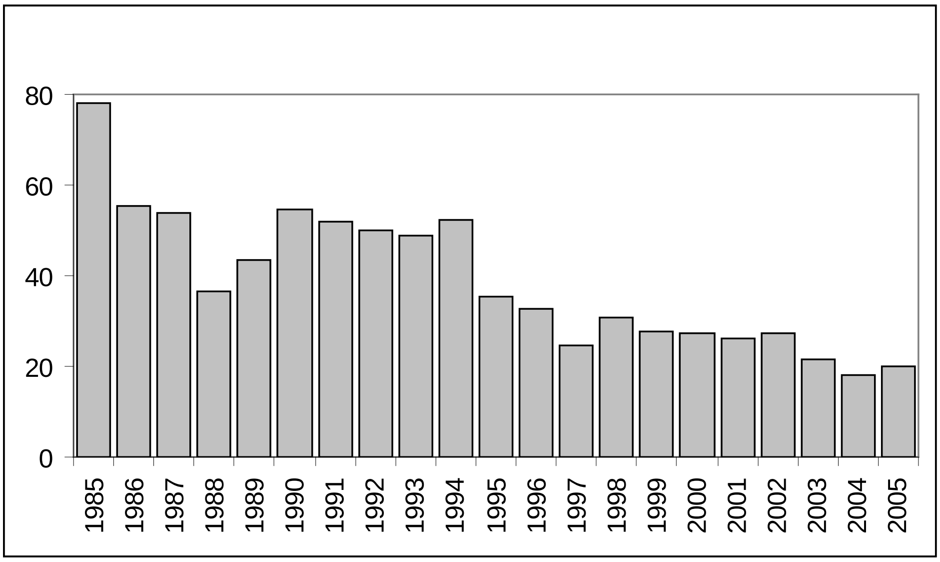


Figure 3. Northeast Atlantic spurdog. Proportion of survey hauls in the English Celtic Sea groundfish survey (1982–2002, top) and Scottish west coast (VIa) survey (Q1, 1985–2005, bottom) in which cpue was ≥20 ind.h^{-1}. (Source: ICES, 2006).

a)



b)

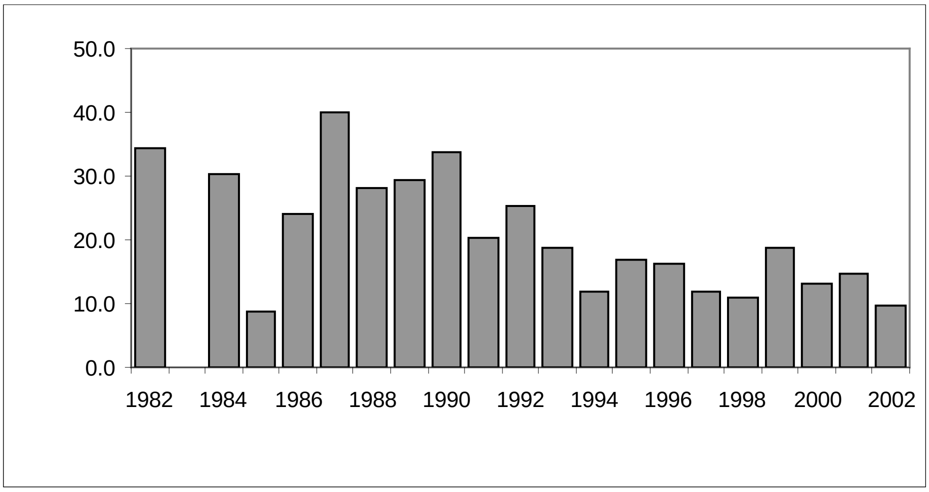
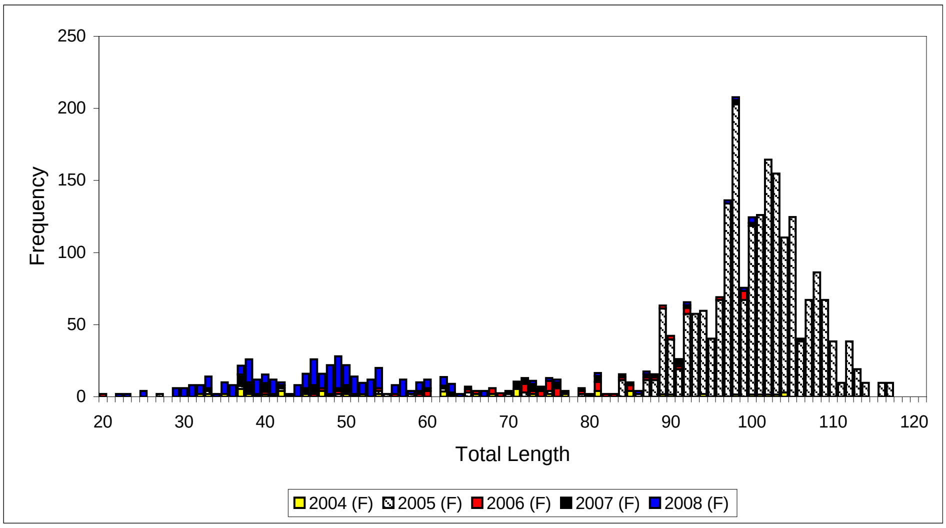


Figure 4. Northeast Atlantic spurdog. Frequency of occurrence in survey hauls in a) the English Q1 Celtic Sea groundfish survey (1982–2002), and b) the Scottish west coast (VIa) survey (Q1, 1985–2005).



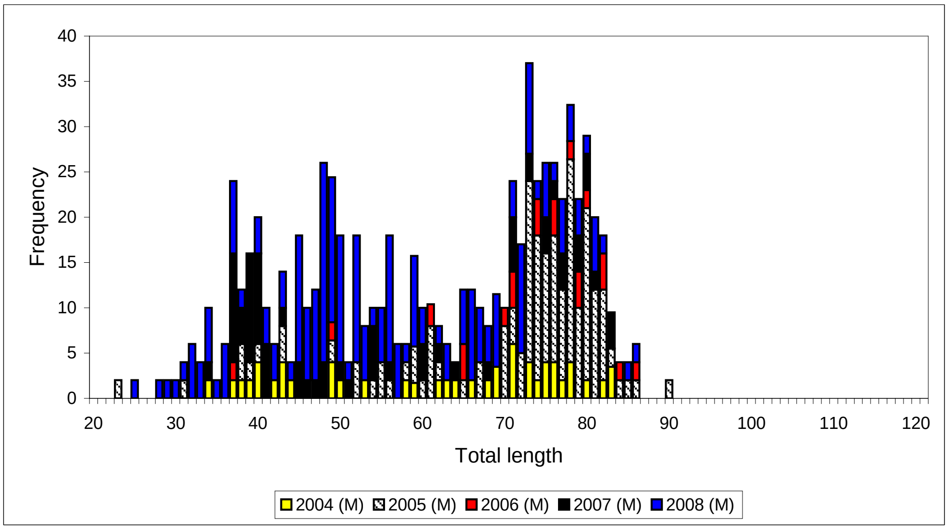


Figure 5. Northeast Atlantic spurdog. Temporal variations in length frequencies of female (top) and male (bottom) spurdog in UK (E&W) Q4 survey.

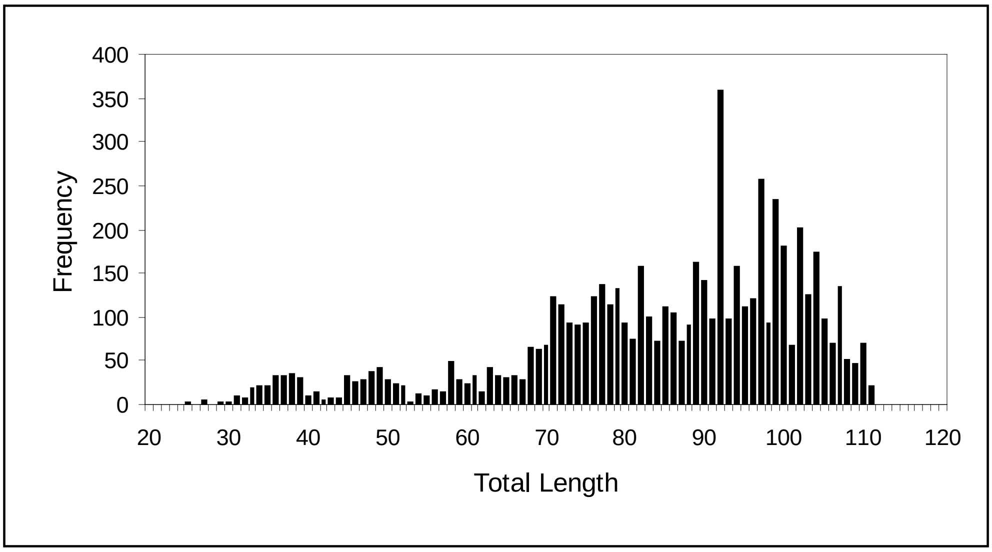


Figure 6. Northeast Atlantic spurdog. Length frequencies of spurdog in UK (NI) GFS Q4 survey 1992–2008.

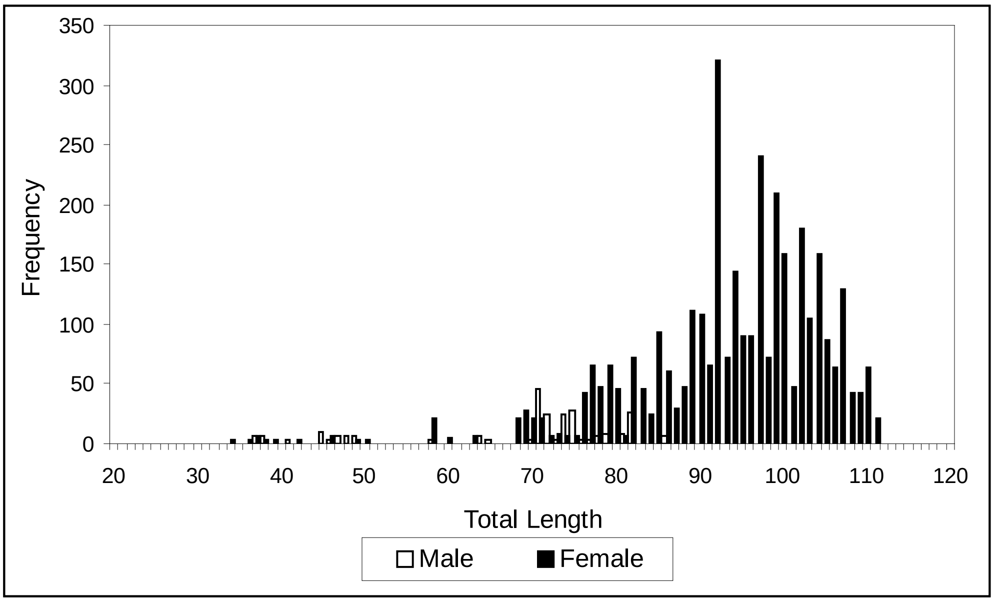


Figure 7. Northeast Atlantic spurdog Sex segregated length frequencies of spurdog in UK (NI) GFS Q4 survey 2006–2008.

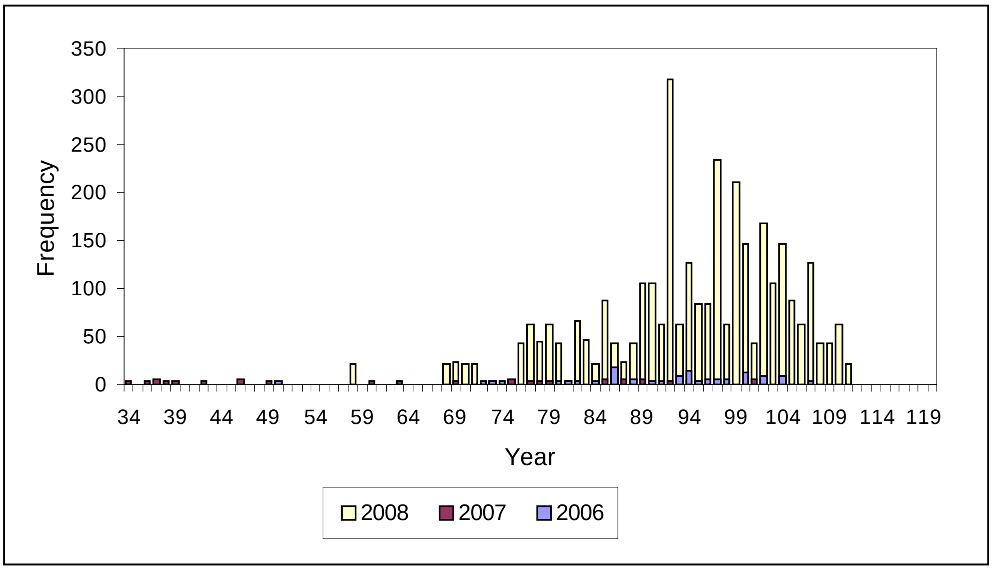


Figure 8. Northeast Atlantic spurdog. Length frequencies of female spurdog in UK (NI) GFS Q4 survey 2006–2008. Dominance of large females observed in 2008 influenced by single large haul.

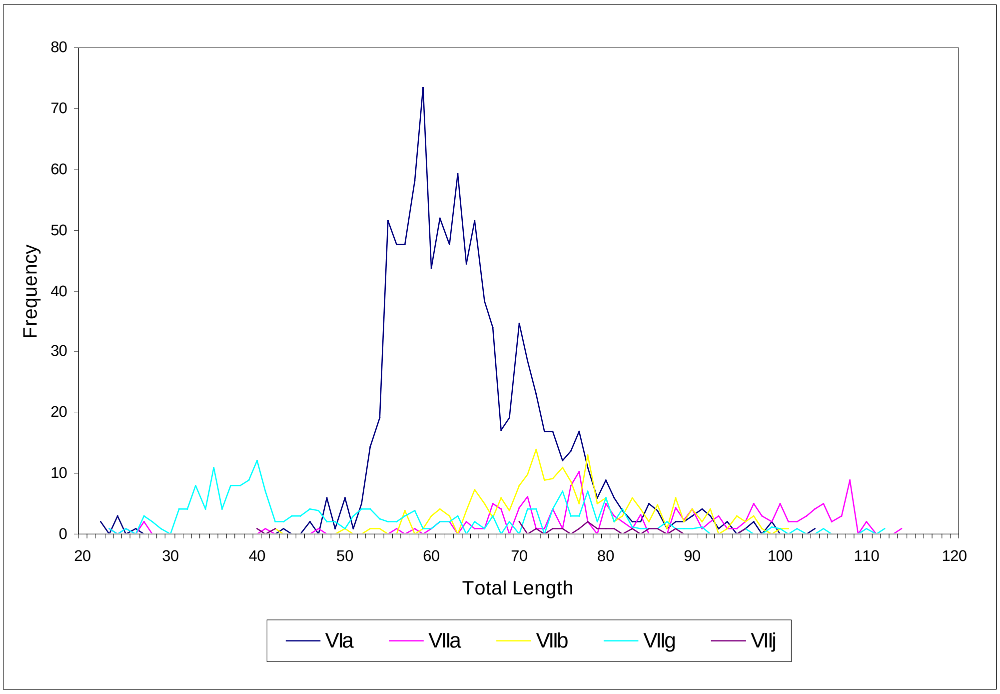


Figure 9. Northeast Atlantic spurdog. Variation in length frequencies of spurdog by region generated from MI GFS Q3 survey.

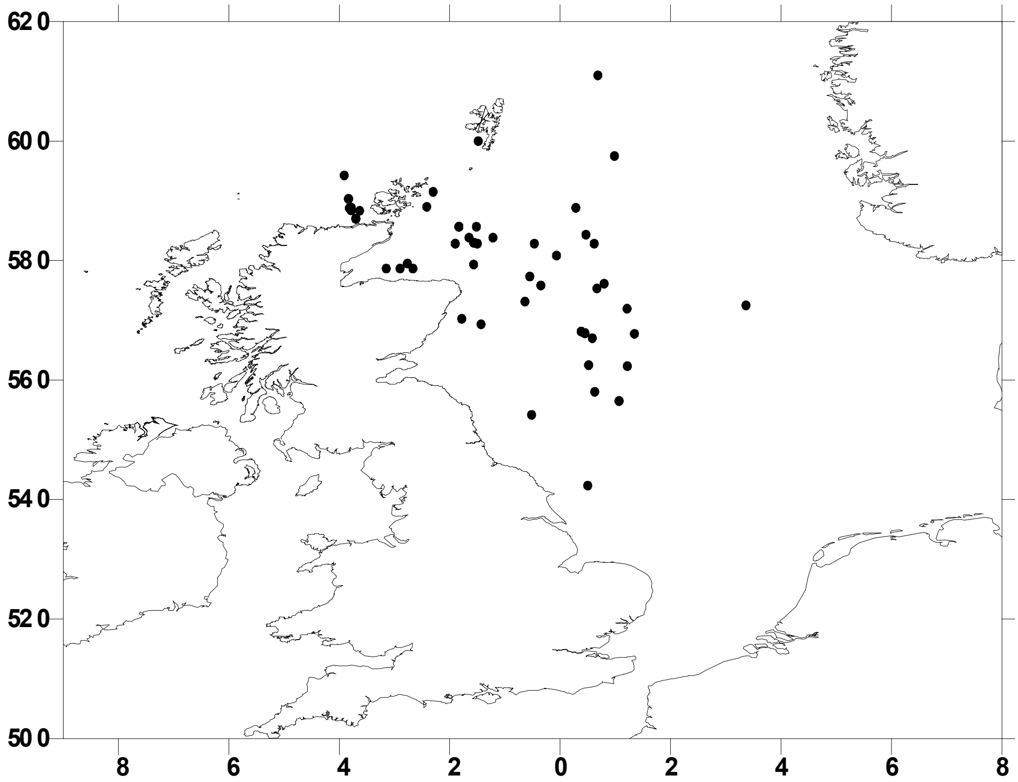
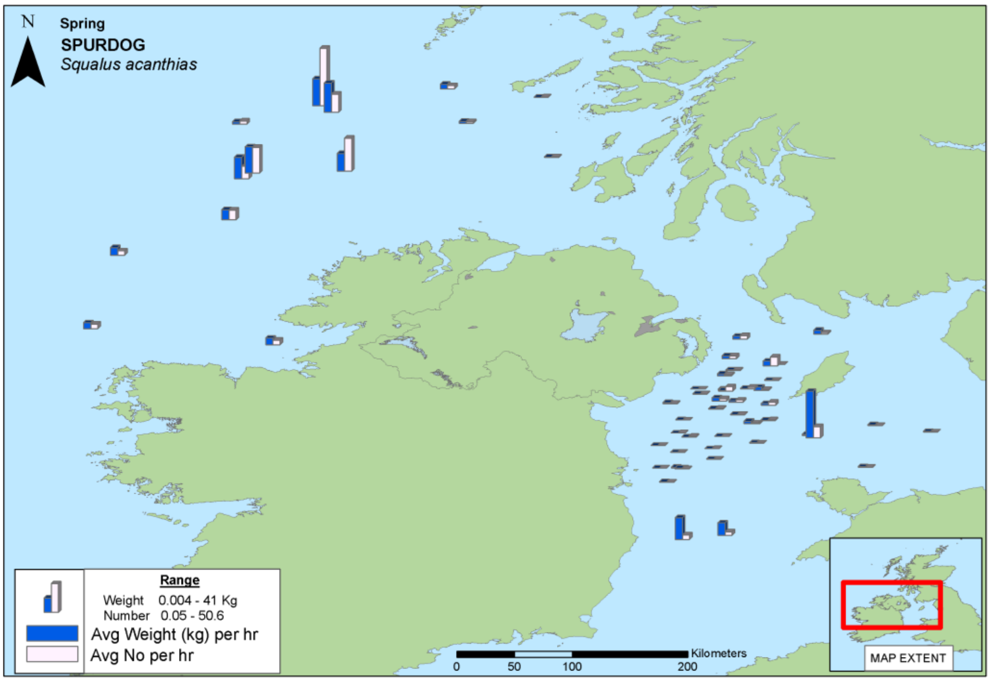


Figure 10. Northeast Atlantic spurdog. Occurrence of spurdog pups (ind. ≤250 mm) in North Sea (Source of dta: DATRAS, downloaded 25 June 2009).



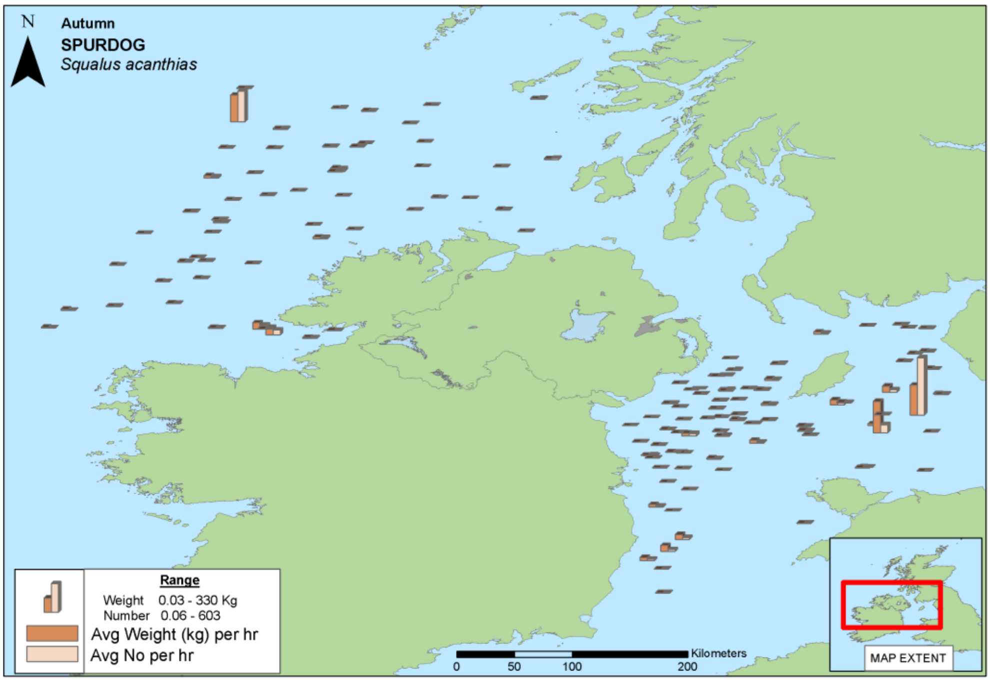


Figure 11. Northeast Atlantic spurdog. Seasonal distribution, average abundance (No. per hr.) and average weight (Kg per hr) of spurdog *Squalus acanthias* in VIIa(N) and VIa(S) as estimated from research surveys (see NIEA. 2008).

Stock Annex

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Porbeagle in the Northeast Atlantic (Subareas I–XIV)
Working Group:	WGEF
Date:	June 2010
Revised by	Gérard Biais

A. General

A.1. Stock definition

WGEF consider that there is a single-stock of porbeagle *Lamna nasus* in the NE Atlantic that occupies the entire ICES area (Subareas I–XIV). This stock extends from Norway, Iceland and the Barents Sea to Northwest Africa. For management purposes the southern boundary of the stock is 36°N and the western boundary at 42°W.

Buencuerpo *et al*., 1998 reported that porbeagle made up 4% of the total catches in longline and gillnet fisheries off the northwest African coast, Iberian Peninsula and Straits of Gibraltar and more information on the distribution and frequency of porbeagle in the CECAF area is needed. Some records of porbeagle south of the ICES area may be misidentified shortfin mako.

The stock is considered separate from that in the NW Atlantic (Campana *et al*., 1999; 2001; 2003). Tagging studies from Norway, the USA and Canada, resulted in 542, 1034 and 256 porbeagles being tagged respectively. In all 197 recaptures were made (53 from Norwegian, 119 for USA and 25 from Canadian studies). Initial studies did not report any transatlantic migrations (Campana *et al*., 2003), although a single transatlantic migration has been reported (e.g. Green, 2007 WD; Figure 6.1). Canadian tagging studies have not reported any recaptures east of 42°W.

Genetic evidence suggests some gene flow across the Atlantic, within the northern hemisphere, as dominant haplotypes from the NE were also present in samples from NW Atlantic population (Pade *et al*., 2006). The same study also found marked differences in haplotype frequencies between northern and southern hemisphere populations, indicating little or no gene flow between them.

Although porbeagle also occurs in the Mediterranean, there is no evidence of mixing with the NE Atlantic stock.

A.2. Fishery

Porbeagle has been exploited commercially since the early 1800s, principally by Scandinavian fishers; however, the “boom” period for this fishery in the NE Atlantic began in the 1930s. The target fishery for porbeagles before the Second World War and was mainly a Norwegian longline fishery in the North Sea, starting in 1926 and landing around 500 t annually in the first years. After a peak in 1933 (ca. 3800 t) the fishery declined. After the war, the target fishery resumed with Norwegian, Faroese and Danish vessels involved. Norway took about 2800 t in 1947. By the 1950s this fishery had extended to the Orkney-Shetland area and the Faroes then to the waters off Ireland and offshore banks. After this, the catches began to decline to below 2000 t annually, and in 1961 a fleet of Norwegian longliners extended their fishing for porbeagle to Northwest Atlantic waters.

In the early 1950s, landings for the Danish porbeagle fishery were greater than 1000 t, but by the mid-late 1950S average landings were 500–600 t per year; however, this declined to under 50 t by 1983. During the 1970s several countries including The Faroes, France, England, Iceland, Germany and Sweden started to report landings of porbeagle,. French landings are largely from the Bay of Biscay and Celtic Sea. They are mainly provided by a longliner targeted fishery (Table 6.1) which landed relatively large quantities from the early 1970s, with a decline in the mid-1980s where landings decreased to around 200 t, with the number of boats in the targeted fishery also declining at this time. After this, catches fluctuated between ca. 200–500 t, with a peak of 640–840 t between 1993 and 1995.

Porbeagle fisheries have generally been seasonal, and many operations landed porbeagle opportunistically and sporadically rather than through directed fisheries. For instance, local fisheries in the Bristol Channel occasionally deploy longlines for porbeagle (Ellis and Shackley, 1995). The landings from Spain are thought to be taken mainly in fisheries using longlines, targeting swordfish and tuna and tend to be greater during spring and autumn, with a drop in summer, despite being erratic in nature (Mejuto, 1985; Lallemand-Lemoine, 1991). The Norwegian fishery was also mainly run between July–October in the eastern North Sea.

Porbeagle are currently landed by several European countries, principally France and, to a lesser extent, UK, Faeroes, Norway and Spain (although Spanish landings data are from the pelagic fleet, and further details of captures in demersal fleets are required).

The only regular, directed target fishery that still exists is the French fishery (although there have been occasional targeted fisheries in the UK). Catches are primarily made on the continental slope in Division VIIId (32%) and on the continental shelf in Divisions VIIj (23%) and VIIg (20%) (Poisson and Séret, 2008). Maps in Figure 6.2 show the distribution of the French catch by statistical rectangle by year and by gear type for the period 1999–2008. An example of the seasonal variation in catches (for 2000) is illustrated in Figure 6.3. Fishing trips generally last 10–18 days, with an average of 14 days. Porbeagle is targeted with drifting longlines set from near to the surface (e.g. in the outer Bristol Channel) or down to 220–230 m depth in deeper waters in the Bay of Biscay fishing grounds. Each longline is 1500 m long with 84 hooks ballasted with 1 kg of lead every 14th hook. Each vessel has ten such lines. The fishing activity occurs during the day, a first set in the early morning with 3–4 longlines soaking for 3.5–4 h, and a second set in the afternoon functioning for 4.5–5 h with all ten longlines deployed in the second set. The location of the second set depends on the catch rates in the first set. Frozen mackerel (*Scomber scombrus*) is used as bait, one third of a fish per hook. Most of the landings take place from March to August.

The number of French vessels landing more than 5 t has been below ten since 1990, fluctuating between three and five vessels (Biais and Vollette, 2009). Average prices, as observed in the Sables d'Olonne and Guilvinec market auctions in 2008, have varied around 3.5 Euros.kg^{-1} of dressed porbeagle. Between 2002 and 2007, the income realized by the porbeagle targeted fishery varies between 26–42% of the annual turnover of the boats (Jung, 2008).

High seas tuna fisheries also take porbeagle but there is little available knowledge of the catches of this fishery (Only Japan reported catches in 1996–1997).

A.3. Ecosystem aspects

Porbeagle shark is a wide-ranging coastal and oceanic species found in temperate and cold-temperate waters worldwide (1–18°C, 0–370 m), and is more common on continental shelves (Stevens *et al.*, 2006a). Campana and Joyce, 2004 reported that more than half of the porbeagle caught, were at temperatures of 5–10°C (at the depth of the hook). They suggest that as porbeagle are among the most cold tolerant of pelagic shark species, they could have evolved to take advantage of their thermoregulatory capability to feed on abundant cold-water prey in the absence of non-thermoregulating competitors.

Porbeagles are opportunistic piscivores (Campana *et al*., 2003). Stomachs of 1022 porbeagles from the Canadian fishery were examined by Joyce *et al*., 2002. Teleosts made up 91% of the diet by weight, with cephalopods being the second most important prey item and were found in 12% of stomachs. Pelagic fish and cephalopods constituted the largest proportion of the diet in spring, whereas groundfish dominated in the fall. This seasonal change follows a migration from deep to shallow water. No diet differences were found between the sexes.

The diet of porbeagle was also analysed by Cherel (unpublished, cited by Hennache and Jung, 2010) who looked at 168 stomachs from French catches. The results are similar to the NW Atlantic study: 90% of the diet are constituted in fish and the remaining part is cephalopods. The main prey species are whiting, blue whiting and horse mackerel.

B. Data

B.1. Commercial catch

Landings

The major landings have been made by Denmark, Norway and France throughout the time series. Norway and Denmark landings are dominating up to the beginning of the seventies, thereafter France is the major contributor to the international landings.

Most of the Spanish catches are from pelagic fisheries for tuna and tuna-like species, with porbeagle catches mostly from ICES Subareas VII–IX but porbeagle is also caught by the Spanish mixed demersal fisheries.

Portuguese landings data were updated during the joint meeting with ICCAT in 2009.

Japanese landings for the NE Atlantic were reported to ICCAT in 1996 and 1997.

Discards

No information available on the discards of the non targeted fishery, although as a high value species, it is likely that specimens caught as bycatch are landed and not discarded.

Because the UE adoption of a maximum landing size, some large fish have been discarded by boats of the directed fishery in 2009 but there is no account of the number these discards.

Quality of catch data

For some nations, porbeagle will have been reported within “sharks *nei*”.

The confusion with shortfin mako (*Isurus oxyrinchus*) is suspected for some historical Spanish catches that are thought to refer to shortfin mako. Some reported landings of shortfin mako by UK-registered vessels fishing in Subareas IV and VI and Divisions VIId–e are also likely to represent misidentified porbeagle. To avoid this problem, some diagnostic characteristics can be used to distinguish porbeagle and shortfin mako (Table 6.2).

French targeted fishery landings are thought to be correctly documented from 1984 onwards. Prior to this period, there are discrepancies between the national data supplied to WGEF and data on the ICES catch statistics, especially in the 1970s. Further studies to check, confirm and harmonize datasets are needed.

Landings data from Spain (Basque Country) indicate that lamnids are taken in other mixed demersal fisheries (Table 6.3), and better estimates of porbeagle catches by Spanish demersal fisheries are required.

Landings data from non-ICES countries fishing in the NE Atlantic appear incomplete. Data are available for Japan only in two years and, furthermore, Republic of Korea and Taiwan (Province of China) are also expected to take porbeagle as a bycatch in tuna fisheries in the NE.

Further examination of national data suggests that there can be occasional confusion between catch numbers and catch weight, with some individual landings (presumably of one fish) reported as 1 kg. The extent of this problem still needs to be evaluated.

Commercial catch composition

Measurement of the length of porbeagle shark catches is an important parameter for assessing population structure, size composition and growth of the stock. It is therefore important that there is a standardized approach to reporting size measurements. This is not easily achieved with larger elasmobranchs, and inaccuracies/inconsistencies are common between datasets. Therefore, care needs to be taken when comparing length data from different sources, and where appropriate conversion factors are required.

The most commonly documented lengths are total length (L_T) and fork length (L_F), and conversion factors between the two have been calculated. However, even these lengths are not taken identically between samplers. A review of this can be found in Francis, 2006.

The length compositions of porbeagle taken in the French fishery have been provided to WGEF in 2009 (see below). However, these data have been collected only sporadically (e.g. Ellis and Shackley, 1995; Gauld, 1989; Mejuto, 1985).

Launched by the National Fishing Industry Organization Committee (CNPMEM), the French NGO Association Pour l'étude et la Conservation des Sélaciens (APECS, the French representative of the European Elasmobranch Association, EEA) implemented an observer programme in 2008-2009 aiming at gathering information on the main biological parameters of porbeagle. This programme named EPPARTIY (Etude de la Pêcherie Palangrière au Requin Taupe de l'Ile d'Yeu) received the collaboration of the fishing industry of l'Ile d'Yeu, the main French porbeagle fishery for the observers.

The length distribution (Fork length over the body) by sex of porbeagle measured during the EPPARTIY programme between April and July 2008 were presented at the 2009 WGEF (Jung, 2008; Figure 6.4). Mean average length of porbeagle landed by month and sex are presented Figure 6.5. Mean length increased from April to June for both sexes and decreased in August, especially for males caught in the Celtic Sea, south of St George's Channel (Divisions VIIg and VIIh).

B.2. Biological

The biology of porbeagle is well described for the NW Atlantic stock (e.g. Jensen *et al*., 2002; Natanson *et al*., 2002; Cassoff *et al*., 2007; Francis *et al*., 2008), although less information is available for the NE Atlantic stock.

Habitat

In the North Atlantic, porbeagle abundance varies seasonally and spatially (Aasen, 1961; 1963; Templeman, 1963; Mejuto and Garcés, 1984; Mejuto, 1985; Gauld, 1989). In the NE Atlantic, the limited studies conducted on this population, and historical catch records indicate that porbeagle segregate by sex and size. Mejuto, 1985 found twice as many males were caught off Spain, whereas Gauld, 1989 found 30% more females were caught off Scotland, and Ellis and Shackley, 1995 found the males predominated in catches in the Bristol Channel. These observations have also been made by Hennache and Jung, 2010. On the shelf edge in the south of Ireland, the male/female ratio was 0.7 but 1.2 in the Bristol Channel and in the North of the Bay of Biscay.

Their movements reveal seasonal patterns, however, this knowledge is incomplete for a large part of the year. French catches indicates that porbeagle is mainly present in spring and in summer along the shelf edge (along the 200m depth line) of the Celtic Sea and of the Bay of Biscay, and in the Saint Georges Channel and in the entrance of the Bristol Channel (Figure 6.3). Two recent studies have been carried out using a limited number of archival satellite tags. In the first one, four porbeagles were tagged caught off the SW England (Pade *et al*., 2009). During July and August the sharks move erratically within the Celtic Sea. One individual was tracked during autumn, and this shark moved to deeper waters off the continental shelf before moving northwards. Sharks occupied a bathymetric range of 0–552 m and water temperatures of 9–19°C. In the second, archival tags were attached on three porbeagles in Northwest Ireland in September 2008. The tags were programmed to pop after 122 days. All three tagged porbeagles migrated South along the shelf edge (Saunders *et al.*, 2010).

Nursery and pupping grounds

The nurseries are probably in continental waters, but there are few published data (Castro *et al*., 1999). However, according to French catch length distribution (Hennache and Jung, 2010), the Saint Georges Channel is likely a nursery area (porbeagle length below 170cm for 90% of the catches and below 125cm for 25%).

Four gravid females were caught in the South of Ireland (Statistical rectangle 25D8) with full term pups (embryo total lengths being 80-81 cm) within a few days in May 2008 (Hennache and Jung, 2010), possibly indicating a pupping ground. This limited knowledge would probably benefit from further satellite archival tagging to examine the movements of gravid females to infer where pupping grounds may be. Comparable studies have recently been undertaken in the NW Atlantic; and this study suggested that pupping grounds may occur in warmer waters south of the main stock area (Campana *et al*., 2010).

Life history parameters

Biological data of the NE Atlantic porbeagle shark are very scarce; with very few published studies (e.g. Mejuto and Garcés, 1984; Gauld, 1989; Stevens, 1990; Pade *et al*., 2006; Green, 2007). The majority of other biological parameters are available from studies conducted elsewhere in the world, mainly in the NW Atlantic, but also in the Pacific to a limited extent (see Table 6.5).

However, recent information has been collected by Hennache and Jung in 2008-2009 by sampling the catches of the French targeted fishery (sex ratio, length-weight relationship). The age have been determined on a sample of vertebrae (n=120). This study indicated that NE Atlantic porbeagle are slower growing than NW Atlantic porbeagle. However, further age and growth studies are needed to provide growth parameters for the NE Atlantic porbeagle stock.

The maturity estimates provided by Jensen *et al.* (2002) for NW Atlantic porbeagle (see Table 6.5) have been used in assessments for NE Atlantic in the absence of appropriate, recent data for NE Atlantic porbeagle.

Estimates of natural mortality include 0.18 (Aasen, 1963), 0.1–0.2 for immature and mature fish (Campana *et* al., 2001) and 0.114 (E. Cortes, unpublished).

B.3. Surveys

No abundance survey carried out for this stock.

B.4. Commercial CPUE

Preliminary analyses of data from the French fishery were undertaken in 2006 (see Section 6 of ICES, 2006, 2008), based on data supplied in Biseau, 2006, WD. These data provided some indication of effort in an otherwise data poor fishery; however, the rate of kg/vessel needs to be treated with some caution, and if possible re-parameterizing to account for true effort, in terms of taking days at sea, size of vessel, changes in fishing area, etc. into account.

More detailed data were presented in 2008 (Jung, 2008). Effort from the French targeted fishery were presented in annual number of hooks (Figure 6.8) taking into account the average day of fishing activity multiplied by the average daily number of fishing operation. Effort reached a maximum of 725 760 hooks in 1994 and decreased to 323 576 hooks deployed in 2007. A nominal cpue index was calculated from the individual vessel landings for the top 12 vessels presented in Table 6.4 (1993–2007). Annual variation ranged from 1 kg/hook (1994) to 0.73 kg/hook (2007) across the time-series, with a peak cpue of around 1.5 kg/hook in 1999, and a low of 0.54 kg/hook in 2005, however there is much variance. Further studies were requested to clarify this trend. Consequently, a longer time-series of logbook data was presented to the 2009 WG to allow a better interpretation of cpue trends (Figure 6.9).

Mejuto and Garcés, 1984 reported that the NW and N Spanish longline fleets had a cpue of 2.07 kg/1000 hooks for porbeagle shark. However, the cpue demonstrated a seasonal trend, with the highest catches being made in the last four months of the year, where the cpue was three to four times higher than in February or March although the effort was of a similar level.

B.5. Other relevant data

C. Assessment: data and method

Stock assessment

An first assessment of the NE Atlantic stock was carried out in 2009 by the joint ICCAT/ICES meeting, using a Bayesian Surplus Production (BSP) model (Babcock and Cortes, 2009) and an age structured production (ASP) model (Porch *et al.* 2006). This assessment has not been updated by the WGEF since 2009, considering the need of a benchmark assessment for these species.

* BSP model:

The BSP model uses catch and standardized cpue data (see Section 6.5.2 and ICCAT, 2009). Because the highest catches occurred in the 1930s and 1950s, long before any CPUE data were available to track abundance trends, several variations of the model were tried, either starting the model run in 1926 or 1961, and with a number of different assumptions. An informative prior was developed for the rate of population increase (*r*) based on demographic data of the NW Atlantic stock. The prior for *K* was uniform on log *K* with an upper limit of 100,000 t. This upper limit was set to be somewhat higher than the total of the catch series from 1926 to the present (total catch= 92,000 t). All of the trials showed that the population continued to decline slightly after 1961, consistent with the trend in the French CPUE series.

The model runs used the most biologically plausible assumptions about unfished biomass or biomass in 1961. The relative 2008 biomass (B2008/BMSY) can be estimated between 0.54 and 0.78 and the relative 2008 fishing mortality rates (F2008/FMSY) between 0.72 and 1.15.

*ASP model:

An age-structured production model was also applied to the NE Atlantic stock of porbeagle to provide contrast with the BSP model (see ICCAT 2009). The same input data used in the BSP model were applied but incorporating age-specific parameters for survival, fecundity, maturity, growth, and selectivity. The stock–recruitment function is also parameterized in terms of maximum reproductive rate at low density.

Depending on the assumed F in the historic period (the model estimated value was considered to be unrealistic), the 2008 relative spawning stock fecundity (SSF2008/SSFMSY) was estimated between 0.21 and 0.43 and the 2008 relative fishing mortality rate (F2008 /FMSY) between 2.54 and 3.32.

The conclusions of these assessments were that the exploratory assessments indicate that current biomass is below BMSY and that recent fishing mortality is near or possibly above FMSY. However, the lack of CPUE data for the peak of the fishery adds considerable uncertainty in identifying the current status relative to virgin biomass.

D. Short-Term Projection

The projections (using the BSP model) were that sustained reductions in fishing mortality would be required if there is to be any stock recovery. Recovery of this stock to B_{msy} under zero fishing mortality would take ca. 15–34 years. Although model outputs suggested that low catches (below 200 t) may allow the stock to increase under most credible model scenarios, the recovery to B_{MSY} could be achieved within 25–50 years under nearly all model scenarios (Table 6.4).

E. Medium-Term Projections

No medium-term projection

F. Long-Term Projections

A yield-per-recruit analysis using FLR (ww.flr-project.org) was conducted by the ICCAT/ICES WG.

The effects of different selection patterns on the NE Atlantic porbeagle stock were evaluated: flat-topped and dome-shaped curves and with maximum selectivity at either age 5 or 13 (age 13 corresponds to age-at-maturity of females and to the current maximum landing length of 210 cm fork length).

The analysis demonstrates that both potential stock size and yields are increased if fishing mortality is reduced on immature fish. If the fishing mortality on individuals greater than 210 cm is reduced to 0, the stock levels are slightly improved at expense of yield (Table 6.6).

H. Other Issues

No

I. References

Aasen, O., 1961. Some observations on the biology of the porbeagle shark (*Lamna nasus* L.). ICES CM 1961/Northern Seas Committee: 109, 7 pp.

Aasen, O. 1963. Length and growth of the porbeagle (*Lamna nasus*, Bonneterre) in the North West Atlantic. *Fisk. Skrift. Ser. Havund*. 13(6):20–37.

Babcock, B.A. and Cortes, E., 2009. Bayesian surplus production model applied to porbeagle catch, CPUE and effort data. ICCAT, Col. Vol. Sci. Pap. SCRS/2009/068, 7pp.

Biais G. and Vollette J. 2009. CPUE of the French porbeagle fishery. WGEF Working Document, 3 pp.

Biseau, A. 2006. Catch data of porbeagle in French artisanal fishery on porbeagle. WGEF Working Document.

Buencuerpo V., Rios S. and Moron J. 1998. Pelagic sharks associated with the swordfish, *Xiphias gladius*, fishery in the eastern North Atlantic Ocean and the Strait of Gibraltar. *Fishery Bulletin*, 96: 667–685.

Campana, S.E., Marks, L., Joyce, W., Hurley, P., Showell, M., and Kulka, D. 1999. An analytical assessment of the porbeagle shark (*Lamna nasus)* population in the Northwest Atlantic. Canadian Stock Assessment, Research Document 1999/158, Ottawa.

Campana S.E. and Joyce W.N. 2004. Temperature and depth associations of porbeagle shark (*Lamna nasus*) in the Northwest Atlantic. *Fisheries Oceanography*, 13: 52–64.

Campana, S. E., Joyce, W., Marks, L. and Harley, S. 2001. Analytical Assessment of the porbeagle shark (*Lamna nasus*) population in the Northwest Atlantic, with estimates of longterm sustainable yield. Canadian Stock Assessment, Research Document 2001/067, Ottawa.

Campana, S.E., Joyce, W. and Marks, L. 2003. Status of the Porbeagle Shark (*Lamna nasus*) Population in the Northwest Atlantic in the Context of Species at Risk. Canadian Stock Assessment, Research Document, 2003/007, Ottawa.

Campana, S.E., Joyce, W., Fowler, M, 2010. Subtropical pupping ground for a cold-water shark. *Canadian Journal of Fisheries and Aquatic Sciences,* 67: 769-773.

Cassoff, R.M., Campana, S.E. and Myklevoll, S. 2007. Changes in baseline growth and maturation parameters of Northwest Atlantic porbeagle, *Lamna nasus*, following heavy exploitation. *Canadian Journal of Fisheries and Aquatic Sciences,* 64: 19–29.

Castro, J.I., Woodley, C.M., and Brudek, R.L. 1999. A Preliminary Evaluation of the Status of Shark Species. FAO Fisheries Technical Paper 380, Rome.

CEC 2008. Council Regulation (EC) No 40/2008 of 16 January 2008 fixing for 2008 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required. Brussels, 23.1.2008, 203pp.

CEC. 2009. Council Regulation (EC) No 43/2009 of 16 January 2009 fixing for 2009 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required. Official Journal of the European Union L 22; 205 pp.

Compagno, L.J.V. 1984. FAO species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of the shark species known to date, parts 1 and 2. FAO Fisheries Synopsis No. 125. FAO, Rome, Italy, pp. 655.

Cortés, E. 1999. Standardized diet compositions and trophic levels of sharks. *ICES Journal of Marine Science* 56: 707–717.

Ellis, J.R. and Shackley, S.E. 1995. Notes on porbeagle sharks, *Lamna nasus*, from the Bristol Channel. *Journal of Fish Biology*, 46: 368–370.

Francis, M.P. 2006. Morphometric minefields-towards a measurement standard for chondrichthyan fishes. *Environmental Biology of Fishes*, 77:407–421.

Francis, M.P., and Stevens, J.D. 2000. Reproduction, embryonic development, and growth of the porbeagle shark, *Lamna nasus*, in the southwest Pacific Ocean. Fish. Bull. 98:41–63.

Francis, M.P., Natanson, L.J., and Campana, S.E. 2008. The Biology and Ecology of the Porbeagle Shark, *Lamna nasus*. *In*: Sharks of the Open Ocean: Biology, Fisheries & Conservation (M.D.Camhi, E.K.Pikitch and E.A.Babcock, Eds). Blackwell Publishing, Oxford, UK. pp. 105–113.

Gauld J.A. 1989 Records of porbeagles landed in Scotland, with observations on the biology, distribution and exploitation of the species. Scottish Fisheries Research Report 45. Dept. Ag., Edinburgh, Scotland: 1–15.

Green, P. 2007 WD. Central Fisheries Board marine sportfish tagging programme 1970 to 2006. Working document to WGEF, 2007.

Hennache C. and Jung, A. 2010. Etude de la pêche palangrière de requin taupe de l'île d'Yeu. Rapport Final. Association pour l'étude et la conservation des sélaciens (APECS), http://www.asso-apecs.org/IMG/pdf/APECS_EPPARTIY_Rapport_final_BD.pdf, 64pp.

ICCAT. 2009. Report of the 2009 Porbeagle Stock Assessments Meeting. Copenhagen, Denmark, 22–27 June, 2009. ICCAT, Col. Vol. Sci. Pap. SCRS/2009/014**,** 42pp.

Harley, S. J. 2002. Statistical catch-at-length model for porbeagle shark (*Lamna nasus*) in the Northwest Atlantic. Col. Vol. Sci. Pap. ICCAT, 54 (4): 1314–1332.

Heessen, H. J. L. (Ed.). 2003. Development of elasmobranch assessments DELASS. Final report of DG Fish Study Contract 99/055, 603 pp.

ICCAT. 2009. Report of the 2009 Porbeagle Stock Assessments Meeting. Copenhagen, Denmark, 22–27 June, 2009. *In Prep.*

ICES. 2006. Report of the Working Group on Elasmobranch Fishes (WGEF), 14–21 June 2006, ICES Headquarters. ICES CM 2006/ACFM:31. 291 pp.

ICES. 2008a. Report of the Working Group Elasmobranch Fishes (WGEF), 3–6 March 2008, Copenhagen, Denmark. ICES CM 2008/ACOM:16. 332 pp.

Jensen, C.F., Natanson, L.J., Pratt, H.L., Kohler, N.E. and Campana, S.E. 2002. The reproductive biology of the porbeagle shark (*Lamna nasus*) in the western North Atlantic Ocean. *Fishery Bulletin,* 100: 727–738.

Joyce, W.N., Campana, S.E., Natanson, L.J., Kohler, N.E., Pratt, H.L. and Jensen, C.F. 2002. Analysis of stomach contents of the porbeagle shark (*Lamna nasus* Bonnaterre) in the Northwest Atlantic. *ICES Journal of Marine Science*, 59: 1263–1269.

Jung A. 2008. A preliminary assessment of the French fishery targeted porbeagle shark (Lamna nasus) in the Northeast Atlantic Ocean: biology and catch statistics Col. Vol. Sci. Pap. ICCAT, (in Press).

Kohler N.F., Casey J.G. and Turner P.A. 1995. Length-weight relationships for 13 species of sharks from the western North Atlantic. *Fishery Bulletin*, 93: 412–418.

Kohler N.F., Turner P.A., Hoey, J.J., Natanson, L.J., and Briggs. R., 2002. Tag and recapture data for three pelagic shark species: blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), and porbeagle (*Lamna nasus*) in the North Atlantic Ocean. Col. Vol. Sci. Pap. ICCAT, 54 (4): 1231–1260.

Lallemand-Lemoine, L. 1991 Analysis of the French fishery for porbeagle *Lamma nasus.* (Bonnaterre, 1788). ICES CM 1991/G:71.

Mejuto, J. 1985. Associated catches of sharks, *Prionace glauca*, *Isurus oxyrinchus*, and *Lamna nasus*, with NW and N Spanish Swordfish Fishery, in 1984. ICES C.M. 1985: H42. International Council for the Exploration of the Sea, Copenhagen, Denmark, 16 pp.

Mejuto, J. and Garcés, A. G. 1984. Shortfin mako, *Isurus oxyrinchus*, and porbeagle, *Lamna nasus*, associated with longline swordfish fishery in NW and N Spain. ICES CM 1984/G:72 Demersal Fish Committee.

Mejuto, J., Ortiz, J., García-Cortés, B., Ortiz de Urbina, J. and Ramos-Cartelle, A.M., 2009. Historical data and standardized catch rates of porbeagle (Lamna nasus) caught as bycatch of the Spanish surface longline fishery targeting swordfish (Xiphias gladius) in the Atlantic ocean. ICCAT, Col. Vol. Sci. Pap. SCRS/2009/053, 23 pp.

Natanson, L.J., Mello, J.J. and Campana, S.E. 2002. Validated age and growth of the porbeagle shark (*Lamna nasus*) in the western North Atlantic Ocean. *Fishery Bulletin*, 100: 266–278.

Pade, N., Sarginson, J., Antsalo, M., Graham, S., Campana, S., Francis, M., Jones, C., Sims, D. and Noble, L. 2006. Spatial ecology and population structure of the porbeagle (*Lamna nasus*) in the Atlantic: an integrated approach to shark conservation. Proceedings of the 10th Annual Science Conference of the European Elasmobranch Association. 11–12 November, 2006. Hamburg.

Pade, N.G., Queiroz, N.Q., Humphries, N.E., Witt, M.J., Jones, C.S., Noble, L.R. and Sims, D.W. (2009). First results from satellite-linked archival tagging of porbeagle shark, Lamna nasus: Area fidelity, wider-scale movements and plasticity in diel depth changes. J. Exp. Mar. Biol. Ecol.,Vol. 370, no. 1-2, pp. 64-74.

Poisson, F and Séret, B. 2008. Pelagic sharks in the Atlantic and Mediterranean French fisheries: Analysis of catch statistics. Col. Vol. Sci. Pap. ICCAT, (in Press).

STECF, 2006. 22nd Report of the Scientific, Technical and Economic Committee for Fisheries. Brussels, 3–7 April, 50pp.

Saunders ., Royer F. and Clarke, M.W. , 2010. Winter migration and diving behaviour of porbeagle shark, *Lamna nasus,* in the northeast Atlantic. ICES Journal of Marine Science.*In Press.*

Stevens, J. D. 1990. Further results from a tagging study of pelagic sharks in the North-east Atlantic. *Journal of the Marine Biological Association of the United Kingdom*, 70: 707–720.

Stevens, J., Fowler, S.L., Soldo, A., McCord, M., Baum, J., Acuña, E., Domingo, A. and Francis, M. 2006. *Lamna nasus*. In: IUCN 2007. *2007 IUCN Red List of Threatened Species.* (www.iucnredlist.org) Downloaded on 24 June 2008.

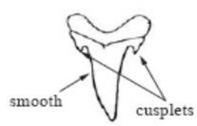
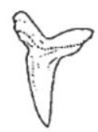
Stevens, J., Fowler, S.L., Soldo, A., McCord, M., Baum, J., Acuña, E. and Domingo, A. 2006. *Lamna nasus* (Mediterranean subpopulation). In: IUCN 2007. *2007 IUCN Red List of Threatened Species.* (www.iucnredlist.org) Downloaded on 30 June 2008.

Templeman, W. 1963. Distribution of sharks in the Canadian Atlantic (with special reference to Newfoundland waters). Bulletin No. 140. Fisheries Research Board of Canada, Ottawa, Ontario, Canada, 77 pp.

Table 6.1. Porbeagle in the NE Atlantic. French landings (%) of porbeagle by broad categories of gear type, 1999–2007.

Gear Type	1999	2000	2001	2002	2003	2004	2005	2006	2007
Longline	77.5%	60.9%	81.0%	78.8%	82.1%	72.3%	74.9%	67.9%	89.0%
Net	12.1%	28.6%	8.1%	10.6%	10.9%	15.9%	11.4%	18.2%	5.0%
Trawl (demersal)	5.8%	6.0%	7.5%	3.5%	4.0%	6.3%	6.2%	8.2%	4.8%
Trawl (pelagic)	4.6%	4.2%	2.6%	5.6%	2.8%	4.8%	7.3%	3.8%	0.8%
Unclassified	0.1%	0.2%	0.7%	1.6%	0.2%	0.8%	0.1%	1.9%	0.4%

Table 6.2. Porbeagle in the NE Atlantic. Characteristics for the identification of porbeagle and shortfin mako (adapted from Compagno, 1984).

	Porbeagle	Mako
Teeth	Lateral cusps present on teeth* 	No cusplets on teeth 
Origin of first dorsal fin	Over or anterior to posterior margins of pectoral fins	Over or behind posterior margin of the pectoral fins
Origin of second dorsal fin	Over origin of anal fin	In front of the origin of the anal fin
Caudal fin	Secondary keel present below main keel on caudal fin	No secondary keel

*** However, sometimes these cusplets appear to be absent in young porbeagle, as they may be covered by some skin, which can lead to misidentification.**

Table 6.3. Porbeagle in the NE Atlantic. Landings of Porbeagle and Shortfin mako (*Lamnidae*) from Spain (Basque Country).

Year	VI	VII	VIII	Total
1996			20	20
1997	0	0	12	12
1998	1	2	24	27
1999	0	8	33	41
2000	0	3	35	38
2001		7	39	45
2002	0	1	15	16
2003		1	21	22
2004		0	10	10
2005	0	1	10	11

2006		5	5
2007	0	15	16
2008		13	13
2009		3*	3

* porbeagle alone

Table 6.4. Porbeagle in the NE Atlantic. Number of fishing trip per year for vessels involved in the targeted porbeagle fishery 1993 to 2007 (Jung, 2008).

Vessel	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	9	10	9	5	5	6	2	3	2	9	9	9	7	8	7
2	4	12	6	9	5	7	4	4	6	4	5	7	2	3	3
3	1	5	6	1	5	5	3	6	5	5	7	6			
4	10	7	6	5	8	3	3	3	1	6	2				
5	6	9	6	4	4	5	4	3	6	2					
6	3	9	9	10	8	7	8	8	5						
7	4	2	4	4	2										
8									5	6	5	7	3		5
9				1	1	2	3	2	2						
10											5	2			3
11					5								5	3	5
12	7	6	7	5											
13					3	3	2	3							
14			6	5	6										
15	11	12													
16				3											
17	4														
18	10														

Table 6.5. Porbeagle in the NE Atlantic. Life-history parameters for porbeagle from the scientific literature.

Parameter	Values	Sample Size	Area	Reference
Reproduction	Ovoviviparous with oophagy			Campana *et al*., 2003
Gestation period	8–9 months			Aasen, 1963; Francis and Stevens, 2000; Jensen *et al*., 2002
Litter size	4 (3.7–4 per year)		Scotland and NW Atlantic	Gauld, 1989; Francis and Stevens, 2000; Jensen *et al*., 2002
Size at birth	60–75 cm		NW Atlantic	Aasen, 1963; Compagno, 1984

Parameter	Values	Sample Size	Area	Reference
	58–67 (LF)		SW Pacific	Francis and Stevens, 2000
Sex Ratio (males : females)	1:1.3	1368 (1954–1987- year-round samples)	Scotland	Gauld, 1989 (data from 1954–1987)
	1:1	1228 (year-round samples)	NW Atlantic	Kohler *et al*., 2002
	1:0.25	65 (year-round samples)	NE Atlantic	Kohler *et al*., 2002
	1:0.5		NE Atlantic (Spain and Azores)	Mejuto, 1985
	1:0.6		N and NW Spain	Mejuto and Garcés, 1984
	1:0.84		Saint Georges Channel	Hennache and Jung, 2010
	1:0.85		North of Bay of Biscay	Hennache and Jung, 2010
	1:1.35		South Ireland	Hennache and Jung, 2010
Embryonic sex ratio	1:1			Francis and Stevens, 2000; Jensen *et al*., 2002
Male age at 50% maturity (years)	~ 8		NW Atlantic	Natanson *et al*., 2002
Female age at 50% maturity (years)	~ 13		NW Atlantic	Natanson *et al*., 2002
Male length at maturity (LF)	150–200 cm 166–184 cm (L50 ~ 174 cm)			Aasen 1961 Jensen *et al*., 2002
Male mean length (LF)	116 cm		NW Atlantic	Kohler *et al*., 2002
	147 cm		NE Atlantic	Kohler *et al*., 2002
Female length at maturity (LF)	210–230 cm (L50 ~ 218 cm) 200–250			Jensen *et al*., 2002 Aasen, 1961
Female mean length (LF)	108 cm		NW Atlantic	Kohler *et al*., 2002
	154 cm		NE Atlantic	Kohler *et al*., 2002
Maximum length (LF)	250 cm (male) 302 cm (female)		NW Atlantic	Campana (unpublished data*)

Parameter	Values	Sample Size	Area	Reference
	253 cm (male) 278 cm (female)		NE Atlantic	Gauld, 1989
Average growth rate	25.2 cm y–1	3	NE Atlantic	Stevens 1990
Life span (years) Maximum age	29–45		NW Atlantic	Campana *et al*., 1999
	40+ (unfished popn. based on natural mortality estimates) 25 (fished, maximum observed)			Campana *et al*., 2001
	males: 25 females: 24 (vertebral counts) Longevity calcs. indicate 45–46 in unfished popn.			Natanson *et al*., 2002
Length-weight relationship	W = (1.4823 x 10–5) LF 2.9641			Kohler *et al*., 1995
	W = ('4 x 10–5) LF 2.7767	1022	Bay of Biscay and Celtic Sea	Hennache and Jung, 2010
	W = ('4 x 10–5) LF 2.7316	564	Bay of Biscay and Celtic Sea	Hennache and Jung, 2010
	W = ('4 x 10–5) LF 2.8226	456	Bay of Biscay and Celtic Sea	Hennache and Jung, 2010
Fork length-total length relationship	LF = 0.8971LT + 1.7939			Kohler *et al*., 1995
Male growth parameters	l□= 257.7 k = 0.080 t0 = -5.78		NW Atlantic	Harley, 2002
Female growth parameters	l□= 309.8 k = 0.061 t0 = -5.90		NW Atlantic	Harley, 2002
Combined sex growth parameters	l□= 289.4 k = 0.066 t0 = -6.06		NW Atlantic	Harley, 2002; Natanson *et al*., 2002
	l□= 267.6 ± 9.3 k = 0.084 ± 0.009 t0 = -5.39 ± 0.47	577	NW Atlantic	Cassoff *et al*., 2007 (1993–2004 data)
Population growth rate	~ 2.5% per year max ~ 5% per year in			Campana *et al*., 2003

Parameter	Values	Sample Size	Area	Reference
Generation time (years)	~ 18		NW Atlantic Atlantic	Campana *et al*., 2003 Cortés, 2000
Intrinsic rate of increase	0.05–0.07		NW Atlantic	Campana *et al*., 2001
Potential rate of increase per year	0.8%		Atlantic	Cortés, 2000
Trophic level	4.2	115 (stomachs)	various (4 studies)	Cortes, 1999
Total mortality coefficient	0.18		NW Atlantic	Aasen, 1963

*** Cited in Francis *et al*., 2008**

Table 6.6: Fishing mortality, yield, biomass and SSB relative to that achieved at the effort level corresponding to the F0.1 level for a flat-topped selection pattern with maximum selection-at-age 3.

Selection Pattern	Age Max Selection	Maximum Landing Length	F	Yield	Biomass	SSB
Domed	5	No	211%	68%	202%	120%
Flat	13	No	211%	79%	280%	176%
Domed	13	No	279%	68%	295%	178%
Flat	5	Yes	150%	84%	134%	105%
Domed	5	Yes	217%	67%	206%	120%
Flat	13	Yes	698%	35%	377%	191%
Domed	13	Yes	698%	35%	377%	191%

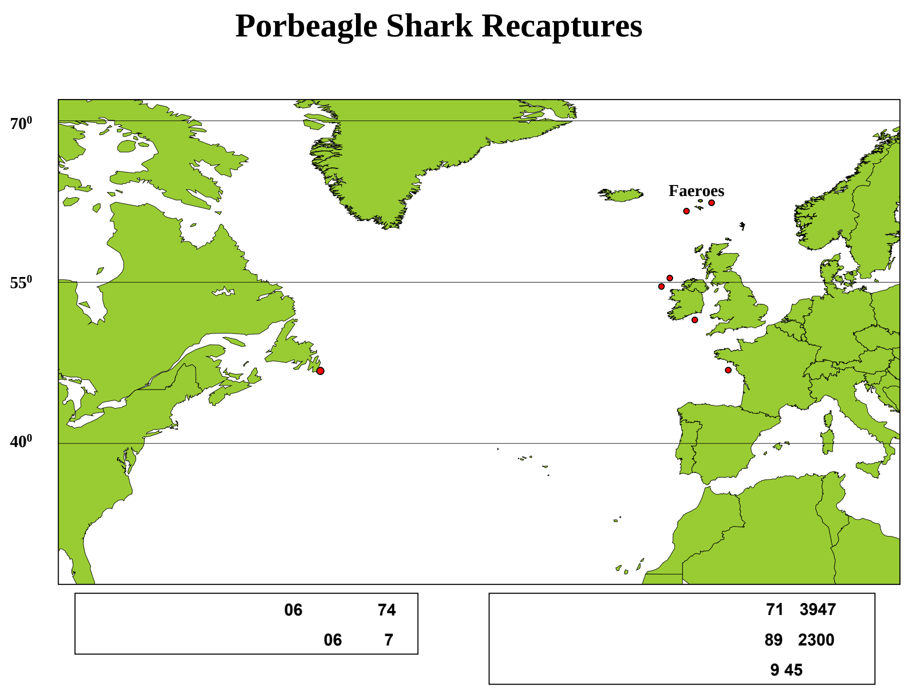
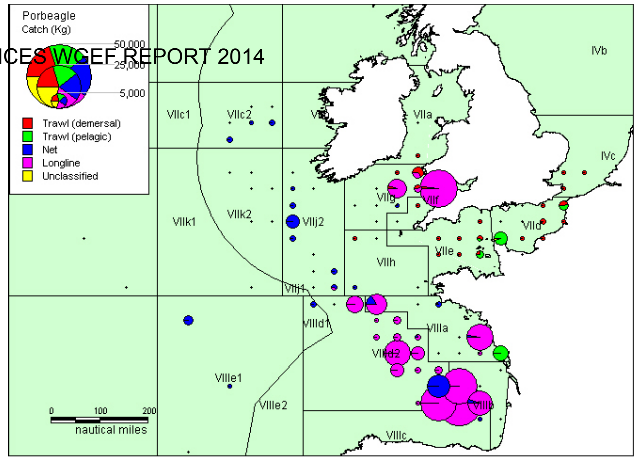
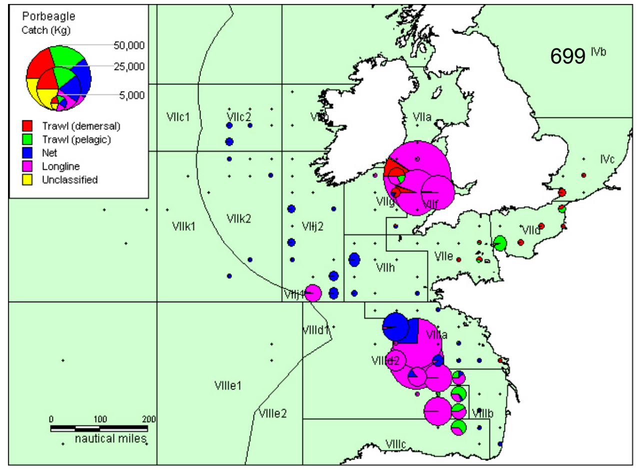


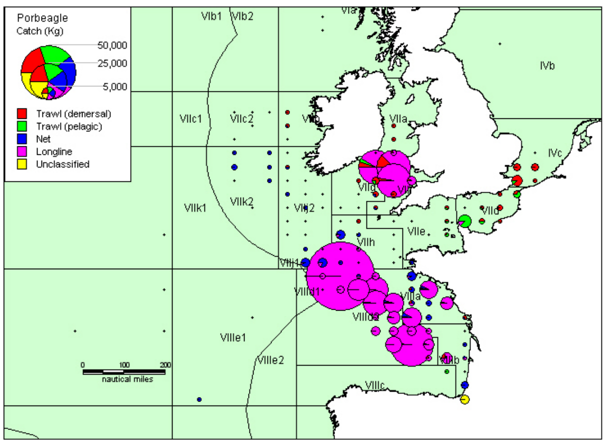
Figure 6.1. Porbeagle in the NE Atlantic. Recapture locations of porbeagle sharks, from Irish Central Fisheries Board tagging programme (Green, 2007 WD).

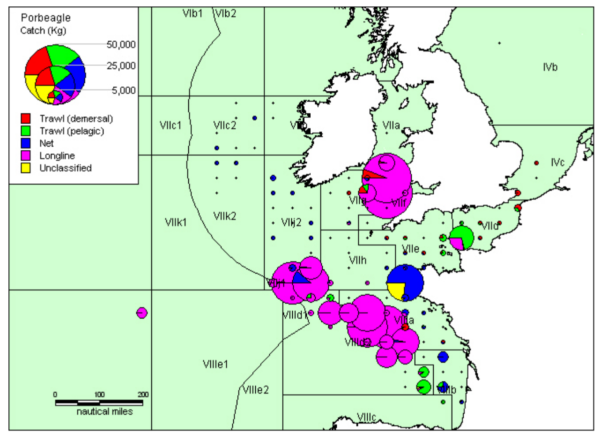




1999

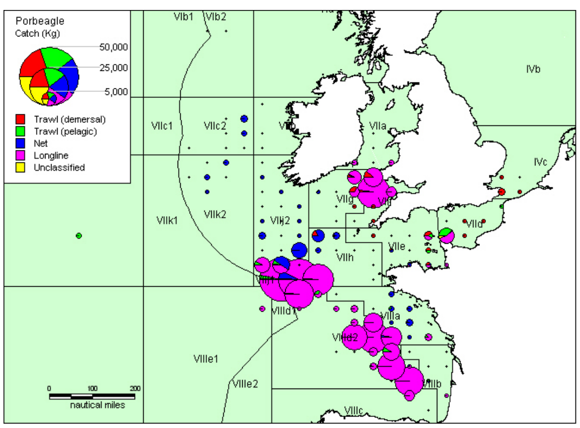
2000

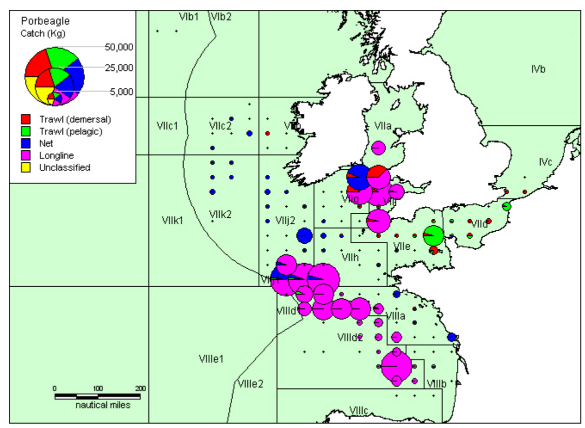




2001

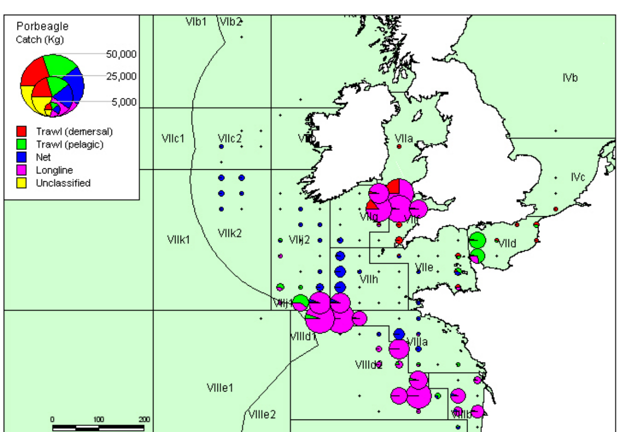
2002





2003

2004



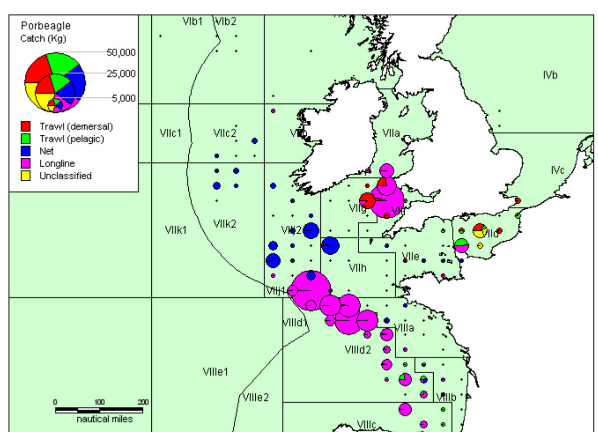
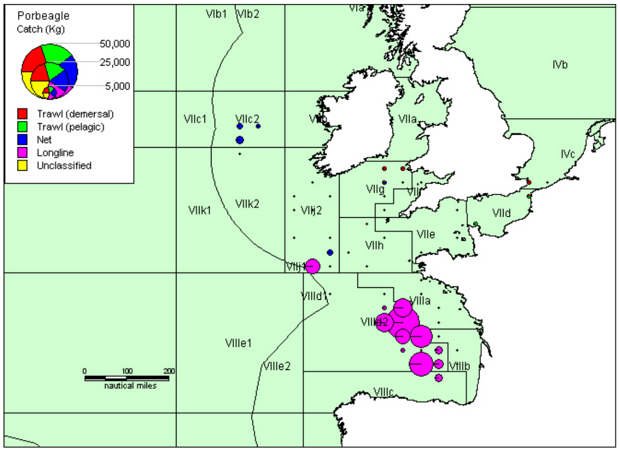
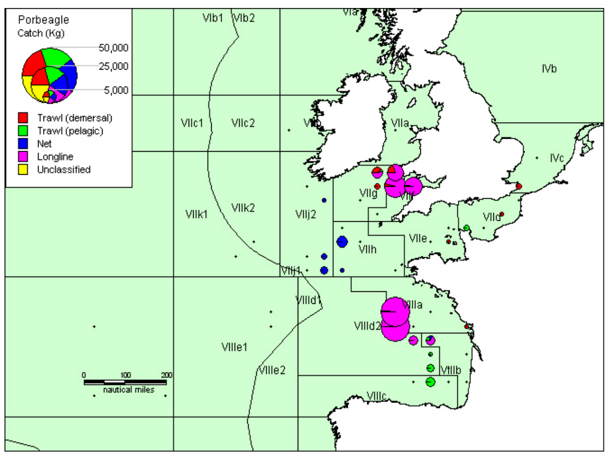


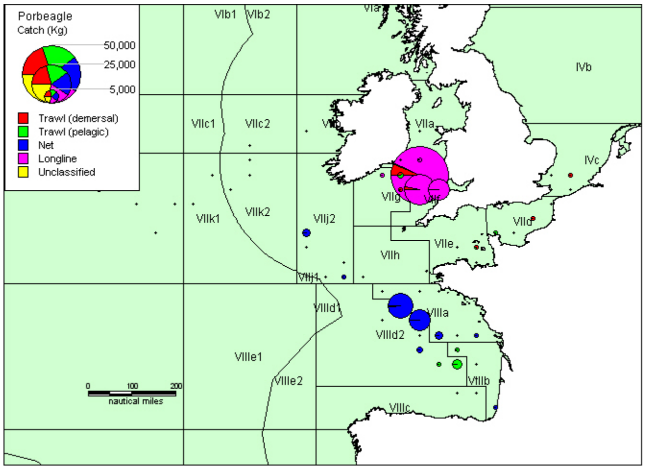
Figure 6.2. Porbeagle in the NE Atlantic. Annual distribution of Porbeagle (*Lamna nasus*) catch by gear and ICES statistical rectangles, 1999–2008.



April–May 2000



June–July 2000



August–September 2000

Figure 6.3. Porbeagle in the NE Atlantic. Seasonal distribution of Porbeagle (*Lamna nasus*) catch by gear and ICES statistical rectangles (2000).

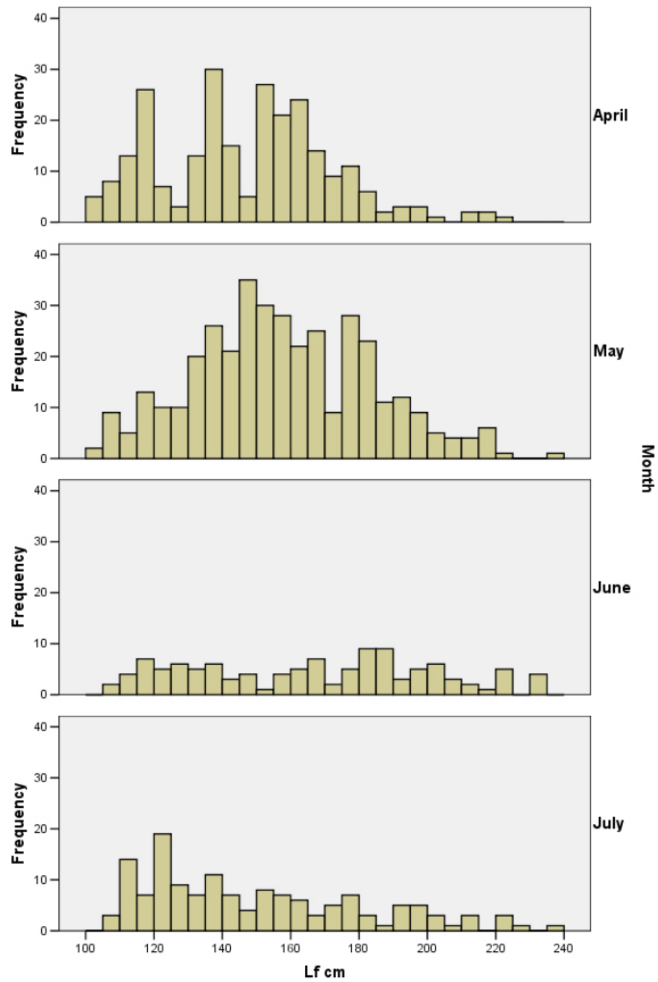


Figure 6.4. Porbeagle in the NE Atlantic. Length–frequency distribution of the landings of the Yeu porbeagle targeted fishery by month in 2008 (April, n = 164; May, n = 350; June, n = 113; July, n = 142) 2008. Source: Jung, 2008.

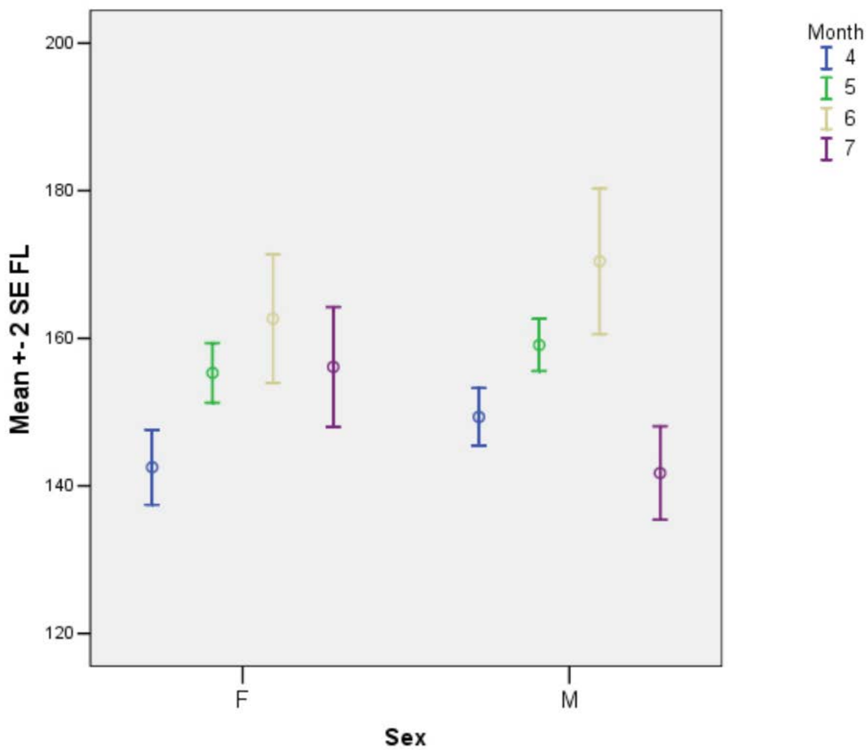


Figure 6.5. Porbeagle in the NE Atlantic. Mean average length of the porbeagle landed in the French targeted fishery by sex for April (blue), May (green), June (yellow) and July (purple). Source: Jung, 2008.

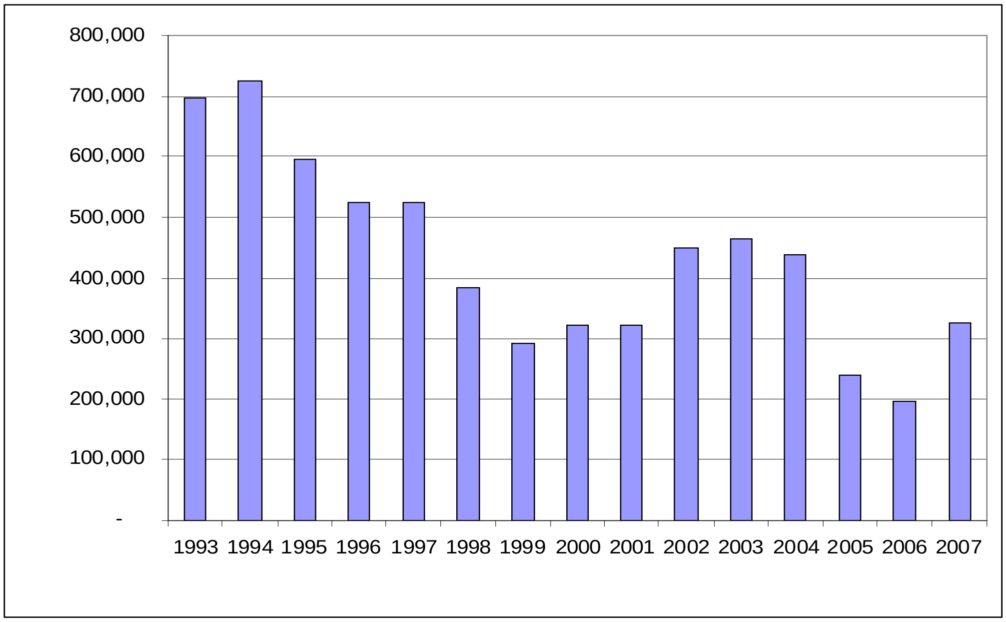


Figure 6.8. Porbeagle in the NE Atlantic. Temporal trend in estimated effort (number of hooks per year) in the French porbeagle fishery, 1993–2007.

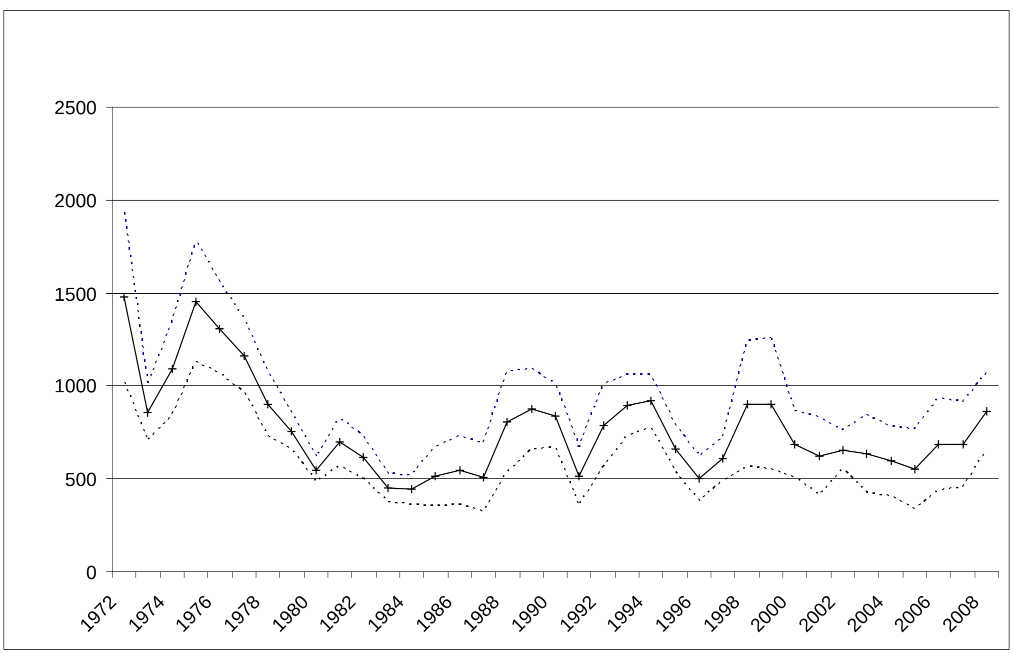


Figure 6.9. Porbeagle in the NE Atlantic. Nominal cpue (kg/day at sea) for porbeagle taken in the French fishery (1972–2008) with confidence interval (± 2 SE of ratio estimate). From Biais and Vollette, 2009, WD.

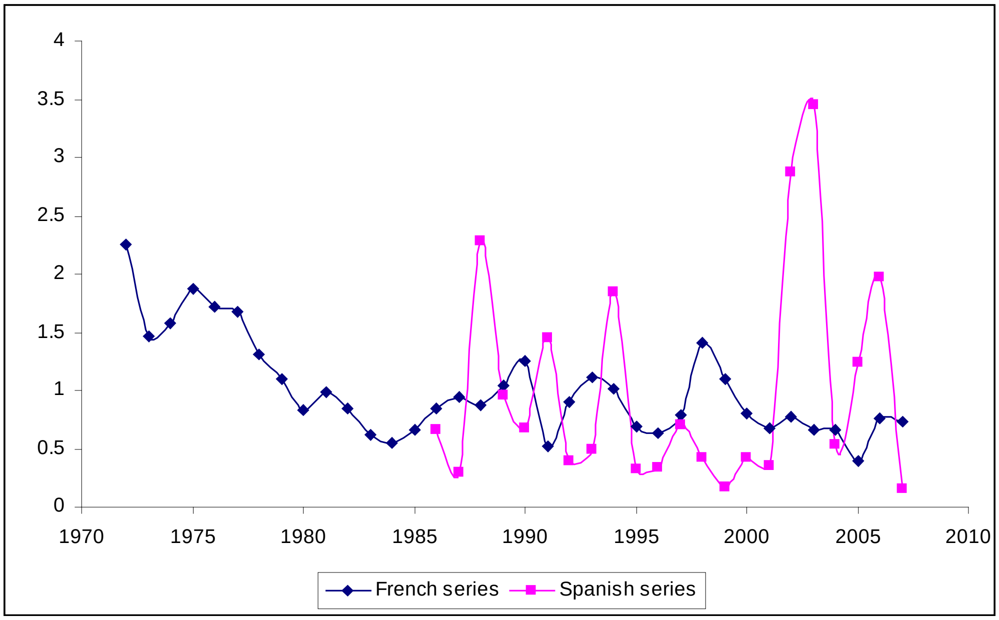


Figure 6.10. Porbeagle in the NE Atlantic. Temporal trends in standardized cpue for the French target longline fishery for porbeagle (1972–2007) and Spanish longline fisheries in the NE Atlantic (1986–2007).

Stock Annex

Stock specific documentation of standard assessment procedures used by ICES.

Stock rjb-89a Common skate (*Dipturus batis*-complex) in Subarea VIII and Division IXa (Bay of Biscay and Atlantic Iberian waters)

Working Group: ………WGDEEP…………………………

Date: (April 2014)

Revised by (WGDEEP 2014 /Samuel Iglésias

A. General

A.1. Stock definition

The species *Dipturus batis* was shown to be a mixture of two species, correctly identified in publication from 1837 to 1926 then combined into one single species for close to one century (Iglésias *et al.*, 2010). The stock unit is therefore a complex of two species *D. cf. flossada* and *D. cf. intermedia* with strong difference in life history trait, in particular maximum size, probably implying difference in the level of fishing mortality that these species are able to sustain.

The population structure of both species is unknown and the definition of a stock unique in Subarea VIII and Division IXa, was make to ascribe an assessment unit to every species caught in the eco-region.

A.2. Fishery

Council Regulation (EU) 43/2014 stated that it shall be prohibited for Union vessels to fish for, to retain on board, to tranship or to land the common skate (*Dipturus batis*) complex (*Dipturus* cf. *flossada* and *Dipturus* cf. *intermedia*) in Union waters of ICES subareas VIII.

A.3. Ecosystem aspects

The two species are present from the coast to about 700 meters depth but they mostly occure on the shelf. They occur on soft (sandy-muddy) bottom. *Dipturus* cf. *flossada* is currently mostly present in the Celtic sea off Scilly and *Dipturus* cf *intermedia* is mostly present off Scotland (Griffits *et al.*, 2010; Iglesias *et al.*, 2010).

B. Data

B.1. Commercial catch

Despite prohibition for Union vessels to land the common skate (*Dipturus batis*) complex, some individuals from area VIIIa were very occasionally landed in French fish markets in 2014. Sampling in fish markets revealed that an adult female, 2 meters long of *Dipturus* cf. *intermedia* was caught and landed in 2014 (the southern record of the species in recent years) and a small individuals of *Dipturus* cf. *flossada* was landed coming from the Glénan archipelago (southern Brittany). As these species are now mostly extirpated from this area, fishermen generally do not identify them and occasionally land them as they don't know about their prohibition.

B.2. Biological

The length at 50% maturity (L50) is estimated to be 115.0/122.9 cm (males/females) and 185.5/197.5 cm (males/females) for *Dipturus* cf. *flossada* and *Dipturus* cf. *intermedia*, respectively. The age at 50% maturity is tentatively suggested as 11 years and 19–20 years for *Dipturus* cf. *flossada* and *Dipturus* cf. *intermedia*, respectively. The maximum lengths and weight (eviscerated) observed in the present study for cf. *flossada* and *Dipturus* cf. *intermedia* were 143.2 cm, 15.2 kg and 228.8 cm, 78.0 kg respectively (Iglesias *et al.*, 2010)

Life history of the two distinct species are mostly unknown in the area as at a larger scale. The 2013-2015 French programm "Pocheteau" is focused on obtaining biological parameters for the two species useful for population dynamic analyses. It is mostly focused on biological tagging and release of individuals onboard French vessels for calibration of age reading (Iglésias pers. commun.). Electronic tagging programm on *Dipturus* cf. *intermedia* revealed the species exhibit pronounced site fidelity to highly localised areas and important vertical movements (Wearmouth and Sims, 2009).

B.3. Surveys (use the ICES surveys acronym)

The common skate (*Dipturus batis*) complex, was not observed in the ICES Divisions VIIIa,b,d during the French EVHOE survey in 2013.

B.4. Commercial Effort and CPUE

Ask to Alain Tétard the Obsmer data from VIIIa and VIIIg

B.5. Other relevant data

A coastal fishermen from the Glénan archipelago (southern Brittany) caught and released several tens of individuals from the beginning of the year 2014 whereas he never observed the species there in the last 30 years.

C. Assessment: data and method

Not applicable

D. Short-Term Projection

Not applicable

E. Medium-Term Projections

Not applicable

F. Long-Term Projections

Not applicable

G. Biological Reference Points

H. Other Issues

H.1. Historical overview of previous assessment methods

I. References

Griffiths, A.M., Sims, D.W., Cotterell, S.P., El Nagar, A., Ellis, J.R., Lynghammar, A., McHugh, M., Neat, F.C., Pade, N.G., Queiroz, N., Serra-Pereira, B., Rapp, T., Wearmouth, V.J. & Genner, M.J. 2010. Molecular markers reveal spatially segregated cryptic species in a critically endangered fish, the common skate (Dipturus batis). Proceedings of the Royal Society B - Biological Sciences, 277: 1497–1503.

Iglésias, S.P., Toulhoat, L. and Sellos, D.Y. 2010. Taxonomic confusion and market mislabelling of threatened skates: Important consequences for their conservation status. Aquatic Conservation: Marine and Freshwater Ecosystems, 20: 319–333.

Wearmouth, V.J. and Sims, D.W. 2009. Movement and behaviour patterns of the critically endangered common skate *Dipturus batis* revealed by electronic tagging. Journal of Experimental Marine Biology and Ecology 380: 77–87.

Stock Annex: template

Stock Annex

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Thornback ray (*Raja Clavata*) in the Bay of Biscay VIIIa-c
Working Group:	WGEF
Date:	25 June 2014
Revised by	Pascal Lorance………..

A. General

A.1. Stock definition

The stock definition is uncertain. For *Raja clavata*, genetic studies have revealed phylogeographic structure among the Mediterranean region, the Azores and the European shelf (Chevolot et al., 2006a), and a weak but significant genetic structure has been found from the southern North Sea to the Celtic Sea (Chevolot et al., 2006b). Despite this, genetic data are still scarcea, and the regional population structure of this species remains poorly known, in particular the extend and potential connectivity between the Bay of Biscay population and its southern and northern neighbors is unknown. Several ray species, including *R. clavata*, might be quite sedentary (e.g. Ellis et al., 2012). However, there is a possible high gene flow in *R. clavata* (Chevolot *et al.*, 2008). This may be understood as stepwise gene flow that maintain genetic homogeneity while population dynamics may vary at smaller spatial scale, owing to variations in growth and mortality.

A.2. Fishery

France and Spain catch the thornback ray in the Bay of Biscay, minor catch are landed by other countries, (Belgium and UK).

Spain

The Spanish demersal fishery along the Cantabrian Sea (VIIIc) and Bay of Biscay (VIIIa,b,d) catches skates and rays using several gears, but most Spanish landings are bycatch of trawl fisheries targeting other demersal species such as hake, anglerfish and megrim. The thornback ray is one of the common rays in these bycatch. In the Cantabrian sea (VIIIc) and IXa) there is also a artisanal fishery (mostly gillnetters) operating in bays or shallow waters.

France

Skates and rays are traditional food resources in France, where directed fisheries for skates and rays were known to occur since the 1800´s. In the 1960´s, skates and rays were primarily taken as bycatch of bottom trawl fisheries operating off the northern part of the Bay of Biscay, the southern Celtic Sea and the English Channel. By this time the thornback ray was seasonally targeted by fisheries, being the dominant skates and rays species landed in France. In the Bay of Biscay, the main ray species in French landings in the 2000 was the cuckoo ray (*Leucoraja naevus*), the thornback ray was the second in the landings accounting for about 10% of rays landings and an average 100 tonnes per year.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

Historically, landings by species of ray and skate have not been available. This improved in the 2000s, but some landings are still reported as Rajidae or *Raja* spp., identification and mislabbeling problems are known to occur.

The working group estimated the proportion of species in the landings by country and ICES Division, from which a time-seriees of landings of raja clavata is derived.

B.2. Biological

The growth parameter of the thornback ray was not estimated in subarea VIII. Growth parameter from Division IXa (Serra-Pereira et al., WD2013) are used but these may be unsuitable as there may be regional difference in life history parameters.

Table 1; Estimates of growth parameters for the thornback ray.

L_∞ (cm)	K (year^{-1})	t0 (years)	Lmax (cm)
128	0.112	-0.62	91.3

Guzman: source of data to confirm, according to the report section this is from Serra-Pereira et al., 2013 WD. I cannot find the WD

B.3. Surveys

The thornback ray is caught is small number in the French EVHOE survey. Population indices, including relative indices of abundance, biomass, mean length and quantiles of the length distribution are derived from this survey (www.ifremer.fr/SIH-indices-campagnes; Figure). The calculated indices of abundance and biomass are swept area estimates raised to the total areas sampled by the survey (ICES Divisions VIIIa,b,c down to 600 m, therefore covering the whole depth range of the species). However, these indices should be used as relative as no account of catachability is made. Further thornback ray is caught in a small proportion of hauls only, with occasional high numbers what make the indices variance large.

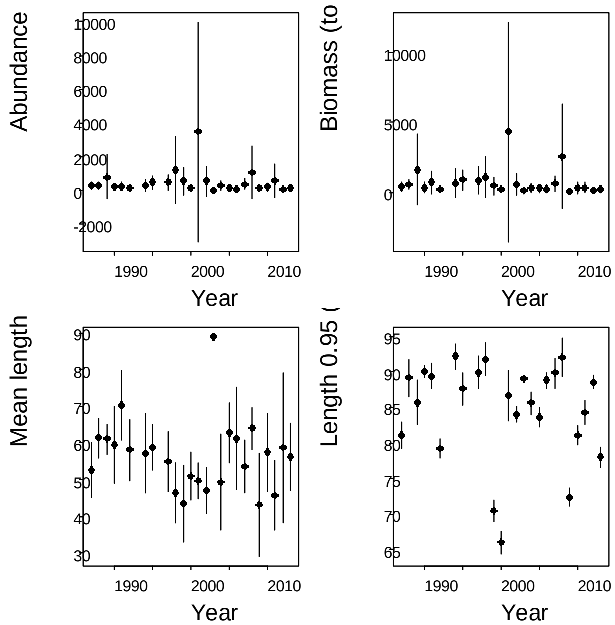


Figure 1. EVHOE survey indices 1987-2013 of the thornback ray in the Bay of Biscay (VIIIabc). Abundance and biomass are raised to the total area surveyed (swept area method) but should be considered relative and in way way absolute estimates.

Distribution maps of the catch in number per haul are alos drawn (Figure 2). Because of the small number of thornback ray caught per year, year to year variations may not be significant. Therefore, years are clustered 3 by 3 to map the spatial distribution and calculate the presence-absence indicator. Years that cannot be grouped by 3, owing to the number of years in the time-series are taken at the start of the time-series because recnet change are more crucial than past variations. Since 1987, thornback ray was occasionnaly caught in high number (up to 56 individuals) in haul at the coast of Southern Brittany, elsewhere in the Bay of Biscay only small numbers are caught, mostly between 100 and 200 m (Figure 2).

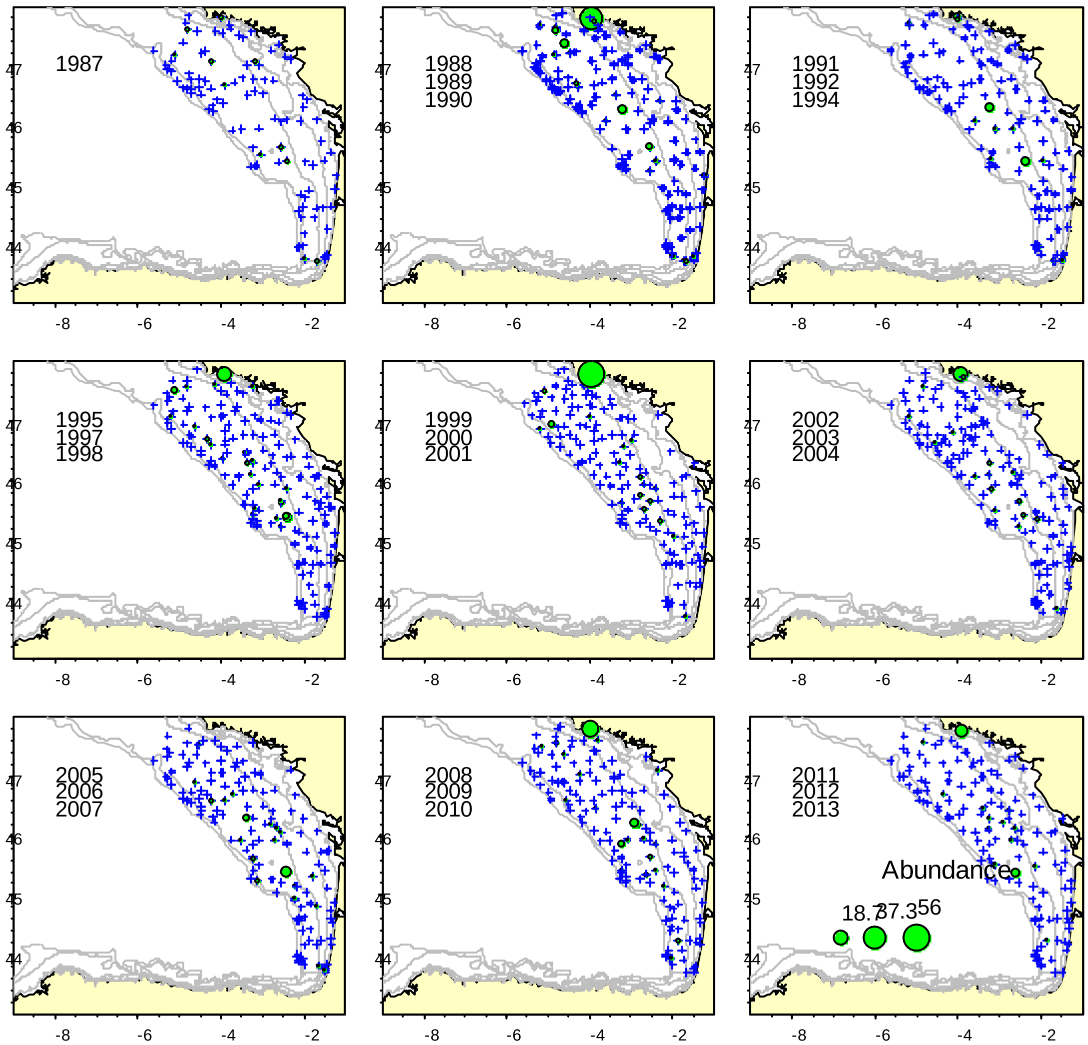


Figure 2. Spatial distribution of catches of thornback ray in the Bay of Biscay from EVHOE survey 1987-2013.

A presence-absence indicator, have also been calculated based on EVHOE and the same groups of 3 years as above. This indicator may be used in addition to more usual indicators to appraise populations trends. The thornbaclk ray have been caught in about 10% of the hauls since 1987, without detectable trends (Table 2).

Table 2. Presence-absence indicator derived the EVHOE survey in the Bay of Biscay.

Year	Total number of hauls	Number of haul with catch of *R. clavata*	Proportion of haul with catch
1987	105	11	0.1
1988-90	443	31	0.07
1991, 1992, 1994	286	19	0.07
1995, 1997, 1998	229	30	0.13
1999-2000	192	19	0.1

2002-04	205	17	0.08
2005-07	199	23	0.12
2008-10	205	24	0.12
2011-13	203	16	0.08

B.4. Commercial CPUE

No commercial CPUE is used for assessment. An LPUE in kg per fishing day from the Basque Country OTB DEF fleet has been included in reported. The fleet is composed of more than 70 Bottom otter trawlers operating in Subarea VIII.

B.5. Other relevant data

C. Assessment: data and method

No assessment

D. Short-Term Projection

None

E. Medium-Term Projections

None

F. Long-Term Projections

None

G. Biological Reference Points

No biological reference point hs been define from the stock

H. Other Issues

H.1. Historical overview of previous assessment methods

N/A

I. References

Chevolot M., Hoarau G., Rijnsdorp A.D., Stam W.T., Olsen J.L., 2006, Phylogeography and population structure of thornback rays (Raja clavata L., Rajidae). Molecular Ecology 15, 3693–3705.

Ellis J.R., Morel G., Burt G., Bossy S., 2011, Preliminary observations on the life history and movements of skates (Rajidae) around the Island of Jersey, western English Channel. Journal of the Marine Biological Association of the United Kingdom 91, 1185–1192.

Stock Annex: template

Stock Annex rjc-echw

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Thornback ray (Raja clavata) in Division VIIe
Working Group:	WGEF
Date:	24 June 2014
Revised by	Alain Tétard

A. General

A.1. Stock definition:

The stock identity of *Raja clavata* in VIIe is unclear. In 2012 advice it was merged with 7d as a 3a47de stock, in 2014 we decided to keep it as a potential unit before to have more valuable information to reattach or not this stock to VIId. Data from surveys are available (CGFS and BTS in VIId and IVc, BTS in VIIe) together with these from the French fisheries observer program. These data show a gap at the limit between VIIe and VIIe (Figure 1 and 2), this area is known to be very rough and not adapted to bottom trawling. The North of Cotentin is known to be a biogeographical limit for some populations, therefore we are waiting more informations coming from studies in progress (tagging, genetic).

A.2. Fishery:

This species is historically mainly exploited by France and UK as a by catch by the trawlers, and as a target species by netters and long liners.

A.3. Ecosystem aspects:

Nurseries occur in shallow waters of the Normano-Breton Gulf (Bay of Mont St Michel, Bay of St Brieuc, West coast of Cotentin), Leblanc and Al., 2014.

B. Data

B.1. Commercial catch:

This species is easy to recognize and very popular on the market, this situation suggest that the specific declarations are good, but it is know that it can by declare locally as various skates. From 2008 onwards the EC has obliged member states to provide species-specific landings data for the major North Sea skates species including *Raja clavata*. This measure is in favour of an increase of the quality of the data coming from industry.

B.2. Biological:

This species is one of the best known skates and its knowledge is progressing with the new studies on skates triggered by the Undulate ray ban in 2009 (Stéphan, 2014).

Movement patterns: tagging experiments are in progress from France and UK (Channel island) in the Normand-Breton Gulf (Stéphan, 2014).

Results from population genetic structure are also in progress.

B.3. Surveys:

French CGFS in VIId, IBTS in VIId-IV, English BTS in VIId-IVc, English BTS in VIIe, French miscellaneous survey not dedicated but catching skates (COMOR, NURSOM, NURSEINE). A new French bottom otter trawl survey in VIIe is planned at autumn 2014 (CAMANOC).

The distribution of the species seems relatively stable during all the series with a regular dominance in the central part of the VIId. The Eastern part shows some connections with the southern North Sea, it's not the case in the Western part where the species is never found (but where the sampling effort is limited).

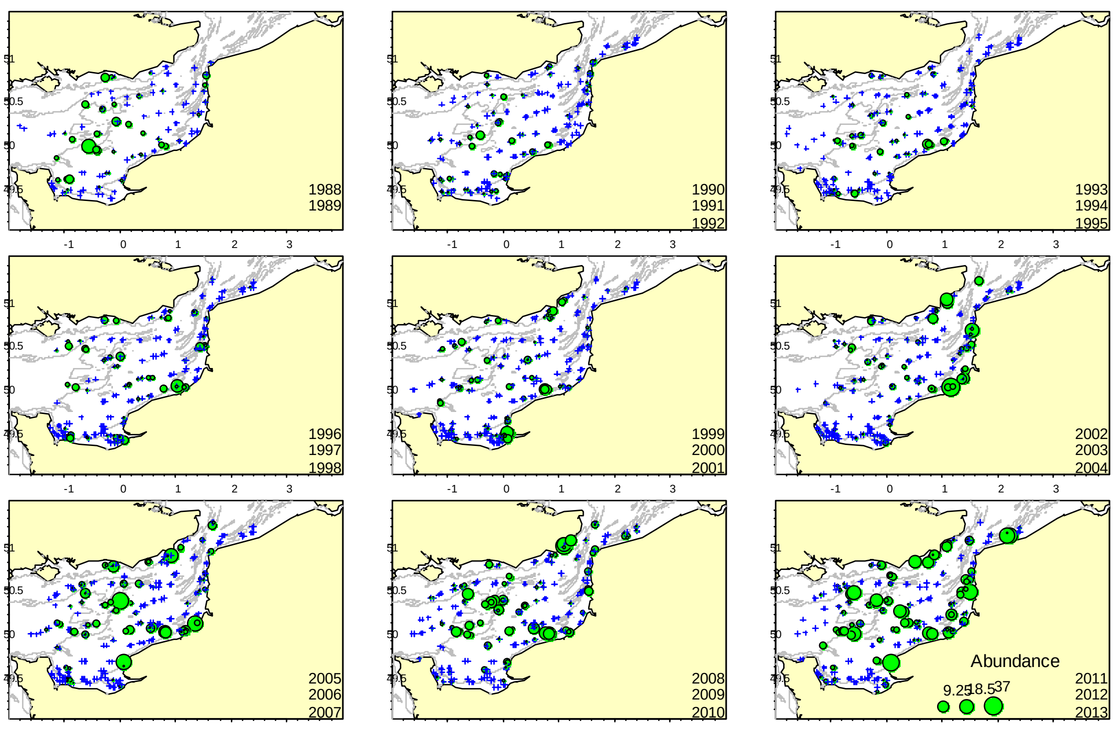


Figure 1.-Spatial distribution of Thornback ray (*Raja clavata*) in VIId from CGFS. The number of fish caught per haul (green circles) is shown for groups of three years. Hauls with no catch of the species are represented by a blue cross (+).

B.4. Commercial CPUE: data are available from landings, fisheries observer program and inquiries for some projects (e.g. French RAIMOUEST project).

The French fisheries observer program shows that the main distribution is the VIId and that there is clearly a link with the IVc (Fig. 2). As with CGFS data we observed off the North of Cherbourg a none sampling area. This area is known to be very rough and not adapted to trawling (nevertheless we have some coastal trawl catches near Cherbourg, skates may caught by longlining, but unfortunately this metier is not sampled.

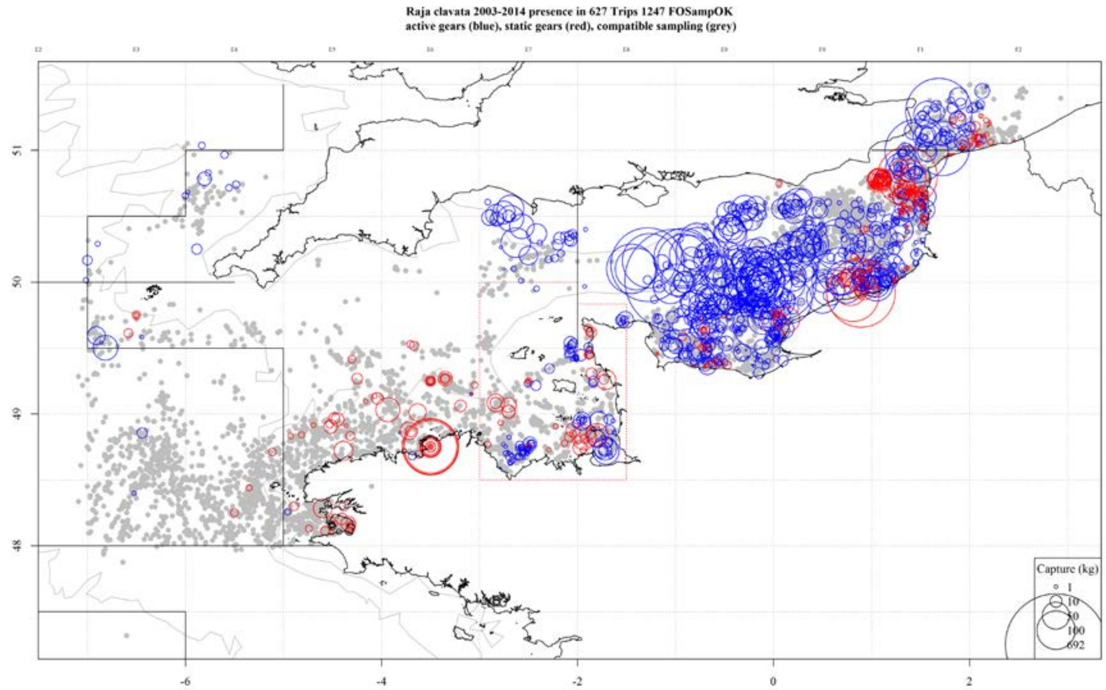


Figure. 2.- French fisheries observer program: *Raja clavata* catches (kg) in the English Channel and adjacent areas from 2003 to the first quarter 2014 (grey dots: hauls from gears susceptible to catch skates with no catch of *R. clavata*; open circles catch in weight of *R. clavata*, blue: towed gears, red: passive gears). Each circle corresponds to one sampled fishing operation.

UK BTS in VIIe shows that Thornback ray is mostly captured in Lyme Bay, North of the Western part of VIIe (Silva WD WGEF2014).

French EVOHE (Figure 3) indicates no connections with VIIh.

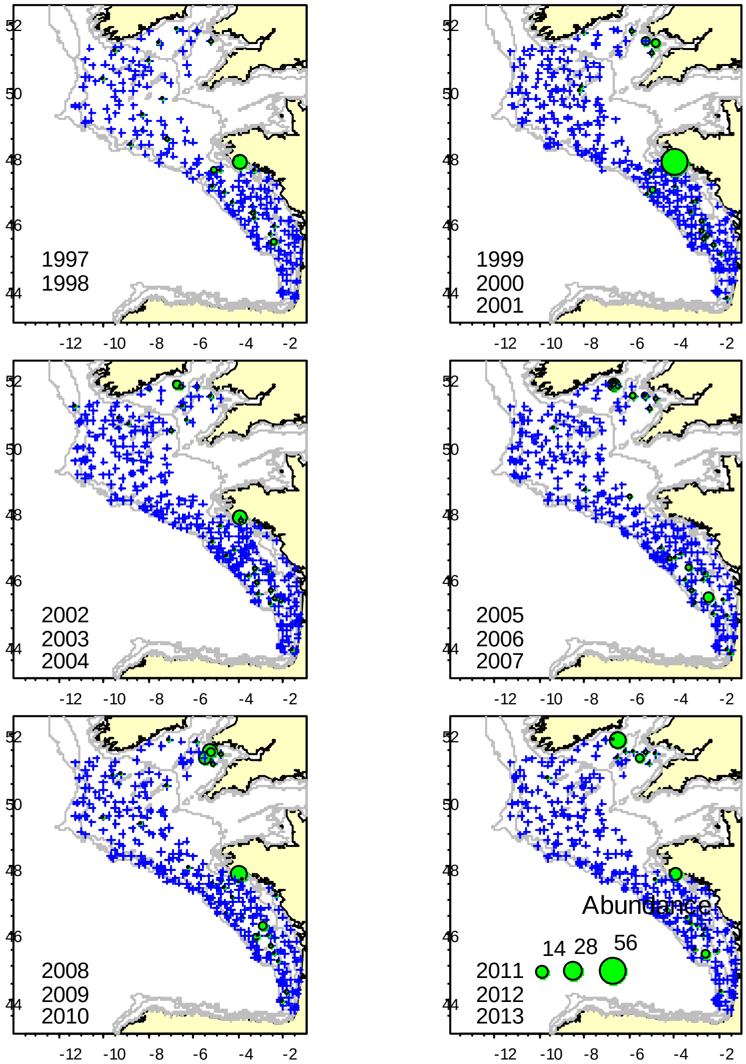


Figure 3.-Spatial distribution of Thornback ray (*Raja clavata*) in VIId from EVOHE. The number of fish caught per haul (green circles) is shown for groups of three years. Hauls with no catch of the species are represented by a blue cross (+).

B.5. Other relevant data:

C. Assessment: data and method

Model used:
Software used:

Model Options chosen:

Input data types and characteristics: (table below is just an example; adapt the description of input accordingly)

D. Short-Term Projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Procedures used for splitting projected catches:

E. Medium-Term Projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Uncertainty models used:

1. Initial stock size:
2. Natural mortality:

3. Maturity:

4. F and M before spawning:

5. Weight at age in the stock:

6. Weight at age in the catch:

7. Exploitation pattern:

8. Intermediate year assumptions:

9. Stock recruitment model used:

F. Long-Term Projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

	Type	***Value***	***Technical basis***
MSY Approach	**MSY $B_{trigger}$**	**xxx t**	**Explain**
	F_{MSY}	**Xxx**	**Explain**
Precautionary Approach	**B_{lim}**	**xxx t**	**Explain**
	B_{pa}	**xxx t**	**Explain**
	F_{lim}	**Xxx**	**Explain**
	F_{pa}	**Xxx**	**Explain**

(Add some text if necessary)

H. Other Issues

H.1. Historical overview of previous assessment methods

2012 first advice, rjc-347de, years 2013 and 2014

I. References

Leblanc, N., Tetard, A., Legrand, V. E. Stephan, L. Hegron Macé, 2014. RAIMOUEST: the French fishery of rays in the Western English Channel (VIIe), 2014 update. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26th June, 2014.

E. Stephan, C. Hennache, A. Delamare, N. Leblanc, V. Legrand, G. Morel, E. Meheust, JL. Jung, 2014. Length at maturity, conversion factors, movement patterns and population genetic structure of undulate ray (Raja undulata) along the French Atlantic and English Channel coasts: preliminary results. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26th June, 2014.

French fisheries observer program (http://sih.ifremer.fr/Description-des-donnees/Les-donnees-collectees/Echantillonnage-des-captures-a-bord-des-navires-de-peche).

J. F. Silva, S. R. McCully, J. R. Ellis and S. Kupschus, 2014. Demersal elasmobranchs in the western English Channel (ICES Division VIIe)

Stock Annex

Stock specific documentation of standard assessment procedures used by ICES.

Stock *Raja clavata* in Western Iberian Waters (west of Galicia, Portugal, and Gulf of Cadiz) (ICES Division IXa)

Working Group: WGEF 2014

Date:

Revised by:

A. General

A.1. Distribution

Global distribution: *Raja clavata* (thornback ray) is a coastal benthic species with a wide geographic distribution in the northeast Atlantic and Mediterranean (Stehmann and Bürkel, 1984). The species is mainly found on hard seabed (e.g. gravel and pebble), in areas of intermediate to strong tidal currents (Ellis *et al.*, 2005).

Species distribution in IXa: The species is distributed along the entire area.

In the west of Galicia this species is found in the sedimentary grounds of the continental shelf (Figure 1). It has a wide depth distribution, from 20 m to 400 m, but it is more abundant between 50-200 m depth, particularly close to 75 m (Figure 2).

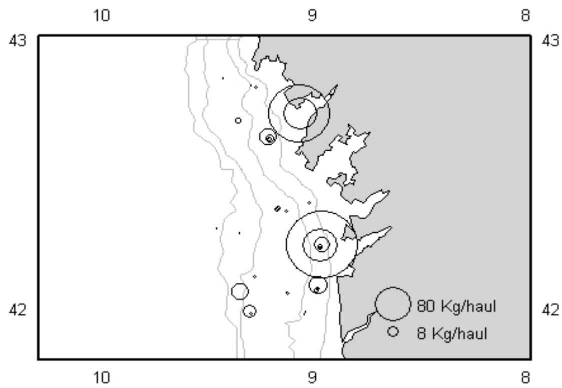


Figure 1 ï West of Galicia (ICES Divisions IXa). *Raja clavata* distribution and catch rate (kg/30 min) in Spanish autumn Ground Fish Survey (SP-GFS) from 1983 to 2013.

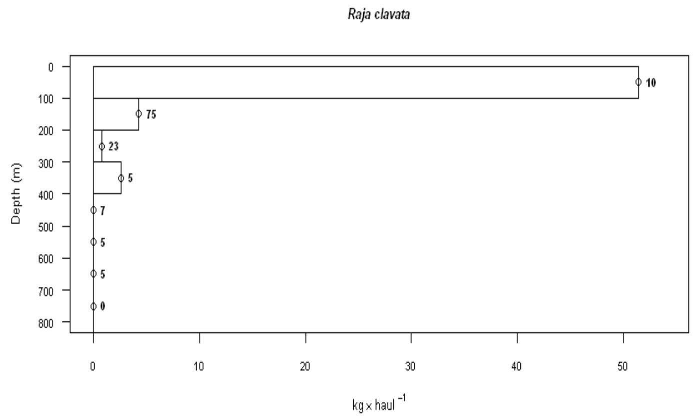


Figure 2 ï West of Galicia (ICES Divisions IXa). *Raja clavata* survey catch rate (kg.30 min) in Spanish autumn Ground Fish Survey (SP-GFS) in 2013 by depth strata. Figure on the right of bars indicate the number of hauls at that depth.

In the Portuguese continental waters the species occurs along the entire coast at depths ranging from 18 m to 700 m, being more abundant in the southwest and southern regions (i.e. south off Cabo Carvoeiro), at depths shallower than 200 m (Figure 3).

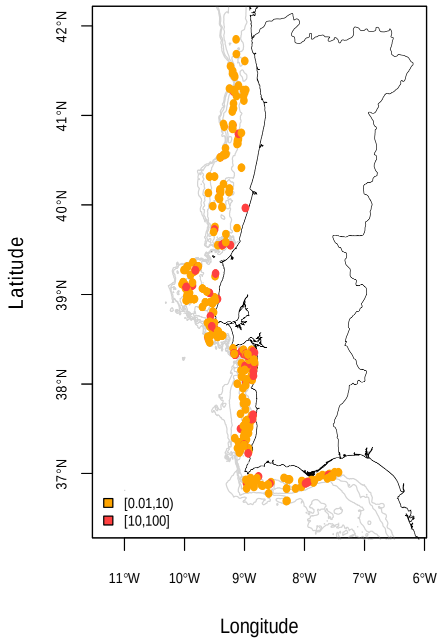


Figure 3 - Portuguese continental coast (ICES Division IXa). *Raja clavata* distribution and catch rate (kg.hour^{-1}) in Portuguese Autumn Groundfish Surveys (PT-GFS) from 1990 to 2013.

In the Gulf of Cadiz *R. clavata* occurs along the whole area at depths ranging from 20 to 800 meters, being especially abundant in trawlable grounds placed in the south area of the Gulf, in the range between 100 and 350 m depth (Figure 4).

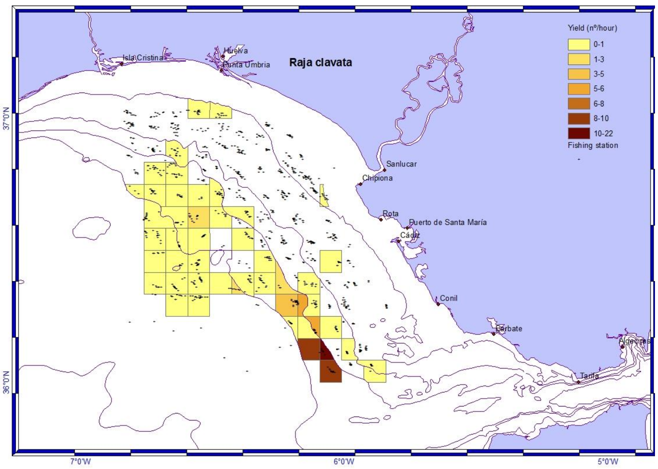


Figure 4 ï Gulf of Cadiz (ICES Division IXa). *R. clavata* distribution and abundance index (no/hour) in the Gulf of Cádiz (from ARSA surveys 1993-2009, Q1 SP ï GCGFS and Q4 SP - GCGFS).

A.2. Species dynamics

In the west of Galicia, *R. clavata* is mainly found on mud and sandy bottoms. It is more abundant in the north of Galicia waters and in the Cantabrian Sea. There is no information regarding size or sex segregation, neither on spawning nor egg laying sites.

In the centre of mainland Portugal, the species occupies a broad range of habitat types, from mud and fine sand to rocky bottoms, showing different spatial dynamics according to the life stage (Serra-Pereira *et al.,* 2014). Spatial segregation by sex was observed; females are more abundant in shallower grounds, while males frequently occur offshore, deeper than 100 m. Distinct areas were identified as egg laying grounds, that differ in depth (all shallower than 100 m), bottom topography and seabed composition (from fine sand to gravel). A seasonal variation in juvenileõs abundance was registered in these areas - higher abundances are recorded during the 1st and 3rd quarters of the year, showing a temporal spatial overlap between egg-laying and nursery grounds. Nursery and egg laying grounds are located at depths shallower than the adults, suggesting the existence of migrations associated to reproduction. Worth to note that in the North Sea and eastern English Channel adults from this species migrate from deeper to shallower waters for mating and for egg deposition. Juveniles tend to stay in shallow waters during the first years of growth and migrate to deeper areas afterwards (Steven, 1936; Walker *et al.*, 1997; Hunter *et al.*, 2005, 2006).

The main habitat of *R. clavata* in the Gulf of Cadiz is located in the influence area of the Mediterranean Outflow Water (MOW), which is warmer and more saline than the above Atlantic Water**.**

A.3. Stock definition

The stock structure of the species along the ICES areas is unknown, although migrations between different areas are admitted (ICES, 2013). For advice purposes, ICES considers a distinct stock unit for Division IXa (west of Galicia, Portugal, and Gulf of Cadiz).

A.4. Fisheries

In the Western area of the Iberian Peninsula Rajidae species are usually caught as by catch in other fisheries. In the past, there was a direct fishery to these species in the north of Spain, mainly in coastal areas and inside estuaries, with a special gillnet called *raeiras* (DOG nº 31 15/02/2011). At the present time there are no direct fisheries for skates and most of the landings come from the trawl fishery targeting other species (Rodriguez-Cabello *et al.*, 2005). Total landings by the Spanish fleet in this area (for all Rajidae species) increased from 1996 to 2001 up to 416 tones and since them remained more or less stable showing fluctuations around 350 tones (Figure 5). In the coastal area inside Galicia estuaries an important artisanal fleet operates catching frequently Rajidae species using different types of gillnets, particularly *miño* (DOG nº 31 15/02/2011). These catches from the artisanal fleet represent around 8.7 % of Galicia total landings from different ICES areas (Bañón *et al.,* 2008).

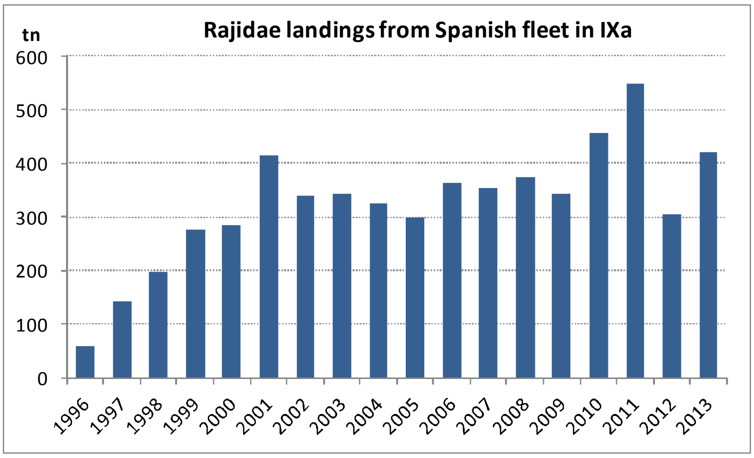


Figure 5 ï West of Galicia (ICES Divisions IXa). Landings (ton) of Rajidae species in IXa by the Spanish fleet.

In the Portuguese continental coast Rajidae species are mainly landed by the polyvalent segment, which represents around 75% of the total landed weight, followed by the trawl segment that represents around 24%. The trawl segment is defined by vessels that operate wish mesh sizes of 55m, 65 or 70 mm. The Portuguese polyvalent segment includes vessels with length overall (LOA) ranging from 5 to 27 m which generally operate between 10 and 150 m deep and exhibit a multi-species and mixed fisheries, capturing a high diversity of species at different fishing grounds. This segment also includes vessels operating with trawl gear with mesh size of 32 cm, and, for analysis purposes, all trawl vessels with LOA smaller than 12 m irrespective of the mesh size. The latter were included in the polyvalent segment due to their different fishing pattern when compared to larger trawlers: fishing operations closer to the coast and daily trips. All these vessels can have more than one fishing gear (e.g. trammel nets, gillnets, longline, trawl, traps and/or pots) and consequently different fishing gears may be used in one fishing trip. Within the polyvalent segment, Rajidae are mainly caught by nets, i.e. trammel and gillnets; for the period between 2008 and 2013 the landed weight derived from nets represented 65 to 78% of the total landed weight, while longline and artisanal trawl represented 19- 24%, and up to 9% respectively.

In the Gulf of Cádiz area Rajidae are taken as by-catch of fisheries targeting demersal species.

A.5. Ecosystem aspects

In the west coast of the Iberian Peninsula the most important features enhancing primary production are coastal upwelling, coastal runoff and river plumes, seasonal currents and internal waves and tidal fronts. Maximum values of chlorophyll usually occur in spring and summer (Nogueira *et al.,* 1997; Moita, 2001), although high chlorophyll values may be recorded in autumn, particularly in zones with elevated retention characteristics; for example, high chlorophyll concentrations are found in the Rías Baixas, at the time of the seasonal transition from upwelling to downwelling (Nogueira *et al.*, 1997; Figueiras *et al.,* 2002). Most of the west Iberian coast, including Galicia and Cantabrian Sea continental shelf, is occupied by cold waters rich in nutrients (Gil, 2008).

The north-south orientation of the coast causes winds from the north to produce offshore transport. During spring and summer, northerly winds along the coast are dominant causing coastal upwelling and producing a southward current at the surface and a northward undercurrent at the slope (Figure 6a) (Fiúza *et al.*, 1982; Alvarez-Salgado *et al*., 2003; Peliz *et al*., 2005; Mason *et al.,* 2006). During winter the prevailing winds are mainly south-westerly, and the atmospheric circulation is dominated by eastward displacement of cyclonic perturbations and their associated frontal systems (Figure 6b) (Relvas *et al.,* 2007). However, in some years the presence of episodic atmospheric anti-cyclonic circulation (the Azores High) could give rise to northerly wind events during winter (Santos *et al.*, 2001; Borges *et al*., 2003). Indeed, investigations on upwelling along the Galician coast in autumn and winter have been characterized in the Galician rias, indicating that the upwelling process along the Galician coast is not a phenomenon restricted to spring and summer (Alvarez *et al.*, 2012).

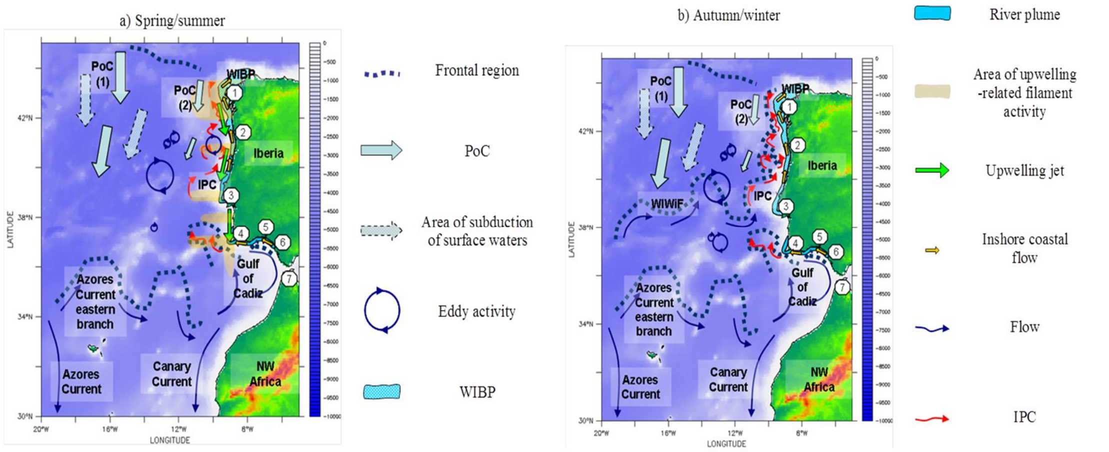


Figure 6 - The western Iberia and Gulf of Cadiz regimes in a) spring and summer, and b) autumn and winter. 1) Cape Finisterre; 2) River Douro; 3) Cabo da Roca; 4) Cape St. Vincent; 5) Guadiana River; 6) Guadalquivir River; 7) Strait of Gibraltar. PoC - southward-flowing Portugal Current, WIBP - Western Iberia Buoyant Plume, IPC - Iberian Poleward Current (Adapted from Peliz *et al.* 2002; Peliz *et al.* 2005).

In winter the Poleward Current (PC) flows northerly. It is a salty surface current (about 200 m deep) of subtropical origin (Eastern North Atlantic Water, also known as the ôNavidadô Current, since because it starts to be evident near Christmas and New Year) and relatively warmer than the surrounding ones (Castro *et al.,* 2011). During winter and spring, the PC results in a convergent front at the boundary between coastal and oceanic water. When saline intrusion is weak, the development of fronts and the formation of a seasonal thermocline are enhanced, leading to phytoplankton blooms. When saline intrusion is intense, strong vertical mixing occurs and prevents phytoplankton growth in spring (Moita, 2001; Santos *et al.,* 2004).

The intermediate deep layers are mainly occupied by a poleward flow of Mediterranean Water (MW), which contours the southwestern slope of the Iberia (Ambar and Howe, 1979), generating the mesoscale features called Meddies. The MW along the west coast of the Iberian Peninsula is characterized by a transport of warm and salty water (typical surface anomalies, 1ï 1.5ºC and 0.1ï 0.3ă in salinity) with velocities up to some 0.2ï 0.3 m s^{-1} reported by Frouin *et al.* (1990).

The Sea Surface Temperature (SST) registered a generalized warming of a few hundredth of degrees a year since 1960, ranging from 0.015°C/year to 0.037°C/year (Relvas *et al.*, 2009). The SST increase has effect on species populations (e.g. recruitment success, migrations changes) (Brander *et. al.*, 2003).

In the Gulf of Cadiz the most important oceanographic process is the occurrence of a strong interaction between two masses of water, the Atlantic Ocean and the Mediterranean Sea through the Strait of Gibraltar. In general, the exchange of water masses through Strait of Gibraltar is guided by the highly saline and warm Mediterranean Outflow Water near the bottom, and the turbulent, less saline, cool-water mass of the Atlantic Intermediate Water at the surface. The pattern of surface circulation is ruled by a clockwise movement, with a general W to E superficial current, whereas the deep circulation is controlled by the westerly current of the highly saline (salinity>37 PSU) Mediterranean water existing through the Strait.

Bottom temperatures are extremely variable ranging between 3ºC and 20.6ºC whereas values of bottom salinity along the continental shelf range from 35.8 to 36 PSU (Díaz *et al.*, 2006). In the slope there is a wide band with values around 37 PSU, the lower slope showing the minimum values which correspond to the Deep Atlantic Water Mass (Díaz *et al.*, 2006).

The continental slope can be differentiated into four provinces: a) a narrow belt between 130 and 400 m formed by the steep upper slope; b) two gently dipping wide terraces located between 400 and 700 m depth; c) a central sector between the terraces in which several, steep and narrow curvilinear ridges and valleys are located trending NE-SW to E-W; d) the lower slope-upper continental rise at water depths from 900 down to 1500-1800 m. Below 900 m, the lower slope is steeply dipping and generally smooth except for shallow valleys placed in a NE-SW direction (Nelson *et al.*, 1993). The main sedimentary types occurring over the slope are bioclastic sands, silicoclastic sands and muddy sands, sandy muds, sandy and muddy contourites (Díaz *et al.*, 1985).

B. Data

B.1. Commercial landings and discards

Due to the sampling methodology based on métier it has not been possible to separate accurately the discards made by the Spanish trawl fleet in Galicia and Cantabrian Sea (VIIIc and IXa). Annual fluctuations were observed with high discard values of 50.6 and 54.6 tons in 2011 and 2013, respectively (Table 1).

Table 1 - Galicia and Cantabrian Sea (ICES divisions VIIIc and IXa). Weight discarded (tons.) of *Raja clavata* (bold) and CV of estimations (italics) in from bottom trawl fishery.

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0,0	**1,0**	**9,9**	**54,5**	**10,9**	**5,5**	**36,0**	**32,4**	**50,6**	**29,6**	**54,6**
-	*57,7*	*54,6*	*75,6*	*45,5*	*76,2*	*47,9*	*43,1*	*50,7*	*28,9*	*39,0*

Data used to estimate Portuguese landings by species derived from the DCF skate pilot study that had as main objectives to establish sampling statistical procedures and define estimators necessary to calculate the inputs for stock assessment purposes. In the Portuguese continental waters, *R. clavata* is the most important landed species. During the period 2008-2013 this species represented, between 40 and 55% (367.0 to 582.3 t) and between 47 and 71% (159.0 to 288.5 t) of the total skates landed weight by the polyvalent and the trawl segments, respectively (Table 2). In 2013 the estimated landed weight of *R. clavata* was 458.5 t for the polyvalent and 172.5 t for the trawl segment.

Table 2 - Portuguese continental coast (ICES Division IXa). *Raja clavata* estimated landed weight, number of vessels and number of trips by fishing segment (trawl and polyvalent), between 2008 and 2013.

	Polyvalent segment			Trawl segment		
Year	No. vessels*	No. trips*	Landed weight (ton) (%RJC/Skates)	No. vessels*	No. trips*	Landed weight (ton) (%RJC/Skates)
2008	1444	36149	533.3 (48%)	81	6513	211.6 (64%)
2009	1412	36239	509.1 (48%)	69	5683	230.0 (60%)
2010	1389	34767	451.5 (40%)	59	5461	159.0 (47%)
2011	1289	36761	582.3 (54%)	60	5139	288.5 (66%)
2012	1240	32565	367.0 (44%)	54	5158	203.1 (71%)
2013	1172	28007	458.5 (55%)	51	4658	172.5 (66%)

* estimates for all skates combined

R. clavata is mainly landed in the centre (*Centro*) and Lisbon (*Lisboa e Vale do Tejo*) regions by both polyvalent and trawl segments (Figure 7).

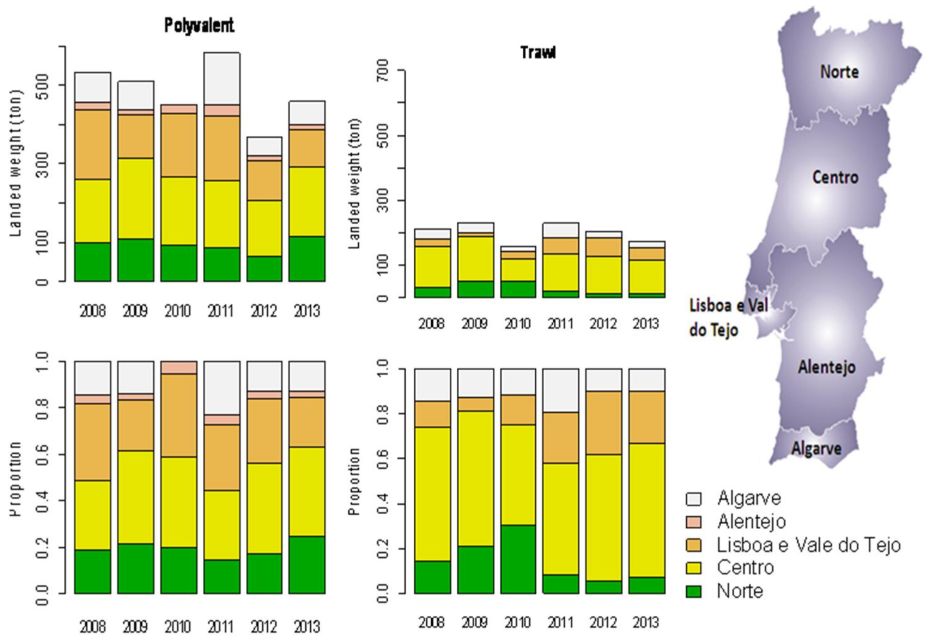


Figure 7 - Portuguese continental coast (ICES Division IXa). *Raja clavata* estimated landing weight and percentage by major region (NUTSII regions) and segment.

For the polyvalent segment and during the period 2008-2013, the landings estimates of *R. clavata* for the group of the five most important landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) represented 45 to 61% of the total landed weight of the species. The sampling program carried out in those landing ports allowed to conclude that *R. clavata* was mainly caught by nets, followed by longline and artisanal trawl (Table 3).

Table 3 - Portuguese continental coast (ICES Division IXa). *Raja clavata* (2008-2013) for the group of landing ports comprising Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal - Number of vessels, number of trips in which the species occurred and landing estimates by fishing gear (nets, longline and trawl) of the polyvalent segment. Last column refers to trips for which no information on the fishing gear is available.

	Nets			Longline			Artisanal trawl			NA	
Year	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips
2008	310	10476	139.4	123	2948	70.0	5	451	3.7	54	235
2009	283	10637	109.1	199	2966	86.3	7	483	5.6	47	157
2010	312	10735	145.1	142	1843	53.5	6	638	13.7	33	163
2011	265	10280	142.8	133	1810	40.9	5	729	9.2	34	171
2012	263	9864	122.2	114	1459	47.5	14	525	16.0	21	107
2013	250	7440	136.6	150	2751	62.9	8	464	15.0	3	3

Information on discards of *R. clavata* produced by the Portuguese polyvalent and bottom otter trawl segments operating in the ICES Division IXa has been collected under the Data Collection Framework (EU DCR). Two polyvalent fisheries (trammel nets operating deeper than 150m and trammel and gillnets operating shallower than 150m) and two bottom otter trawl fisheries (crustacean fishery and demersal fish fishery) were analyzed. The information available is insufficient to reach robust estimates of discards so preliminary results are presented in Table 4.

Table 4 - Portuguese continental coast (ICES Division IXa). *Raja clavata* number of sampled hauls, number of hauls where the species occurred, probability of the species be caught in a haul and a specimen be discarded (p_{CD}) and expected number of discarded specimens per haul per fishery. Polyvalent segment: i) nets operating at depths shallower than 150 m (i.e. trammel and gillnets) and ii) trammel nets operating deeper than 150 m. Trawl segment: i) Crustacean Fishery and ii) Demersal Fish Fishery.

	Polyvalent Segment		Trawl Segment	
	Nets <150 m deep	Trammel nets >150 m deep	Crustacean Fishery	Demersal Fish Fishery
nº of sampled hauls	41	57	665	1162
nº of hauls in which the species occurred	21	21	13	100
p_{CD}	0.08	0.17	0.02	0.09
Expected number of discarded specimens per haul	2	3	3	1

In the Gulf of Cadiz, catch and landing data from commercial fisheries are often poor because of a general lack of species-specific recordings. No management program has been established yet in this area. Fisheries research has traditionally been focused on the most commercially important teleosts and poor research has been undertaken on chondrichthyans.

B.2. Length frequency distribution

The length distribution of the Spanish bottom trawl surveys carried out off Galicia (SP-GFS) indicates that most of the *R. clavata* specimens caught are juveniles or immature specimens. Length ranged from 13 to 97 cm (Figure 8).

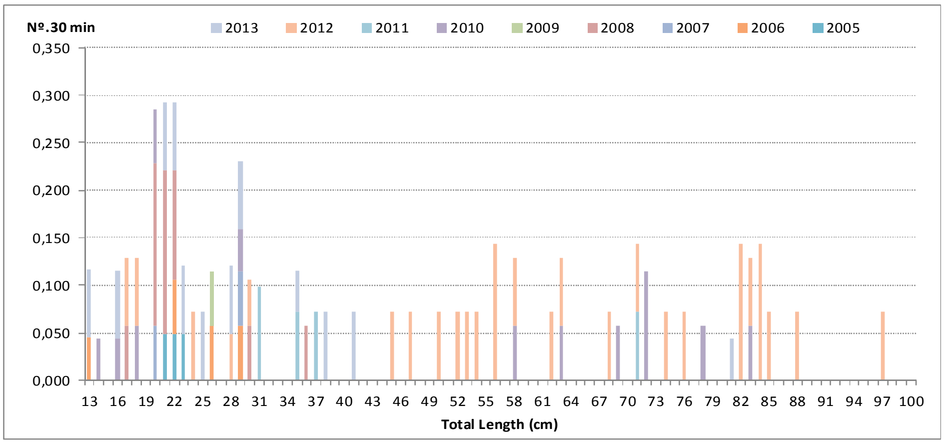


Figure 8 ï West of Galicia (ICES division IXa). Length frequency distributions of *Raja clavata* (2005-2013) obtained from Spanish bottom trawl surveys in IXa. Values are expressed in numbers per 30 minute trawl.

In the Portuguese continental waters, sampling length frequency distributions of *R. clavata* at the five main landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) are presented in Figure 9 for nets and for longlines separately. Length frequency distributions were built with no extrapolation to the total estimated landed weight of the species. The length distributions, as well as the length ranges, are similar between the two gears and among years.

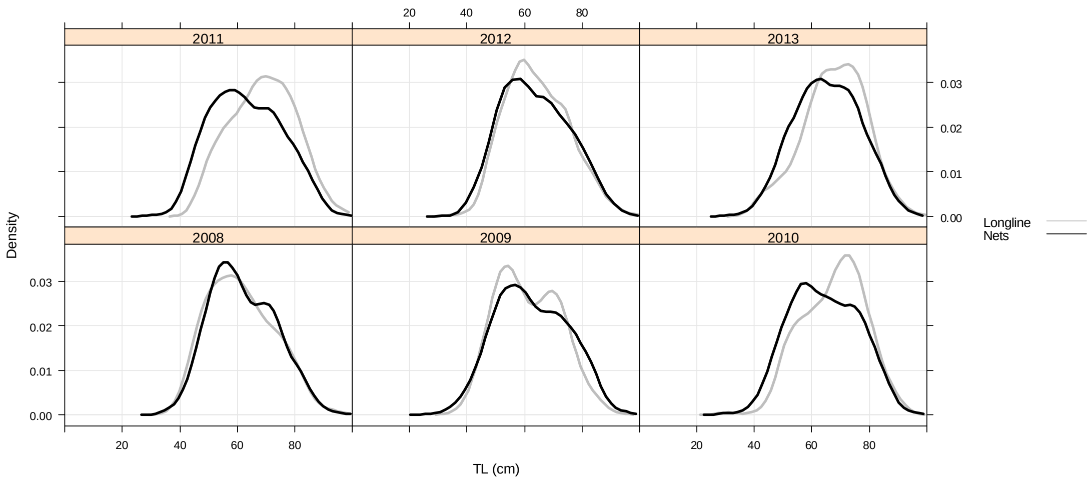


Figure 9 - Portuguese continental coast (ICES Division IXa). Sampling length frequency distributions of *R. clavata* at the five main landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) during the period 2008-2013.

In the Gulf of Cadiz length frequency distributions data are obtained from the ARSA survey series (Table 5; Figure 10).

Table 5 ï Gulf of Cadiz (ICES division IXa). *Raja clavata* mean total length (cm) by depth strata in the ARSA survey series (Q1 SP – GCGFS and Q4 SP – GCGFS)

Raja clavata **ARSA series total mean length (cm)**			
Depth strata / Season	**SPRING**	**AUTUMN**	**BOTH**
A (15 - 30 m)		**48**	**48**
B (31 - 100 m)		**53**	**53**
C (101 - 200 m)	**18**	**56**	**34**
D (201 - 500 m)	**41**	**46**	**43**
E (501 - 800 m)	**50**	**64**	**54**
All (15 - 800 m)	**42**	**48**	**45**

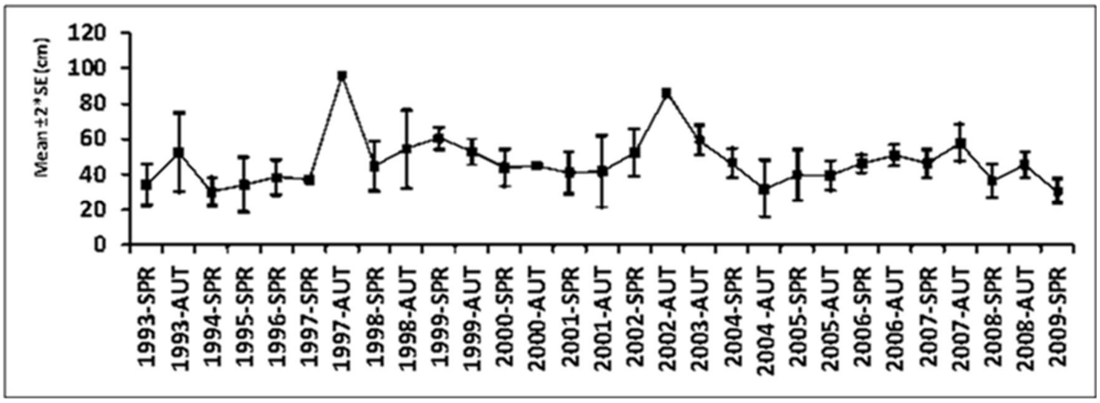


Figure 10 ï Gulf of Cadiz (ICES division IXa). Trend of the mean size for *Raja clavata* in ARSA surveys (1993-2009).

B.3. Survivorship

Under the scope of the EU DCF skate pilot study carried out in mainland Portugal, data on survivorship of *R. clavata* after fishing was collected onboard fishing trips of polyvalent vessels operating with trammel or gillnets. Survivorship was qualitatively evaluated by assuming that the health status of fish after capture is a good indicator of the survivorship index (Enever *et al.,* 2009). The following scale was used to assign health status to each sampled individual (Enever *et al.,* 2009): 1) Good: vigorous wing/body movement and rapid spiracle movement; 2) Moderate: limp wing/body and spiracle movement and; 3) Poor: dead or nearly dead, no body movement, slight spiracle movement. In general, this species presents high levels of survivorship.

There are no studies about skates´ survivorship neither in the west of Galicia nor in the Gulf of Cadiz.

B.4. Commercial LPUE

The index of abundance of *Raja clavata* was estimated from the Portuguese polyvalent segment as the landed weight of the species per trip (fishing effort unit), LPUE, using official commercial data. In the polyvalent segment, landings from trips in which nets were used are relatively more important than those from longlines. Since no major differences on length structure of the specimens caught among the two fishing gears are observed, it is admitted that the standardized LPUE using fishery data derived from nets are representative of the polyvalent segment.

B.5. Biology

In the Portuguese continental waters, *R. clavata* size-at-first-maturity is 78 cm for females and 68 cm for males, which corresponds to ages of 7 and 5 years old, respectively (Serra-Pereira *et al.,* 2008). Egg laying females are more frequent between May and January, although reproductively active females can be found throughout the year. Fecundity is estimated to be around 136 eggs per female per year. Egg capsules are rectangular-shaped (72 mm in length and 52 mm in width) with posterior horns larger than the anterior ones, dark brown colored and covered with fibers (Serra-Pereira *et al.,* 2011). Juveniles of *R. clavata* feed preferentially on indiscriminate crustaceans and shrimps as the benthic *Solenocera membranacea*, while adults, besides the former preys, also feed on brachyuran crabs, as the pelagic *Polybius henslowii,* and bony fishes (Farias *et al.,* 2006). *R. clavata* has an estimated potential rate of population increase of 0.66 (following Jennings *et al.,* 1999) and an estimated natural mortality of 0.18 (following Jensen 1996).

In Galicia and Cantabrian Sea *R. clavata* feeds mainly on crustacea 80% (V). However the size of the crustacean preys varies according to the predator size (Figure 11). Small skates prey mainly on Crangonidae and Peracarida species, *Lophogaster typicus* and some Brachiura. As they increase in size they prey on larger Brachiura species mainly belonging to Portunidae family as *P. henslowii* and *Liocarcinus depurator*, and bigger Peracarida species such as *Solenocera membranacea*. Teleost fish increase their importance in the diet as *R. clavata* increases in size; nevertheless for specimens less than 50 cm it does not reach the 4% (V) and are mainly species from families Callionimoidea and Gobioidea. In specimens larger than 50 cm the percentage of teleost fish increases up to 15 %, being the most important the blue whiting, *Micromesistius poutassou* (5%) and, less importantly the horse mackerel *Trachurus trachurus* (1.8%), *Argentina sphyraena* (1.1%) and the mackerel, *Scomber scombrus* (1%) (Velasco *et al.,* 2002).

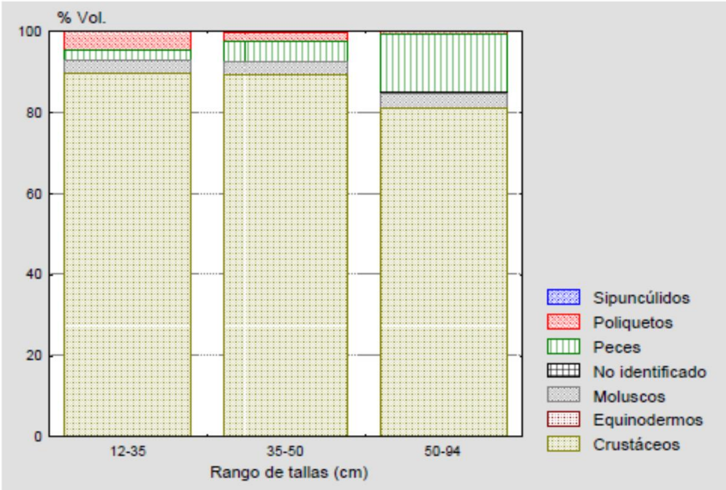


Figure 11 - Galicia and Cantabrian Sea (ICES divisions VIIIc and IXa). Diet of *Raja clavata* (data from Velasco *et al*., 2002).

Sánchez *et al.* (2005) applied a trophodynamic model (ECOPATH) to the Cantabrian Sea ecosystem using as variables the biomass indices obtained from bottom trawl surveys, production, biological parameters, feeding diets and catches and discards of the fisheries. The trophic level of skates (mainly *R. clavata*), the trophic level of the main elasmobranch groups and their relationship with others species inhabiting the same area were estimated. Skates (mainly *R. clavata*) have a trophic level of 3.8 (ranked 8) after Tuna (4.0), large hake (4.0) and other demersal predators such as *Lophius* spp and megrims. Estimations of natural (M) and fishing mortality (F) obtained from ECOPATH trophodinamic model gave values of 0.12 and 0.18 respectively. Skates are subject to more impacts than the small sharks in general. Many other trophic groups compete with skates, like benthic cephalopods (that have 90% of prey overlap) and all the components of the main trophic flow pelagic-demersal (phytoplankton->mesozooplankton-> suprabenthic zooplankton->small demersal fish->blue whiting).

B.6. Surveys

Spanish bottom trawl surveys (SP-GFS) are carried out annually along the continental shelf of Galicia and Cantabrian Sea (north of Spain) during autumn (Septemberï October). The historical series begun in 1980 however not until 1983 were standardized. These surveys are based on a stratified random sampling design, using an otter trawl 44/60 gear with a mesh size of 60 mm, and 20 mm in the cod-end (Sánchez, 1993; ICES, 2010). The survey area was stratified according to depth and biogeographically criteria (Figure 12). Five geographical sectors (MF, FE, EP, PA and AB) and three depth strata at the 70,120, 200 and 500 meter isobaths were defined. The first geographical sector (MF) corresponds to ICES area (IXa). The number of hauls per stratum is proportional to the trawlable surface area. Trawl tow duration is 30 min at a speed of 3 knots (Sánchez *et al*., 2002). An average of 122 ± 3.76 hauls (coverage of 5.4 hauls for every 1000 Km²) is usually performed each year during the whole survey. Supplementary hauls in deeper bottoms (500-700 m) and shallows waters (30ï 80 m) may be conducted depending of the ship time available at sea In particular, in the IXa area, an average of 19 hauls are preformed. This survey does not provide sufficient data to assess the stock status of *R. clavata* which can possibly be related with species distribution pattern and/or with inadequate survey design to catch this species.

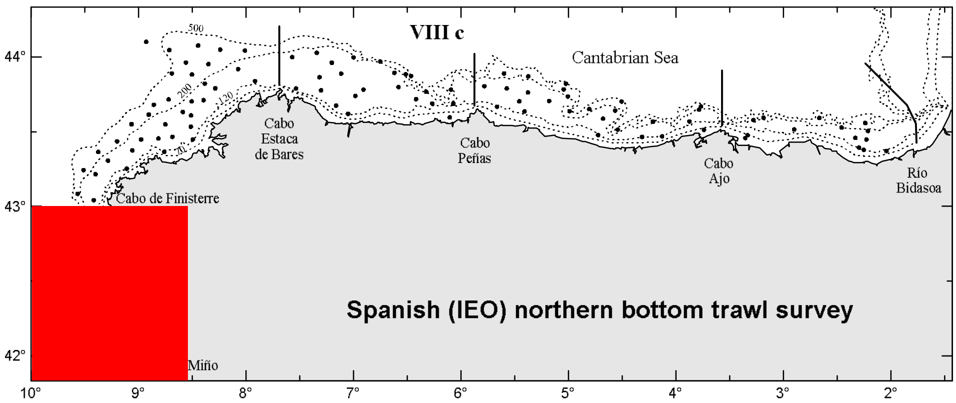


Figure 12 ï West of Galicia (ICES division IXa). Spanish (IEO) northern bottom trawl survey (SP-GFS) stratification design.

The Portuguese Autumn Groundfish Survey (PT-GFS) has been conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, ex-IPIMAR) and has the main objective to monitor the abundance and distribution of hake (*Merluccius merluccius*) and horse mackerel (*Trachurus trachurus*) recruitment (Cardador *et al.,* 1997). In these surveys, *R. clavata* is the most frequent skate species caught (88% of the total weight of skates). PT-GFS is performed along the Portuguese continental coast, extending from latitude 41°20'N to 36°30'N (ICES Division IXa) from 20 to 500 m deep. The surveys have been carried with the Portuguese RV ñNoruegaò, which is a stern trawler of 47.5 m length, 1500 horse power and 495 GRT and using a Norwegian Campell Trawl (1800/96 NCT) with a 20 mm codend mesh size and groundrope with bobbins. PT-GFS fishing operations are performed during daylight and the duration of each tow change in 2002 from 60 to 30 min. The surveyed area is stratified into 12 sectors (from north to south: CAM: Caminha, MAT: Matosinhos, AVE: Aveiro, FIG: Figueira, BER: Berlenga, LIS: Lisboa, SIN: Sines, MIL: Vila Nova de Mil Fontes, SAG: Sagres, POR: Portimão, VSA: Vila Real de Santo António), each further divided into four depth strata: 1) 20-100 m, 2) 101-200 m, 3) 201-500 m, and 4) 501-750 m. In 1996, 1999, 2003 and 2004 the RV ñNoruegaò was unavailable, and the surveys were conducted using a different vessel, the RV ñCapricórnioò and operating a different bottom trawl net, CAR type FGAV019, without rollers in the groundrope (ICES, 2007). In 2012 no survey was conducted.

The Spanish bottom trawl survey IBTS-GC-Q1-Q4 (ARSA) in the Gulf of Cadiz has been carried out in the spring and autumn from 1993 to 2013. The surveyed area corresponds to the continental shelf and upper-middle slope from the latitude 6º 20ôW to 7º 20ôW and from 15 m to 800 m depth covering an area of 7224 Km^2. The surveys were carried out on board of the R/V *Cornide de Saavedra*, a stern trawler of 67 m length and 1133 GRT until spring 2013. Since autumn 2013 surveys were carried out on board the R/V Miguel Oliver. Hauls were performed with a standard Baka 44/66 bottom trawl gear, the standard sampler used by the Instituto Español de Oceanografía in their surveys sampling the Spanish Atlantic shelf, with a 60.3 m headline and 43.8 m footrope. The gear employed had a stretched mesh of 40 mm in the codend and it was covered internally with a 20 mm mesh size. Mean vertical and horizontal opening were 1.8 m and 21 m, respectively. Sampling design followed a random stratified scheme with 5 depth strata (15-30 m, 31-100 m, 101-200 m, 201-500 m, 501-800 m). The number of hauls per strata was proportional to the trawlable surface adjusted to the ship time available at sea, with coverage of around 5.4 hauls for every 1000 Km^2. Haul duration was 60 minutes and they were carried out during daylight at a mean towing speed of 3.0 knots.

C. Assessment: data and method

Data:

- Fishery dependent data:
    - Landings estimates by species
    - Fishing effort (unit: number of fishing trips) by fishing gear
    - Length frequency distribution by fishing gear
    - Discards
- Fishery independent data
    - Portuguese Autumn Groundfish Surveys (PT-GFS) catch rate (kg.h^{-1})
    - Spanish bottom trawl survey IBTS-GC-Q1-Q4 (ARSA) in the Gulf of Cadiz (kg.h^{-1})
    - Length distribution

Methods:

1) Landings estimates by species for polyvalent and trawl segment in Portuguese continental waters

For each year *y* and landing port *p*, the landing estimates of each species were estimated based on the proportion of the species by sampled trip. A weighted proportion $p\square a_{(\square,\square)}$ was determined as:

$$pa_{(y,p)} = \frac{\sum_{i=1}^{n} \left(pa_{(y,p)i} \times w_{(y,p)i} \right)}{wt_{(y,p)}}$$

where the $pa_{(y,p)i}$ is the proportion of the species at the i^{th} fishing trip, $w_{(y,p)i}$ is the landed weight of skates in the i^{th} fishing trip and $wt_{(y,p)}$ is the total landed weight of skates in all the sampled trips at landing port *p* in year *y*. The estimate of the variance of $pa_{(y,p)}$ is determined as:

$$var\left(pa_{(y,p)} \right) = \frac{1}{n \bar{w}_{(y,p)}^{2}} \frac{\sum_{i=1}^{n} \left(w_{(y,p)i}^{2} . pa_{(y,p)i} \left(1 - pa_{(y,p)i}\right) \right)}{n_{(y,p)} - 1}$$

where $n_{(y,p)}$ is the number of sampled trips for the y year and p landing port.
For the selected species the total landed weight $W_{(y,p)}$ () in landing port *p* and year *y* was calculated as:

$$W_{(y,p)} = pa_{(y,p)} \times w_{(y,p)}$$

where $w_{(y,p)}$ is the total landed weight of skates.

At landing ports for which fishing effort was estimated by group (groups correspond to set of vessels determined as function of vessel size, seasonality in fishing skates and fishing gear), the proportion of the species for the year *y*, port *p* and group *g* were obtained as:

$$pa_{(y,p,g)} = \frac{\sum_{i=1}^{n} \left(pa_{(y,p,g)i} \times w_{(y,p,g)i} \right)}{wt_{(y,p,g)}}$$

where $pa_{(y,p,g)i}$ is the observed proportion of the species in i^{th} fishing trip, $w_{(y,p,g)i}$ is the landed weight of skates in the i^{th} fishing trip and $wt_{(y,p,g)}$ is the total landed weight of skates in the sampled trips. The variance of $pa_{(y,p,g)}$ was estimated in the same way as for $pa_{(y,p)}$.

The total landed weight of the species $W_{(y,p)}$ in landing port *p* and year *y* was calculated as:

$$W_{(y,p)} = \sum_{g} pa_{(y,p,g)} \times w_{(y,p,g)}$$

Note that when there were gaps of information to estimate the proportion, the median of the proportion estimates for the previous 3 years was assigned to the gaps.

2) Fishing effort (unit: number of fishing trips) by fishing gear for the main landing ports in Portuguese continental waters

The fishing effort by fishing gear for each main landing ports was estimated using a stepwise procedure that has been already described by Maia *et al.* (2013 WD) and that can be summarized as:

Step 1

Definition of homogeneous groups of vessels characterized by sharing similar fishing regimes, according to: a) vessel size further subdivided into small, medium or large that corresponds to 25%, 50% and 75% quartiles of the vesselǿs LOA; b) seasonality pattern, that includes three levels ñoccasional", "seasonal" or "constant". Seasonality levels were established based on: i) the number of trips with positive landings of skates, ii) the total landed weight of skates, and iii) the frequency of months of activity with skates.

Step 2

Definition of discriminant rules later used to assign the fishing gear to fishing trips for which the fishing gear was not known. The discriminant rules were established through the application of the flexible discriminant analysis (FDA; Leisch *et al.,* 2009) to the interview data collected from each sampled trip. In the FDA the input data matrix include: i) the relative weight and value, in each fishing trip, of the main accompanying species or genera by gear, ii) the group assigned to each trip in Step 1); and iii) fishing licences for each vessel. The data were previously transformed through factor analysis for mixed data (Pages J. 2004; Le *et al*., 2008). This procedure involves the data transformation of qualitative and quantitative variables that will later constitute the input data matrix of FDA. The selected main accompanying species corresponded to the top five species in terms of occurrence, of landed weight and of value in the sampled trips.

3) Standardized LPUE for the polyvalent fleet using nets in Portuguese continental waters

In the standardization process of LPUE, a stepwise generalized linear model (GLM) procedure was applied to find the best GLM model and an estimate LPUE index time series based on the relationship between LPUE vs. available predictive factor variables.

The function bestglm implemented in R software was used to select the best subset of inputs variables (McLeod AI and Xu, 2010). The selection was based on a variety of information criteria and their comparison, following a simple exhaustive search algorithm (Morgan and Tatar, 1972). This algorithm uses a lexicographical method that evaluates the loglikelihoods for all possible glm models. Lognormal error distribution was assumed in the standardization. This distribution is commonly assumed for standardizing catch and effort data, assuming that the expected value of a transformed response variable is related to a linear combination of exploratory variables (Maunder and Punt, 2004).

Different diagnostic plots, e.g. the distribution of residuals and the quantile-quantile (Q-Q) plots, were used to assess the error distribution (assuming lognormal distribution), as well as the model fits for the standardization of the LPUE. Changes in deviance explained by the selected model and the proportions of deviance explained to the total explained deviance was determined and used as indicative of r^2.

The standard errors of the year effects and LPUE for a reference conditions, in the present case: net as fishing gear, 1st quarter of the year; medium vessel size and constant seasonality, were calculated by the delta method. The delta method is commonly applied when functions are too complex for analytically computing their variance. According to this method, a linear approximation of the function, usually with a one-step Taylor approximation, is firstly obtained and then its variance is computed (Oehlert, 1992). In the polyvalent segment, landings from trips in which nets were used are relatively more important than those from longlines. Since no major differences on length structure of the specimens caught among the two fishing gears are observed, it is admitted that the standardized LPUE using fishery data derived from nets are representative of the polyvalent segment.

4) Discards

Information on discards has been collected by the Data Collection Framework (EU DCF/NP) for two main segments: bottom otter-trawl and polyvalent.

Information on bottom otter trawl discards derived from the Portuguese on-board sampling program started in 2003 that collects data, amongst other, on i) bottom otter trawl Crustacean fishery targeting deep-water rose shrimp, Norway lobster and blue whiting and; ii) bottom otter trawl demersal fish fishery targeting horse-mackerel, cephalopods and other finfish (Prista *et al.* 2013 WD). The programme is based on a quasi-random sampling of trips from a set of cooperative vessels known to operate in each target fishery. The protocol consists in sort a sample from the catch of each haul into a retained fraction and a discarded fraction following instruction by fishermen. Number, weight and length composition of each taxa in each fraction are recorded. The sampling protocol did not suffered significant changes between 2003 and 2013, apart from in 2011 that the size of catch samples doubled from one to two boxes and the within-trip selection of hauls was standardized to ñat least, every other haul/segmentò (see Prista *et al.* (2012) for more detail).

Information on polyvalent segment is obtained from two fisheries: i) net fisheries which includes the trammel or gillnets as fishing gear that operate at depths shallower than 150 m and target a multi-species complex and; ii) trammel nets fishery targeting anglerfish that operate at depth deeper than 150 m.

Data on net fisheries discards was obtained from the pilot study on the métiers where skates are caught. In this sampling scene all the hauls performed with nets (trammel or gillnets) were sampled. Collected information included: number, length and sex of all caught skate specimens caught, as well as, its final destination (landed or discarded). Information on trammel discards was derived from the pilot study on the Portuguese trammel nets fishery. The onboard protocol involve to sampling every hauls performed with trammel nets operating from 200 to 600 m deep. The information collected onboard consisted in total length of all individuals caught (identified at a species level) and categorization into discarded or retained individuals (for more detail see Moura *et al.* 2013 WD).

The procedure adopted for each fishery and for each skate species analyzed was similar and take into account the fact that the skates are not the target species for any fishery studied. The probability of the species be caught in a haul and a specimen of that species be discarded (p_{cd}) is determined as:

$$p_{cd} = p_c \times p_d$$

where p_c corresponds to the probability of the species be caught in one fishing haul and p_d is the probability of a specimen be discarded within the whole set of specimens caught in the sampled hauls.

The expected number of discarded specimens per haul ([illegible]) was calculated:

$$[illegible] = \sum [illegible] \times [illegible]$$

where x_i is the number of discarded specimens at the i^{th} haul and p_i is the probability that a specimen is derived from i^{th} within the whole set of sampled hauls (n).

5) Standardized survey biomass index

In Portuguese continental waters, biomass indexes of *R. clavata* were standardized using the catch rates by fishing haul obtained for Portuguese Autumn Groundfish Surveys (PT-GFS) from 2003 to 2013. Generalized linear mixed models (GLMM; Bolker *et al.*, 2009) were used in the standardization process (see Figueiredo et al., 2013 WD for further details). In the essayed models catch rate of the species in each haul ($Kg.h^{-1}$) was the response variable and several linear predictors were considered: i) type of fishing net (NCT or CAR); ii) year; iii) fishing sector; iv) initial depth (in meters); v) trawling duration (in minutes); vi) period (morning or afternoon). Apart from factor year, the remaining predictors were selected depending on their significance after the model adjustment. Interactions were not considered because, if included, the degrees of freedom available decreased substantially and the adjustment was very poor.

GLMM models were adjusted to the survey data through the use of package ôMASSô (Venables and Ripley, 2002) implemented in R software. In the model, error of the catch rate was assumed to follow a Tweedie random variable, whose probability density function is expressed as:

$$f(y: \mu, \sigma^2, p) = a(y: \sigma^2, p) \exp\left\{ -\frac{1}{2\sigma^2} d(y: \mu, p) \right\}$$

where µ is the location parameter; ů^2 is the diffusion parameter and; p is the power parameter.

The Tweedie family of distributions is a family of exponential dispersion models with variance $Var(Y) = \sigma^2.\mu^p$, that depending on the value of p includes other distributions (Dunn and Smyth, 2008; Jørgensen, 1997). When $1<p < 2$ the distribution corresponds to mixed distributions known as compound Poisson models (Jørgensen, 1997) that in the present case, and due to the high frequency of zeroes, seems to be the most appropriate distribution to use.

The estimation of the p parameter was done following the procedure proposed by Shono (2008). According to this, the power parameter (p) is estimated by maximizing the profile log-likelihood across the grid values of (p) in the range of $1 < p < 2$ through the explicit form of the probability density function. The package ôTweedieô (Dunn, 2009) implemented in R was used to estimate p.

In the GLMM adjustment, the factor Sector was considered as a random effect and since the random terms do not contribute to the fixed part of the mean its influence was isolated. The estimation of regression coefficients was done under the framework of quasi-likelihood and by fixing the value of *p* in the estimate obtained.

Model adequacy was check based on residual analysis. Fitted values were transformed ($2\varepsilon^{1-(p/2)}$) to the constant information-scale, so that the expected pattern for the compound Poisson distribution was a straight line (McCullagh and Nelder, 1989; Draper *et al.*, 1998; Ortiz and Arocha, 2004). Residuals were also analysed using Tweedie quantiles, and the graphical tools for residuals set with the Tweedie distribution (qqplots) were constructed. Three types of plots were examined: (i) histogram of the deviance residuals; (i) deviance residuals and Pearson residuals against the standardized fitted values to check for systematic departures from the assumptions underlying the statistical distribution; and (iii) Tweedie QQ-plot (with Tweedie quantiles) for deviance residuals and for Pearson residuals.

The annual biomass index predictions for the selected statistical model were obtained following the procedure referred in Candy (2004) and by considering the depth fixed at a reference level (mean depth). The estimates of the variance of the sum of linear predictors used to estimate the approximate confidence intervals of annual indices were determined using the delta method which is implemented at the R package ómsmô (Jackson, 2013). The delta method is a general approach for computing confidence intervals for functions of maximum likelihood estimates. This method allows finding approximations of the variance of functions of random variables based on Taylor series (Oehlert, 1992).

Software used:

All the data analysis was performed in R software (R Development Core Team, 2009).

I. References

Alvarez-Salgado, X., Figueiras, F., Perez, F., Groom, S., Nogueira, E., Borges, A., Chou, L., Castro, C., Moncoiffe, G., Rëos, A., Miller,A., Frankignoulle, M., Savidge, G., Wollast, R. 2003. The Portugal coastal counter current off NW Spain: new insights on its biogeochemical variability. Progress in Oceanography 56, 281ï 321.

Álvarez, I. Prego, R., de Castro, M. and Varela, M., 2012. Galicia upwelling revisited: out-of-season events in the rias (1967ï 2009). Ciencias Marinas (2012), 38(1B): 143ï 159

Ambar, L., and Howe, M.R. 1979. Observations of the Mediterranean outflow-I Mixing in the Mediterranean outflow. Deep-Sea Research, 26: 535-554.

Bañón Díaz, R., Quinteiro Fernández,R, García Tasende, M., Juncal Caldas,L.M., Campelos Álvarez, J.M., Gancedo Baranda, A., Lamas Rodríguez, F., Morales de la Fuente,C. and Ribó Landín, J, 2008. Composición, distribución y abundancia de rayas (Elasmobranchii: Rajidae) en aguas costeras de Galicia. Foro Ac. Rec. Mar. Rías Gal. 10: 325-331 2008.

Bolker, B.M., Brooks, M.E., Clark, C.J., Geange, S.W., Poulsen, J.R., Stevens, M.H.H. and White, J-S.S. 2009. Generalized linear mixed models: a practical guide for ecology and evolution. Trends in ecology and evolution 24: 127-135.

Borges, M.F., Santos, A.M.P., Crato, N., Memdes, H., Mota, B. 2003. Sardine regime shifts off Portugal: a time series analysis of catches and wind conditions. In Fish Stock Assessments and predictions: Integrating Relevant knowledge (editors O. Ulltang and G. Blom) Scientia Marina Volume 67, Suplement 1, April 2003.

Brander, K., Blom, G., Borges, M., Erzini, K., Henderson, G., MacKenzie, B., Mendes, H., Santos, A. and Toresen R. 2003. Changes in fish distribution in the eastern North Atlantic: Are we seeing a coherent response to changing temperature? ICES Mar. Sci. Symp., 219, 261ï 270.

Candy, S. 2004. Modelling catch and effort data using generalised linear models, the Tweedie distribution, random vessel effects and random stratum-by-year effects. CCAMLR Science 11: 59-80.

Cardador, F., Sanchéz, F., Pereiro, F.J., Borges, M.F., Caramelo, A.M., Azevedo, M., Silva, A., Pérez, N., Martins, M.M., Olaso, I., Pestana, G., Trujillo, V. and Fernandez A. 1997. Groundfish surveys in the Atlantic Iberian waters (ICES divisions VIIIc and IXa): history and perspectives. ICES CM 1997/Y:8.

Castro, M., Gómez-Gesteira, M., Álvarez, I., and Crespo, A.J.C. 2011. Atmospheric modes influence on Iberian Poleward Current variability. Continental Shelf Research, 31:425ï 432.

Diaz, J.I., M. Farrán and A. Maldonado. 1985. Surfical sediment distribution patterns in the Gulf of Cádiz controlled by the geomorphic features and physical oceanographic parameters. *6th European Regional Meeting of Sedimentology*. I.A.S., Lleida 85: 129-132.

Díaz, V., L.M. Fernández, J. Gil, F. Ramos and M.P. Jiménez. 2006. Gulf of Cadiz Regional Ecosystem. *ICES Working Group for Regional Ecosystem Description*. ICES/WGRED 2006.

Draper, N. R., Smith, H. and Pownell, E. 1966. Applied regression analysis (Vol. 3). New York: Wiley.

Dunn, P.K., 2009. Tweedie: Tweedie exponential family models. R package version 1.6.2.

Dunn, P.K. and Smyth, G.K. 2008. Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. Statistics and Computing 18: 73ï 86.

Ellis, J. R., Cruz-Martinez, A., Rackham, B. D. and Rogers, S. I. 2005. The distribution of chondrichthyan fishes around the British Isles and implications for conservation. Journal of Northwest Atlantic Fishery Science 35: 195-213.

Enever, R., Catchpole, T.L., Ellis, J.R. and Grant, A. 2009. The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters. Fish.Res.97(1ï 2):72-76.

Farias, I., Figueiredo, I., Moura, T., Gordo, L.S., Neves, A. and Serra-Pereira, B. 2006. Diet comparison of four ray species (*Raja clavata, Raja brachyura, Raja montagui* and *Leucoraja naevus*) caught along the Portuguese continental shelf. Aquat. Living Resour. 19, 105ï 114.

Figueiras, F. G., Labarta, U. and Fernández-Reiriz, M. J. 2002. Coastal upwelling, primary production and mussel growth in the Rías Baixas of Galicia. Hydrobiologia, 484: 121-131.

Figueiredo, I. and Serra-Pereira, B. 2012. Modelling *Raja clavata* abundance from Portuguese IBTS data (1990-2011) using GLMM with Tweedie distribution. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-09.

Fiúza, A.F.G., Macedo, M.E. and R. Guerreiro, 1982. Climatological space and time variations of the Portuguese coastal upwelling. Oceanol. Acta, 5: 31-40.

Frouin, R., Fiúza, A.F.G., Ambar, I. and Boyd, T.J. 1990. Observations of a poleward surface current off the coasts of Portugal and Spain during winter. J. Geophys. Res., 95: 679ï 691.

Gil, J., 2008. Macro and mesoscale physical patterns in the Bay of Biscay. J. Mar. Biol. Ass. UK., 88 (2): 217-225.

Hunter, E., Berry, F., Buckley, A.A., Stewart, C. and Metcalfe, J.D. 2006. Seasonal migration of thornback rays and implications for closure management. Journal of Applied Ecology 43: 710-720.

Hunter, E., Buckley, A.A., Stewart, C. and Metcalfe, J.D. 2005. Migratory behaviour of the thornback ray, *Raja clavata*, in the southern North Sea. Journal of the Marine Biological Association of the United Kingdom 85: 1095-1105.

ICES. 2007. Report of the International Bottom Trawl Survey Working Group (IBTSWG). 27ï 30 March 2007, Séte, France, pp. 182.

ICES, 2010. Manual for the International Bottom Trawl Surveys in the Western and southern Areas. pp. 58.

ICES. 2013. Report of the Working Group on Elasmobranch Fishes (WGEF), 17ï 21 June 2013, Lisbon, Portugal. ICES CM2013/ACOM:19. 680pp.

Jackson, C. 2013. Package ómsmô: Multi-state Markov and hidden Markov models in continuous time. R package version 1.1.4.

Jennings, S., Greenstreet, S.P.R. and Reynolds, J.D. 1999. Structural change in an exploited fish community: a consequence of differential fishing effects on species with contrasting life histories. Journal of Animal Ecology 68, 617-627.

Jensen, A.L. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Canadian Journal of Fisheries and Aquatic Sciences 53, 820ï 822.

Jørgensen, B. 1997. The Theory of Dispersion Models. Chapman and Hall, London, p. 237.

Le S., Josse J. and Husson. F. 2008. FactoMineR: An R package for multivariate analysis. Journal of Statistical Software. Vol 25 (1).

Leisch F., Hornik K. and Ripley B.D. 2009. Mixture and flexible discriminant analysis. R package version 0.4-2.

Maia, C., Serra-Pereira, B. and Figueiredo, I. 2013. Skates and rays estimates of landings by species from the Portuguese vessels operating in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-09.

Mason, E., Coombs, S., Oliveira, P., Angélico, M.M. and Stratoudakis, Y. 2006. An overview of the literature concerning the oceanography of the eastern North Atlantic region. Relat. Cient.Téc. Inst. Invest. Pescas Mar. Série Cooperação, 51pp.

Maunder, M.N. and Punt, A.E. 2004. Standardizing catch and effort data: A review of recent approaches. Fish.Res. 70: 141-159.

Ortiz, M. and Arocha, F. 2004. Alternative error distribution models for standardization of catch rates of non-target species from a pelagic longline fishery: billfish species in the Venezuelan tuna longline fishery, Fish.Res. 70(2ï 3): 275-297.

McCullagh, P. and Nelder, J.A. 1989. Generalized Linear Models. London, Chapman Hall.

McLeod AI and Xu C 2010 bestglm: Best Subset GLM. URL http://CRAN.R-project.org/package=bestglm.

Moita, T. 2001. Estrutura, variabilidade e dinâmica do Fitoplâncton na costa de Portugal Continental. PhD Thesis. University of Lisbon, Portugal. 272 pp.

Morgan, J.A. and Tatar J.F. 1972. Calculation of the Residual Sum of Squares for all Possible Regressions." Technometrics, 14, 317-325.

Moura, T., Fernandes, A., Figueiredo, I., Alpoim, R. 2013. Pilot Study on the Portuguese trammel net fishery in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-10.

Nelson, C.H., J. Baraza and J. Maldonado. 1993. Mediterranean undercurrent sandy contourites, Gulf of Cadiz, Spain. In: D.A.V. Stow and J.C. Faugeres (Editors), *Contourites and bottom currents. Sediment.* Geol., 82: 103-131.

Nogueira, E., Pérez, F.F. and Ríos, A.F. 1997. Modelling thermohaline properties in an estuarine upwelling ecosystem (Ria de Vigo; NW Spain) using Box-Jenkins transfer function models. Est. Coast. Shelf Sci., 44: 685-702.

Oehlert, G. W. 1992. A note on the delta method. The American Statistician, 46: 27-29.

Pages J. 2004. Analyse factorielle de donnees mixtes. Revue Statistique Appliquee. LII (4). pp. 93-111.

Peliz, A., Rosa, T., Santos, A. and Pissarra, J. 2002. Fronts, jets, and counter flows in the Western Iberian upwelling system. Journal of Marine Systems 35, 61ï 77.

Peliz, A., Dubert, J., Santos, A., Oliveira, P. and Le Cann, B. 2005. Winter upper ocean circulation in the Western Iberian Basin ï Fronts, Eddies and Poleward Flows: an overview. Deep Sea Research I 52, 621ï 646.

Prista. N., Jardim, E., Fernandes, A.C., Silva, D., Ferreira, A.L., Abreu, P., Fernandes, P. 2012. Manual of Onboard Sampling Procedures: Fixed Gears. Relatórios Cientícos e Técnicos do Instituto Investigação das Pescas e do Mar, 56 (pp. 23 + Annexes).

Prista, N. and Fernandes, C. 2013. Discards of elasmobranchs by the Portuguese bottom otter trawl and deep-water set longline fisheries operating in ICES Division XIa (2004ï 2012). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-15.

R Development Core Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna. Austria. ISBN 3-900051-070. http://www.R-project.org.

Relvas, P., Barton, E., Dubert, J., Oliveira, P., Peliz, A., da Silva, J. and Santos, A. 2007. Physical oceanography of the western Iberia, ecosystem: Latest views and challenges, Prog. Oceanogr., 74, 149ï 173.

Relvas, P., Luís, J. and Santos, A.M.P. 2009. Importance of the mesoscale in the decadal changes observed in the northern Canary upwelling system, Geophys. Res. Lett., 36, L22601, doi:10.1029/2009GL040504

Rodríguez-Cabello, C. Fernández A., I. Olaso, F. Sánchez, F., Gancedo, R., Punzón, A. and Cendrero, O.2005. Overview of Continental Shelf Elasmobranch Fisheries in the Cantabrian Sea. J. Northw. Atl. Fish. Sci., Vol. 35:

Sánchez, F., 1993. Las comunidades de peces de la plataforma del Cantábrico. Publicaciones Especiales del Instituto Español de Oceanografía, 13, 137 pp.

Sánchez, F., Blanco, M., Gancedo, R., 2002. Atlas de los peces demersales y de los invertebrados de interés comercial de Galicia y el Cantábrico. Otoño 1997-1999. Instituto Español de Oceanografia. MYC Ed.CYAN. Madrid, pp. 158

Sánchez, F., Rodríguez-Cabello, C. and Olaso, I., 2005. The Role of Elasmobranchs in the Cantabrian Sea Shelf Ecosystem and Impact of the Fisheries on Them. J. Northw. Atl. Fish. Sci., Vol. 35: 467ï 480

Santos, A.M.P., Borges, M.F. and Groom, S. 2001. Sardine and horse mackerel recruitment and upwelling off Portugal. ICES Journal of Marine Science. Vol 58, No 3, 589-596.

Santos, A.M.P., Peliz, Á.J., Dubert, J., Oliveira, P.B., Angelico, M.M. and P. Ré. 2004. Impact of a winter upwelling event on the distribution and transport of sardine (Sardina pilchardus) eggs and larvae off western Iberia: a retention mechanism. Continental Shelf Research, 24: 149-165.

Serra-Pereira, B., Erzini, K., Maia, C. and Figueiredo, I. 2014. Identification of potential essential fish habitats for skates based on fishersô knowledge. Environmental Management, 53(5):985-98.

Serra-Pereira, B., Figueiredo, I. And Gordo, L.S. 2011. Maturation, fecundity, and spawning strategy of the thornback ray, *Raja clavata:* do reproductive characteristics vary regionally? Marine Biology. 158(10): 2187-2197.

Serra-Pereira, B., Figueiredo, I., Moura, T. And Gordo, L.S. 2008. Description of dermal denticles from the caudal region of *Raja clavata* and their use for the estimation of age and growth. ICES Journal of Marine Science. 65:1701-1709.

Shono, H. 2008. Application of the Tweedie distribution to zero-catch data in CPUE analysis. Fisheries Research 93: 154-162.

Stehmann, M.F.W. and Bürkel, D.L. 1984. Rajidae. In Fishes of the North-eastern Atlantic and the Mediterranean, volume 1, pp. 163-196. Ed. by P. J. P. WHITEHEAD, M. BAUCHOT, J. HUREAU, J. NIELSEN and E. TORTONESE. UNESCO, Chaucer Press, UK.

Steven, G. A. 1936. Migrations and Growth of the Thornback Ray (*Raja clavata* L.). Journal of the Marine Biological Association of the United Kingdom 20: 605-614.

Velasco, F, Olaso, I. and Serrano, A., 2002. Alimentación de tres especies de la familia Rajidae en el sur del Golfo de Vizcaya. ICES CM/2002

Venables, W.N. and Ripley, B.D. 2002. Modern Applied Statistics with S, Fourth ed. Springer, New York.

Walker, P. A., Howlett, G. and Millner, R. 1997. Distribution, movement and stock structure of three ray species in the North Sea and eastern English Channel. ICES Journal of Marine Science 54: 797-808.

Stock Annex
Small-eyed ray (*Raja microocellata*) in Divisions VIId,e (English Channel)

Stock Annex rje-ech

Stock specific documentation of standard assessment procedures used by ICES.

Stock	rje-ech: Small-eyed ray (*Raja microocellata*) in Divisions VIId,e (English Channel)
Working Group:	WGEF
Date:	24 June 2014
Revised by	Alain Tétard

A. General

A.1. Stock definition

There are localized concentrations of *R. microocellata* in the English Channel, including around the Channel Islands (Ellis et al., 2011) and Baie of Douarnenez, Brittany (Rousset, 1990), with small numbers taken elsewhere.

Data from surveys (CGFS and BTS in VIId and IVc, BTS in VIIe) and from French observations aboard commercial vessels confirm low catches related to a patchy and very coastal distribution. North of the norman-breton Gulf is confirmed as a presence area.

A.2. Fishery

This species is mainly exploited by French and UK (including Channel Islands) fleets, as a bycatch by the trawlers, and as a target species by small, coastal netters and longliners.

A.3. Ecosystem aspects

This species may have a very coastal distribution.

B. Data

B.1. Commercial catch

The quality of specific landings is improving since 2008 with the obligation to have a separate declaration for this species but is still considered poor (landing as miscellaneous skates).

B.2. Biological

Knowledge is increasing with new studies on the costal skates after the undulate ray ban (see Stephan and Al., 2014 and Leblanc and Al., 2014.

B.3. Surveys

Survey data used include the French CGFS in VIId, IBTS in VIId-IV, and the English BTS in VIId-IVc and in VIIe.

CGFS indicates that the geographical distribution of the species in VIId is very coastal and that the apparent abundance is low.

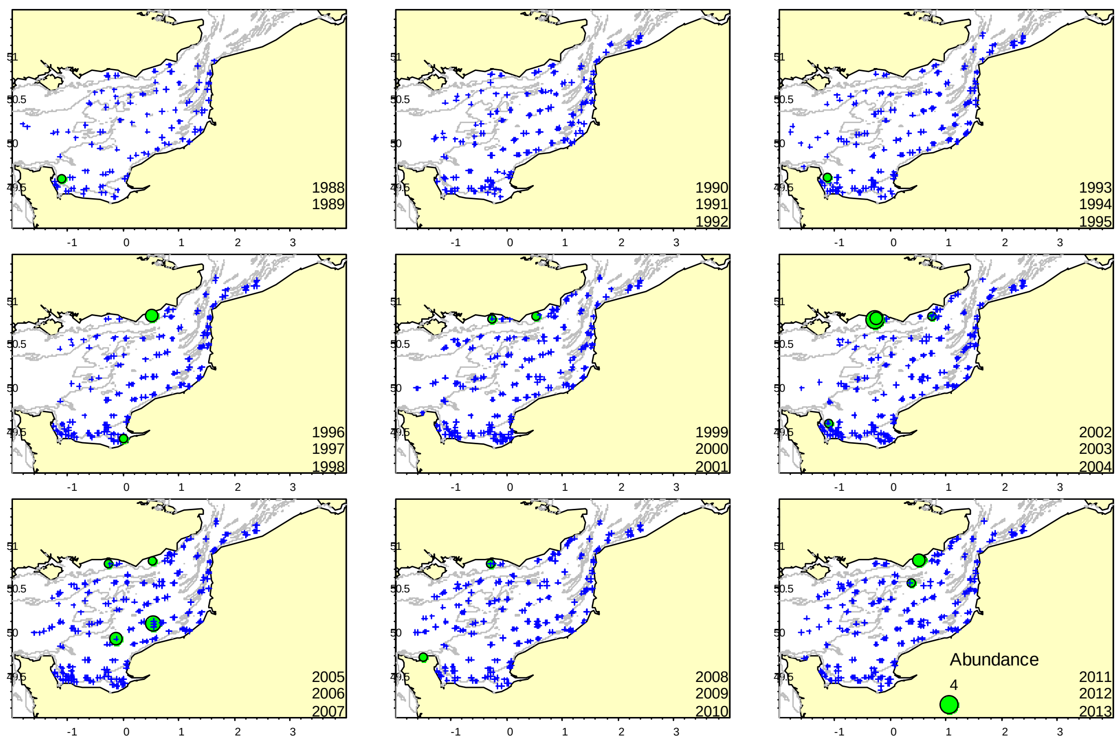


Figure 1.-Spatial distribution of small-eyed ray (*Raja microocellata*) in VIId from CGFS. The number of fish caught per haul (green circles) is shown for groups of three years. Hauls with no catch of the species are represented by a blue cross (+).

English BTS in VIIe gives few records of this species, and whilst these were generally from coastal waters with smaller size groups likely to occur in waters shallower than can be surveyed by the research vessel. (Figure 2).

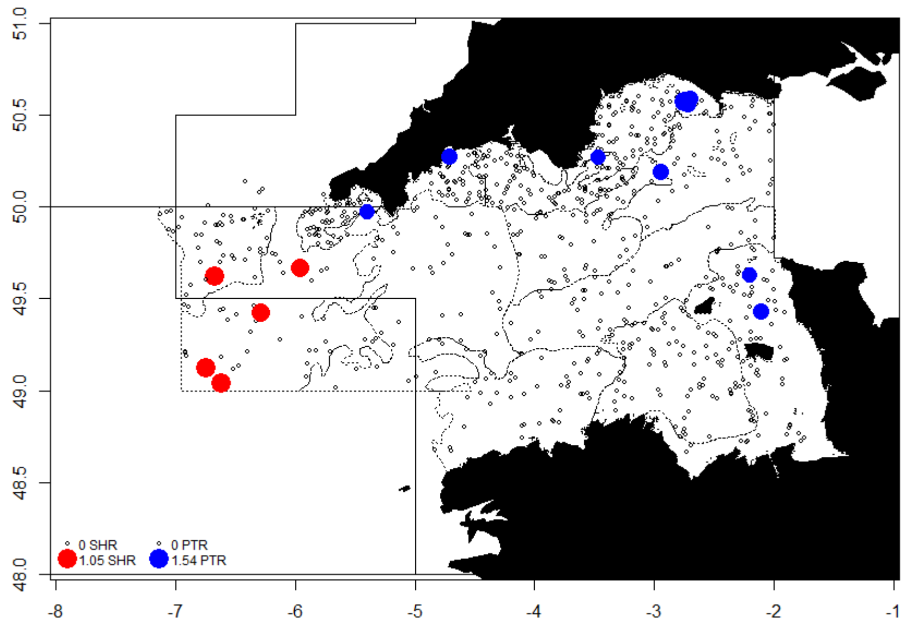


Figure 2.-Spatial distribution of small-eyed ray (*Raja microocellata*) (blue) in VIIe English BTS (2006-2014).

B.4. Commercial CPUE

French fisheries observer program give a general information on distribution at the English Channel scale (Figure 3). Except a high value subject to caution the catches are generally very coastal (Norman-Breton Gulf, Lyme bay, Brittany).

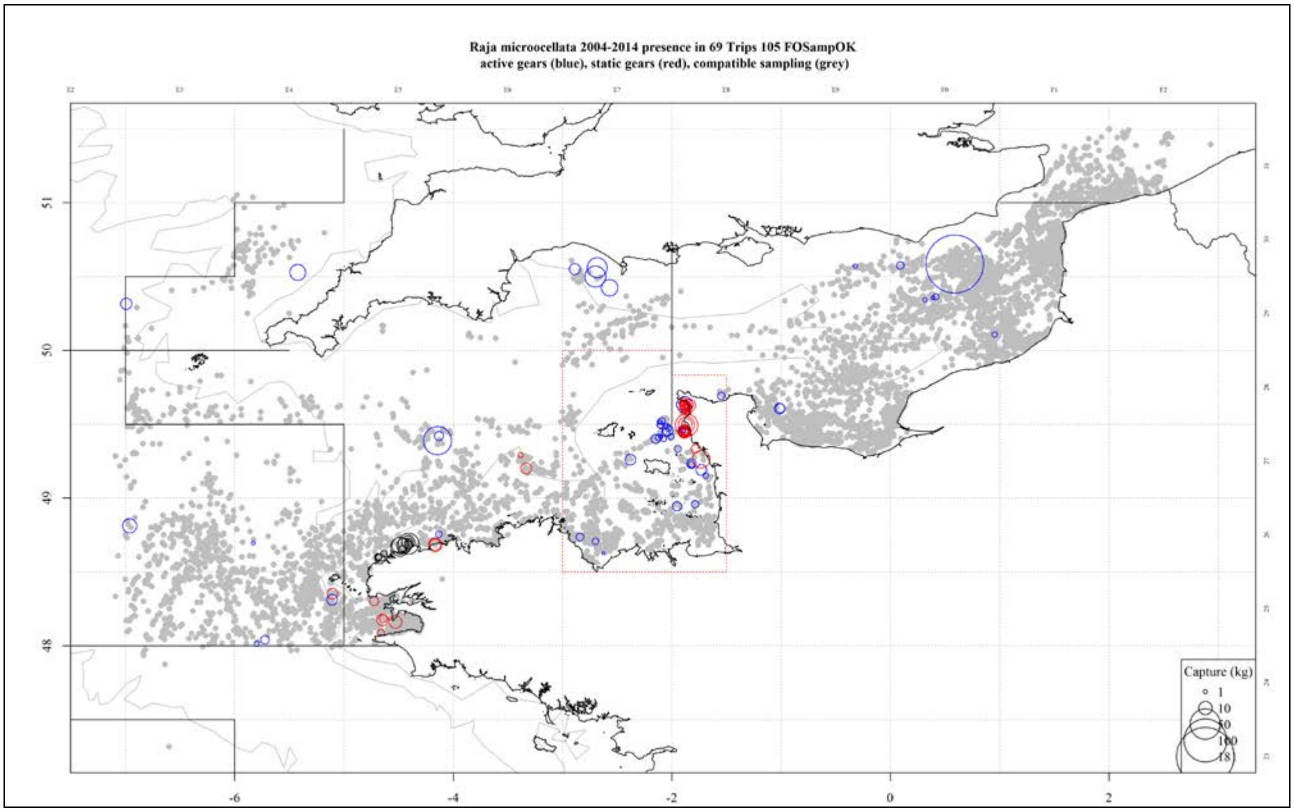


Figure. 3.- French fisheries observer program: *Raja microocellata* catches (kg) in the English Channel and adjacent areas from 2003 to the first quarter 2014 (grey dots: hauls from gears susceptible to catch skates with no catch of R microocellata; open circles catch in weight of R microocellata, blue: towed gears, red: passive gears). Each circle corresponds to one sampled fishing operation.

B.5. Other relevant data:

C. Assessment: data and method

Model used:

D. Short-Term Projection

None

E. Medium-Term Projections

None

F. Long-Term Projections

None

G. Biological Reference Points

	Type	*Value*	*Technical basis*
MSY Approach	**MSY $B_{trigger}$**	**xxx t**	**Explain**
	F_{MSY}	**Xxx**	**Explain**
Precautionary Approach	**B_{lim}**	**xxx t**	**Explain**
	B_{pa}	**xxx t**	**Explain**
	F_{lim}	**Xxx**	**Explain**
	F_{pa}	**Xxx**	**Explain**

H. Other Issues

H.1. Historical overview of previous assessment methods

2012: first advice for rje-ech, years 2013 and 2014.

I. References

Leblanc, N., Tetard, A., Legrand, V. E. Stéphan, L. Hegron Macé, 2014. RAIMOUEST: the French fishery of rays in the Western English Channel (VIIe), 2014 update. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26th June, 2014.

Stéphan, E., Hennache, C., Delamare, A., Leblanc, N., Legrand, V., Morel, G., Meheust, E., Jung, JL., 2014. Length at maturity, conversion factors, movement patterns and population genetic structure of undulate ray (*Raja undulata*) along the French Atlantic and English Channel coasts: preliminary results. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26th June, 2014.

French fisheries observer program (http://sih.ifremer.fr/Description-des-donnees/Les-donnees-collectees/Echantillonnage-des-captures-a-bord-des-navires-de-peche).

J. F. Silva, S. R. McCully, J. R. Ellis and S. Kupschus, 2014. Demersal elasmobranchs in the western English Channel (ICES Division VIIe). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26th June, 2014

Stock Annex

Stock specific documentation of standard assessment procedures used by ICES.

Stock *Raja brachyura* in Western Iberian Waters (west of Galicia, Portugal, and Gulf of Cadiz) (ICES Division IXa)

Working Group: WGEF 2014

Date:

Revised by

A. General

A.1. Distribution

Global distribution: *Raja brachyura* (blonde ray) is a coastal benthic species with a wide geographic distribution in the northeast Atlantic (Stehmann and Bürkel, 1984) being often found in sandbanks (Ellis *et al.*, 2005).

Species distribution in IXa: The species is distributed along the entire area.

In the west of Galicia the species is found on sand and sand-rock bottoms along the coast at depths ranging from 20 to 120 m.

In the Portuguese continental waters the species occurs along the entire coast at depths ranging from 10 to 700 m (Figure 1), being more abundant at depths shallower than 200 m.

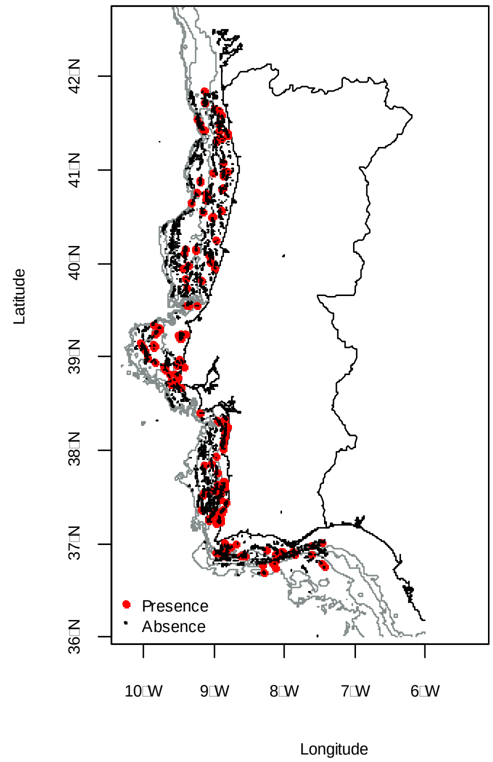


Figure 1 – Portuguese continental waters (ICES division IXa). *Raja brachyura* distribution in Portuguese Autumn Groundfish Surveys (PT-GFS) and Winter Groundfish Surveys (PtGFS-WIBTS-Q1) from 1990 to 2013.

A.2. Species dynamics

In the west of Galicia no information on nursery or spawning areas is available. The length of specimens caught by the artisanal fleet varied from 26 to 116 cm suggesting that both juveniles and adults are present in this area.

In center off Portugal, the species lives preferentially in areas shallower than 100 m deep, showing different spatial dynamics according to its life stages (Serra-Pereira *et al.*, 2014). Most of the times the two sexes occur in equal proportions but spatial segregation by sex may exist. Nursery and egg deposition grounds are situated inshore, at different types of seabeds, which can vary from sandy to rocky bottoms. A seasonal variation in abundance of juveniles was registered - higher abundances are recorded during the 4rd quarter of the year, showing a temporal spatial overlap between egg-laying and nursery grounds. A higher abundance of adults is recorded during the 2nd quarter of the year, in more offshore grounds characterized by sand surrounding rocks. This different spatial pattern is likely to be related with migrations associated to reproduction; adults migrate to more inshore and shallow waters to reproduce.

A.3. Stock definition

The stock structure of the species along the all ICES areas is unknown. Migrations between different areas are admitted (ICES, 2013). For advice purposes, ICES considered a distinct stock unit for Division IXa (west of Galicia, Portugal, and Gulf of Cadiz).

A.4. Fisheries

In the Western area of the Iberian Peninsula Rajidae species are usually caught as by-catch from other fisheries. In the past and in the north of Spain, there were direct fisheries to rays and skates. These fisheries mainly operated in coastal areas and inside estuaries, with a special gillnet called *raeiras* (DOG nº 31 15/02/2011). At the present there are no direct fisheries for skates and most of the landings come from the trawl fishery targeting other species (Rodriguez-Cabello *et al*., 2005). Total landings by the Spanish fleet in ICES Division IXa (for all Rajidae species) increased from 1996 to 2001 up to 416 t and since them remained more or less stable showing fluctuations around 350 tones (Figure 3). In the coastal area inside Galicia estuaries an important artisanal fleet operates catching frequently Rajidae species using different types of gillnets, particularly *miño* (DOG nº 31 15/02/2011). Catches from the artisanal fleet represent around 8.7 % of Galician total landings (Bañón *et al*., 2008). *R. brachyura* and *R. montagui* are the main species caught with this gillnet (Bañón *et al.*, 2008).

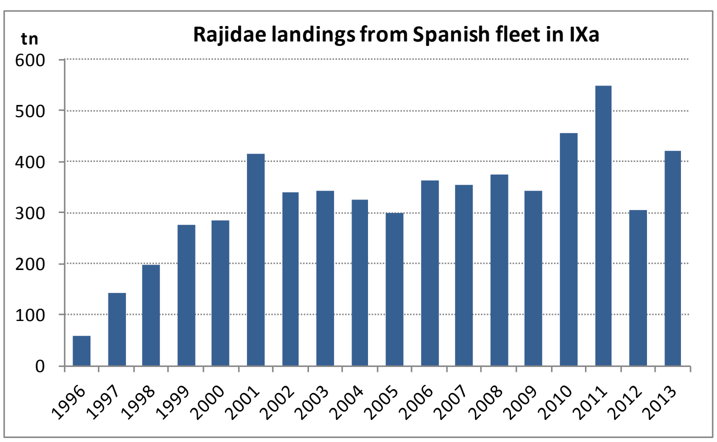


Figure 2 – West of Galicia (ICES division IXa). Annual total landings (t) of Rajidae species from the Spanish fleet.

In the Portuguese continental coast Rajidae species are mainly landed by the polyvalent segment, which represents around 75% of the total landed weight, followed by the trawl segment that represents around 24%. The trawl segment is defined by vessels that operate wish mesh sizes of 55m, 65 or 70 mm. The Portuguese polyvalent segment includes vessels with length overall (LOA) ranging from 5 to 27 m which generally operate between 10 and 150 m deep and exhibit a multi-species and mixed fisheries, capturing a high diversity of species at different fishing grounds. This segment also includes vessels operating with trawl gear with mesh size of 32 cm, and, for analysis purposes, all trawl vessels with LOA smaller than 12 m irrespective of the mesh size. The latter were included in the polyvalent segment due to their different fishing pattern when compared to larger trawlers: fishing operations closer to the coast and daily trips. All these vessels can have more than one fishing gear (e.g. trammel nets, gillnets, longline, trawl, traps and/or pots) and consequently different fishing gears may be used in one fishing trip. Within the polyvalent segment, Rajidae are mainly caught by nets, i.e. trammel and gillnets; for the period between 2008 and 2013 the landed weight derived from nets represented 65 to 78% of the total landed weight, while longline and artisanal trawl represented 19- 24%, and up to 9% respectively.

In the Gulf of Cádiz area Rajidae are taken as by-catch of fisheries targeting demersal species.

A.5. Ecosystem aspects

In the west coast of the Iberian Peninsula the most important features enhancing primary production are coastal upwelling, coastal runoff and river plumes, seasonal currents and internal waves and tidal fronts. Maximum values of chlorophyll usually occur in spring and summer (Nogueira *et al.*, 1997; Moita, 2001), although high chlorophyll values may be recorded in autumn, particularly in zones with elevated retention characteristics; for example, high chlorophyll concentrations are found in the Rías Baixas, at the time of the seasonal transition from upwelling to downwelling (Nogueira *et al.*, 1997; Figueiras *et al.*, 2002). Most of the west Iberian coast, including Galicia and Cantabrian Sea continental shelf, is occupied by cold waters rich in nutrients (Gil, 2008).

The north-south orientation of the coast causes winds from the north to produce offshore transport. During spring and summer, northerly winds along the coast are dominant causing coastal upwelling and producing a southward current at the surface and a northward undercurrent at the slope (Figure 4a) (Fiúza *et al.*, 1982; Alvarez-Salgado *et al*., 2003; Peliz *et al*., 2005; Mason *et al.*, 2006). During winter the prevailing winds are mainly south-westerly, and the atmospheric circulation is dominated by eastward displacement of cyclonic perturbations and their associated frontal systems (Figure 4b) (Relvas *et al.*, 2007). However, in some years the presence of episodic atmospheric anti-cyclonic circulation (the Azores High) could give rise to northerly wind events during winter (Santos *et al.*, 2001; Borges *et al*., 2003). Indeed, investigations on upwelling along the Galician coast in autumn and winter have been characterized in the Galician rias, indicating that the upwelling process along the Galician coast is not a phenomenon restricted to spring and summer (Alvarez *et al*., 2012).

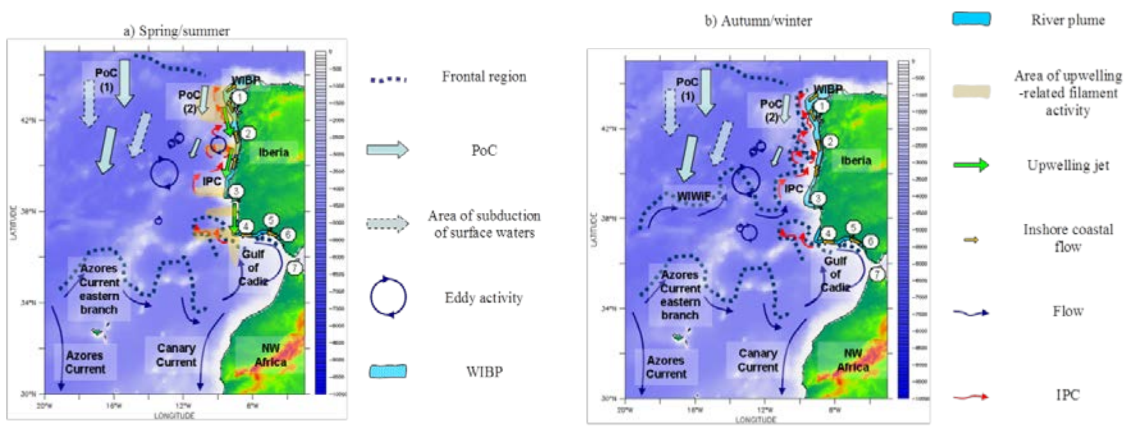


Figure 4 - The western Iberia and Gulf of Cadiz regimes in a) spring and summer, and b) autumn and winter. 1) Cape Finisterre; 2) River Douro; 3) Cabo da Roca; 4) Cape St. Vincent; 5) Guadiana River; 6) Guadalquivir River; 7) Strait of Gibraltar. PoC - southward-flowing Portugal Current, WIBP - Western Iberia Buoyant Plume, IPC - Iberian Poleward Current (Adapted from Peliz *et al*. 2002; Peliz *et al*. 2005).

In winter the Poleward Current (PC) flows northerly. It is a salty surface current (about 200 m deep) of subtropical origin (Eastern North Atlantic Water, also known as the 'Navidad' Current, since because it starts to be evident near Christmas and New Year) and relatively warmer than the surrounding ones (Castro *et al.*, 2011). During winter and spring, the PC results in a convergent front at the boundary between coastal and oceanic water. When saline intrusion is weak, the development of fronts and the formation of a seasonal thermocline are enhanced, leading to phytoplankton blooms. When saline intrusion is intense, strong vertical mixing occurs and prevents phytoplankton growth in spring (Moita, 2001; Santos *et al.*, 2004).

The intermediate deep layers are mainly occupied by a poleward flow of Mediterranean Water (MW), which contours the southwestern slope of the Iberia (Ambar and Howe, 1979), generating the mesoscale features called Meddies. The MW along the west coast of the Iberian Peninsula is characterized by a transport of warm and salty water (typical surface anomalies, 1–1.5ºC and 0.1–0.3‰ in salinity) with velocities up to some 0.2–0.3 m s^{-1} reported by Frouin *et al*. (1990).

The Sea Surface Temperature (SST) registered a generalized warming of a few hundredth of degrees a year since 1960, ranging from 0.015°C/year to 0.037°C/year (Relvas *et al.*, 2009). The SST increase has effect on species populations (e.g. recruitment success, migrations changes) (Brander *et. al*., 2003).

In the Gulf of Cadiz the most important oceanographic process is the occurrence of a strong interaction between two masses of water, the Atlantic Ocean and the Mediterranean Sea through the Strait of Gibraltar. In general, the exchange of water masses through Strait of Gibraltar is guided by the highly saline and warm Mediterranean Outflow Water near the bottom, and the turbulent, less saline, cool-water mass of the Atlantic Intermediate Water at the surface. The pattern of surface circulation is ruled by a clockwise movement, with a general W to E superficial current, whereas the deep circulation is controlled by the westerly current of the highly saline (salinity>37 PSU) Mediterranean water existing through the Strait.

Bottom temperatures are extremely variable ranging between 3ºC and 20.6ºC whereas values of bottom salinity along the continental shelf range from 35.8 to 36 PSU (Díaz *et al.*, 2006). In the slope there is a wide band with values around 37 PSU, the lower slope showing the minimum values which correspond to the Deep Atlantic Water Mass (Díaz *et al.*, 2006).

The continental slope can be differentiated into four provinces: a) a narrow belt between 130 and 400 m formed by the steep upper slope; b) two gently dipping wide terraces located between 400 and 700 m depth; c) a central sector between the terraces in which several, steep and narrow curvilinear ridges and valleys are located trending NE-SW to E-W; d) the lower slope-upper continental rise at water depths from 900 down to 1500-1800 m. Below 900 m, the lower slope is steeply dipping and generally smooth except for shallow valleys placed in a NE-SW direction (Nelson *et al.*, 1993). The main sedimentary types occurring over the slope are bioclastic sands, silicoclastic sands and muddy sands, sandy muds, sandy and muddy contourites (Díaz *et al.*, 1985).

B. Data

B.1. Commercial landings and discards

Due to the sampling methodology based on métier it has not been possible to separate accurately the discards made by the Spanish trawl fleet in Galicia and Cantabrian Sea (VIIIc and IXa). Annual fluctuations were observed with 7.7 t discarded in 2013 (Table 1).

Table 1. Galicia and Cantabrian Sea (ICES divisions VIIIc and IXa). Estimates of discard (t) of *Raja brachyura* (bold) and of their coefficient of variation (in italics) in Iberian waters (VIIIc-IXa) from the Spanish bottom trawl fishery.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Raja brachyura	**0,1**	**90,8**	**1,2**	**11,6**	**31,6**	**2,1**	**10,4**	**6,0**	**34,1**	**5,5**	**7,7**
	99,8	*50,6*	*63,9*	*92,7*	*59,2*	*47,8*	*43,8*	*54,8*	*68,5*	*65,1*	*49,1*

Data used to estimate Portuguese landings by species were derived from the DCF skate pilot study that aimed to establish sampling statistical procedures and to define estimators to calculate inputs for stock assessment purposes. During the period 2008-201, *R. brachyura* represented between 11 and 20% (116.5 to 177.3 t) and between 5 and 13% (15.7 to 46.8 t) of the total skates landed weight by the polyvalent and the trawl segments, respectively (Table 2). In 2013 the estimated landed weight was about 165 t for the polyvalent and 21 t for the trawl segment.

Table 2 – Portuguese continental waters (ICES division IXa). *Raja brachyura* annual estimates of landed weight, number of vessels and number of trips by fishing segment (polyvalent and trawl); period from 2008 to2013

	Polyvalent segment			Trawl segment		
Year	No. vessels*	No. trips*	Landed weight (ton) (%RJH/Skates)	No. vessels*	No. trips*	Landed weight (ton) (%RJH/Skates)
2008	1444	36149	165.2 (15%)	81	6513	27.7 (8%)
2009	1412	36239	116.5 (11%)	69	5683	46.8 (12%)
2010	1389	34767	177.3 (16%)	59	5461	43.7 (13%)
2011	1289	36761	143.2 (13%)	60	5139	17.6 (5%)
2012	1240	32565	149.1 (18%)	54	5158	15.7 (6%)
2013	1172	28007	164.7 (20%)	51	4658	20.5 (8%)

* estimates for all skates combined

Raja brachyura is mainly landed in the center (*Centro*) and Lisbon (*Lisboa e Vale do Tejo*) regions by both polyvalent and trawl segments (Figure 4).

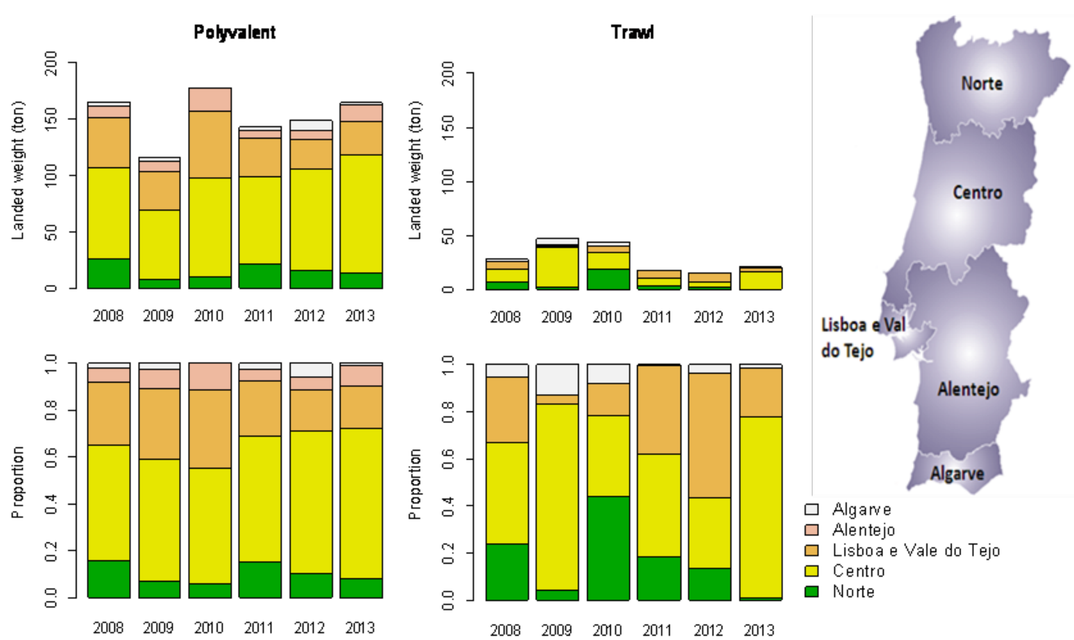


Figure 4 - Portuguese continental waters (ICES division IXa). *Raja brachyura* landing weight and percentage by major region (NUTSII regions) and fishing segment.

For the polyvalent segment and during the period 2008-2013, the landing estimates of *R. brachyura* at the five most important landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) represented 50 to 54% of the total landed weight of the species. In these landing ports *R. brachyura* is mainly caught by nets, followed by longline and artisanal trawl (Table 3).

Table 3 - Portuguese continental waters (ICES division IXa). *Raja brachyura* (2008-2013) for the group of landing ports comprising Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal - Number of vessels, number of trips in which the species occurred and landing estimates by fishing gear (nets, longline and trawl) of the polyvalent segment. Last column refers to trips for which no information on the fishing gear used is available.

	Nets			Longline			Artisanal trawl			NA	
Year	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips
2008	258	9725	49.0	84	1558	14.3	10	355	4.4	54	235
2009	230	7501	44.6	91	1601	5.6	5	276	2.1	47	157
2010	256	9303	80.6	65	704	4.4	4	361	4.0	33	163
2011	146	6168	68.9	40	388	2.2	13	658	6.6	34	171
2012	236	9049	71.0	47	509	1.8	12	476	4.4	21	107
2013	194	6458	66.3	23	200	1.1	5	409	10.3	3	3

Discards information on *R. brachyura* from the Portuguese polyvalent and bottom otter trawl segments operating in the ICES Division IXa has been collected by the Data Collection Framework (EU DCR). Two polyvalent fisheries (trammel nets operating deeper than 150m and nets which include both trammel and gillnets, operating shallower than 150m) and two bottom otter trawl fisheries (crustacean fishery and demersal fish fishery) were analyzed. The information available is insufficient to reach robust estimates of discards so preliminary results are presented in Table 4.

Table 4 - Portuguese continental waters (ICES division IXa). *Raja brachyura* number of sampled hauls, number of hauls where the species occurred, probability of the species be caught in a haul and a specimen be discarded (p_{CD}) and expected number of discarded specimens per haul per fishery. Polyvalent segment: i) nets operating at depths shallower than 150

m (i.e. trammel and gillnets) and ii) trammel nets operating deeper than 150 m. Trawl segment: i) Crustacean Fishery and ii) Demersal Fish Fishery.

	Polyvalent Segment	Trawl Segment	
	Nets <150 m deep	Crustacean Fishery	Demersal Fish Fishery
nº of sampled hauls	41	665	1162
nº of hauls in which the species occurred	15	3	17
p_{CD}	0.04	0.005	0.01
Expected number of discarded specimens per haul	4	3	1

In the Gulf of Cadiz, ray and skate catch and landing data from commercial fisheries are deficient because there is a general lack of species-specific recordings. No management program has been established yet in this area. Research on resources from this area has traditionally been focused on the most commercially important teleosts and few studies on chondrichthyans have been undertaken.

B.2. Length frequency distribution

In the west of Galicia (ICES Division IXa) no length data from the Spanish bottom trawl surveys is available. Biological data collected from specimens caught by the artisanal fleet (mainly *miño* gillnets) in Galicia coastal area shows that length range from 26-116 cm with a mean length of 66 ± 20 cm (Table 5).

Table 5 - West of Galicia (ICES division IXa). Length range (cm) , mean length plus and minus standard deviation (s.d.) of *Raja brachyura* .

	Male		Female		Total	
	Range	Mean (±SD)	Range	Mean (±SD)	Range	Mean (±SD)
R. brachyura	30-112	67 ± 19	26-116	65 ± 18	26-116	66±20

In Portuguese continental waters (ICES division IXa), length frequency distributions of *R. brachyura* at the five main landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) are presented in Figure 5 for nets and longline separately. Length frequency distributions were built with no extrapolation to the total estimated landed weight of the species. The length distribution and the ranges of length are similar between the two gears and among years.

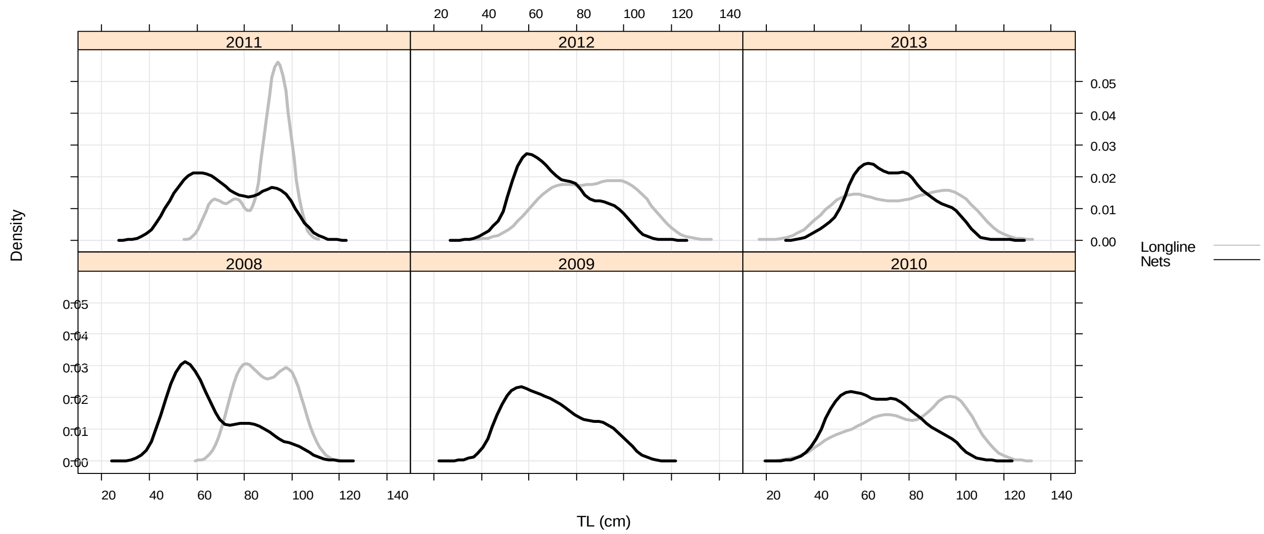


Figure 5 - Portuguese continental waters (ICES Division IXa). Length frequency distributions of *Raja brachyura* (2008-2013) by fishing gear (nets and loglines).

B.3. Survivorship

Under the scope of the EU DCF skate pilot study carried out in mainland Portugal, data on survivorship of *R. clavata* after fishing was collected onboard fishing trips of polyvalent vessels operating with trammel or gillnets. Survivorship was qualitatively evaluated by assuming that the health status of fish after capture is a good indicator of the survivorship index (Enever *et al.*, 2009). The following scale was used to assign health status to each sampled individual (Enever *et al.*, 2009): 1) Good: vigorous wing/body movement and rapid spiracle movement; 2) Moderate: limp wing/body and spiracle movement and; 3) Poor: dead or nearly dead, no body movement, slight spiracle movement. In general, this species presents high levels of survivorship.

There are no studies on skates survivorship neither in the west of Galicia nor in the Gulf of Cadiz.

B.4. Commercial LPUE

The index of abundance of *R. brachyura* was estimated for the Portuguese polyvalent segment as the landed weight of the species per trip (fishing effort unit), LPUE, using official commercial data. In the polyvalent segment, landings from trips in which nets were used as fishing gear are relatively more important in terms of landed weight than longline. Since no major differences on length structure of the specimens caught among the two fishing gears are observed, it is admitted that the standardized LPUE using fishery data derived from nets are representative of the polyvalent segment.

B.5. Biological

In Portuguese continental waters, size-at-first-maturity of *Raja brachyura* is 97 cm for females and 88 cm for males. Reproduction occurs between March and July (Pina-Rodrigues, 2012). Juveniles and adults prey on a variety of bony fishes as *Gymnammodytes semisquamatus*, polychaetes, mysids and shrimps (Farias et al. 2006).

B.6. Surveys

The surveys available for this area were not designed primarily to inform on the populations of *R. brachyura*, which presents a patchy and shallower distribution. The gears used, timing of the surveys and distribution of sampling stations are considered not optimal for informing on the species and/or life-history stages.

C. Assessment: data and method

Data:

- Fishery dependent data:
  - Landings estimates by species
  - Fishing effort (unit: number of fishing trips) by fishing gear
  - Length frequency distribution for the polyvalent fishing segment
  - Discards

Methods:

1) **Landings estimates by species for polyvalent and trawl segment in Portuguese continental waters**

For each year *y* and landing port *p*, the landing estimates of each species were estimated based on the proportion of the species by sampled trip. A weighted proportion $\widehat{pa}_{(y,p)}$ was determined as:

$$\widehat{pa}_{(y,p)} = {\sum_{i=1}(pa_{(y,p)i} \times w_{(y,p)i})}\Big/{wt_{(y,p)}}$$

where the $pa_{(y,p)i}$ is the proportion of the species at the i^{th} fishing trip, $wt_{(y,p)}$ is the landed weight of skates in the i^{th} fishing trip and $w_{(y,p)i}$ is the total landed weight of skates in all the sampled trips at landing port *p* in year *y*. The estimate of the variance of $\widehat{pa}_{(y,p)}$ is determined as:

$$var(\widehat{pa}_{(y,p)}) = \frac{1}{(wt_{(y,p)})^2} \frac{\sum_{i=1}((w_{(y,p)i})^2 . pa_{(y,p)i}(1 - pa_{(y,p)i}))}{n_{(y,p)} - 1}$$

where $n_{(y,p)}$ is the number of sampled trips for the y year and p landing port.
For the selected species the total landed weight $\widehat{w}_{(y,p)}$ () in landing port *p* and year *y* was calculated as:

$$\widehat{w}_{(y,p)} = \widehat{pa}_{(y,p)} \times W_{(y,p)}$$

where $w_{(y,p)}$ is the total landed weight of skates.

At landing ports for which fishing effort was estimated by group (groups correspond to set of vessels determined as function of vessel size, seasonality in fishing skates and fishing gear), the proportion of the species for the year *y*, port *p* and group *g* were obtained as:

$$\widehat{pa}_{(y,p,g)} = \sum_{i=1}(pa_{(y,p,g)i} \times w_{(y,p,g)i}) \Big/ wt_{(y,p,g)}$$

where $pa_{(y,p,g)i}$ is the observed proportion of the species in i^{th} fishing trip, $w_{(y,p,g)i}$ is the landed weight of skates in the i^{th} fishing trip and $wt_{(y,p,g)}$ is the total landed weight of skates in the sampled trips. The variance of $\widehat{pa}_{(y,p,g)}$ was estimated in the same way as for $\widehat{pa}_{(y,p)}$.

The total landed weight of the species $\widehat{w}_{(y,p)}$ in landing port *p* and year *y* was calculated as:

$$\widehat{w}_{(y,p)} = \sum_{g} \widehat{pa}_{(y,p,g)} \times W_{(y,p,g)}$$

Note that when there were gaps of information to estimate the proportion, the median of the proportion estimates for the previous 3 years was assigned to the gaps.

2) Fishing effort (unit: number of fishing trips) by fishing gear for the main landing ports in Portuguese continental waters

The fishing effort by fishing gear for each main landing ports was estimated using a stepwise procedure that has been already described by Maia *et al.* (2013 WD) and that can be summarized as:

Step 1

Definition of homogeneous groups of vessels characterized by sharing similar fishing regimes, according to: a) vessel size further subdivided into small, medium or large that corresponds to 25%, 50% and 75% quartiles of the vessel's LOA; b) seasonality pattern, that includes three levels "occasional", "seasonal" or "constant". Seasonality levels were established based on: i) the number of trips with positive landings of skates, ii) the total landed weight of skates, and iii) the frequency of months of activity with skates.

Step 2

Definition of discriminant rules later used to assign the fishing gear to fishing trips for which the fishing gear was not known. The discriminant rules were established through the application of the flexible discriminant analysis (FDA; Leisch *et al.*, 2009) to the interview data collected from each sampled trip. In the FDA the input data matrix include: i) the relative weight and value, in each fishing trip, of the main accompanying species or genera by gear, ii) the group assigned to each trip in Step 1); and iii) fishing licences for each vessel. The data were previously transformed through factor analysis for mixed data (Pages J. 2004; Le *et al*., 2008). This procedure involves the data transformation of qualitative and quantitative variables that will later constitute the input data matrix of FDA. The selected main accompanying species corresponded to the top five species in terms of occurrence, of landed weight and of value in the sampled trips.

3) Standardized LPUE for the polyvalent fleet using nets in Portuguese continental waters s

In the standardization process of LPUE, a stepwise generalized linear model (GLM) procedure was applied to find the best GLM model and to estimate LPUE index time series based on the relationship between LPUE vs. available predictive factor variables.

The function bestglm implemented in R software was used to select the best subset of inputs variables (McLeod and Xu, 2010). The selection was based on a variety of information criteria and their comparison, following a simple exhaustive search algorithm (Morgan and Tatar, 1972). This algorithm uses a lexicographical method that evaluates the loglikelihoods for all possible glm models. Lognormal error distribution was assumed in the standardization. This distribution is commonly assumed for standardizing catch and effort data, assuming that the expected value of a transformed response variable is related to a linear combination of exploratory variables (Maunder and Punt, 2004).

Different diagnostic plots, e.g. the distribution of residuals and the quantile-quantile (Q-Q) plots, were used to assess the error distribution (assuming lognormal distribution), as well as the model fits for the standardization of the LPUE. Changes in deviance explained by the selected model and the proportions of deviance explained to the total explained deviance was determined and used as indicative of r^2.

The standard errors of the year effects and LPUE for a reference condition, in the present case: nets as fishing gear, large vessel size and constant seasonality landing in the Peniche fishing port, were calculated by the delta method. The delta method is commonly applied when functions are too complex for analytically computing their variance. According to this method, a linear approximation of the function, usually with a one-step Taylor approximation, is firstly obtained and then its variance is computed (Oehlert, 1992). In the polyvalent segment, landings from trips in which nets were used are relatively more important than those from longlines. Since no major differences on length structure of the specimens caught among the two fishing gears are observed, it is admitted that the standardized LPUE using fishery data derived from nets are representative of the polyvalent segment.

4) Length-based yield per recruit

Length data collected under the DCF sampling program on the main landing Portuguese ports for skates from both polyvalent and trawl fleets, were used to estimate an estimated of total fishing mortality (Z). Length compositions were raised to the total landed weight of *R. brachyura* from polyvalent and trawl fisheries. However given the fact polyvalent fleet represents nearly 85% of the total landing of the species a length based catch curve proposed by Cadima (2003) was applied to this segment.

Since no major changes on the length structure of the exploited population among years within the period 2009-2013 nor changes on fishing regime on vessels catching this species were evidence it as assumed a steady state- A combined length frequency distribution was considered for the whole period (Figure 6). The mean annual catch by length, class of 3 cm interval, was used as input data.

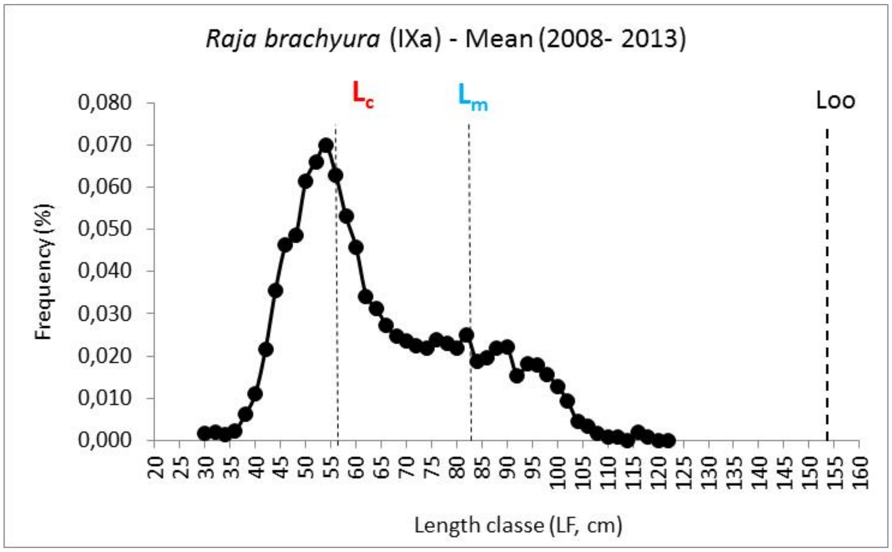


Figure 6 - Length frequency data of *Raja brachyura* catches from the Portuguese polyvalent fleet with indication of length of first capture (Lc) and Length of first capture to the fishery (Lm).

The Beverton-Holt yield-per-recruit model approach (Beverton and Holt, 1957) was used to calculate yield-per-recruit curves following the formulation suggested by Cadima (2003) which accounts for the exploitable spawning biomass. Input data used in the analysis is summarized on following table (Table 6).

Table 6 - Input data used in the yield-per-recruit analysis.

Parameters	Value	Definition
Loo (cm)	154,7	Assymptotic average maximum length
K ($year^{-1}$)	0,129	Growth coefficient of the Von Bertalanfy growth model
To ($year^{-1}$)	-0,84	Hypotetical age at which the species a zero length
a=	0,0020	Condition factor parameter of length-weight relationship
b=	3,20	Slope parameter of length-weight relationship
Lmax (LT, cm)	147	Maximum length usualy oberved on the population.
Lr (LT,cm)	42	Length of recruitment to the fishing area
Tr ($year^{-1}$)	1,6	Age of recruitment to the fishing area
Lc (LT, cm)	56	Length of first capture to the fishery (L50% from selectivity curve)
Tc ($year^{-1}$)	3	Age of first capture to the fishery (age at L50%)
Lm (LF, cm)	83	Length of first maturity (Lm50% from the maturity ogive)
Tm ($year^{-1}$)	5	Age of first maturity (age at Lm50%)
M	0,19	Natural mortality
Zcurrent	0,36	Current total fishing mortality
Lopt (LF)	103	Length class (L_{opt}) with the highest biomass in an unfished population
Tmax	22	Maximum age (age at Lmax)
c=Lc/Loo	0,36	Relative size at entry (Exploitation pattern).Usually=0.4 range 0.2-0.7.
cm=Lm/Loo	0,54	Relative size at maturity (Maturity ogive).
Fcurrent	0,17	Current fishing mortality (F=Z-M)
Ecurr=F/Z	0,47	Current exploitation rate

The total fishing mortality Z was estimated using the length-converted catch curve under the assumption of a steady-state for the *R. brachyura* population and Z constant throughout the life of a cohort. To correct from the fact that fish growth in length is not linear, but slows down as length and age increase, determining that older size groups contain more age groups than younger size groups. The approach here used is the one proposed by Ricker (1975, p. 33 and pp. 60–64).

The natural mortality (M) parameter was assumed as the mean value of estimates obtained following methods presented in table 7.

Table 7 - Natural mortality estimates according Hoening (1983), Alagaraja (1984), Pauly (1980), Gunderson and Dygert (1988) and Jensen (1996). M: considered natural mortality.

Hoenig (1983)	Alagaraja (1984)	Pauly (1980)	Gunderson & Dygert (1988)	Jensen (1996)	**M**
0.13	0.21	0.21	0.21	0.19	0.19

1) Discards

Information on discards has been collected by the Data Collection Framework (EU DCF/NP) for two main segments: bottom otter-trawl and polyvalent.

Information on bottom otter trawl discards derived from the Portuguese on-board sampling program started in 2003 that collects data, amongst other, on i) bottom otter trawl Crustacean fishery targeting deep-water rose shrimp, Norway lobster and blue whiting and; ii) bottom otter trawl demersal fish fishery targeting horse-mackerel, cephalopods and other finfish (Prista *et al.* 2013 WD). The programme is based on a quasi-random sampling of trips from a set of cooperative vessels known to operate in each target fishery. The protocol consists in sort a sample from the catch of each haul into a retained fraction and a discarded fraction following instruction by fishermen. Number, weight and length composition of each taxa in each fraction are recorded. The sampling protocol did not suffered significant changes between 2003 and 2013, apart from in 2011 that the size of catch samples doubled from one to two boxes and the within-trip selection of hauls was standardized to “at least, every other haul/segment” (see Prista *et al*. (2012) for more detail).
Information on polyvalent segment is obtained from two fisheries: i) net fisheries which includes the trammel or gillnets as fishing gear that operate at depths shallower than 150 m and target a multi-species complex and; ii) trammel nets fishery targeting anglerfish that operate at depth deeper than 150 m.

Data on net fisheries discards was obtained from the pilot study on the métiers where skates are caught. In this sampling scene all the hauls performed with nets (trammel or gillnets) were sampled. Collected information included: number, length and sex of all caught skate specimens caught, as well as, its final destination (landed or discarded). Information on trammel discards was derived from the pilot study on the Portuguese trammel nets fishery. The onboard protocol involve to sampling every hauls performed with trammel nets operating from 200 to 600 m deep. The information collected onboard consisted in total length of all individuals caught (identified at a species level) and categorization into discarded or retained individuals (for more detail see Moura *et al.* 2013 WD).

The procedure adopted for each fishery and for each skate species analyzed was similar and take into account the fact that the skates are not the target species for any fishery studied. The probability of the species be caught in a haul and a specimen of that species be discarded (p_{CD}) is determined as:

$$p_{CD} = p_C \times p_D$$

where p_C corresponds to the probability of the species be caught in one fishing haul and p_D is the probability of a specimen be discarded within the whole set of specimens caught in the sampled hauls.

The expected number of discarded specimens per haul $E[D]$ was calculated:

$$E[D] = \sum_{i=1}^{n} x_i \times p_i$$

where x_i is the number of discarded specimens at the i^{th} haul and p_i is the probability that a specimen is derived from i^{th} within the whole set of sampled hauls (n).

Software used:

All the data analysis was performed in R software (R Development Core Team, 2009).

I. References

Alagaraja, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. Indian Journal of Fisheries, 31:177–208.

Alvarez-Salgado, X., Figueiras, F., Perez, F., Groom, S., Nogueira, E., Borges, A., Chou, L., Castro, C., Moncoiffe, G., Rıos, A., Miller,A., Frankignoulle, M., Savidge, G., and Wollast, R. 2003. The Portugal coastal counter current off NW Spain: new insights on its biogeochemical variability. Progress in Oceanography 56, 281–321.

Álvarez, I., Prego, R., de Castro, M., and Varela, M., 2012. Galicia upwelling revisited: out-of-season events in the rias (1967–2009). Ciencias Marinas, 38 (1B): 143–159.

Ambar, L., and Howe, M.R. 1979. Observations of the Mediterranean outflow-I Mixing in the Mediterranean outflow. Deep-Sea Research, 26: 535-554.

Bañon, R., Quinteiro-Fernández, R., García-Tasende, M., Juncal-Caldas, L.M., Campelos-Álvarez, J.M., Gancedo-Baranda, A., Lamas-Rodríguez, F., Morales-de-la-Fuente, C., and Ribó-Landín, J., 2008.

Composición, distribución y abundancia de rayas (Elasmobranchii: Rajidae) en aguas costeras de Galicia. Foro dos Recursos Mariños e da Acuicultura das Rías Galegas, 10:325-331.

Beverton, R.J.H., and Holt, S.J. 1957. On the dynamics of exploited fish populations. Fishery Investigations, Series II, 19:533 p.

Borges, M.F., Santos, A.M.P., Crato, N., Memdes, H., and Mota, B. 2003. Sardine regime shifts off Portugal: a time series analysis of catches and wind conditions. In Fish Stock Assessments and predictions: Integrating Relevant knowledge (editors O. Ulltang and G. Blom). Scientia Marina Volume 67, Suplement 1, April 2003.

Brander, K., Blom, G., Borges, M., Erzini, K., Henderson, G., MacKenzie, B., Mendes, H., Santos, A., and Toresen R. 2003. Changes in fish distribution in the eastern North Atlantic: Are we seeing a coherent response to changing temperature? ICES Marine Science Symposium, 219, 261–270.

Cadima, E.L. 2003. Fish stock assessment manual. FAO Fisheries technical paper 393. Rome: DANIDA.

Castro, M., Gómez-Gesteira, M., Álvarez, I., and Crespo, A.J.C. 2011. Atmospheric modes influence on Iberian Poleward Current variability. Continental Shelf Research, 31:425–432.

Díaz, J.I., Farrán, M., and Maldonado, A. 1985. Surfical sediment distribution patterns in the Gulf of Cádiz controlled by the geomorphic features and physical oceanographic parameters. 6th European Regional Meeting of Sedimentology. I.A.S., Lleida 85: 129-132.

Díaz, V., L.M., Fernández, J.G., Ramos, F., and Jiménez, M.P. 2006. Gulf of Cadiz Regional Ecosystem. ICES Working Group for Regional Ecosystem Description. ICES/WGRED 2006.

Ellis, J. R., Cruz-Martinez, A., Rackham, B. D., and Rogers, S. I. 2005. The distribution of chondrichthyan fishes around the British Isles and implications for conservation. Journal of Northwest Atlantic Fishery Science 35: 195-213.

Enever, R., Catchpole, T.L., Ellis, J.R., and Grant, A. 2009. The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters. Fisheries Research, 97(1–2):72-76.

Farias, I., Figueiredo, I., Moura, T., Gordo, L.S., Neves, A., and Serra-Pereira, B. 2006. Diet comparison of four ray species (*Raja clavata, Raja brachyura, Raja montagui* and *Leucoraja naevus*) caught along the Portuguese continental shelf. Aquatic Living Resources, 19, 105–114.

Figueiras, F. G., Labarta, U., and Fernández-Reiriz, M. J. 2002. Coastal upwelling, primary production and mussel growth in the Rías Baixas of Galicia. Hydrobiologia, 484: 121-131.

Fiúza, A.F.G., Macedo, M.E., and R. Guerreiro, 1982. Climatological space and time variations of the Portuguese coastal upwelling. Oceanologica Acta, 5: 31-40.

Frouin, R., Fiúza, A.F.G., Ambar, I., and Boyd, T.J. 1990. Observations of a poleward surface current off the coasts of Portugal and Spain during winter. Journal of Geophysical Research, 95: 679–691.

Gil, J., 2008. Macro and mesoscale physical patterns in the Bay of Biscay. Journal of the Marine Biological Association of the UK, 88 (2): 217-225.

Gunderson, D. R., and P. H. Dygert.1988. Reproductive effort as a predictor of natural mortality. Journal du Conseil International pour l'Exploration de la Mer, 44: 200–209.

Hoenig, J. M. 1983. Empirical use of longevity data to estimate mortality rates. Fishery Bulletin, 82:898–903.

ICES, 2013. Report of the Working Group on Elasmobranch Fishes (WGEF), 17–21 June 2013, Lisbon, Portugal. ICES CM2013/ACOM:19. 680pp.

Jensen, A. L. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Canadian Journal of Fisheries and Aquatic Sciences, 53:820–822.

Le S., Josse J., and Husson. F. 2008. FactoMineR: An R package for multivariate analysis. Journal of Statistical Software, 25 (1).

Leisch F., Hornik K., and Ripley B.D. 2009. Mixture and flexible discriminant analysis. R package version 0.4-2.

Maia, C., Serra-Pereira, B., and Figueiredo, I. 2013. Skates and rays estimates of landings by species from the Portuguese vessels operating in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013-09.

Mason, E., Coombs, S., Oliveira, P., Angélico, M.M., and Stratoudakis, Y. 2006. An overview of the literature concerning the oceanography of the eastern North Atlantic region. Relatórios Científicos e Técnicos do Instituto de Investigação das Pescas e do Mar. Série Cooperação, 51pp.

Maunder, M.N., and Punt, A.E. 2004. Standardizing catch and effort data: A review of recent approaches. Fisheries Research, 70: 141-159.

McLeod, A.I., and Xu, C. 2010. bestglm: Best Subset GLM. URL http://CRAN.R-project.org/package=bestglm.

Moita, T. 2001. Estrutura, variabilidade e dinâmica do Fitoplâncton na costa de Portugal Continental. PhD Thesis. University of Lisbon, Portugal. 272 pp.

Morgan, J.A., and Tatar J.F. 1972. Calculation of the Residual Sum of Squares for all Possible Regressions. Technometrics, 14, 317-325.

Moura, T., Fernandes, A., Figueiredo, I., and Alpoim, R. 2013. Pilot Study on the Portuguese trammel net fishery in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013-10.

Nelson, C.H., Baraza, J., and Maldonado, J. 1993. Mediterranean undercurrent sandy contourites, Gulf of Cadiz, Spain. In: D.A.V. Stow and J.C. Faugeres (Editors), Contourites and bottom currents. Sedimentary Geology, 82: 103-131.

Nogueira, E., Pérez, F.F., and Ríos, A.F. 1997. Modelling thermohaline properties in an estuarine upwelling ecosystem (Ria de Vigo; NW Spain) using Box-Jenkins transfer function models. Estuarine and Coastal and Shelf Science, 44: 685-702.

Oehlert, G. W. 1992. A note on the delta method. The American Statistician, 46: 27-29.

Pages, J. 2004. Analyse factorielle de données mixtes. Revue Statistique Appliquee. LII (4). pp. 93-111.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. ICES Journal of Marine Science, 39:175–192.

Peliz, A., Dubert, J., Santos, A., Oliveira, P., and Le Cann, B. 2005. Winter upper ocean circulation in the Western Iberian Basin – Fronts, Eddies and Poleward Flows: an overview. Deep Sea Research I 52, 621–646.

Peliz, A., Rosa, T., Santos, A., and Pissarra, J. 2002. Fronts, jets, and counter flows in the Western Iberian upwelling system. Journal of Marine Systems 35, 61–77.

Pina-Rodrigues, M.T. 2012. Age, growth and maturity of two skate species (*Raja brachyura* and *Raja montagui*) from the continental Portuguese coast. (Master thesis) Gent University. (49pp).

Prista, N., and Fernandes, C. 2013. Discards of elasmobranchs by the Portuguese bottom otter trawl and deep-water set longline fisheries operating in ICES Division IXa (2004–2012). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013-15.

Prista, N., Jardim, E., Fernandes, A.C., Silva, D., Ferreira, A.L., Abreu, P., and Fernandes, P. 2012. Manual of Onboard Sampling Procedures: Fixed Gears. Relatórios Cientícos e Técnicos do Instituto Investigação das Pescas e do Mar, 56 (pp. 23 + Annexes).

R Development Core Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna. Austria. ISBN 3-900051-070. http://www.R-project.org.

Relvas, P., Barton, E., Dubert, J., Oliveira, P., Peliz, A., da Silva, J., and Santos, A. 2007. Physical oceanography of the western Iberia, ecosystem: Latest views and challenges. Progress in Oceanography, 74:149–173.

Relvas, P., Luís, J., and Santos, A.M.P. 2009. Importance of the mesoscale in the decadal changes observed in the northern Canary upwelling system. Geophysical Research Letters, 36: L22601, doi:10.1029/2009GL040504

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada, 191:1–382.

Rodríguez-Cabello, C. Fernández A., I. Olaso, F. Sánchez, F., Gancedo, R., Punzón, A., and Cendrero, O. 2005. Overview of Continental Shelf Elasmobranch Fisheries in the Cantabrian Sea. Journal of the Northwest Atlantic Fishery Science, 35:375-385.

Santos, A.M.P., Borges, M.F., and Groom, S. 2001. Sardine and horse mackerel recruitment and upwelling off Portugal. ICES Journal of Marine Science, 58: 589-596.

Santos, A.M.P., Peliz, Á.J., Dubert, J., Oliveira, P.B., Angelico, M.M., and P. Ré, 2004. Impact of a winter upwelling event on the distribution and transport of sardine (*Sardina pilchardus*) eggs and larvae off western Iberia: a retention mechanism. Continental Shelf Research, 24: 149-165.

Serra-Pereira, B., Erzini, K., Maia, C., and Figueiredo, I. 2014. Identification of potential essential fish habitats for skates based on fishers' knowledge. Environmental Management, 53(5):985-98.

Stehmann, M.F.W., and Bürkel, D.L. 1984. Rajidae. In Fishes of the North-eastern Atlantic and the Mediterranean, volume 1, pp. 163-196. Ed. by P. J. P. Whitehead, M. Bauchot, J. Hureau, J. Nielsen and E. Tortonese. UNESCO, Chaucer Press, UK.

Stock Annex

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Spotted ray (*Raya montagui*) in the Bay of Biscay
Working Group:	WGEF
Date:	June 2014
Revised by	WGEF 2014 /Gérard Biais

A. General

A.1. Stock definition

WGEF decided to consider a stock unit in the Bay of Biscay. Discontinuity in the species distribution between the Celtic Sea and the Bay of Biscay supports this stock definition (Johnston G. *et al.*, 2014).

A.2. Fishery

The Bay of Biscay landings are mainly French (90 % in 2002-13) and from division 8a. The main French gear is the fixed net in recent years.

A.3. Ecosystem aspects

The spotted ray occurs on the continental shelf, in areas with seabed composed of mud, fine sand or gravel. It is most common at depth less than 120 m. Juveniles are found in inshore areas.

B. Data

B.1. Commercial catch

An international landing series is available from 1999 onwards. The landings have been comprised between 35 t and 75 t from 1999 to 2009 with no trend. Since 2010, increasing trends are observed in both French and Spanish landings. Total international landing raised 109 t in 2012 and 172 t in 2013. However, this increase may be partly because the better species identification in the auction halls. Furthermore, there may be issues of misidentification of this species with blonde ray (*Raja Bachyura*).

B.2. Biological

Length distributions are not provided to ICES.

Maturity length and growth parameter (Von Bertalanffy) are been estimated for the Portuguese spotted ray population (Pina-Rodrigues M.T., 2012)

B.3. Surveys (use the ICES surveys acronym)

The spotted ray is sporadically present in the EVHOE catches (Figures 1 and 2). The occurrence of this ray in the EVHOE catches does not suggest any recent change in abundance.

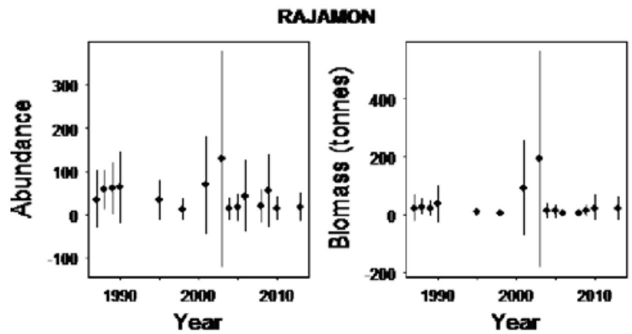


Figure 1: EVHOE survey indices 1987-2013 of the spotted ray in the Bay of Biscay (VIIIabc). Abundance and biomass are raised to the total area surveyed (swept area method) but should be considered relative and in way absolute estimates.

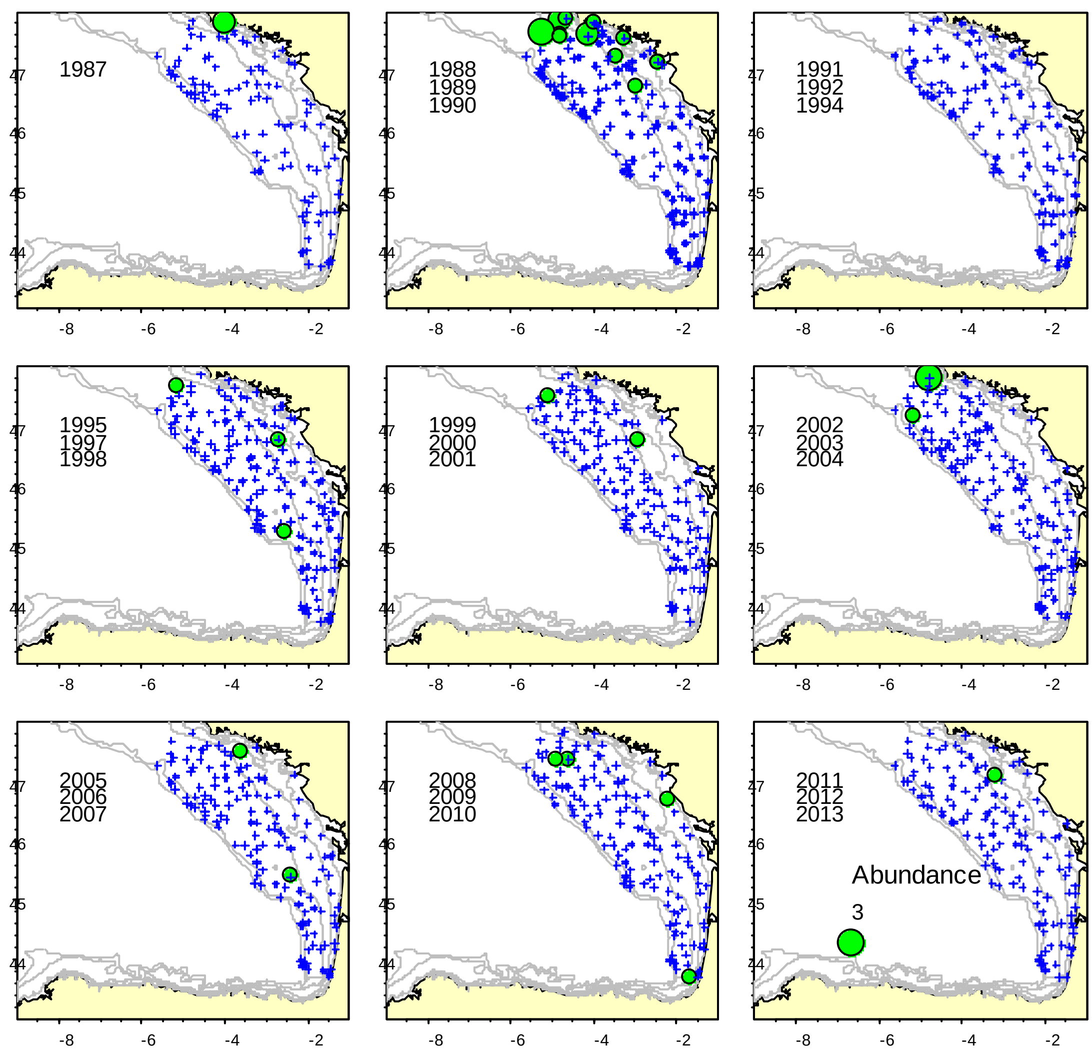


Figure 2: Spatial distribution of catches of spotted ray in the Bay of Biscay from EVHOE survey 1987-2013 by 3 years (except 1987).

B.4. Commercial CPUE

No available commercial CPUE.

B.5. Other relevant data

None

C. Assessment: data and method

No analytical assessment

D. Short-Term Projection

None

E. Medium-Term Projections

None

F. Long-Term Projections

None

G. Biological Reference Points

No reference points have been adopted by ICES for this stock

H. Other Issues

H.1. Historical overview of previous assessment methods

Not relevant

I. References

Johnston G., A. Tetard, A. Ribeiro Santos, E. Kelly and M. Clarke, 2014. Spawning and nursery areas of selected rays and skate species in the Celtic Seas. Working Document to WGEF 2014

Pina-Rodrigues, M.T. 2012. Age, growth and maturity of two skate species (Raja brachyura and Raja montagui) from the continental Portuguese coast. (Master thesis) Gent University. (49pp)

Stock Annex

Stock specific documentation of standard assessment procedures used by ICES.

Stock *Raja montagui* in Western Iberian Waters (west of Galicia, Portugal, and Gulf of Cadiz) (ICES Division IXa)

Working Group: WGEF 2014

Date:

Revised by

A. General

A.1. Distribution

Global distribution: *Raja montagui* (spotted ray) is a species with a wide geographic distribution in the northeast Atlantic and Mediterranean (Stehmann and Bürkel, 1984) with records down to 400 m around the Balearic Islands (western Mediterranean) (Massutí and Moranta 2003). Juveniles are found in inland waters, like the Thames Estuary (Ellis *et al.*, 2005) and also in sheltered nursery areas (Walker *et al.* 1997).

Species distribution in IXa: The species is distributed along the entire area.

In Galician waters this species is not very abundant and is mainly found in shallow waters (less than 120 m) (Figure 1).

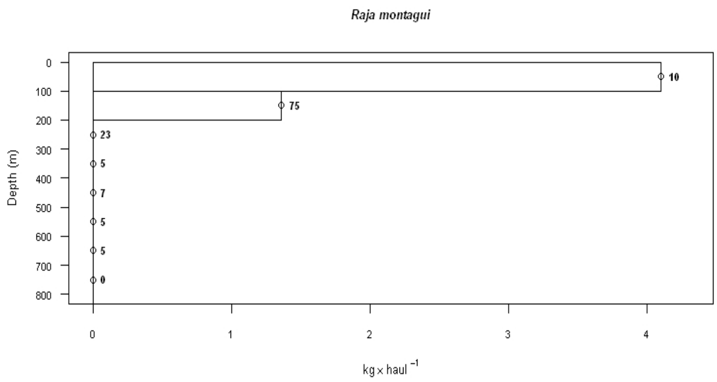


Figure 1 ï West of Galicia (ICES division IXa). *Raja montagui* survey catch rate (kg/30 min) in Spanish autumn Ground Fish Survey (SP-GFS) in 2013 by depth strata. Figure on the right of bars indicate the number of hauls at that depth.

In Portuguese continental waters *R. montagui* occurs along the entire coast from 18 m to 700 m deep (Figure 2), being more abundant in south-west region at depths shallower than 200m.

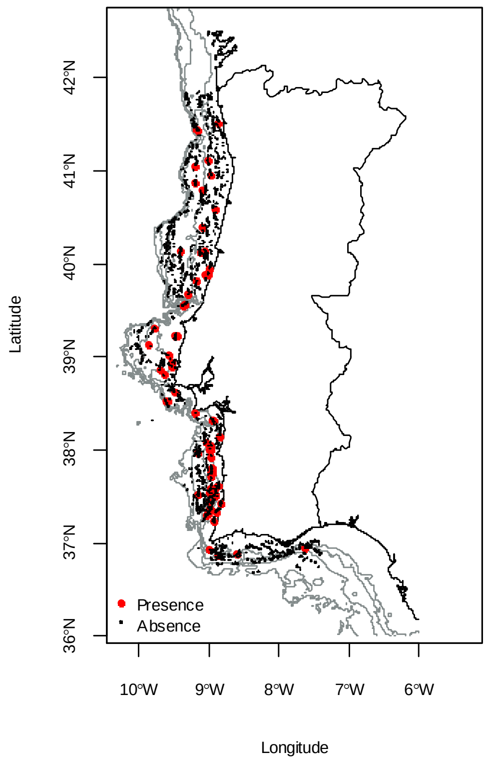


Figure 2 ï Portuguese continental coast (ICES division IXa). *Raja montagui* presence and absence in fishing hauls performed during the Portuguese Autumn Groundfish Surveys (PT-GFS) and the Portuguese crustacean surveys /Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29)) from 1990 to 2013.

In the Gulf of Cadiz *R. montagui* occurs along the whole area at depths ranging from 90 to 700 meters, being especially abundant in trawlable grounds placed in the south area of the Gulf, in the range between 100 and 350 meters depth.

A.2. Species dynamics

In the west of Galicia *R. montagui* is found in different types of grounds - sand, mud and rocky bottoms - mainly in estuarine waters, between 20 m to 100 m depth.

In the centre of mainland Portugal, the species occupies a broad range of habitats, from mud and fine sand to rocky bottoms, showing different spatial dynamics according to the life stage (Serra-Pereira *et al.* 2014). Adults live preferentially at depths greater than 100m, over seabeds composed of muddy and sandy sediments, migrating to shallow waters during mating season and egg deposition. Spawning and nursery grounds are situated at sandy and rocky bottoms at depths shallower than 100 m. in seasonal variation in juvenileõs abundance was registered in these areas ï higher abundances are recorded during the 1st and 4th quarters of the year, which is in accordance with the species hatching period. Most of the times the two sexes occur in equal proportions but spatial segregation by sex may occur in certain areas.

The main habitat of *R. montagui* in the Gulf of Cadiz is located in the influence area of the Mediterranean Outflow Water (MOW), which is warmer and more saline than the above Atlantic Water**.**

A.3. Stock definition

The stock structure of the species along the all ICES areas is unknown, although migrations between different areas are admitted (ICES, 2013). For advice purposes, ICES considered a distinct stock unit for Division IXa (west of Galicia, Portugal, and Gulf of Cadiz).

A.4. Fisheries

In the Western area of the Iberian Peninsula Rajidae species are usually caught as by catch in other fisheries. In the past, there was a direct fishery to these species in the north of Spain, mainly in coastal areas and inside estuaries, with a special gillnet called *raeiras* (DOG nº 31 15/02/2011). At the present time there are no direct fisheries for skates and most of the landings come from the trawl fishery targeting other species (Rodriguez-Cabello *et al.*, 2005). Total landings by the Spanish fleet in this area (for all Rajidae species) increased from 1996 to 2001 up to 416 tones and since them remained more or less stable showing fluctuations around 350 tones (Figure 3). In the coastal area inside Galicia estuaries an important artisanal fleet operates catching frequently Rajidae species using different types of gillnets, particularly *miño* (DOG nº 31 15/02/2011). These catches from the artisanal fleet represent around 8.7 % of Galicia total landings from different ICES areas (Bañón *et al.,* 2008). *Raja montagui* and *R. brachyura* are the main species caught with this gillnet (Bañón *et al.,* 2008).

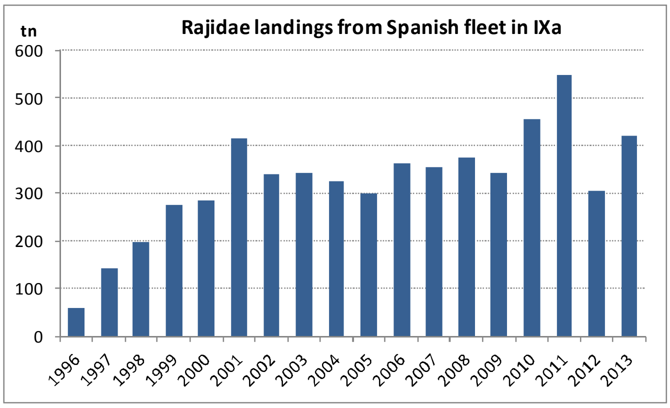


Figure 3 - West of Galicia (ICES division IXa). Landings (t) of Rajidae species in IXa by the Spanish fleet.

In the Portuguese continental coast Rajidae species are mainly landed by the polyvalent segment, which represents around 75% of the total landed weight, followed by the trawl segment that represents around 24%. The trawl segment is defined by vessels that operate wish mesh sizes of 55m, 65 or 70 mm. The Portuguese polyvalent segment includes vessels with length overall (LOA) ranging from 5 to 27 m which generally operate between 10 and 150 m deep and exhibit a multi-species and mixed fisheries, capturing a high diversity of species at different fishing grounds. This segment also includes vessels operating with trawl gear with mesh size of 32 cm, and, for analysis purposes, all trawl vessels with LOA smaller than 12 m irrespective of the mesh size. The latter were included in the polyvalent segment due to their different fishing pattern when compared to larger trawlers: fishing operations closer to the coast and daily trips. All these vessels can have more than one fishing gear (e.g. trammel nets, gillnets, longline, trawl, traps and/or pots) and consequently different fishing gears may be used in one fishing trip. Within the polyvalent segment, Rajidae are mainly caught by nets, i.e. trammel and gillnets; for the period between 2008 and 2013 the landed weight derived from nets represented 65 to 78% of the total landed weight, while longline and artisanal trawl represented 19- 24%, and up to 9% respectively.

In the Gulf of Cádiz area Rajidae are taken as by-catch of fisheries targeting demersal species.

A.3. Ecosystem aspects

In the west coast of the Iberian Peninsula the most important features enhancing primary production are coastal upwelling, coastal runoff and river plumes, seasonal currents and internal waves and tidal fronts. Maximum values of chlorophyll usually occur in spring and summer (Nogueira *et al.,* 1997; Moita, 2001), although high chlorophyll values may be recorded in autumn, particularly in zones with elevated retention characteristics; for example, high chlorophyll concentrations are found in the Rías Baixas, at the time of the seasonal transition from upwelling to downwelling (Nogueira *et al.*, 1997; Figueiras *et al.,* 2002). Most of the west Iberian coast, including Galicia and Cantabrian Sea continental shelf, is occupied by cold waters rich in nutrients (Gil, 2008).

The north-south orientation of the coast causes winds from the north to produce offshore transport. During spring and summer, northerly winds along the coast are dominant causing coastal upwelling and producing a southward current at the surface and a northward undercurrent at the slope (Figure 3a) (Fiúza *et al.*, 1982; Alvarez-Salgado *et al.*, 2003; Peliz *et al.*, 2005; Mason *et al.,* 2006). During winter the prevailing winds are mainly south-westerly, and the atmospheric circulation is dominated by eastward displacement of cyclonic perturbations and their associated frontal systems (Figure 3b) (Relvas *et al.,* 2007). However, in some years the presence of episodic atmospheric anti-cyclonic circulation (the Azores High) could give rise to northerly wind events during winter (Santos *et al.*, 2001; Borges *et al.*, 2003). Indeed, investigations on upwelling along the Galician coast in autumn and winter have been characterized in the Galician rias, indicating that the upwelling process along the Galician coast is not a phenomenon restricted to spring and summer (Alvarez *et al.*, 2012).

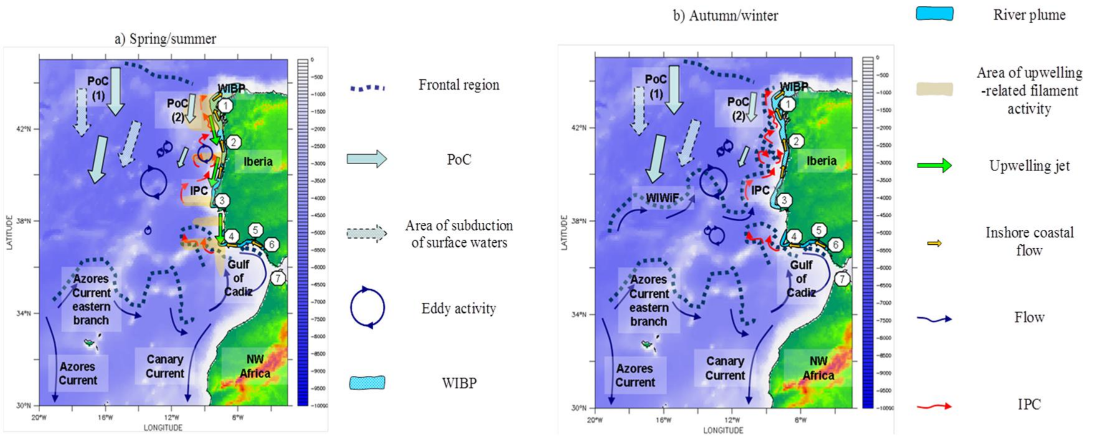


Figure 3 - The western Iberia and Gulf of Cadiz regimes in a) spring and summer, and b) autumn and winter. 1) Cape Finisterre; 2) River Douro; 3) Cabo da Roca; 4) Cape St. Vincent; 5) Guadiana River; 6) Guadalquivir River; 7) Strait of Gibraltar. PoC - southward-flowing Portugal Current, WIBP - Western Iberia Buoyant Plume, IPC - Iberian Poleward Current (Adapted from Peliz *et al.* 2002; Peliz *et al.* 2005).

In winter the Poleward Current (PC) flows northerly. It is a salty surface current (about 200 m deep) of subtropical origin (Eastern North Atlantic Water, also known as the ôNavidadô Current, since because it starts to be evident near Christmas and New Year) and relatively warmer than the surrounding ones (Castro *et al.,* 2011). During winter and spring, the PC results in a convergent front at the boundary between coastal and oceanic water. When saline intrusion is weak, the development of fronts and the formation of a seasonal thermocline are enhanced, leading to phytoplankton blooms. When saline intrusion is intense, strong vertical mixing occurs and prevents phytoplankton growth in spring (Moita, 2001; Santos *et al.,* 2004).

The intermediate deep layers are mainly occupied by a poleward flow of Mediterranean Water (MW), which contours the southwestern slope of the Iberia (Ambar and Howe, 1979), generating the mesoscale features called Meddies. The MW along the west coast of the Iberian Peninsula is characterized by a transport of warm and salty water (typical surface anomalies, 1ï 1.5ºC and 0.1ï 0.3ă in salinity) with velocities up to some 0.2ï 0.3 m s^{-1} reported by Frouin *et al*. (1990).

The Sea Surface Temperature (SST) registered a generalized warming of a few hundredth of degrees a year since 1960, ranging from 0.015°C/year to 0.037°C/year (Relvas *et al.*, 2009). The SST increase has effect on species populations (e.g. recruitment success, migrations changes) (Brander *et. al*., 2003).

In the Gulf of Cadiz the most important oceanographic process is the occurrence of a strong interaction between two masses of water, the Atlantic Ocean and the Mediterranean Sea through the Strait of Gibraltar. In general, the exchange of water masses through Strait of Gibraltar is guided by the highly saline and warm Mediterranean Outflow Water near the bottom, and the turbulent, less saline, cool-water mass of the Atlantic Intermediate Water at the surface. The pattern of surface circulation is ruled by a clockwise movement, with a general W to E superficial current, whereas the deep circulation is controlled by the westerly current of the highly saline (salinity>37 PSU) Mediterranean water existing through the Strait.

Bottom temperatures are extremely variable ranging between 3ºC and 20.6ºC whereas values of bottom salinity along the continental shelf range from 35.8 to 36 PSU (Díaz *et al.*, 2006). In the slope there is a wide band with values around 37 PSU, the lower slope showing the minimum values which correspond to the Deep Atlantic Water Mass (Díaz *et al.*, 2006).

The continental slope can be differentiated into four provinces: a) a narrow belt between 130 and 400 m formed by the steep upper slope; b) two gently dipping wide terraces located between 400 and 700 m depth; c) a central sector between the terraces in which several, steep and narrow curvilinear ridges and valleys are located trending NE-SW to E-W; d) the lower slope-upper continental rise at water depths from 900 down to 1500-1800 m. Below 900 m, the lower slope is steeply dipping and generally smooth except for shallow valleys placed in a NE-SW direction (Nelson *et al.*, 1993). The main sedimentary types occurring over the slope are bioclastic sands, silicoclastic sands and muddy sands, sandy muds, sandy and muddy contourites (Díaz *et al.*, 1985).

B. Data

B.1. Commercial catch

Spanish landings of *R. montagui* in IXa (Galicia and South of Spain combined) reached 144.8 ton in 2013, mostly (85%) belonging to the south area. Due to the sampling methodology based on métier it has not been possible to separate accurately the discards made by the Spanish trawl fleet in Galicia and Cantabrian Sea (VIIIc and IXa). Annual fluctuations were observed however this species is low discarded (Table 1).

Table 1. Galicia and Cantabrian Sea (ICES divisions VIIIc and IXa). Weight discarded (ton) of *Raja montagui* (bold) and CV of estimations (italics) from bottom trawl fishery.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Raja montagui	**26,0**	**1,3**	**0,2**	**0,7**	**0,4**	**1,2**	**1,6**	**0,0**	**1,4**	**4,1**	**5,2**
	66,1	*69,8*	*99,6*	*75,8*	*99,8*	*94,0*	*70,3*	-	*47,5*	*63,8*	*89,8*

Data used to estimate Portuguese landings by species derived from the DCF skate pilot study that had as main objectives to establish sampling statistical procedures and define estimators necessary to calculate the inputs for stock assessment purposes. In the Portuguese continental waters during the period 2008-2013, *R. montagui* represented between 8 and 19% (76.9 to 216.1 t) and between 8 and 17% (29.4 to 58.5 t) of the total skates landed weight by the polyvalent and trawl segments, respectively (Table 2). In 2013 the estimated landed weight of *R. montagui* was 80.5 t for the polyvalent and 30.4 t for trawl segment.

Table 2 ï Portuguese continental coast (ICES division IXa). *Raja montagui* estimated landed weight, number of vessels and number of trips by fishing segment (polyvalent and trawl), between 2008 and 2013.

	Polyvalent segment			Trawl segment		
Year	No. vessels*	No. trips*	Landed weight (ton) (%RJM/Skates)	No. vessels*	No. trips*	Landed weight (ton) (%RJM/Skates)
2008	1444	36149	111.7 (10%)	81	6513	32.5 (10%)
2009	1412	36239	142.7 (13%)	69	5683	41.2 (11%)
2010	1389	34767	216.1 (19%)	59	5461	58.5 (17%)
2011	1289	36761	91.1 (8%)	60	5139	29.4 (8%)
2012	1240	32565	76.9 (9%)	54	5158	30.9 (11%)
2013	1172	28007	80.5 (10%)	51	4658	30.4 (12%)

* estimates for all skates combined

Raja montagui is mainly landed in the center (*Centro*) and south (*Algarve*) regions by the polyvalent segment and in center (*Centro*) by the trawl segment (Fig. 4).

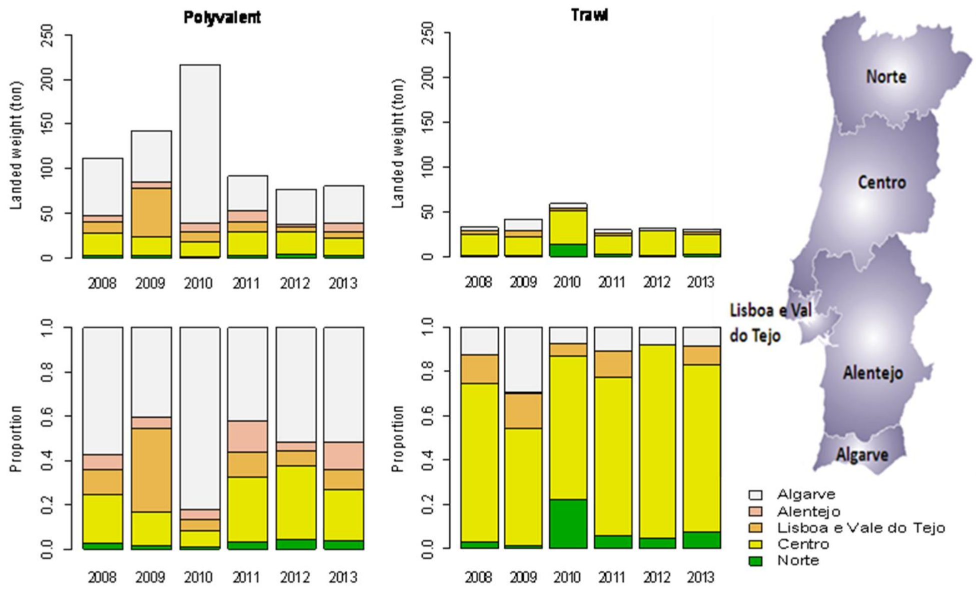


Figure 4 - Portuguese continental coast (ICES division IXa). *Raja montagui* landing weight and percentage by major region (NUTSII regions) and segment.

For the polyvalent segment and during the period 2008-2013, the landings estimates of *R. montagui* for the group of the five most important landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) represented 7 to 43% of the total landed weight of the species. The sampling program carried out in those landing ports allowed to conclude that *R. montagui* was mainly caught by nets, followed by longline and artisanal trawl (Table 3).

Table 3 - Portuguese continental coast (ICES division IXa). *Raja montagui* (2008-2013) for the group of landing ports comprising Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal - Number of vessels, number of trips in which

the species occurred and landing estimates by fishing gear (nets, longline and trawl) of the polyvalent segment. Last column refers to trips for which no information on the fishing gear is available.

	Nets			Longline			Artisanal trawl			NA	
Year	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips
2008	209	6536	12.7	60	1063	2.7	2	120	0.3	54	235
2009	235	7119	46.7	110	1797	3.5	4	265	0.6	47	157
2010	164	4835	9.9	53	499	0.6	5	363	2.1	33	163
2011	125	3757	8.4	66	862	1.4	5	438	3.7	34	171
2012	152	5615	11.1	64	847	2.3	5	383	2.4	21	107
2013	168	6123	9.5	93	1133	2.5	5	407	3.2	3	3

Information on discards of *R. montagui* produced by the Portuguese polyvalent and bottom otter trawl segments operating in the ICES Division IXa has been collected under the Data Collection Framework (EU DCR). Two polyvalent fisheries (trammel nets operating deeper than 150m and trammel and gillnets operating shallower than 150m) and two bottom otter trawl fisheries (crustacean fishery and demersal fish fishery) were analyzed. The information available is insufficient to reach robust estimates of discards so preliminary results are presented in Table 4.

Table 4 - Portuguese continental coast (ICES division IXa). *Raja montagui* number of sampled hauls, number of hauls where the species occurred, probability of the species be caught in a haul and a specimen be discarded (pCD) and expected number of discarded specimens per haul per fishery. Polyvalent segment: i) nets operating at depths shallower than 150 m (i.e. trammel and gillnets) and ii) trammel nets operating deeper than 150 m. Trawl segment: i) Crustacean Fishery and ii) Demersal Fish Fishery.

	Polyvalent Segment		Trawl Segment	
	Nets <150 m deep	Trammel nets >150 m deep	Crustacean Fishery	Demersal Fish Fishery
nº of sampled hauls	41	57	665	1162
nº of hauls in which the species occurred	17	13	2	22
p_{CD}	0.10	0.08	0.003	0.01
Expected number of discarded specimens per haul	3	3	2	1

In the Gulf of Cadiz, catch and landing data from commercial fisheries are often poor because of a general lack of species-specific recordings. No management program has been established yet in this area. Fisheries research has traditionally been focused on the most commercially important teleosts and poor research has been undertaken on chondrichthyans.

B.2. Length frequency distribution

Length frequency distributions obtained from landings sampling of the Spanish trawl fleet in IXa ICES division during 2003 are present in Figure 5. The mean length obtained from gillnets landings operating close to the coast and estuaries is shown in Table 5 (Bañón *et al.,* 2008).

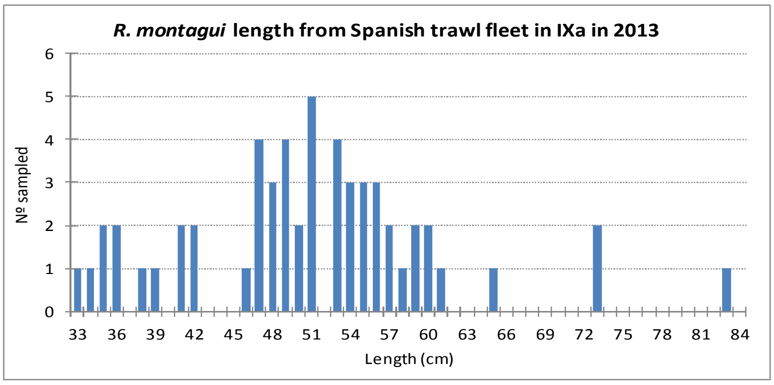


Figure 5 ï West of Galicia (ICES division IXa). *Raja montagui* length frequency distributions obtained from landings sampling of the Spanish trawl fleet during 2003.

Table 5 - West of Galicia (ICES division IXa). *Raja montagui* mean length and range by sex (2000-2006) obtained from gillnets operating in Galician coastal waters during the period 2000-2006.

	Males		Females		Total	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
R. montagui	18-106	59±17	22-110	60±19	18-110	59±19

In Portuguese continental waters, sampling length frequency distributions of *R. montagui* at the five main landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) are present in Figure 6 for nets and longlines separately. Length frequency distributions were built with no extrapolation to the total estimated landed weight of the species. The length distributions, as well as, the length ranges are similar between the two gears among years.

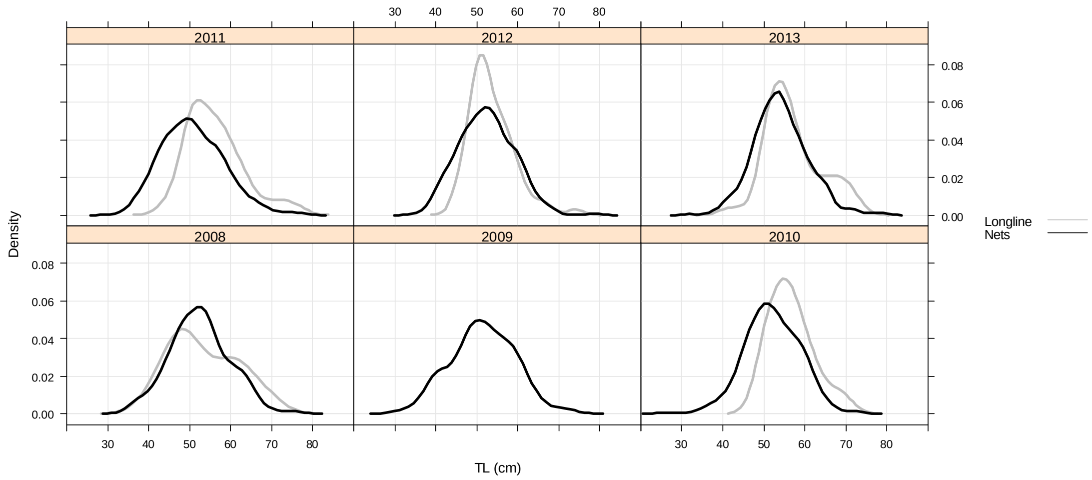


Figure 6 - Portuguese continental coast (ICES division IXa). Sampling length frequency distributions of *Raja montagui* at the five main landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) during the period 2008-20013.

B.3. Survivorship

Under the scope of the EU DCF skate pilot study carried out in mainland Portugal, data on survivorship of *R. montagui* after fishing was collected onboard fishing trips of polyvalent vessels operating with trammel or gillnets. Survivorship was qualitatively evaluated by assuming that the health status of fish after capture is a good indicator of the survivorship index (Enever *et al.,* 2009). The following scale was used to assign health status to each sampled individual (Enever *et al.,* 2009): 1) Good: vigorous wing/body movement and rapid spiracle movement; 2) Moderate: limp wing/body and spiracle movement and; 3) Poor: dead or nearly dead, no body movement, slight spiracle movement. In general, this species presents high levels of survivorship.

There are no studies about skates´ survivorship neither in the west of Galicia nor in the Gulf of Cadiz.

B.4. Commercial LPUE

The landed weight of the species per trip (fishing effort unit), LPUE, was used as the index of abundance. LPUE was determined based on the commercial data. In the polyvalent segment, landings from trips in which nets were used as fishing gear are relatively more important in terms of landed weight than longline. No major differences on length structure of the specimens caught among the two fishing gears are observed

(Figure 6). In face of that, it is admitted that the standardized LPUE using fishery data derived from nets are representative of the polyvalent segment.

B.5. Biological

In Portuguese continental waters, *R. montagui* size-at-first-maturity is 56 cm for females and 48 cm for males and reproduction occurs between April and July (Pina-Rodrigues, 2012). Juveniles of *R. montagui* feed on a variety of polychaetes, amphipods as *Ampelisca* sp. and mysids (*Lophogaster typicus*), while adults, also feed on bony fishes, such as, *Micromesistius poutassou* (Farias *et al.,* 2006).

In Galicia and Cantabrian Sea *R. montagui* feeds mainly on crustacea 50-60% (V) along the entire size range, however the crustacean preys varies according to the predator size. Small individuals feed more on Natantia (*Solenocera membranacea*) and Crangonidae preys, and as it increases the size there are more percentage of brachiura species such as (*Polybius henslowii* and *Liocarcinus depurator*). The importance of fish prey increases according to the size of *R. montagui* ranging from 18% in small rays to 40% in the larger ones. In small rays gobidea and callionymoidea species are the most important while in larger fish (>35 cm) *Micromesistius poutassou* 9.7 % and *Ammodytes tobianus* 8%. Policheata only represent between 4-10% according to predator size (Figure 7) (Velasco *et al.,* 2002).

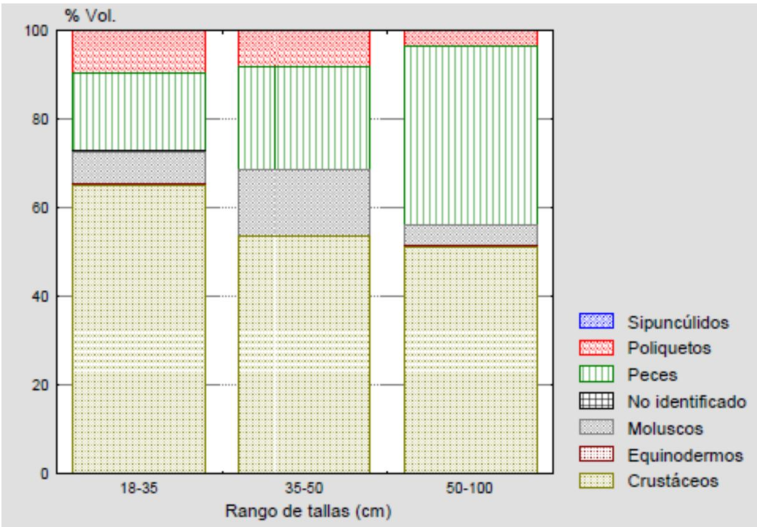


Figure 7 - Galicia and Cantabrian Sea (ICES divisions VIIIc and IXa). Diet of *Raja montagui* (data from Velasco *et al.,* 2002).

B.6. Surveys

Spanish bottom trawl surveys (SP-GFS) are carried out annually along the continental shelf of Galicia and Cantabrian Sea (north of Spain) during autumn (Septemberï October). The historical series begun in 1980 however not until 1983 were standardized. These surveys are based on a stratified random sampling design, using an otter trawl 44/60 gear with a mesh size of 60 mm, and 20 mm in the cod-end (Sánchez, 1993; ICES, 2010). The survey area was stratified according to depth and biogeographically criteria (Figure 8). Five geographical sectors (MF, FE, EP, PA and AB) and three depth strata at the 70,120, 200 and 500 meter isobaths were defined. The first geographical sector (MF) corresponds to ICES area (IXa). The number of hauls per stratum is proportional to the trawlable surface area. Trawl tow duration is 30 min at a speed of 3 knots (Sánchez *et al*., 2002). An average of 122 ± 3.76 hauls (coverage of 5.4 hauls for every 1000 Km^2) is usually performed each year during the whole survey. Supplementary hauls in deeper bottoms (500-700 m) and shallows waters (30ï 80 m) may be conducted depending of the ship time available at sea In particular, in the IXa area, an average of 19 hauls are preformed. This survey does not provide sufficient data to assess the stock status of *R. montagui* which can possibly be related with species distribution pattern and/or with inadequate survey design to catch this species.

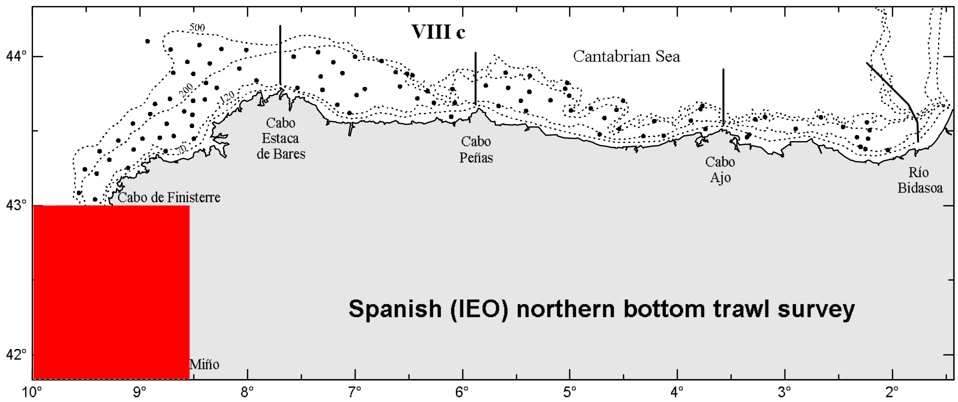


Figure 7 - West of Galicia (ICES division IXa). Spanish (IEO) northern bottom trawl survey (SP-GFS) stratification design.

The Portuguese Autumn Groundfish Survey (PT-GFS) has been conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, ex-IPIMAR) and has the main objective to monitor the abundance and distribution of hake (*Merluccius merluccius*) and horse mackerel (*Trachurus trachurus*) recruitment (Cardador *et al.,* 1997). In these surveys, *R. clavata* is the most frequent skate species caught (88% of the total weight of skates). PT-GFS is performed along the Portuguese continental coast, extending from latitude 41°20'N to 36°30'N (ICES Division IXa) from 20 to 500 m deep. The surveys have been carried with the Portuguese RV ñNoruegaò, which is a stern trawler of 47.5 m length, 1500 horse power and 495 GRT and using a Norwegian Campell Trawl (1800/96 NCT) with a 20 mm codend mesh size and groundrope with bobbins. PT-GFS fishing operations are performed during daylight and the duration of each tow change in 2002 from 60 to 30 min. The surveyed area is stratified into 12 sectors (from north to south: CAM: Caminha, MAT: Matosinhos, AVE: Aveiro, FIG: Figueira, BER: Berlenga, LIS: Lisboa, SIN: Sines, MIL: Vila Nova de Mil Fontes, SAG: Sagres, POR: Portimão, VSA: Vila Real de Santo António), each further divided into four depth strata: 1) 20-100 m, 2) 101-200 m, 3) 201-500 m, and 4) 501-750 m. In 1996, 1999, 2003 and 2004 the RV ñNoruegaò was unavailable, and the surveys were conducted using a different vessel, the RV ñCapricórnioò and operating a different bottom trawl net, CAR type FGAV019, without rollers in the groundrope (ICES, 2007). In 2012 no survey was conducted.

The Spanish bottom trawl survey IBTS-GC-Q1-Q4 (ARSA) in the Gulf of Cadiz has been carried out in the spring and autumn from 1993 to 2013. The surveyed area corresponds to the continental shelf and upper-middle slope from the latitude 6º 20ôW to 7º 20ôW and from 15 m to 800 m depth covering an area of 7224 Km^2. The surveys were carried out on board of the R/V *Cornide de Saavedra*, a stern trawler of 67 m length and 1133 GRT until spring 2013. Since autumn 2013 surveys were carried out on board the R/V Miguel Oliver. Hauls were performed with a standard Baka 44/66 bottom trawl gear, the standard sampler used by the Instituto Español de Oceanografía in their surveys sampling the Spanish Atlantic shelf, with a 60.3 m headline and 43.8 m footrope. The gear employed had a stretched mesh of 40 mm in the codend and it was covered internally with a 20 mm mesh size. Mean vertical and horizontal opening were 1.8 m and 21 m, respectively. Sampling design followed a random stratified scheme with 5 depth strata (15-30 m, 31-100 m, 101-200 m, 201-500 m, 501-800 m). The number of hauls per strata was proportional to the trawlable surface adjusted to the ship time available at sea, with coverage of around 5.4 hauls for every 1000 Km^2. Haul duration was 60 minutes and they were carried out during daylight at a mean towing speed of 3.0 knots. This survey does not provide sufficient data to assess the stock status of *R. montagui* which can possibly be related with species distribution pattern and/or with inadequate survey design to catch this species.

C. Assessment: data and method

Data:

- Fishery dependent data:
  - Landings estimates by species
  - Fishing effort (unit: number of fishing trips) by fishing gear
  - Length frequency distribution by fishing gear
  - Discards
- Fishery independent data
  - Portuguese Autumn Groundfish Surveys (PT-GFS) catch rate (kg.h^{-1})
  - Length distribution

Methods:

1) **Landings estimates by species for polyvalent and trawl segment in Portuguese continental waters**

For each year *y* and landing port *p*, the landing estimates of each species were estimated based on the proportion of the species by sampled trip. A weighted proportion $\hat{pa}_{(y,p)}$ was determined as:

$$\hat{pa}_{(y,p)} = \frac{\sum_{i=1}^{n}\left(pa_{(y,p)i} \times w_{(y,p)i}\right)}{w_{(y,p)}}$$

where the $pa_{(y,p)i}$ is the proportion of the species at the *i*[th] fishing trip, $w_{(y,p)i}$ is the landed weight of skates in the *i*[th] fishing trip and $w_{(y,p)}$ is the total landed weight of skates in all the sampled trips at landing port *p* in year *y*. The estimate of the variance of $\hat{pa}_{(y,p)}$ is determined as:

$$var(\hat{pa}_{y,p}) = \frac{1}{\bar{w}_{(y,p)}^{2}} \frac{\sum_{i=1}^{n}\left(w_{(y,p)i}^{2} . pa_{(y,p)i}\left(1 - pa_{(y,p)i}\right)\right)}{n_{(y,p)} - 1}$$

where $n_{(y,p)}$ is the number of sampled trips for the y year and p landing port.
For the selected species the total landed weight $W_{y,p}$ () in landing port *p* and year *y* was calculated as:

$$W_{(y,p)} = \hat{pa}_{(y,p)} \times w_{(y,p)}$$

where $w_{(y,p)}$ is the total landed weight of skates.

At landing ports for which fishing effort was estimated by group (groups correspond to set of vessels determined as function of vessel size, seasonality in fishing skates and fishing gear), the proportion of the species for the year *y*, port *p* and group *g* were obtained as:

$$\hat{pa}_{(y,p,g)} = \frac{\sum_{i=1}^{n}\left(pa_{(y,p,g)i} \times w_{(y,p,g)i}\right)}{w_{(y,p,g)}}$$

where $pa_{(y,p,g)i}$ is the observed proportion of the species in i^{th} fishing trip, $w_{(y,p,g)i}$ is the landed weight of skates in the i^{th} fishing trip and $wt_{(y,p,g)}$ is the total landed weight of skates in the sampled trips. The variance of $pa_{(y,p,g)}$ was estimated in the same way as for $pa_{(p,y)}$.

The total landed weight of the species $W_{p,y}$ in landing port p and year y was calculated as:

$$W_{(p,y)} = \sum_{g} pa_{(y,p,g)} \times W_{(y,p,g)}$$

Note that when there were gaps of information to estimate the proportion, the median of the proportion estimates for the previous 3 years was assigned to the gaps.

2) Fishing effort (unit: number of fishing trips) by fishing gear for the main landing ports in Portuguese continental waters

The fishing effort by fishing gear for each main landing ports was estimated using a stepwise procedure that has been already described by Maia *et al.* (2013 WD) and that can be summarized as:

Step 1

Definition of homogeneous groups of vessels characterized by sharing similar fishing regimes, according to: a) vessel size further subdivided into small, medium or large that corresponds to 25%, 50% and 75% quartiles of the vesselȏs LOA; b) seasonality pattern, that includes three levels ñoccasional", "seasonal" or "constant". Seasonality levels were established based on: i) the number of trips with positive landings of skates, ii) the total landed weight of skates, and iii) the frequency of months of activity with skates.

Step 2

Definition of discriminant rules later used to assign the fishing gear to fishing trips for which the fishing gear was not known. The discriminant rules were established through the application of the flexible discriminant analysis (FDA; Leisch *et al.,* 2009) to the interview data collected from each sampled trip. In the FDA the input data matrix include: i) the relative weight and value, in each fishing trip, of the main accompanying species or genera by gear, ii) the group assigned to each trip in Step 1); and iii) fishing licences for each vessel. The data were previously transformed through factor analysis for mixed data (Pages J. 2004; Le *et al*., 2008). This procedure involves the data transformation of qualitative and quantitative variables that will later constitute the input data matrix of FDA. The selected main accompanying species corresponded to the top five species in terms of occurrence, of landed weight and of value in the sampled trips.

3) Standardized LPUE for the polyvalent fleet using nets in Portuguese continental waters

In the standardization process of LPUE, a stepwise generalized linear model (GLM) procedure was applied to find the best GLM model and an estimate LPUE index time series based on the relationship between LPUE vs. available predictive factor variables.

The function bestglm implemented in R software was used to select the best subset of inputs variables (McLeod AI and Xu, 2010). The selection was based on a variety of information criteria and their comparison, following a simple exhaustive search algorithm (Morgan and Tatar, 1972). This algorithm uses a lexicographical method that evaluates the loglikelihoods for all possible glm models. Lognormal error distribution was assumed in the standardization. This distribution is commonly assumed for standardizing catch and effort data, assuming that the expected value of a transformed response variable is related to a linear combination of exploratory variables (Maunder and Punt, 2004).

Different diagnostic plots, e.g. the distribution of residuals and the quantile-quantile (Q-Q) plots, were used to assess the error distribution (assuming lognormal distribution), as well as the model fits for the standardization of the LPUE. Changes in deviance explained by the selected model and the proportions of deviance explained to the total explained deviance was determined and used as indicative of r^2.

The standard errors of the year effects and LPUE for a reference conditions, in the present case: net as fishing gear, large vessel size and constant seasonality, were calculated by the delta method. The delta method is commonly applied when functions are too complex for analytically computing their variance. According to this method, a linear approximation of the function, usually with a one-step Taylor approximation, is firstly obtained and then its variance is computed (Oehlert, 1992). In the polyvalent segment, landings from trips in which nets were used as fishing gear are relatively more important in terms of landed weight than longline. No major differences on length structure of the specimens caught among the two fishing gears are observed (Figure 6). In face of that, it is admitted that the standardized LPUE using fishery data derived from nets are representative of the polyvalent segment.

4) Discards

Information on discards has been collected by the Data Collection Framework (EU DCF/NP) for two main segments: bottom otter-trawl and polyvalent.

Information on bottom otter trawl discards derived from the Portuguese on-board sampling program started in 2003 that collects data, amongst other, on i) bottom otter trawl Crustacean fishery targeting deep-water rose shrimp, Norway lobster and blue whiting and; ii) bottom otter trawl demersal fish fishery targeting horse-mackerel, cephalopods and other finfish (Prista *et al.* 2013 WD). The programme is based on a quasi-random sampling of trips from a set of cooperative vessels known to operate in each target fishery. The protocol consists in sort a sample from the catch of each haul into a retained fraction and a discarded fraction following instruction by fishermen. Number, weight and length composition of each taxa in each fraction are recorded. The sampling protocol did not suffered significant changes between 2003 and 2013, apart from in 2011 that the size of catch samples doubled from one to two boxes and the within-trip selection of hauls was standardized to ñat least, every other haul/segmentò (see Prista *et al*. (2012) for more detail).
Information on polyvalent segment is obtained from two fisheries: i) net fisheries which includes the trammel or gillnets as fishing gear that operate at depths shallower than 150 m and target a multi-species complex and; ii) trammel nets fishery targeting anglerfish that operate at depth deeper than 150 m.

Data on net fisheries discards was obtained from the pilot study on the métiers where skates are caught. In this sampling scene all the hauls performed with nets (trammel or gillnets) were sampled. Collected information included: number, length and sex of all caught skate specimens caught, as well as, its final destination (landed or discarded). Information on trammel discards was derived from the pilot study on the Portuguese trammel nets fishery. The onboard protocol involve to sampling every hauls performed with trammel nets operating from 200 to 600 m deep. The information collected onboard consisted in total length of all individuals caught (identified at a species level) and categorization into discarded or retained individuals (for more detail see Moura *et al.* 2013 WD).

The procedure adopted for each fishery and for each skate species analyzed was similar and take into account the fact that the skates are not the target species for any fishery studied. The probability of the species be caught in a haul and a specimen of that species be discarded [illegible]p[illegible] [illegible]is determined as:

[illegible] = [illegible] × [illegible]

where $p_{[illegible]}$ corresponds to the probability of the species be caught in one fishing haul and $p_{[illegible]}$ is the probability of a specimen be discarded within the whole set of specimens caught in the sampled hauls.

The expected number of discarded specimens per haul $E(X)$ was calculated:

$$E(X) = \sum_{i=1}^{n} x_i \times p_i$$

where x_i is the number of discarded specimens at the i^{th} haul and p_i is the probability that a specimen is derived from i^{th} within the whole set of sampled hauls (n).

5) Standardized survey biomass index

Biomass indexes of *R. montagui* were standardized using the catch rates by fishing haul obtained for Portuguese Autumn Groundfish Surveys (PT-GFS). Generalized linear mixed models (GLMM; Bolker *et al*., 2009) were used in the standardization process (see Figueiredo *et al.,* 2013 WD for further details). In the essayed models catch rate of the species in each haul ($Kg.h^{-1}$) was the response variable and several linear predictors were considered: i) type of fishing net (NCT or CAR); ii) year; iii) fishing sector; iv) initial depth (in meters); v) trawling duration (in minutes); vi) period (morning or afternoon). Apart from factor year, the remaining predictors were selected depending on their significance after the model adjustment. Interactions were not considered because, if included, the degrees of freedom available decreased substantially and the adjustment was very poor.

GLMM models were adjusted to the survey data through the use of package “MASS” (Venables and Ripley, 2002) implemented in R software. In the model, error of the catch rate was assumed to follow a Tweedie random variable, whose probability density function is expressed as:

$$f(y; \mu, \sigma^2, p) = a(y; \sigma^2, p) \exp\left\{-\frac{1}{2\sigma^2} d(y; \mu, p)\right\}$$

where μ is the location parameter; σ^2 is the diffusion parameter and; p is the power parameter.

The Tweedie family of distributions is a family of exponential dispersion models with variance $Var(Y) = \sigma^2.\mu^p$, that depending on the value of p includes other distributions (Dunn and Smyth, 2008; Jørgensen, 1997). When $1<p < 2$ the distribution corresponds to mixed distributions known as compound Poisson models (Jørgensen, 1997) that in the present case, and due to the high frequency of zeroes, seems to be the most appropriate distribution to use.

The estimation of the p parameter was done following the procedure proposed by Shono (2008). According to this, the power parameter (p) is estimated by maximizing the profile log-likelihood across the grid values of (p) in the range of $1 < p < 2$ through the explicit form of the probability density function. The package óTweedieô (Dunn, 2009) implemented in R was used to estimate p.

In the GLMM adjustment, the factor Sector was considered as a random effect and since the random terms do not contribute to the fixed part of the mean its influence was isolated. The estimation of regression coefficients was done under the framework of quasi-likelihood and by fixing the value of p in the estimate obtained.

Model adequacy was check based on residual analysis. Fitted values were transformed ($2\varepsilon^{1-(p/2)}$) to the constant information-scale, so that the expected pattern for the compound Poisson distribution was a straight line (McCullagh and Nelder, 1989; Draper *et al.*, 1998; Ortiz and Arocha, 2004). Residuals were also analysed using Tweedie quantiles, and the graphical tools for residuals set with the Tweedie distribution (qqplots) were constructed. Three types of plots were examined: (i) histogram of the deviance residuals; (i) deviance residuals and Pearson residuals against the standardized fitted values to check for systematic departures from the assumptions underlying the statistical distribution; and (iii) Tweedie QQ-plot (with Tweedie quantiles) for deviance residuals and for Pearson residuals.

The annual biomass index predictions for the selected statistical model were obtained following the procedure referred in Candy (2004) and by considering the depth fixed at a reference level (mean depth). The estimates of the variance of the sum of linear predictors used to estimate the approximate confidence intervals of annual indices were determined using the delta method which is implemented at the R package ómsmô (Jackson, 2013). The delta method is a general approach for computing confidence intervals for functions of maximum likelihood estimates. This method allows finding approximations of the variance of functions of random variables based on Taylor series (Oehlert, 1992).

Software used:

All the data analysis was performed in R software (R Development Core Team, 2009).

I. References

Alvarez-Salgado, X., Figueiras, F., Perez, F., Groom, S., Nogueira, E., Borges, A., Chou, L., Castro, C., Moncoiffe, G., Rĕos, A., Miller,A., Frankignoulle, M., Savidge, G., Wollast, R. 2003. The Portugal coastal counter current off NW Spain: new insights on its biogeochemical variability. Progress in Oceanography 56, 281ï 321.

Álvarez, I. Prego, R., de Castro, M. and Varela, M., 2012. Galicia upwelling revisited: out-of-season events in the rias (1967ï 2009). Ciencias Marinas (2012), 38(1B): 143ï 159

Ambar, L., and Howe, M.R. 1979. Observations of the Mediterranean outflow-I Mixing in the Mediterranean outflow. Deep-Sea Research, 26: 535-554.

Bañón Díaz, R., Quinteiro Fernández,R, García Tasende, M., Juncal Caldas,L.M., Campelos Álvarez, J.M., Gancedo Baranda, A., Lamas Rodríguez, F., Morales de la Fuente,C. and Ribó Landín, J, 2008. Composición, distribución y abundancia de rayas (Elasmobranchii: Rajidae) en aguas costeras de Galicia. Foro Ac. Rec. Mar. Rías Gal. 10: 325-331 2008.

Bolker, B.M., Brooks, M.E., Clark, C.J., Geange, S.W., Poulsen, J.R., Stevens, M.H.H. and White, J-S.S. 2009. Generalized linear mixed models: a practical guide for ecology and evolution. Trends in ecology and evolution 24: 127-135.

Borges, M.F., Santos, A.M.P., Crato, N., Memdes, H., Mota, B. 2003. Sardine regime shifts off Portugal: a time series analysis of catches and wind conditions. In Fish Stock Assessments and predictions: Integrating Relevant knowledge (editors O. Ulltang and G. Blom) Scientia Marina Volume 67, Suplement 1, April 2003.

Brander, K., Blom, G., Borges, M., Erzini, K., Henderson, G., MacKenzie, B., Mendes, H., Santos, A. and Toresen R. 2003. Changes in fish distribution in the eastern North Atlantic: Are we seeing a coherent response to changing temperature? ICES Mar. Sci. Symp., 219, 261ï 270.

Candy, S. 2004. Modelling catch and effort data using generalised linear models, the Tweedie distribution, random vessel effects and random stratum-by-year effects. CCAMLR Science 11: 59-80.

Cardador, F., Sanchéz, F., Pereiro, F.J., Borges, M.F., Caramelo, A.M., Azevedo, M., Silva, A., Pérez, N., Martins, M.M., Olaso, I., Pestana, G., Trujillo, V. and Fernandez A. 1997. Groundfish surveys in the Atlantic Iberian waters (ICES divisions VIIIc and IXa): history and perspectives. ICES CM 1997/Y:8.

Castro, M., Gómez-Gesteira, M., Álvarez, I., and Crespo, A.J.C. 2011. Atmospheric modes influence on Iberian Poleward Current variability. Continental Shelf Research, 31:425ï 432.

Diaz, J.I., M. Farrán and A. Maldonado. 1985. Surfical sediment distribution patterns in the Gulf of Cádiz controlled by the geomorphic features and physical oceanographic parameters. *6th European Regional Meeting of Sedimentology*. I.A.S., Lleida 85: 129-132.

Díaz, V., L.M. Fernández, J. Gil, F. Ramos and M.P. Jiménez. 2006. Gulf of Cadiz Regional Ecosystem. *ICES Working Group for Regional Ecosystem Description*. ICES/WGRED 2006.

Draper, N. R., Smith, H. and Pownell, E. 1966. Applied regression analysis (Vol. 3). New York: Wiley.

Dunn, P.K., 2009. Tweedie: Tweedie exponential family models. R package version 1.6.2.

Dunn, P.K. and Smyth, G.K. 2008. Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. Statistics and Computing 18: 73ï 86.

Ellis, J. R., Cruz-Martinez, A., Rackham, B. D. and Rogers, S. I. 2005. The distribution of chondrichthyan fishes around the British Isles and implications for conservation. Journal of Northwest Atlantic Fishery Science 35: 195-213.

Enever, R., Catchpole, T.L., Ellis, J.R. and Grant, A. 2009. The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters. Fish.Res.97(1ï 2):72-76.

Farias, I., Figueiredo, I., Moura, T., Gordo, L.S., Neves, A. and Serra-Pereira, B. 2006. Diet comparison of four ray species (*Raja clavata, Raja brachyura, Raja montagui* and *Leucoraja naevus*) caught along the Portuguese continental shelf. Aquat. Living Resour. 19, 105ï 114.

Figueiras, F. G., Labarta, U. and Fernández-Reiriz, M. J. 2002. Coastal upwelling, primary production and mussel growth in the Rías Baixas of Galicia. Hydrobiologia, 484: 121-131.

Figueiredo, I. and Serra-Pereira, B. 2012. Modelling *Raja clavata* abundance from Portuguese IBTS data (1990-2011) using GLMM with Tweedie distribution. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-09.

Fiúza, A.F.G., Macedo, M.E. and R. Guerreiro, 1982. Climatological space and time variations of the Portuguese coastal upwelling. Oceanol. Acta, 5: 31-40.

Frouin, R., Fiúza, A.F.G., Ambar, I. and Boyd, T.J. 1990. Observations of a poleward surface current off the coasts of Portugal and Spain during winter. J. Geophys. Res., 95: 679ï 691.

Gil, J., 2008. Macro and mesoscale physical patterns in the Bay of Biscay. J. Mar. Biol. Ass. UK., 88 (2): 217-225.

Hunter, E., Berry, F., Buckley, A.A., Stewart, C. and Metcalfe, J.D. 2006. Seasonal migration of thornback rays and implications for closure management. Journal of Applied Ecology 43: 710-720.

Hunter, E., Buckley, A.A., Stewart, C. and Metcalfe, J.D. 2005. Migratory behaviour of the thornback ray, *Raja clavata*, in the southern North Sea. Journal of the Marine Biological Association of the United Kingdom 85: 1095-1105.

ICES. 2007. Report of the International Bottom Trawl Survey Working Group (IBTSWG). 27ï 30 March 2007, Séte, France, pp. 182.

ICES, 2010. Manual for the International Bottom Trawl Surveys in the Western and southern Areas. pp. 58.

ICES. 2013. Report of the Working Group on Elasmobranch Fishes (WGEF), 17ï 21 June 2013, Lisbon, Portugal. ICES CM2013/ACOM:19. 680pp.

Jackson, C. 2013. Package ámsmâ: Multi-state Markov and hidden Markov models in continuous time. R package version 1.1.4.

Jennings, S., Greenstreet, S.P.R. and Reynolds, J.D. 1999. Structural change in an exploited fish community: a consequence of differential fishing effects on species with contrasting life histories. Journal of Animal Ecology 68, 617-627.

Jensen, A.L. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Canadian Journal of Fisheries and Aquatic Sciences 53, 820ï 822.

Jørgensen, B. 1997. The Theory of Dispersion Models. Chapman and Hall, London, p. 237.

Le S., Josse J. and Husson. F. 2008. FactoMineR: An R package for multivariate analysis. Journal of Statistical Software. Vol 25 (1).

Leisch F., Hornik K. and Ripley B.D. 2009. Mixture and flexible discriminant analysis. R package version 0.4-2.

Maia, C., Serra-Pereira, B. and Figueiredo, I. 2013. Skates and rays estimates of landings by species from the Portuguese vessels operating in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-09.

Mason, E., Coombs, S., Oliveira, P., Angélico, M.M. and Stratoudakis, Y. 2006. An overview of the literature concerning the oceanography of the eastern North Atlantic region. Relat. Cient.Téc. Inst. Invest. Pescas Mar. Série Cooperação, 51pp.

Maunder, M.N. and Punt, A.E. 2004. Standardizing catch and effort data: A review of recent approaches. Fish.Res. 70: 141-159.

Ortiz, M. and Arocha, F. 2004. Alternative error distribution models for standardization of catch rates of non-target species from a pelagic longline fishery: billfish species in the Venezuelan tuna longline fishery, Fish.Res. 70(2ï 3): 275-297.

McCullagh, P. and Nelder, J.A. 1989. Generalized Linear Models. London, Chapman Hall.

McLeod AI and Xu C 2010 bestglm: Best Subset GLM. URL http://CRAN.R-project.org/package=bestglm.

Moita, T. 2001. Estrutura, variabilidade e dinâmica do Fitoplâncton na costa de Portugal Continental. PhD Thesis. University of Lisbon, Portugal. 272 pp.

Morgan, J.A. and Tatar J.F. 1972. Calculation of the Residual Sum of Squares for all Possible Regressions." Technometrics, 14, 317-325.

Moura, T., Fernandes, A., Figueiredo, I., Alpoim, R. 2013. Pilot Study on the Portuguese trammel net fishery in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-10.

Nelson, C.H., J. Baraza and J. Maldonado. 1993. Mediterranean undercurrent sandy contourites, Gulf of Cadiz, Spain. In: D.A.V. Stow and J.C. Faugeres (Editors), *Contourites and bottom currents. Sediment.* Geol., 82: 103-131.

Nogueira, E., Pérez, F.F. and Ríos, A.F. 1997. Modelling thermohaline properties in an estuarine upwelling ecosystem (Ria de Vigo; NW Spain) using Box-Jenkins transfer function models. Est. Coast. Shelf Sci., 44: 685-702.

Oehlert, G. W. 1992. A note on the delta method. The American Statistician, 46: 27-29.

Pages J. 2004. Analyse factorielle de donnees mixtes. Revue Statistique Appliquee. LII (4). pp. 93-111.

Peliz, A., Dubert, J., Santos, A., Oliveira, P. and Le Cann, B. 2005. Winter upper ocean circulation in the Western Iberian Basin ï Fronts, Eddies and Poleward Flows: an overview. Deep Sea Research I 52, 621ï 646.

Peliz, A., Rosa, T., Santos, A. and Pissarra, J. 2002. Fronts, jets, and counter flows in the Western Iberian upwelling system. Journal of Marine Systems 35, 61ï 77.

Pina-Rodrigues, M.T. 2012. Age, growth and maturity of two skate species (*Raja brachyura* and *Raja montagui)* from the continental Portuguese coast. (Master thesis) Gent University. (49pp).

Prista. N., Jardim, E., Fernandes, A.C., Silva, D., Ferreira, A.L., Abreu, P., Fernandes, P. 2012. Manual of Onboard Sampling Procedures: Fixed Gears. Relatórios Científcos e Técnicos do Instituto Investigação das Pescas e do Mar, 56 (pp. 23 + Annexes).

Prista, N. and Fernandes, C. 2013. Discards of elasmobranchs by the Portuguese bottom otter trawl and deep-water set longline fisheries operating in ICES Division XIa (2004ï 2012). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-15.

R Development Core Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna. Austria. ISBN 3-900051-070. http://www.R-project.org.

Relvas, P., Barton, E., Dubert, J., Oliveira, P., Peliz, A., da Silva, J. and Santos, A. 2007. Physical oceanography of the western Iberia, ecosystem: Latest views and challenges, Prog. Oceanogr., 74, 149ï 173.

Relvas, P., Luís, J. and Santos, A.M.P. 2009. Importance of the mesoscale in the decadal changes observed in the northern Canary upwelling system, Geophys. Res. Lett., 36, L22601, doi:10.1029/2009GL040504

Rodríguez-Cabello, C. Fernández A., I. Olaso, F. Sánchez, F., Gancedo, R., Punzón, A. and Cendrero, O.2005. Overview of Continental Shelf Elasmobranch Fisheries in the Cantabrian Sea. J. Northw. Atl. Fish. Sci., Vol. 35:

Sánchez, F., 1993. Las comunidades de peces de la plataforma del Cantábrico. Publicaciones Especiales del Instituto Español de Oceanografía, 13, 137 pp.

Sánchez, F., Blanco, M., Gancedo, R., 2002. Atlas de los peces demersales y de los invertebrados de interés comercial de Galicia y el Cantábrico. Otoño 1997-1999. Instituto Español de Oceanografia. MYC Ed.CYAN. Madrid, pp. 158

Sánchez, F., Rodríguez-Cabello, C. and Olaso, I., 2005. The Role of Elasmobranchs in the Cantabrian Sea Shelf Ecosystem and Impact of the Fisheries on Them. J. Northw. Atl. Fish. Sci., Vol. 35: 467ï 480

Santos, A.M.P., Borges, M.F. and Groom, S. 2001. Sardine and horse mackerel recruitment and upwelling off Portugal. ICES Journal of Marine Science. Vol 58, No 3, 589-596.

Santos, A.M.P., Peliz, Á.J., Dubert, J., Oliveira, P.B., Angelico, M.M. and P. Ré. 2004. Impact of a winter upwelling event on the distribution and transport of sardine (Sardina pilchardus) eggs and larvae off western Iberia: a retention mechanism. Continental Shelf Research, 24: 149-165.

Serra-Pereira, B., Erzini, K., Maia, C. and Figueiredo, I. 2014. Identification of potential essential fish habitats for skates based on fishersô knowledge. Environmental Management, 53(5):985-98.

Shono, H. 2008. Application of the Tweedie distribution to zero-catch data in CPUE analysis. Fisheries Research 93: 154-162.

Stehmann, M.F.W. and Bürkel, D.L. 1984. Rajidae. In Fishes of the North-eastern Atlantic and the Mediterranean, volume 1, pp. 163-196. Ed. by P. J. P. WHITEHEAD, M. BAUCHOT, J. HUREAU, J. NIELSEN and E. TORTONESE. UNESCO, Chaucer Press, UK.

Steven, G. A. 1936. Migrations and Growth of the Thornback Ray (*Raja clavata* L.). Journal of the Marine Biological Association of the United Kingdom 20: 605-614.

Velasco, F, Olaso, I. and Serrano, A., 2002. Alimentación de tres especies de la familia Rajidae en el sur del Golfo de Vizcaya. ICES CM/2002

Venables, W.N. and Ripley, B.D. 2002. Modern Applied Statistics with S, Fourth ed. Springer, New York.

Walker, P. A., Howlett, G. and Millner, R. 1997. Distribution, movement and stock structure of three ray species in the North Sea and eastern English Channel. ICES Journal of Marine Science 54: 797-808.

Stock Annex

Stock specific documentation of standard assessment procedures used by ICES.

- Stock Cuckoo ray (*Leucoraja naevus*) in Subarea VIII (Bay of Biscay and Cantabrian Sea)
-

Working Group: WGEF

Date: June 2014

Revised by Guzman Diez, Pascal Lorance

A. General

A.1. Stock definition

The cuckoo ray (*Leucoraja naevus*) is distributed in the North- Eastern Atlantic from the North of Norway and Iceland to the Sudivison IXa south in European waters. It can be found further south in the Mediterranean sea and off Africa from Morocco to Senegal. The stock was formerly included in the management unit of the demersal elasmobranch in the Bay of Biscay and Iberian waters ecoregion.

A.2. Fishery

L. naevus is the most common species in the Spanish and French trawl demersal fishery along the Cantabrian Sea (VIIIc) and Bay of Biscay (VIIIa,b,d) trawler in VIIIabd making approximately 65% of the total rays landing in this subarea since 1999. In the Basque Country waters (VIIIc), the coastal artisanal (trammel net), fishery targets demersal teleost species (mainly hake, monkfish and mackerel), but also several skates and rays species. In this fishery *L. naevus* is the third most abundant species after *R. clavata* and *R. montagui*

A.3. Ecosystem aspects

It is a demersal species found in depth range 20 - 500 m, but usually 20 - 250 m. It seems to be more abundant sandy and muddy bottoms.

B. Data

B.1. Commercial catch

The landing estimates (tonnes) of this species in subarea VIII since 1999 are given in the table below. Increasing landings might be ascribed to the reporting of rays and skates landings in an aggregated category in earlier years.

landings VIII (t)
L. naevus

1999	319
2000	999
2001	867
2002	871
2003	884
2004	951
2005	1175
2006	847
2007	743
2008	1011
2009	1298
2010	1065
2011	1016
2012	1023
2013	1350

Discard estimates of the OTB Spanish fleet in 2013 were 52 t (4% of total *L. naevus* Spanish landings) .

B.2. Biological

According a recent study carried out in subarea VIII the percentage of adult females in 3a (spawning capable) and 3b (actively spawning) stages indicates that individuals of both stages coexist simultaneously throughout the year and a proportion of the total cuckoo rays sampled (usually <20%) is in spawning stage at any time, except in perhaps the months of June-July and December.(G. Diez pers. comm.)

B.3. Surveys

This species is found in the Spanish IEO Q4-IBTS survey (VIIIc), ITSASTEKA survey (VIIIc East) and in the French EVHOE Survey in VIIIabd.

The EVHOE survey shows that a large patch were the species is abundant straddles across the limit of the eco-region to the Celtic Seas (Figure 1).

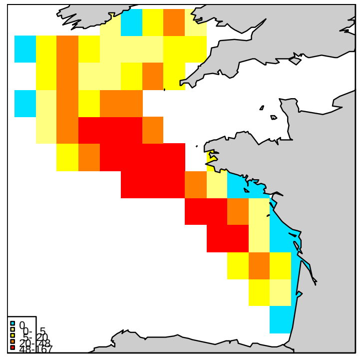


Figure 1. Spatial distribution of catches of cuckoo ray in the EVHOE survey years 1997-2013 combined.

Population indices are available from the EVHOE survey both for the part of the stock in subarea VIII since 1987 and for the enlarged survey coverage in VII and VIII since 1997 (Figure 2).

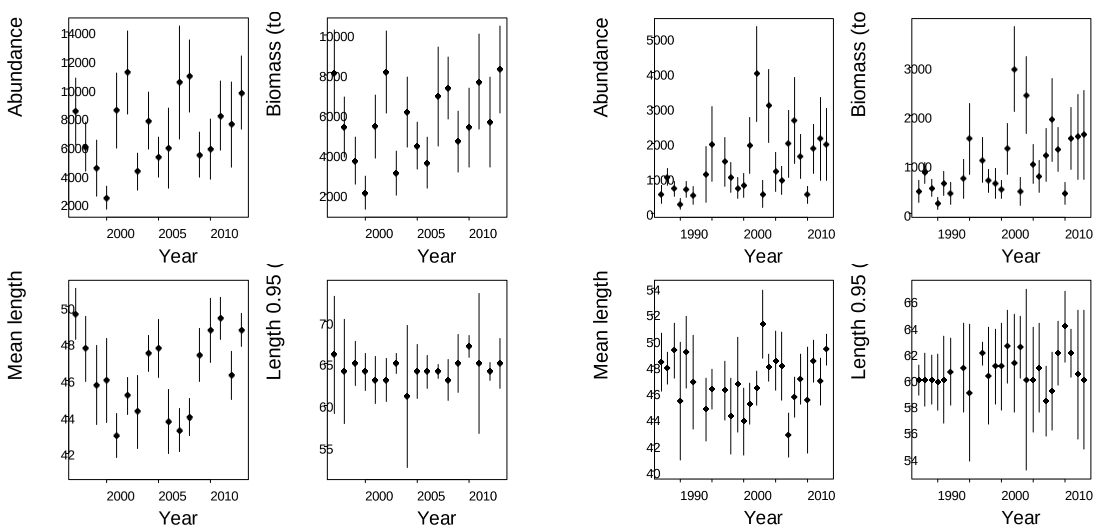


Figure 2. Populations indices of cuckoo ray (*Leucoraja naevus*), (left) ICES Division Vg,k and VIIIa,b,d (1997-2013) and (right) Division VIIIa,b,d (1987-2013). Abundance and biomass are relative stratified indices raised to the whole area surveyed (swept area method), mean length and 0.95 perscentile of the length distribution are stratified estimates.

B.4. Commercial Effort and CPUE

Data of nominal LPUE -series for the Basque Country's OTB DEF>=70 in Subarea VIII from 2001 to 2013 is available for L. naevus. Acoording this information the L. naevus LPUE has been above 100 kg/day except in 2002, 2009, 2010 and 2013.The lowest peak was observed in 2010 with 44 kg/day and the highest in 2007 with 169 kg/day.

B.5. Other relevant data

C. Assessment: data and method

Model used: None

Survey trends-based assessment using the Spanish IEO Q4-IBTS survey (VIIIc), ITSASTEKA survey (VIIIc East) and in the French EVHOE Survey in VIIIabd.

D. Short-Term Projection

Not applicable

E. Medium-Term Projections

Not applicable

F. Long-Term Projections

Not applicable

G. Biological Reference Points

H. Other Issues

H.1. Historical overview of previous assessment methods

I. References

Iglésias, S.P., Toulhoat, L. and Sellos, D.Y. 2010. Taxonomic confusion and market mislabelling of threatened skates: Important consequences for their conservation status. Aquatic Conservation: Marine and Freshwater Ecosystems, 20: 319–333.

Wearmouth, V.J. and Sims, D.W. 2009. Movement and behaviour patterns of the critically endangered common skate *Dipturus batis* revealed by electronic tagging. Journal of Experimental Marine Biology and Ecology 380: 77–87.

Stock Annex

Stock specific documentation of standard assessment procedures used by ICES.

Stock *Leucoraja naevus* in Western Iberian Waters (west of Galicia, Portugal, and Gulf of Cadiz) (ICES Division IXa)

Working Group: WGEF 2014

Date:

Revised by

A. General

A.1. Distribution

Global distribution: *Leucoraja naevus* (cuckoo ray) is a species with a wide geographic distribution in the northeast Atlantic and Mediterranean (Stehmann and Bürkel, 1984; Ellis *et al*. 2005).

Species distribution in IXa: The species is distributed along the entire area.

In Galicia waters the species is found along the continental shelf mainly between 70 to 200 m depth.

In the Portuguese continental waters *L. naevus* occurs along the entire coast at depths ranging from 30 m to 700 m (Figure 1), being more abundant in the south-west and southern regions at depths shallower than 500 m.

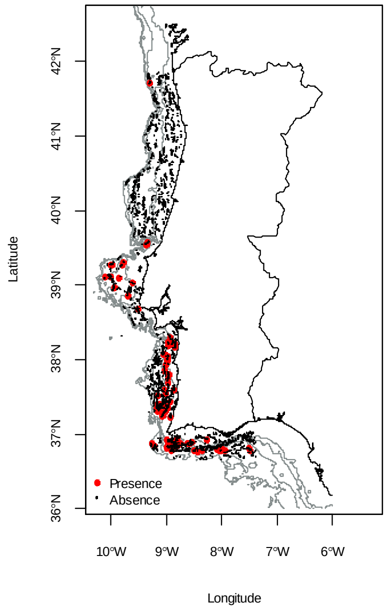


Figure 1 - Portuguese continental coast (ICES division IXa). *Leucoraja naevus* distribution in Portuguese Groundfish Surveys (PT-GFS) and crustacesn surveys /Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29)) from 1990 to 2013.

In the Gulf of Cadiz *L. naevus* occurs along the whole area at depths ranging from 50 to 800 m, being especially abundant in trawlable grounds placed in the southern area of the Gulf, in the range between 260 and 520 m depth (Figure 2).

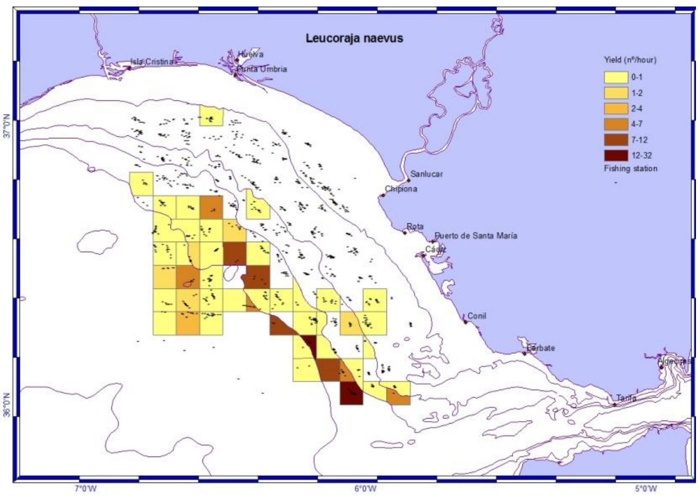


Figure 2 ï Gulf of Cadiz (ICES division IXa). *Leucoraja naevus* distribution and abundance index (no/hour) in the Gulf of Cádiz (from ARSA surveys 1993-2009, Q1 SP ï GCGFS and Q4 SP - GCGFS).

A.2. Species dynamics

In the Cantabrian Sea *L. naevus* is most abundant in the central area in sedimentary grounds constituded mostly of sand and mud, contrary to the western region of Galicia where the species is less abundant.

In the center of Portugal, the species is more abundant in offshore grounds, situated at >100 m depth (Serra-Pereira *et al.,* 2014). Those areas are characterized by soft sediments, between mud and fine sand, often forming submarine beaches. All life stages, including egg capsules, were found sharing the same grounds simultaneity. Most of the times the two sexes occur in equal proportions but spatial segregation by sex may occur in certain areas.

In the Gulf of Cadiz the main habitat of *L. naevus* is located in the influence area of the Mediterranean Outflow Water (MOW), which is warmer and more saline than the above Atlantic Water.

A.3. Stock definition

The stock structure of the species along the all ICES areas is unknown, although migrations between different areas are admitted (ICES, 2013). For advice purposes, ICES considered a distinct stock unit for Division IXa (west of Galicia, Portugal, and Gulf of Cadiz).

A.4. Fisheries

In the Western area of the Iberian Peninsula Rajidae species are usually caught as by catch in other fisheries. In the past, there was a direct fishery to these species in the north of Spain, mainly in coastal areas and inside estuaries, with a special gillnet called *raeiras* (DOG nº 31 15/02/2011). At the present time there are no direct fisheries for skates and most of the landings come from the trawl fishery targeting other species (Rodriguez-Cabello *et al.*, 2005). Total landings by the Spanish fleet in this area (for all Rajidae species) increased from 1996 to 2001 up to 416 tones and since them remained more or less stable showing fluctuations around 350 tones (Figure 3). In the coastal area inside Galicia estuaries an important artisanal fleet operates catching frequently Rajidae species using different types of gillnets, particularly *miño* (DOG nº 31 15/02/2011). These catches from the artisanal fleet represent around 8.7 % of Galicia total landings from different ICES areas (Bañón *et al.,* 2008).

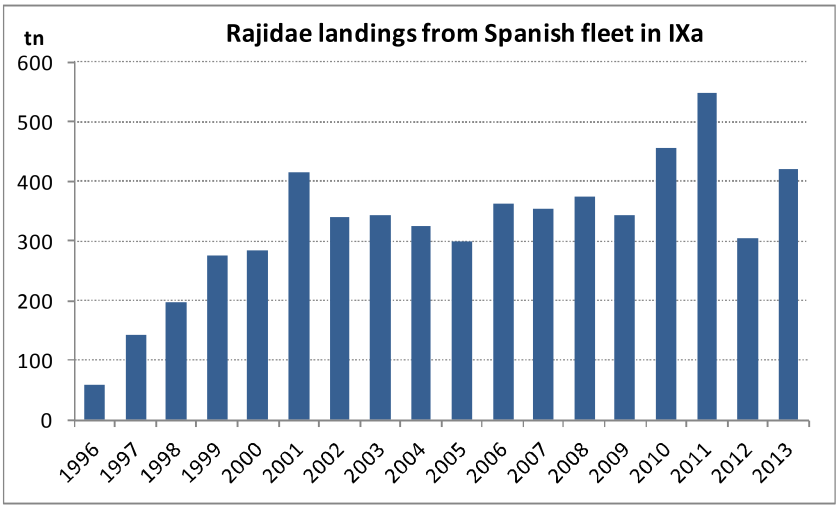


Figure 3 ï West of Galicia (ICES division IXa). Landings (ton) of Rajidae species in IXa by the Spanish fleet.

In the Portuguese continental coast Rajidae species are mainly landed by the polyvalent segment, which represents around 75% of the total landed weight, followed by the trawl segment that represents around 24%. The trawl segment is defined by vessels that operate wish mesh sizes of 55m, 65 or 70 mm. The Portuguese polyvalent segment includes vessels with length overall (LOA) ranging from 5 to 27 m which generally operate between 10 and 150 m deep and exhibit a multi-species and mixed fisheries, capturing a high diversity of species at different fishing grounds. This segment also includes vessels operating with trawl gear with mesh size of 32 cm, and, for analysis purposes, all trawl vessels with LOA smaller than 12 m irrespective of the mesh size. The latter were included in the polyvalent segment due to their different fishing pattern when compared to larger trawlers: fishing operations closer to the coast and daily trips. All these vessels can have more than one fishing gear (e.g. trammel nets, gillnets, longline, trawl, traps and/or pots) and consequently different fishing gears may be used in one fishing trip. Within the polyvalent segment, Rajidae are mainly caught by nets, i.e. trammel and gillnets; for the period between 2008 and 2013 the landed weight derived from nets represented 65 to 78% of the total landed weight, while longline and artisanal trawl represented 19- 24%, and up to 9% respectively.

In the Gulf of Cádiz area Rajidae are taken as by-catch of fisheries targeting demersal species.

A.5. Ecosystem aspects

In the west coast of the Iberian Peninsula the most important features enhancing primary production are coastal upwelling, coastal runoff and river plumes, seasonal currents and internal waves and tidal fronts. Maximum values of chlorophyll usually occur in spring and summer (Nogueira *et al.,* 1997; Moita, 2001), although high chlorophyll values may be recorded in autumn, particularly in zones with elevated retention characteristics; for example, high chlorophyll concentrations are found in the Rías Baixas, at the time of the seasonal transition from upwelling to downwelling (Nogueira *et al.*, 1997; Figueiras *et al.,* 2002). Most of the west Iberian coast, including Galicia and Cantabrian Sea continental shelf, is occupied by cold waters rich in nutrients (Gil, 2008).

The north-south orientation of the coast causes winds from the north to produce offshore transport. During spring and summer, northerly winds along the coast are dominant causing coastal upwelling and producing a southward current at the surface and a northward undercurrent at the slope (Figure 4a) (Fiúza *et al.*, 1982; Alvarez-Salgado *et al.*, 2003; Peliz *et al.*, 2005; Mason *et al.,* 2006). During winter the prevailing winds are mainly south-westerly, and the atmospheric circulation is dominated by eastward displacement of cyclonic perturbations and their associated frontal systems (Figure 4b) (Relvas *et al.,* 2007). However, in some years the presence of episodic atmospheric anti-cyclonic circulation (the Azores High) could give rise to northerly wind events during winter (Santos *et al.*, 2001; Borges *et al.*, 2003). Indeed, investigations on upwelling along the Galician coast in autumn and winter have been characterized in the Galician rias, indicating that the upwelling process along the Galician coast is not a phenomenon restricted to spring and summer (Alvarez *et al.*, 2012).

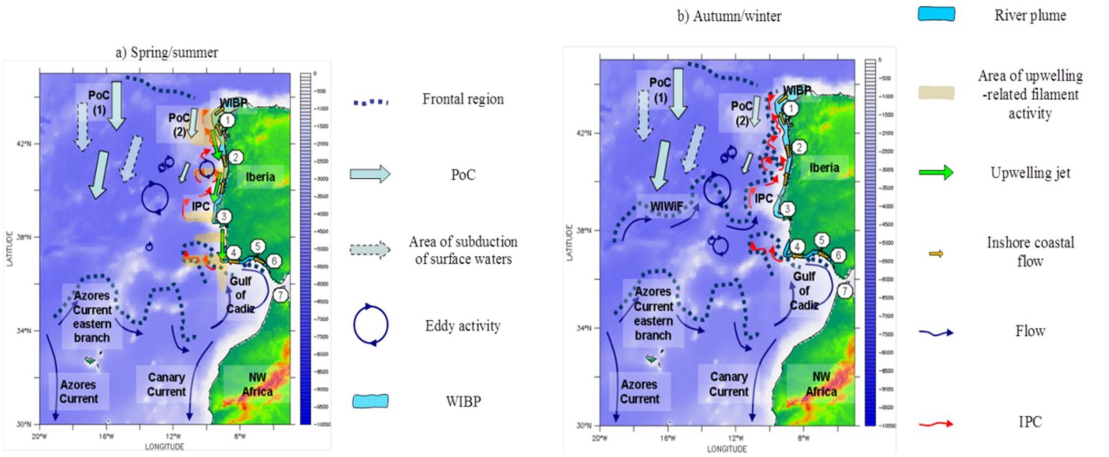


Figure 4 - The western Iberia and Gulf of Cadiz regimes in a) spring and summer, and b) autumn and winter. 1) Cape Finisterre; 2) River Douro; 3) Cabo da Roca; 4) Cape St. Vincent; 5) Guadiana River; 6) Guadalquivir River; 7) Strait of Gibraltar. PoC - southward-flowing Portugal Current, WIBP - Western Iberia Buoyant Plume, IPC - Iberian Poleward Current (Adapted from Peliz *et al*. 2002; Peliz *et al.* 2005).

In winter the Poleward Current (PC) flows northerly. It is a salty surface current (about 200 m deep) of subtropical origin (Eastern North Atlantic Water, also known as the ôNavidadôCurrent, since because it starts to be evident near Christmas and New Year) and relatively warmer than the surrounding ones (Castro *et al.,* 2011). During winter and spring, the PC results in a convergent front at the boundary between coastal and oceanic water. When saline intrusion is weak, the development of fronts and the formation of a seasonal thermocline are enhanced, leading to phytoplankton blooms. When saline intrusion is intense, strong vertical mixing occurs and prevents phytoplankton growth in spring (Moita, 2001; Santos *et al.,* 2004).

The intermediate deep layers are mainly occupied by a poleward flow of Mediterranean Water (MW), which contours the southwestern slope of the Iberia (Ambar and Howe, 1979), generating the mesoscale features called Meddies. The MW along the west coast of the Iberian Peninsula is characterized by a transport of warm and salty water (typical surface anomalies, 1ï 1.5ºC and 0.1ï 0.3ă in salinity) with velocities up to some 0.2ï 0.3 m s^{-1} reported by Frouin *et al*. (1990).

The Sea Surface Temperature (SST) registered a generalized warming of a few hundredth of degrees a year since 1960, ranging from 0.015°C/year to 0.037°C/year (Relvas *et al.*, 2009). The SST increase has effect on species populations (e.g. recruitment success, migrations changes) (Brander *et. al*., 2003).

In the Gulf of Cadiz the most important oceanographic process is the occurrence of a strong interaction between two masses of water, the Atlantic Ocean and the Mediterranean Sea through the Strait of Gibraltar. In general, the exchange of water masses through Strait of Gibraltar is guided by the highly saline and warm Mediterranean Outflow Water near the bottom, and the turbulent, less saline, cool-water mass of the Atlantic Intermediate Water at the surface. The pattern of surface circulation is ruled by a clockwise movement, with a general W to E superficial current, whereas the deep circulation is controlled by the westerly current of the highly saline (salinity>37 PSU) Mediterranean water existing through the Strait.

Bottom temperatures are extremely variable ranging between 3ºC and 20.6ºC whereas values of bottom salinity along the continental shelf range from 35.8 to 36 PSU (Díaz *et al.*, 2006). In the slope there is a wide band with values around 37 PSU, the lower slope showing the minimum values which correspond to the Deep Atlantic Water Mass (Díaz *et al.*, 2006).

The continental slope can be differentiated into four provinces: a) a narrow belt between 130 and 400 m formed by the steep upper slope; b) two gently dipping wide terraces located between 400 and 700 m depth; c) a central sector between the terraces in which several, steep and narrow curvilinear ridges and valleys are located trending NE-SW to E-W; d) the lower slope-upper continental rise at water depths from 900 down to 1500-1800 m. Below 900 m, the lower slope is steeply dipping and generally smooth except for shallow valleys placed in a NE-SW direction (Nelson *et al.*, 1993). The main sedimentary types occurring over the slope are bioclastic sands, silicoclastic sands and muddy sands, sandy muds, sandy and muddy contourites (Díaz *et al.*, 1985).

B. Data

B.1. Commercial landings and discards

Spanish landings of *L. naevus* in Galicia and South of Spain reached 10.7 t in 2013 (90 % coming from the southern area). Those were quite similar to the 2012 landings of 12 t. This species represented 3% of the total Rajidae species landed in 2013. Due to the sampling methodology based on métier it has not been possible to separate accurately the discards made by the Spanish trawl fleet in Galicia and Cantabrian Sea (VIIIc and IXa). Annual fluctuations were observed with 29.3 t discarded in 2013, high value compare to the last five years (Table 1).

Table 1 - Galicia and Cantabrian Sea (ICES divisions VIIIc and IXa). Weight discarded (ton) of *Leucoraja naevus* (bold) and CV of estimations (italics) from bottom trawl fishery.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Leucoraja naevus	**73,0**	**187,6**	**6,5**	**63,5**	**19,7**	**2,7**	**14,5**	**9,6**	**2,2**	**5,6**	**29,3**
	56,4	*57,6*	*69,3*	*51,7*	*63,9*	*52,0*	*79,3*	*70,2*	*40,3*	*40,5*	*38,5*

Data used to estimate Portuguese landings by species derived from the DCF skate pilot study that had as main objectives to establish sampling statistical procedures and define estimators necessary to calculate the inputs for stock assessment purposes. In the Portuguese continental waters, between 2008-2013, *L. naevus* represented between 2 and 3% (16.6 to 29.3 ton) and between 4 and 8% (9.7 to 29.1 ton) of the total skates landed weight by the polyvalent and the trawl segments, respectively (Table 2). In 2013 the estimated landed weight of *L. naevus* was 16.6 t for the polyvalent and 9.7 t for the trawl segment.

Table 2 - Portuguese continental coast (ICES division IXa). *Leucoraja naevus* estimated landed weight, number of vessels and number of trips by fishing segment (trawl and polyvalent), between 2008 and 2013.

	Polyvalent segment			Trawl segment		
Year	No. vessels*	No. trips*	Landed weight (ton) (%RJN/Skates)	No. vessels*	No. trips*	Landed weight (ton) (%RJN/Skates)
2008	1444	36149	25.8 (2%)	81	6513	24.0 (7%)
2009	1412	36239	26.5 (3%)	69	5683	23.7 (6%)
2010	1389	34767	29.3 (3%)	59	5461	25.7 (8%)
2011	1289	36761	27.3 (3%)	60	5139	29.1 (8%)
2012	1240	32565	21.0 (3%)	54	5158	18.2 (6%)
2013	1172	28007	16.6 (2%)	51	4658	9.7 (4%)

* estimates for all skates combined

Leucoraja naevus is mainly landed in the center (*Centro*) and Alentejo regions by the polyvalent segment and in Algarve by trawl segment (Figure 5).

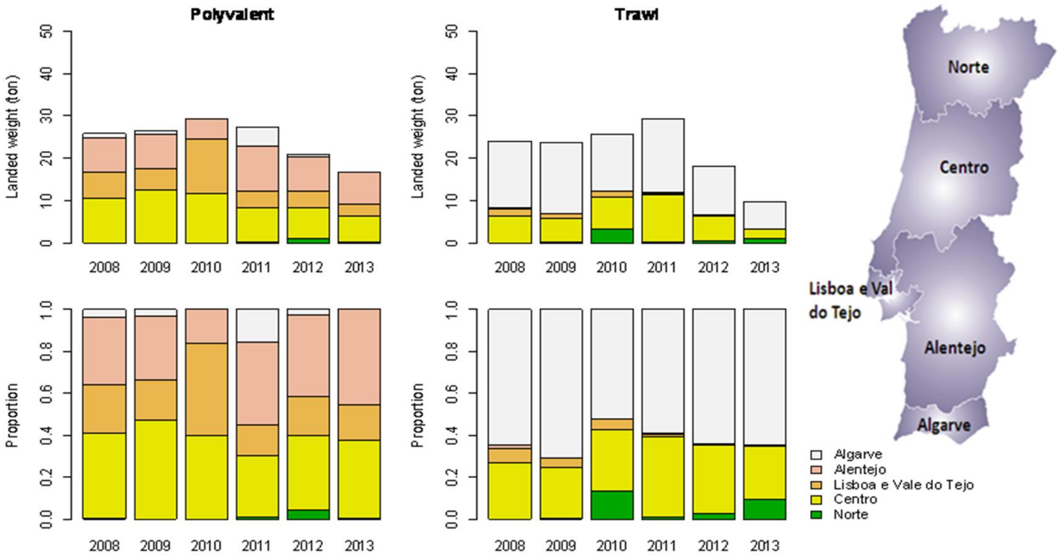


Figure 5 - Portuguese continental coast (ICES division IXa). *Leucoraja naevus* landing weight and percentage by major region (NUTSII regions) and segment.

For the polyvalent segment and during the period 2008-2013, the landings estimates of *L. naevus* for the group of the five most important landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) represented 33 to 57% of the total landed weight of the species. The sampling program carried out in those landing ports allowed to conclude that *L. naevus* was mainly caught by nets (Table 3) and trawl.

Table 3 ï Portuguese continental coast (ICES division IXa). *Leucoraja naevus* (2008-2013) for the group of landing ports comprising Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal - Number of vessels, number of trips in which the species occurred and landing estimates by fishing gear (nets, longline and trawl) of the polyvalent segment. Last column refers to trips for which no information on the fishing gear is available.

	Nets			Longline			Artisanal trawl			NA	
Year	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips
2008	73	2507	1.6	64	1365	4.9	2	122	0.9	54	235
2009	53	1301	3.2	67	1404	5.2	3	163	0.0	47	157
2010	71	3043	10.1	39	458	2.5	3	224	1.2	33	163
2011	81	2369	2.5	23	362	1.9	4	319	1.0	34	171
2012	156	5822	4.5	23	450	2.4	5	363	0.6	21	107
2013	107	2974	3.7	17	311	1.0	5	378	0.6	3	3

Information on discards of *L. naevus* produced by the Portuguese polyvalent and bottom otter trawl segments operating in the ICES Division IXa has been collected under the Data Collection Framework (EU DCR). Two polyvalent fisheries (trammel nets operating deeper than 150m and trammel and gillnets operating shallower than 150m) and two bottom otter trawl fisheries (crustacean fishery and demersal fish fishery) were analyzed. The information available is insufficient to reach robust estimates of discards so preliminary results are presented in Table 4.

Table 4 ï Portuguese continental coast (ICES division IXa). *Leucoraja naevus* number of sampled hauls, number of hauls where the species occurred, probability of the species be caught in a haul and a specimen be discarded (p_{CD}) and expected number of discarded specimens per haul per fishery. Polyvalent segment: i) nets operating at depths shallower than 150 m (i.e. trammel and gillnets) and ii) trammel nets operating deeper than 150 m. Trawl segment: i) Crustacean Fishery and ii) Demersal Fish Fishery.

	Polyvalent Segment		Trawl Segment	
	Nets <150 m deep	Trammel nets >150 m deep	Crustacean Fishery	Demersal Fish Fishery
nº of sampled hauls	41	57	665	1162
nº of hauls in which the species occurred	4	22	4	16
p_{CD}	0.02	0.17	0.006	0.02
Expected number of discarded specimens per haul	3	12	2	1

In the Gulf of Cadiz, catch and landing data from commercial fisheries are often poor because of a general lack of species-specific recordings. No management program has been established yet in this area. Fisheries research has traditionally been focused on the most commercially important teleosts and poor research has been undertaken on chondrichthyans.

B.2. Length frequency distribution

In the Portuguese continental waters, sampling length frequency distributions of *L. naevus* at the five main landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) are presented in Figure 6 for nets and longlines separately. Length frequency distributions were built with no extrapolation to the total estimated landed weight of the species. The length distributions, as well as the length ranges, are similar between the two gears among years.

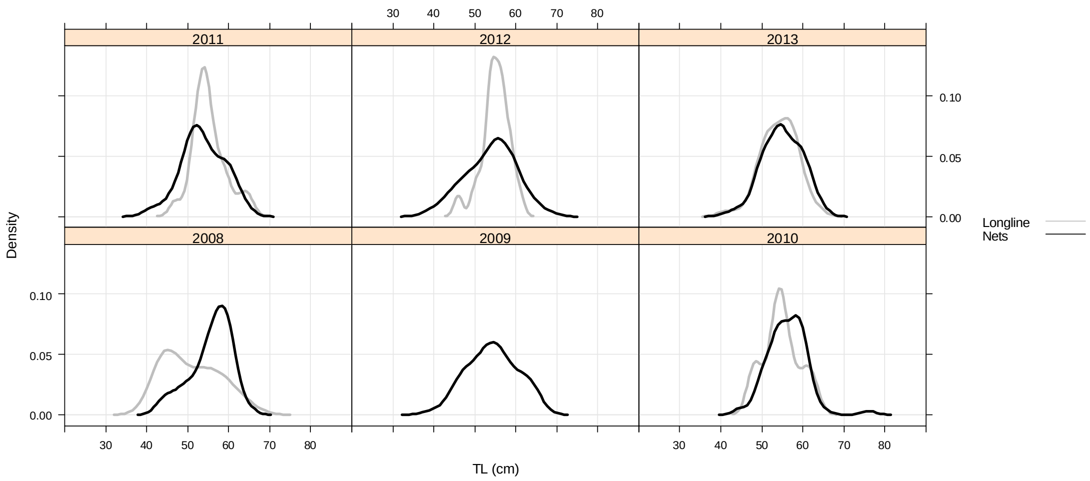


Figure 6 - Portuguese continental coast (ICES division IXa). Sampling length frequency distributions of *Leucoraja naevus* at the five main landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) during the period 2008-2013.

In the Gulf of Cadiz length frequency distributions data are obtained from the ARSA survey series (Table 4; Figure 7).

Table 5 ï Gulf of Cadiz (ICES division IXa). *Leucoraja naevus* mean length (cm) in the depth strata of the ARSA survey series (Q1 SP ï GCGFS and Q4 SP ï GCGFS)

Leucoraja naevus **ARSA series total mean length (cm)**			
Depth strata / Season	**SPRING**	**AUTUMN**	**BOTH**
A (15 - 30 m)			
B (31 - 100 m)	**11**	**45**	**28**
C (101 - 200 m)	**40**	**42**	**42**
D (201 - 500 m)	**37**	**35**	**36**
E (501 - 800 m)	**38**	**36**	**37**
All (15 - 800 m)	**37**	**36**	**36**

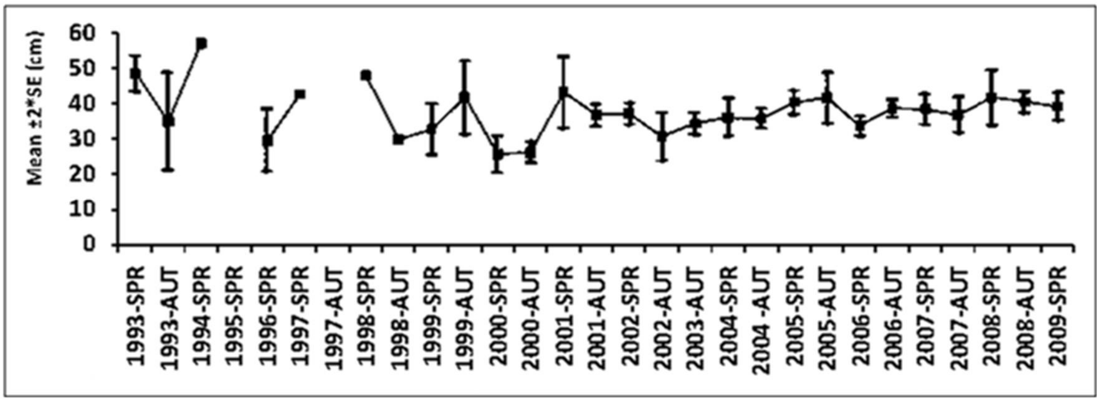


Figure 7- Gulf of Cadiz (ICES division IXa). Trend of the mean size for *L. naevus* in ARSA surveys (1993-2009) (Q1 SP ï GCGFS and Q4 SP ï GCGFS).

B.3. Survivorship

Under the scope of the EU DCF skate pilot study carried out in mainland Portugal, data on survivorship of *R. clavata* after fishing was collected onboard fishing trips of polyvalent vessels operating with trammel or gillnets. Survivorship was qualitatively evaluated by assuming that the health status of fish after capture is a good indicator of the survivorship index (Enever *et al.,* 2009). The following scale was used to assign health status to each sampled individual (Enever *et al.,* 2009): 1) Good: vigorous wing/body movement and rapid spiracle movement; 2) Moderate: limp wing/body and spiracle movement and; 3) Poor: dead or nearly dead, no body movement, slight spiracle movement. In general, this species presents high levels of survivorship.

There are no studies about skates´ survivorship neither in the west of Galicia nor in the Gulf of Cadiz.

B.4. Commercial LPUE

Polyvalent and trawl segments contributed with around 50% each for the *L. naevus* total estimated landed weight and both segments were considered to estimate LPUE. The landed weight of the species per trip (fishing effort unit), LPUE, was used as the index of abundance. LPUE was determined from the commercial data collected from 2008 to 2013. In the polyvalent segment, landings from trips in which nets were used as fishing gear are relatively more important in terms of landed weight than longline. Among the two fishing gears there are no major differences on length structure of the specimens caught (Fig. 7). In face of that, it is admitted that the standardized LPUE using fishery data derived from nets are representative of the polyvalent segment.

B.5. Biological

In Portuguese waters, *L. naevus* size-at-first-maturity is 56 cm for both males and females. Egg laying females are more frequent between January and May, although reproductively active females can be found throughout the year. Fecundity is estimated to be around 63 eggs female^{-1} year^{-1} released in nine batches of seven follicles each (Maia *et al*. 2012). Juveniles of *L. naevus* feed on indiscriminate small crustaceans as *Lophogaster typicus* and *Solenocera membranacea* and mysids, while adults prey preferentially on bony fishes such as the species *Gymnammodytes semisquamatus* (Farias *et al*. 2006).

In Galicia and Cantabrian Sea, the diet of L. *naevus* is fundamentally based on crustacea for individuals less than 50 cm, which represents more than the 80% of volume (%V) (Figure 8). Larger specimens feed preferably on fishes (nearly 70%V). The main species within the Crustacea were (*Processa* spp. y *Solenocera membranácea*) althouh in smaller specimens also small crustacea like the mysid *Lophogaster typicus* and amphipods are included. Regarding fish prey, small rays (<50) feed mainly on gobidae and callyonymus species while large rays feed on flatfish like *Microchirus variegates (*13.4%) and *Micromesistius poutassou* (9.6%), *Calionymus* spp. (7%) and *Antonogadus macrophtalmus* (2.7%). The presence of poliqueta is also constant along the length range but only (5% V)

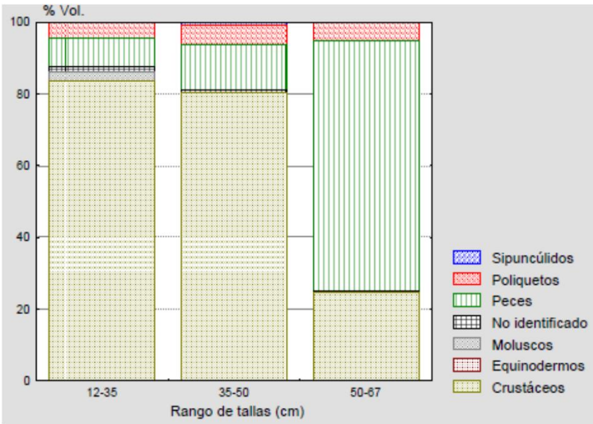


Figure 8 ï Galicia and Cantabrian Sea (ICES divisions VIIIc and IXa). Diet of *Leucoraja naevus* (data from Velasco *et al*., 2002).

B.6. Surveys

Spanish bottom trawl surveys (SP-GFS) are carried out annually along the continental shelf of Galicia and Cantabrian Sea (north of Spain) during autumn (Septemberï October). The historical series begun in 1980 however not until 1983 were standardized. These surveys are based on a stratified random sampling design, using an otter trawl 44/60 gear with a mesh size of 60 mm, and 20 mm in the cod-end (Sánchez, 1993; ICES, 2010). The survey area was stratified according to depth and biogeographically criteria (Figure 9). Five geographical sectors (MF, FE, EP, PA and AB) and three depth strata at the 70,120, 200 and 500 meter isobaths were defined. The first geographical sector (MF) corresponds to ICES area (IXa). The number of hauls per stratum is proportional to the trawlable surface area. Trawl tow duration is 30 min at a speed of 3 knots (Sánchez *et al*., 2002). An average of 122 ± 3.76 hauls (coverage of 5.4 hauls for every 1000 Km²) is usually performed each year during the whole survey. Supplementary hauls in deeper bottoms (500-700 m) and shallows waters (30ï 80 m) may be conducted depending of the ship time available at sea In particular, in the IXa area, an average of 19 hauls are preformed. This survey does not provide sufficient data to assess the stock status of *L. naevus* which can possibly be related with species distribution pattern and/or with inadequate survey design to catch this species.

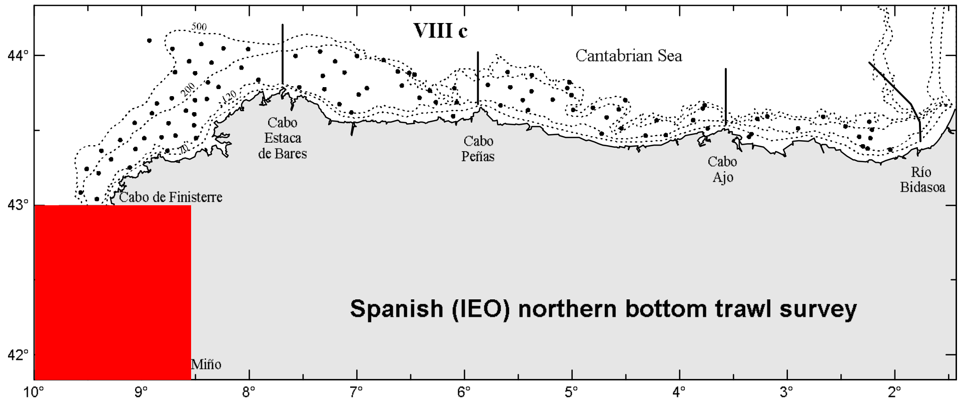


Figure 9 ï West of Galicia (ICES division IXa). Spanish (IEO) northern bottom trawl survey (SP-GFS) stratification design.

The Portuguese crustacean surveys /Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29)) has been conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, ex-IPIMAR) and has the main objective is to monitor the abundance and distribution of the main crustaceans species, namely *Nephrops norvegicus* (Norway lobster), *Parapenaeus longirostris* (rose shrimp) and *Aristeus antennatus* (red shrimp). The PT-CTS (UWTV (FU 28-29) have been carried out during the 2nd quarter (May-July) of the year and covers the southwest coast (Alentejo, FU 28) and south coast (Algarve, FU 29). The surveys have been carried with the Portuguese RV ñNoruegaò, which is a stern trawler of 47.5 m length, 1500 horse power and 495 GRT. A regular grid composed by 22 rectangles in FU 28 and 59 rectangles in FU 29 is used, with one station within each rectangle. Each rectangle has 6.6 minutes of latitude x 5.5 minutes of longitude for the SW coast and vice-versa for the south coast, corresponding approx. to 33 nm2. The grid was designed for a trawl survey to cover the main crustacean fishing grounds within the range of 200-750 m. The areas deeper than 750 m, where the giant scarlet prawn occurs, are not covered. The hauls fishing operations are carried out during daytime with a speed of 3 knots and the duration of each tow change in 2005 from 60 to 30 min. Although the crustacean species are the target (Norway lobster, rose shrimp and red and blue shrimp), data from all other taxa and species are also collected, as well as marine litter.

The Spanish bottom trawl survey IBTS-GC-Q1-Q4 (ARSA) in the Gulf of Cadiz has been carried out in the spring and autumn from 1993 to 2013. The surveyed area corresponds to the continental shelf and upper-middle slope from the latitude 6º 20ôW to 7º 20ôW and from 15 m to 800 m depth covering an area of 7224 Km^2. The surveys were carried out on board of the R/V *Cornide de Saavedra*, a stern trawler of 67 m length and 1133 GRT until spring 2013. Since autumn 2013 surveys were carried out on board the R/V Miguel Oliver. Hauls were performed with a standard Baka 44/66 bottom trawl gear, the standard sampler used by the Instituto Español de Oceanografía in their surveys sampling the Spanish Atlantic shelf, with a 60.3 m headline and 43.8 m footrope. The gear employed had a stretched mesh of 40 mm in the codend and it was covered internally with a 20 mm mesh size. Mean vertical and horizontal opening were 1.8 m and 21 m, respectively. Sampling design followed a random stratified scheme with 5 depth strata (15-30 m, 31-100 m, 101-200 m, 201-500 m, 501-800 m). The number of hauls per strata was proportional to the trawlable surface adjusted to the ship time available at sea, with coverage of around 5.4 hauls for every 1000 Km^2. Haul duration was 60 minutes and they were carried out during daylight at a mean towing speed of 3.0 knots.

C. Assessment: data and method

Data:

- Fishery dependent data:
  - Landings estimates by species
  - Fishing effort (unit: number of fishing trips) by fishing gear
  - Length frequency distribution by fishing gear
  - Discards
- Fishery independent data
  - Portuguese Crustacean Surveys / Nephrops TV Surveys (PT-CTS (UWTV(FU 28-29)) catch rate ($kg.hl^{-1}$)
  - Spanish bottom trawl survey IBTS-GC-Q1-Q4 (ARSA) in the Gulf of Cadiz ($kg.h^{-1}$)
  - Length distribution

Methods:

1) Landings estimates by species for polyvalent and trawl segment in Portuguese continental waters

For each year *y* and landing port *p*, the landing estimates of each species were estimated based on the proportion of the species by sampled trip. A weighted proportion $\hat{pa}_{(p,y)}$ was determined as:

$$\hat{pa}_{(p,y)} = \frac{\sum_{i=1}^{n} \left(pa_{(p,y)i} \times w_{(p,y)i} \right)}{W_{(p,y)}}$$

where the $pa_{(p,y)i}$ is the proportion of the species at the i^{th} fishing trip, $w_{(p,y)i}$ is the landed weight of skates in the i^{th} fishing trip and $W_{(p,y)}$ is the total landed weight of skates in all the sampled trips at landing port *p* in year *y*. The estimate of the variance of $\hat{pa}_{(p,y)}$ is determined as:

$$var(\hat{pa}_{y,p}) = \frac{1}{n_{(y,p)}\bar{w}_{(y,p)}^{2}} \frac{\sum_{i=1}^{n}\left(w_{(y,p)i}^{2} . pa_{(y,p)i}\left(1 - pa_{(y,p)i}\right)\right)}{n_{(y,p)} - 1}$$

where $n_{(y,p)}$ is the number of sampled trips for the y year and p landing port.
For the selected species the total landed weight $L_{y,p}$ () in landing port p and year y was calculated as:

$$L_{(y,p)} = \hat{pa}_{(y,p)} \times w_{(y,p)}$$

where $w_{(y,p)}$ is the total landed weight of skates.

At landing ports for which fishing effort was estimated by group (groups correspond to set of vessels determined as function of vessel size, seasonality in fishing skates and fishing gear), the proportion of the species for the year y, port p and group g were obtained as:

$$\hat{pa}_{(y,p,g)} = \frac{\sum_{i=1}^{n}\left(pa_{(y,p,g)i} \times w_{(y,p,g)i}\right)}{wt_{(y,p,g)}}$$

where $pa_{(y,p,g)i}$ is the observed proportion of the species in i^{th} fishing trip, $w_{(y,p,g)i}$ is the landed weight of skates in the i^{th} fishing trip and $wt_{(y,p,g)}$ is the total landed weight of skates in the sampled trips. The variance of $\hat{pa}_{(y,p,g)}$ was estimated in the same way as for $\hat{pa}_{(y,p)}$.

The total landed weight of the species $L_{y,p}$ in landing port p and year y was calculated as:

$$L_{(y,p)} = \sum_{g} \hat{pa}_{(y,p,g)} \times w_{(y,p,g)}$$

Note that when there were gaps of information to estimate the proportion, the median of the proportion estimates for the previous 3 years was assigned to the gaps.

2) Fishing effort (unit: number of fishing trips) by fishing gear for the main landing ports in Portuguese continental waters

The fishing effort by fishing gear for each main landing ports was estimated using a stepwise procedure that has been already described by Maia *et al.* (2013 WD) and that can be summarized as:

Step 1

Definition of homogeneous groups of vessels characterized by sharing similar fishing regimes, according to: a) vessel size further subdivided into small, medium or large that corresponds to 25%, 50% and 75% quartiles of the vesselôs LOA; b) seasonality pattern, that includes three levels ñoccasional", "seasonal" or "constant". Seasonality levels were established based on: i) the number of trips with positive landings of skates, ii) the total landed weight of skates, and iii) the frequency of months of activity with skates.

Step 2

Definition of discriminant rules later used to assign the fishing gear to fishing trips for which the fishing gear was not known. The discriminant rules were established through the application of the flexible discriminant analysis (FDA; Leisch *et al.,* 2009) to the interview data collected from each sampled trip. In the FDA the input data matrix include: i) the relative weight and value, in each fishing trip, of the main accompanying species or genera by gear, ii) the group assigned to each trip in Step 1); and iii) fishing licences for each vessel. The data were previously transformed through factor analysis for mixed data (Pages J. 2004; Le *et al*., 2008). This procedure involves the data transformation of qualitative and quantitative variables that will later constitute the input data matrix of FDA. The selected main accompanying species corresponded to the top five species in terms of occurrence, of landed weight and of value in the sampled trips.

3) Standardized LPUE for the polyvalent fleet using nets in Portuguese continental waters

In the standardization process of LPUE, a stepwise generalized linear model (GLM) procedure was applied to find the best GLM model and an estimate LPUE index time series based on the relationship between LPUE vs. available predictive factor variables.

The function bestglm implemented in R software was used to select the best subset of inputs variables (McLeod AI and Xu, 2010). The selection was based on a variety of information criteria and their comparison, following a simple exhaustive search algorithm (Morgan and Tatar, 1972). This algorithm uses a lexicographical method that evaluates the loglikelihoods for all possible glm models. Lognormal error distribution was assumed in the standardization. This distribution is commonly assumed for standardizing catch and effort data, assuming that the expected value of a transformed response variable is related to a linear combination of exploratory variables (Maunder and Punt, 2004).

Different diagnostic plots, e.g. the distribution of residuals and the quantile-quantile (Q-Q) plots, were used to assess the error distribution (assuming lognormal distribution), as well as the model fits for the standardization of the LPUE. Changes in deviance explained by the selected model and the proportions of deviance explained to the total explained deviance was determined and used as indicative of r^2.

The standard errors of the year effects and LPUE for a reference condition, the polyvalent present case: net as fishing gear, 1st quarter of the year; medium vessel size and constant seasonality and; the trawl present condition: vessel, were calculated by the delta method. The delta method is commonly applied when functions are too complex for analytically computing their variance. According to this method, a linear approximation of the function, usually with a one-step Taylor approximation, is firstly obtained and then its variance is computed (Oehlert, 1992). In the polyvalent segment, landings from trips in which nets were used are relatively more important than those from longlines. Since no major differences on length structure of the specimens caught among the two fishing gears are observed, it is admitted that the standardized LPUE using fishery data derived from nets are representative of the polyvalent segment.

4) Discards

Information on discards has been collected by the Data Collection Framework (EU DCF/NP) for two main segments: bottom otter-trawl and polyvalent.

Information on bottom otter trawl discards derived from the Portuguese on-board sampling program started in 2003 that collects data, amongst other, on i) bottom otter trawl Crustacean fishery targeting deep-water rose shrimp, Norway lobster and blue whiting and; ii) bottom otter trawl demersal fish fishery targeting horse-mackerel, cephalopods and other finfish (Prista *et al.* 2013 WD). The programme is based on a quasi-random sampling of trips from a set of cooperative vessels known to operate in each target fishery. The protocol consists in sort a sample from the catch of each haul into a retained fraction and a discarded fraction following instruction by fishermen. Number, weight and length composition of each taxa in each fraction are recorded. The sampling protocol did not suffered significant changes between 2003 and 2013, apart from in 2011 that the size of catch

samples doubled from one to two boxes and the within-trip selection of hauls was standardized to ñat least, every other haul/segmentò (see Prista *et al.* (2012) for more detail).
Information on polyvalent segment is obtained from two fisheries: i) net fisheries which includes the trammel or gillnets as fishing gear that operate at depths shallower than 150 m and target a multi-species complex and; ii) trammel nets fishery targeting anglerfish that operate at depth deeper than 150 m.

Data on net fisheries discards was obtained from the pilot study on the métiers where skates are caught. In this sampling scene all the hauls performed with nets (trammel or gillnets) were sampled. Collected information included: number, length and sex of all caught skate specimens caught, as well as, its final destination (landed or discarded). Information on trammel discards was derived from the pilot study on the Portuguese trammel nets fishery. The onboard protocol involve to sampling every hauls performed with trammel nets operating from 200 to 600 m deep. The information collected onboard consisted in total length of all individuals caught (identified at a species level) and categorization into discarded or retained individuals (for more detail see Moura *et al.* 2013 WD).

The procedure adopted for each fishery and for each skate species analyzed was similar and take into account the fact that the skates are not the target species for any fishery studied. The probability of the species be caught in a haul and a specimen of that species be discarded (p_{cd}) is determined as:

$$p_{cd} = p_c \times p_d$$

where p_c corresponds to the probability of the species be caught in one fishing haul and p_d is the probability of a specimen be discarded within the whole set of specimens caught in the sampled hauls.

The expected number of discarded specimens per haul ($E(X)$) was calculated:

$$E(X) = \sum_{i=1}^{n} x_i \times p_i$$

where x_i is the number of discarded specimens at the i^{th} haul and p_i is the probability that a specimen is derived from i^{th} within the whole set of sampled hauls (n).

5) Standardized survey biomass index

In Portuguese continental waters, biomass indexes of *L. naevus* were standardized using the catch rates by fishing haul obtained for Portuguese Crustacesn Surveys / Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29)). Generalized linear mixed models (GLMM; Bolker *et al*., 2009) were used in the standardization process (see Figueiredo *et al.,* 2013 WD for further details). In the essayed models catch rate of the species in each haul ($Kg.h^{-1}$) was the response variable and several linear predictors were considered: i) type of fishing net (NCT or CAR); ii) year; iii) fishing sector; iv) initial depth (in meters); v) trawling duration (in minutes); vi) period (morning or afternoon). Apart from factor year, the remaining predictors were selected depending on their significance after the model adjustment. Interactions were not considered because, if included, the degrees of freedom available decreased substantially and the adjustment was very poor.

GLMM models were adjusted to the survey data through the use of package ôMASSô (Venables and Ripley, 2002) implemented in R software. In the model, error of the catch rate was assumed to follow a Tweedie random variable, whose probability density function is expressed as:

$$f(y: \mu, \sigma^2, p) = a(y: \sigma^2, p) \exp\left\{ -\frac{1}{2\sigma^2} d(y: \mu, p) \right\}$$

where µ is the location parameter; ů^2 is the diffusion parameter and; *p* is the power parameter.

The Tweedie family of distributions is a family of exponential dispersion models with variance $Var(Y) = \sigma^2 . \mu^p$, that depending on the value of p includes other distributions (Dunn and Smyth, 2008; Jørgensen, 1997). When $1 < p < 2$ the distribution corresponds to mixed distributions known as compound Poisson models (Jørgensen, 1997) that in the present case, and due to the high frequency of zeroes, seems to be the most appropriate distribution to use.

The estimation of the *p* parameter was done following the procedure proposed by Shono (2008). According to this, the power parameter (*p*) is estimated by maximizing the profile log-likelihood across the grid values of (*p*) in the range of $1 < p < 2$ through the explicit form of the probability density function. The package ôTweedieô (Dunn, 2009) implemented in R was used to estimate *p*.

In the GLMM adjustment, the factor Sector was considered as a random effect and since the random terms do not contribute to the fixed part of the mean its influence was isolated. The estimation of regression coefficients was done under the framework of quasi-likelihood and by fixing the value of p in the estimate obtained.

Model adequacy was check based on residual analysis. Fitted values were transformed ($2\varepsilon^{1-(p/2)}$) to the constant information-scale, so that the expected pattern for the compound Poisson distribution was a straight line (McCullagh and Nelder, 1989; Draper *et al.*, 1998; Ortiz and Arocha, 2004). Residuals were also analysed using Tweedie quantiles, and the graphical tools for residuals set with the Tweedie distribution (qqplots) were constructed. Three types of plots were examined: (i) histogram of the deviance residuals; (i) deviance residuals and Pearson residuals against the standardized fitted values to check for systematic departures from the assumptions underlying the statistical distribution; and (iii) Tweedie QQ-plot (with Tweedie quantiles) for deviance residuals and for Pearson residuals.

The annual biomass index predictions for the selected statistical model were obtained following the procedure referred in Candy (2004) and by considering the depth fixed at a reference level (mean depth). The estimates of the variance of the sum of linear predictors used to estimate the approximate confidence intervals of annual indices were determined using the delta method which is implemented at the R package ómsmô (Jackson, 2013). The delta method is a general approach for computing confidence intervals for functions of maximum likelihood estimates. This method allows finding approximations of the variance of functions of random variables based on Taylor series (Oehlert, 1992).

Software used:

All the data analysis was performed in R software (R Development Core Team, 2009).

I. References

Alvarez-Salgado, X., Figueiras, F., Perez, F., Groom, S., Nogueira, E., Borges, A., Chou, L., Castro, C., Moncoiffe, G., Rēos, A., Miller,A., Frankignoulle, M., Savidge, G., Wollast, R. 2003. The Portugal coastal counter current off NW Spain: new insights on its biogeochemical variability. Progress in Oceanography 56, 281ï 321.

Álvarez, I. Prego, R., de Castro, M. and Varela, M., 2012. Galicia upwelling revisited: out-of-season events in the rias (1967ï 2009). Ciencias Marinas (2012), 38(1B): 143ï 159

Ambar, L., and Howe, M.R. 1979. Observations of the Mediterranean outflow-I Mixing in the Mediterranean outflow. Deep-Sea Research, 26: 535-554.

Bañón Díaz, R., Quinteiro Fernández,R, García Tasende, M., Juncal Caldas,L.M., Campelos Álvarez, J.M., Gancedo Baranda, A., Lamas Rodríguez, F., Morales de la Fuente,C. and Ribó Landín, J, 2008. Composición, distribución y abundancia de rayas (Elasmobranchii: Rajidae) en aguas costeras de Galicia. Foro Ac. Rec. Mar. Rías Gal. 10: 325-331 2008.

Bolker, B.M., Brooks, M.E., Clark, C.J., Geange, S.W., Poulsen, J.R., Stevens, M.H.H. and White, J-S.S. 2009. Generalized linear mixed models: a practical guide for ecology and evolution. Trends in ecology and evolution 24: 127-135.

Borges, M.F., Santos, A.M.P., Crato, N., Memdes, H., Mota, B. 2003. Sardine regime shifts off Portugal: a time series analysis of catches and wind conditions. In Fish Stock Assessments and predictions: Integrating Relevant knowledge (editors O. Ulltang and G. Blom) Scientia Marina Volume 67, Suplement 1, April 2003.

Brander, K., Blom, G., Borges, M., Erzini, K., Henderson, G., MacKenzie, B., Mendes, H., Santos, A. and Toresen R. 2003. Changes in fish distribution in the eastern North Atlantic: Are we seeing a coherent response to changing temperature? ICES Mar. Sci. Symp., 219, 261ï 270.

Candy, S. 2004. Modelling catch and effort data using generalised linear models, the Tweedie distribution, random vessel effects and random stratum-by-year effects. CCAMLR Science 11: 59-80.

Cardador, F., Sanchéz, F., Pereiro, F.J., Borges, M.F., Caramelo, A.M., Azevedo, M., Silva, A., Pérez, N., Martins, M.M., Olaso, I., Pestana, G., Trujillo, V. and Fernandez A. 1997. Groundfish surveys in the Atlantic Iberian waters (ICES divisions VIIIc and IXa): history and perspectives. ICES CM 1997/Y:8.

Castro, M., Gómez-Gesteira, M., Álvarez, I., and Crespo, A.J.C. 2011. Atmospheric modes influence on Iberian Poleward Current variability. Continental Shelf Research, 31:425ï 432.

Diaz, J.I., M. Farrán and A. Maldonado. 1985. Surfical sediment distribution patterns in the Gulf of Cádiz controlled by the geomorphic features and physical oceanographic parameters. *6th European Regional Meeting of Sedimentology*. I.A.S., Lleida 85: 129-132.

Díaz, V., L.M. Fernández, J. Gil, F. Ramos and M.P. Jiménez. 2006. Gulf of Cadiz Regional Ecosystem. *ICES Working Group for Regional Ecosystem Description*. ICES/WGRED 2006.

Draper, N. R., Smith, H. and Pownell, E. 1966. Applied regression analysis (Vol. 3). New York: Wiley.

Dunn, P.K., 2009. Tweedie: Tweedie exponential family models. R package version 1.6.2.

Dunn, P.K. and Smyth, G.K. 2008. Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. Statistics and Computing 18: 73ï 86.

Ellis, J. R., Cruz-Martinez, A., Rackham, B. D. and Rogers, S. I. 2005. The distribution of chondrichthyan fishes around the British Isles and implications for conservation. Journal of Northwest Atlantic Fishery Science 35: 195-213.

Enever, R., Catchpole, T.L., Ellis, J.R. and Grant, A. 2009. The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters. Fish.Res.97(1ï 2):72-76.

Farias, I., Figueiredo, I., Moura, T., Gordo, L.S., Neves, A. and Serra-Pereira, B. 2006. Diet comparison of four ray species (*Raja clavata, Raja brachyura, Raja montagui* and *Leucoraja naevus*) caught along the Portuguese continental shelf. Aquat. Living Resour. 19, 105ï 114.

Figueiras, F. G., Labarta, U. and Fernández-Reiriz, M. J. 2002. Coastal upwelling, primary production and mussel growth in the Rías Baixas of Galicia. Hydrobiologia, 484: 121-131.

Figueiredo, I. and Serra-Pereira, B. 2012. Modelling *Raja clavata* abundance from Portuguese IBTS data (1990-2011) using GLMM with Tweedie distribution. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-09.

Fiúza, A.F.G., Macedo, M.E. and R. Guerreiro, 1982. Climatological space and time variations of the Portuguese coastal upwelling. Oceanol. Acta, 5: 31-40.

Frouin, R., Fiúza, A.F.G., Ambar, I. and Boyd, T.J. 1990. Observations of a poleward surface current off the coasts of Portugal and Spain during winter. J. Geophys. Res., 95: 679ï 691.

Gil, J., 2008. Macro and mesoscale physical patterns in the Bay of Biscay. J. Mar. Biol. Ass. UK., 88 (2): 217-225.

ICES. 2007. Report of the International Bottom Trawl Survey Working Group (IBTSWG). 27ï 30 March 2007, Séte, France, pp. 182.

ICES, 2010. Manual for the International Bottom Trawl Surveys in the Western and southern Areas. pp. 58.

ICES. 2013. Report of the Working Group on Elasmobranch Fishes (WGEF), 17ï 21 June 2013, Lisbon, Portugal. ICES CM2013/ACOM:19. 680pp.

Jackson, C. 2013. Package ớmsmộ: Multi-state Markov and hidden Markov models in continuous time. R package version 1.1.4.

Jennings, S., Greenstreet, S.P.R. and Reynolds, J.D. 1999. Structural change in an exploited fish community: a consequence of differential fishing effects on species with contrasting life histories. Journal of Animal Ecology 68, 617-627.

Jensen, A.L. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Canadian Journal of Fisheries and Aquatic Sciences 53, 820ï 822.

Jørgensen, B. 1997. The Theory of Dispersion Models. Chapman and Hall, London, p. 237.

Le S., Josse J. and Husson. F. 2008. FactoMineR: An R package for multivariate analysis. Journal of Statistical Software. Vol 25 (1).

Leisch F., Hornik K. and Ripley B.D. 2009. Mixture and flexible discriminant analysis. R package version 0.4-2.

Maia, C., Serra-Pereira, B. and Figueiredo, I. 2013. Skates and rays estimates of landings by species from the Portuguese vessels operating in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-09.

Maia,C., Erzini, K., Serra-Pereira, B. and Figueiredo, I. 2012. Reproductive biology of cuckoo ray *Leucoraja naevus*. Journal of Fish Biology 81 (4): 1285ï 1296.

Mason, E., Coombs, S., Oliveira, P., Angélico, M.M. and Stratoudakis, Y. 2006. An overview of the literature concerning the oceanography of the eastern North Atlantic region. Relat. Cient.Téc. Inst. Invest. Pescas Mar. Série Cooperação, 51pp.

Maunder, M.N. and Punt, A.E. 2004. Standardizing catch and effort data: A review of recent approaches. Fish.Res. 70: 141-159.

Ortiz, M. and Arocha, F. 2004. Alternative error distribution models for standardization of catch rates of non-target species from a pelagic longline fishery: billfish species in the Venezuelan tuna longline fishery, Fish.Res. 70(2ï 3): 275-297.

McCullagh, P. and Nelder, J.A. 1989. Generalized Linear Models. London, Chapman Hall.

McLeod AI and Xu C 2010 bestglm: Best Subset GLM. URL http://CRAN.R-project.org/package=bestglm.

Moita, T. 2001. Estrutura, variabilidade e dinâmica do Fitoplâncton na costa de Portugal Continental. PhD Thesis. University of Lisbon, Portugal. 272 pp.

Morgan, J.A. and Tatar J.F. 1972. Calculation of the Residual Sum of Squares for all Possible Regressions." Technometrics, 14, 317-325.

Moura, T., Fernandes, A., Figueiredo, I., Alpoim, R. 2013. Pilot Study on the Portuguese trammel net fishery in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-10.

Nelson, C.H., J. Baraza and J. Maldonado. 1993. Mediterranean undercurrent sandy contourites, Gulf of Cadiz, Spain. In: D.A.V. Stow and J.C. Faugeres (Editors), *Contourites and bottom currents. Sediment.* Geol., 82: 103-131.

Nogueira, E., Pérez, F.F. and Ríos, A.F. 1997. Modelling thermohaline properties in an estuarine upwelling ecosystem (Ria de Vigo; NW Spain) using Box-Jenkins transfer function models. Est. Coast. Shelf Sci., 44: 685-702.

Oehlert, G. W. 1992. A note on the delta method. The American Statistician, 46: 27-29.

Pages J. 2004. Analyse factorielle de donnees mixtes. Revue Statistique Appliquee. LII (4). pp. 93-111.

Peliz, A., Dubert, J., Santos, A., Oliveira, P. and Le Cann, B. 2005. Winter upper ocean circulation in the Western Iberian Basin ï Fronts, Eddies and Poleward Flows: an overview. Deep Sea Research I 52, 621ï 646.

Peliz, A., Rosa, T., Santos, A. and Pissarra, J. 2002. Fronts, jets, and counter flows in the Western Iberian upwelling system. Journal of Marine Systems 35, 61ï 77.

Prista. N., Jardim, E., Fernandes, A.C., Silva, D., Ferreira, A.L., Abreu, P., Fernandes, P. 2012. Manual of Onboard Sampling Procedures: Fixed Gears. Relatórios Cientícos e Técnicos do Instituto Investigação das Pescas e do Mar, 56 (pp. 23 + Annexes).

Prista, N. and Fernandes, C. 2013. Discards of elasmobranchs by the Portuguese bottom otter trawl and deep-water set longline fisheries operating in ICES Division XIa (2004ï 2012). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17ï 21th June, 2013-15.

R Development Core Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna. Austria. ISBN 3-900051-070. http://www.R-project.org.

Relvas, P., Barton, E., Dubert, J., Oliveira, P., Peliz, A., da Silva, J. and Santos, A. 2007. Physical oceanography of the western Iberia, ecosystem: Latest views and challenges, Prog. Oceanogr., 74, 149ï 173.

Relvas, P., Luís, J. and Santos, A.M.P. 2009. Importance of the mesoscale in the decadal changes observed in the northern Canary upwelling system, Geophys. Res. Lett., 36, L22601, doi:10.1029/2009GL040504

Rodríguez-Cabello, C. Fernández A., I. Olaso, F. Sánchez, F., Gancedo, R., Punzón, A. and Cendrero, O.2005. Overview of Continental Shelf Elasmobranch Fisheries in the Cantabrian Sea. J. Northw. Atl. Fish. Sci., Vol. 35:

Sánchez, F., 1993. Las comunidades de peces de la plataforma del Cantábrico. Publicaciones Especiales del Instituto Español de Oceanografía, 13, 137 pp.

Sánchez, F., Blanco, M., Gancedo, R., 2002. Atlas de los peces demersales y de los invertebrados de interés comercial de Galicia y el Cantábrico. Otoño 1997-1999. Instituto Español de Oceanografia. MYC Ed.CYAN. Madrid, pp. 158

Sánchez, F., Rodríguez-Cabello, C. and Olaso, I., 2005. The Role of Elasmobranchs in the Cantabrian Sea Shelf Ecosystem and Impact of the Fisheries on Them. J. Northw. Atl. Fish. Sci., Vol. 35: 467ï 480

Santos, A.M.P., Borges, M.F. and Groom, S. 2001. Sardine and horse mackerel recruitment and upwelling off Portugal. ICES Journal of Marine Science. Vol 58, No 3, 589-596.

Santos, A.M.P., Peliz, Á.J., Dubert, J., Oliveira, P.B., Angelico, M.M. and P. Ré. 2004. Impact of a winter upwelling event on the distribution and transport of sardine (Sardina pilchardus) eggs and larvae off western Iberia: a retention mechanism. Continental Shelf Research, 24: 149-165.

Serra-Pereira, B., Erzini, K., Maia, C. and Figueiredo, I. 2014. Identification of potential essential fish habitats for skates based on fishersô knowledge. Environmental Management, 53(5):985-98.

Shono, H. 2008. Application of the Tweedie distribution to zero-catch data in CPUE analysis. Fisheries Research 93: 154-162.

Stehmann, M.F.W. and Bürkel, D.L. 1984. Rajidae. In Fishes of the North-eastern Atlantic and the Mediterranean, volume 1, pp. 163-196. Ed. by P. J. P. WHITEHEAD, M. BAUCHOT, J. HUREAU, J. NIELSEN and E. TORTONESE. UNESCO, Chaucer Press, UK.

Steven, G. A. 1936. Migrations and Growth of the Thornback Ray (*Raja clavata* L.). Journal of the Marine Biological Association of the United Kingdom 20: 605-614.

Velasco, F, Olaso, I. and Serrano, A., 2002. Alimentación de tres especies de la familia Rajidae en el sur del Golfo de Vizcaya. ICES CM/2002

Venables, W.N. and Ripley, B.D. 2002. Modern Applied Statistics with S, Fourth ed. Springer, New York.

Walker, P. A., Howlett, G. and Millner, R. 1997. Distribution, movement and stock structure of three ray species in the North Sea and eastern English Channel. ICES Journal of Marine Science 54: 797-808.

Stock Annex

Stock specific documentation of standard assessment procedures used by ICES.

Stock *Raja undulata* in Western Iberian Waters (west of Galicia, Portugal, and Gulf of Cadiz) (ICES Division IXa)

Working Group: WGEF 2014

Date:

Revised by:

A. General

A.1. Distribution

Global distribution: *Raja undulata* (undulate ray) is a coastal benthic species with a wide geographic distribution in the northeast Atlantic and Mediterranean (Stehmann and Bürkel, 1984).

Species distribution in IXa: The species displays a patchy distribution along the division IXa area.

In mainland Portugal *Raja undulata* occurs along the continental coast, being more frequently caught in the some areas of north off Matosinhos and Aveiro, in the centre off Peniche (Figure 1), in the southwest coast off Setúbal (Baeta *et al.* 2010) and in the Algarve (Coelho *et al.* 2005). The species, particularly juveniles, is also registered in estuarine and lagoon habitats, like Tagus River (centre of Portugal) and Ria Formosa (south of Portugal). In the first area, data derived from fishing hauls performed during four research surveys onboard Aquário Vasco da Gama research vessel (with a total of 13 hauls), showed that the species occurred in 50% of the trips and in 31% of the fishing hauls. Although the bathymetric distribution of the species ranges from 4 to 128 m deep, it is more abundant between 30 and 40 m deep.

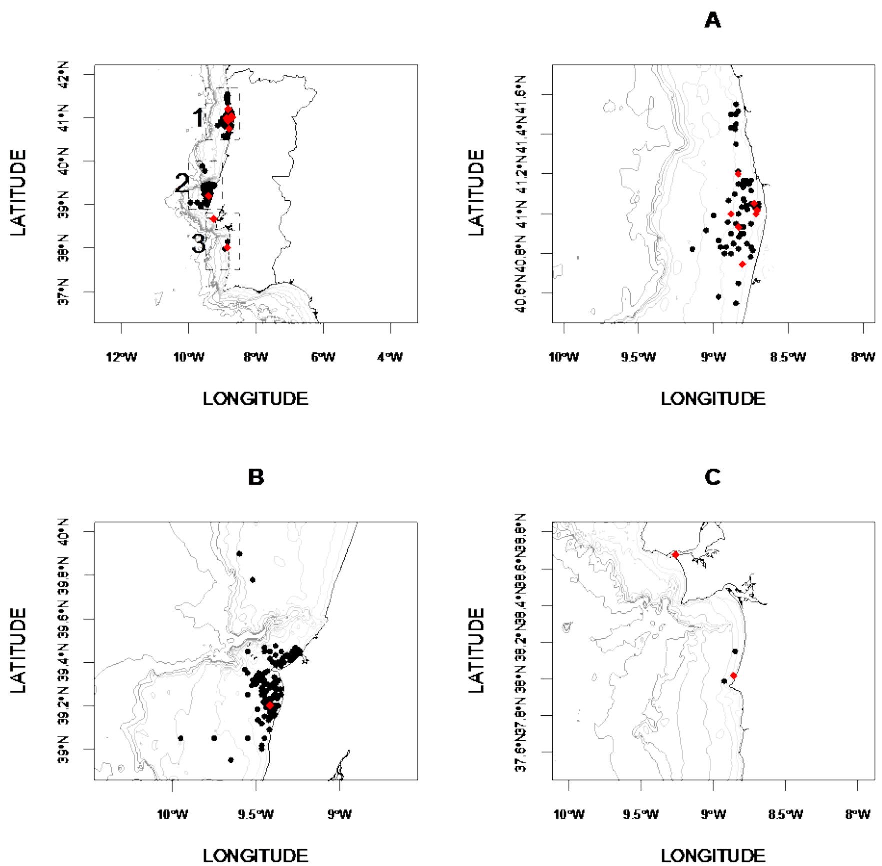


Figure 1 - Portuguese continental coast (ICES Division IXa). Distribution of *Raja undulata* (black) and egg-laying areas (red), detailed by area: 1) north (n=80), 2) centre (n=247) and 3) southwest (n=4).

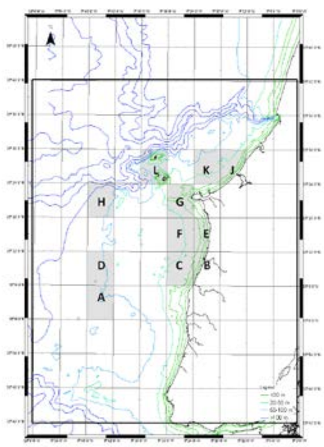
A.2. Species dynamics

In the Portuguese coast this species mainly occurs associated to sand or coarse sand bottoms, sometimes mixed with shells. Fishery data and fishermen information recorded in interviews give support to the concentration of the species in specific places along the Portuguese continental coast. This spatial pattern is in accordance with the patchy distribution admitted for the species in other areas. In fact such pattern has been also observed in other European areas. In those areas, it is further admitted that there is little exchange between discrete areas, within which the species may be locally abundant (Ellis *et al*., 2012).

In Portuguese continental areas, egg-laying sites of this species were observed along the coast (north, centre and southwest regions), between 10 and 55 m depth (but mainly at depths shallower than 30 m). Estuaries and coastal lagoons are likely to be important habitats for the species, since both newborn/juveniles and egg-laying females were mainly found to occur in those areas.

At the centre off Portuguese continental coast, Santa Cruz (B), Areia Branca (E) and Foz do Arelho (J) were the fishing grounds where *R. undulata* are more abundant (Table 1). Those three grounds are located close to shore and shallower than 50 m deep, with a geomorphology dominated by underwater beaches. In those fishing grounds the species is present all year round, but its abundance is higher during the second quarter of the year. Additionally, off Santa Cruz (C) and Berlengas (L), nursery sites were identified (Serra-Pereira *et al.*, 2014).

Table 1. Portuguese continental coast (ICES Division IXa). Description of the main fishing grounds around the Peniche where *Raja undulata* occurs. Information on: location, depth range, geomorphology, catch percentages of *Raja undulata* in weight in relation to the total catch of skate species, TL range (cm) and identification of nursery areas.



	Name (coordinates)	Depth range (m)	Geomorphology	Catches (%)	TL range (cm)	*Nursery area*
B	***Santa Cruz*** (39.2ºN, 9.4ºW)	15-55	The skates found in this fishing ground were captured in sand seabed close to rocks.	18.1%	40-95	
C	***Off Santa Cruz*** (39.2ºN, 9.5ºW)	15-110	The skates found in this fishing ground were captured in sand seabed close to rocks.	5.8%	42-90	✓
E	***Areia Branca*** (39.3ºN, 9.4ºW)	13-73	The sand on this fishing ground is mixed with shells.	24.6%	49-93	
F	***Off Areia Branca*** (39.3ºN, 9.5ºW)	24-73	The sand on this fishing ground is mixed with shells	5.3%	44-95	
G	***Mar do Cachimbo*** (39.4ºN, 9.5ºW)	18-110	Isthmus (rocky bottom) that makes the connection between the islands off Peniche and the mainland, at between 30 and 40 m depth [2]	2.3%	41-82	
J	***Foz do Arelho*** (39.5ºN, 9.3ºW)	15-91	Seabed composed of black sand, muddy sand and mud, but to northeast (i.e. closer to this spatial unit) the seabed is composed mostly of black sand [1]	14.5%	49-96	
K	***Baleal*** (39.5ºN, 9.4ºW)	18-128	Situated between the 30 and 50 m isobaths, with seabed composed of a compact sediment with high levels of clay with interstratified levels of sand, overlaid by sandstones or medium orange grains and	9.6%	48-90	

			some disseminated pebbles. Between Óbidos Lagoon (near Foz do Arelho) and Peniche the coastline is sandy, with narrow beaches, and interrupted by rocky outcrops [3,4].			
L	***Berlengas*** (39.5ºN, 9.6ºW)	18-548	Irregular seabed (with many protruding rocks), composed mainly of rock surrounded by sand [1]	9.4%	45-91	✓

[1] Boavida, 1948; [2] Vanney and Mougenot 1981; [3] Diniz, 1988; [4] Ferreira et al. 1989.

A.3. Stock definition

Although in ICES area the stock structure of the species is unknown, short range migrations between different areas of species concentration are admitted (ICES, 2013). For advice purposes, ICES considers a distinct stock unit for Division IXa (west of Galicia, Portugal, and Gulf of Cadiz).

A.4. Fisheries

In ICES Division IXa no fisheries targeting *R. undulata* are known to occur.

An important artisanal fleet that frequently catches Rajidae (represents around 8.7 % of Galicia total landings from the different ICES areas) operates inside Galicia estuaries with different types of gillnets, particularly the *miño*. A sampling program carried out between 2004 and 2006 showed that 44% of the skates sampled corresponded to *R. undulata* (Bañón *et al*., 2008).

In Portuguese continental coast the data collected under the Pilot Study on Skates (EU DCF) and EU PNAB/DCF indicates that *R. undulata* is more frequently caught by the polyvalent fleet, particularly by trammel nets, than by the trawl fleet (Figure 2). This may reflect differences on fishing grounds where the two fleets operate: the polyvalent fleet may operate close to the coast while trawl fleet is only allowed to operate at a distance 6 nm apart from the coast, where the species is not so abundant.

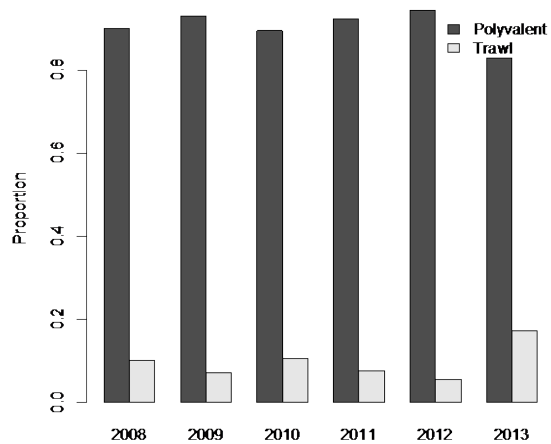


Figure 2 - Portuguese continental coast (ICES Division IXa). Estimated catches of *Raja undulata*, for the polyvalent and trawl fleet segments.

A.5. Ecosystem aspects

In the west coast of the Iberian Peninsula the most important features enhancing primary production are coastal upwelling, coastal runoff and river plumes, seasonal currents and internal waves and tidal fronts. Maximum values of chlorophyll usually occur in spring and summer (Nogueira *et al.*, 1997; Moita, 2001), although high chlorophyll values may be recorded in autumn, particularly in zones with elevated retention characteristics; for example, high chlorophyll concentrations are found in the Rías Baixas, at the time of the seasonal transition from upwelling to downwelling (Nogueira *et al.*, 1997; Figueiras *et al.*, 2002). Most of the west Iberian coast, including Galicia and Cantabrian Sea continental shelf, is occupied by cold waters rich in nutrients (Gil, 2008).

The north-south orientation of the coast causes winds from the north to produce offshore transport. During spring and summer, northerly winds along the coast are dominant causing coastal upwelling and producing a southward current at the surface and a northward undercurrent at the slope (Figure 3a) (Fiúza *et al.*, 1982; Alvarez-Salgado *et al*., 2003; Peliz *et al*., 2005; Mason *et al.*, 2006). During winter the prevailing winds are mainly south-westerly, and the atmospheric circulation is dominated by eastward displacement of cyclonic perturbations and their associated frontal systems (Figure 3b) (Relvas *et al.*, 2007). However, in some years the presence of episodic atmospheric anti-cyclonic circulation (the Azores High) could give rise to northerly wind events during winter (Santos *et al.*, 2001; Borges *et al*., 2003). Indeed, investigations on upwelling along the Galician coast in autumn and winter have been characterized in the Galician rias, indicating that the upwelling process along the Galician coast is not a phenomenon restricted to spring and summer (Alvarez *et al*., 2012).

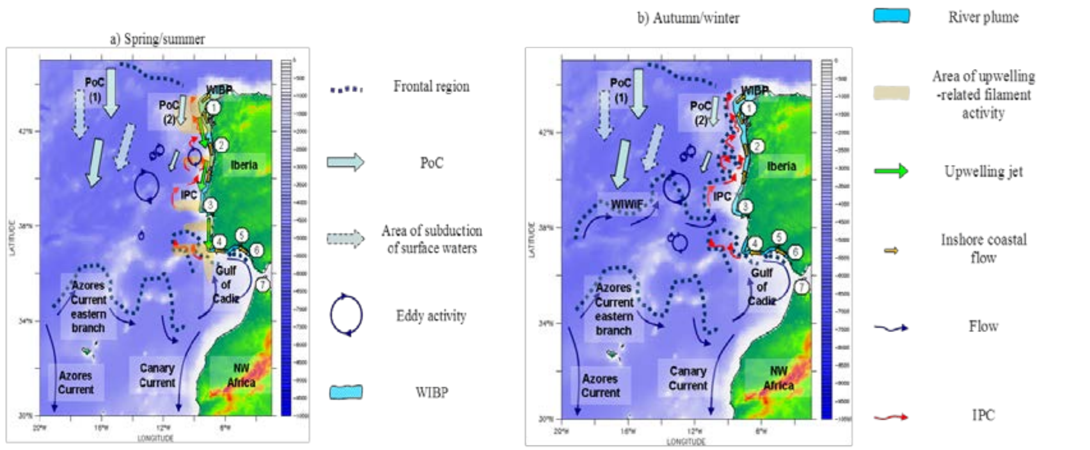


Figure 3 - The western Iberia and Gulf of Cadiz regimes in a) spring and summer, and b) autumn and winter. 1) Cape Finisterre; 2) River Douro; 3) Cabo da Roca; 4) Cape St. Vincent; 5) Guadiana River; 6) Guadalquivir River; 7) Strait of Gibraltar. PoC - southward-flowing Portugal Current, WIBP - Western Iberia Buoyant Plume, IPC - Iberian Poleward Current (Adapted from Peliz *et al*. 2002; Peliz *et al*. 2005).

In winter the Poleward Current (PC) flows northerly. It is a salty surface current (about 200 m deep) of subtropical origin (Eastern North Atlantic Water, also known as the 'Navidad' Current, since because it starts to be evident near Christmas and New Year) and relatively warmer than the surrounding ones (Castro *et al.*, 2011). During winter and spring, the PC results in a convergent front at the boundary between coastal and oceanic water. When saline intrusion is weak, the development of fronts and the formation of a seasonal thermocline are enhanced, leading to phytoplankton blooms. When saline intrusion is intense, strong vertical mixing occurs and prevents phytoplankton growth in spring (Moita, 2001; Santos *et al.*, 2004).

The intermediate deep layers are mainly occupied by a poleward flow of Mediterranean Water (MW), which contours the southwestern slope of the Iberia (Ambar and Howe, 1979), generating the mesoscale features called Meddies. The MW along the west coast of the Iberian Peninsula is characterized by a transport of warm and salty water (typical surface anomalies, 1–1.5ºC and 0.1–0.3‰ in salinity) with velocities up to some 0.2–0.3 m s^{-1} reported by Frouin *et al*. (1990).

The Sea Surface Temperature (SST) registered a generalized warming of a few hundredth of degrees a year since 1960, ranging from 0.015°C/year to 0.037°C/year (Relvas *et al*., 2009). The SST increase has effect on species populations (e.g. recruitment success, migrations changes) (Brander *et. al*., 2003).

In the Gulf of Cadiz the most important oceanographic process is the occurrence of a strong interaction between two masses of water, the Atlantic Ocean and the Mediterranean Sea through the Strait of Gibraltar. In general, the exchange of water masses through Strait of Gibraltar is guided by the highly saline and warm Mediterranean Outflow Water near the bottom, and the turbulent, less saline, cool-water mass of the Atlantic Intermediate Water at the surface. The pattern of surface circulation is ruled by a clockwise movement, with a general W to E superficial current, whereas the deep circulation is controlled by the westerly current of the highly saline (salinity>37 PSU) Mediterranean water existing through the Strait.

Bottom temperatures are extremely variable ranging between 3ºC and 20.6ºC whereas values of bottom salinity along the continental shelf range from 35.8 to 36 PSU (Díaz *et al.*, 2006). In the slope there is a wide band with values around 37 PSU, the lower slope showing the minimum values which correspond to the Deep Atlantic Water Mass (Díaz *et al.*, 2006).

The continental slope can be differentiated into four provinces: a) a narrow belt between 130 and 400 m formed by the steep upper slope; b) two gently dipping wide terraces located between 400 and 700 m depth; c) a central sector between the terraces in which several, steep and narrow curvilinear ridges and valleys are located trending NE-SW to E-W; d) the lower slope-upper continental rise at water depths from 900 down to 1500-1800 m. Below 900 m, the lower slope is steeply dipping and generally smooth except for shallow valleys placed in a NE-SW direction (Nelson *et al.*, 1993). The main sedimentary types occurring over the slope are bioclastic sands, silicoclastic sands and muddy sands, sandy muds, sandy and muddy contourites (Díaz *et al.*, 1985).

B. Data

B.1. Commercial landings and discards

Due to the EU legislation adopted for *R. undulata* (Council regulation (EC) No 43/2009), discards of this species are likely to have increased since 2009. *Raja undulata* is mainly captured by small artisanal vessels with little conditions to hold observers and enable data collection on captures and discards. However, information collected until 2010 and onboard data shows that both the frequency of occurrence and the catch rate of the species along the occidental coast off mainland Portugal are higher in areas off Matosinhos and Aveiro. Information collected on landing ports (interviews to fishermen) also indicates a high frequency of occurrence in catches from the polyvalent fleet in Sines and Olhão. In fact, despite the irregular estimates, relatively high abundances in the catches of this species by the polyvalent fleet were registered in 2009 and in 2012 for each landing port, respectively.

The interquartile range of the catch (kg) by fishing trip for Torreira and Espinho (located off Matosinhos and Aveiro), Baleal and off Santa Cruz (located off Peniche) and Cabo Raso (located off Cascais) are presented in Figure 4. The median estimates of the catch weight were similar between Torreira, Espinho, Baleal and off Santa Cruz. In the first two fishing grounds the catches reached a maximum value of 112 kg per trip, which corroborates the higher abundance of the species in that area.

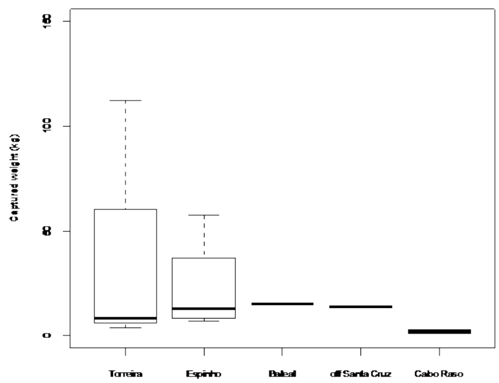


Figure 4 - Portuguese continental coast (ICES Division IXa). Interquartlie ranges of captured weight (Kg) by trip of *Raja undulata,* recorded onboard fishing vessels using trammel nets, by fishing ground: a) located off Matosinhos and Aveiro - Torreira (n=6 hauls) and Espinho (n=7 hauls); b) located off Peniche - Baleal (n=11 hauls) and off Santa Cruz (n=8 hauls); c) located off Cascais - Cabo Raso (n=4 hauls).

Information on discards of *R. undulata* produced by the Portuguese polyvalent (gillnets and trammel nets) and bottom otter trawl segments operating in the ICES Division IXa has been collected under the Data Collection Framework (EU DCR). The level of discard is very low (Prista *et al.*, 2014 WD) and the information available is insufficient to reach robust estimates of discards.

In the Gulf of Cadiz, catch and landing data from commercial fisheries are often poor because of a general lack of species-specific recordings. No management program has been established yet in this area. Fisheries research has traditionally been focused on the most commercially important teleosts and poor research has been undertaken on chondrichthyans.

B.2. Length frequency distribution

In Portuguese continental coast, the data collected under the EU Data Collection Framework (DCF, PNAB), since 2008, and under the Pilot Study on Skates (included in DCF) during 2011-2013, show that in recent years the length structure of the population caught shifted to larger individuals. Also, length frequency distribution of the catches is different between fishing gears (Figure 5).

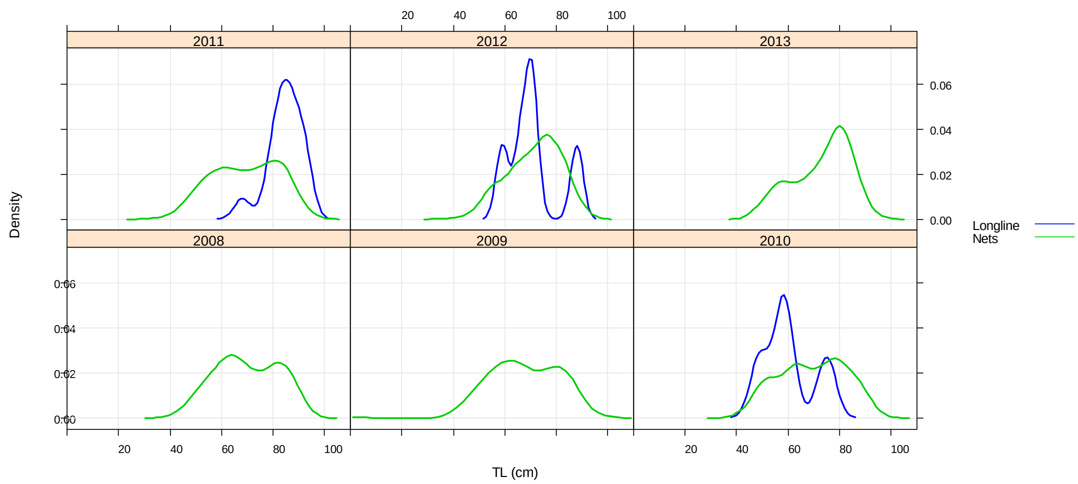


Figure 5. Portuguese continental coast (ICES Division IXa). Length frequency distribution of *Raja undulata* by fishing gear (longline and nets) for the period 2008-2013.

From data collected onboard fishing vessels operating with trammel nets at different areas off the Portuguese continental coast, caught specimens of *R. undulata* measured between 47 and 88 cm total length. The interquartile range of specimen's total length (Figure 6) and the sex ratio (1:1) was similar between regions. This pattern is in agreement with the patchy distribution admitted for the species, which implies that the species concentrate in specific areas within which it is able to develop the whole life cycle.

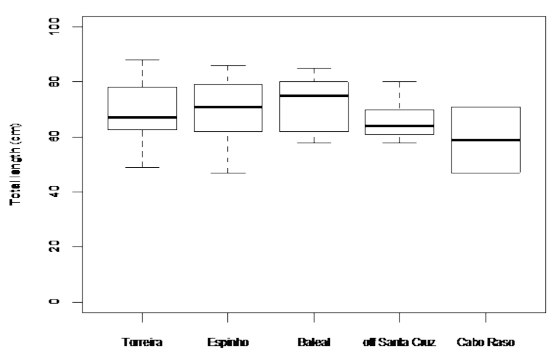


Figure 6. Portuguese continental coast (ICES Division IXa). Interquartlie range of specimen's total length (cm) of *Raja undulata*, recorded onboard fishing vessels operating with trammel nets, by fishing ground: a) located off Matosinhos and Aveiro - Torreira (n=6 hauls) and Espinho (n=7 hauls); b) located off Peniche - Baleal (n=11 hauls) and off Santa Cruz (n=8 hauls); c) located off Cascais - Cabo Raso (n=4 hauls).

B.3. Survivorship

Under the scope of the EU DCF skate pilot study carried out in mainland Portugal, data on survivorship of *R. undulata* after fishing was collected onboard fishing trips of polyvalent vessels operating with trammel or gillnets. Survivorship was qualitatively evaluated by assuming that the health status of fish after capture is a good indicator of the survivorship index (Enever *et al.*, 2009). The following scale was used to assign health status to each sampled individual (Enever *et al.*, 2009): 1) Good: vigorous wing/body movement and rapid spiracle movement; 2) Moderate: limp wing/body and spiracle movement and; 3) Poor: dead or nearly dead, no body movement, slight spiracle movement.

There are no studies about skates´ survivorship neither in the west of Galicia nor in the Gulf of Cadiz.

B.4. Commercial CPUE

The index of abundance of *Raja undulata* was estimated from the Portuguese polyvalent segment as the landed weight of the species per trip (fishing effort unit), CPUE, and using data collected onboard commercial vessels. CPUE standardisation was constrained to the polyvalent fleet, since the species has no representatively in the trawl segment. Within the polyvalent segment, and since the species is more frequently caught with nets (particularly trammel nets), the latter it was admitted that the standardized CPUE using fishery data derived from nets is representative of the polyvalent segment.

B.5. Biology

The potential rate of population increase was calculated following the proxy proposed by Jennings *et al*. (1999), which assumes a single annual peak of egg-laying. The value of *r'*, when compared to that of other species allows to indirectly evaluate the productivity of a species comparing their vulnerability to fishing.

Natural mortality was calculated using two methods, Pauly's (1980) and Jensen's (1996). And the growth-maturity-longevity relationship calculated as L_{50}/L_∞ vs. $k*L_\infty$ (Frisk *et al*. 2001), which theoretically indicates where the maximum possible yield is reached if the entire cohort is harvested (Holt 1958).

Table 2 summarizes all the biological data available.

Table 2 - Portuguese continental coast (ICES Division IXa). Summary of biological information published for *Raja undulata*.

Period	1999-2001	1999-2001	2003-2006	2001-2008	2003-2013
Region	Algarve	Algarve	Centre	North/Centre	North/Centre
Depth range (m)	-	-	-	-	4 to 128 (mostly 30-40)
Egg-laying depth range (m)	-	-	-	-	10 to 55 (mostly < 30)
TL range (cm)	19.4-88.2	32.0-83.2	23.7-90.5	48.0-95.9	23.5-95.9
$\mathbf{L_{50}}$ (cm) F	76.2	-	83.8	-	86.2±2.6
M	73.6	-	78.1	-	76.8±2.4
$\mathbf{I_{50}}$ (years) F	8.98	-	9	-	8.7±0.3
M	7.66	-	8	-	7.6±0.4
$\mathbf{M_{50}}$ **(cm)**	-	-	-	-	95.7±15.3
Reproductive period	Dec-Feb	-	Feb-May	-	Dec-Jun
Fecundity (eggs per female)	-	-	-	-	69.8±3.4
Fecundity/batch (eggs per female)	-	-	-	-	15
Number of batches	-	-	-	-	3.6
Size-at-birth (cm)	-	-	-	-	13.5
L_{max} (cm)	88.2	83.2	90.5	-	95.9
$\mathbf{L_\infty}$ (cm)	110.2	119.3	113.7	-	-
k (year^{-1})	0.11	0.12	0.15	-	-
$\mathbf{t_0}$ (years)	-1.58	-0.41	-0.01	-	-
I_{max} (years)	13	9	12	-	12.6
I_∞ (years)	-	28.9	23.6	-	-
$\mathbf{TW \sim aTL^b}$ **a**	-	-	-	1.92*10^{-5}	-
b	-	-	-	2.86	-
r' (Jennings et al. (1999)	-	-	-	-	0.49
M (Jensen 1996)	-	-	-	-	0.24
(Pauly 1980)	-	-	-	-	0.27
References	[1], [2]	[3]	[3]	[4]	[5]

(*TL*: total length; L_{50}: size-at-maturity; I_{50}: age-at-maturity; M_{50}: size-at-maternity; Fecundity; L_∞: asymptotic length; *k*: growth rate; t_0: size ate age-0; L_{max}: maximum observed length; I_{max}: maximum observed age; $\mathbf{I_\infty}$: maximum theoretical age; $TW \sim aTL^b$: weight-length relationship; *r'*: potential rate of population increase; M: natural mortality)

[1] Coelho and Erzini 2002; [2] Coelho and Erzini 2006; [3] Moura et al. 2007; [4] Serra-Pereira et al. 2010; [5] Serra-Pereira et al. *submitted*.

B.6. Surveys

The surveys available for this area were not designed primarily to inform on the populations of *R. undulata*, which presents a patchy and shallower distribution. The gears used, timing of the surveys and distribution of sampling stations are considered not optimal for informing on the species and/or life-history stages.

C. Assessment: data and method

Data:

- Fishery dependent data:
  - Landings estimates by species
  - Fishing effort (unit: number of fishing trips) by fishing gear
  - Length frequency distribution by fishing gear
  - Discards
- Fishery independent data
  - Portuguese Autumn Groundfish Surveys (PT-GFS) catch rate ($kg.haul^{-1}$)
  - Length distribution

Methods:

1) Standardized CPUE for the polyvalent fleet using nets in Portuguese continental waters

In the standardization process of CPUE, a stepwise generalized linear model (GLM) procedure was applied to find the best GLM model and an estimate CPUE index time series based on the relationship between CPUE vs. available predictive factor variables.

The function bestglm implemented in R software was used to select the best subset of inputs variables (McLeod AI and Xu, 2010). The selection was based on a variety of information criteria and their comparison, following a simple exhaustive search algorithm (Morgan and Tatar, 1972). This algorithm uses a lexicographical method that evaluates the loglikelihoods for all possible glm models. Lognormal error distribution was assumed in the standardization. This distribution is commonly assumed for standardizing catch and effort data, assuming that the expected value of a transformed response variable is related to a linear combination of exploratory variables (Maunder and Punt, 2004).

Different diagnostic plots, e.g. the distribution of residuals and the quantile-quantile (Q-Q) plots, were used to assess the error distribution (assuming lognormal distribution), as well as the model fits for the standardization of the CPUE. Changes in deviance explained by the selected model and the proportions of deviance explained to the total explained deviance was determined and used as indicative of r^2.

The standard errors of the year effects and CPUE for a reference conditions, in the present case: net as fishing gear, 1st quarter of the year; medium vessel size and constant seasonality, were calculated by the delta method. The delta method is commonly applied when functions are too complex for analytically computing their variance. According to this method, a linear approximation of the function, usually with a one-step Taylor approximation, is firstly obtained and then its variance is computed (Oehlert, 1992).

Software used:

All the data analysis was performed in R software (R Development Core Team, 2009).

I. References

Álvarez, I., Prego, R., de Castro, M., and Varela, M., 2012. Galicia upwelling revisited: out-of-season events in the rias (1967–2009). Ciencias Marinas, 38 (1B): 143–159.

Alvarez-Salgado, X., Figueiras, F., Perez, F., Groom, S., Nogueira, E., Borges, A., Chou, L., Castro, C., Moncoiffe, G., Rios, A., Miller,A., Frankignoulle, M., Savidge, G., and Wollast, R. 2003. The Portugal coastal counter current off NW Spain: new insights on its biogeochemical variability. Progress in Oceanography, 56:281–321.

Ambar, L., and Howe, M.R. 1979. Observations of the Mediterranean outflow-I Mixing in the Mediterranean outflow. Deep-Sea Research, 26:535-554.

Baeta, F., Batista, M., Maia, A., Costa, M.J., and Cabral, H. 2010. Elasmobranch bycatch in a trammel net fishery in the Portuguese west coast. Fisheries Research, 102:123-129. doi:10.1016/j.fishres.2009.10.016

Bañon, R., Quinteiro-Fernández, R., García-Tasende, M., Juncal-Caldas, L.M., Campelos-Álvarez, J.M., Gancedo-Baranda, A., Lamas-Rodríguez, F., Morales-de-la-Fuente, C., and Ribó-Landín, J., 2008. Composición, distribución y abundancia de rayas (Elasmobranchii: Rajidae) en aguas costeras de Galicia. Foro dos Recursos Mariños e da Acuicultura das Rías. Galegas, 10:325-331.

Boavida, J.G. 1948. Roteiro de Pesca de Arrasto da Costa Continental Portuguesa. 285 pp

Borges, M.F., Santos, A.M.P., Crato, N., Mendes, H., and Mota, B. 2003. Sardine regime shifts off Portugal: a time series analysis of catches and wind conditions. In Fish Stock Assessments and predictions: Integrating Relevant knowledge (editors O. Ulltang and G. Blom) Scientia Marina Volume 67, Suplement 1, April 2003.

Brander, K., Blom, G., Borges, M., Erzini, K., Henderson, G., MacKenzie, B., Mendes, H., Santos, A., and Toresen R. 2003. Changes in fish distribution in the eastern North Atlantic: Are we seeing a coherent response to changing temperature? ICES Marine Science Symposium, 219, 261–270.

Castro, M., Gómez-Gesteira, M., Álvarez, I., and Crespo, A.J.C. 2011. Atmospheric modes influence on Iberian Poleward Current variability. Continental Shelf Research, 31:425–432.

Coelho, R., and Erzini, K. 2002. Age and growth of the undulate ray, *Raja undulata*, in the Algarve (southern Portugal). Journal of the Marine Biological Association of the United Kingdom, 82: 987-990.

Coelho, R., and Erzini, K. 2006. Reproductive aspects of the undulate ray, *Raja undulata*, from the south coast of Portugal. Fisheries Research, 81:80-85.

Coelho, R., Erzini, K., Bentes, L., Correia, C., Lino, P. G., Monteiro, P., Ribeiro, J., and Gonçalves, J.M.S. 2005. Semi-pelagic longline and trammel net elasmobranch catches in Southern Portugal: catch composition, catch rates and discards. Journal of Northwest Atlantic Fishery Science, 35:531-537.

Díaz, J.I., Farrán, M., and Maldonado, A. 1985. Surfical sediment distribution patterns in the Gulf of Cádiz controlled by the geomorphic features and physical oceanographic parameters. 6th European Regional Meeting of Sedimentology. I.A.S., Lleida 85: 129-132.

Díaz, V., L.M., Fernández, J.G., Ramos, F., and Jiménez, M.P. 2006. Gulf of Cadiz Regional Ecosystem. ICES Working Group for Regional Ecosystem Description. ICES/WGRED 2006.

Diniz, F. 1988. Análise polínica da jazida carbonosa a SW do vale da janela (Ferrel). In: JNICT (ed) Reunião do projecto: dinâmica sedimentar da plataforma continental a norte de Peniche. Museu Nacional de História Natural - Museu e Laboratório Mineralógico e Geológico. Lisboa, pp 21–22.

Ellis, J.R., McCully, S.R., and Brown, M.J. 2012. An overview of the biology and status of undulate ray Raja undulata in the north-east Atlantic Ocean. Journal of Fish Biology, 80:1057-1074.

Enever, R., Catchpole, T.L., Ellis, J.R., and Grant, A. 2009. The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters. Fisheries Research, 97(1–2):72-76.

Ferreira, O., Dias, J.A., and Carvalho, G.S. 1989. Síntese de conhecimentos sobre a dinâmica sedimentar da zona costeira entre Peniche e o rio Minho. Rel. DISEPLA: 8/88. 31 pp

Figueiras, F. G., Labarta, U., and Fernández-Reiriz, M. J. 2002. Coastal upwelling, primary production and mussel growth in the Rías Baixas of Galicia. Hydrobiologia, 484: 121-131.

Fiúza, A.F.G., Macedo, M.E. and R. Guerreiro, 1982. Climatological space and time variations of the Portuguese coastal upwelling. Oceanologica Acta, 5: 31-40.

Frouin, R., Fiúza, A.F.G., Ambar, I., and Boyd, T.J. 1990. Observations of a poleward surface current off the coasts of Portugal and Spain during winter. Journal of Geophysical Research, 95: 679–691.

Gil, J., 2008. Macro and mesoscale physical patterns in the Bay of Biscay. Journal of the Marine Biological Association of the UK, 88 (2): 217-225.

ICES, 2013. Report of the Working Group on Elasmobranch Fishes (WGEF), 17–21 June 2013, Lisbon, Portugal. ICES CM2013/ACOM:19. 680pp.

Jennings, S., Greenstreet, S.P.R., and Reynolds, J.D. 1999. Structural change in an exploited fish community: a consequence of differential fishing effects on species with contrasting life histories. Journal of Animal Ecology 68, 617-627.

Jensen, A.L. 1996. Beverton and holt life history invariants result from optimal trade-off of reproduction and survival. Canadian Journal of Fisheries and Aquatic Sciences 53, 820–822.

Mason, E., Coombs, S., Oliveira, P., Angélico, M.M., and Stratoudakis, Y. 2006. An overview of the literature concerning the oceanography of the eastern North Atlantic region. Relat. Cient.Téc. Inst. Invest. Pescas Mar. Série Cooperação, 51pp.

Maunder, M.N., and Punt, A.E. 2004. Standardizing catch and effort data: A review of recent approaches. Fisheries Research, 70: 141-159.

McLeod, A.I., and Xu, C. 2010. bestglm: Best Subset GLM. URL http://CRAN.R-project.org/package=bestglm.

Moita, T. 2001. Estrutura, variabilidade e dinâmica do Fitoplâncton na costa de Portugal Continental. PhD Thesis. University of Lisbon, Portugal. 272 pp.

Morgan, J.A., and Tatar J.F. 1972. Calculation of the Residual Sum of Squares for all Possible Regressions. Technometrics, 14, 317-325.

Moura, T., Figueiredo, I., Farias, I., Serra-Pereira, B., Coelho, R., Erzini, K., Neves, A., and Gordo, L. S. 2007. The use of caudal thorns for ageing Raja undulata from the Portuguese continental shelf, with comments on its reproductive cycle. Marine and Freshwater Research 58: 983-992.

Nelson, C.H., Baraza, J., and Maldonado, J. 1993. Mediterranean undercurrent sandy contourites, Gulf of Cadiz, Spain. In: D.A.V. Stow and J.C. Faugeres (Editors), Contourites and bottom currents. Sedimentary Geology, 82: 103-131.

Nogueira, E., Pérez, F.F., and Ríos, A.F. 1997. Modelling thermohaline properties in an estuarine upwelling ecosystem (Ria de Vigo; NW Spain) using Box-Jenkins transfer function models. Estuarine, Coastal and Shelf Science, 44: 685-702.

Oehlert, G. W. 1992. A note on the delta method. The American Statistician, 46: 27-29.

Pauly, D. 1980. On the interrelationship between natural mortality, growth parameters, and mean environmental temperatures in 175 fish stocks. Journal du Conseil, 39: 175–192.

Peliz, A., Dubert, J., Santos, A., Oliveira, P. and Le Cann, B. 2005. Winter upper ocean circulation in the Western Iberian Basin – Fronts, Eddies and Poleward Flows: an overview. Deep Sea Research I 52, 621–646.

Peliz, A., Rosa, T., Santos, A. and Pissarra, J. 2002. Fronts, jets, and counter flows in the Western Iberian upwelling system. Journal of Marine Systems 35, 61–77.

Prista, N., Fernades, A., Maia, C., Moura, T., and Figueiredo I. 2014. Discards of elasmobranchs in the Portuguese fisheries operating in ICES Division XIa: Bottom otter trawl, deepwater set longlines, set gillnet and trammel net fisheries (2004–2013). WD WGEF 2014, Lisbon, 17–26 June 2014 : 20 pp.

R Development Core Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna. Austria. ISBN 3-900051-070. http://www.R-project.org.

Relvas, P., Barton, E., Dubert, J., Oliveira, P., Peliz, A., da Silva, J. and Santos, A. 2007. Physical oceanography of the western Iberia, ecosystem: Latest views and challenges, Prog. Oceanogr., 74, 149–173.

Relvas, P., Luís, J. and Santos, A.M.P. 2009. Importance of the mesoscale in the decadal changes observed in the northern Canary upwelling system, Geophys. Res. Lett., 36, L22601, doi:10.1029/2009GL040504

Santos, A.M.P., Borges, M.F., and Groom, S. 2001. Sardine and horse mackerel recruitment and upwelling off Portugal. ICES Journal of Marine Science. Vol 58, No 3, 589-596.

Santos, A.M.P., Peliz, Á.J., Dubert, J., Oliveira, P.B., Angelico, M.M., and P. Ré, 2004. Impact of a winter upwelling event on the distribution and transport of sardine (Sardina pilchardus) eggs and larvae off western Iberia: a retention mechanism. Continental Shelf Research, 24: 149-165.

Serra-Pereira, B., Farias, I., Moura, T., Gordo, L. S., Santos, M., and Figueiredo, I. 2010. Morphometric ratios of six commercially landed species of skate from the Portuguese continental shelf, and their utility for identification. ICES Journal of Marine Science, 67: 1596-1603.

Serra-Pereira, B., Erzini, K., Maia, C., and Figueiredo, I. 2014. Identification of potential essential fish habitats for skates based on fishers’ knowledge. Environmental Management, 53(5):985-98.

Serra-Pereira, B., Erzini, K., and Figueiredo, I. submitted. Using biological parameters and reproductive strategy of the undulate ray Raja undulata to evaluate sensitivity to exploitation. Journal of Fish Biology.

Stehmann, M.F.W. and Bürkel, D.L. 1984. Rajidae. In Fishes of the North-eastern Atlantic and the Mediterranean, volume 1, pp. 163-196. Ed. by P. J. P. WHITEHEAD, M. BAUCHOT, J. HUREAU, J. NIELSEN and E. TORTONESE. UNESCO, Chaucer Press, UK.

Vanney, J-R, and Mougenot, D. 1981. La plate-forme continentale du Portugal et les provinces adjacentes: analyse geomorphologique. Memórias dos Serviços Geológicos de Portugal, 28:1-86.

Stock Annex
Undulate ray (*Raja undulata*) in Divisions VIId,e (English Channel)

Stock Annex rju-ech

Stock specific documentation of standard assessment procedures used by ICES.

Stock	rju-ech: Undulate ray (*Raja undulata*) in Divisions VIId,e (English Channel)
Working Group:	WGEF
Date:	21 June 2014
Revised by	Alain Tétard

A. General

A.1. Stock definition

Raja undulata is known to have a patchy and localized distribution (where it can be locally abundant). It seems to form a separate stock in the English Channel (divisions VIIde). Data from surveys (CGFS and BTS in VIId and IVc, BTS in VIIe) and from French observations aboard commercial vessels suggest a main area of abundance in the Normand-Breton Gulf (southeast of the western Channel including the Mont St Michel Bay, West Coast of Cotentin Peninsula and Channel Islands waters) connected to areas of lesser density to the west along the north coast of Brittany and to the East (Figures 2 and 3). The species seems to occur at much lower abundance further east, in the southern North Sea (ICES Division IVc), and West in the Celtic Sea (VIIh), suggesting that the English Channel may form a stock unit.

A.2. Fishery

This species was historically mainly exploited by French and UK (including Channel Islands) fleets, as a bycatch by the trawlers, and as a target species by small, coastal netters and longliners. A landing ban of this species in all eco regions was introduced in 2009. In 2014 R. undulata was removed from the list of prohibited species in VII, VIII but it is subject to a 0 TAC. Therefore, no landings data are available since 2009. The quality of landings data in previous years is considered poor as the species was often landed as miscellaneous rays.

A.3. Ecosystem aspects:

R. undulata is mostly a coastal species. Based on French onboard observation, a major nursery area was identified in shallow waters of the Normand-Breton Gulf (Figure 3). This area is characterised by mixed and coarse sediments in coastal waters. The participatory science project of eggs cases collection along the French coast from APECS (Association pour l'Etude et la Conservation des sélaciens) also reflects the higher abundance of eggs in this area (http://www.asso-apecs.org/IMG/pdf/Rapport_capoera_bilan_des_actions_2012_vf.pdf). Adult fish also occur in coastal areas but have a larger habitat including occurrences in the central eastern Channel (Figure 2) where the seafloor is mostly coarse sediments.

B. Data

B.1. Commercial catch

Before the ban commercial landings of undulate ray were reported separately by UK in 2008 only and were never reported separately by France and other countries. Since 2009, this species is completely discarded and no longer occurs in the commercial landings (Leblanc, 2013). Discards in French fisheries in 2011-2013 were estimated to more than 1500 tonnes per year from the French on-board observation program, mostly from VIIe.

B.2. Biological

Data are historically poor. The ban has triggered biological studies and more results have become available (distribution, size at maturity, length/weight relation, length/width relation).

Movement patterns: results from tagging in the Normand-Breton Gulf (1488 released, 77 recaptured up to 2014 corresponding to 5.2 %) seem to confirm high site fidelity. 58.4% in the western English Channel of the recaptured skates were taken at the release location (less than 5 km between release and recapture positions) and 75.3% at less than 20 km (Stéphan et al., 2014).

Preliminary results on population genetic structure: genetic polymorphism of the mitochondrial control region (MCR) was studied. The total absence of polymorphism in the test samples of 19 French individuals prompted to hypothesize that an extension of this analysis to the complete sampling would not be more informative. Microsatellite polymorphism analysis is in progress.

Table 1.- Maturity data of Undulate ray from the Normand-Breton Gulf (Stéphan et al., 2014)

Sex	Number of fish (no. of females between 70 and 93 cm)	No. mature	Length of the smallest mature (cm)	Length of the largest immature (cm)	Length at 50 % maturity (L50, cm)
Male	889	594	74	91	78.2
Female	289 (79)	119	78	86	(82.8)

Table 2.- Relationship between total length (TL) and disc width (DW) where DW = a TL + b and correlation coefficient r2 (Stéphan et al., 2014). Samples are from the Normand-Breton Gulf.

Sex	Number of fish	TL range (cm)	a	b	r2
Combined	1739	18-103	0.59	2.58	0.97
Male	972	18-99	0.57	3.64	0.97
Female	767	18-103	0.61	1.94	0.98

B.3. Surveys

Survey data used include the French CGFS in VIId, IBTS in VIId-IV, and the English BTS in VIId-IVc and in VIIe. There are also French small scale surveys in VIId catching skates.

The French CGFS provides indices of abundance and biomass of the species in VIId (Figure 1). Indices from are raised to the total area of VIId (swept area method), they must however be used as relative because not account of catchability is taken and the species is abundant in waters shallower than those sampled. The survey indices should be considered representative of the relative abundance of large undulate rays in offshore waters (Figure 2).

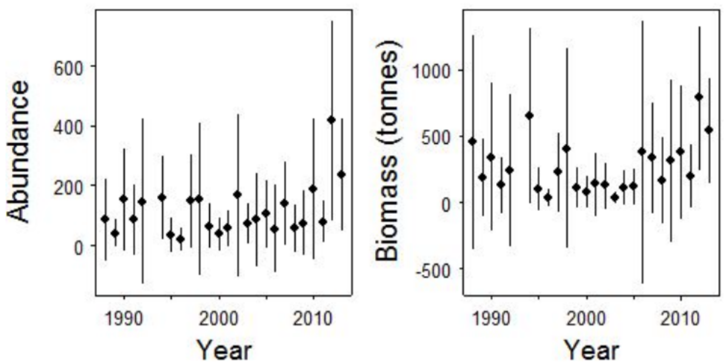


Figure 1.- Abundance and biomass indices of undulate ray from CGFS.

The geographical distribution of the species seems to have been relatively stable from 1988 to 2013. It is more abundant to the west of the area surveyed (Figure 2). In the last two years a spectacular jump of abundance is observed (Fig. 2).

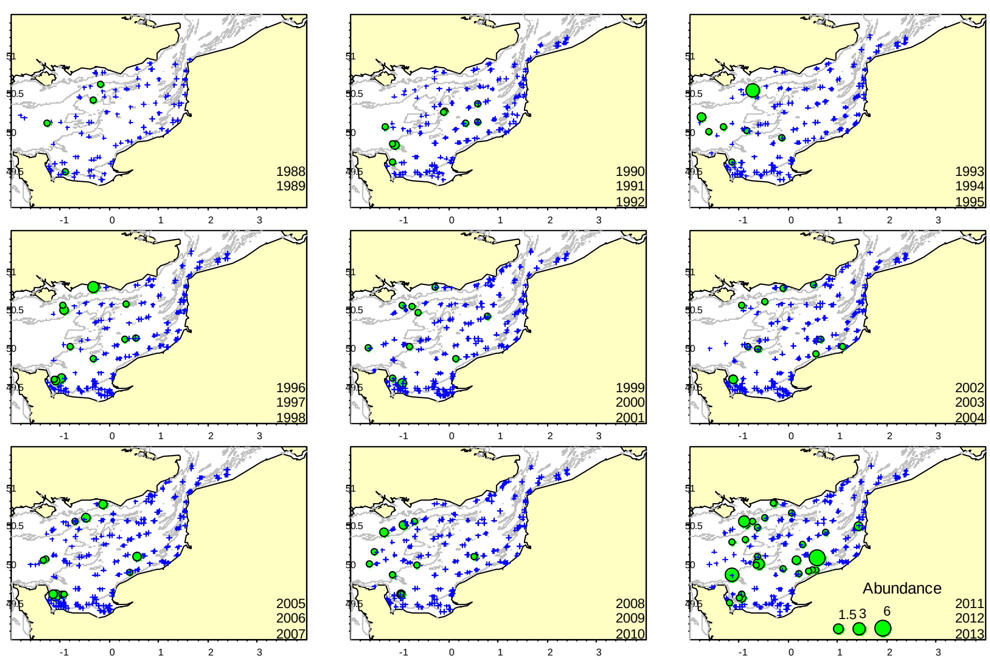


Figure 2.-Spatial distribution of undulate ray (*Raja Undulata*) in VIId from CGFS. The number of fish caught per haul (green circles) is shown for groups of three years. Hauls with no catch of the species are represented by a blue cross (+).

B.4. Commercial CPUE

Due to the prohibition of landings and the poor data quality before the prohibition, the only data susceptible to provide CPUEs from commercial fleets are on board observations. These are carried out in application of the DCF and have been strongly supplemented by national projects since the landings prohibition. One on these projects, the French RAIMOUEST project, also included interviews of skippers which included some questions on the area of higher catch rates.

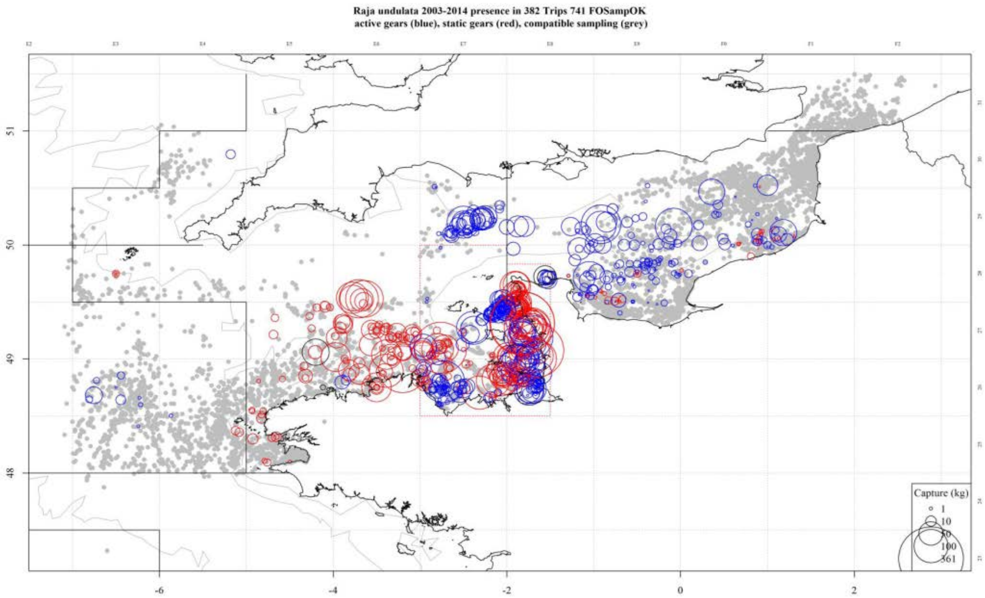


Figure. 3.- French fisheries observer program: *Raja undulata* catches (kg) in the English Channel and adjacent areas from 2003 to the first quarter 2014 (grey dots: hauls from gears susceptible to catch skates with no catch of R undulate; open circles catch in weight of R undulata, blue: towed gears, red: passive gears). Each circle corresponds to one sampled fishing operation.

B.5. Other relevant data:

C. Assessment: data and method

Model used: discards estimate
Software used: R COST libraries (available at http://wwz.ifremer.fr/cost/Cost-Project, see also Jansen *et al.*, 2009)

D. Short-Term Projection

None

E. Medium-Term Projections

None

F. Long-Term Projections

None

G. Biological Reference Points

	Type	*Value*	*Technical basis*
MSY Approach	**MSY $B_{trigger}$**	**xxx t**	**Explain**
	F_{MSY}	**Xxx**	**Explain**
Precautionary Approach	**B_{lim}**	**xxx t**	**Explain**
	B_{pa}	**xxx t**	**Explain**
	F_{lim}	**Xxx**	**Explain**
	F_{pa}	**Xxx**	**Explain**

H. Other Issues

H.1. Historical overview of previous assessment methods

2012: first advice for rju-ech, years 2013 and 2014.

I. References

Jansen T., Degel H., Vigneau J., Jardim E., 2009, Definition of Standard Data-Exchange Format for Sampling, Landings, and Effort Data from Commercial Fisheries. ICES Cooperative Research Report, N° 296, 48 pp.

Leblanc, N., Tetard, A., Legrand, V. 2013. RAIMOUEST: the French fishery of rays in the Western English Channel (VIIe). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013.

Leblanc, N., Tetard, A., Legrand, V. E. Stéphan, L. Hegron Macé, 2014. RAIMOUEST: the French fishery of rays in the Western English Channel (VIIe), 2014 update. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26th June, 2014.

Stéphan, E., Hennache, C., Delamare, A., Leblanc, N., Legrand, V., Morel, G., Meheust, E., Jung, JL., 2014. Length at maturity, conversion factors, movement patterns and population genetic structure of undulate ray (*Raja undulata*) along the French Atlantic and English Channel coasts: preliminary results. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26th June, 2014.

French fisheries observer program (http://sih.ifremer.fr/Description-des-donnees/Les-donnees-collectees/Echantillonnage-des-captures-a-bord-des-navires-de-peche).

Annex 3: Working documents presented to WGEF 2014

Twenty-six working documents were submitted to the working group. These are listed below, with a brief summary. These summaries are from the working documents and do not necessarily imply agreement from WGEF. Relevant information, where used, is included in the relevant stock sections.

Bal, G., White, J., Johnston, G., Roche, W., O'Reilly, S., Green, P. and Fitzmaurice, P. 2014. Estimates of yearly population size of angel sharks from Tralee Bay. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/01.

Abstract: The exploratory works aims at getting first rough estimates of the yearly size of the populations of Angel Shark present in Tralee Bay. To do so, we here exploited a long capture–mark–recapture (CMR) dataset supported by catch declaration from a recreational rod fishery. A Cormack-Jolly-Seber model is developed in a Bayesian framework to get a fair appraisal of uncertainty in a probabilistic way.

Bendall, V., Hetherington, S., O'Brien, C., Righton, D., Riley, A. and Cragg, A. 2014. Proposal for a UK pilot project to develop a real-time spurdog by-catch avoidance programme to mitigate the potential for spurdog to become a choke species and so minimize fishing induced mortality. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/02.

Abstract: In this working document, the UK outlines a pilot project proposal under article 7 and/or article 14 of Regulation (EU) No 1380/2013 of the European Parliament and of the Council to allow industry participants to adapt their fishing behaviour to avoid significant spurdog by-catch, ahead of the introduction of the Landing Obligation for spurdog. The UK pilot project would be undertaken in the Celtic Sea (ICES Divisions VIIe–j). The purpose would be to aid conservation of spurdog, while providing legitimate flexibility within the future Landing Obligation to account for unpredictable and unavoidable catches. The proposal is of relevance to the WGEF whose views are sought.

Biais, G, Hennache, C., Stéphan, É and Delamare, A. 2014 Mark–recapture abundance estimate of undulate ray in the Bay of Biscay WD for 2014 ICES WGEF. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/03.

Abstract: An undulate ray (*Raja undulata*) tagging survey was carried out from the end of 2011 to mid-2014 in the Bay of Biscay with the partnership of the fishing industry. It demonstrates that the undulate ray can be found all along the French coast from the Loire estuary to the Spanish boarder, forming several isolated units, the more important being likely in the central part of the Bay of Biscay (Pertuis Charentais – Gironde area). Even in this latter limited area, the population is structured in subunits with a low exchange rate between them. This population structure allowed to estimate abundance by mark–recapture in the Gironde estuary, using a Petersen estimate. The conditions that must be respected for such closed population estimate are analysed. The conclusions are that as long i) longline catch of rays longer than 65 cm are used to the be sure to have an equal capture probability and no recruitment effect, ii) recaptures are within 4.5 months from tagging in winter to neglect tag losses and iii) number of tagged rays are corrected for emigration and mortality, an abundance estimate can be provided. The biomass of undulate ray in the inner Gironde estuary can thus be estimated to range from 61 to 76 t in the 2013–2014 winter (95% confidence interval is 36–135 t). This first trial allows to have some guidelines for future mark–recapture estimates of the abundance of a species for which the use of other methods may be difficult.

Davie, S. 2014. Irish ray lpue trends and spatial distributions. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/04.

Abstract: Within Irish fishing practices a number of different ray species are caught as a primary target and as a bycatch whilst targeting a variety of other species. Understanding and separating the targeted fishing from the remainder of fishing practices can result in

more insightful and accurate representation of stock trends. This working document presents Irish raw lpue trends in units of both fishing days and fishing hours at several aggregation levels. Two levels of species aggregation were examined, a general ray category encompassing all ray species reported by Irish fishers to provide longer term trends in ray targeting practices. The group was disaggregated into four species of interest: blonde (*Raja brachyura*), spotted (*Raja montagui*), cuckoo (*Leucoraja naevus*), and thornback (*Raja clavata*) for the most recent years (2011–2013) where the reporting of individual ray species has become standard practice.

De Oliveira, J. A. A. 2014. Proposed modification to survey-based derivation of HR (harvest rate) to account for natural mortality. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/05.

Abstract: This Working Document proposes potential adjustment to deal with natural mortality when calculating a survey-based harvest rate (HR).

Diez. G., Mugerza, E., Iriondo, A., and Santurtun, M. 2014. Characterization of the rays catches of the Basque trammelnet fleet in the Bay of Biscay (VIIIc East). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/06.

Abstract: Gillnets and in particular trammelnets are the artisanal fishing gears most used in the Basque Country. The trammelnet has been identified as the fishing gear with significant rays landings, this coastal artisanal fleet consists of 55 small vessels using gillnets and trammelnets in different periods of the year. Vessels have an average length of 12.7 m and 82.4 kW engine power. The soak time is about for 48 h and targets a large number of demersal teleost species, mainly monkfish. During the period 2011–2013, up to 118 trip/hauls of 21 vessels belonged to the nine main ports of the Basque Country were sampled with the aim to characterize the specific composition of the landed rays, the species-specific cpue and the geographical distribution of the catches.

Ellis, J. R., McCully, S. R. and Poisson, F. 2014. A global review of elasmobranch discard survival studies and implications in relation to the EU 'discard ban'. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/07.

Abstract: There is a need to better understand the survivorship of discarded fish, both for commercial stocks and species of management concern. The landing obligations that are currently being phased in as part of the European Union's reformed Common Fisheries Policy means that an increasing number of fish stocks, with certain exceptions, should not be discarded unless it can be demonstrated that there is a high probability of survival. This working document reviews various approaches which can be used to examine the discard survival of elasmobranchs (in terms of at-vessel mortality and post-release mortality), with relevant findings summarised by the main fishing gears used. Discard survival varies with biological attributes (e.g. species, size, sex and mode of gill ventilation) as well as variety of factors associated with capture (e.g. gear type, soak time, catch weight and composition, handing practices and temperature). In general, demersal species with buccal-pump ventilation have a higher survival than obligate ram ventilators; some studies indicate that females may have a higher survival than males; and it is apparent that some taxa (e.g. hammerhead sharks *Sphyrna* spp. and thresher sharks *Alopias* spp.) are prone to high rates of mortality when caught.

Fernández-Zapico, O., Velasco, F., Rodríguez-Cabello, C., Punzón, A., Serrano, A., Ruiz-Pico, S. and Blanco, M. 2014. Results on main elasmobranch species captured in the bottom trawl surveys on the Northern Spanish Shelf. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/08.

Abstract: This working document presents the results on the most significant elasmobranch species captured in the Spanish Groundfish Survey on Northern Spanish shelf in 2013. The main species in biomass terms in this survey, in decreasing order of abundance, are *Scyliorhinus canicula, Raja clavata, Galeus melastomus, Raja montagui, Galeus atlanticus, Leucoraja naevus* and *Etmopterus spinax*. Biomass, distribution and length ranges were analysed. All species have shown an increase in biomass with regard to previous years in Division VIIIc, some (as S. *canicula, S. stellaris, E. spinax* and *R. clavata*) reaching peaks in the time-series. Not so in Division IXaN that presents declines in most of the cases (*S. canicula, Deania* spp. and *R. clavata*). 2013 survey was the first of the series carried out in a new vessel (RV Miguel Oliver), therefore these results have to be considered with caution.

Figueiredo, I., Maia, C. and Serra-Pereira, B. 2014. Overview of the information available on *Raja undulata* from Portuguese mainland waters (ICES Division IXa). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/09.

Abstract: For Portuguese waters (ICES Division IXa), IPMA has compiled and analysed the available data on *R. undulata* from different sources, particularly fishery-dependent data that includes both interviews to fishermen at the landing ports and on-board observations. The aim of this compilation is to update the information on this species particularly in what concerns the spatial distribution, abundance, biology, survivorship rate after fishing and productivity/susceptibility of the species.

Iglesias, S., Barreau, T. and Caraguel, J.M. 2014. Life history, ecology and fishery susceptibility of *Dipturus* spp. in European waters. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/10.

Abstract: This 2013–2015 French program is focused on getting biological parameters needed for the running of population dynamic models of European *Dipturus* species. It continues the study revealing the confusion of threatened skates under the single name *Dipturus batis* (Iglesias *et al*., 2010). It is mostly focused on the species complex *Dipturus* cf *flossada* and *Dipturus* cf. *intermedia*. Additional data are also obtained for *D. oxyrinchus* and *D. nidarosiensis*. The first aim is to do a calibration of the age reading based on vertebral rings. A tagging programme at sea using commercial and research vessels including stain injection will permit to validate the periodicity of vertebral rings formation for these species. Other aims are to obtain data on growth, sexual maturation, longevity, fecundity, spatio-temporal area of biological importance (nursery area, mating area), horizontal movements and feeding. Survival to capture will also be estimated. For the 590 specimens currently observed (511 *D. batis*, 75 *D. oxyrinchus*, 4 *D. intermedia*) 235 tags put, 196 stain injections done, 326 specimens measured and sampled, 84 individuals landed for dissection.

Iglesias, S., Mayot, S. and Lebon, P-Y. 2014. Mislabelling of chondrichthyans in French landings. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/11.

Abstract: Preliminary studies revealed significant mislabelling in landings of chondrichthyans in France with consequences on stock assessment and conservation of threatened species. This 2012–2014 French program is focused 1) on the evaluation of the mislabelling ratio, at local and at national scale; 2) To identify nature and origin of mislabelling; 3) to propose solution for the improvement of data quality. From June 2012 to April 2014, 29 of the 38 French fishmarket were sampled. A total of 47 300 specimens (77 tonnes) from 674 landings were individually identified. A total of 42 different chondrichthyan species were identified. About 20–30% (final data not yet elevated) of landings are incorrectly labelled. As an example, *Chimaera opalescens*, a species recently described represent about 20% of the weight landed under the name *Chimaera monstrosa*. The species *Raja brachyura* is commonly confused as *R. montagui*. The Species *Dipturus nidarosiensis* is continuously confused as *Dipturus oxyrinchus* and the species *Scyliorhinus stellaris* is continuously confused as *S. canicula*. The study reveal mislabelling is mostly due to 1) mistake of identification by fishmarket staff and explained by lack of taxonomic training; 2) involuntary grouping of cryptic species in a same batch; 3) Voluntary grouping of distinct species in a batch when volumes are small (only observed in coastal fishery); 4) unavailability of landing name in the taxonomic repository of fishmarket data processing. As a solution it is proposed for 2015 to realise 1) a training on chondrichthyans labelling of the French fishmarket staff; 2) To propose solution for each fishmarket to grow up the data quality by modifying their species listing and their labelling practices. At the end of this process it is plan to evaluate the gain of data quality of Chondrichthyans in French landings.

Johnston, G., Tetard, A., Ribeiro Santos, A., Kelly, E. and Clarke, M. 2014. Spawning and nursery areas of selected rays and skate species in the Celtic Seas. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/12.

Abstract: All countries funded under the EU Data Collection Framework collect at-sea observations on catch and discard levels of fish caught on commercial surveys. These observer programmes routinely collect species and length data from commercial and non-commercial species. Sex data may also be collected for certain species. This study looks at observer records of selected skate and ray species collected by Irish, UK and French observer programmes.

Leblanc, N., Tetard, A., Legrand, V., Stephan, E., Hegron Macé, L. 2014. RAIMOUEST: the French fishery of rays in the Western English Channel (VIIe), 2014 update. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/13.

Abstract: The landing ban of *Raja undulata* has raised misunderstanding for French fishermen, particularly for those fishing in the Normano-Breton Gulf (Southeast of ICES Division VIIe) where this species is very abundant. In this context, the RAIMOUEST project was launched as a professional and scientist partnership in order to enhance fisheries data on the main ray species caught in the Normano-Breton Gulf (*Raja undulata, Raja brachyura*, *Raja clavata, Raja montagui* and *Raja microocellata*). The French ray fisheries fleet was identified and a sample of fishermen involved in rays fishing was interviewed. Landings and effort data (logbooks), auctions sales and sampling at sea aboard professional fishing vessels were analysed. This working document presents the current results of this study. The French fleet concerned by ray fishing in the Normano-Breton Gulf in 2012 was composed of 289 vessels, mainly coastal trawlers/dredgers and small length size netters and longliners. *R. undulata* is the main ray species in this area. This species seems to form a local stock in the Normano-Breton Gulf with some continuity in the Eastern English Channel and the Western part of the Western English Channel. Three ways of analysis were used to provide an indicative level of *R. undulata* stock: French landings before 2009 were estimated at least at 300 tons in the Western English Channel (VIIe) and 160 tons in the Normano-Breton Gulf; sales at auctions of the Basse-Normandie fleet before 2009 were estimated at 235 tons in the western English Channel and 35 tons in the eastern English Channel (VIId); discards by the French bottom trawl fleet in ICES Division VIIe in 2012 and 2013 were estimated at 750 tons. Information on the spatial distribution of the other ray species in the English Channel.

McCully, S. R. and Ellis, J. R. 2014. Biological studies to inform management of smooth-hounds (*Mustelus* spp.) in the Northeast Atlantic. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/14.

Abstract: Seasonal catches of starry smooth-hound (*Mustelus asterias*) have been commonplace around the UK coast for many years. However, until recently, these have predominantly been discarded due to a low commercial value. In the 33 year time-series of national landings reported to ICES, smooth-hound catches are at an all-time high, exceeding 3000 t per year since 2009. Within parts of the UK, smooth-hound landings have increased in recent years, which may relate to increased abundance in northern European waters and/or emerging market opportunities. Anecdotal information from the fishing industry suggests that increased exploitation may also be, in part, a response to the current zero TAC for spurdog (*Squalus acanthias*). Following a prioritisation exercise of the chondrichthyans of the British Isles, this species was deemed to be a high priority for study, given its life-history, importance of UK waters to the stock and the emerging commercial interest. As little is known regarding many aspects of the biology of this species, a biological sampling programme was initiated to help collect life-history parameters necessary for future stock assessments and management measures to be appraised. Monthly samples of *Mustelus* have been collected and fully dissected. Data on conversion factors, maturity and fecundity information, diet composition and hepatosomatic indices are presented, with comments made on the utility of these for informing on future management.

Moura, T., Fernandes, A. and Alpoim, R. 2014. Results from the pilot study on the Portuguese trammelnets fishery targeting anglerfish in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/15.

Abstract: To evaluate the level of bycatch and discards of sharks and to increase the knowledge on the fishery, a pilot study on the Portuguese trammelnets fishery targeting anglerfish in ICES Division IXa between 200 and 600 m deep started in May 2012 under the PNAB/DCF. Fifty hauls were sampled from June 2012 to December 2013 on board of four vessels operating at three different geographical areas of the Portuguese continental coast. Six of the 13 captured species (30 individuals caught in 8 hauls) belong to the EU list of deep-water sharks (UE regulation 1182/2013). All but one were caught deeper than 500 m, and 21 were caught deeper than 600 m (maximum depth sampled =630). Results collected up-to-date show that the fishery targeting anglerfish between 200 and 600 m has low impact in deep-water shark populations. Most of the species are likely to be observed deeper than 600 m.

Pinho, M.R. 2014a. Resuming elasmobranchs survey data from the Azores (ICES X). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/16.

Abstract: This paper updates the elasmobranchs information from the Azorean bottom longline survey, ICES Area Xa2, for the WGEF 2014. Information on species, total abundance, abundance by depth and length is provided.

Pinho, M. R. 2014b. Elasmobranchs from the Azorean fisheries (ICES Area X). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/17.

Abstract: About 58 elasmobranch species are listed as occurring in the Azores. The species covers pelagic, benthopelagic and benthic habitats from shallow to deep-water strata in areas around coastal of the islands, banks and seamounts. However, only about 17 shark species are identified by the auctions on the landings. Elasmobranchs catches from the Azores (ICES Area X) are mainly bycatches from three main fisheries: the swordfish fishery, the demersal fishery and the black scabbarfish fishery. Biological sampling data are scarce because these species have low sampling priory. This paper updates the elasmobranchs landings from the Azores, ICES Area X for 2014 WGEF meeting.

Pinho, M. R and Silva, H. 2014. Biology and fishery of kitefin (*Dalatias licha*, Bonaterre 1788) off the Azores: A review. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/18.

Abstract: This Working Document provides an overview of the fishery and biology of kitefin shark off the Azores, giving information on the distribution, growth, reproductive biology and trophic role of the species, as well as the development and management of the fishery.

Prista, N., Fernandes, A.C., Maia, C., Teresa Moura, T. andFigueiredo, I. 2014. Discards of elasmobranchs in the Portuguese fisheries operating in ICES Division XIa: Bottom otter trawl, deep-water set longlines, set gillnet and trammelnet fisheries (2004–2013). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/19.

Abstract: We compile the information available on the discards of elasmobranchs produced by Portuguese vessels operating in Portuguese ICES Division IXa. The data were collected by the Portuguese on-board sampling programme (EU DCR/NP) between 2004 and 2013. We describe the on-board sampling programme, estimation algorithms and data quality assurance procedures. We provide results for four fisheries: the bottom otter trawl fishery that targets crustaceans and blue whiting (OTB_CRU), the bottom otter trawl fish fishery that targets demersal fish (OTB_DEF), the deep-water set longline fishery that targets black scabbardfish (LLS_DWS) and the set gillnet and trammelnet fishery that target demersal fish (GNS/GTR_DEF). The low frequency of occurrence of many species and insufficiencies in the current estimation algorithms when dealing with zero-inflated data and more complex fisheries (e.g., multi-gear multi-species trips of GNS/GTR_DEF fishery) precluded the estimation annual discards for all species and fisheries. In the OTB fisheries, discards of most elasmobranchs assessed by WGEF 2014 were null or rare, notable exceptions being *Galeus melastomus* and *Scyliorhinus canicula* which appear to register <50 tonnes/year and <200 tonnes/year of discards. In 2013, 17 tonnes of *Galeus melastomus* are estimated to have been discarded in the OTB_CRU fishery. In what concerns LLS_DWS and GNS/GTR_DEF fisheries, *Galeus melastomus, Scyliorhinus canicula, Raja clavata* and *R. montagui* were the most frequently discarded. A final remark is made on discards from other elasmobranch species that are not presently assessed by WGEF.

Rohr, A., Stephan, E., Tachoires, S. 2014. Literature review on spatio-temporal management measures linked to elasmobranch species. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/20.

Abstract: A bibliographical synthesis about spatio-temporal management measures (STMM) on elasmobranch was written by APECS (Association Pour l'Etude et la Conservation des Sélaciens) in partnership with French marine protected areas agency, and with the help of fishery professional organizations, recreational fishery representatives and scientists. The aim of the study is to analyse previous experiences on implementing such measures, all over the world, and to determine the efficiency of these measures. The paper contains a synthesis on scientific recommendations, a description on a few study cases and a discussion on which measure is the most relevant for one species or a functional group of species (bottom-dwelling, neritic non-migratory, neritic migratory, deep-water, oceanic, and gigantic/planktivorous species). STMM have the potential to play an important role in the preservation of elasmobranch, especially for species with a high site-fidelity. For mobile species, the protection of key stages of life cycle or essential habitats is an interesting option for management. New studies are necessary to complete the current knowledge on biology and ecology on elasmobranch species. If fishing appears as the main threat, the impacts of all human activities linked to these species need to be studied and controlled.

Ruiz-Pico, S., Velasco, F., Baldó, F., Rodríguez-Cabello, C., and Fernández-Zapico, O. 2014. Results on main elasmobranch species captured during the 2001–2013 Porcupine Bank (NE Atlantic) bottom trawl surveys. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/21.

Abstract: This working document presents the results on the most significant elasmobranch species of the Porcupine Bank Spanish surveys in 2013. The main species in biomass terms in this survey were *Galeus melastomus* (blackmouth catshark), *Deania calcea* (birdbeak dogfish), *Deania profundorum* (arrowhead dogfish), *Scyliorhinus canicula* (lesser spotted dogfish), *Scymnodon ringens* (Knifetooth dogfish), *Etmopterus spinax* (velvet belly lantern shark), *Dalatias licha* (Kitefin shark) *Hexanchus griseus* (bluntnose sixgill shark), *Leucoraja circularis* (sandy ray), *Leucoraja naevus* (cuckoo ray), *Dipturus nidarosiensis* (Norwegian skate) and *Dipturus* spp. / *Dipturus cf. flossada* / *Dipturus cf. intermedia* (common skate). Biomass, distribution and length ranges were analysed. Many of these species occupy mainly the deep areas covered in the survey, especially *D. calcea, D. profundorum* and *S. ringens.*

Shephard, S., Johnston, G. and Clarke, M. 2014. Estimation of mortality in rays and skates in the Celtic Seas, including a proposal on target F. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/22.

Abstract: Rays and skates in general, and in the Celtic Seas ecoregion in particular, are data-poor stocks. Current ICES advice (2012) was based on the DLS method. In many cases the precautionary buffer was applied because it was not possible to demonstrate that a given stock was not over-exploited. This working document aims to provide estimates of fishing mortality for these species, with particular reference to proposed target fishing mortality reference points.

Silva, J. F., McCully, S. R., Ellis, J. R. and Kupschus, S. 2014. Demersal elasmobranchs in the western English Channel (ICES Division VIIe). Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/23.

Abstract: In 2006 a new Cefas beam trawl survey was initiated in the western English Channel to provide information on sole *Solea solea* and plaice *Pleuronectes platessa*, as well as providing information on other demersal fish and ecosystem components. The western English Channel is an important area for a number of demersal elasmobranchs, with species of interest including undulate ray *Raja undulata*, which is locally abundant and, prior to their prohibited status, was an important commercial species in some inshore areas. This study presents preliminary results on the spatial distribution and size frequency for all dogfish, skates and rays encountered during 2006–2014. Results indicated that species including common skate *Dipturus batis*-complex, cuckoo ray *Leucoraja naevus*, thornback ray *Raja clavata* and undulate ray showed persistent association with specific sites, with lesser-spotted dogfish *Scyliorhinus canicula* and smooth-hounds *Mustelus* spp. distributed over much of the survey grid. Juvenile skates were routinely caught, as beam trawls are more selective for smaller fish. Mature specimens of the smaller bodied skate species, such as cuckoo ray, were also represented in the catch, while fewer mature specimens of the larger bodied skate species (e.g. undulate, blonde and thornback ray) were observed.

Stéphan, E., Hennache, C., Delamare, A., Leblanc, N., Legrand, V., Morel, G., Meheust, E. and Jung, J.L. 2014. Length at maturity, conversion factors, movement patterns and population genetic structure of undulate ray (*Raja undulata*) along the French Atlantic and English Channel coasts: preliminary results. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/24.

Abstract: This working document presents information on observed lengths at first maturity, largest immature fish, estimated lengths at 50% maturity (L50) and total length-disc width conversion factors for male and female undulate ray along the French Atlantic and English Channel coasts. Preliminary observations on movement patterns of *R. undulata* and preliminary results on population genetic structure are also presented. Based on the analysis of more than 800 individuals, L50 was estimated at 81.2 cm in Atlantic and 78.2 cm in the western English Channel. Maturity data presented for females should be viewed as preliminary estimations and additional skates will be examined by the end of summer 2014 to refine the maturity data for females by the end of 2014.Total length and disc width were highly correlated and constants required for the conversion are given in by area and sex. On the 3971 tagged and released undulate rays, 272 were recaptured, 195 in the Bay of Biscay and 77 in the Western English Channel. All the skates tagged in a region were recaptured in the same region, and distance travelled stayed short even after long time at liberty. 48.7% in Bay of Biscay and 58.4% in the western English Channel of the recaptured skates were taken at the release location and 89.7% in the Bay of Biscay and 75.3% in the western English Channel were recaptured less than 20 km from the release location. These results seem to confirm high site fidelity in the central Bay of Biscay area and indicate the same tendency in the Normano-Breton Gulf. It is hoped that more recapture data will be available in a near future to allow further examination of potential seasonal movements and to investigate possible differences considering sex or size-class. A study on population genetic structure was initiated at the beginning of 2014. The polymorphism of the mitochondrial DNA control region (MCR) and at five microsatellites loci optimized for *Raja undulata* was investigated on individuals of less than 77 cm in total length, considered as immature, from six sites of the Bay of Biscay and the French coasts of the English Channel. A few individuals from Morocco and one individual from Ireland, representing the south and north limits of the species range were added. Analyses are still ongoing and other analyses are planned on individuals of more than 80 cm in total length.

Vollen, T. 2014. Data on spurdog from two Norwegian surveys; the Shrimp survey and the Coastal survey updated with new data in 2014. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/25.

Abstract: This WD is an update of WGEF WD 2012-18 "Data on spurdog from two Norwegian surveys; the Shrimp survey and the Coastal survey" and WGEF WD 2013 "Data on spurdog from two Norwegian surveys; the Shrimp survey and the Coastal survey" updated with new data in 2014. For 2013/2014 there are no dramatic changes in the catches compared to previous years. The new data support the existing trends; increasing in the Shrimp survey and decreasing in the Coastal Survey. Small individuals are still present in the catches, even though numbers are less important than previous two years.

Wögerbauer, C., O'Reilly, S., Green, P. and Roche, W. 2014. IFI Marine Sportfish Tagging Programme: Preliminary results for selected species. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–26 June 2014; 2014/26.

Abstract: Inland Fisheries Ireland is the statutory agency charged with conserving, developing, protecting and promoting the inland fisheries and sea angling resource. IFI's Marine Sportfish Tagging Programme was initiated in 1970 by the Inland Fisheries Trust who operated it through selected angling charter vessel skippers. By the late 1960s results from the sea angling competitions around Ireland were showing a decline in important angling species. The purpose of the tagging project was to encourage catch and release as a conservation measure and to develop a tagging programme to investigate species migratory patterns. The programme has expanded since its initiation with the majority of current charter skippers involved. This report is a preliminary assessment of tagging data from the IFI programme for three species: Angel shark (*Squatina squatina*), Undulate ray (*Raja undulata*), and Common skate (*Dipturus batis*) compiled for the ICES WGEF (Working Group on Elasmobranch Fishes) assessment taking place in June 2014. Data for Blonde ray (*Raja brachyura*), Spotted ray (*Raja montagui*) and Thornback ray (*Raja clavata*) are also presented.

Presentations given at the meeting included:

- Proposal of an ecosystem survey in the English Channel (Ifremer).
- Stock identity of skates, critical review from French data (Ifremer).