ICES SGHIST REPORT 2011

SCICOM STEERING GROUP ON SUSTAINABLE USE OF ECOSYSTEMS

ICES CM 2011/SSGSUE:11

REF. SCICOM

Report of the Study Group on the History of Fish and Fisheries (SGHIST)

24–27 October 2011

Cefas, Lowestoft, UK

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2011. Report of the Study Group on the History of Fish and Fisheries (SGHIST), 24-27 October 2011, Cefas, Lowestoft, UK. ICES CM 2011/SSGSUE:11. 36 pp.

Contents

Executive summary

The Study Group on the History of Fish and Fisheries (SGHIST) brings together fisheries scientists, historians and marine biologists working on multidecadal to centennial changes in the marine environment, and aims at improving the understanding of the long term dynamics of fish populations, fishing fleets, and fishing technologies. The results are used for setting baselines for management, restoration and conservation of marine resources and ecosystems.

The third meeting of SGHIST was held at Cefas, Lowestoft, UK, from 24–27 October 2011 and was attended by 12 scientists from across Europe (and one scientist in the US through correspondence). Two years previously, the first (2009) meeting of SGHIST had focused on data recovery and digitization. The second (2010) SGHIST meeting had focused on historical data analysis and methodologies, particularly on fishing power change and spatio-temporal dynamics. The emphasis of the current, third SGHIST was on the use of long-term historical data to help disentangling the effects of climate change and fishing pressure (and/or other drivers) on fish population dynamics.

Participants updated the metadatabase, initiated at the meeting of the Workshop on Historical Data on Fisheries and Fish (WKHIST) in 2008, providing an overview of data recovery activities and historical datasets in the group (ToR a). Work was presented on the combined technological, economic, and social drivers of change in UK North Sea demersal fisheries, as well as on developments in Polish fisheries in the Baltic (ToR b).

Historical fisheries data are potentially extremely valuable in assessing impacts of climate change on fish populations (ToR c), because such long-term datasets are more likely to cover both warming and cooling periods making it less likely to find spurious results if two variables vary in synchrony. Further, longer-term datasets are also more likely to cover periods of contrasting fishing pressure (such as significantly reduced fishing during both World Wars as opposed to the very intensive levels of fishing during the 1970s–1980s in various European seas).

During SGHIST, different approaches were presented to assess impact of climate change and/or other pressures on fish dynamics:

- Multiple linear regression analyses (e.g. GLM) whereby the combined effects of different potentially driving variables on a response variable (e.g. fish abundance or distribution) are analysed statistically (example: climate and fishing effects on distribution shifts of North Sea cod);
- Scenario modelling, "what-if" analyses whereby it is tested what would be the effect of leaving out one driving factor at the time, such as an environmental factor, fishing, eutrophication, or seal predation (example: multidecadal responses of the eastern Baltic cod to human-induced trophic changes, fishing, and climate);
- Generalized additive models (GAMs) that may be possible in particularly data rich circumstances (example: Bohuslän lobster study);
- Wavelet analyses to understand periodicity in time-series (example: Bohuslän lobster study).

In order to disentangle climate-related from fisheries effects, time-series of both climatic and fishing pressure variables are needed. With regards to climat-

ic/environmental variables, there are currently a reasonable number of long-running datasets available, especially on temperature (but much less so for seabed than for sea surface temperature) and salinity. More rarely are historical climatic datasets spatially resolved at a finer scale. Acknowledging such gaps in historical climatic data, it nevertheless has proven far more difficult to obtain long-term historical data on fishing pressure. The following approaches are suggested to obtain time-series of fishing pressure or proxies thereof:

- Fishing mortality rate (F) derived from fish stock assessments (often available from 1960- or 1970s- only, see Pinnegar and Engelhard 2008);
- Number of hours fishing (by rectangle 1923- for UK trawl fisheries; internationally 1990s-), number of days at sea, etc.;
- Fishing effort expressed as kilowatt times fishing days (useful in a situation with increasing fishing power or a heterogeneous fishing fleet; VLIZ, Belgian data, 1938-);
- Landings divided by an (independent) biomass estimate, 1960s-;
- There can be mismatches between the time-spans of available data on landings/catches, and fishing pressure and this may impact the key conclusions – especially if most of the pressure took place before the point in the time where data become available.

Further, case studies were presented on historical changes in fish and fisheries in both sides of the Atlantic (ToR d). This included a century of Belgian sea fisheries; Swedish lobster catch reconstructions from 1875 to the present; an update on historical ecological studies in the Gulf of Maine; and a history of Danish oyster fisheries.

The Study Group plans to hold its next meeting from 4–7 September 2012 in Oostende, Belgium, co-chaired by Georg Engelhard (UK) and Ann-Katrien Lescrauwaet (Belgium) who will take over the co-chair role from Bo Poulsen (Denmark).

1 Opening of the meeting

The meeting of the **Study Group on the History of Fish and Fisheries** (SGHIST) took place at the Centre for Environment, Fisheries & Aquaculture Science (Cefas) in Lowestoft, UK, from 24–27 October 2011. The list of participants and contact details are given in Annex 1. The Chairs, Georg Engelhard (Cefas, UK) and Bo Poulsen (then Roskilde University, Denmark) welcomed the participants and the Terms of Reference (see Section 2) were discussed and an agenda proposed largely set up around the Terms of Reference.

2 Terms of reference

The SG met under the following set of Terms of Reference:

a) coordinate data recovery activities for historical information on fish, fisheries and marine ecosystems;

b) discuss and report on long-term dynamics of fishing fleets and fishing technologies, including methods for estimation of technological creeping;

c) discuss and report on research linking climate change and dynamics of fish populations from historical data;

d) present case studies on history of fish and fisheries representing both sides of the Atlantic and the Mediterranean.

The ToRs were achieved through the following activities:

a) By updating the metadatabase on historical information on fish, fisheries and marine ecosystems. By reporting on recent efforts to catalogue and/or digitize historical fish and fisheries data;

b) By building upon last year's workshop on the analysis of fishing power change, and on how "technological creep" may be accounted for in studies on stock dynamics;

c) By a workshop on how long-term, historical fisheries data, linked with climatic and/or fishing pressure data, may be used to examine the effects of climate change and/or fishing pressure on fish population dynamics;

d) By encouraging participation from all over the North Atlantic and the Mediterranean, and in light of the recently completed HMAP-project and studies elsewhere, by welcoming comparative studies using historical fish and fisheries data.

3 ToR a) Data recovery activities – metadatabase and digitization efforts

3.1 Updates for the SGHIST metadatabase

Already during the precursor to SGHIST, WKHIST (2008) we set up a metadatabase with the intent to serve as a reference point for the potentials in more studies on the history of fish and fisheries. The metadatabase has continued to grow over the years, and following the work of 2011 another 15 datasets were added, so that the database now comprises of 78 different sets of data. New data comes from Poland, Sweden, The United States and Italy.

The entries of Italian origin are particularly rich on untraditional types of data, such as the references to 18th–20th century's naturalists' accounts of the marine fauna of the Mediterranean. Other types of metadata are the records dealing with landings data from the Adriatic Sea, in particular from Venice and the former Habsburg territory of Trieste as well as their respective fish markets. These datasets have proven valuable assets when trying to extend backwards the existing national Italian fisheries statistics, which exist only for the post WWII period.

From Sweden come records of the Swedish lobster fisheries going as far back as 1875, where unusually precise locations of cpue can be deduced. Furthermore, data on length distribution of multiple species in the Kattegat-Skagerrak area are rescued from early 20th century scientific surveys, while multispecies catch and effort data have been digitized from 1857 onwards.

Data from the 20th century Polish fleet is now also part of the metadatabase, with references to several interesting datasets from multiple species and covering the 20th century of Baltic fisheries as well as overseas.

The American updates are linked to the sustained effort of the marine environmental history group based around the University of New Hampshire and partners on the American northeast, where archival records have been dug out for more than a decade. The new data centers on fisheries statistics from the Gulf of Maine coastal fishing grounds from 1867–1963. This include qualitative descriptions of fisheries, aquaculture, legislation, gear and industry as well as quantitative statistics on catch by species and county, as well as gear, men employed, value of gear, and sometimes catch by gear by county.

3.2 Update of the present state of the Sound Toll Registers Project

Bo Poulsen

One of the greatest data mining exercises within history in recent years is the Dutch led effort to digitize the so-called Sound Toll Registers (www.soundtoll.nl). For more than 350 years between 1497–1857 the Danish king levied a toll on all ships sailing in and out of The Sound – the then main entrance point for trade between the countries around the Baltic Sea and the wider World. The preserved records from the toll, which are now being digitized, total some 1.8 million ships passages (Gøbel, 2010). For future research the STRO project will provide a unique measurement for taking stock of more than 350 years of World trade. A sizeable portion of the records now being entered relates to trade in marine resources. Common commercially caught fish include herring and cod, while dozens of other species show up in the database, such as shellfish, oysters, whale bones or sardines.

While the project is still running some 70 years in the 18th century is already available for download online through open access. The consortium in charge of the digitization process regularly hold conferences and workshops, which are announced on the project website.

3.3 Update on historical survey and landings data entry for Defra project MF1108 "100 Years of Change"

Georg Engelhard

The UK Department for Environment, Food and Rural Affairs (Defra), and its agency the Centre for Environment, Fisheries and Aquaculture Science (Cefas), belong to the world's longest running fisheries research bodies and hold unique historical fisheries data which is potentially extremely valuable in examining climate change impacts. Such data are highly relevant to understanding the long-term effects of fisheries, pollution, and other human impacts on marine living resources. Yet despite this uniqueness, very few pre-1970s data were electronically available until recently. The *100 Years of Change* project aims to collate and digitize fish and fisheries data, collected over the past 100 years by Defra, Cefas, and predecessors. This includes both commercial data on UK fisheries, and scientific surveys, which were carried out by Cefas beginning in 1902. Ultimately, the commercial data in particular will be used to to examine changes in distribution of commercially important fish populations throughout the 20th and early 21st Centuries, in relation to climate change and fishing pressure. The scientific survey data will serve to investigate long-term changes in stock structure, age and size compositions of key fish populations.

1. *Commercial fisheries data.* The total number of Defra 'Statistical Charts' on commercial fisheries that have been digitized, so far, is 1807. These span the years 1913–1980 and cover the North Sea. Each single chart shows, for a given year and fish species, and separately for each ICES statistical rectangle (1°latitude by 0.5°latitude): the catches (landings) as well as the catch-per-unit-effort, by UK trawl fisheries, with separate charts for fishing effort (number of hours fishing) by rectangle. This year we have completed all annual charts for UK trawl fisheries in the North Sea, and have added in historical charts on seiners and longliners, and we are indebted to Phil Davison (Cefas) for his efforts.

2. *Cefas scientific surveys.* The first scientific surveys by the Lowestoft Laboratory (now Cefas) were carried out in 1902. This marked the beginning of a series of very well-documented surveys from 1902 to 1909, by RV "Huxley". No surveys were then carried out in the years immediately before, during and after the First World War. During the years 1920-1939, between 10–15 surveys were generally carried out annually, mostly by RV "George Bligh", but many of these were not typical "fish surveys" (targeted at e.g. plankton, hydrochemistry, the collection of fish to be used in laboratory experiments but without records on catches per haul, etc.), so that mostly between 1 and 4 "fish surveys" were available for data entry for these years. Cefas survey effort was fully interrupted by the Second World War, when our survey vessels were needed for service in the Royal Navy (e.g. for mine-sweeping action). Cefas surveys then commenced again in 1947 (RV "Sir Lancelot") and, using various research vessels, have continued until the present with generally between 10–20 sur-

veys each year (but many surveys not targeted at sampling fish but with different cruise aims).

Historical surveys have been entered directly into the FSS database of Cefas, which is the standard database at Cefas that holds all information on the surveys currently carried out by Cefas research vessels (back to 1977 before the start of this project). Entered into FSS, the format of historical data entries is as comparable as possible to the contemporary survey data. The vast majority of historical surveys were digitized onsite by subcontractor JD Pattison Management Services, in close collaboration with several Cefas staff. Figure 1 shows the total number of surveys as entered by onset of the SG in October 2011.

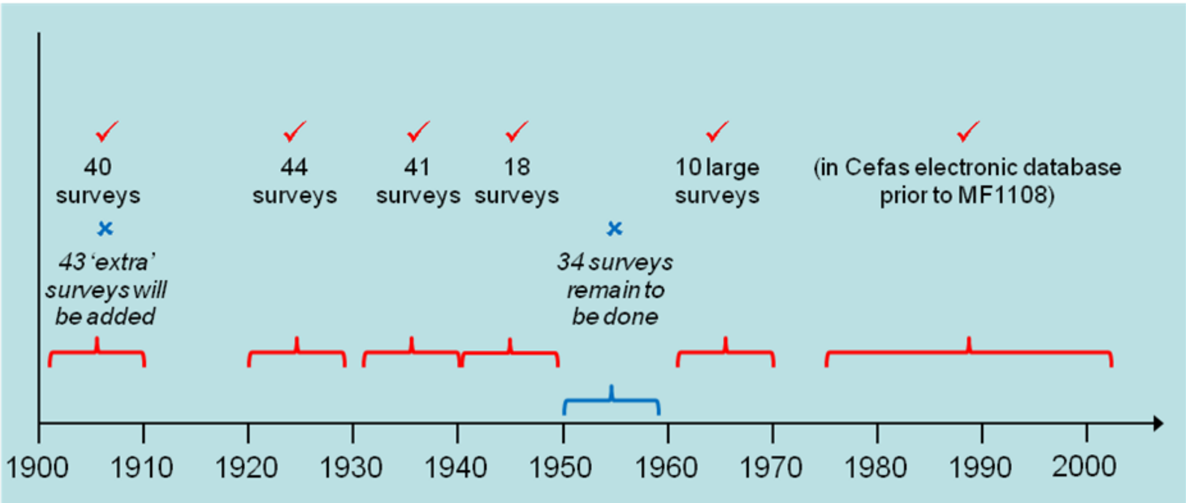

Figure 1. Timeline of historical Cefas surveys as entered by October 2011. Since then, entry of surveys for the 1950s has been completed and additional surveys for the 1900s and 1960s have been added.

4 ToR b) Long-term dynamics of fishing fleets and fishing technologies

4.1 Drivers of change in European Herring Fisheries, c. 1350–present

Bo Poulsen, Poul Holm, Christiaan van Bochove

When trying to understand fishing power and long-term technological changes in fisheries, the empirical past of commercially important fisheries offers a huge reservoir of assessing the importance of different factors. The European herring fisheries are one the World's biggest fisheries of the last Millennium. This study tries to pin down which factors played a dynamic role in how the fisheries developed over a multi-centennial scale. The focus is on i) consumer demands, ii) fishing technology, iii) environmental changes.

From the point of view of the demand side of the economy, consumption patterns played a major role for the long-term development of the herring industry. The per capita herring consumption seems to have reached an all time high in the 14th-15th centuries, followed by a steady decline. Then, modern infrastructure, principally railways and new preservation techniques, such as freezing technology opened up new markets after c. 1850. The consumption of fresh fish further seems to have been on a steady rise simultaneously to the infrastructural changes.

With regards to fishing technology, the timing of when North Europeans went to sea to fish has been documented by archaeologists and dated to somewhere in the 9th–10th centuries. However, until the early 15th century all fisheries were land-locked in the sense that they had to return to shore with their catches for processing. All this changed when Flemish fishers started to fish offshore using long driftnets deployed from converted cargo vessels. The decked vessels held storage for barrels, salt, and provisions for months. The factory vessel was born, and in terms of efficient fishing this was only surpassed with the introduction of steam from the 1880s onwards. Finally, the period after WWII, when sonar, echosounding and nylon gear – often in connection with huge purse-seines were introduced, should be heralded as another technological landmark in the history of fishing.

It is further argued that the environment can be seen as an agent – or rather conditioner of change in the European herring industry over seven centuries. Until the invention of the offshore fishing industry, the size of catches was entirely limited by the nearshore abundance of herring. When this limitation was overcome, the output of herring was able to flourish until the ceiling of total carrying capacity seemingly was hit from the 1920s onwards.

4.2 Drivers influencing dominance and subsequent decline of English North Sea demersal fisheries

Tina Kerby, William Cheung, Georg Engelhard

Landing trends in commercial fisheries are not only influenced by natural fluctuations or fishing pressure, but also by changing drivers affecting the fishing industry. Hence, for accurate interpretation of fisheries data and revealing trends in fisheries, the historical contexts of influencing drivers have to be understood. In this study, long-term datasets covering over 100 years of international North Sea demersal fisheries were compiled, focusing on England, and relating commercial landings to historical events and political, technological and economical drivers that influenced this fishery. In the 19th and first half of the 20th century Great Britain, and in particular England, had unchallenged dominance in North Sea demersal fisheries in Europe, but lost this lead in the second half of the 20th century. For England, favorable terms of political, technological and economical drivers brought about this vast rise, but as well influenced the decline.

In the following, the two eras of dominance and decline in the past century of English North Sea demersal fisheries are presented, highlighting the impacts of these drivers on a fisheries' development. However, the rise of this fishing sector began with the Industrial Revolution which commenced in Great Britain in the 18th and 19th centuries, and is taken into account when describing the development in English demersal fisheries.

4.2.1 Period 1900–1950s: drivers influencing the dominance of English North Sea demersal fisheries

Economy. – With the Industrial Revolution taking place in the 18th and 19th centuries in Great Britain, agricultural productivity enhanced, sanitation improved and living standards rose, leading to an increasing population and a higher food demand. In the 1820s the steam railway was introduced and with the development of the railway network, new markets opened up for the fishing industry (Alward, 1932). Inland markets could now be reached, and fresh fish became an article of cheap mass consumption in the growing towns and cities throughout the country (Robinson, 1998). It was the conjunction of these two circumstances – the railway allowing a quicker supply of goods, and the increased food demand – that paved the way for a dramatic expansion in the English fishing sector. At the beginning of the 20th century, the fish and chip shop trade emerged and grew in popularity of the British working class (Walton, 1992). The increase in domestic demand of white fish exceeded the supply in the waters surrounding the British Isles, allowing a profitable distant water fishery (Ashcroft, 2000).

Technology. – In 1881, the first purpose built steam trawler was introduced in Great Britain (Robinson, 1998) allowing operations on further fishing grounds within the North Sea, towing larger nets and beams, accelerating the fishing process and navigation independent of wind and tides (Collins, 1889). A large fleet of steam trawlers developed rapidly, leading to unchallenged dominance of the English demersal fleet. With the introduction of the otter trawl, fishing efficiency increased by an estimated 37% compared to formerly used beam trawls (Garstang, 1900). In the early 1920s, the Vigneron-Dahl trawl further increased the efficiency by 25–50% (Hickling, 1931). With improving propulsion technology (e.g. engine performance, fuel consumption) the operating range of trawlers expanded and English vessels could extend their fishing grounds to distant waters, notably around Iceland, the Faroe Islands, the Barents Sea, and North Africa (Fulton 1911).

Politics. – During the 19th century the general opinion prevailed that fish stocks cannot be depleted, and the Sea Fishing Act of 1866 laid the fundament for unrestricted fishing (Anon. 1868). At the beginning of the 20th century, the English trawling fleets were expanding their fishing grounds from the North Sea to highly profitable distant waters like the Faroe Islands, Greenland, the Barents Sea, and in particular Iceland. Especially the two leading ports in demersal fisheries, Hull and Grimsby, shifted their North Sea fleet to operate in distant waters, landing large quantities from there but with the consequence of declining North Sea catches. Although fisheries were in principle unrestricted, the two World Wars (1914–1918 and 1939–1945) brought the North Sea fishery to a near-standstill with great effects on the fishing sectors in Great Britain. Especially for the English trawling industry the impacts of the wars were severe as fishers and the largest and most modern fishing vessels were requisitioned for naval service, leaving England only a fraction of its former trawling fleet. Many fishers and fishing vessels were lost in the act of wars.

4.2.2 Period 1950s–present: drivers influencing the decline of English North Sea demersal fisheries

Economy. – In the decades following the Second World War, England's large trawling fleets continued to operate largely on the distant water grounds. With the introduction of Economic Exclusive Zones (EEZs) in the 1970s, however, the previous governing principle of open access to the seas belonged to the past. This implied that England was left with an overcapitalized distant-water fleet with limited fishing opportunities due to the lost access to their principal former fishing grounds. Further, the demand for fish changed in the post-war years: from the 1950s onwards the overall per capita fish consumption declined continuously (Reid, 2000), and in recent years customer awareness rose when buying fish, e.g. regarding the promotion of sustainable fisheries.

Technology. – After the Second World War, purpose-built motor trawlers driven by marine diesel were introduced, which gradually replaced conventional steam trawlers. Fisheries benefited from this development as motor trawlers were equipped with compact engines allowing significant savings on space, which could be used for bunkering fish (Robinson, 2000). When catches from the so far fished distant grounds were falling, the English fishing industry was going to even further fishing areas, e.g. around Greenland (Robinson, 2000). Large stern freezer trawlers were constructed enabling the storage of catch for much longer periods and permitting longer fishing voyages (Thompson, 1988). Further, the catching process was improved through new technological devices (e.g. echosounder, nets made out of synthetic fiber), allowing a more precise and efficient fishery (Burgess, 1961; Kristjonsson, 1959; 1971). Meanwhile, the international demersal fishery in the North Sea expanded significantly from the 1950s to 1970s, with various countries becoming heavily involved in the exploitation of North Sea fish stocks and undermining England's dominance in fisheries.

Politics. – Developments in the North Sea demersal fisheries have been strongly influenced by politics in the post-war years and especially in the 1970s and 1980s by the introduction of the EEZs. The outcome of the so-called "Anglo-Icelandic Cod Wars" had a severe impact on the English distant-water fisheries. With Iceland gradually expanding its territorial waters (1958–1961: 4 to 12 nautical miles; 1972-73: to 50 nautical miles; 1975-76: to 200 nautical miles), the English fleets successively had to withdraw their vessels from the grounds they had previously been so dependent upon. With the accession of the UK to the European Union (EC 1972) and the implementation of the EEZs, the British fishing industry had to adjust further. The fishing areas now became largely confined to European Community waters and British inshore areas, and the fleet was too large and overcapitalized for these waters (Thompson 1988). Furthermore, the industry had to adapt to the management of fish catches through the implementation of the quota and TAC (Total Allowable Catch) system. Owing to this principle of relative stability, the UK suffered from the introduction of the TACs which was based on historical fishing patterns, because England's catches in the North Sea had declined and the fixed percentage therefore was low. England's formerly successful fishing ports, and particularly Hull and Grimsby, struggled with this set of restrictions and experienced serious cutbacks in fishing activity.

The compilation and analysis of the dataset highlight the importance in understanding the historical context in interpreting fisheries data. In the case of England, political, technological and economical drivers have strongly affected its developments in fisheries. Benefiting from its technological and economic lead in the 19th and first half of the 20th century and with a large domestic market, England's demersal fisheries in the North Sea grew to a much larger scale than those of other European countries. Later on with the introduction of EEZs in the 1970s, the earlier emphasis on distant waters worked to the disadvantage of the English trawl fisheries and England lost its dominance in demersal fisheries, not only in the North Sea. This study shows that for a more comprehensive understanding of changes in fisheries landings, all factors influencing the fisheries should be taken into account. Therefore, besides biological responses of fish stocks to fishing and environmental changes, political, economical and technological factors have to be incorporated into the analysis.

4.3 Some simple thoughts about the science of fisheries management

Sidney Holt

In general control of complex systems is better effected by regulation of input than of output. Hence these notes are directed more to the primary regulation of fisheries by controls on inputs (fishing power, operational rules) than by output (TACs, desired catches).

The dynamics of an exploited fish population are determined principally by the relationships among three intrinsic variables and one extrinsic one. The three are measures of the rate of growth of an individual in size, which we'll call K; the natural mortality rate M, and the reproductive rate R. The fourth is the fishing mortality rate F. The important relationships are:

- the ratio of fishing to natural mortality: F/M and
- the ratio of growth rate to natural mortality: K/M and
- the dependence on population abundance/density of the difference ($R - M$).

It is important to remember that abundance and density changes may differ. Thus, commonly, the effective geographical range of the population contracts as its abundance is reduced by fishing. This is because density (abundance per square kilometre) varies from place to place and fishers will always prefer to operate, if possible, in places where natural or residual densities are highest. But fish will be sooner eliminated from localities where natural densities are lower – i.e. where the habitat is less favourable. These factors lead to what has been called "the basin model" of assessment and they explain that methods of estimation of stock trends from changes over time in "catch-per-unit-effort" (*cpue*) almost always lead to underestimation of the rate at which a stock is declining under the pressure of fishing. Another common cause of underestimation of stock decline is unnoticed technical or operational improvements in fishing methods.

The relationship between the two types of mortality is sometimes expressed as: Exploitation rate = $E = F/(F+M)$ which ranges from zero to one. The biological optimum is commonly in the vicinity of E = 0.7 or less, i.e. fishing mortality is not more than twice the natural mortality rate. This is only a very rough guide.

Evidently for fish with high natural mortality rates fishing has to be relatively intense in order to optimize sustainable catches – fish have to be caught before most of them die naturally. And *vice versa* for naturally long-lived species; for those species it is best to have low exploitation rates, allowing the relatively long-lived fish to grow.

The details depend on the selectivity of the fishery, that is whether fish of all sizes or a wide range of sizes are subject to fishing mortality, or only a certain limited range of sizes/ages. In general the more selective the fishery, for whatever reason – specification of gear, locality or season of permitted deployment, or other – the higher will be the fishing mortality rate required to optimize sustainable yields.

The value of ***F*** (hence ***E***) is determined primarily by the amount of fishing effort, ***f***, appropriately calibrated. Fishing effort is the product of the total fishing power (***p***) of the entire fleet and the average deployment of that power, (***d***) i.e. days at sea, hours spent searching and fishing etc., again appropriately calibrated, expressed as a proportion of available time. The fishing power of the fleet is simply the sum of all the powers of individual fleet units (vessels), also appropriately calibrated.

Immediately after the Second World War the dominant idea in Europe was to limit the growth of fleets to something below their sizes before the war. For various reasons this idea became replaced by the idea of catch limits, partly because in the international sphere the US, very active in developing international regulation, saw fleet limitation as an undesirable limitation of the universal right to go fishing. But effort limitation also had a bad reputation, especially from experience in regulating the Pacific halibut fishery, because although deployed effort was limited the fleet power was not; this led inevitably to an extremely inefficient fishery because ships were eventually only allowed to operate a few days per year.

The simplicity and directness of limiting fisheries by setting TACs are illusory. There are so many ways, and such strong temptations, to conceal the fact that illegal catches have been taken, unmarketable catch being discarded etc.. In addition the "correct" setting of a TAC depends on reliable prediction of future stock abundance, particularly of next year's recruitment. This is one of the most difficult things to do – and often expensive – in fisheries research and assessment practice. Fishing power and deployment are, on the other hand, relatively easy to keep track of, both in terms of presence in ports and, nowadays, with available tracking technology.

Computer simulations of managed fisheries have also shown that they are far more stable in the medium and long-terms when the primary control is limitation of the deployment of available fishing power rather than the limitation of catches. Economic stability is also best ensured by the proper balance between available power and percentage deployment of that power over time. Regulation by power and effort control do however call for much more attention to be given to the various necessary calibrations but the time frame for these is much longer than that needed to determine annual TACs; the efficiency of a certain trawler, for example, does not change wildly from one year to the next, nor do new methods with enhanced efficiency appear every year. A proper power regulatory system does, however, require that technological enhancements to fishing methods, and other operational changes, be properly accounted for in a timely manner.

Lastly I should mention that more than twenty years ago the Australian scientist/engineer W. de la Mare, showed by computer simulations, that efforts to hold a stock at MSY-level by setting catch limits must always fail, even when the population model is perfectly specified and all its parameters precisely estimated. De la Mare's study was made in the context of the management of whaling but his results and conclusions are generally applicable.

5 ToR c) Research linking climate change and dynamics of fish populations from historical data

5.1 Cod moves in mysterious ways: shifting distribution in the North Sea during the last century

Georg Engelhard, David Righton, Tina Kerby, John Pinnegar

The distribution of cod within the North Sea has shown major shifts over the course of the last century (Engelhard *et al.*, 2011b). This has become evident from an analysis of almost one-hundred years of British commercial fisheries data, digitized from Cefas archives. Combined with contemporary fisheries data, these span the period 1913–2010 (excepting both World Wars), at the spatially detailed level of ICES rectangle (0.5° Latitude, 1° Longitude). New analysis of old data reveals that From the 1920s to 1980s cod were especially distributed in the CW and NW North Sea, but in the 1990s a "hollowing out" of cod from their previous stronghold east of Scotland and NE England occurred leading to an eastward shift. In the 2000s, a strong decline of cod in the southeastern North Sea implied that cod now mostly occur in the N and NE North Sea (Figure 2). As a result, the current distribution of cod in the North Sea is almost the opposite of that during most of the 20th Century!

We previously reported on clear links between long-term distribution shifts of two North Sea flatfish species and climatic and/or fishing variables: plaice showed a *northward* and *deepening* shift that could be attributed to climate change but not to fishing pressure, whereas sole showed a *southward* and *shallowing* shift that could be related to climate change *and* fishing pressure (Engelhard *et al.*, 2011a). For cod, we also examined longitudinal, latitudinal, and depth distribution shifts in relation to changes in sea temperature, and newly compiled long-term data on cod fishing mortality, cod SSB, and cod recruitment over the past 90 years. Statistical analysis revealed that generally, climatic variables did not show clear, significant relationships with the latitudinal, longitudinal, or depth centre of gravity of cod distribution. However, the eastward shift of cod was significantly correlated with both fishing mortality and temperature although there was no clear linear relationship; the deepening shift was significantly correlated with fishing mortality but the relationship was not strong. This tentatively suggests that the recent shifts of cod distribution in the North Sea are primarily linked to the "hollowing out" of cod from its previous stronghold, the central-western North Sea.

In summary, we documented important distribution shifts of cod throughout the course of the past century, but it proved difficult to partition these shifts to either climate change or fishing (in contrast to sole and plaice where these links were evident). We conclude that it would be too simplistic to attribute the recent northward shift of cod to climate change alone (in line with Neat and Righton 2007, but less so with Perry *et al.*, 2005 and Rindorf and Lewy, 2006). Rather, links with fishing mortality hint that localized depletions of cod from their historic stronghold in the WC North Sea (off NE England and E Scotland) are an important contributing factor.

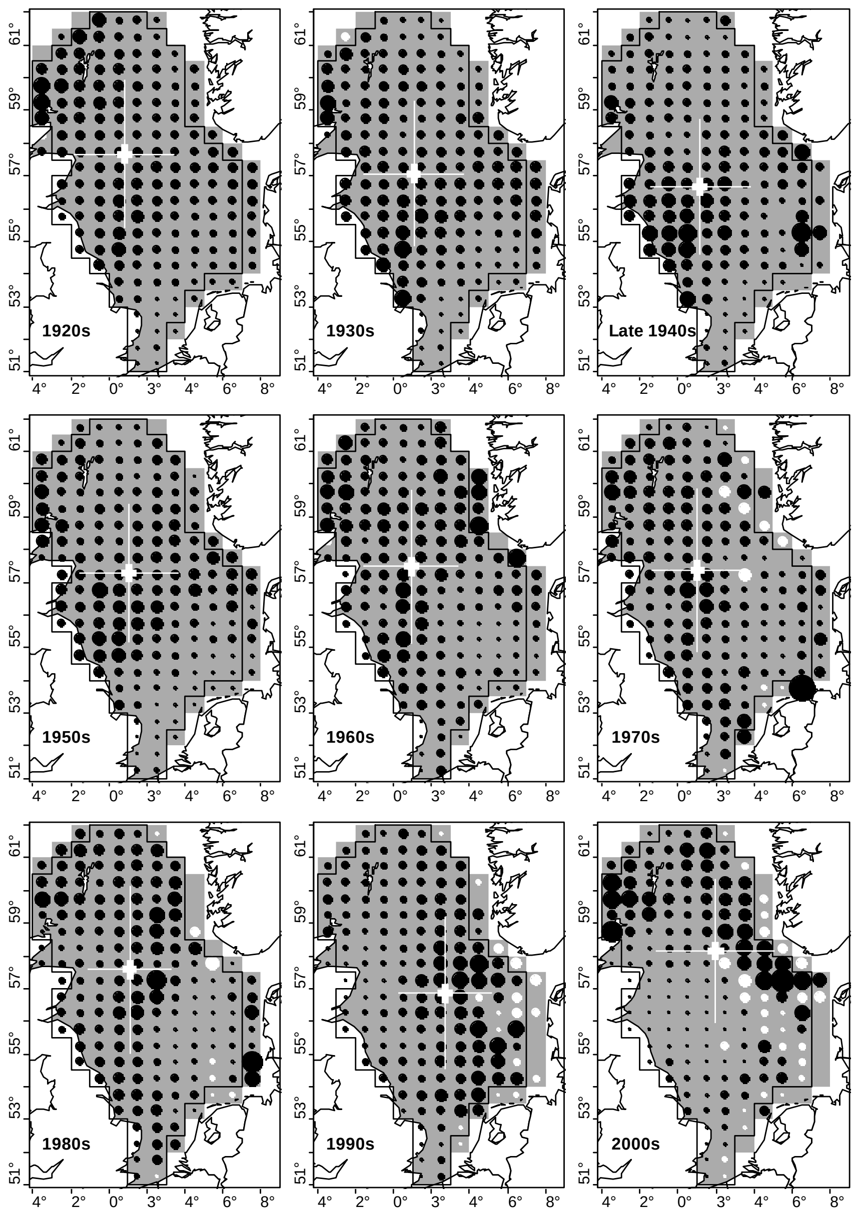

Figure 2. Shifting distribution of cod within the North Sea. Notice relatively minor shifts during 1920s–1980s but major eastward shift in 1990s and northward shift during 2000s. The white cross shows the "centre of gravity" (longitudinal and latitudinal) of North Sea cod distribution. From Engelhard *et al.*, 2011b.

5.2 Shifts in spawning seasonality of sole

Georg Engelhard, Jennifer Fincham, Adriaan Rijnsdorp

This study reveals that over the past 4 decades a shift in in the *timing of spawning* of sole has taken place, in relation to climate change (Figure 3). The work was carried out as an MSc project at Cefas by Jennifer Fincham (Imperial College; supervised by Georg Engelhard [Cefas], Adriaan Rijnsdorp [Imares] and Albert Phillimore [Imperial College]), and was also presented at the 8th International Flatfish Symposium (November 2011, IJmuiden).

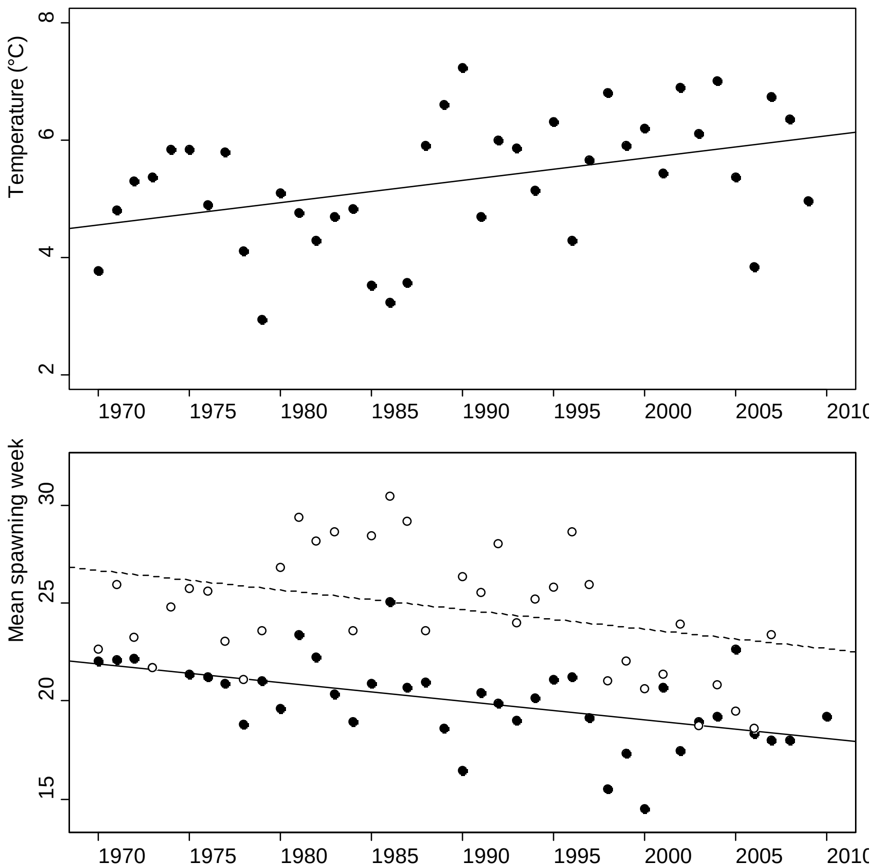

Figure 3. Long-term changes in (a) the average winter sea surface temperature of the southern North Sea, and (b) shift in the mean spawning week of sole in two areas of the North Sea: the southern (black dots) and eastern-central North Sea (white dots). Notice not only the long-term trend of advanced spawning, but also that individual, particularly cold winters are often linked with shifts towards later spawning in both substocks. Spawning is later in the (colder) central than southern North Sea.

The work shows that the generally warming temperatures in the North Sea over the past 40 years (Figure 3a) have coincided with a shift towards significantly earlier timing of spawning in sole, both in the central and southern North Sea substocks (Figure 3b). Similar changes have happened in the eastern English Channel and Irish Sea. Statistical analyses by linear mixed-effects models revealed significant relationships between temperature changes and the timing of spawning of sole (Fincham *et al.* submitted). These shifts in timing might have consequences for fisheries management, but may also require further study in the light of a possible mismatch with planktonic prey availability for the sole larvae.

5.3 North Sea cod: case study of a crisis

Colin Bannister

5.3.1 Pre-amble

The fishery for cod (*Gadus morhua* L.) in the North Sea is one of the many economically important cod fisheries in the shelf seas of the North Atlantic. This presentation described the now well-known large rise and fall in the biomass of North Sea cod that began during the so-called "gadoid outburst" of the 1960s and 70s, but ultimately ended with the cod overfishing crisis of the early 2000s, from which the stock has still not recovered, despite heroic attempts to regulate the harvest rate. In the context of the longer-term history of North Sea cod (Figure 4), this was in effect a single large perturbation that raises important questions about the most likely causative factors. The text is abstracted and updated from Bannister (2001), and the figures are taken from lectures presented annually at King's College, London.

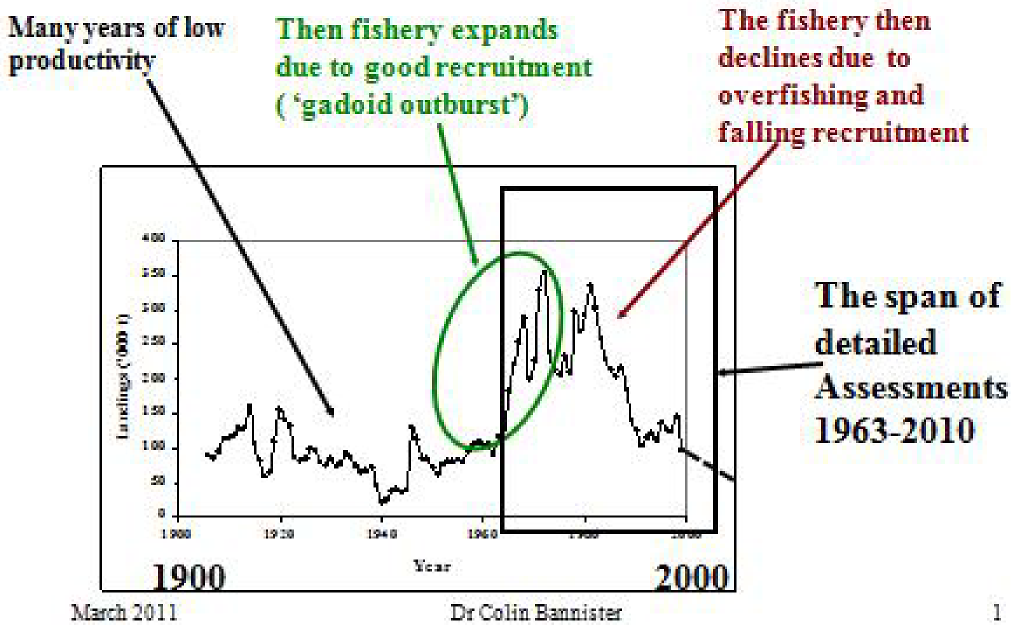

Figure 4. North Sea Cod: trend in landings from 1900–2000 (from Pope and Macer, 1996).

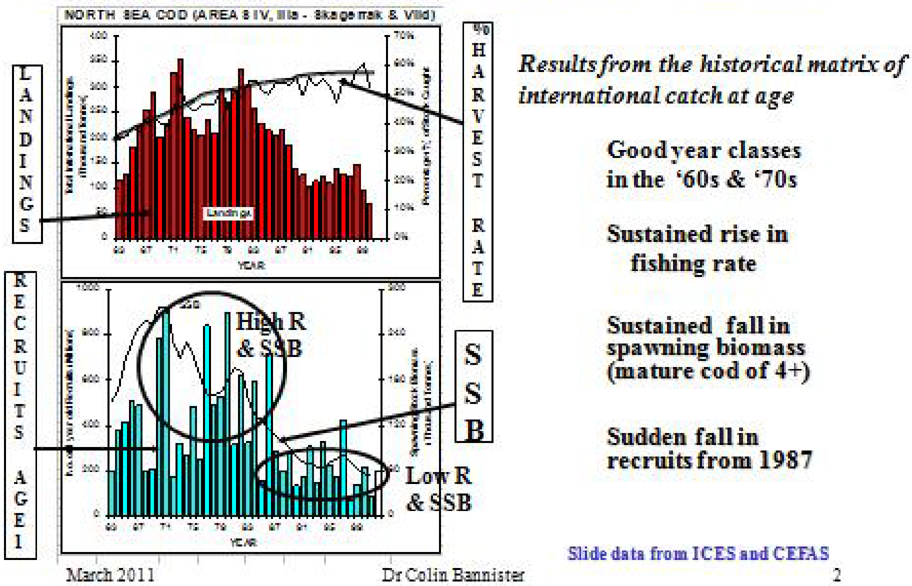

Figure 5. North Sea cod: output from the ICES analytical assessment, 2001.

5.3.2 Changes in the North Sea cod stock

The presentation described trends in landings, fishing mortality (F), recruitment (R), and spawning-stock biomass (SSB) derived from analytical assessment undertaken annually by ICES that extend back to 1963 (Figure 5), as well as earlier estimates of F and SSB back-calculated to 1920 (Figure 9) by Pope and Macer (1996).

From the 1960s to the mid-1980s, North Sea cod landings peaked in the range 200-350 kilotonnes (kt) due to a succession of large recruitments (Figure 5) that attracted a rapid rise in fishing activity, mainly by UK vessels compensating the markets for reduced supplies from distant water fisheries curtailed by the impact of 200 mile limits in the 1970s. Following the good year-classes, SSB (mature females aged 4+) peaked at 265 kt in 1971, but increased F provoked a prolonged decline. By the mid 1980s, mean F on ages 2 to 4 was 0.9 to 1.0, equivalent to 60% per annum, resulting in fewer than 5% of any year class reaching the mean age of maturity, and reducing SSB to 100 kt. Then in 1987, annual recruitment of cod aged 1, previously in the range 250 to 2800 million, suddenly fell to low values in the range 86–933 million. As a result of this step change, the geometric mean of recruitment-at-age 1fell from 740 million in the period 1963–1987 to 207 million in the period 1988-2009. This produced a marked shift towards the left lower quadrant of the stock–recruitment diagram (Figure 6), pushing SSB below the 150 000 t precautionary reference point (B_{pa}) and then below the 70 000 t limit reference point (B_{lim}). This led to anguished EU negotiations to restore SSB above B_{lim} as soon as possible, using drastic cuts in total allowable catch to reduce F, backed up by days at sea restrictions, and by an increase in mesh size to 120 mm in order to reduce the catch of immature cod. A larger increase in mesh size was ruled out because gadoids smaller than cod occur as a bycatch.

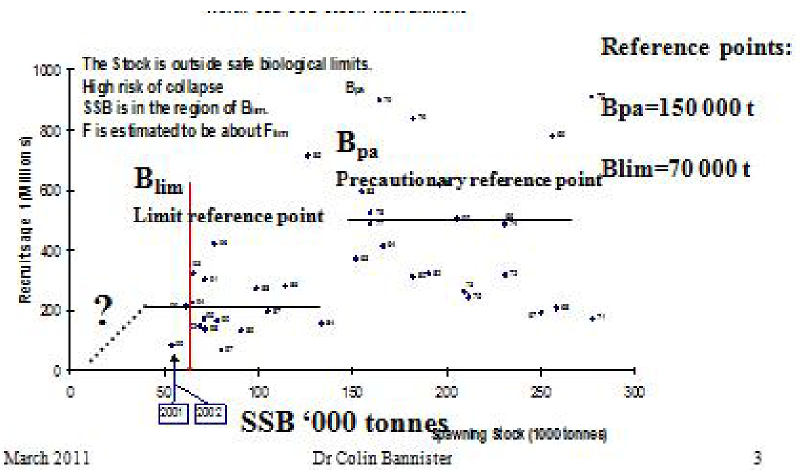

Figure 6. North Sea cod: stock–recruitment plot derived from the ICES analytical assessment, 2001. Note that recruitment of 1 year old cod declines at low stock size.

The likelihood and pace of stock recovery depends on whether cod recruitment can return to former levels, which in turn depends on what caused recruitment to fall in the first place. The cod stock–recruitment plot implies that the decrease in cod recruitment is a direct result of stock depletion, so that if F is reduced, recruitment should increase again, but the cod stock–recruitment plot contains no information about other possible effects, such as changes in the abundance of pelagic stocks, or the effect of recent environmental changes, as discussed below.

5.3.3 Pelagic-demersal stock interactions

A collapse of the previously large stock of North Sea herring due to severe overfishing in the 1960s preceded the onset of high cod recruitment in the 1970s, whilst the subsequent post-closure recovery of herring in the 1980s coincided with an accelerated decline in cod SSB (Figure 7) albeit at the same time as F on cod was reaching a peak. In the North Sea, adult herring can eat the early planktonic stages of cod so that, simplistically, changes in herring predation might affect cod recruitment, although specific studies of this hypothesis are lacking.

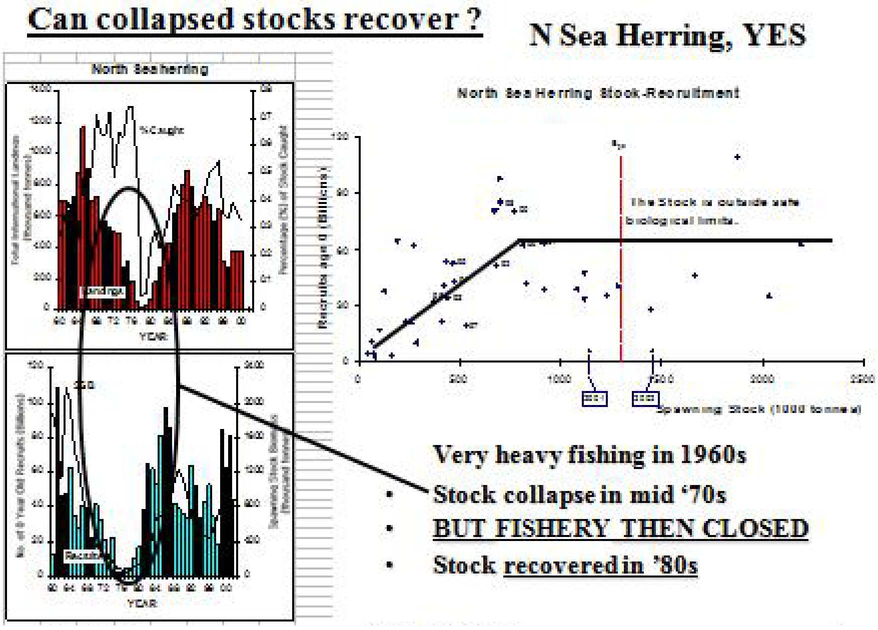

Figure 7. North Sea herring: output from the ICES analytical assessment, 2001.

5.3.4 Changes in sea temperature, plankton abundance, and the North Atlantic Oscillation

It is notable that recruitment and SSB declined simultaneously in several gadoid stocks round Britain in the late 1980s (Figure 8). The obvious common factor is the very high F in all these stocks, but it is also likely that environmental change has contributed to this common response. The downward step in gadoid recruitment from 1987 coincides with a half degree Celsius increase in water temperature. Research on the relation between temperature and cod recruitment at different latitudes shows that in Arctic areas cod recruitment improves with warmer temperatures, whereas in mid-latitudes (North Sea, Irish Sea and West of Scotland) cod recruitment deteriorates in warmer years (Planque and Frédou, 1999). Warming has also coincided with increased catches of bass, mullet, boarfish, and blue mouthed redfish in the southern and central North Sea.

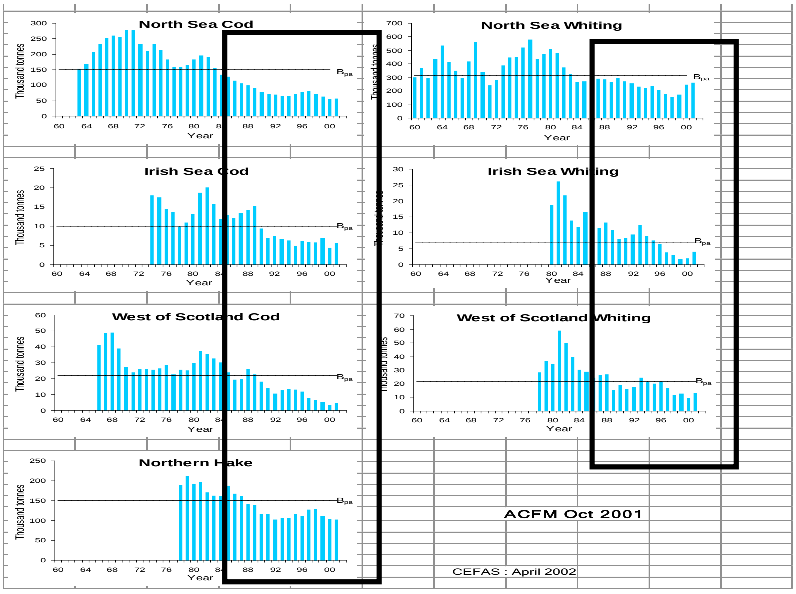

Figure 8. SSB and recruitment fell at the same time in several gadoid stocks in the 1990s.

In the North Sea the change in cod recruitment coincided with wider scale changes in the plankton (Beaugrand *et al.,* 2003). High cod recruitment in the 1960s coincided with strong plankton abundance, and weak recruitment after 1985 coincided with weak plankton abundance. There was also a species change from *Calanus finmarchicus* to *Calanus helgolandicus*, and copepods became smaller in size, especially relative to the size of prey preferred by cod. These changes occurred during a progressive northward retreat of Arctic and cold temperate species, and their replacement by oceanic and more southerly species (Beaugrand *et al.,* 2002).

There have been marked changes in the sign of the North Atlantic Oscillation. A positive NAO drives westerly winds over Europe causing warmer, wetter and stormier winters, whereas a negative NAO is associated with a cooler less windy regime. The NAO regularly flips between positive and negative sign, but whereas in the 1960s, prior to the gadoid outburst, the NAO was strongly negative, the NAO was mainly positive in years of low cod catches from 1900 to the 1960s, and from 1985 onwards. The 20 year span of the latest positive phase is particularly marked, and simulations suggest that it can only have come about with the aid of anthropogenic climate warming (Gillett, *et al.,* 2003).

5.3.5 Discussion

Low gadoid recruitment since the late 1980s coincides with heavy fishing, but also with higher water temperature, notable changes in the plankton, and a positive phase in the North Atlantic Oscillation. It appears that environmental factors must have contributed to the change in cod recruitment, and although the detailed mechanisms are still unknown the concern is that cod recruitment may not revert to former levels. The gadoid outburst, however caused, appears to be a unique event, and even if the subsequent decline in stock includes an environmental component, F has been higher recently than at any other time in the recorded history of the fishery (Figure 9). If environmental change is reducing recruitment, it is even more important to increase the number of spawning cod by effective management of the fishery. Scenario modelling suggests that even if temperature increases and recruitment stays low, a real reduction in F could recover spawning biomass to above 300 k t, and long-term yield to 140-200 kt (Turrell, 2006).

A further factor to be considered is the oceanographic feature called the North Atlantic Oscillation. Over time, the atmospheric pressure difference between the Azores high pressure area and the Iceland low pressure area „seesaws" between positive and negative (the North Atlantic Oscillation) because of cyclical fluctuations in pressure and wind patterns generated in the tropics. A positive NAO drives westerly winds over Europe causing warmer, wetter and stormier winters, whereas a negative NAO is associated with a cooler and less windy regime. The long-term trend in the NAO since 1800 suggest that in years of low cod catches from 1900 to the 1960s, and from 1985 onwards, the NAO was mainly positive, whereas in the 1960s, prior to the gadoid outburst, the NAO was strongly negative. Overall, therefore, low gadoid recruitment since the late 1980s not only coincides with heavy fishing, but also with higher temperature, notable changes in the plankton, and a positive phase in the North Atlantic Oscillation, There is insufficient information to determine clearly whether or how these relationships are all causally linked, although the Beaugrand data are strongly indicative that they are.

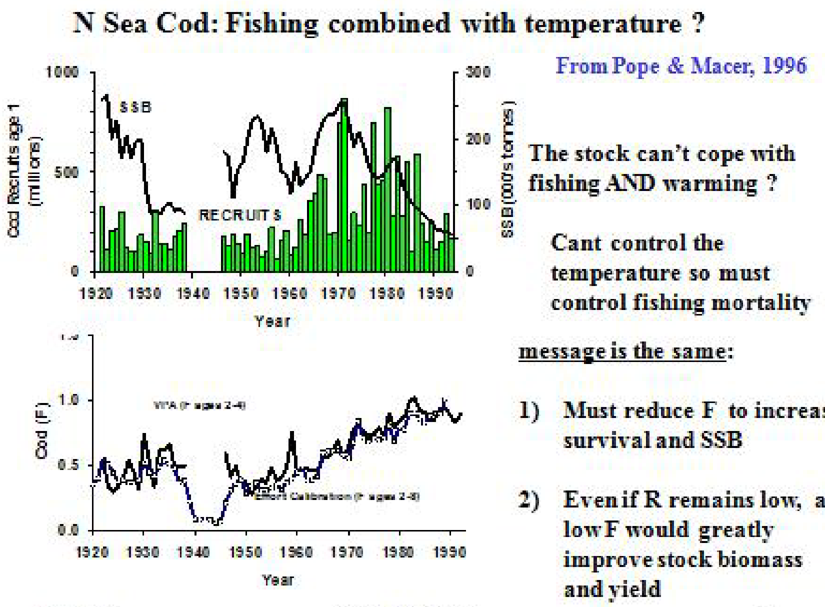

Figure 9. North Sea cod: trends in SSB, R, and F since 1920 (Pope and Macer, 1996).

Is it still worth controlling fishing? Although environmental factors must have contributed to the change in cod recruitment, and may not reverse, F is still high, and is the only factor that managers can change in an attempt to promote stock recovery. This is emphasized in Figure 9, where a long span of data on catch and fishing mortality for North Sea cod is compiled (Pope and Macer, 1996). This emphasizes that even if the decline in stock after the gadoid outburst includes an environmental component, F has been higher recently than at any other time in the recorded history of assessed stock status. Scenario modelling suggests that even if future recruitment stays low for environmental reasons, a real reduction in F could recover spawning biomass to above 300 000 t, and long-term yield to 140 000–200 000 t (Turrell, 2006), as noted earlier.

5.3.6 Conclusion

The cod stocks round Britain have been seriously depleted by the high fishing rate, the capture of too many immature fish, and the likely effects of higher water temperature and plankton changes on cod recruitment. To improve spawning stocks it remains essential to reduce the rate of fishing, and to improve the fishing pattern by preventing the capture of immature fish. Models show that if F is really cut back, much higher SSB and long-term yields are feasible, even if recruitment stays low. Finally, it is not reasonable to blame the failure of fisheries management on the EU or the Common Fisheries Policy directly. Exploitation by many nations, fleets and gears fishing competitively on common property resources, always conflicts with the conservation of stocks, and has caused overfishing and management difficulties around the world since the turn of the century. The problem was there long before the EU took control of the Community EEZ.

5.4 Multidecadal responses of the eastern Baltic cod to human-induced trophic changes, fishing, and climate

Margit Eero

Recent research efforts have extended the time-series of biomass of the eastern Baltic cod back to the 1920s (Eero *et al.*, 2007; 2008). The newly reconstructed time-series of cod stock dynamics extends to the period when the Baltic was still considered oligotrophic and contained large seal populations. Moreover, exploitation of cod in the Baltic was low until the 1940s–1950s (Eero *et al.*, 2008). This combination of long ecological datasets transcending the historical development of key human impacts enabled us to investigate how the onset of those impacts affected the population dynamics and productivity of cod (Eero *et al.*, 2011). Two of the main research questions in focus were:

1) What were the relative contributions of changes in fishing and climate to an increase in the cod stock to record high levels in the late 1970s–early 1980s?

2) Did eutrophication have a major role in this population expansion?

To address these questions, simulations of population dynamics were conducted, "turning off" the positive effect of one variable at a time; i.e. i) favourable climate; ii) increased nutrients; iii) reduced fishing. The results showed that the favourable climate and reduced fishing equally contributed to the record high cod biomass in the early 1980s, whereas the contribution of increased nutrients was minor (Figure 10).

The major trends in the cod stock in the 20th century coincided with changes in climate-driven hydrographic conditions. The stock size was additionally modified due to the trophic changes and exploitation intensity. Before the 1940s, the cod biomass was partly restricted by a high abundance of seal predators and presumably also by low nutrient availability. By the 1950s–1960s, these limiting factors were replaced by fishing. In the late 1980s–early 2000s, the stock was suffering from unfavourable hydrographic conditions and high fishing pressure. The period corresponding to the record high cod biomass in the late 1970s–early 1980s stands out as representing a combination of milder pressures on the stock, i.e. a prolonged period with favourable climate, low predation, increasing ecosystem productivity, and reduced fishing pressure; this situation has not occurred at other time periods during the past century (Figure 11).

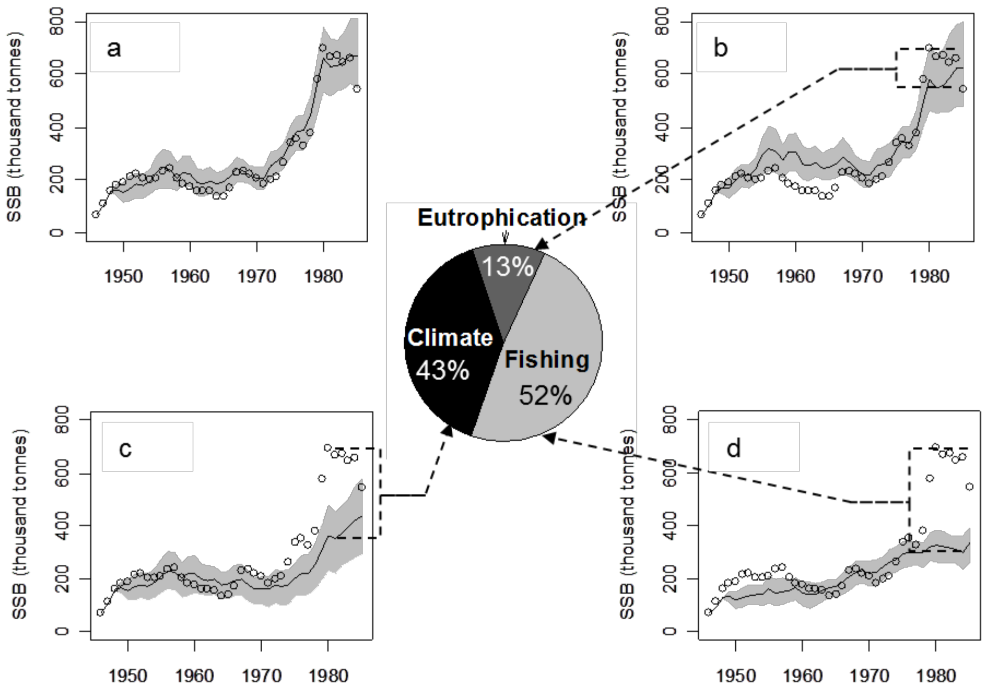

Figure 10. The four panels show simulated cod SSB (shown as a line; grey area represents 95% CI) using recruitment predicted from (a) hydrographic index, SSB, and nutrient concentration; (b) hydrographic index and SSB; (c) SSB and hydrographic index at the mean level as observed in 1982–2003; (d) hydrographic index, SSB, and nutrient concentration; fishing mortality was applied at the mean level observed in 1957–1972. Data points (open circles) in each panel show SSB estimated from analytical assessments. The pie chart illustrates the relative impacts (% difference between simulated and observed SSB) of eutrophication, climate, and fishing on the average cod SSB during the peak in 1980–1984, based on the three scenarios (from Eero *et. al.*, 2011).

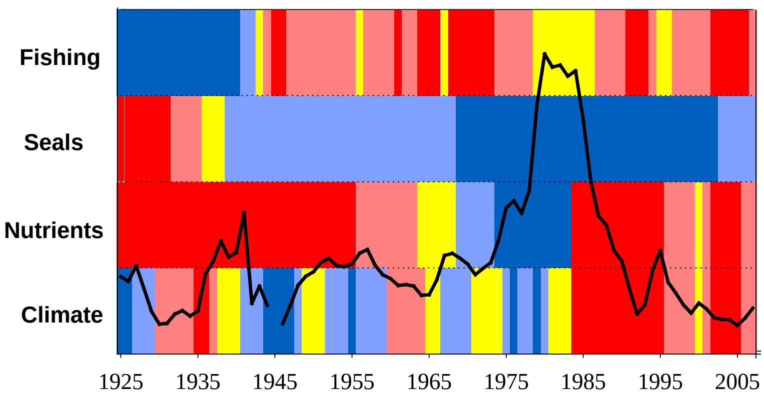

Figure 11. Changes in climate-driven hydrographic conditions, nutrient concentration, seal abundance, and fishing mortality compared to trends in SSB of the eastern Baltic cod (shown as a line) during 1925–2007. The data for climate and fishing variables are lagged in relation to SSB to represent their potential impacts on age groups 3–7 in SSB in a given year. The values of the parameters shown by the five colour categories represent 20th percentiles of the range of observed values (from minimum to maximum) for each variable during the analysed period. The colours represent beneficial and detrimental effects on cod, coded from red (detrimental) to yellow (neutral or moderate) to blue (beneficial; from Eero *et al.*, 2011)

5.5 Linking historical fish dynamics with climate and fishing pressure: on example of the Polish fishery of Baltic cod (1945–2010)

Włodzimierz Grygiel

In the years 1945–1975, Polish overall landings of Baltic fish increased, from 2606 to 213665 t (Figure 12), and this was accompanied by an increase in fishing capacity (main engine power) of vessels, from 1.8 to 70.9 thousand kW (Grygiel *et al.*, 2011, 2012). The years 1955–1975 were especially characterized by an increase of the annual landings of Baltic fish by the state-owned fleet, from 30 to 147 thousand t, and a rise in employment from 5035 to 6573 fishers, as well as in the number of fishing vessels, from 166 to 238. In the years 1945-1975 (before the introduction of EEZs), the fishing success depended more on the technical advancement of the fishing fleet than on the sizes of Baltic fish stocks. A visible increase of the Polish annual catches came with the introduction of modern stern cutters type B-410 in the mid-1970s. The fast development of the five Baltic state-owned- and three long-distance fishing companies was largely a result of increased, although varied, subsidization.

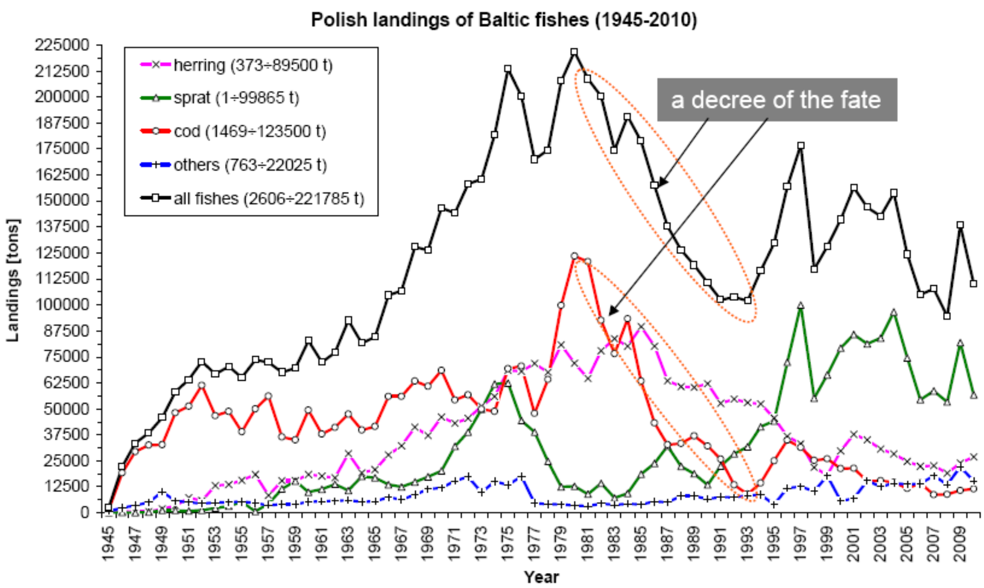

Figure 12. Trends in Polish fish landings from the Baltic, 1945–2010 (Grygiel *et al.*, 2011).

The sum of Polish landings of Baltic fish over the recent 66 years was 7.9 million t. In the years 1945–1975, fish landings increased by 82-times, accompanied by an increase in fishing power of vessels. In 1980, Polish landings from the Baltic peaked at 221 785 t, but in the following 12 years they decreased by 54% owing to a ”decree of the fate” (Grygiel *et al.*, 2011, 2012; Figure 12). Among species caught by the Polish fishers in the period of 1945-1986 were mainly cod, herring and sprat, with average shares of 49%, 32% and 14%, respectively. In the 1990s, the Baltic sprat landings began to increase rapidly, and dominated not only Polish, but also the international Baltic fishery for many years (ICES, 2011). The first phase of the recession in almost the entire Baltic fishery, including Poland, took place in the mid-1980s, when the landings, mainly cod and herring, were suddenly significantly reduced (ICES, 2011; Figure 12). Decrease of Baltic cod landings resulted from a decline in the abundance of recruiting year-classes (Figure 13) as an effect of considerable changes in the hydrological regime of the Baltic, i.e. a reduction in seawater salinity of the Bornholm and Gdańsk deeps (Grygiel *at al.*, 2004; Figure 14), and increased fishing pressure by the commercial fishery (Figure 13). In the years 1980–1993, the Polish landings of Baltic cod decreased from the long-term maximum of 123 500 tons to 8 909 tons (minimum landings, repeated again in 2007 and 2008). The above-mentioned occurrence can be considered as an example of impact of a decree of the fate on the commercial fishery.

The result of decreasing commercial landings of Baltic fish in the mid-1980s was the introduction of annual fishing limits, among others for cod, herring and sprat. Therefore, in contrast to the long-distance fishery, from this time the fundamental problem of stable development of the Baltic fishery was the fish stocks size, but not availability of fishing grounds.

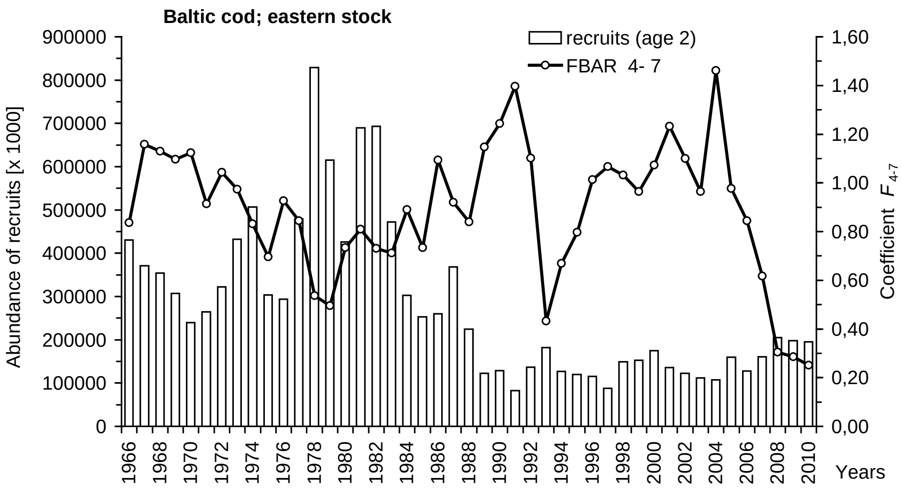

Figure 13. Changes of the eastern Baltic cod stock recruits abundance and fishing pressure (expressed as fishing mortality *F*, calculated for the age groups 4–7 by the ICES–WGBFAS [Grygiel *et al.*, 2012 after ICES, 2011]).

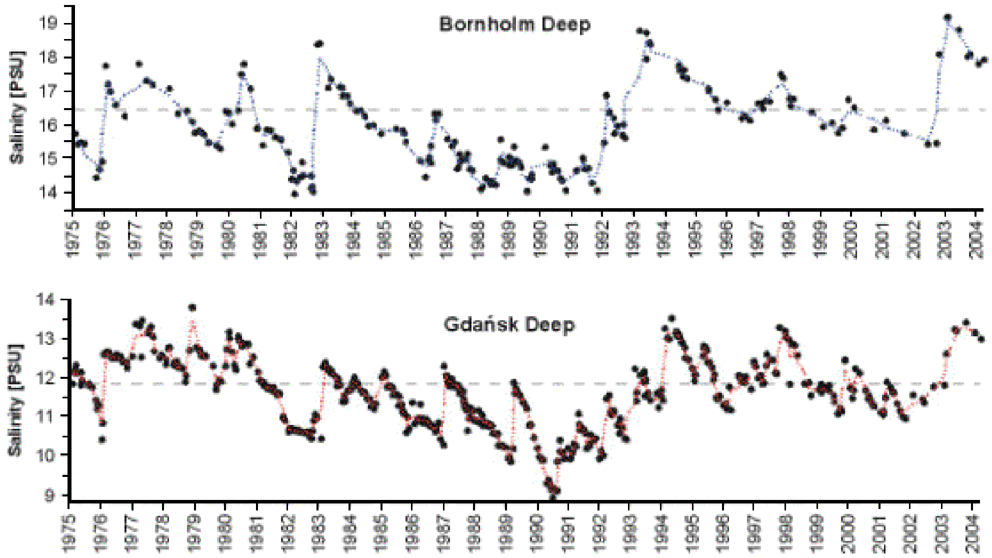

Figure 14. Fluctuations within years of the mean salinity in the bottom layers of the Bornholm and Gdańsk deeps (within the Polish EEZ) during 1975–2004. Dashed line marks the annual, long-term (1956–2003) mean salinity (Grygiel *et al.*, 2004; 2012).

5.6 Historical spatio-temporal dynamics of eastern North Sea cod

Valerio Bartolino, Massimiliano Cardinale, Henrik Svedäng, Hans W. Linderholm, Michele Casini, Anders Grimwall

The identification of historical baselines of marine ecosystems is a fundamental prerequisite for defining their sustainable management and conservation. Recent analyses of historical data of fish abundance and distribution have shown promising potentialities, but pose numerous difficulties such as fragmentation and inhomogeneities in the amount of available information in space and time. Using mixed-effects models in a multiscale analysis we identified an appropriate spatio-temporal scale of investigation of a high-quality spatially explicit historical dataset, and we reconstructed the long-term spatial dynamics of cod (*Gadus morhua*) in the Kattegat-Skagerrak along the 20th century. At the broad scale of our investigation, we identified a northern and southern main aggregation of adult cod in the study area, characterized by largely independent spatial dynamics, but a common extensive loss of coastal aggregations during the last decades. Population size widely fluctuated through the century, with a possible peak during the decade after the war. From the 1960s we observed a progressive contraction of the population, up to the historical minimum in the 2000s when only 30% of the estimated early century cod biomass was left. Our reconstruction showed that the collapse of the cod population in the area matched the peak in landings, while anticipated the warming trend of at least two decades, supporting the major role played by the post-war development of the industrial fisheries in the decrease of local abundances and disappearance of local adult cod aggregations.

6 ToR d) Case studies on history of fish and fisheries representing both sides of the Atlantic and the Mediterranean

6.1 A century of Sea Fisheries in Belgium

Ann-Katrien Lescrauwaet

In 2009 the Flanders Marine Institute (VLIZ) started with the inventory, digitization and integration of sources and references that contain historical data and research results related to the sea fisheries of Flanders/Belgium. Specialized databases and archives were screened for quantitative data and time-series (>5 consecutive years) in relation with historical landings, value of landings, fleet parameters, scientific assessments and monitoring. A detailed overview of the sources is available online at http://www.vliz.be/cijfers_beleid/zeevisserij/pub_bijdrage.php.

The main objective is to reconstruct historical time-series, trends and reference values for the sea fisheries of Belgium, at the lowest possible taxonomic level (i.e. species), temporal and geographical scale for parameters related to fleet size and fishing power, landings and catches, value of landings (income and average prices), policy and management. The resulting time-series are integrated into the Historical Fisheries Database 'HiFiData' (VLIZ 2009). The results are quality-controlled, standardized datasets that are accessible for further integration, for research purposes and for other applications such as timelines and instruments for decision supporting. The objectives were extended to include historical legislation and technical regulations in fisheries management, so as to provide a broader context for interpretation of trends and reference values. More information on this initiative is available online (in Dutch and English): http://www.vliz.be/NL/Cijfers_Beleid/Belgische_Zeevisserij. Methodology and sources are described in Lescrauwaet *et al.* (2010).

Recent developments in 2011 include:

1) A historical reconstruction of the size (number, gross tonnage) and capacity (driving power, kW) of the Belgian sea fishing fleet from 1832 to the present is presented by port of call (De Panne, Koksijde, Oostende, Zeebrügge, Blankenberge, Heist) on a per annum basis and trends are described. Secondly, the results are integrated with the historical landings (Lescrauwaet *et al.*, 2010) to provide a measure of change in landings per unit of power (LPUP) and landings per unit of effort (LPUE). Finally, change in catch efficiency is examined by comparing LPUE/LPUP today with those of historical times.

2) Official statistical tables were uncovered that give account of monthly landings by species and by fishing area for the WWII period (1940–1945). Although a well-coordinated and centralized statistical national and international (to ICES) reporting system on sea fisheries was in place in Belgium by 1929, quantitative datasets on the total fishery production collected during the WWII period of restricted fishing, were previously unknown in national and international reporting.

3) Detailed monthly landings for 7 species of commercial importance for Belgian sea fisheries (cod, plaice, sole, hake, brill, haddock and conger eel) were collected and digitized for the period 1947–1980. These monthly data on landings and value of landings are reported according to 3 broad length or weight categories for the 7 species (category boundary classes defined

by species, "small", "medium" and "large") and reported by ICES Subarea, for all subareas covered by the Belgian sea fishing fleet. A second dataset was reconstructed for the same 7 species on a monthly basis and per species, but reported (in the original paper copies) as spatially aggregated "North Sea" landings. An example is included in Figure 15.

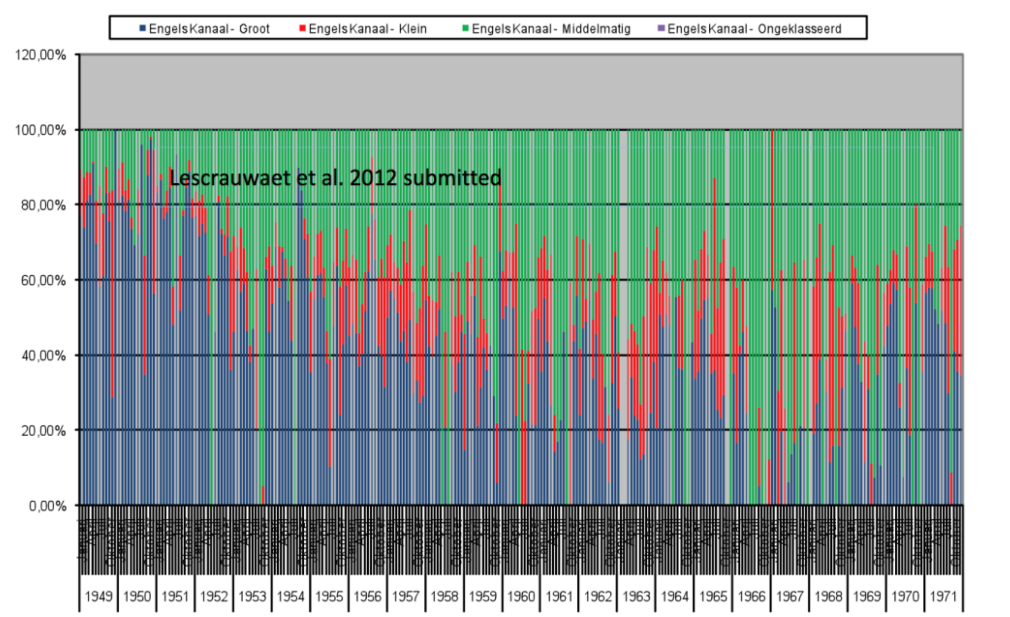

Figure 15. Monthly landings of sole into Belgium, caught in the English Channel during the years 1949 to 1971. Monthly absolute values (kg) are expressed as proportion (%) of the total catch from this fishing area for small (red), medium (green) and large (blue) specimens. Preliminary data presented here are not yet corrected for documented changes in length class boundaries (source: HiFiData).

6.2 Lobster catch reconstruction – implications for management?

Andreas Sundeløf, Valerio Bartolino, Mats Ulmestrand, Massimiliano Cardinale

Through the history of population ecology fluctuations of populations have been a surmounting topic. Endogenous causes of fluctuations and oscillations have been recognized for 80 years. In a historical dataset lobster catches show periodic fluctuations. These fluctuations are dampened and disappear over time. The disappearance of the periodicity coincided with a substantial increase in fishing effort. The oscillation has not reappeared and the shifting baseline syndrome has changed our perception of, not only, the status of the stock, but also the regulating pressures. The current study helps to reset the baseline and reinterpret the ecological realm of European lobster in Sweden. We describe the transition of a naturally regulated lobster population to a heavily exploited fisheries controlled stock. This is shown by the incorporation of environmental and endogenous processes in generalized additive models, autocorrelation/ partial autocorrelation functions and periodicity analyses of two different and overlapping time-series.

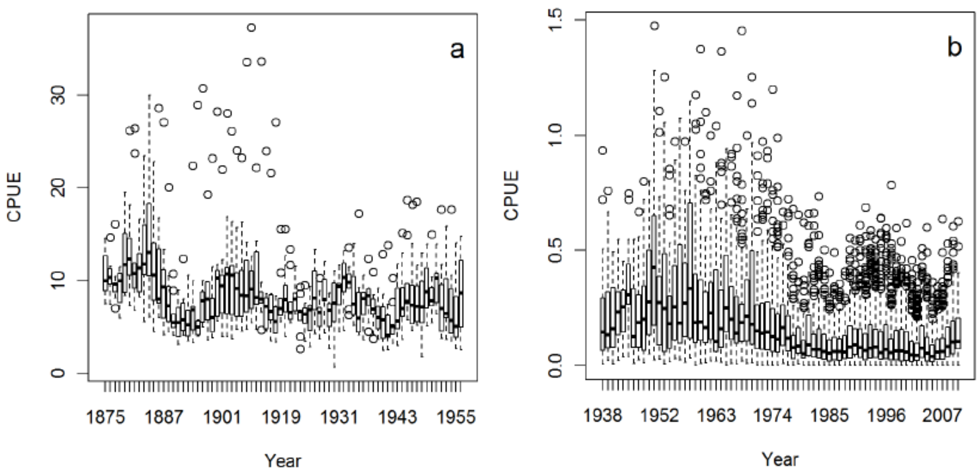

Figure 16. Lobster cpue derived from SREAS data (a) and Logbook data (b). The SREAS data were aggregated by area and year distinguishing it from the logbook data where catches could be extracted per pulled pot, hence the different y-axes scales.

6.3 Historical ecological studies on the Gulf of Maine

Emily Klein (through correspondence)

As a reminder, I'm interested in long-term change and patterns in ecosystem dynamics, function, and structure in the Gulf of Maine (GOM). At this time, I have finished digitizing the Canadian records for 20+ species, fish and invertebrates, from 1871 to 1940. These data are incredibly spatially explicit, reported by town for the Canadian coast, of which I've digitized the Bay of Fundy and GOM Nova Scotia. I will apply non-linear time-series analysis to these data, in conjunction with US statistics, to look at underlying dynamics. The non-linear approaches, developed by George Sugihara and his group at the Scripps Institute of Oceanography, provide a data-driven way to determine linear and non-linear dynamics in time-series, as well as time-series with statistically similar patterns. The multivariate methods can determine if similarities in patterns between catch time-series are the result of similar dynamics (e.g. correlated) or if the time-series are dynamically coupled (that is, they result from the same system – a step beyond correlation and indicating a common underlying mechanism/common underlying drivers). Finally, these methods allow novel ways to use coupled time-series to predict one another, providing avenues for filling in missing data for single or multiple years.

I plan to use the resulting dynamics in conjunction with historical qualitative literature and ecosystem modelling to look at GOM ecosystem structure through time. This work will build off the GOM ecosystem model for the present time-period, created with the MIMES (Multi-scale Integrated Models for Ecosystem Services) framework by a team based at Boston University (namely Roel Boumans, Les Kaufman, and Irit Altman). I have been working with them to learn MIMES, and I hope to alter the model they have designed to reflect the historic GOM.

More specifically, at present I am tackling the problem of effort and technological creep in the GOM info with my colleague, Karen Alexander. We are digitizing gear data from the US to provide spatially explicit time-series of gear and effort, which can be applied to historical time-series of catch to provide a proxy of abundance. These abundance proxies will then be run through the non-linear analyses, and eventually be used to run ecosystem models of the past system. Karen and I hope to have effort data by December, and will be working through abundance proxies and non-linear analysis over the winter. I plan on returning to Scripps in the early spring to work with Sugihara and his group on the multivariate methods. Developing the historical ecosystem model will also continue over the winter.

In addition to my work, the historical ecology group here in New England has been developing new projects we are very excited about. They are currently in the very early planning stages, and we hope to generate specific proposals over winter (this text primarily courtesy of Karen Alexander):

1) Cod bone project: Several archaeologists we've talked to over the years told us about their rooms full of cod bones recovered from digs all over the North Atlantic. These bones go back from around a 150 to thousands of years. Context tells you how the cod were caught and the site gives you the location, so you know the area they came from. We want to see how much genetic variability there was over space and time, as well as size, age, etc., to discover whether there were distinct populations that were geographically faithful and how much conditions changed over time. While we'd be initially focused on cod, bones of other fish bones exist in these collections as well.

2) Primary productivity: We are working on a proposal for a project to explore long-term primary productivity, water quality, and nearshore environmental health, initially using plankton remains and nutrient signatures in core samples. These cores would show changes in sediment deposition that might affect mineral and chemical nutrients phytoplankton need for growth, and bacterial signatures that tell you something about the health of the watershed, particularly changes in anthropogenic contaminants. An additional recent suggestion was doing box samples as well as to acquire shells for isotopic analysis, as well as a general idea of the surroundings of the core. This aspect might mirror work done by Alan Wanamaker, who found a 174 year old quahog and was able to derive environmental conditions from the datable layers of its shell (it died for Science). Tree rings keyed to solar output as well as weather conditions can be used to calibrate the core- and box-sample evidence. Finally, there is interest from UNH solar scientists in seeing how changes in solar output affect the oceans. It looks like there are good time-series about solar output, some of which are linked to tree rings. Thus, there appears to be a possibility to trace nearshore productivity back to the source (sunlight). Results from these basic drivers and trophic levels are critical for understanding creatures higher up in the food chain – in addition to providing insight on the old adage that primary productivity doesn't change.

3) Forage fish catch and market impacts: There has been some impetus for attempting to understand change in forage fish over time for the entire Northeast coast, with the goal being how monetarily beneficial it once was. The motivation is to explain to management and fisheries what has been lost in terms of capital, not just numbers of fish. However, as with my work and most other historical investigations, there is a wealth of data available, but no clear way to estimate biomass (except for alewives in 1950, for which the DeLury method would probably work). We are working on gear datasets that give catch by principal species (and sometimes by market sized), gear type, number of vessels using that gear type, total days fishing, and the fishing ground where these fish were caught. These are

sometimes limited in species reported. When the Statistical Areas are introduced in the 1930s they give this information for them at the same time as all the rest of it, so you can actually look at the difference that spatial scale makes in the metrics.

4) Secondary productivity: Understanding primary productivity in the GoM would allow us to look at secondary productivity and see if and when the link in the chain is broken. This project would build on several others mentioned here.

5) In addition: Karen Wilson, Theo Willis, Joan Trial and the Diadromous Species Restoration Research Network (DSRRN) people are looking at variability as a way to estimate alewife abundance on Maine rivers, and we've been working with them with our Maine data. Theo, Karen W., Bill and Karen Alexander also have a paper in the works about cod stomach contents and how they didn't eat lobster.

6.4 History of Danish oyster fisheries – abundance dynamics linked with climate

Bo Poulsen

Today, most fish consumption in the developed World is dominated by preferences for taste and fashion rather than nutritional necessities. This is a pattern of modernity. In recent decades much attention has been devoted to issue of historical developments in the diversification of demand and supply of consumer goods from the Late Middle Ages onwards. One aspect of this process is what is known as the ”conspicuous consumption”, or the consumption of products which were not absolute necessities in terms of upholding one’s life, but nonetheless causes of frequent environmental side effects. A general rise in this diversification has been linked with a general rise in labour productivity, economies of scale and what has been termed the industrious revolution as an engine of growth for a modernizing World.

Oysters, a type of food that has hardly anything to offer from a strict calorific point of view and cannot be seen as a necessity in any way, is one example of how consumer preferences underwent large changes in a modernizing Northern Europe. Within the Danish Kingdom, oysters from the shores of Schleswig-Holstein, the Limfjord and Kattegat areas all rose to prominence over these centuries, but little is understood about how these oyster beds came to be fished, later cultivated, managed and consumed – ultimately all of them to the degree of commercial extinction.

Three distinct oyster populations developed partly in succession, with the Holstein oysters being fished from the early 1700s, the Kattegat oysters from c. 1750–1870 and the Limfjord oysters from the 1860s, where the largest ever Danish oyster fishery came in operation. None of the fisheries were open access, all were subject to state licensing of the fisheries, yet management regimes failed to preserve the stocks in the long run. The causes of the rise and fall of the different oyster beds do not appear to be just individual disaster stories, but can only be understood in a comparative fashion, where the demands of the European consumer of Danish oysters found in cities all over the Baltic played a decisive role. Quite like the role played by the modern consumer.

7 References

Alward, G. L. 1932. The Sea Fisheries of Great Britain and Ireland: a Record of the Development of the Fishing Industry and its World-wide Ramifications Albert Gait, Grimsby.

Anon. 1868. Report of the commissioners appointed to inquire into the sea fisheries of the United Kingdom, presented by command, 1866. Her Majesty's Stationery Office, London.

Ashcroft, N. 2000. The diminishing commons: politics, war and territorial waters in the twentieth century. *In:* England's Sea Fisheries: the Commercial Sea Fisheries of England and Wales since 1300. Ed. by D. J. Starkey, C. Reid and N. Ashcroft. Chatham Publishing, London, pp. 217–226.

Bannister, R. C. A. 2001. The rise and fall of cod (*Gadus morhua* L.) in the North Sea. *In:* Management of shared fish stocks. Ed. by A. I. L. Payne, C. M. O'Brien and S. I. Rogers. Blackwell, Oxford, pp. 316–338.

Beaugrand, G., Brander, K. M., Lindley, J. A., Souissi, S., Reid, P. C. 2003. Plankton effect on cod recruitment in the North Sea. Nature, 426: 661–664.

Beaugrand, G., Reid, P. C., Ibañez, F., Lindley, J. A., Edwards, M. 2002. Reorganization of North Atlantic marine copepod biodiversity and climate. Science, 296: 1692–1694.

Burgess, J. 1961. Post-war trends towards improved fishing gear and equipment. *In:* Atlantic Ocean fisheries. Ed. by G. Borgstrom, A. J. Heighway. Fishing News (Books) Ltd, London, pp. 64-68.

Collins, J. W. 1889. The beam trawl fishery of Great Britain with notes on beam trawling in other European countries. Government Printing Office, Washington DC.

EC 1972. Treaty concerning the accession to the European Economic Community (EEC) and the European Atomic Energy Community (EAEC) of the Kingdom of Denmark, Ireland, the Kingdom of Norway and the United Kingdom of Great Britain and Northern Ireland, 22 January 1972, OJ L 73, 27.03.1972

Eero, M., Köster, F. W., MacKenzie, B. R. 2008. Reconstructing historical stock development of the eastern Baltic cod (*Gadus morhua*) before the beginning of intensive exploitation. Canadian Journal of Fisheries and Aquatic Sciences, 65: 2728–2741.

Eero, M., Köster, F. W., Plikshs, M., Thurow, F. 2007. Eastern Baltic cod (*Gadus morhua callarias*) stock dynamics: extending the analytical assessment back to the mid-1940s. ICES Journal of Marine Science, 64: 1257–1271.

Eero, M., MacKenzie, B. R., Köster, F. W., Gislason, H. 2011. Multi-decadal responses of a cod (*Gadus morhua*) population to human-induced trophic changes, exploitation and climate variability. Ecological Applications, 21: 214–226, doi: 10.1890/09–1879.1

Engelhard, G. H., Pinnegar, J. K., Kell, L. T., Rijnsdorp, A. D. 2011a. Nine decades of North Sea sole and plaice distribution. ICES Journal of Marine Science, 68: 1090–1104.

Engelhard, G. H., Righton, D. A., Kerby, T. K., Pinnegar, J. K. 2011b. Cod behaves in mysterious ways: shifting distribution in the North Sea during the last century. ICES CM 2011/D:06.

Fincham, J. I., Rijnsdorp, A. D., Engelhard, G. H. (submitted) Shifts in the timing of spawning of sole linked to warming sea temperatures. Journal of Sea Research.

Garstang, W. 1900. The impoverishment of the sea: a critical summary of the experimental and statistical evidence bearing upon the alleged depletion of the trawling grounds. Journal of the Marine Biological Association of the UK, 6: 1–69.

Gillet, N. P., Graf, H. F., Osborn, T. J. 2003. Climate change and the North Atlantic Oscillation. *In:* North Atlantic Oscillation: Climatic Significance and Environmental Impact. Ed. by. J. W. Hurrell *et al*. Geophysical Monographs, 134, p. 193.

Gøbel, E. 2010. The Sound Toll Registers Online Project, 1497–1857. International Journal of Maritime History, 22: 305–324.

Grygiel, W., Trella, K., Grelowski, A. 2004. Variation in the occurrence of visiting, non-numerous, and alien fish species in the autumn-winter seasons of 1976–2004 in the southern Baltic Sea. Poster No. 69/PH02 – Alien Fish Species Symposium (6-10.09.2004, Tallinn); [in: XI European Congress of Ichthyology, Abstract volume], p. 179.

Grygiel, W., Trella, K., Kuzebski, E. 2011. Long-term (1920–2010) changes of the Polish long-distance and the Baltic Sea fishery structure – an effect of mutual concurrence or a decree of the fate? ICES CM 2011/D:09; 27 pp. [in:] ICES CM Documents 2011; ISBN 978-87-7482-093-2.

Grygiel, W., Trella, K., Kuzebski, E. 2012. Long-term (1920–2010) changes in the structure of the Polish long-distance and the Baltic Sea fishery. National Marine Fisheries Institute, Gdynia (MS under publication process); 36 pp.

Hickling, C. F. 1931. A comparison of the Vigneron-Dahl trawling gear with the steam otter trawl, in the hake fishery. Journal du Conseil International pour l'Exploration de la Mer, 6: 421–431.

ICES. 2011. Report of the Baltic Fisheries Assessment Working Group (WGBFAS). ICES CM 2011\ACOM:10; Copenhagen; 842 pp.

Kristjonsson, H. 1959. Modern Fishing Gear of the World. Fishing News (Books) Ltd., London.

Kristjonsson, H. 1971. Modern Fishing Gear of the World: 3. Fish Finding, Purse Seining, Aimed Trawling. Fishing News (Books) Ltd., London.

Lescrauwaet, A.-K., Debergh, H., Vincx, M., Mees, J. 2010. Fishing in the past: historical data on sea fisheries landings in Belgium. Marine Policy, 6: 1279–1289.

Neat, F., Righton, D. 2007. Warm water occupancy by North Sea cod. Proceedings of the Royal Society, B 274: 789–798.

Pinnegar, J. K., Engelhard, G. H. 2008. The 'shifting baseline' phenomenon: a global perspective. Reviews in Fish Biology and Fisheries, 18: 1–16.

Planque, B., Frédou, T. 1999. Temperature and the recruitment of Atlantic cod (*Gadus morhua* L.). Canadian Journal of Fisheries and Aquatic Sciences, 56: 2069–2077.

Pope, J. G., Macer, C. T. 1966. An evaluation of the stock structure of North Sea cod, haddock and whiting since 1920, together with a consideration of the impacts of fisheries and predation effects on their biomass and recruitment. ICES Journal of Marine Science, 53: 1157–1169.

Reid, C. 2000. From trawler to table: the fish trades since the late Nineteenth Century. *In:* England's Sea Fisheries: the Commercial Sea Fisheries of England and Wales since 1300. Ed. by D. J. Starkey, C. Reid and N. Ashcroft. Chatham Publishing, London, pp. 157–165.

Rindorf, A., Lewy, P. 2006. Warm, windy winters drive cod north and homing of spawners keeps them there. Journal of Applied Ecology, 43: 445–453.

Robinson, R. 1996. Trawling: the rise and fall of the British trawl fishery. University of Exeter Press, Exeter.

Robinson, R. 1998. The development of the British distant-water trawling industry, 1880–1939. *In:* Exploiting the Sea: Aspects of Britain's Maritime Economy since 1870. Ed. by D. J. Starkey, A. G. Jamieson. University of Exeter Press, pp. 148–166.

Robinson, R. 2000. Steam power and distant-water trawling. *In:* England's Sea Fisheries: the Commercial Sea Fisheries of England and Wales since 1300. Ed. by D.J. Starkey, C. Reid and N. Ashcroft. Chatham Publishing, London, pp. 206-216.

Thompson, M. 1988. Hull & Grimsby Stern Trawling Fleet 1961–88. Hutton Press Ltd, North Humberside.

Turrell, W. R. 2006. Climate change and Scottish fisheries. Fisheries Research Services Collaborative Report No 12/06. Marine Laboratory, Aberdeen.

Walton, J. K. 1992. Fish and Chips and the British Working Class 1870–1940. Leicester University Press, Leicester.

Annex 1: List of participants

Name	Address	Phone/Fax	E-mail
Georg H. Engelhard *(Co-Chair)*	Centre for Environment, Fisheries & Aquaculture Science (Cefas), Pakefield Road, Lowestoft NR33 0HT, UK	+44 1502 527747	georg.engelhard@cefas.co.uk
Bo Poulsen *(Co-Chair)*	Roskilde University, Universitetsvej 1, building 03.2.2, DK-4000 Roskilde, Denmark. – **New address**: Aalborg University, Fibigerstræde 5, DK-9220 Aalborg, Denmark	+45 9940 9154	bpoulsen@cgs.aau.dk
Colin Bannister	32 Gunton Drive, Lowestoft NR32 4QA, UK		rcabannister@yahoo.co.uk
Valerio Bartolino	Department of Aquatic Resources (SLU-Aqua) - Swedish Agricultural University (SLU), 45321 Lysekil, Sweden	+46 18 671000	valerio.bartolino@slu.se
Margit Eero	Technical University of Denmark, Charlottenlund Slot, Jægersborg Allé 1, 2920 Charlottenlund, Denmark	+45 35883318	mee@aqua.dtu.dk
Włodzimierz Grygiel	National Marine Fisheries Research Institute (NMFRI), Department of Fisheries Resources, ul. Kollataja 1, 81-332 Gdynia, Poland	+48 58 7356270	wlodzimierz.grygiel@mir.gdynia.pl
Poul Holm	Trinity College Dublin, University of Dublin, Ireland	+353 1 896 8490	holmp@tcd.ie
Sidney J. Holt	Voc. Palazzetta 68, Paciano (PG), 06060 Italy	+39 075 830 7035	sidneyholt@mac.com
Kieran Hyder	Centre for Environment, Fisheries & Aquaculture Science (Cefas), Pakefield Road, Lowestoft NR33 0HT, UK	+44 1502 524501	kieran.hyder@cefas.co.uk

Name	Address	Phone/Fax	E-mail
Tina K. Kerby	School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK; **and** Centre for Environment, Fisheries & Aquaculture Science (Cefas), Pakefield Road, Lowestoft NR33 0HT, UK	+44 1603 591383	t.kerby@uea.ac.uk tina.kerby@cefas.co.uk
Emily Klein *(through correspondence)*	University of New Hampshire, 8 College Road, Durham NH 03824, USA	+1 603 8623213	emily.klein@unh.edu
Ann-Katrien Lescrauwaet	Flanders Marine Institute (VLIZ), InnovOcean site, Wandelaarkaai 7, B-8400 Oostende, Belgium	+32 59 342146	ann-katrien@vliz.be
Andreas Sundelöf	Department of Aquatic Resources (SLU-Aqua), Swedish Agricultural University (SLU), 45330 Lysekil, Sweden	+46 10 4784059	andreas.sundelof@slu.se

Annex 2: Agenda

Location: The Study Group will take place at Cefas, Pakefield Road, Lowestoft, where it will be held in Room 24A (ground floor; tel. 01502 527722). The agreed agenda is as follows:

Monday 24 October

(9:00–14:00)	(Meeting room is already open informally to SG participants from 9:00 onwards with wireless access, but the SG itself will not yet start)
14:00–14:15	**Start** of the SG, welcome by hosts
14:15–17:30	Presentations providing research updates on history of fish and fisheries (15 min, with 5 min discussion)

Tuesday 25 October

9:00–10:00	Update of metadatabase on historical fisheries data
10:00–12:00	Presentations on long-term studies linking fish population dynamics with climate (change) and/or fishing pressure (or other factors)
13:30–17:30	Workshop I: Linking historical fish dynamics with climate and/or fishing pressure

Wednesday 26 October

9:00–11:00	Research updates talks about fish spatio-temporal dynamics
11:00–12:00	Begin discussion of future work with historical fisheries data
13:30–17:30	Workshop II: Dealing with the particular issues of historical fisheries data; including fishing power change and irregularly spaced sampling effort

Thursday 27 October

9:00–10:00	Further discussion on opportunities for collaborative research, what are historical fisheries studies going to produce for policy advise, the wider public and funding opportunities
10:00–12:30	Drafting the outline of the SG report.
12:30–13:00	**Close** of the SG
(13:00–18:00)	(Meeting room remains available to SG participants optionally if needed, and opportunity to draft input for SG report)

Annex 3: SGHIST Terms of Reference for the next meeting

The **Study Group on the History of Fish and Fisheries** (SGHIST), chaired by Georg Engelhard, UK, and Ann-Katrien Lescrauwaet*, Belgium, will meet in Oostende, Belgium, 4–7 September 2012 to:

a) Coordinate data recovery activities for historical information on fish and fisheries;

b) Develop methods that can be applied to historical data in order to estimate long-term dynamics of stock, fishing fleet and fishing technologies, including spatial dynamics;

c) Examine how historical data can help to disentangle the effects of climate change, fisheries and other potential drivers on dynamics of exploited populations;

d) Present case studies on the history of fish and fisheries from both sides of the Atlantic and the Mediterranean;

e) Describe the availability of historic biodiversity data for each of the regions covered by the Marine Strategy Framework Directive and assess the utility of such data for assessing historic states and informing target setting (by others) for the Directive.

SGHIST will report by 20 December 2012 (via SSGSUE) for the attention of the SCICOM.

Supporting information

Priority	The activities of this Group will improve the understanding of the long-term changes in fish stocks productivity and structure of the marine ecosystems. Consequently these activities are considered to have a high priority.
Scientific justification	There is growing interest in historical data on fish and fisheries and the past marine ecosystem in general. The interest is on the discovery, recovery, digitization and analysis of historical data. The analysis of historical data are expected to give insight in long-term trends in fish stocks and fisheries which can be related to exploitation and long-term changes of the marine environment. Long-term data can be an important tool in disentangling the effects of fishing pressure and climate change on fish and shellfish populations. Historical data can help in establishing baseline levels and targets for indicators of Good Environmental Status for the Marine Strategy Framework Directive. The work links to the activities of the global network on History of Marine Animal Populations. Several fisheries research institutes in Europe have started to make inventories of historical information and the workshop is intended to bring these initiatives together.
Resource requirements	No specific requirements
Participants	The Group should be attended by some 15 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	Linked to the ICES Mission to “advance the scientific capability to give advice on human activities affecting, and affected by, marine ecosystems”(ICES Advisory Plan 2007-2011).
Linkages to other committees or groups	Groups of the Fisheries Technology Committee. Working Group on Ecosystem Effects of Fishing Activities. Working Group on Biodiversity Science. Working Group on Fisheries-Induced Evolution.
Linkages to other organizations	Global Network on History of Marine Animal Populations.