Food and Agriculture
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REVIEW of **biological data**, **spatial distribution of the stocks** and **ecological connectivity** between areas beyond national jurisdiction and the exclusive economic zones in the **Western Central Atlantic Fishery Commission region**

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REVIEW of biological data, spatial distribution of the stocks and **ecological connectivity** between areas beyond national jurisdiction and exclusive economic zones in the **WESTERN CENTRAL ATLANTIC FISHERY COMMISSION REGION**

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Abbreviations

ABJN	areas beyond national jurisdiction
AIS	automatic identification system
BMSY	spawning stock biomass (SSB) that results from fishing at FMSY for a long time
BRD	bycatch reduction device
CARICOM	Caribbean Community
CFMC	Caribbean Fishery Management Council
Chl a	chlorophyll a
CI	confidence interval
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLME	Caribbean Large Marine Ecosystem
CMM	conservation and management measures
CMS	Connectivity Modelling System
COPPESAALC	Commission for Small-Scale and Artisanal Fisheries and Aquaculture of Latin America and the Caribbean
CPUE	catch per unit effort
CRFM	Caribbean Regional Fisheries Mechanism
DCRF	Data Collection Reference Framework
dFAD	drifting fish aggregating device
EEZ	exclusive economic zone
ERA	ecological risk analysis
F	fishing mortality
FAD	fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
FDSWG	Fisheries Data and Statistics Working Group
FIRMS	Fisheries and Resources Monitoring System
F_{MSY}	Fishing mortality consistent with achieving maximum sustainable yield (MSY)
GC	Guiana Current
GEBCO	General Bathymetric Chart of the Oceans
GMLME	Gulf of Mexico Large Marine Ecosystem
GOM	Gulf of Mexico
HCR	harvest control rule
ICCAT	International Commission for the Conservation of Atlantic Tunas
iDCRF	interim Data Collection Reference Framework
IUCN	International Union for Conservation of Nature
IUU	illegal, unreported and unregulated (fishing)

IWG	Intersessional Working Group (of WECAFC)
LBI	length-based indicators
LME	large marine ecosystem
mFAD	moored fish aggregating device
MSY	maximum sustainable yield
NBC	North Brazil Current
NBCR	North Brazil Current Ring
NBSLME	North Brazil Shelf Large Marine Ecosystem
NEC	North Equatorial Current
NECC	North Equatorial Counter Current
NEI	not elsewhere included
NOAA	National Oceanic and Atmospheric Administration (of the United States of America)
OSPESCA	Central American Fisheries and Aquaculture Organization
PSA	productivity–susceptibility assessment
RFB	regional fishery body
RFMO	regional fishery management organization
SCRS	Standing Committee on Research and Statistics (of ICCAT)
SEC	South Equatorial Current
SEUSALME	South East United States of America Large Marine Ecosystem
SICA	Sistema de la Integración Centroamericana (Central American Integration System)
SIDS	Small Island Developing State
SSB	spawning stock biomass
SSB_{MSY}	spawning stock biomass capable of producing MSY
SSF_{MSST}	spawning stock fecundity at the minimum spawning stock threshold
SSF_{MSY}	spawning stock fecundity correspondent to MSY
Sv	Sverdrups
TAC	total allowable catch
TED	turtle excluder device
WECAFC	Western Central Atlantic Fishery Commission
YOY	young of the year

Executive summary

In the 17th session of the Western Central Atlantic Fisheries Commission (WECAFC), the Commission endorsed a roadmap for progressing towards the development of a model for a regional fisheries management entity or arrangement in the WECAFC region. The roadmap called for a second preparatory meeting of the WECAFC strategic reorientation, in which an ad hoc Intersessional Working Group (IWG) was assigned to conduct preliminary work to gather information, best practices and options for the development of such an entity or arrangement. This review was developed as a project in response to the needs of the IWG in its task of identifying key options and priorities. The objectives of the project included the revision of the data available and the information gaps in the WECAFC region with respect to:

1) stock identification, distribution, structure, abundance estimates and other relevant information pertaining to stocks that occur in exclusive economic zones (EEZs), that are or may be transboundary or shared stocks and/or straddling stocks, as well as stocks occurring in the high seas of the WECAFC region;

2) WECAFC fisheries mapping;

3) fisheries and stocks managed by other organizations that overlap geographically with the WECAFC region; and

4) the ecological connectivity between areas beyond national jurisdiction (ABNJ)/high seas and EEZ/coastal waters.

The review describes a group of selected species that are considered to be important to Member States of the WECAFC. It classifies them into transboundary and straddling/highly migratory stocks and their fisheries and provides information on the state of exploitation of the selected species. The review also considers the ecological connectivity between the high seas and the EEZs of coastal nations. Lastly, it highlights issues that need to be addressed to generate a sound scientific knowledge base in support of the strategic reorientation of the Commission.

The selection of the fisheries resources included in this review used as a starting point Appendix 3.1 of the *WECAFC Reference list of aquatic species* which was presented in the WECAFC interim Data Collection Reference Framework (iDCRF) version 2021.0.7, namely WECAFC "main" species and "other reference" species. The 69 species selected include 65 species from the *WECAFC Reference list of aquatic species* and four species that do appear in any of the WECAFC reference lists. The four species are included in this review because of their relative importance to the region's fisheries. Once the species were selected for review, they were classified into transboundary and straddling species.

This review provides information on the fisheries for 38 transboundary and 31 straddling species caught by commercial and recreational fleets, with a focus on the most recent catch statistics of the Food and Agriculture Organization of the United Nations (FAO) 2015 to 2019. It includes updated information on the distribution, life history, stock identification and stock status of each species reviewed and provides newly developed maps that show an updated spatial distribution of catches, catches by gear, the relative abundance of most straddling species and the fishing areas for most transboundary species.

This review demonstrates that the shared fisheries of the WECAFC region include fish that are caught in the waters of more than one country and in the high seas. Of the 38 species classified as transboundary, the queen conch (*Aliger gigas*, formerly *Lobatus gigas* and *Strombus gigas*) is the only species that is not considered transboundary by current research. Nonetheless, queen conch in the Caribbean should be considered a shared stock with transboundary issues. The remainder of the species classified as transboundary show no relevant discrepancies. One characteristic is that several groups of species show clear relevance within and between the large marine ecosystems (LMEs) in the region. The spiny lobster is widely distributed and exploited across all LMEs. The group of groundfish species is most intensively exploited in the North Brazil Shelf Large Marine Ecosystem (NBSLME) and parts of the southern coast of the Caribbean large Marine Ecosystem (CLME), except for the whitemouth croaker (*Micropogonias furnieri*) which is widely distributed in the coastal areas of the southern Gulf of Mexico Large Marine Ecosystem (GMLME), CLME and NBSLME.

Other transboundary species such as shelf shrimps can be separated into two groups: those corresponding to the GMLME and South East United States of America Large Marine Ecosystem (SEUSALME), and those corresponding to the CLME and NBSLME, with a couple of species that are broadly distributed across all LMEs of the region (redspotted shrimp, *Farfantepenaeus brasiliensis* and Atlantic seabob, *Xiphopenaeus kroyeri*). Although classified as transboundary, in most cases these species are managed as stock units by individual countries across the region and not as shared stocks. The four pelagic fish species classified as transboundary are under the mandate of the only regional fisheries management organization (RFMO) operating in the region (the International Commission for the Conservation of Atlantic Tunas [ICCAT]). Seven elasmobranch species were classified as transboundary. The review showed that most of the shark catches come from multispecies fisheries and small-scale fisheries off the NBSLME and southern coasts of the CLME, except for bonnethead shark (*Sphyrna tiburo*) that is more common in the GMLME. Most of the shark species are dressed at sea and grouped; this practice hinders proper identification and reporting of the catches. In addition, a considerable number of small individuals are landed in the NBSLME, likely juveniles, which may be an indication of the existence of nursery areas for some shark species. The need for enhanced efforts to identify the species that may use the area as nursery grounds is a critical issue in the conservation of shark species in the WECAFC region.

Of the 31 species classified as straddling/highly migratory, two are not under the mandate of ICCAT. These are the fourwing flyingfish (*Hirundichthys affinis*) and the common dolphinfish (*Coryphaena hippurus*).

This review demonstrated that information on reported catches and fishing effort across the region's fisheries is unbalanced, incomplete and out of date. Regardless of the Member State's development status, the fishery data relevant to the WECAFC region is incomplete. The most notable is the limited information on basic fishing effort data, i.e. fleet characteristics, number of vessels dedicated to an important fishery, the number of fishers, gear type by fleet(s), among other issues. The review of the most recent reported catches (2015 to 2019) by Member States showed two outstanding issues: the first is that in species-specific reported catches there were discrepancies between the data reported to FAO and those reported in other official databases (national or ICCAT) for the same species and year. The second, is the use of carry-over catch values, in some cases for several years, in certain species-specific reported catches.

Basic information on fishing effort in least developed countries with large coastal areas and multiple fisheries is limited, aggregated and most of the time not up to date (with very few exceptions). In contrast, countries with small and limited coastal areas tend to be more organized. Nonetheless, in both cases the fishing effort information is limited and unbalanced, at best. It is recognized that the limited information on catch and effort data in the region is due to the absence of a regional Data Collection Reference Framework (DCRF). Efforts endorsed by the WECAFC are focused on establishing a foundation for comprehensive fisheries data collection in the WECAFC region, although it is recognized that this may take years to put in place.

The review identified the different fishery regional bodies in the WECAFC region and noted that ICCAT is the only RFMO with a mandate that overlaps with almost all the straddling/highly migratory species considered in the review. The literature review indicates that most Member States are targeting or have an interest in expanding their large pelagic fisheries towards tuna species and/or tuna-like species. Therefore, it would be in their best interests to become involved in the process established by ICCAT to review the state of resources under its mandate.

The ecological connectivity between the high seas and the region's EEZs is largely dominated upstream by the North Brazil Current (NBC) and the North Brazil Current rings (NBCRs), and by the North Equatorial Current (NEC) downstream, which seem to have inferred influence in some of the straddling/highly migratory species exploited in the region. These two major currents are largely responsible for the connection of the straddling/highly migratory species (such as tuna and tuna-like species) exploited in the region. For some transboundary species it is less evident, but a lack of direct empirical evidence for the potential connectivity between the two distant ecosystems precludes any assertion that poor management around the boundary of either of the ecosystems will result in the loss of catches downstream (i.e. within the WECAFC region). Nonetheless, this review presents a recently published study that reveals the countries that depend most on the spawning grounds of neighbouring states are concentrated in the Caribbean islands (although the study did not specify the species that were responsible for that effect in the Caribbean region).

It is hoped that the review will serve as the basis of an actionable process to facilitate the decision-making required to transform WECAFC into a regional fisheries management entity or arrangement. Considerations for a way forward are expressed in Appendix A and may help in the transformation process. The appendix addresses several issues, including potential examples for a regional mandate with binding conservation and management measures (CMM) and ways to address deep-sea fishing in the ABNJ of the WECAFC region.

Dolphinfish caught by Venezuelan artisanal fisher © FAO/Alejandro Tagliafico

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Introduction

1. Introduction

The Western Central Atlantic Fishery Commission (WECAFC) was established in 1973 by Resolution 4/61 of the Food and Agriculture Organization of the United Nations (FAO) Council under Article VI (1) of the FAO Constitution. WECAFC is a regional fishery body (RFB) with the mandate to issue fishery management advice which may be implemented by its members on a voluntary basis. RFBs do not have the authority to issue binding advice to their members.

The WECAFC area covers nearly 15 million km^2 of marine area, extending from Cape Hatteras in North Carolina, United States of America (35° north) to south of Cape Recife, Brazil (10° south). This area covers the southeast coast of the United States, the Gulf of Mexico (GOM), the Caribbean Sea and the northeast coast of South America. Approximately 51 percent of the mandate area is in areas beyond national jurisdiction (ABNJ) and around 81 percent corresponds to waters with depths greater than 400 m. With the exception of northern Brazil, which is included in FAO Major Fishing Area 41, the management area corresponds to FAO Major Fishing Area 31.

The Commission, during its 16th session, agreed to launch a process to develop a regional fisheries management organization (RFMO) in the WECAFC area of competence, and to collaborate in fisheries management and conservation in the ABNJ with respect to straddling stocks, deep-sea fish stocks and highly migratory species that are not under the mandate of the International Commission for the Conservation of Atlantic Tunas (ICCAT) (FAO WECAFC, 2016). However, in the First Preparatory Meeting of the WECAFC for the Transformation into an RFMO, a different approach to the reorientation of WECAFC was recommended (FAO WECAFC, 2020). The approach determined that a new entity or arrangement would need to consider core issues, including: a) an advisory role in science, capacity building, technology transfer and monitoring, control and surveillance; and b) binding conservation and management measures (CMM) decisions at the level of the ABJN, with the possibility of retaining the option to include the exclusive economic zones (EEZs) in order to maintain flexibility for certain stocks or species. This would be in keeping with the example of the North Atlantic Fisheries Organization. Other aspects to be included would be the fight against illegal, unreported and unregulated (IUU) fishing, and trade issues, such as traceability and catch documentation schemes.

WECAFC Member States concurred that there are limitations on the data collection in the region and that there is a clear need to obtain stock data and other relevant information to make adequate fisheries management decisions. They emphasized that, when deciding on CMMs, not all species have to be managed and that priorities and procedures must be established to respect the sovereign rights of WECAFC Member States. In addition, there is growing concern about fishing by distant-water fishing nations in a large area of the high seas of the WECAFC region that may be affecting the availability of fish (particularly straddling resources) in the EEZs of the Member States.

WECAFC Member States noted that in the 1970s and 1980s, in the absence of the necessary data and information, management of shared fisheries would have been impossible. Subsequently, major investments by the countries, with support from the Danish International Development Agency's capacity building projects and the FAO/Norway EEZ programme, contributed to the improvement of information on fisheries and stocks status (FAO WECAFC, 2021). However, in the 1990s and the first decade of of the 2000s, less emphasis was placed on fisheries statistics and the need for sharing fishery data and statistics between States, particularly for use in regional assessments. This resulted in an increase in the significant gaps in basic fishery data that already existed and which complicated management actions because decisions had to be made without scientific evidence. The situation with respect to the availability of credible and adequate basic fishery data for monitoring and stock evaluations worsened. Fishery managers were faced with much less data when making decisions for management and conservation purposes.

Several WECAFC meetings agreed on the need to improve basic fishery data and statistics, as well as the need to develop and implement agreed data sharing policies to support decision-making, noting the lack of good data was a serious impediment to robust and effective management of marine resources in the region (FAO WECAFC, 2019). The Commission endorsed a partnership with FAO's Fisheries and Resources Monitoring System (FIRMS) to provide decision-makers with sufficient and reliable information to develop effective fisheries policies in accordance with the FAO Code of Conduct for Responsible Fisheries.

The most recent session of the Commission (its seventeenth) was convened in 2019 in Miami, Florida, United States (FAO WECAFC, 2020b). At the session, Member States adopted two recommendations, namely that: i) WECAFC endorses the structure and concept of developing a list of main fisheries species, including socioeconomic data; ii) WECAFC endorses the interim Data Collection Reference Framework (DCRF) as a foundation for fishery data and statistics collection and collation, to feed the needs of developing, monitoring, assessing and reviewing regional fisheries policies; promotes a WECAFC-CRFM-OSPESCA[1] regional database; and strengthens the collaboration between the Fisheries Data and Statistics Working Group (FDSWG) and other WECAFC working groups to refine DCRF and associated data sharing polices.

The aim of the DCRF is to provide a means for achieving improved data collection in the entire region for the purpose of informing regional and subregional management plans. As part of this objective, there is a need to support the Secretariat of WECAFC in implementing targeted actions of the 2019–2020 workplan on improved regional fisheries governance. Among other actions, the workplan included a comprehensive and detailed mapping of WECAFC fisheries and management practices for an informed strategic reorientation.

During WECAFC's 17th Session, the Commission endorsed the roadmap for progressing towards the development of a model for a regional fisheries management entity or arrangement in the WECAFC region. The outlined roadmap called for a Second Preparatory Meeting of the WECAFC Strategic Reorientation. In advance of the Second Preparatory meeting, an ad hoc Intersessional Working Group (IWG) was tasked with gathering information, best practices and options for the development of such an entity or arrangement. These tasks were to facilitate activities and outputs to inform the Second Preparatory Meeting of the WECAFC

[1] WECAFC-Caribbean Regional Fisheries Mechanism-Central American Fisheries and Aquaculture Organization

Strategic Reorientation and would provide support to the WECAFC Secretariat, which was tasked with facilitating the work of the WECAFC ad hoc IWG and the Second Preparatory Meeting.

In response to the need to support the IWG in its work of informed identification of key options and priorities, a project was established. The objectives of the project included the revision of the data available, and information gaps in the WECAFC region, with regard to:

i) stock identification, distribution, structure, abundance estimates and other relevant information, for stocks occurring exclusively in EEZs, that are or may be transboundary or shared stocks and/or straddling stocks, as well as stocks occurring in the high seas of the WECAFC;

ii) WECAFC fisheries mapping;

iii) fisheries and stocks managed by other organizations that overlap geographically with WECAFC; and

iv) the ecological connectivity between ABNJ/high seas and EEZ/coastal waters.

This document describes a group of selected species that are considered of great importance to Member States of the WECAFC region, their classification into transboundary and straddling/highly migratory stocks, and their fisheries, including information on the state of exploitation of the selected species. It also considers the ecological connectivity between the high seas and the EEZs of coastal nations. Lastly, it highlights issues that need to be addressed to generate a sound scientific knowledge base in support of the strategic reorientation of the Commission.


Pink winged flyingfish © Wikimedia

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General considerations

2. General considerations

In the First Preparatory Meeting of the WECAFC for the Transformation into a RFMO held in Bridgetown, Barbados on 25 and 26 March 2019, WECAFC Member States concurred that there are limitations on the data collection in the region and that there is a clear need to obtain stock data and other relevant information to make suitable fisheries management decisions. They also agreed on several time-specific approaches, starting with the ABNJ where binding measures can be implemented, and including selected straddling and transboundary species, or highly migratory stocks within the EEZs, without prejudice to the sovereign rights of WECAFC Member States.

In preparation for the WECAFC ad hoc IWG and the Second Preparatory Meeting of the WECAFC Strategic Reorientation – as a key intersessional process endorsed by the 17th biennial session of the WECAFC – it was agreed to establish the relevant information and scientific knowledge base in support of the deliberations of the Second Preparatory Meeting by reviewing the information on fish stocks and fisheries that occur exclusively in EEZs, that are transboundary and straddling stocks, as well as those occurring in the high seas of the WECAFC region, and the ecological connectivity between ABNJ/high seas and EEZ/coastal waters.

2.1 Species and stocks considered in this review

The selection of the fishery resources (in the broad sense) to be included in this review used as a starting point those fish resources that appear in Appendix 3.1 of the *WECAFC Reference list of aquatic species* presented in the WECAFC interim Data Collection Reference Framework (iDCRF) (iDCRF Version 2021.0.7). These are WECAFC “main” species and “other reference” species. Each of these two groups is further divided into several subgroups. Species in Group 1 are those considered to be main reference species. These are key species of the region and of specific interest to the WECAFC mandate and for which States are strongly encouraged to report catches. The key species are defined as follows and are supported on one or more primary subgroup bases (i.e. criteria for inclusion) and they have specific reporting requirements under the iDCRF (Version 2021.0.7):

i) subgroup basis 1: species with fisheries management plans endorsed (conch, lobster, flyingfish) or under development (e.g. conch, lobster and flyingfish, North Brazil Shelf Guianas shrimp and groundfish) (i.e. as in iDCRF Appendix 3.1a);

ii) subgroup basis 2: species of interest to historical working groups of regional bodies (WECAFC, CRFM, OSPESCA, including through their interim coordination mechanism). These species would include those such as small and/or coastal tunas, dolphinfish, wahoo, reef and shelf species (e.g. shrimps, groupers, snappers, acoupas, etc.), recreational and commercially targeted and threatened sharks and rays (i.e. as in iDCRF Appendix 3.1b);

iii) subgroup basis 3: species in high seas ABNJ/straddling/shared (i.e. as in Appendix 3.1c) and not under the mandate of another RFMO (i.e. as in iDCRF Appendix 3.2a); and

iv) subgroup basis 4: species for the WECAFC region originating from the 1978 working party on fishery statistics and/or of interest for other reasons (e.g. of local interest, including high commercial value, for biodiversity reasons, or for the importance of impacts from climate change) (i.e. as in iDCRF Appendix 3.1d).

Group 2 species are those "other species" (subgroup Basis 5) having reporting mandates to a neighbouring RFMO (e.g. the International Commission for the Conservation of Atlantic Tunas [ICCAT]) including tuna and tuna like species (i.e. as in iDCRF Appendix 3.2a).

Of the 196 species that appear in the *WECAFC reference list of aquatic species* presented in the iDCRF (Version 2021.0.7, Appendix 3.1), all nine species of the Group 1, Subgroup Basis 1 were selected (iDCRF Appendix 3.1a). A total of 17 species from the Subgroup Basis 3 (iDCRF Appendix 3.1b); 17 species from the Subgroup Basis 4 (iDCRF Appendix 3.1d); and 22 species from the Subgroup Basis 5 were also selected (iDCRF Appendix 3.2a). In addition, four species – one species of groundfish, smalleye croaker (*Nebris microps*), one species of grouper, gag grouper (*Mycteroperca microlepis*) and two elasmobranch species, bonnethead shark (*Sphyrna tiburo*) and pelagic stingray (*Pteroplatytrygon violacea*) – that were not included in any of the iDCRF reference lists, were included in this review, based on their relative importance in the region's fisheries. The list of 69 selected species considered in this review is presented in Table 2.1 (key regional species, ground fish, reef and slope species), Table 2.2 (pelagic and oceanic species) and Table 2.3 (sharks and rays).

Fishers in Saint Vincent and the Grenadines © AdobeStock

Table 2.1 List of key regional species, groundfish, reef and slope species in the Western Central Atlantic Fishery Commission region selected for review

Code	Scientific name/English name	Area of occurrence	Palacios-Abrantes *et al.*, 2020	Classification for this review
Key regional species				
SLC	*Panulirus argus*/Caribbean spiny lobster	SEUSALME, GMLME, CLME, NBSLME	X	Transboundary
COO	*Aliger gigas* gigas (formerly *Lobatus gigas* and *Strombus gigas*)/queen conch	SEUSALME, GMLME, CLME, NBSLME	–	Transboundary
Groundfish				
YNA	*Cynoscion acoupa*/acoupa weakfish	CLME, NBSLME	–	Transboundary
YNJ	*Cynoscion jamaicensis*/Jamaica weakfish	CLME, NBSLME	–	Transboundary
YNV	*Cynoscion virescens*/green weakfish	CLME, NBSLME	–	Transboundary
WKK	*Macrodon ancylodon*/king weakfish	CLME, NBSLME	X	Transboundary
CKM	*Micropogonias furnieri*/whitemouth croaker	GMLME, CLME, NBSLME	X	Transboundary
NBM	*Nebris microps*/smalleye croaker	CLME, NBSLME	–	Transboundary
Reef and slope species				
Groupers				
GPR	*Epinephelus morio*/red grouper	All WECAFC EEZs	X	Transboundary
GPN	*Epinephelus striatus*/Nassau grouper	SEUSALME, GMLME, CLME	X	Transboundary
EEU	*Epinephelus guttatus*/red hind	SEUSALME, GMLME, CLME	X	Transboundary
MAB	*Mycteroperca bonaci*/black grouper	All WECAFC EEZs	X	Transboundary
MKM	*Mycteroperca microlepis*/gag grouper	GMLME, SEUSALME	–	Transboundary
Snappers				
LJN	*Lutjanus analis*/mutton snapper	All WECAFC EEZs	–	Transboundary
SNR	*Lutjanus campechanus*/northern red snapper	SEUSALME, GMLME, CLME	X	Transboundary
LJI	*Lutjanus griseus*/grey snapper	All WECAFC EEZs	–	Transboundary
SNC	*Lutjanus purpureus*/southern red snapper	CLME, NBSLME	X	Transboundary
SNL	*Lutjanus synagris*/lane snapper	All WECAFC EEZs	X	Transboundary
SNY	*Ocyurus chrysurus*/yellowtail snapper	All WECAFC EEZs	X	Transboundary
Shelf shrimps				
ABS	*Farfantepenaeuss aztecus*/northern brown shrimp	SEUSALME, GMLME	X	Transboundary
APS	*Farfantepenaeuss duorarum*/northern brown shrimp	SEUSALME, GMLME, CLME	X	Transboundary
PST	*Litopenaeus setiferus*/northern white shrimp	SEUSALME, GMLME	–	Transboundary
PNU	*Farfantepenaeus subtilis*/northern white shrimp	CLME, NBSLME	–	Transboundary
SOP	*Farfantepenaeus notialis*/northern white shrimp	CLME, NBSLME	X	Transboundary
PNT	*Litopenaeus schmitti*/southern white shrimp	CLME, NBSLME	–	Transboundary
PNB	*Farfantepenaeus brasiliensis*/redspotted shrimp	SEUSALME, GMLME, CLME, NBSLME	–	Transboundary
BOB	*Xiphopenaeus kroyeri*/Atlantic seabob	SEUSALME, GMLME, CLME, NBSLME	X	Transboundary

Source: Authors' own analysis.

Table 2.2 List of pelagic species (oceanic) in the Western Central Atlantic Fishery Commission region selected for review

Code	Scientific name/English name	Area of occurrence	Palacios-Abrantes *et al.*, 2020	This review
Pelagic species (oceanic)				
FFV	*Hirundichthys affinis*/flyingfish	CLME, high seas	–	Straddling
BFT	*Thunnus thynnus*/northern bluefin tuna	ALL WECAFC	X	Straddling
YFT	*Thunnus albacares*/yellowfin tuna	All WECAFC	X	Straddling
ALB	*Thunnus alalunga*/albacore	All WECAFC	X	Straddling
BET	*Thunnus obesus*/bigeye tuna	All WECAFC	X	Straddling
SKJ	*Katsuwonus pelamis*/skipjack tuna	All WECAFC	X	Straddling
BLF	*Thunnus atlanticus*/blackfin tuna	All WECAFC	X	Straddling
LTA	*Euthynnus alletteratus*/little tunny	All WECAFC	X	Straddling
BON	*Sarda sarda*/Atlantic bonito	All WECAFC	X	Straddling
FRI	*Auxis thazard*/frigate tuna	All WECAFC	X	Straddling
BLT	*Auxis rochei*/bullet tuna	All WECAFC	X	Straddling
SWO	*Xiphias gladius*/swordfish	All WECAFC	X	Straddling
BUM	*Makaira nigricans*/blue marlin	All WECAFC	X	Straddling
SAI	*Istiophorus albicans*/Atlantic sailfish	All WECAFC	X	Straddling
WHM	*Tetrapturus albidus*/Atlantic white marlin	All WECAFC	X	Straddling
SPF	*Tetrapturus pfluegeri*/longbill spearfish	All WECAFC	X	Straddling
RSP	*Tetrapturus georgii*/roundscale spearfish	All WECAFC	X	Straddling
WAH	*Acanthocybium solandri*/wahoo	All WECAFC	X	Straddling
DOL	*Coryphaena hippurus*/common dolphinfish	All WECAFC	X	Straddling
SSM	*Scomberomorus maculatus*/Atlantic Spanish mackerel	GMLME, SEUSALME	X	Straddling
KGM	*Scomberomorus cavalla*/king mackerel	All WECAFC	X	Straddling
CER	*Scomberomorus regalis*/cero	CLME	X	Straddling
BRS	*Scomberomorus brasiliensis*/serra Spanish mackerel	CLME, NBSLME	X	Straddling

Table 2.3 List of sharks and rays (threatened and not) in the Western Central Atlantic Fishery Commission region selected for review

Code	Scientific name/English name	Area of occurrence	Palacios-Abrantes *et al.*, 2020	This review
Sharks and rays (threatened and not)				
OCS	*Carcharhinus longimanus*/oceanic whitetip shark	All WECAFC	X	Straddling
RHN	*Rhincodon typus*/whale shark	All WECAFC	X	Straddling
FAL	*Carcharhinus falciformis*/silky shark	All WECAFC	X	Straddling
BTH	*Alopias superciliosus*/bigeye thresher shark	All WECAFC	X	Straddling
SMA	*Isurus oxyrinchus*/shortfin mako	All WECAFC	X	Straddling
BSH	*Prionace glauca*/blue shark	All WECAFC	X	Straddling
JPE	*Sphyrna lewini*/scalloped hammerhead shark	SEUSALME, GMLME, CLME, NBSLME	X	Straddling
SPK	*Sphyrna mokarran*/great hammerhead	All WECAFC	X	Straddling
SPZ	*Sphyrna zygaena*/smooth hammerhead	SEUSALME, GMLME, CLME, NBSLME	X	Straddling
TIG	*Galeocerdo cuvier*/tiger shark	All WECAFC	X	Straddling
RMB	*Mobula birostris*/giant oceanic manta ray	All WECAFC	–	Straddling
PLS	*Pteroplatytrygon violacea*/pelagic stingray	All WECAFC	–	Straddling
CCL	*Carcharhinus limbatus*/blacktip shark	All WECAFC EEZs	–	Transboundary
CCR	*Carcharhinus porosus*/smalltail shark	GMLME, CLME, NBSLME	–	Transboundary
RHR	*Rhizoprionodon porosus*/Caribbean sharpnose shark	SEUSALME, CLME, NBSLME	–	Transboundary
RHL	*Rhizoprionodon lalandii*/Brazilian sharpnose shark	CLME, NBSLME	–	Transboundary
CTJ	*Mustelus higmani*/smalleye smoothhound	CLME, NBSLME	–	Transboundary
SPQ	*Sphyrna tudes*/smalleye hammerhead	CLME, NBSLME	–	Transboundary
SPJ	*Sphyrna tiburo*/bonnethead shark	SEUSALME, GMLME, CLME, NBSLME	–	Transboundary

Once the species of interest were selected (tables 2.1, 2.2 and 2.3), the next step was to define their shared nature within the WECAFC region. Shared stocks can be classified into three non-exclusive categories: transboundary stocks that cross the EEZs of two or more bordering coastal states; straddling stocks that cross neighbouring EEZs and the adjacent high seas; and highly migratory stocks that cross non-neighbouring EEZs and the high seas (such as most tunas) (Munro, Van Houtte and Willmann, 2004). Noting that there is not a list for transboundary or straddling species, such as the one for highly migratory species in Annex 1 of the United Nations Convention on the Law of the Sea, the classification of transboundary stocks in the WECAFC region was based on the method developed by Palacios-Abrantes *et al*. (2019). The method relied on multiple data sources, including occurrence, distribution models and catch data, and only considered a species to be present in a grid cell if all data sources showed positive occurrence. From the list of 633 exploited transboundary species worldwide identified by Palacios-Abrantes *et al*. (2019), matched species for the WECAFC region were identified and classified as transboundary species initially. Of the 69 species selected in tables 2.1, 2.2 and 2.3, 47 species matched the study. The remaining 22 were classified as transboundary following the study´s criteria (Palacios-Abrantes *et al*., 2019). The separation between transboundary and straddling stocks of the 69 species selected was based on regional knowledge of the species' distribution, i.e. in addition to the movement of the species fished between neighbouring nations, the confirmed catches of the same species occurring in the high seas (ABNJ) gave the species the straddling stock classification. Therefore, within the WECAFC region all highly migratory species were also considered straddling species, and those species fished only between neighbouring nations were considered transboundary. The classification resulted in 38 transboundary and 31 straddling species in the WECAFC region (tables 2.1, 2.2 and 2.3).

Noting that FAO only reports catches by countries in Major Fishing Areas, a number of FAO information resources were used as a source of information on the biological characteristics and geographical distribution of the species. These included the FAO species catalogues and other information products provided by the FAO FishFinder (FAO, 2023a), previously known as Species Identification and Data Programme, and FIRMS stocks and fishery fact sheets (FAO, 2023b), including those that appear in Appendix 3.3 in the WECAFC DCRF (Version 2021.0.7). In addition, information provided by regional and subregional organizations as well as the most recently published literature, the public media and expert opinion, were all utilized to develop a comprehensive summary for the species of interest (or groups of species) in each section.

2.2 Data approach and issues

This review builds on the most recently published review of the state of the fisheries resources of the WECAFC region and on recent information published by ICCAT, the RFMO with mandate over the region, and the RFBs present in the region.

Fisheries mapping was developed initially from the information available in the geographical and spatial data from the ICCAT database, and FIRMS´s Tuna Atlas. Several sets of base maps were created to show EEZs, the ABNJ area and the different LMEs in the WECAFC region.

The General Bathymetric Chart of the Oceans (GEBCO) 2021 grid (GEBCO, 2020), was used as a source to show the depth intervals (0–50 m, >50–100 m and >100–200 m) on the maps.

In some cases, bathymetric data was also used to delineate the general distribution of species, based on their respective depth ranges. The polygons of the maritime areas (EEZ, FAO Major Fishing Areas and LMEs) were downloaded from the MarineRegions.org web portal (Marineregions, 2023). The geospatial analysis and the generated maps were designed using the QGIS 3.20.1 software (QGIS Development Team, 2021) and the statistical programming language R version 4.0.5 (R Core Team, 2021).

These group of maps serve as a basis for the general geographical distribution, spatial distribution of catches, fishing gear, effort, catch areas and sightings for each species or group of species. Geographical spatial distribution maps were created from several sources, including but not limited to, ICCAT (ICCAT, 2023a), International Union for Conservation of Nature (IUCN) red list (IUCN, 2023), the Ocean Biodiversity Information System platform (OBIS, 2023), the Sea Around Us (Sea Around Us, 2023) and Robertson and Van Tassell (2019).

Fishery maps that included spatial distribution of catches, fishing gear and industrial longline effort were created from the most recent ICCAT database included in the Task 2 catch/effort data (ICCAT, 2023b) for all tuna, tuna-like species and elasmobranchs that are oceanic, pelagic and highly migratory under the ICCAT mandate (ICCAT, 2019a, ICCAT Recommendation 19-01 MISC). For species outside the ICCAT database, maps displaying fishing areas were based on the available spatial catch data information and from sightings (of a few elasmobranch species) obtained from the review of the most recently published literature.

The data used to review the most recent catch statistics for the selected transboundary and straddling resources were obtained from the most recent FAO dataset (FAO, 2021a) for 2015 to 2019 and extracted for FAO Major Fishing Area 31. Noting that the WECAFC region includes a portion of northern Brazil, and further noting that Brazil reports marine fishery catch data as FAO Major Fishing Area 41, without discriminating between the WECAFC portion. Only reported data for FAO Major Fishing Area 31 were used for catch statistics. In a few instances, and for species under ICCAT's mandate, FAO catch statistics were replaced with the updated data and identified accordingly in the catch table.

The review of the importance of the selected transboundary and straddling resources for the countries in the WECAFC region was based on the species or species group rank value by order of importance. The most important countries, representing greater than 80 percent or more than 90 percent of the total accumulated catch for 2015 to 2019, were considered in the analyses. Noting that a comprehensive database on fisheries and socioeconomics is not available for the WECAFC region, the information presented is based on fishery-specific data obtained from published resources. Therefore, the information is unbalanced across the region.

Grouper © Pixabay

3

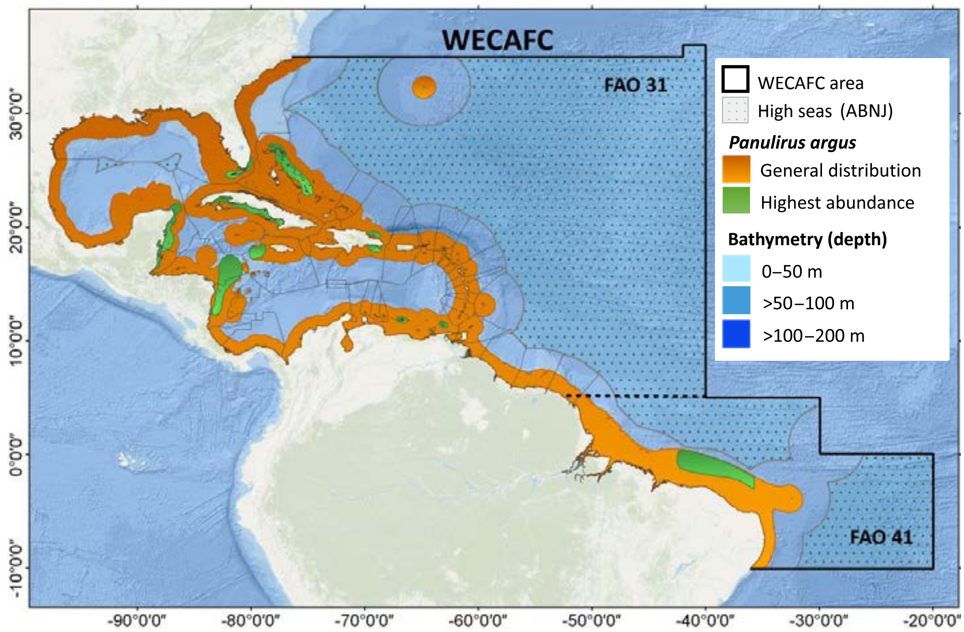
Transbounday and shared stocks

3. Transboundary and shared stocks

3.1 Key regional species

Caribbean spiny lobster (*Panulirus argus*). This species is distributed in the subtropical and tropical western Atlantic from Bermuda and the east coast of the United States, from North Carolina to Rio de Janeiro, Brazil, including the GOM and the Caribbean Sea, from shallow waters to depths up to 100 m (Butler *et al.*, 2011). It occupies various marine habitats, including seagrass beds, mangroves, coral reefs and rocky substrates. The highest concentrations based on capture fisheries data occur in the western Caribbean and Brazil (Figure 3.1).

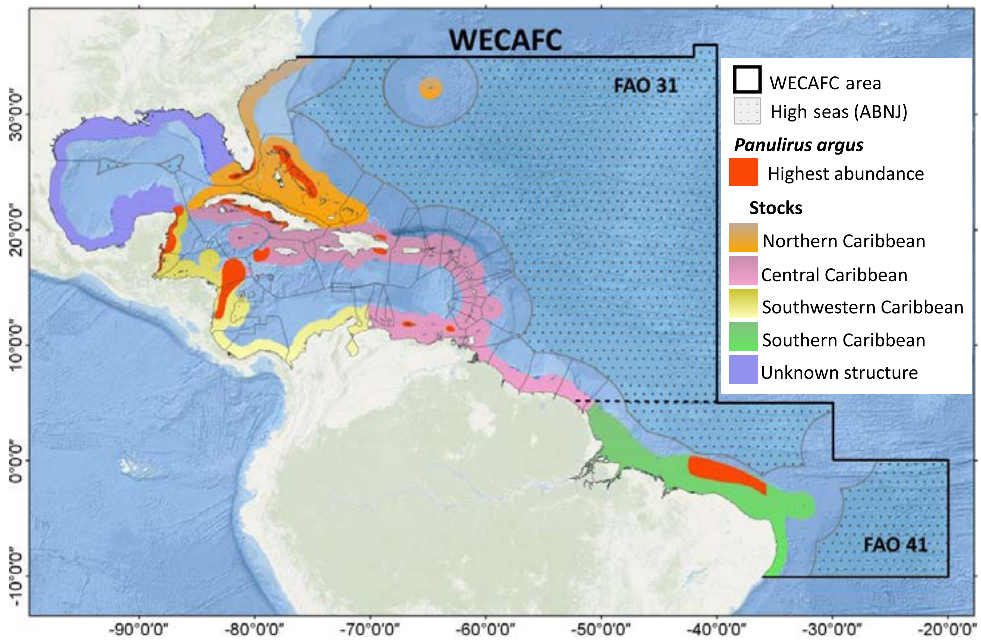
Figure 3.1. Caribbean spiny lobster (*Panulirus argus*, SLC) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The species has a complex life cycle, with a 6-month to 12-month planktonic larval period and important larval dispersal throughout the Caribbean. However, larvae are also retained in local gyres, predominantly off Costa Rica and Panama, off Honduras and south of Cuba, and north of the Bahamas, contributing to local recruitment (Kough, Paris and Butler, 2013; Segura-García *et al.*, 2019). Subsequently, larvae migrate to coastal shallow nursery areas for 6 months to 8 months. A recent stock structure has been proposed for the WECAFC region (Truelove *et al.*, 2016; FAO, 2019a). The five-stock structure is represented by a Brazilian stock, eastern Caribbean stock, western Caribbean stock, Atlantic stock and an undefined GOM stock (Figure 3.2). However, the United States has identified one stock for the northern GOM and the southeastern United States, and three stocks in its territories (Puerto Rico, Saint Thomas, Saint John and Saint Croix in the United States Virgin Islands). The potentially distinct stocks within the WECAFC area highlight the need to definitively delimit each stock and to understand the interaction between them in terms of larval export and recruitment to the fishery.

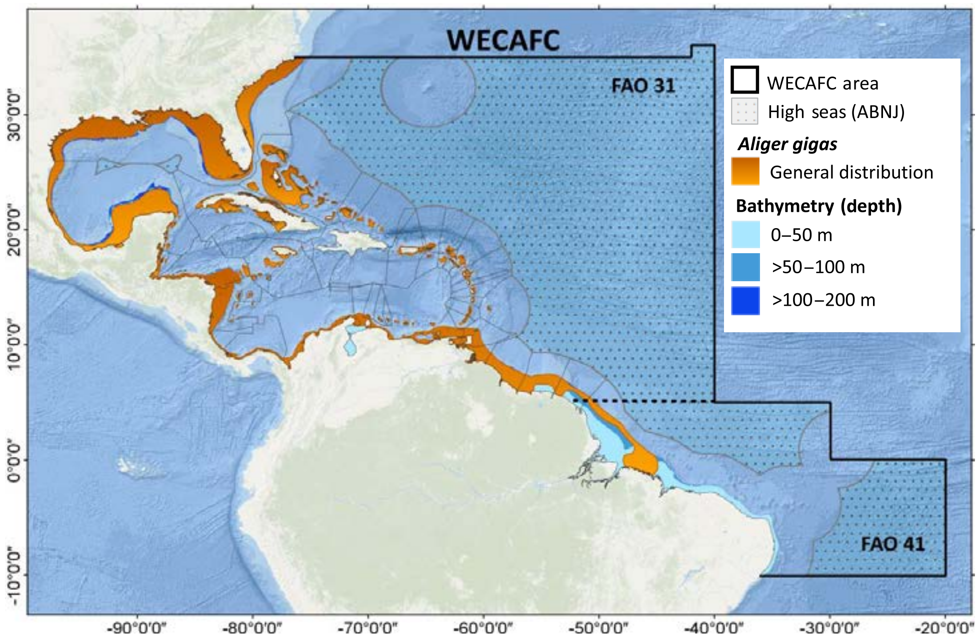
Figure 3.2. Caribbean spiny lobster (*Panulirus argus*, SLC) known stocks in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Queen conch (*Aliger gigas*, formely *Lobatus gigas* and *Strombus gigas*). This species was recently renamed to *Aliger gigas* (Maxwell *et al*., 2020). It is a large gastropod mollusc, endemic to the Caribbean and utilized across its range since pre-Columbian times (Antczak *et al*., 2013). Consequently, it has an important fishery and the species is culturally significant. The queen conch occurs throughout the Caribbean Sea, the GOM and around Bermuda (Figure 3.3). Various queen conch life stages occupy different habitats, which extend over a broad depth spectrum: larvae (veliger) can be found in surface waters and approach the sea floor when ready to settle; early juveniles can be found buried in coarse sandy habitats, near to reefs and seagrass beds, and adults prefer a variety of habitats, like sandy algal flats, gravel, hard bottom rubble, smooth hard coral, or beach rock bottoms (Prada *et al*., 2017). In general, queen conch move progressively away from inshore nursery areas towards deeper habitats as they increase in size and age. Nursery areas are usually very shallow (less than 5 m), while mature and old individuals are found in deeper waters, up to 59 m (García-Sais *et al*., 2012). The movement of queen conch between different habitats appears to be associated with reproduction. Initial studies have shown that queen conch migrate from deeper to shallower depths to spawn (Laughlin and Weil, 1984). A more recent study indicated that queen conch form reproductive aggregations to spawn, usually in deeper waters (20 m to 45 m) (Frenkiel *et al*., 2009). Reproduction may be greatly affected by low densities because of excessive fishing effort, but a density value of 100 adults/ha within the mating area has been recommended as a minimum reference value to enforce the precautionary principle for successful reproduction (Prada *et al.*, 2017). Stock structure in the WECAFC region is unclear. Early genetic studies into stock structure indicated high levels of gene flow between several Caribbean northern islands (Mitton, Berg Jr and Orr, 1989; Campton *et al*,. 1992). Other studies have confirmed the existence of connectivity among distant locations throughout the region (Morales, 2004). It seems that many of the life history characteristics of queen conch vary over relatively small spatial scales and this may be most troublesome for stock assessment.

Figure 3.3. Queen conch (*Aliger gigas*, formerly known as *Lobatus* and *Strombus*, COO) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

3.1.1 The fishery

Caribbean spiny lobster. Lobster tails is the main product of the spiny lobster fishery. Tails are almost always exported in frozen form, although recently in Nicaragua live or pre-cooked whole lobster are being exported to European and Asian markets with the correspondent added value and higher prices, and more investments in the infrastructure of processing plants (FAO, 2019a). This resource is one of the most valuable in the WECAFC region with an average annual landed catch of around 25 000 tonnes valued at about USD 850 million dollars (OSPESCA, CRFM and COPACO, in prep.).

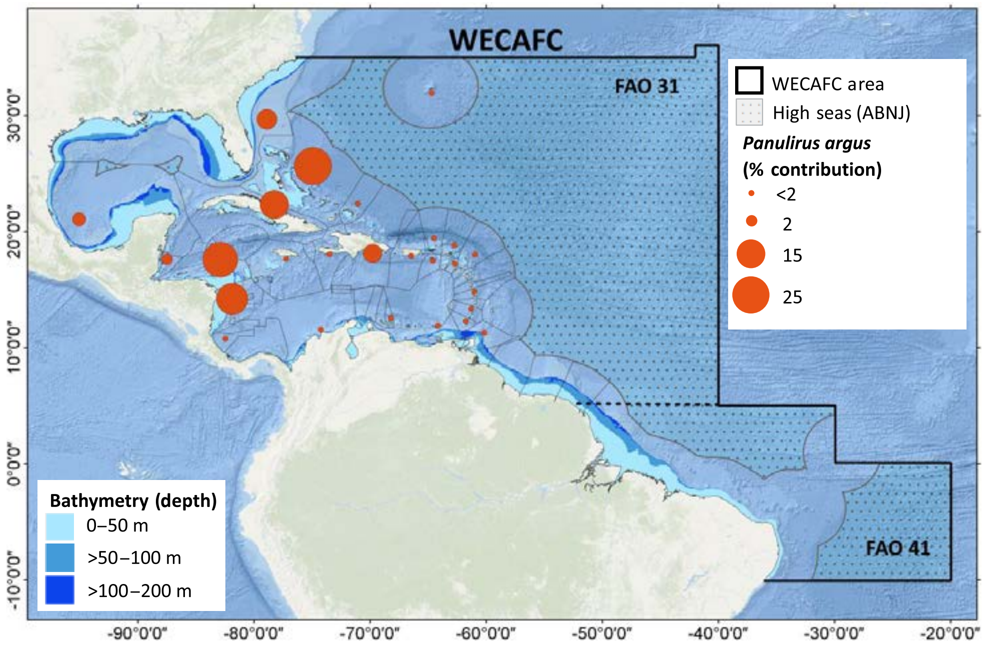
According to recent FAO landing statistics, the largest production of Caribbean spiny lobster is from the Bahamas and fluctuated between 5 800 tonnes and 8 400 tonnes between 2017 and 2019, producing 23.71 percent of the accumulated landed catch in 2015 to 2019 in the WECAFC region (Table 3.1). Over 91 percent of the accumulated landed catch of Caribbean spiny lobster comes from seven countries in the WECAFC region (Figure 3.4), of which the top four (the Bahamas, Honduras, Nicaragua and Cuba) contribute 76 percent of the accumulated catch for 2015 to 2019. The United States of America and Belize – that ranked fifth and eighth respectively for accumulated landed catch of Caribbean spiny lobster from 2015 to 2019 – reported no catches for 2019, while Panama reported 12 tonnes of lobster (*Panulirus* spp.) in 2019. This indicates that landed catch statistics for a valuable resource like Caribbean spiny lobster are in critical need of updating. In addition, Brazil´s reported landed catch of Caribbean spiny lobster (*Panulirus argus* and *Panulirus laevicauda*) for the same period is around 7 000 tonnes, but is reported for FAO Major Fishing Area 41. Although it is likely that a proportion of that amount is caught within the WECAFC region, the exact quantity is unclear.

Table 3.1 Caribbean spiny lobster (*Panulirus argus*) catch by country for the period 2015–2019 (tonnes)

Group: Key regional species. Species: *Panulirus argus* – Caribbean spiny lobster. Species code: SLC								
Country	**2015**	**2016**	**2017**	**2018**	**2019**	**Rank**	**%**	**%cum**
Bahamas (the)	6 526	8 482	7 709	5 824	6 225.7	1	23.71	
Honduras	6 156	6 100	6 100	6 100	6 100	2	20.84	44.56
Nicaragua	6 473	5 567	5 031	4 335	4 074.9	3	17.38	61.94
Cuba	4 035	4 634	4 147	4 540	3 278.4	4	14.07	76.01
United States of America	2 690	2 453	1 743	2 813	0	5	6.62	82.63
Dominican Republic (the)	1 282	1 562	1 677	2 024	1 905	6	5.76	88.39
Mexico	780	822	866	921	807	7	2.86	91.25
Belize	855	774	774	0	0	8	1.64	92.89
Jamaica	350	323	484	239	229	9	1.11	94.00
Antigua and Barbuda	277	277	277	277	277	10	0.94	94.94
Haiti	250	250	250	250	250	11	0.85	95.80
Anguilla	207	290	205	205	205	12	0.76	96.56
Venezuela (Bolivarian Republic of)	635	103	105	105	105	13	0.72	97.27
Turks and Caicos Islands (the)	218	260	218	154	129	14	0.67	97.94
Puerto Rico	192	118	69	129	147.54	15	0.45	98.39
Bonaire. Sint Eustatius and Saba	125	88	93	95	95	16	0.34	98.73
Colombia	3	30	150	20	200.75	17	0.28	99.00
United States Virgin Islands (the)	57	69	70	44	44	18	0.19	99.20
Saint Vincent and the Grenadines	56	30	54	63	49	19	0.17	99.37
British Virgin Islands (the)	40	40	40	40	40	20	0.14	99.50
Martinique	34	35	35	35	35	21	0.12	99.62
Bermuda	35	30	26	24	37	22	0.10	99.73
Grenada	30	30	30	30	30	23	0.10	99.83
Saint Kitts and Nevis	22	18	30	37	25	24	0.09	99.92
Trinidad and Tobago	21	21	21	21	21.32	25	0.07	99.99
Costa Rica	9	4	0	0	0	26	0.01	100.00

Source: Authors’ analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Figure 3.4. Caribbean spiny lobster (*Panulirus argus*, SLC) percentage contribution of total accumulated catch for the period 2015–2019



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The main fishing methods used for catching Caribbean spiny lobster are free diving and traps; other methods include scuba diving and hookah. Additional methods include *condos* or *casitas cubanas* and trammel nets, although recently the use of nets has been banned in some countries. Most of the Caribbean spiny lobster fishery is artisanal throughout the region, but there are several countries that also have an industrial fishery, among them are Brazil, Colombia, Honduras, Jamaica, Nicaragua, and Trinidad and Tobago (Table 3.2). About 15 000 vessels are involved in the artisanal fisheries. These vessels are made of fibreglass or wood, are between 6 m and 11.5 m in length and generally use outboard motors of 25 HP to 75 HP. The number of fishers involved is estimated to be approximately 60 000 (OSPESCA, 2018). In 2017, industrial fishing involved an estimated 620 active vessels of which 90 percent used traps/pots and 10 percent diving. The steel or fibreglass-hulled vessels are between 16 m and 24 m and powered by diesel engines of 325 HP to 540 HP. The number of fishers participating in the industrial fishery is estimated to be 8 000, with 40 percent using diving as a fishing method and 60 percent using traps/pots (OSPESCA, 2018). The catch level depends on the fishing season and the most productive time is in the first three months of the season.

Table 3.2 Caribbean spiny lobster (*Panulirus argus*) effort by country

			Effort					
Country	**Fishery**		**Diving**			**Gear**		
	Artisanal	Industrial	Free	Scuba	*Hookah*	Condos	Traps	Trammel net
Anguilla	X		X			X	X	
Antigua and Barbuda	X		X				X	
Bahamas (the)	X		X			X	X	
Barbados	No fishing							
Belize	X		X			X	X	
Bermuda	X		X				X	
Brazil	X	X	X	X		X	X	X
Colombia	X	X	X				X	
Costa Rica	X		X					X
Cuba	X		X			X	X	
Curaçao	X		X					
Dominica	X		X				X	
Dominican Republic (the)	X		X	X	X	X	X	
Martinique	X		X					
Grenada	X		X				X	
Guatemala	X		X		X			X
Guyana	No fishing							
Haiti	X		X			X	X	
Honduras	X	X	X	X	X		X	
Jamaica	X	X	X	X		X	X	X
Mexico	X		X	X	X	X	X	X
Montserrat	No fishing							
Saba Island (Bonaire, Sint Eustatius and Saba)	X							
Nicaragua	X	X	X	X	X		X	
Panama	X							
Saint Kitts and Nevis	X		X				X	
Saint Lucia	X						X	X
Saint Vincent and the Grenadines	X		X				X	
Suriname	No fishing							
Trinidad and Tobago	X	X	X			X	X	
Turk and Caicos Islands (the)	X		X			X		
United States of America	X		X	X	X	X	X	
Venezuela (Bolivarian Republic of)	X		X				X	X

Source: Authors' compilation.

Noting the economic importance of the trade in Caribbean spiny lobster for the region and the way the big producer countries are distributed spatially (Figure 3.4), science has demonstrated that most lobster fisheries are recruitment driven (Ehrhardt, 2005; Kough, Paris and Butler, 2013). Therefore, understanding recruitment mechanisms as well as the environmental and ecological effects on recruitment dynamics are vital to the objectives of the ecosystem approach to fisheries management. A suggested approach for renewal rates of spiny lobster in the Caribbean is to calculate the number of post-larvae that arrive in each fishing area and survive to become recruits to the fishery (Arteaga-Ríos *et al.*, 2007; Caputi *et al*,. 2014). Such an approach would require that each country in the region contributes to the enrichment of the common larval pool and assures regional survival by allowing every spiny lobster in every fishery to reach maturity and reproduce (Buesa, 2018). Actions required to achieve this would be to enforce minimum size limits and a permanent capture ban on berried females, and to introduce reproduction-oriented closed seasons across the entire Caribbean region.

Queen conch. The white conch meat is the main product of the queen conch fishery. Total queen conch production is difficult to estimate because of incomplete and/or non-comparable data across the region. The statistics of many fishing countries are not comparable because the countries lack and/or do not apply fishery-specific conversion factors for the different processing grades that can be found throughout the region (Prada *et al.*, 2017).

In the past 30 years, the overall harvest of conch has increased, largely driven by increasing demand and the expansion of the fishery into previously unexploited deeper waters. Concern over the apparent decline in conch populations in several Caribbean countries led to the inclusion of queen conch on Appendix II of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES) in 1992 and the overall declining trend in queen conch landings resulted in the application of the first CITES Significant Trade Review in 1995 to exports from Antigua and Barbuda, Barbados, Dominica, Saint Lucia and Trinidad and Tobago. Later, under the second CITES Queen conch Significant Trade Review in 2003, a temporary moratorium was imposed on the Dominican Republic, Haiti and Honduras (Theile, 2001; MRAG, 2013; Prada *et al.*, 2017).

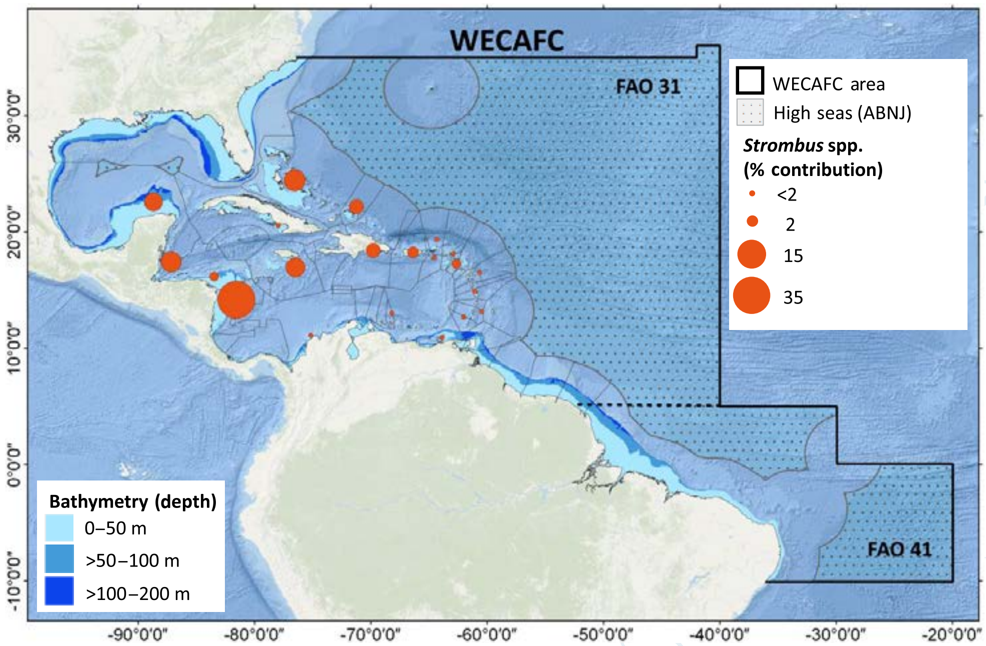
According to recent FAO landing statistics, the largest production of queen conch meat is from Nicaragua, with over 11 000 tonnes produced between 2017 and 2019. The country also produced 34.34 percent of the accumulated landed catch in 2015 to 2019 in the WECAFC region (Table 3.3). A group of major producers for the same period, with average annual reported landings of over 3 000 tonnes, include the Bahamas and Belize. Mexico, an important producer, has dropped below 2 000 tonnes in recent years (2018 to 2019). Jamaica, a major producer in the last decade, has reported 3 750 tonnes since 2013 and zero tonnes in 2019, which appears to be a carry-over of catch statistics over several years. This group of five countries produce over 72 percent of the accumulated landed catch of queen conch meat in the region. A second group of countries, with landings of more than 1 000 tonnes over the past five years, includes the Dominican Republic, Antigua and Barbuda, the Turks and Caicos Islands and Puerto Rico (United States). All the aforementioned countries account for 90 percent of the accumulated total queen conch landings over the period 2015 to 2019. Spatially, the major producers are off and around the Mesoamerican reef area, the Greater Antilles and northern areas (the Bahamas, the Turks and Caicos Islands), in contrast with the eastern and southern areas of the Caribbean Sea (Figure 3.5). However, it has been noted that in general, it appears that there are anomalous trends in the historical reported landings and there are indications that perhaps the inclusion of the shell may lead to critical mistakes in estimated catches of queen conch. Situations like this one reinforce the urgent need to apply more adequate conversion factors for better catch estimates and an understanding of real patterns (FAO, 2020).

Table 3.3 Stromboid conchs (*Strombus* spp.) catch by country for the period 2015–2019 (tonnes)

Group: Key regional species. Species: *Strombus* spp. – Stromboid conchs NEI. Species code: –								
Country	**2015**	**2016**	**2017**	**2018**	**2019**	**Rank**	**%**	**%cum**
Nicaragua	11 161	9 260	11 020	12 395	11 651.3	1	34.34	
Bahamas (the)	4 045	2 696	3 289	4 027	3 068.59	2	10.60	44.93
Belize	2 349	2 776	3 032	4 082	4 288	3	10.23	55.16
Jamaica	3 750	3 750	3 750	3 750	0	4	9.28	64.44
Mexico	4 342	1 132	4 820	1 268	1 699	5	8.21	72.65
Dominican Republic (the)	1 447	1 634	1 755	1 691	1 710	6	5.10	77.75
Antigua and Barbuda	1 583	1 583	1 583	1 583	1 583	7	4.90	82.64
Turks and Caicos Islands (the)	1 257	1 493	1 857	2 047	765	8	4.59	87.24
Puerto Rico	1 188	1 069	944	1 085	812.46	9	3.16	90.39
Honduras	842	800	800	800	450	10	2.28	92.68
Saint Kitts and Nevis	537	648	561	529	340	11	1.62	94.29
Cuba	525	477	405	475	482.1	12	1.46	95.76
Saint Lucia	514	488	525	398	365.22	13	1.42	97.17
Saint Vincent and the Grenadines	267	330	213	310	285	14	0.87	98.04
Haiti	200	200	200	50	50	15	0.43	98.48
United States Virgin Islands (the)	94	196	121	91	92.4	16	0.37	98.84
Guadeloupe	100	115	115	115	115	17	0.35	99.19
Colombia	0	0	118.5	0	387.1	18	0.31	99.50
Anguilla	100	42	80	80	80	19	0.24	99.74
Curaçao	26	26	26	26	26	20	0.08	99.82
Grenada	26	26	26	26	26	21	0.08	99.90
Sint Maarten (Dutch part)	13	13	13	13	13	22	0.04	99.94
Bonaire. Sint Eustatius and Saba	15	11	10	6	10	23	0.03	99.97
British Virgin Islands (the)	5	5	5	5	5	24	0.02	99.99
Martinique	2	2	2	2	2	25	0.01	100.00
Venezuela (Bolivarian Republic of)	0	2	2	2	2	26	0.005	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*.Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Figure 3.5. *Strombus* spp. (*Stromboid* conchs NEI) percentage contribution of total accumulated catch for the period 2015–2019



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The main fishing methods for queen conch are free diving, scuba and surface compressor (hookah) diving techniques. The queen conch fishing fleet in the Caribbean Community (CARICOM) countries consists of small canoes or dories of 7 m to 10 m powered by outboard engines or sail/oars and carrying 1 to 4 divers; larger vessels are also used and involve more fishers and multiday trips (MRAG, 2013). On the offshore banks off Jamaica, industrial vessels made of steel hulls of up to 35 m length and powered by inboard engines are used as "mother" vessels (industrial vessels). These vessels can carry over 40 divers and operate for a week or longer. The vessels serve as a base for daily fishing trips where fishers use smaller dories with outboard engines or oars that carry one to two divers. Industrial fishing takes place in the Dominican Republic, Jamaica, Honduras and Nicaragua. The normal practice on industrial vessels is for the meat to be extracted from the conch, pre-processed and stored on ice or frozen. In the French Antilles (EU [FR Martinique and FR Guadeloupe]), queen conch is also captured by bottom gillnets and trammel nets (300 m to 400 m long). An overview of queen conch fishing effort for certain countries in the WECAFC region that have conch fisheries reveals that the Bahamas, Belize and Haiti have an important number of fishers and small boats involved in the fishery and the catch is taken by free diving over daily trips (Table 3.4). In the remainder of the small islands in the Caribbean, the number of fishers and boats involved in the fishery is small, with the exception of the Turks and Caicos Islands where fisher numbers are over 200.

Table 3.4 Summary overview of the queen conch fishing effort in several countries of the Western Central Atlantic Fishery Commission region

	No. Fishers	No. small boats	No. industrial vessels	Free diving only	Compressor	Average trip (days)
Dominican Republic (the), Honduras, Jamaica, Nicaragua	> 1 000	70–247	82	-	Yes	Over 10 days industrial; daily small boats
Bahamas (the), Belize, Haiti	> 1 000	300–4 000	-	Yes	Only the Bahamas	Up to a week
Antigua and Barbuda, Barbados, Cayman Islands (the), Colombia, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Turks and Caicos Islands (the)	≤ 100	<100	-	-		Daily

Source: Prada, M.C., Appeldoorn, R.S., Van Eijs, S. & Pérez, M.M. 2017. *Regional queen conch fisheries management and conservation plan*. FAO Fisheries and Aquaculture Technical Paper No. 610. Rome, FAO. 70 pp.

The queen conch fishery provides income for approximately 20 000 fishers, mostly artisanal, and it is an important and traditional source of low-fat protein for the Caribbean population (Prada *et al.*, 2017). In most countries, queen conch fishers are artisanal and have a high dependence on this resource for income and/or high-quality meat for their families, but no major studies have been undertaken to determine the benefits and specific reliance of local communities on the artisanal queen conch fishery.

Queen conch is an important resource for regional trade and its economic importance varies considerably across the region. White conch meat is the main product of the fishery, followed by the queen conch shell and pearls. Recently, conch opercula have entered the trade as exported product from Jamaica and Nicaragua (Prada *et al.*, 2017). The United States has been a major importer of queen conch products, with over 2 000 tonnes imported in 2018 (NOAA, 2023a). The market in the European Union has been expanding for this species.

3.1.2 State of the stocks

Caribbean spiny lobster. According to the FAO *State of world fisheries and aquaculture* (SOFIA) *2018*, Caribbean spiny lobster stocks appear to be "maximally-sustainably fished" throughout most of the species' range, based on historical landings up to 2015 from the Bahamas, Nicaragua and Cuba (FAO, 2018a; Table 3.5). (The stocks were considered to be "fully fished" in previous editions of SOFIA.) Assessments of stocks under the management of the United States indicate that all three Caribbean stocks (Saint Croix, Saint Thomas/Saint John and Puerto Rico) are not overfished nor undergoing overfishing (SEDAR, 2019a), and the GOM/southeast Atlantic stock is not subject to overfishing, but the population status is unknown (SEDAR, 2005). Assessments presented at the first and second meetings of the Joint OSPESCA/WECAFC/CRFM/Caribbean Fishery Management Council (CFMC) Working Group on Caribbean Spiny Lobster (FAO, 2015, 2019a) indicate that the stocks appear to have improved compared with 2006, and that the status in individual countries is either fully fished/stable (Anguilla, Antigua and Barbuda, the Bahamas, Belize, Cuba, Mexico and Nicaragua), overfished (Brazil, Colombia, Jamaica, Grenada, Haiti and Saint Lucia) or unknown (the Dominican Republic, Honduras, EU [FR Martinique] and Panama).

Table 3.5 Transboundary stocks status in the Western Central Atlantic Fishery Commission region: key species, groundfish, large pelagic fish

	FIRMS & this review (after 2010)		FAO categorization	Reference year	Other sources	ICCAT				
Common name, species name	**Abundance Level**	**Exploitation rate**	**WECAFC/SAG/IX/2018/3**		**USA SEDAR**	**Year**	**Stock unit**	**Assessment year**	**Overfished**	**Overfishing**
Key regional species										
Caribbean spiny lobster, *Panulirus argus*	See text	See text	F	2015	U	2019	NA	NA	NA	NA
Queen conch, *Aliger gigas*	See text	See text	F/O	2016	O	2007	NA	NA	NA	NA
Queen conch										
Acoupa weakfish, *Cynoscion acoupa*	See text	See text	–	–	–	–	NA	NA	NA	NA
Jamaica weakfish, *Cynoscion jamaicensis*	See text	See text	–	–	–	–	NA	NA	NA	NA
Green weakfish, *Cynoscion virescens*	See text	See text	–	–	–	–	NA	NA	NA	NA
King weakfish, *Macrodon ancylodon*	See text	See text	–	–	–	–	NA	NA	NA	NA
Whitemouth croaker, *Micropogonias furnieri*	See text	See text	–	–	–	–	NA	NA	NA	NA
Smalleye croaker, *Nebris microps*	See text	See text	–	–	–	–	NA	NA	NA	NA
Large pelagic fish										
King mackerel, *Scomberomorus cavalla*	–	–	F	2012	GOM-F SE- F	2014	NW Atlantic	2016	–	Vulnerability: high*
Atlantic Spanish mackerel, *Scomberomorus maculatus*	–	–	F	2016	GOM-F SE- F	2013	NW Atlantic	2016	–	Vulnerability: high*
Serra Spanish mackerel. *Scomberomorus brasiliensis*	–	–	O	2012	–	–	NW Atlantic	2016	–	Vulnerability: moderate*
Carite chinigua (*Scomberomorus regalis*)	–	–	?	–	–	–	NW Atlantic	2016	–	Vulnerability: low*

Notes: SE= southeast USA; F= fully exploited; O= overexploited; U= non-fully exploited.
*ICCAT. 2017a. Report of the 2015 Blue Shark Stock Assessment Session, 27–31 July 2015. Madrid. *ICCAT Collective Volume of Scientific Papers*, 72(4): 866–1019.

Source: Authors' compilation.

Queen conch. According to SOFIA 2018, Caribbean queen conch stocks appear to be fully fished and/or overfished based on information from the Bahamas, Jamaica and Nicaragua (FAO, 2018a) (Table 3.5). The status of many stocks within the region is unknown or at least highly uncertain (MRAG, 2013). In 2007, the United States' Caribbean queen conch management review indicated that the species was overfished and experiencing overfishing (SEDAR, 2007a). In 2019, queen conch became a candidate for the United States' Endangered Species Act (ESA), thus initiating a status review for the species (NOAA, 2022). Currently, the United States considers the queen conch overfished, except for in Puerto Rico and the United States Virgin Islands, where it is subject to a rebuilding management plan. Belize indicated that its exploited queen conch stock is stable (FAO, 2020–2023a). In the Turks and Caicos Islands, stock status is uncertain (FAO, 2020–2023b), in Saint Lucia it is overfished and experiencing overfishing, and in Antigua it is likely overexploited (FAO, 2020–2023c).

In the last meeting of the CFMC/OSPESCA/WECAFC/CRFM/CITES Working Group on Queen Conch (FAO, 2020) several commitments were made to improve the sampling and assessment methods, including the robust estimation of conversion factors so that data can be comparable among countries, resulting in more accurate and precise information. The importance of survey design(s) was highlighted by the working group as a method to obtain better estimates of population densities. Also emphasized was the need to develop guidelines for conch density survey protocols that could be standardized across the region (with priority given to those countries already conducting surveys. Such protocols may include information on habitat type, depth and size/age classes (FAO, 2020). Another important commitment was to determine the genomic connectivity across the Caribbean using new genetic techniques, initially in countries with common fishing grounds. This would be useful for understanding the small-scale population structure required for management.

3.2 The groundfish resources

Acoupa weakfish (*Cynoscion acoupa*). In the WECAFC region, this species is most common in northeastern South America where it is locally abundant in some areas (Chao, Nalovic and Williams, 2021). It is distributed from Panama to Lake Maracaibo (Bolivarian Republic of Venezuela) (Figure 3.6A) but is not present in central Bolivarian Republic of Venezuela. The species occurs from the northeastern coastal areas of the Bolivarian Republic of Venezuela through to the Gulf of Paria and south along the NBSLME to Brazil (Cervigón, 2005). It is a demersal species that occurs along the coast, mostly in shallow waters at depths up to 30 m (Le Joncour, Blanchard and Tagliarolo, 2020). It is commonly found over mud or sandy mud bottoms near the mouths of rivers and in coastal lagoons. Juveniles and larvae shelter in mangrove swamps (Barletta and Saint-Paul, 2010; Rousseau, Blanchard and Gardel, 2017). It forms spawning aggregations in estuaries in the spring and summer in Maracaibo Lake (Montaño and Morales, 2013) and attains sexual maturity around two years of age. Longevity is at least 15 years (de Espinosa, 1972). The stock structure of the species in the region is poorly known. The available information, based on genetic studies, indicates that there is a single stock in northern Brazil (Oliveira *et al.*, 2020). This species is likely fished by coastal communities throughout its range but known fishing areas are reported by commercial fisheries in the Gulf of Venezuela in the southern Caribbean, the Gulf of Paria and along the NBSLME (Figure 3.6B).

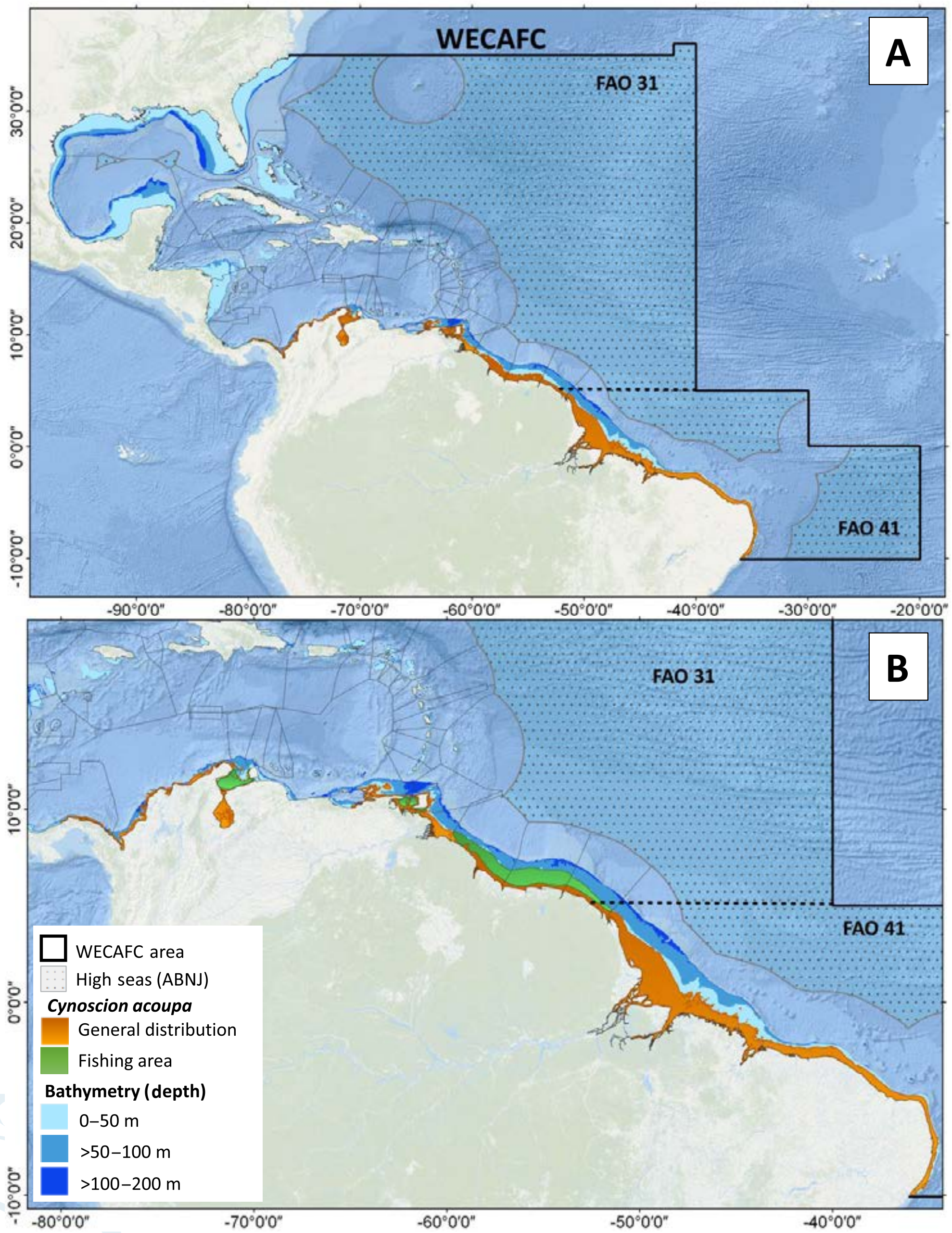
Table 3.6 Transboundary stocks status in the Western Central Atlantic Fishery Commission region: reef and slope species, shelf shrimps

	FIRMS & this review (after 2010)		FAO categorization	Reference year	Other sources	ICCAT				
Common name, species name	**Abundance level**	**Exploitation rate**	**WECAFC/SAG/IX/2018/3**		**USA SEDAR**	**Year**	**Stock unit**	**Assessment year**	**Overfished**	**Overfishing**
Reef and slope species										
Groupers										
Red grouper, *Epinephelus morio*	–	–	USGOM – O USSE – F MEX – O	2015 2013 2015	GOM – F SE – O	2019 2017	NA	NA	NA	NA
Nassau grouper, *Epinephelus striatus*	–	–	BAH – O Cuba – O	2016 2016	Threatened ESA	2016	NA	NA	NA	NA
Red hind, *Epinephelus guttatus*	–	–	–	–	USCAR – O	2014	NA	NA	NA	NA
Gag grouper, *Mycteroperca microlepis*	–		USGOM – F USSE– F	2015 2012	GOM – F SE – F	2021 2021	NA	NA	NA	NA
Black grouper, *Mycteroperca bonaci*	–	See text (Mexico)	–	–	F	2010	NA	NA	NA	NA
Snappers										
Northern red snapper, *Lutjanus campechanus*	–	See text (Mexico)	USGOM – F USSE – O MEX – O	2016 2014 2016	GOM – F SE – O	2018 2017	NA	NA	NA	NA
Mutton snapper, *Lutjanus analis*	–	–	USGOM – F	2013	USCAR – F GOM – F SE – F	2007 2015 2015	NA	NA	NA	NA
Grey snapper, *Lutjanus griseus*	–	–	USGOM – F	2015	GOM – O USCAR – O	2018 2008	NA	NA	NA	NA
Yellowtail snapper, *Ocyurus chrisurus*	–	See text (Cuba, Brazil)	–	–	USCAR – F GOM – F SE – F	2020				
Southern red snapper, *Lutjanus purpureus*	–	See text (NBSLME)	–	–	–	–	NA	NA	NA	NA
Lane snapper, *Lutjanus synagris*	–	See text (NBSLME)	MEX – O Cuba – O	2016 2016	GOM – F	2016	NA	NA	NA	NA
Shelf shrimps										
Northern brown shrimp, *Penaeus aztecus*			USA – F Mex – F	2016 2014	GOM – F SE – F	2016 2013	NA	NA	NA	NA
Northern pink shrimp, *Penaeus duorarum*			USA – F Mex – O	2017 2012	GOM – F SE – F	2017 2017	NA	NA	NA	NA
Northern white shrimp, *Penaeus setiferus*			USA – F	2016	GOM – F SE – F	2016 2013	NA	NA	NA	NA
Southern brown shrimp, *Farfantepenaeus subtilis*		See text French Guiana	–	–	–	–	NA	NA	NA	NA
Southern pink shrimp, *Farfantepenaeus notialis*		See text (NBSLME)	–	–	–	–	NA	NA	NA	NA
Southern white shrimp, *Litopenaeus schmitti*		(See text (NBSLME)	–	–	–	–	NA	NA	NA	NA
Redspotted shrimp, *Farfantepenaeus brasiliensis*		See text (NBSLME)	–	–	–	–	NA	NA	NA	NA
Atlantic seabob, *Xiphopenaeus kroyeri*		Guy – F Sur – F 2019	Mex – F Guy – F Sur – F	2014	–	–	NA	NA	NA	NA

Notes: F= fully exploited; O= overexploited; BAH= the Bahamas; Guy= Guyana; Mex= Mexico; SE= southeast; Sur= Suriname; USCAR= United States Caribbean; USGOM= United States Gulf of Mexico; USSE= United States southeast.

Source: Authors' compilation.

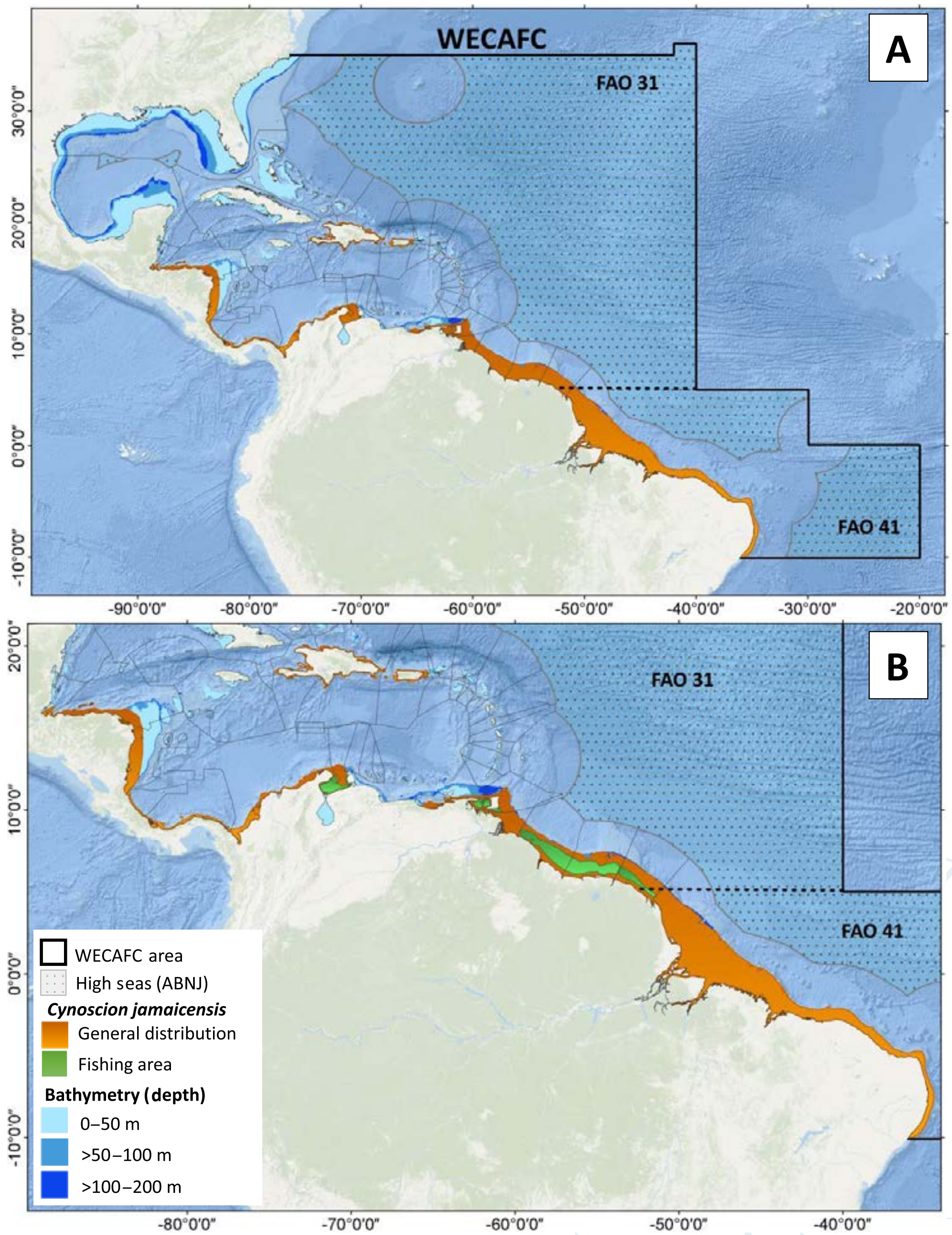
Figure 3.6. *Cynoscion acoupa* (acoupa weakfish, YNA) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Jamaica weakfish (*Cynoscion jamaicensis*). This species is distributed in the western Atlantic from the Gulf of Honduras along the coast of Central America through to the Gulf of Venezuela. It is absent from central Bolivarian Republic of Venezuela (Cervigón, 2005), but reappears from northeastern Bolivarian Republic of Venezuela to Brazil along the NBSLME (Figure 3.7A). In the Caribbean islands, the species is present in the islands of Hispaniola (Greater Antilles) and Puerto Rico and it increases in abundance in the southern portion of its range, such as the NBSLME area (Frédou and Villwock de Miranda, 2015a). Jamaica weakfish is generally found over mud and sandy mud bottoms off the coastline between 5 m and 120 m in depth. Nursery and feeding grounds are in estuaries (Frédou and Villwock de Miranda, 2015a). The stock structure of the species in the region is unknown. It is likely fished by coastal communities throughout its range but known fishing areas are reported by commercial fisheries in the Gulf of Venezuela in the southern Caribbean, the Gulf of Paria and along the NBSLME (Figure 3.7B)

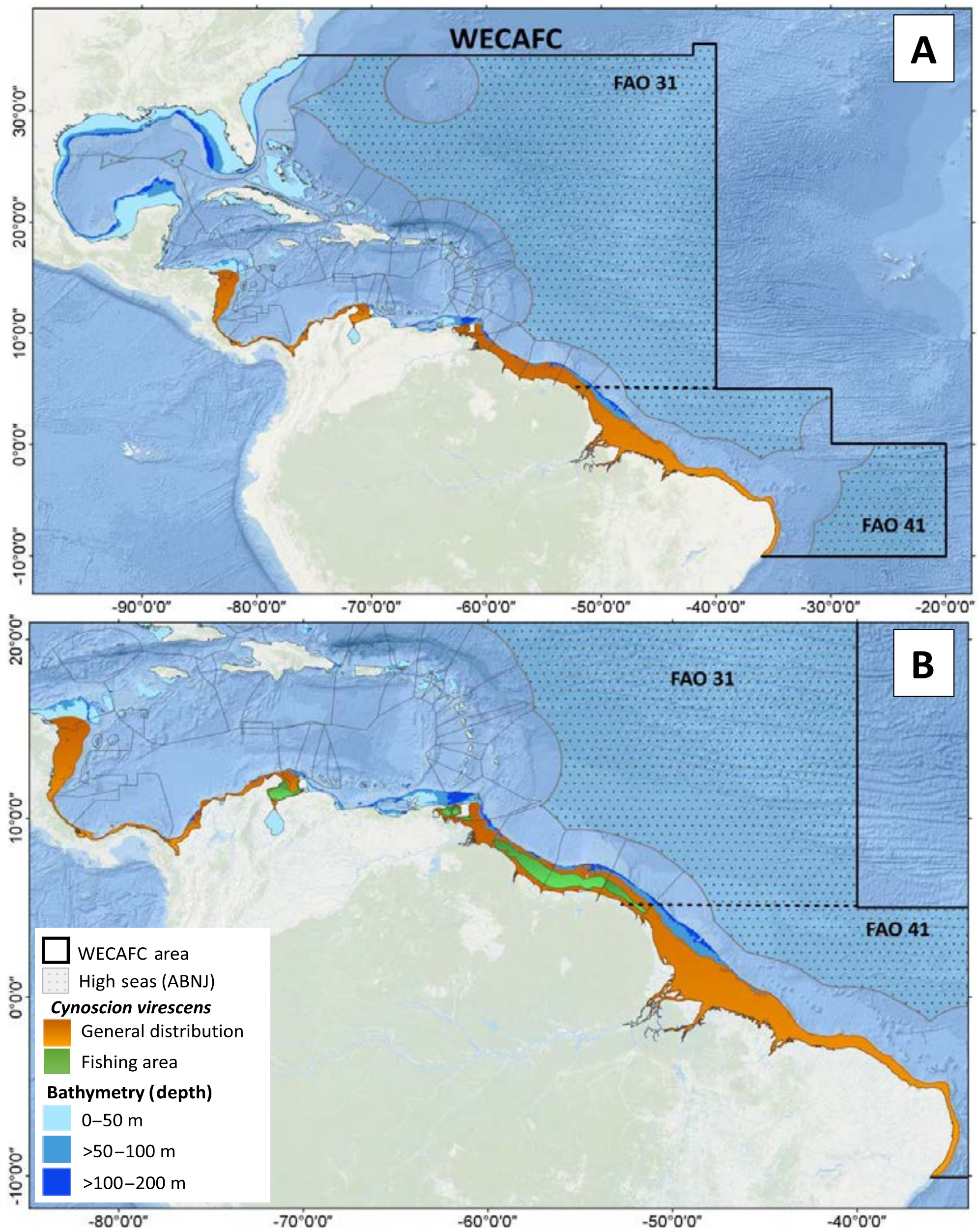
Figure 3.7. *Cynoscion jamaicensis* (Jamaica weakfish, YNJ) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Green weakfish (*Cynoscion virescens*). This species is distributed in the western Atlantic along the coast of Central and South America, from Laguna de Caratasca in Honduras to Tubarao, Brazil (Figure 3.8A). It is absent from the central coast of Bolivarian Republic of Venezuela (Cervigón, 2005, but common and abundant in the NBSLME area and common in Brazil (Hornby *et al.*, 2015; Frédou and Villwock de Miranda, 2015b). Green weakfish is generally found over mud and sandy mud bottoms at between 6 m and 70 m depth, especially near river mouths. Juveniles inhabit estuaries during summer and adults are known to inhabit estuaries of all the major rivers in the NBSLME area (Novoa, 2000; Cervigón, 2005). It is mostly demersal during the day and moves towards the surface at night, feeding mainly on shrimps and occasionally on fish (Frédou and Villwock de Miranda, 2015b). The stock structure of the species in the region is unknown, but it is likely fished by coastal communities throughout its range. Known fishing areas for green weakfish are reported by commercial fisheries in the Gulf of Venezuela in the southern Caribbean, the Gulf of Paria and along the NBSLME (Figure 3.8B).

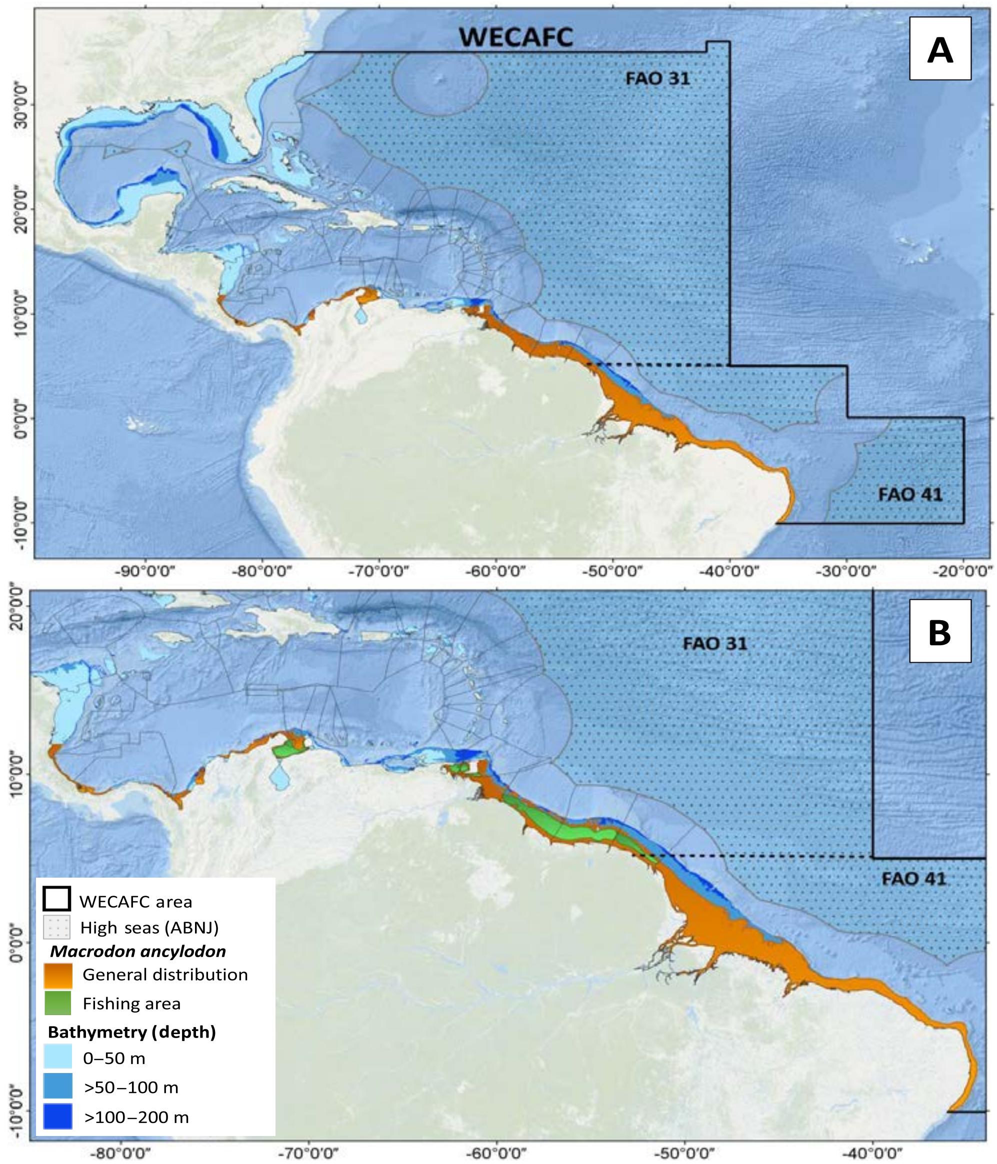
Figure 3.8. ***Cynoscion virescens*** **(green weakfish, YNV) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region**



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

King weakfish (*Macrodon ancylodon*). In the WECAFC region, this species has a spotty distribution in southern Central America and northwestern South America (Figure 3.9A). However, king weakfish has a continual distribution from the Gulf of Paria south to Brazil, along the NBSLME where it is common and abundant in estuaries (Novoa, 2000; Molinet, Arocha and Cárdenas, 2008; Harper *et al*., 2015). The species occurs over mud or sandy bottoms in coastal waters at depths of up to 60 m (Frédou *et al*., 2015). Juveniles inhabit estuaries and coastal lagoons. It feeds mainly on shrimps and small fish and at sexual maturity, it migrates to coastal areas where it has restricted migratory habits in coastal and estuarine areas. King weakfish spawns near river mouths, with larvae and juveniles entering estuaries for protection and feeding (Frédou *et al*., 2015). The stock structure in the region, based on genetic studies, broadly consists of a tropical group (from the Bolivarian Republic of Venezuela to Pernambuco in northeast Brazil) and a subtropical group (from São Paulo southeast of Brazil to Argentina) (Santos *et al*., 2006). King weakfish is likely fished by coastal communities throughout its range but known fishing areas are reported by commercial fisheries in the Gulf of Venezuela in the southern Caribbean, the Gulf of Paria and along the NBSLME (Figure 3.9B).

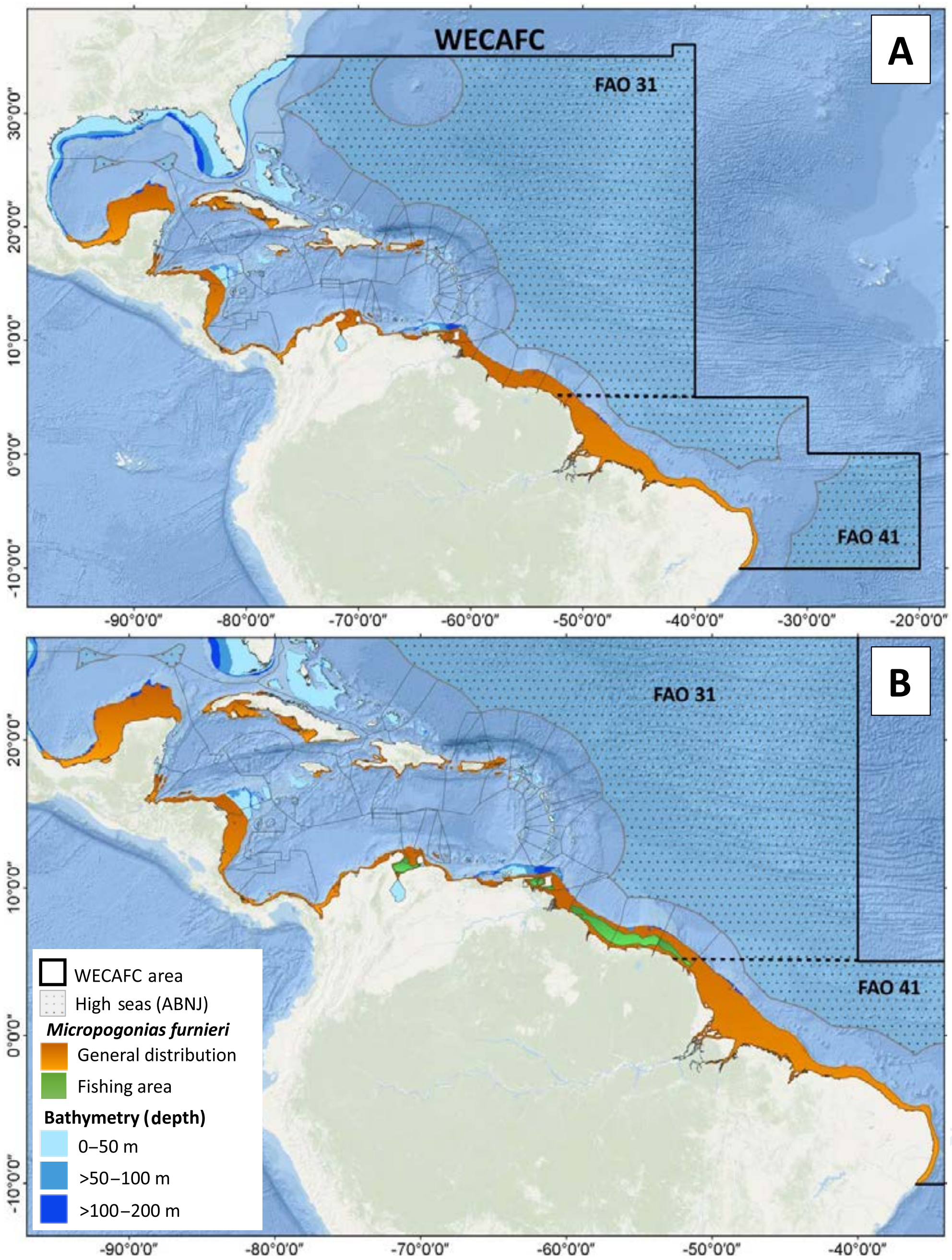
Figure 3.9. *Macrodon ancylodon* (king weakfish, WKK) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Whitemouth croaker (*Micropogonias furnieri*). The whitemouth croaker is the most widely distributed croaker species in the WECAFC region (Figure 3.10A). It occurs from Veracruz in the GOM to northern Quintana Roo in the Yucatan Peninsula; is present in the Caribbean islands of Cuba, Jamaica, La Hispaniola (Greater Antilles), Puerto Rico and Saint Croix; and along the coasts of Central and South America, from southern Belize to Brazil (Aguilera Socorro *et al*., 2015). Whitemouth croaker is generally found over mud and sandy mud bottoms in coastal waters to about 120 m depth. It is one of the dominant croaker species in the upper NBSLME area, the Gulf of Paria, as well as the northeastern shelf of the Bolivarian Republic of Venezuela owing to the seasonal influence of the Orinoco River's flow into the Caribbean (Cervigón, 2005; Molinet *et al*., 2008). Nursery and feeding grounds are in estuaries. The species is dependent on estuaries during the early juvenile stages and spawning takes place between spring and summer and is concentrated in shallow coastal waters (Aguilera Socorro*et al*., 2015). The stock structure of the species in the WECAFC region is currently unknown, but the available information indicates that there are three genetic stocks in the southwestern Atlantic, from Pará State in Brazil through to Uruguay and Argentina (Vasconcellos *et al*., 2015). This species is likely fished by coastal communities throughout its range but known fishing areas are reported by commercial fisheries in the Gulf of Venezuela in the southern Caribbean, the Gulf of Paria and along the NBSLME (Figure 3.10B).

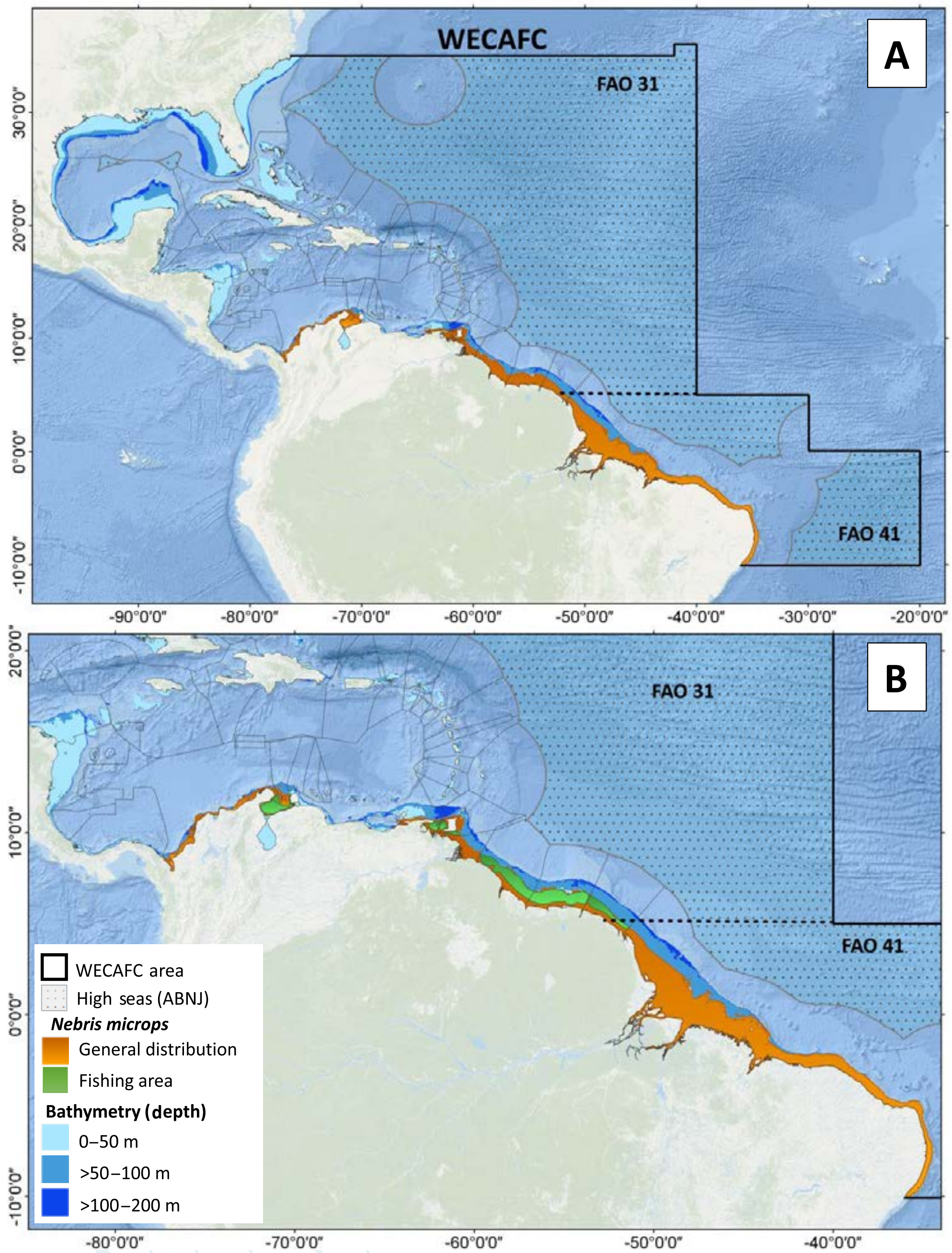
Figure 3.10. *Micropogonias furnieri* (whitemouth croaker, CKM) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Smalleye croaker (*Nebris microps*). The geographical distribution of the smalleye croaker is from the Gulf of Urabá (Panamá–Colombia) to the Gulf of Venezuela in the southwestern Caribbean; and from northeastern Bolivarian Republic of Venezuela to the Gulf of Paria and along the NBSLME to Brazil (Figure 3.11A). The smalleye croaker is widely distributed and common in many parts of its range. It inhabits coastal waters and estuaries and its presence is reduced in waters with salinity over 30 ppm (Cervigón, 2005). The species is caught as bycatch and in mixed catch sciaenid fisheries throughout its range but is more common in EU (FR Guiana) (Harper *et al.*, 2015). It is found over sandy mud bottoms in coastal waters to about 50 m depth (Aguilera and Haimovici, 2020) and also enters estuaries, especially in the juvenile stages. The species feeds mainly on shrimps and small crustaceans. The maximum reported size for smalleye croaker is 50 cm total length but it commonly occurs at a total length of 30 cm (Chao, 2002). The stock structure of the species in the region is unknown, but it is likely fished by coastal communities throughout its range. Known fishing areas are reported by commercial fisheries in the Gulf of Venezuela in the southern Caribbean, the Gulf of Paria and along the NBSLME (Figure 3.11B).

Figure 3.11. *Nebris microps* (smalleye croaker, NBM) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

3.2.1 The fishery

The shared groundfish resources described in this review are all members of the family Sciaenidae (croakers, drums and other species). As a general characteristic, the members of this family in the region are estuarine-dependent, their dispersal expands and contracts over the continental shelf associated with coastal lagoons and estuaries, depending on seasonal river flow into the ocean and tides. The areas in which these species occur are mostly associated with shrimp species that are in most cases subjected to intensive fishing. Most of the croaker species are caught as bycatch in the shrimp fisheries and are generally reported grouped with other marine fishes. On a few occasions when an artisanal coastal fishery targets brackish water species, sciaenids are likely to be reported grouped, i.e. as *Cynoscion* spp. (weakfishes).

According to recent FAO landing statistics for the period 2015 to 2019, eight countries in the WECAFC region report landings of croakers, drums and/or weakfishes, but only one country reports species-specific landings (Table 3.7). However, the species-specific reporting of the Bolivarian Republic of Venezuela´s landings reflects a high number of carry-over values in the recent period for almost all reported species, except for the whitemouth croaker. Nonetheless, the proportion between species shows that the whitemouth croaker is the most important species in the catches, followed by the acoupa weakfish. The other three species –Jamaica, green and king weakfishes – have relatively similar proportional reported catches and represent about a third of the total species-specific sciaenid landed catch from the Bolivarian Republic of Venezuela.

Table 3.7 Groundfish catch by country for the period 2015–2019 (tonnes)

Group: Groundfish. Species: Sciaenidae (family) – croakers. drums NEI. Species code: –								
Country	**2015**	**2016**	**2017**	**2018**	**2019**	**Rank**	**%**	**%cum**
Colombia	0	42	125	83	209.27	1	38.01	
Venezuela (Bolivarian Republic of)	0	95	100	100	100	2	32.69	70.70
Guatemala	106	73	46	77	47	3	28.88	99.59
United States of America	0	0	1	3	0	4	0.33	99.92
Mexico	0	0	0	0	1	5	0.08	100.00
Group: Groundfish. Species: *Cynoscion* spp. – weakfishes NEI. Species code: –								
Mexico	4 267	4 706	4 736	5 271	4 225	1	74.34	
French Guiana	825	715	973	887	850	2	13.62	87.96
Venezuela (Bolivarian Republic of)	3518	0	0	0	0	3	11.27	99.23
Nicaragua	52	77	34	21	19.74	4	0.65	99.88
Dominican Republic (the)	31	2	2	2	0	5	0.12	100.00
Group: Groundfish. Species: *Cynoscion acoupa* – acoupa weakfish. Species code: YNA								
Venezuela (Bolivarian Republic of)	0	2 310	2 380	2 380	2 380	1	100.00	100.00
Group: Groundfish. Species: *Cynoscion virescens* – green weakfish. Species code: YNV								
Venezuela (Bolivarian Republic of)	0	660	680	680	680	1	100.00	100.00
Group: Groundfish. Species: *Macrodon ancylodon* – king weakfish. Species code: WKK								
Venezuela (Bolivarian Republic of)	0	828	850	850	850	1	100.00	100.00
Group: Groundfish. Species: *Micropogonias furnieri* – whitemouth croaker. Species code: CKM								
Venezuela (Bolivarian Republic of)	0	828	850	850	850	1	100.00	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

The reported catches grouped under *Cynoscion* spp. (weakfishes NEI [not elsewhere included]) show that Mexico accounts for 74.34 percent of the total accumulated catches for 2015 to 2019 in the region (Table 3.7), followed by EU (FR Guiana) (13.62 percent) and Bolivarian Republic of Venezuela (11.27 percent). In the case of the Bolivarian Republic of Venezuela, the difference between 2015 values and those of the following years (2016 to 2019) is likely due to the breakdown to the species level and reporting them separately from 2016 to 2019, as seen in the species-specific reported catches for Bolivarian Republic of Venezuela. In the case of Mexico, weakfish catches, mostly sand weakfish (*Cynoscion arenarius*), spotted weakfish (*Cynoscion nebulosus*) and silver seatrout (*Cynoscion nothus*) are likely part of the commercial bycatch of the Atlantic Spanish mackerel artisanal fisheries which set gillnets off Veracruz, and other sciaenid species associated with the artisanal fisheries off the coastal estuaries in the same area. One of the more representative species in these artisanal fisheries is the whitemouth croaker (Beléndez *et al*., 2014; Government of Mexico, 2018). In the case of EU (FR Guiana), the assumption is that weakfish reported catches are likely of acoupa weakfish and green weakfish. This assumption is based on the assessment information for the small-scale coastal fisheries (FAO, 2019b; Tagliarolo, 2019). The other two countries reporting weakfish catches – Nicaragua and the Dominican Republic – account for a small fraction of the total accumulated weakfish catch. In Nicaragua, the weakfish catches are likely acoupa and Jamaica weakfish from the artisanal coastal fisheries that operate off coastal lagoons and estuaries, and potentially from the industrial shrimp fisheries (CIPA, 2008; INAPESCA, 2018). In the case of the Dominican Republic, there is no specific information on weakfish catches or the fisheries that capture them, but it is likely to be Jamaica weakfish associated with the shrimp fisheries in the north of the island (Herrera *et al*., 2011).

Another group of sciaenid reported catches are the croakers and drums. Catches are reported by a small number of countries with individual catches below 500 tonnes over the recent period (2015 to 2019). Colombia, Bolivarian Republic of Venezuela and Guatemala account for 99.59 percent of the accumulated catch (Table 3.7). In Colombia, croaker catches could be a combination of the shared species selected in this section due to the geographical distribution of all the species; catches are likely associated with artisanal fisheries in Colombia´s major estuaries such as the Ciénaga Grande de Santa Marta, which utilize set gillnets, as well as part of the retained bycatch of the shrimp fisheries (Rueda *et al*., 2011; Lindop *et al*., 2015a). In Bolivarian Republic of Venezuela, the reported catches are likely of other sciaenid species not included with the commonly reported species, such as shorthead drum (*Larimus breviceps)* (Cervigón, 2005; Molinet *et al*., 2008). As for Guatemala, there is no indication that the sciaenids are part of the catches of its Caribbean fisheries (Lindop *et al*., 2015b). However, noting that there are trawl shrimp fisheries and that the geographic distribution of Jamaica weakfish and whitemouth croaker extends to Guatemala, the possibility exists that these species may be part of the croaker catches reported by Guatemala.

The FAO statistics do not reflect the detailed catch levels of croakers, drums and weakfishes for the countries whose fishing operations take place in the NBSLME and beyond. The group of countries catching this group of species directly, or as part of the retained bycatch of their shrimp fisheries, are Guyana, Suriname and to some extent EU (FR Guiana). They report their catches of sciaenid species under the FAO group of Ostheicthyes (marine fishes NEI). However, in recent years there has been an historical catch reconstruction of all the sciaenid species reviewed in this section (Mohammed and Lindop, 2015a, 2015b; MacDonald *et al*., 2015; Hornby *et al*., 2015; Harper *et al*., 2015) and some time series have been used in subregional assessments. This reflects the level of importance of this group of species in the NBSLME and indicates that more detailed attention is required, owing to the transboundary nature of the sciaenid species exploited by all countries in the region (FAO, 2019b; FAO, 2021b).

In Trinidad and Tobago, where sciaenid species (e.g. acoupa, Jamaica and king weakfish, and whitemouth croaker), are either targeted by the artisanal multigear fleet using gears such as gillnets, fish pots, demersal handlines and demersal longlines, or caught as bycatch in the trawl nets of the shrimp fishery (Mohammed *et al*. 2011; Mohammed and Lindop, 2015a). The artisanal multigear fleet, which targets soft-bottom fish like croakers, drums and weakfishes, operates mainly off the west and south coasts of Trinidad, and the shrimp trawlers operate mainly in the Gulf of Paria. Generally, boats in the artisanal fishery called *pirogues* are wooden, fibreglass or fibreglass-coated open boats of 7 m to 9 m in length, powered by one or two outboard engines usually between 45 HP to 75 HP.

In Guyana until the 1980s, the entire artisanal catch of finfish and shrimp was absorbed into the fresh fish market and consumed domestically. However, since then, artisanal fishers have exported certain valuable fishes such as acoupa weakfish, among other species (MacDonald *et al*., 2015). Several sciaenids, such weakfishes (king weakfish, acoupa weakfish and green weakfish) and croakers (whitemouth croaker and smalleye croaker) are part of the retained catch of the large-scale commercial Atlantic seabob fishery; trawlers configured to catch Atlantic seabob target finfish when the shrimp is not abundant. However, most of Guyana's fishing effort occurs in the relatively shallow waters of the continental shelf, where 60 percent of the artisanal boats use gillnets. The artisanal fleet consists of 1 147 boats equipped with different types of gillnets (Chinese seine, pin seine, gillnet [nylon and polyethylene] anchor seine and circle seine), which are likely the ones used to catch sciaeneids (Drugan, 2019). Artisanal boats are made of wood, are between 6 m and 18 m in length and powered by sail, outboard or inboard engine. The size of the boats defines the type of the gear and the target species.

In Suriname, the fishing fleet can be divided into the industrial trawl and artisanal fleets. The industrial fleet can be subdivided into shrimp-targeted and finfish-targeted fisheries. Under the industrial fishery categorization, there is a demersal bottom trawl fishery with a maximum number of 47 licenses. These vessels are typically around 20 m (maximum length of 32 m) with an engine of 500 HP (Smith and Burkhardt, 2017). Fishing trips typically last 4 to 8 days and fishing generally takes place during daytime. Fishing areas are from a depth of 32 m and maximum days at sea per vessel are limited to 170 (Government of Suriname, 2021a). A series of management measures was adopted recently that includes limits on mesh sizes and the deployment of a bycatch reduction device (BRD). The sciaenid catch consists primarily of Jamaica weakfish, followed by green weakfish and whitemouth croaker. King weakfish is the primary species in the retained catch of the Atlantic seabob fishery, followed by green weakfish and smalleye croaker. Jamaica weakfish is the main retained bycatch species of the shrimp fishery (Meeremans, Babb-Echteld and Willems, 2017). The artisanal fleet is more diverse and operates with different gears but is dominated by drift gillnet. The coastal drift gillnet fishery operates from two types of boats known as Guyana-type boats: 8 m to 14 m long (recently limited to 330 licenses), powered by 25 HP to 50 HP (maximum of 75 HP) outboard engines; and closed decked Guyana-type boat, 15 m long with 155 HP (max.) diesel inboard engines (Hornby *et al.*, 2015). These vessels are responsible for the catch of large demersal fish like the sciaenids. The drift gillnet fleet targets acoupa and green weakfish, operating from the coast to depths of 16 m, using gillnets of 2 000 m (maximum of 3 000 m to 4 000 m) in length with 20 cm mesh. Boats (10 licenses) using pin seine and bank fishing, target smalleye croaker and acoupa weakfish operating from the coast up to 16 m, using nets of 2 000 m in length with 5 cm mesh. Boats (max length of 10 m) in estuaries using driftnets of 500 m in length (75 licenses), with 12.7 cm mesh and operating at depths of between 5 m to 9 m target king weakfish and smalleye croaker (Government of Suriname, 2021b).

In EU (FR Guiana), the target species for the coastal small-scale fishery is acoupa weakfish, although green weakfish are also caught. There is also an important bycatch of sciaenids in the shrimp fishery, the most important of which is king weakfish and smalleye croaker (Harper *et al.*, 2015). Whether the sciaenids are retained or not is not known.

In Bolivarian Republic of Venezuela, the coastal artisanal fishery uses handlines to catch a variety of species, including whitemouth croaker and Jamaica weakfish off the northeastern coasts, with relative abundance estimates of 21 kg/day and up to 38 kg/day, respectively (Arocha *et al.*, 2006). The artisanal multigear fleet in the Gulf of Paria, much like the one in Trinidad, targets soft bottom fishes such as croakers, drums and weakfishes, among other species. It operates mainly off the west coasts and in the central area of the Gulf of Paria. Generally, boats in the artisanal fishery, called *peñeros* are wooden, open, of 7m to 9 m in length and powered by one or two outboard engines, usually between 45 HP to 75 HP. The fishery targeting sciaenids uses drift gillnets of 1 000 m to 2 800 m long, although bottom longlines and handlines are used to catch acoupa and green weakfish (Novoa, 2000; Arocha *et al.*, 2006). King weakfish is usually caught with gillnets. The approximate number of boats operating in the area where croakers, drums and weakfishes are caught was 3 000 registered *peñeros* in 2016. In recent years, due to the ban of the bottom trawl fishery in Bolivarian Republic of Venezuela, a new industrial fleet was developed – the multiple-gear fishing fleet, also known as *Polivalente Costa Afuera* (Laurent Singh *et al.*, 2020). The fleet consists of transformed shrimp trawlers of 15 m to 29 m in length, with engines between 300 HP and 1 140 HP and storage of between 8 tonnes and 115 tonnes. The estimated number of vessels operating in the area is about 50, with an average crew of eight fishers and a trip duration of about 25 days at sea. The main area in which the fleet operates is along the NBSLME between the Orinoco River delta and the Essequibo River and the main fishes caught are several species of catfishes. Acoupa and green weakfish were an important part of the catch, representing over 10 percent of the total catch over the period 2015 to 2018. The gears used to catch sciaenids include bottom longline as the primary gear, followed by shark longline and traps.

3.2.2 State of the stocks

Acoupa weakfish, whitemouth croaker, Jamaica weakfish and green weakfish are commonly caught off the NBSLME with trawls and gillnets. Recent assessments indicate that all species are at high risk of overexploitation and there is a high risk the biomass will fall below the limit reference point, with potential recruitment overfishing of green weakfish, at least in some parts of the area (CLME, 2013). Recent research on green weakfish, using length-based indicators (LBI) suggests sustainable fishing, but the use of inappropriate LBI values (e.g. L-infinity) is a cause for concern (McManus, 2018). In Guyana, the stock assessment for green weakfish suggested that fishing mortality is at a level consistent with maximum sustainable yield (MSY), based on body length information (Santos *et al*., 2018), and the productivity–susceptibility assessment (PSA) suggested that fisheries pose a high risk to stock status (Drugan, 2019). In EU (FR Guiana), stock assessment of acoupa weakfish showed that despite the high uncertainty of model outputs (depletion-based stock reduction analysis and Bayesian biomass dynamics model), the stock appeared to be overexploited, partly due to the high levels of illegal fishing in the area (Tagliarolo; 2019; FAO, 2021b).

The available stock assessment information and the PSA conducted on king weakfish (Drugan, 2019) indicated that there is no clear quantitative evidence that the stock is healthy or unhealthy. The stock is subject to a high degree of fishing pressure from multiple fisheries on juveniles and adults and is likely at least fully exploited if not overexploited.

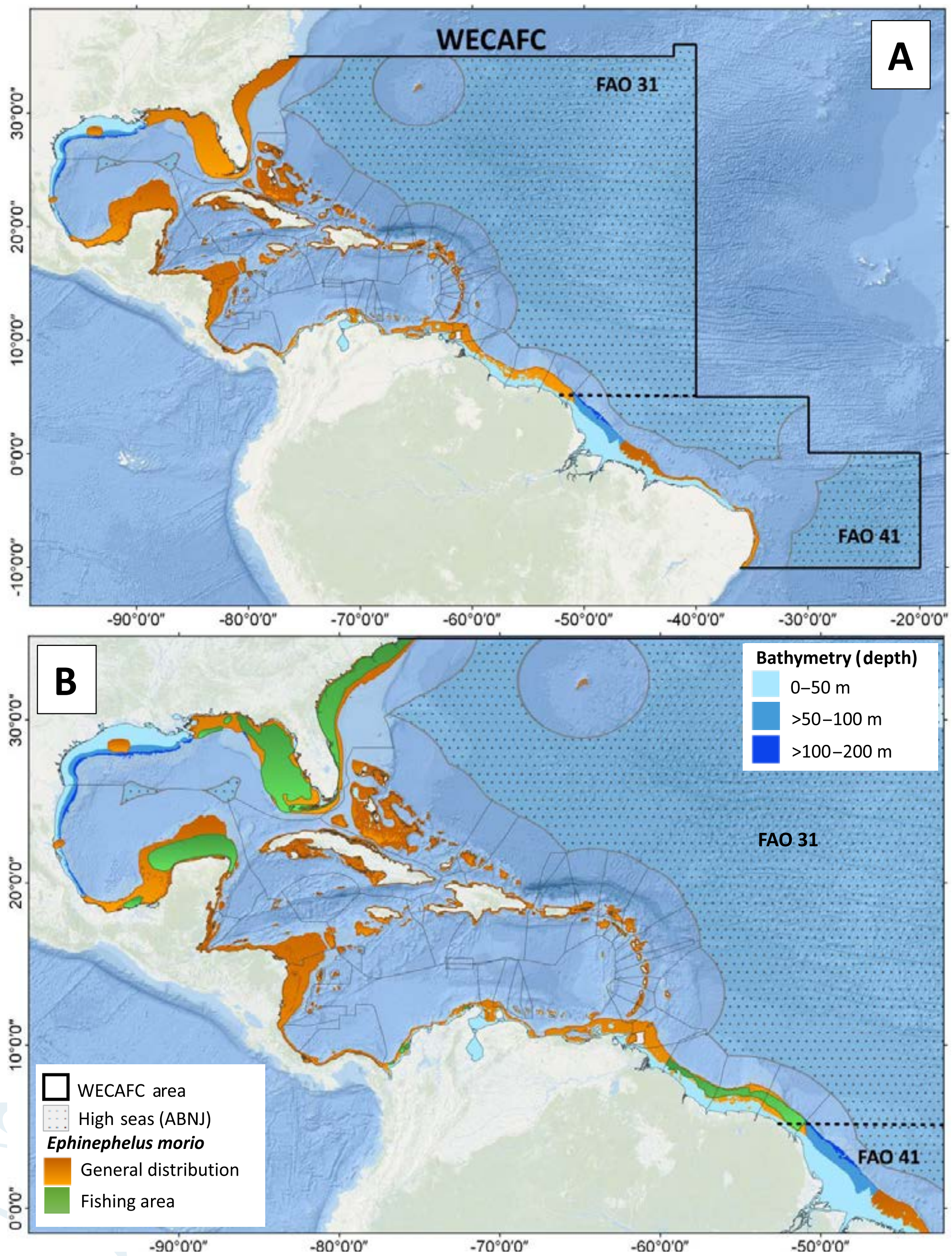
Stock assessment of smalleye croaker in Guyana suggested that fishing mortality is at a level consistent with producing MSY. However, the PSA for smalleye croaker suggests that fisheries pose a high risk to stock status (Drugan, 2019).

3.3 The reef and slope resources

3.3.1 The groupers

Red grouper (*Epinephelus morio*). Red grouper is distributed in the western Atlantic from North Carolina, south along the Atlantic coast of the United States, in the GOM from the Florida Keys north to Alabama, in the Flower Garden Banks, and from Veracruz, Mexico to northwestern Cuba, throughout the Caribbean Sea and along the coastline of South America, but with a gap in large river mouths (Figure 3.12A) (Brule, 2018). Its depth range is from 5 m to 300 m. Adults occur over sandy or mud bottoms on continental shelves from 50 m to 300 m, whereas larger juveniles are found in crevices and under ledges on rocky reefs from 5 m to 25 m. Smaller juveniles can occur on shallow seagrass beds and inshore reefs. There is no indication that this species aggregates to spawn, but it can be caught in large numbers during the spawning season. The known spawning season is between late winter and early spring in different areas of the GOM and the Atlantic coast of the United States (Brule, 2018). In the GOM, genetic analyses suggest the existence of a single stock, but do not rule out the possibility of several reproductively distinct stocks, supported by distribution discontinuity and life-history traits (Zatcoff, Ball and Sedberry, 2004). However, for the management purposes of the United States and Mexico there are three recognized stock units: the South Atlantic unit of the United States, the GOM unit of the United States and the Mexican GOM unit. The most important reported fishing areas are off the Yucatan Peninsula, around the Florida Peninsula, off Colombia and the NBSLME (Figure 3.12B).

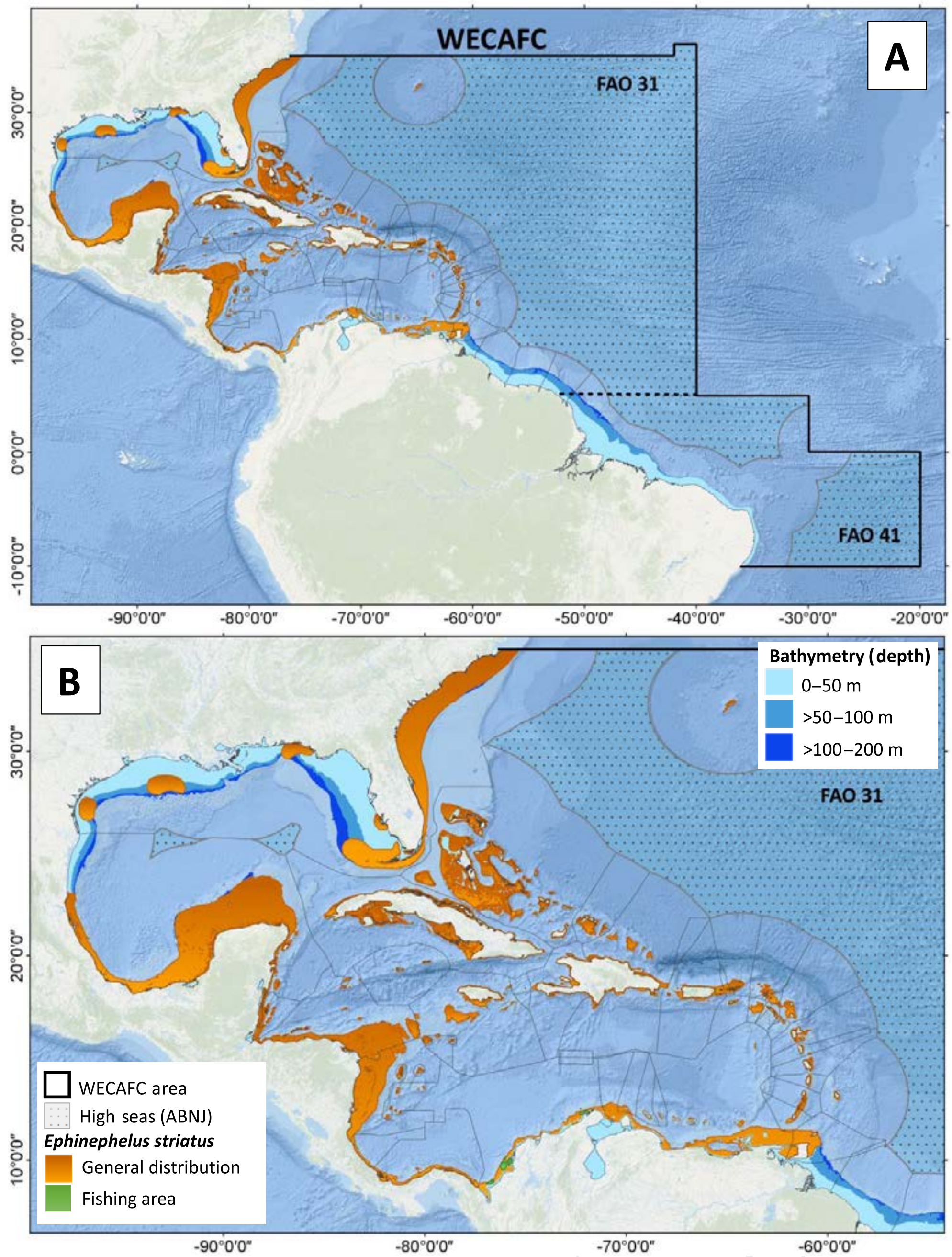
Figure 3.12. *Epinephelus morio* (red grouper, GPR) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Nassau grouper (*Epinephelus striatus*). Nassau grouper is naturally abundant in areas with large shelf habitat (Figure 3.13A), such as the Bahamas, Belize, Cuba and other islands of the Greater Antilles, and less abundant in areas such as continental South America (e.g. Colombia and Bolivarian Republic of Venezuela) (Sadovy, Aguilar-Perera and Sosa-Codera, 2018). This species prefers clear water with high relief coral reefs or rocky substrate. It occurs to a depth of at least 140 m, but individuals have been known to regularly descend to depths of 255 m during the spawning season. This species exhibits highly synchronized seasonal migrations to specific sites, typically located on outer reef drop-offs, where hundreds to tens of thousands of individuals aggregate to spawn (Sadovy, Aguilar-Perera and Sosa-Codera *et al.*, 2018). Genetic studies show evidence of strong genetic differentiation among Nassau grouper subpopulations in the Caribbean region (Jackson *et al.*, 2014). The genetic barriers proposed separate the Bahamas and eastern Caribbean, central Caribbean and Mesoamerican Reef/Belize. Presently, fishing areas for Nassau grouper were only recorded off the Colombian coast (Figure 3.13B).

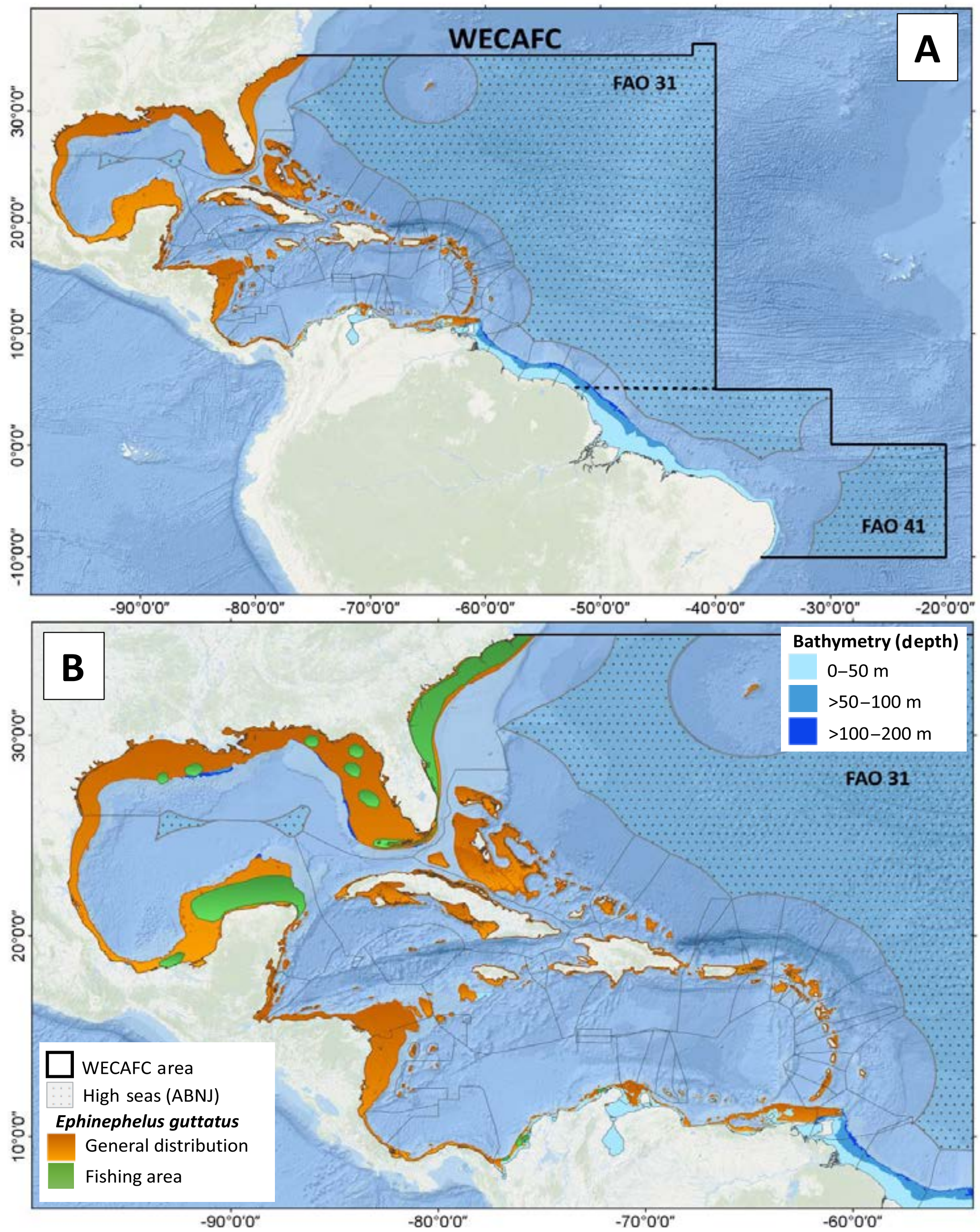
Figure 3.13. *Epinephelus striatus* (Nassau grouper, GPN) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Red hind (*Epinephelus guttatus*). This species is distributed in the western Atlantic from North Carolina south along the coast of the United States, Bermuda, the Bahamas, throughout the GOM and the Caribbean Sea (Figure 3.14A). It is one of the most common species of *Epinephelus* in the West Indies, but it is not highly valued in the market when compared to other groupers (Brule *et al*., 2018). This species inhabits coral reefs and rocky bottoms. Females rest on or close to the seabed, while males are territorial within a group of up to five females. This species forms spawning aggregations and spawning occurs almost exclusively within the aggregation period. It spawns from December to April in the Caribbean, from May to July in Bermuda and from January to April on the Campeche Bank in the southern GOM (Tuz-Sulub *et al*., 2006; Caballero-Arango, 2013; Tuz-Sulub and Brulé, 2015). There are at least six known spawning aggregation sites in Puerto Rico. The most important reported fishing areas are off the Yucatan Peninsula, in several spots in the northern and eastern GOM, southeastern United States, and off Colombia (Figure 3.14B).

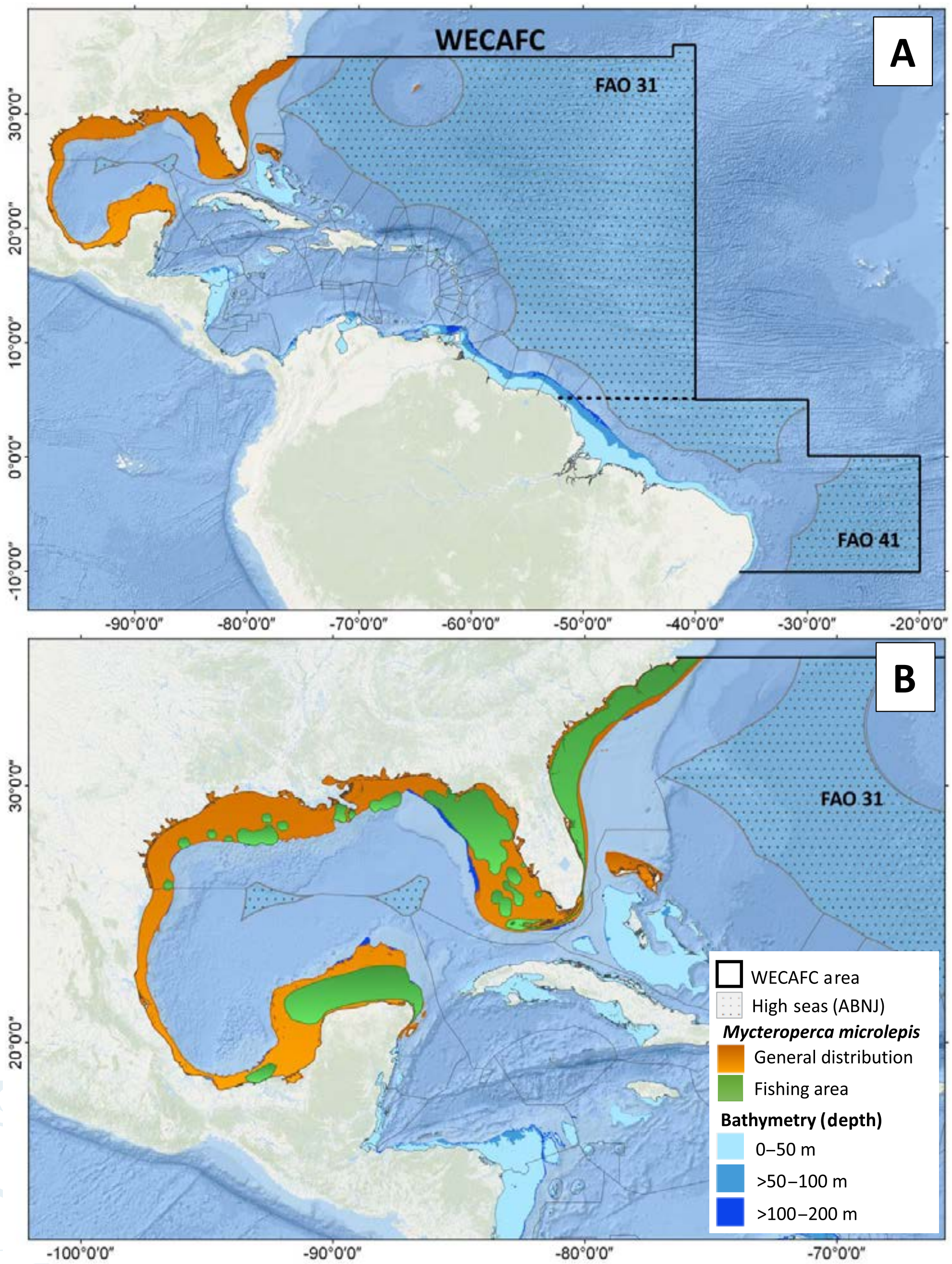
Figure 3.14. *Epinephelus guttatus* (red hind, EEU) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Gag grouper (*Mycteroperca microlepis*). Gag grouper is distributed in the western Atlantic from North Carolina south along the coast of the United States, Bermuda, and throughout the GOM, except Cuba (Figure 3.15A) (Koenig, Bertoncini and Ferreira, 2018). This reef-associated species is usually found offshore on rocky bottoms and occasionally inshore on rocky or grassy bottoms. Overall, the species prefers habitats characterized by maximum structural complexity, at depths of between 70 m and 100 m. It spawns exclusively on shelf-edge reefs, preferably on rocky ridges next to drop-offs, in December and January. Females form pre-spawning aggregations in shallower areas prior to migrating to the spawning aggregation sites in deeper water, while males remain near spawning sites in deep water year-round. Primary spawning season seems to be between winter and spring (Koenig, Bertoncini and Ferreira, 2018). Information about stock structure shows the species is centered in the northern WECAFC region, but is unclear about the distribution of the species between the GOM and Atlantic coast of the United States (Chapman *et al*., 1999). For the management purposes of the United States, the recognized stock units are the United States GOM and the southeastern Atlantic coast of the United States. The most important reported fishing areas are off the northern Yucatan Peninsula, in several spots in the northern and eastern GOM, and the southeastern United States (Figure 3.15B).

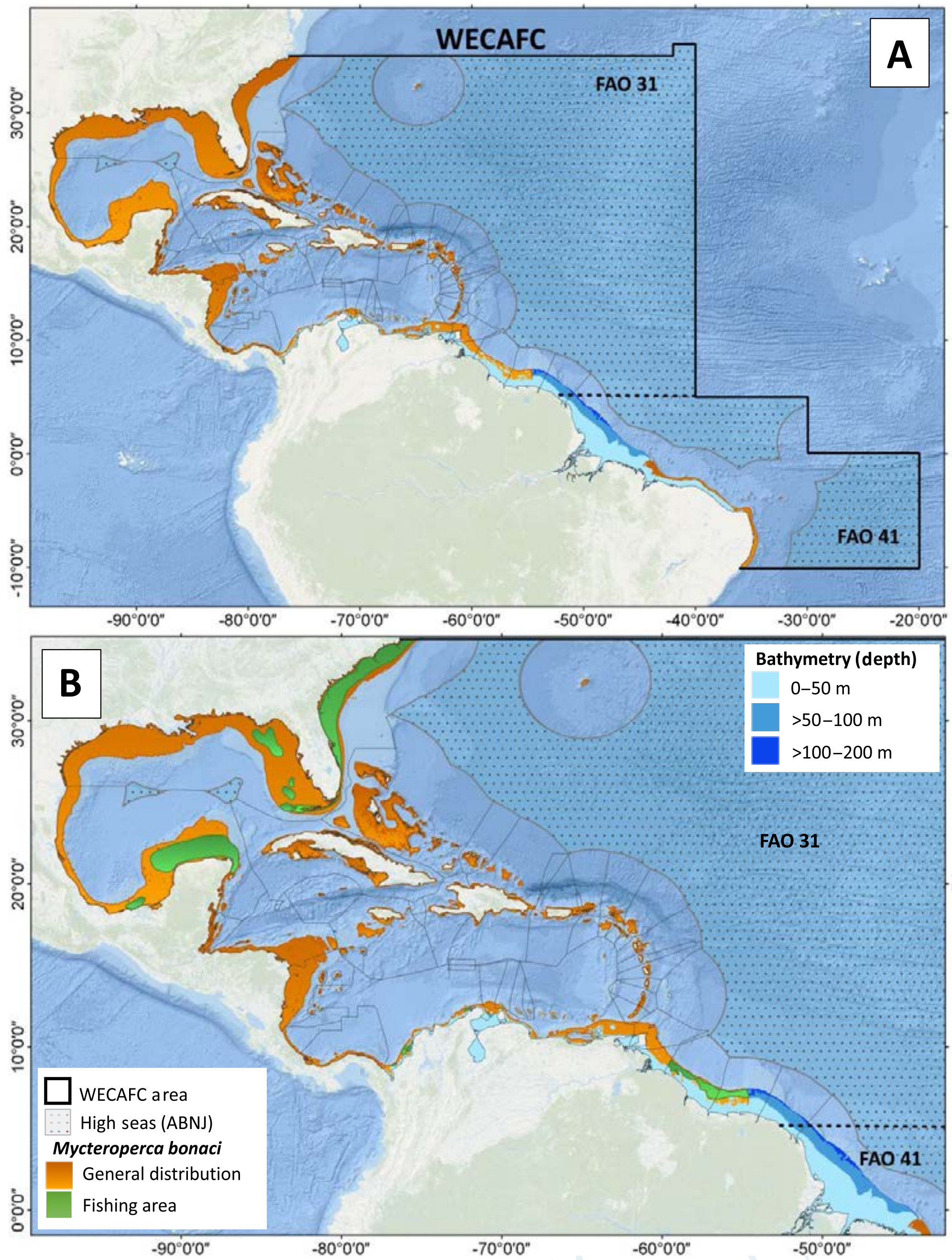
Figure 3.15. *Mycteroperca microlepis* (gag grouper, MKM) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Black grouper (*Mycteroperca bonaci*). This species is distributed in the western Atlantic from Cape Canaveral, Florida, south along the coastline of the United States, Bermuda, the Bahamas, in the GOM from the Florida Keys north to Alabama, the Flower Garden Banks and surrounding area, and from southern Texas south along the coastline of Mexico to Cuba, throughout the Caribbean Sea and the northern part of the NBSLME (Figure 3.16A) (Padovani-Ferreira *et al.*, 2018). It is considered a solitary species and known to form spawning aggregations in the GOM and Caribbean Sea. Spawning occurs during winter and in the early spring months from November to May but varies by area. Juveniles settle in shallow sandy-rocky patch reefs and sometimes occur in estuaries, seagrass and oyster rubble habitat. In the United States there are two stocks: one for the United States GOM and another for the United States South Atlantic and the United States Caribbean (Puerto Rico and the United States Virgin Islands) (SEDAR, 2010). In the remainder of the region, the stock structure of the species is limited (González-Salas *et al*., 2020). The most important reported fishing areas are off the Yucatan Peninsula, around the Florida Peninsula, off Colombia and the NBSLME (Figure 3.16B).

Figure 3.16. *Mycteroperca bonaci* (black grouper, MAB) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region

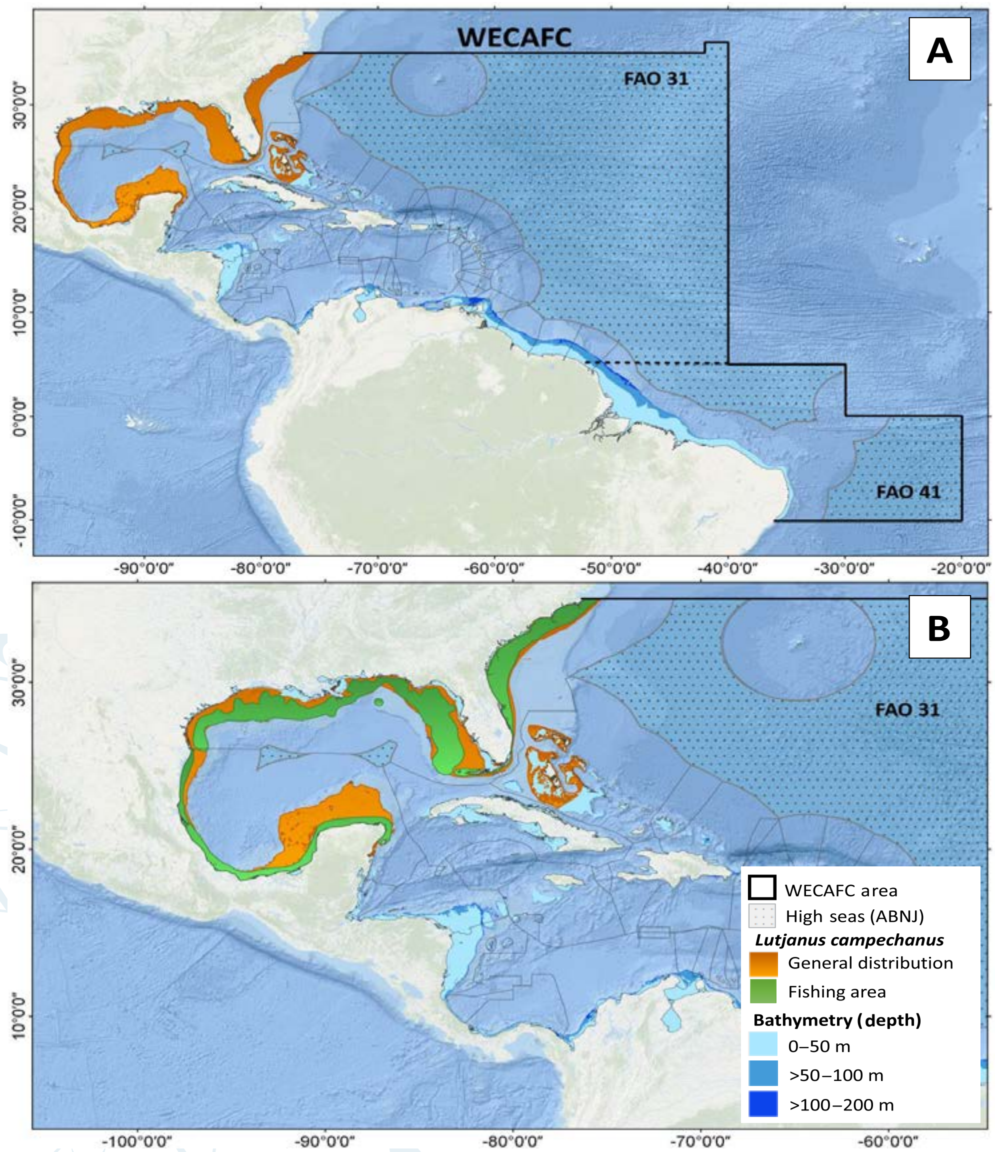


Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

3.3.2 The snappers

Northern red snapper (*Lutjanus campechanus*). Red snapper is generally found at 10 m to 180 m in the GOM and along the eastern coasts of North America, Central America and northern South America (Figure 3.17A) (Anderson *et al*., 2015). Red snapper feed on fish, shrimp, crab, worms, cephalopods and some phyto and zooplankton. Spawning season varies with location, but in most cases occurs nearly year-round. The spawning season off the southeastern United States extends from May to October, peaking in July to September. On Campeche Bank, it spawns between April and October (Anderson *et al*., 2015). The stock structure information is limited to the northern WECAFC region. It appears not to show significant genetic variation between the specimens of the northern GOM and those of the southern GOM, but it is believed they are unlikely to be part of the same population (Gold and Richardson, 1998). The species is managed as separate stock units by the United States and Mexican fishing authorities (SEDAR, 2017a; Government of Mexico, 2018). Fishing areas are likely distributed across its range but known areas are commonly found off the Mexican coasts in the GOM and the southern United States (Figure 3.17B).

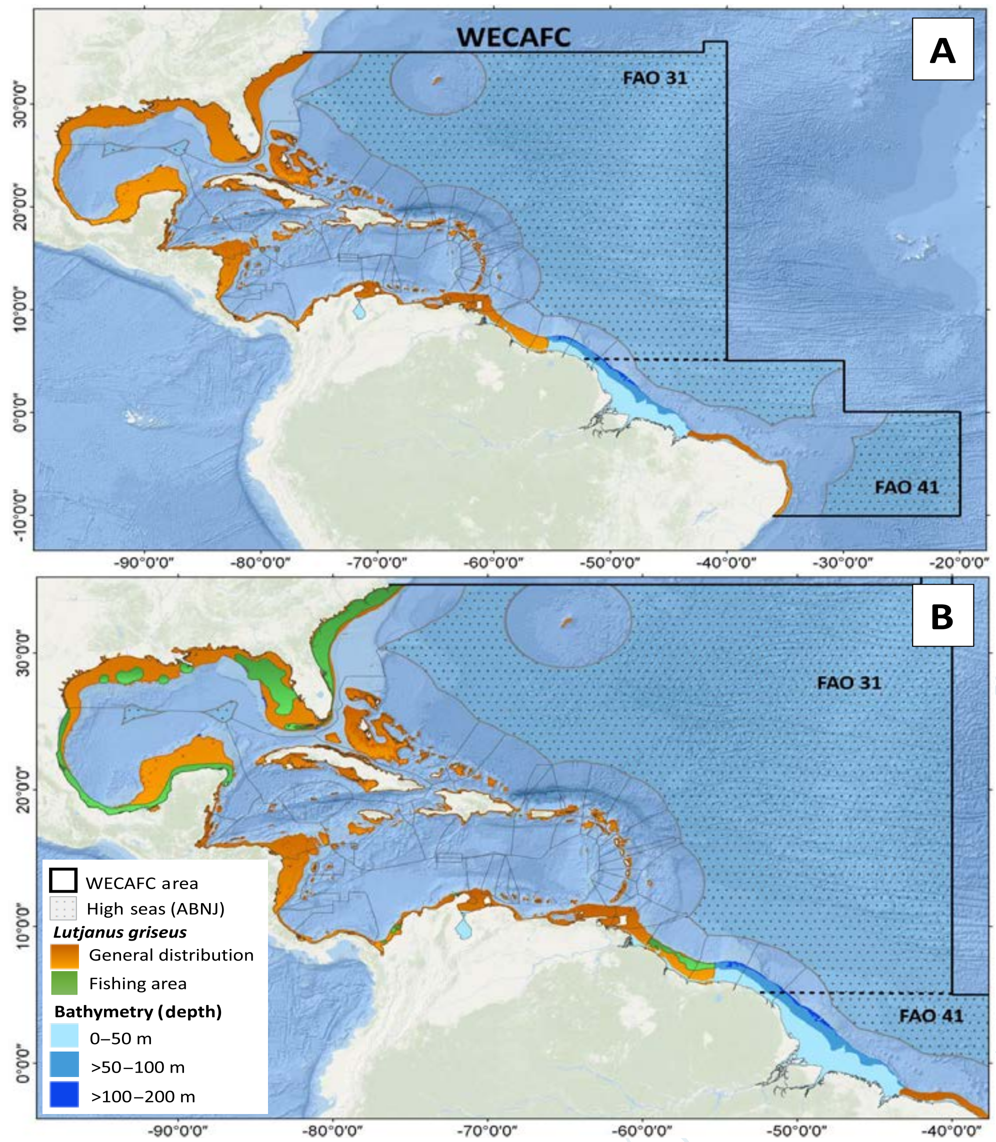
Figure 3.17. *Lutjanus campechanus* (northern red snapper, SNR) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Grey snapper (*Lutjanus griseus*). The species occurs in tropical, subtropical and warm temperate waters from Bermuda to Brazil, and throughout the GOM and the Caribbean Sea (Figure 3.18A). It is a common snapper and can be very abundant throughout its range. As a juvenile, grey snapper settles close to shore in estuaries, seagrass beds or shallow reefs, and gradually moves offshore as it grows larger; adults are generally located close to shore or offshore on hard bottoms and in coral habitats (Lindeman *et al.*, 2016a). It spawns offshore in groups, showing simple migratory spawning (Domeier and Colin, 1997). Spawning occurs primarily in the summer months, between May and September in association with the lunar cycle. The stock structure of grey snapper in the northern part of the region consists of at least four genetically distinct stocks, one in the southern GOM and northwestern Caribbean, one in the northwestern GOM, one in the northeastern GOM, and another in the southeastern United States (Gold *et al.*, 2009; Rosado-Nic *et al.*, 2020). In the southern part of the region, several subpopulations such as those that exist in the Greater Antilles (Cuba in particular) and the southern Caribbean (e.g. Bolivarian Republic of Venezuela) are likely to exist but none have been defined (Lindeman *et al.*, 2016a). Known fishing areas are recorded for the GOM, southern United States, off Colombia and in the NBSLME (Figure 3.18B).

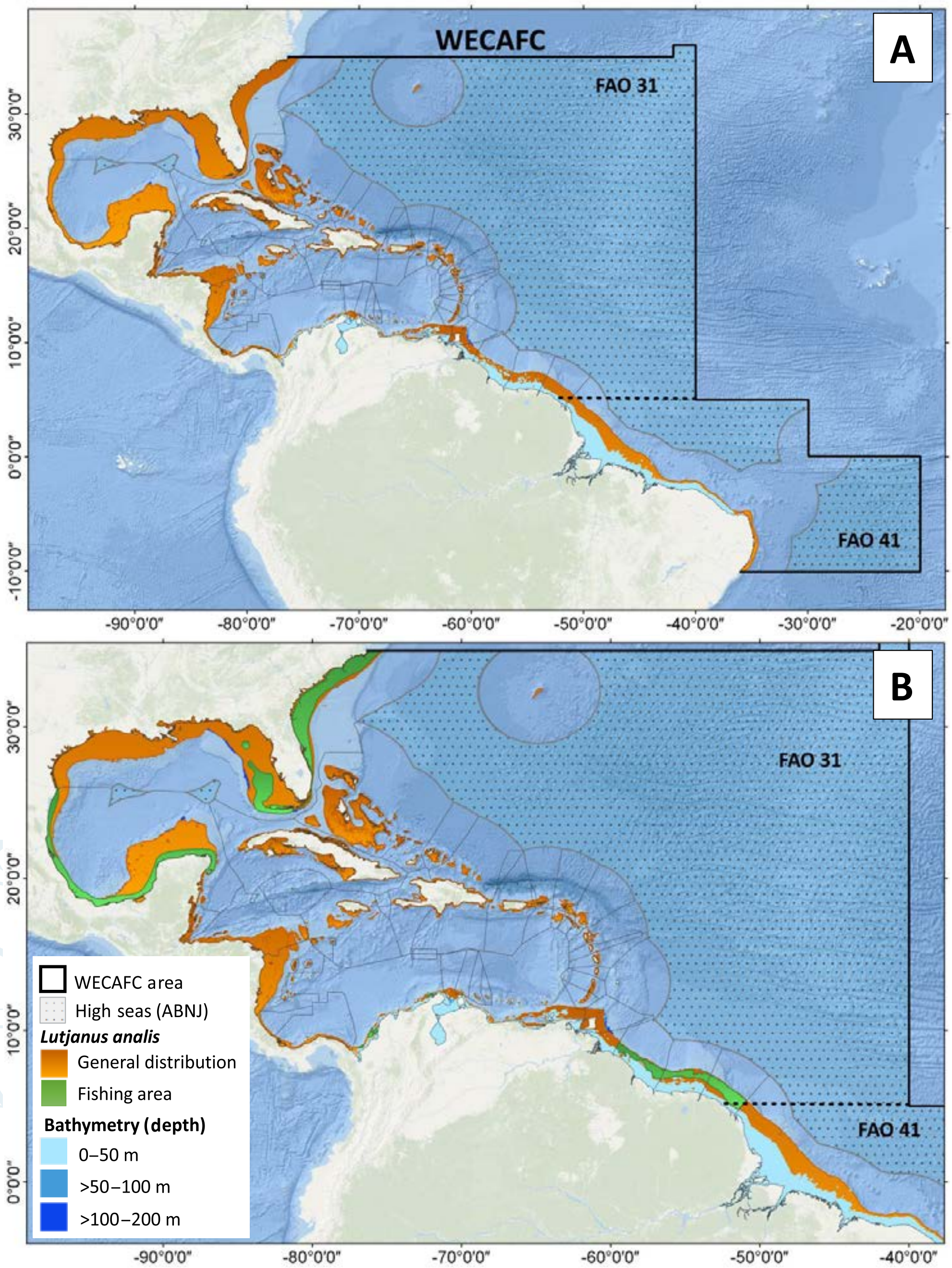
Figure 3.18. *Lutjanus griseus* (grey snapper, LJI) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Mutton snapper (*Lutjanus analis*). Mutton snapper is distributed from Cape Hatteras, North Carolina, south along the coast of the United States, the Bahamas, in the GOM from the Florida Keys north to Tampa, off the Mississippi Delta region, and from Texas (Corpus Christi) south along Mexico to Cuba, throughout the Caribbean Sea, and along the coastline of South America (Figure 3.19A) (Lindeman *et al*., 2016b). It occurs over reef, seagrass and rubble bottoms, in continental shelf areas, as well as in clear waters around islands.

Figure 3.19. *Lutjanus analis* (mutton snapper, LJN) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region

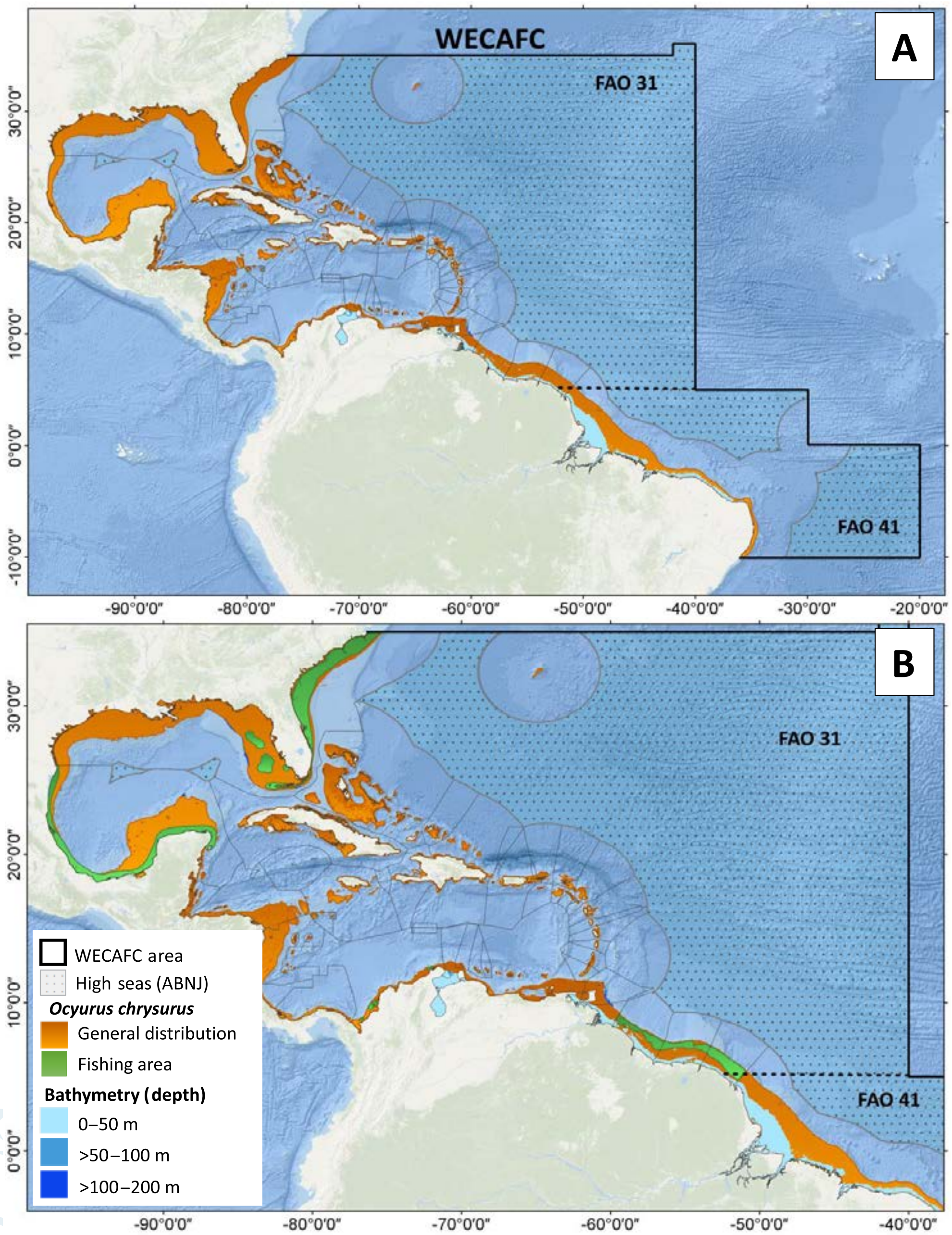


Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Large adults are usually found among rocks and coral while juveniles occur over sandy bottoms and in seagrass (*Thalassia testudinum*) habitats. Spawning aggregations are documented from Belize. In Cuba, spawning aggregations occur on several shelf regions between May and August in depths of 20 m to 40 m (Lindeman *et al*., 2016a). An important spawning aggregation site at Dry Tortugas, Florida, has been subject to management attention. The stock structure in the region is not completely clear. A study supports a single stock hypothesis for specimens from the Florida Keys, Puerto Rico and the United States Virgin Islands (Carson *et al*., 2011). It is likely that there are other subpopulations in the southern WECAFC region. Known fishing areas are recorded for the Mexican GOM, southern United States, off Colombia and in the NBSLME area (Figure 3.19B).

Yellowtail snapper (*Ocyurus chrysurus*). The species is widely distributed and abundant in the tropical and subtropical parts of the region. Despite its wide range, yellowtail snapper is most abundant in the Bahamas and throughout the Caribbean (Figure 3.20A) (Lindeman *et al*., 2016c). The species inhabits clear coastal waters, mostly over hard bottoms and around coral reefs; it usually occurs above the bottom and frequently occurs in aggregations. Adults can be very abundant in reef areas, and the species is fished throughout its geographical range. Young individuals are found in shallow vegetation and on shallow hard bottoms, whereas adults move to shallow coral reef areas (Nagelkerken *et al*., 2000). Spawning can occur throughout the year, with peaks at different times in different areas (Smith, 1997). In Cuban waters, peak spawning takes place during April, with another less intensive peak in September (Claro, Lindeman and Parenti, 2001). The stock structure of yellowtail snapper is not clearly understood, but populations from the waters of the southeastern United States are believed to belong to a single stock. Populations from Brazil and Belize are significantly different (da Silva *et al*., 2015). The genetic links between the GOM and the Caribbean remain unknown. Known fishing areas are in the Mexican GOM, southern United States, off Colombia and in the NBSLME area (Figure 3.20B).

Figure 3.20. ***Ocyurus chrysurus*** **(yellowtail snapper, SNY) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region**

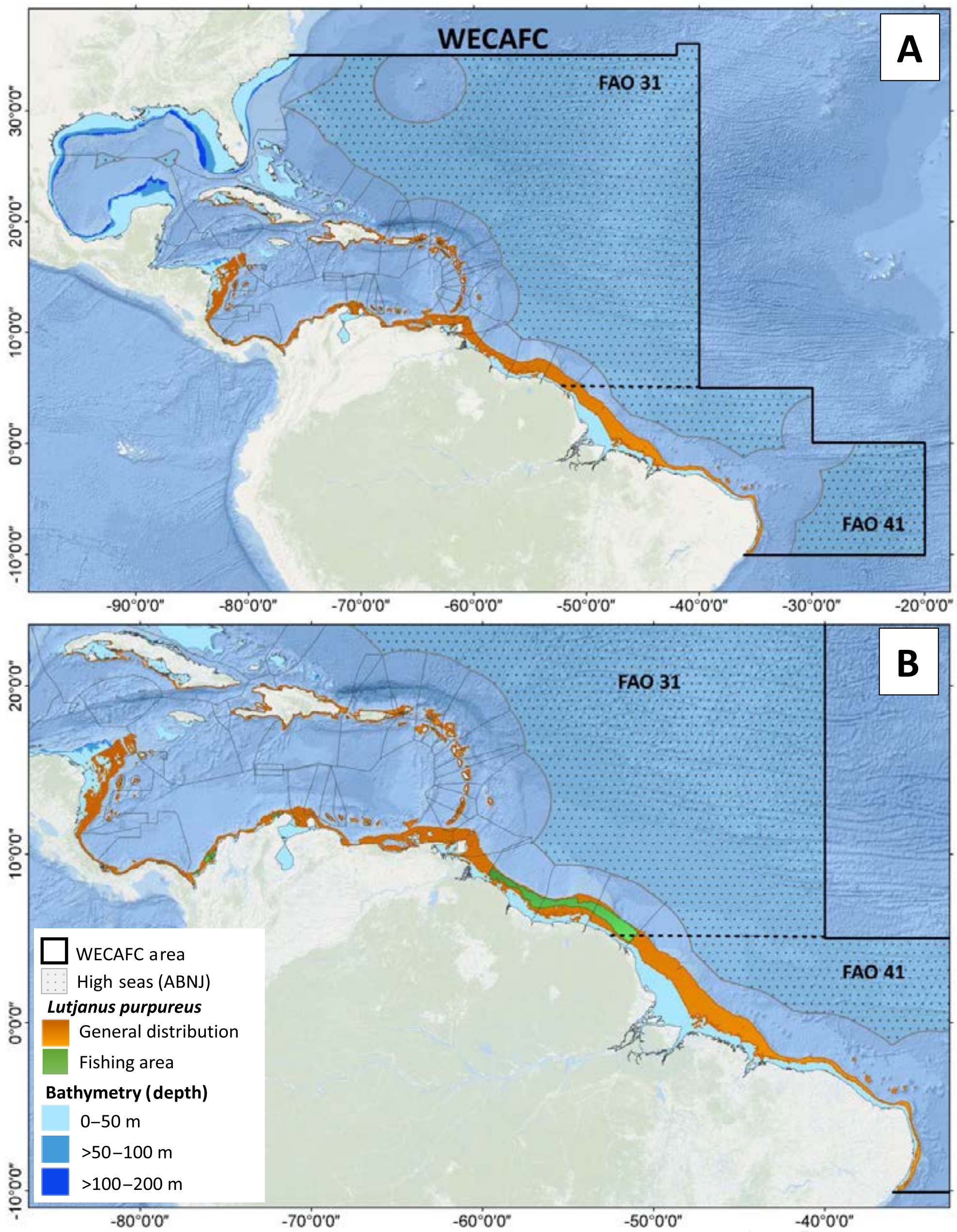


Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Southern red snapper (*Lutjanus purpureus*). This species is distributed in the tropical western Atlantic Ocean, throughout most of the Caribbean Sea from Cuba southwards to northeastern Brazil (Figure 3.21A). It is most abundant on the continental shelf off Honduras and in the Brazil-Guianas Shelf, and less common around the Antilles where it is confined to deeper water. Southern red snapper inhabits rocky areas between about 30 m and 160 m, most commonly in depths of between 70 m and 120 m. Adults feed mainly on fishes, shrimps, crabs and cephalopods. Spawning occurs mainly during spring and summer (Allen, 1985). The stock structure of the species in the region is not fully understood.

A distinct population of southern red snapper exists in Brazil (Gomes, Sampaio and Schneider, 2012), but there is insufficient information available for the Caribbean region. Known fishing areas are off Colombia and in the NBSLME (Figure 3.21B).

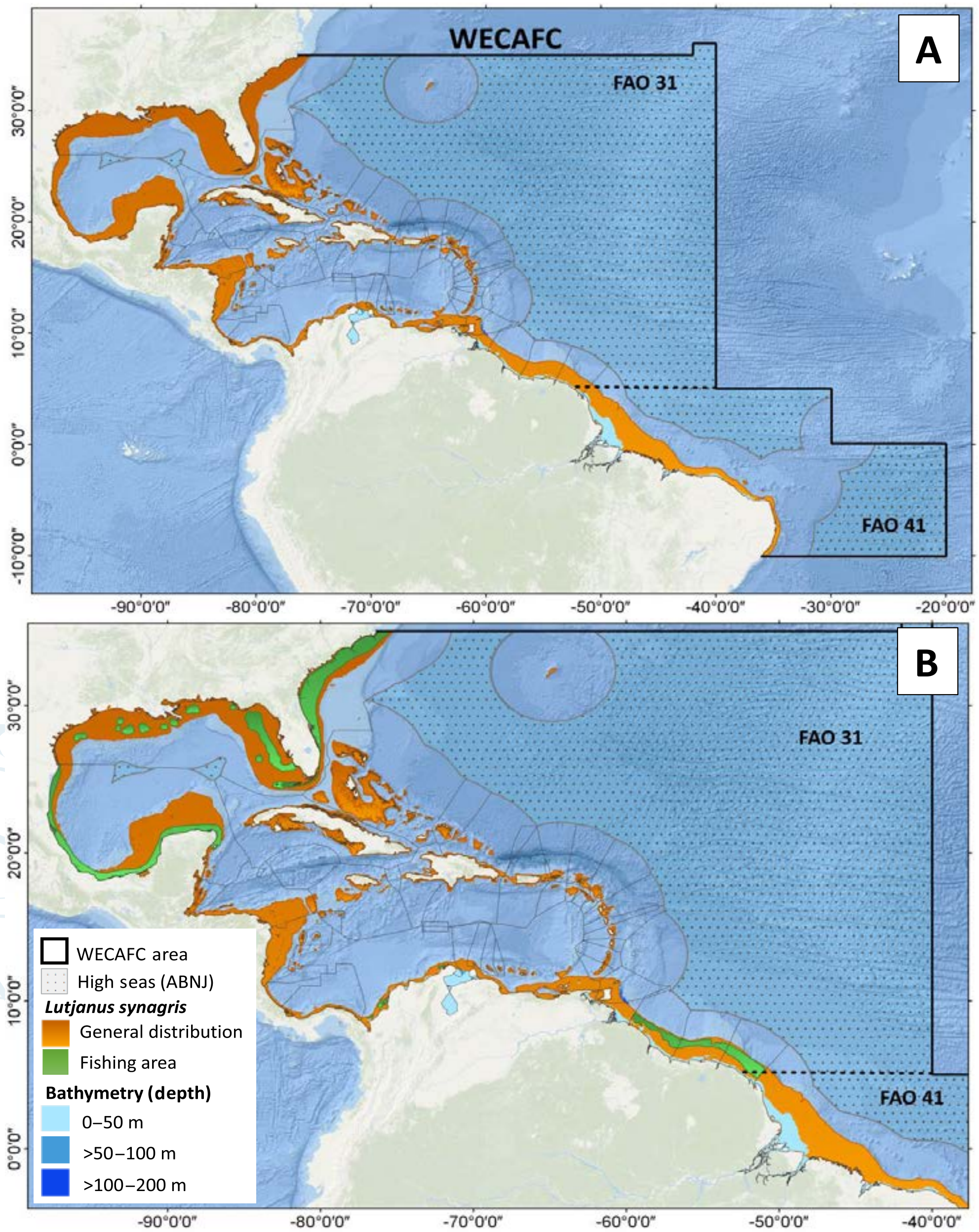
Figure 3.21. *Lutjanus purpureus* (southern red snapper, SNC) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Lane snapper (*Lutjanus synagris*). This western Atlantic species is distributed from North Carolina south along the coast of the United States, Bermuda, the Bahamas, throughout the GOM and the Caribbean Sea, and along the South American coast to Santa Catarina, Brazil (Figure 3.22A) (Lindeman *et al.*, 2016d). It is found in a variety of habitats, often around coral and rocky reefs and over vegetated sandy areas. Lane snapper is found in turbid and clear waters. It occurs to a maximum depth of 400 m, but generally in much shallower waters over continental and insular shelves. Fish in the early life stages can be found among a variety of structural habitat types, including seagrasses and close to shore over hard bottoms. There are multispecies spawning aggregations off the coast of Cuba that include this species, with the largest production on the southwest coast of the island (Lindeman *et al.*, 2016d). The available studies on stock structure show the existence of at least three subpopulations in the northern WECAFC region: one in the western GOM, one in the eastern GOM, and one in the northern Caribbean (Puerto Rico) (Karlsson, Saillant and Gold, 2009; Gold *et al.*, 2011). Given the life history of most lutjanids, where juvenile and adult fish are relatively sedentary, preferring inshore, soft or sandy habitats or nearshore hard bottom habitats, it is likely that there are other subpopulations in the southern WECAFC region (Sierra, Castillo and Fujiwara, 2021). Fishing areas for lane snapper, as for most snappers reviewed, are recorded for the Mexican GOM, southern United States, off Colombia, and in the NBSLME area (Figure 3.22B).

Figure 3.22. *Lutjanus synagris* (lane snapper, SNL) general distribution (A) and fishing area (B) in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

3.3.3 The fishery

The reef and slope shared fishery resources selected are all members of the families Serranidae (groupers) and Lutjanidae (snappers). A characteristic of several members of these families is that they reproduce in mass spawning aggregations that form for brief periods at specific times and places each year. These aggregations will attract the biggest fish and are predictable, making them highly susceptible to overfishing. There are several examples of declining populations of groupers and snappers in the WECAFC region because the fishes have been subject to intensive fishing on spawning aggregations. This is the case with Nassau grouper, gag grouper and mutton snapper, among others.

Groupers and snappers are valuable in multiple countries and stakeholders in the WECAFC region, whether they are prized for food, livelihoods from fish sales or dive tourism. The species provide considerable income in the region and declines in population abundance as a result of uncontrolled fishing of aggregations can affect many different economic sectors. Of particular concern are the negative impacts on small-scale and artisanal fisheries that depend heavily on reef fishes.

According to FAO landing statistics for the period 2015 to 2019, few countries' landings reports are species-specific; most countries report at the family level or genus level for both groups (groupers and snappers). For groupers, Mexico is responsible for most of the accumulated reported catch under Serranidae (grouper, seabasses NEI) with 96.24 percent of the total accumulated catch in the period reviewed. It is also responsible for the total of *Mycteroperca* spp. (Brazilian groupers NEI), which in Mexico are called *negrillo* and *abadejo* (Table 3.8). In Mexico, the main target species is red grouper, *mero o cherna Americana*, and is fished by three fleets: artisanal; artisanal mid-range and a foreign fleet from Cuba called *Flota cubana*. The fleet consists of a mother ship with six boats, each fishing with bottom longline gear of up to 350 hooks (Government of Mexico, 2018). The other two fleets limit the number of hooks allowed. In 2014, 4 200 artisanal boats were in operation. In the artisanal fishery, the bottom longline is limited to 750 m and a maximum of 250 hooks, whereas the artisanal mid-range fleet is allowed to use up to four bottom longlines with 500 hooks each, or one bottom longline with 2 000 hooks. The main fishing grounds are concentrated in the Campeche Bank, off the state of Yucatan (Monroy-García, Galindo-Cortez and Hernández-Flores, 2014). In Mexico, the mero, negrillo, and abadejo (red grouper and Brazilian grouper NEI) fishery has several management regulations, including minimum size, gear limitations, an annual seasonal closure, and area limitation (Government of Mexico, 2018). However, there are 10 other grouper species that are considered to be target species (five *Epinephelus* spp. and five *Mycteroperca* spp.) but are not disaggregated by species in any of the fleets. It is possible that *negrillo* (black grouper, *Mycteroperca bonaci*) and *abadejo* (gag grouper) are reported as Brazilian groupers NEI (*Mycteroperca* spp.) (Monroy-García, Galindo-Cortez and Hernández-Flores, 2014).

Table 3.8 Groupers catch by country for the period 2015–2019 (tonnes)

Country	2015	2016	2017	2018	2019	Rank	%	%cum
Group: Reef and slope species – Groupers. Species: Serranidae (family) – groupers. seabasses NEI. Species code: –								
Mexico	10 419	8 684	11 565	9 726	9 816	1	96.24	
Antigua and Barbuda	163	163	163	163	163	2	1.56	97.81
Nicaragua	105	111	116	155	145.7	3	1.21	99.02
Venezuela (Bolivarian Republic of)	245	32	35	35	35	4	0.73	99.75
Colombia	30	7	16	0	72.20	5	0.24	99.99
Grenada	1	1	1	1	1	6	0.01	100.00
Group: Reef and slope species – Groupers. Species: *Epinephelus* spp . – groupers NEI. Species code: –								
Dominican Republic (the)	758	758	815	787	795	1	68.75	
Venezuela (Bolivarian Republic of)	228	125	130	130	130	2	13.05	81.80
United States of America	65	57	62	42	1	3	3.99	85.79
Saint Kitts and Nevis	18	39	52	55	46	4	3.69	89.48
Bahamas (the)	69	29	44	38	15	5	3.43	92.91
French Guiana	20	17	23	21	15	6	1.69	94.60
United States Virgin Islands (the)	18	26	21	15	15	7	1.67	96.27
Aruba	12	22	20	20	20	8	1.65	97.92
Cuba	19	17	14	14	10	9	1.30	99.22
Saint Vincent and the Grenadines	17	3	0	0	0	10	0.35	99.57
Puerto Rico	5	3	2	3	2.29	11	0.27	99.84
British Virgin Islands (the)	1	1	1	1	1	12	0.09	99.93
Bermuda	2	1	0	1	0	13	0.07	100.00
Group: Reef and slope species – Groupers. Species: *Epinephelus morio* – red grouper. Species code: GRP								
United States of America	2 575	2 408	1 782	1 272	1	1	94.51	
Dominican Republic (the)	84	84	90	109	100	2	5.49	100.00
Group: Reef and slope species – Groupers. Species: *Epinephelus striatus* – Nassau grouper. Species code: GPN								
Bahamas (the)	53	31	51	81	163	1	66.24	
Colombia	0	0	27	1	72.20	2	17.51	83.75
Cuba	30	20	23	20	0	3	16.25	100.00
Group: Reef and slope species – Groupers. Species: *Epinephelus guttatus* – red hind. Species code: EEU								
Grenada	120	110	110	110	110	1	63.88	
Saint Vincent and the Grenadines	47	18	31	16	22	2	15.28	79.16
Bermuda	18	30	14	23	20	3	11.98	91.14
Puerto Rico	27	15	7	13	14.7	4	8.75	99.89
United States of America	0	1	0	0	0	5	0.11	100.00
Group: Reef and slope species – Groupers. Species: *Mycteroperca* spp.– Brazilian groupers NEI. Species code: –								
Mexico	1 822	1 327	2 022	1 486	1 643	1	100.0	100.00
Group: Reef and slope species – Groupers. Species: *Mycteroperca microlepis* – gag grouper. Species code: MKM								
United States of America	383	562	323	344	44	1	100.0	100.00
Group: Reef and slope species – Groupers. Species: *Mycteroperca bonací* – black grouper. Species code: MAB								
Bermuda	25	14	15	16	18	1	100.0	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

The Dominican Republic and the Bolivarian Republic of Venezuela are the two countries that report most of the total accumulated catch of *Epinephelus* spp. (grouper NEI), with 81.8 percent: 68.75 percent (Dominican Republic) and 13.05 percent (Bolivarian Republic of Venezuela) for the period 2015 to 2019 (Table 3.8). In the Dominican Republic, the fishery for groupers (*Epinephelus* spp.) is the same as the one for snappers (Lutjanidae) for which the country reports 26.36 percent of the total accumulated catches for 2015 to 2019, second after Mexico (Table 3.9). In both cases, the fishery for groupers and snappers consists of small-scale (artisanal) fleets that target species near the shelf edge and on the offshore ocean banks of the Dominican Republic, La Navidad and La Plata, as well as other small banks in the north of the island (Herrera *et al.*, 2011). The fishing grounds for the coastal artisanal fleet are in the southwest part of the island where the shelf drop is close to the coast, off Barahona and Pedernales, and in the northeastern part of the island off Samaná Peninsula. Fishing depths are between 100 m and 500 m. There are mainly two types of vessels that harvest fish species off the Dominican Republic: *yola*, a flat wooden boat sometimes re-coated with fibreglass, 5 m to 7 m long and powered by a 5 HP to 25 HP outboard engine; and *bote* or *panga*, a modest-sized fibreglass boat with a high bow, narrow waterline beam, and a flotation bulge along the gunwale, or top edge of the hull. These are powered with different sized outboard engines (15 HP to 40 HP) depending on the length of the boat (5 m to 7 m) (Gentner *et al*., 2018). The fishing gears used are handline, longline and traps. It is likely that fishing on the offshore banks will be undertaken by an artisanal mid-range fleet capable of fishing offshore, with holding facilities on board (noting the fishing grounds are 90 NM offshore). The published information indicates that the main groupers/snappers caught are yellowedge grouper (*Hyporthodus flavolimbatus*) and queen snapper (*Etelis oculatus*) but the multispecific reef fleet operating in the southwest using traps also catches Nassau grouper (Herrera *et al*., 2011).

Table 3.9 Part 1: Snappers catch by country for the period 2015–2019 (tonnes)

Group: Reef and slope species – snappers. Species: Lutjanidae (family) – snappers. jobfishes NEI. Species code: –								
Country	**2015**	**2016**	**2017**	**2018**	**2019**	**Rank**	**%**	**%cum**
Mexico	1 791	2 082	1 988	2 332	1 844	1	42.85	
Dominican Republic (the)	1 116	1 116	1 199	1 409	1 335	2	26.36	69.21
Venezuela (Bolivarian Republic of)	2 447	112	115	115	115	3	12.40	81.61
Antigua and Barbuda	333	333	333	333	333	4	7.11	88.72
Colombia	15	33	507	67	102.2	5	3.09	91.81
Costa Rica	96	66	65	65	65	7	1.52	93.34
Grenada	70	70	70	70	70	6	1.49	94.83
Cuba	80	67	60	60	50	9	1.35	96.18
Anguilla	50	43	52	52	52	8	1.06	97.25
Aruba	30	40	45	45	48	10	0.89	98.13
Puerto Rico	20	55	41	63	12.9	12	0.82	98.95
Barbados	21	31	31	22	25	11	0.56	99.51
United States Virgin Islands (the)	17	23	25	10	10	13	0.36	99.87
Bermuda	2	5	2	2	2	14	0.06	99.93
Saint Vincent and the Grenadines	2	1	2	2	2	15	0.04	99.97
United States of America	3	2	0	1	2	16	0.03	100.00
Group: Reef and slope species – Snappers. Species: *Lutjanus* spp.). Código de la especie: Snappers NEI. Species code: –								
Bahamas (the)	357	258	192	523	284.1	1	48.13	
Nicaragua	300	155	156	191	179.5	2	29.27	77.40
British Virgin Islands (the)	70	70	70	70	70	3	10.44	87.83
Saint Kitts and Nevis	21	32	47	72	61	4	6.94	94.78
Saint Lucia	34	39	35	27	40.05	5	5.22	100.00
Group: Reef and slope species – snappers. Species: *Lutjanus campechanus* – northern red snapper. Species code: SNR								
Mexico	4 211	4 995	4 674	5 594	4 164	1	66.06	
United States of America	3 058	2 940	3 072	3 072	3	2	33.94	100.00
Group: Reef and slope species snappers. Species: *Lutjanus griseus* – grey snapper. Species code: LJI								
Mexico	359	581	398	651	452	1	80.99	
United States of America	147	142	109	107	1	3	16.79	97.78
Bermuda	8	10	19	16	14	2	2.22	100.00
Group: Reef and slope species – snappers. Species: *Lutjanus analis* – mutton snapper. Species code: LJN								
Venezuela (Bolivarian Republic of)	0	158	165	165	165	1	55.07	
United States of America	102	69	88	102	2	2	30.61	85.68
Colombia	0	0	0	0	114.0	3	9.62	95.30
Puerto Rico	20	9	6	9	11.71	4	4.70	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

In Bolivarian Republic of Venezuela, the fishery is operated by small-scale (artisanal) fleets that target grouper and snapper species on the edge of the shelf, on hard bottoms and on the reefs of the Venezuelan islands. There are three small-scale (artisanal) fisheries that target this group of species: i) the artisanal coastal fleet that uses small wood/fibreglass vessels (≤10 m, 75 HP outboard engine) with a crew of 2 to 3 fishers, and operates off the Venezuelan Caribbean coasts and islands; ii) the mid-range fleet, that consists of mid-size wood vessels (10 m to 14 m) with inboard engines and a crew of 5 to 7 fishers, which also operates off the Venezuelan Caribbean coasts and islands; and iii) the long-range artisanal fleet, with larger size wooden vessels (14 m to 24 m) which operates in the waters of the NBSLME (off Guyana and Suriname) with a crew of 10 to 15 fishers (Mendoza, 2015). When targeting grouper and snapper, the mid- and long-range fleets are known as the *pargo-mero* artisanal fleet, most of which is based in Margarita Island. The preferred gears for the artisanal coastal fleet are handlines, traps and bottom gillnets. In the mid- and long-range artisanal fleets, handlines and bottom longlines are generally used. Most of the grouper catch is from the northeastern part of Bolivarian Republic of Venezuela, including the catch from the NBSLME (73 percent in the 1990s), followed by the northwestern area (17 percent) off La Guajira. Ten percent of the catches were from the central area, including the offshore reef islands (Los Roques, Las Aves) (Novoa *et al*., 1998). The grouper catch is not disaggregated but records indicate that the most common species in the catches are red hind and Nassau grouper, commonly caught in the Venezuelan reef islands; the yellowedge grouper is the main species caught by the long-range artisanal fleet fishing along the NBSLME (off Guyana and Suriname), as well as some catches of snowy grouper (*Hyporthodus niveatus*); red grouper, Atlantic goliath grouper (*Epinephelus itajara*), and rock hind (*Epinephelus adscensionis*) are caught by the coastal and mid-range artisanal fleets along the coasts of the Bolivarian Republic of Venezuela and the shelf islands (Novoa *et al*., 1998; Mendoza and Lárez, 2004; Cervigón and Ramírez, 2012).

The FAO statistics for snappers follow a pattern similar to that described for groupers, above: most reporting by country is at the family level or at the genus level. For snappers, three countries are responsible for most of the accumulated reported catch under Lutjanidae (snappers, jobfishes NEI) with 81.61 percent of the total catch in the period reviewed (Table 3.9). Mexico reported 42.85 percent of the total catch of snappers, coming from the *Huachinango* and *Pargo* fishery, which has 13 snappers as target species, including the northern red snapper – the main target – and other common species such as the mutton snapper, grey snapper, lane snapper and yellowtail snapper, particularly in the area off Yucatán State (Government of Mexico, 2018). Unlike the grouper fishery, the snapper fishery is characterized by a multispecific artisanal coastal fleet that operates along the Mexican coasts, using boats with outboard engines and a crew of 3 to 4 fishers using handline gear. The artisanal mid-range grouper-directed fleet, with line gear called *bicicletas* (which consist of a series of hooks along a single line drop line) also catches snappers.

Two countries that report important snapper catches are the Dominican Republic, with 26.36 percent of the total catch, and Bolivarian Republic of Venezuela with 12.40 percent of the Lutjanidae (snappers, jobfishes NEI) catch. In both countries, the fishery operations are the same as those deployed in the grouper fishery, described previously. However, the Dominican Republic also has a multispecies reef fishery that takes place on the coral reefs along the entire length of the country's coast, up to 30 m depth. This fishery catches several snapper species using traps and handline gear. The most frequently caught species are mutton snapper, grey snapper, lane snapper and yellowtail snapper. It is noted that the only snapper species reported to FAO by the Dominican Republic is southern red snapper which makes up 13.33 percent of the total accumulated species reported by the country (tables 3.9 and 3.10); however, there are no known reports of this species in the Dominican Republic (Smithsonian Tropical Research Institute, 2023). In Bolivarian Republic of Venezuela, the snapper species reported are from catches reported by the coastal artisanal fleet that operates along the coast of the country, using predominantly traps, handlines and gillnets. In contrast to the mid- and long-range artisanal fisheries, the snapper catch taken by this fishery is reported by species because different prices are paid for each species. Consequently, catches of e.g. mutton snapper, southern red snapper, lane snapper and yellowtail snapper are reported by Bolivarian Republic of Venezuela to FAO.

There are five countries that report *Lutjanus* spp. (snapper NEI). The Bahamas, the British Virgin Islands and Nicaragua account for 87.83 percent of the total accumulated catches for 2015 to 2019 (Table 3.9). The Bahamas accounts for 48.13 percent of the snapper NEI catches. These are taken by the small-scale commercial (artisanal) sector that primarily targets demersal species and does disaggregate the snapper catch in the grouper fishery. Both groups of species are caught using spears, fish traps, hook and line, or nets. Aggregating devices are sometimes used to attract snappers and grunts. Deepwater grouper and snapper species are caught using fish traps in ropes lowered down the drop-off from shallow to deep water, ranging in depth from 24 m to 244 m (Moultrie *et al.*, 2016). Nicaragua accounts for 29.27 percent of the reported snapper catches. These are also from the artisanal finfish fishery which consists of about 2 440 boats of different sizes (8 m to 11 m), with inboard (23 HP) and outboard (75 HP) engines, as well as sails. About 48 percent of the boats are powered. The gears commonly used are gillnets and handlines (CIPA, 2008; Haas *et al.*, 2015). The British Virgin Islands accounts for 10.44 percent of the total snapper catches which are landed by the small-scale (commercial) fishery. The main fishing gear used is the fish trap, but handline gear and fishing nets are also used. The finfish landed are snappers and groupers among other reef-associated species (FAO, 2004). Most fishers market their own catch at various places within the territory, usually at or near landing sites, with an appreciable number of fishers selling their catch directly to hotels and restaurants and a small number to local companies.

At the species level, red grouper is mainly reported by the United States, with 94.51 percent of the total accumulated catch for 2015 to 2019. For Nassau grouper, the total catch is reported by three countries, namely the Bahamas (66.24 percent), Colombia (17.51 percent) and Cuba (16.25 percent) (Table 3.8). The artisanal fisheries of the Bahamas and Cuba have traditionally targeted this species, whereas catches in Colombia appear to be occasional landings by that country's artisanal fisheries operating in the reef areas of San Andres Island and the Chocó-Darién reef system where the species is known to occur (Bolaños-Cubillos *et al.*, 2015; Escobar-Sierra *et al.*, 2021). For red hind, most of the recent catch (91.14 percent) is reported by three island nations: Grenada, Saint Vincent and the Grenadines and Bermuda (Table 3.8). In Grenada and Saint Vincent and the Grenadines, red hind is a common species landed by the demersal fisheries over shallow reef areas, probably using bottom longline gear (Mohammed and Lindop, 2015b; Harvey, 2018). Catches of red hind and black grouper by Bermuda are from line fishing, which is a common fishing practice among the artisanal fishers, and trolling with lures to catch black grouper in the shallower parts of the reef platform (Luckhurst and Trott, 2009, 2015). For gag grouper, the total recent catch is reported by the United States, with fishers mainly using vertical hook and line gear, and some also using longlines and spears. The species also makes up a large part of the recreational catch in the United States South Atlantic and GOM (SEDAR, 2014a, 2016a, 2021a, 2021b).

For the snappers at the species level, in the northern area of the WECAFC region, northern red snapper is only reported by Mexico (66.06 percent) and the United States (33.94 percent). Most of the accumulated catch (97.8 percent) of grey snapper for 2015 to 2019 is reported by Mexico (80.99 percent) and the United States (16.79 percent) (Table 3.9).

In the Caribbean and NBSLME, most of the total accumulated catches of mutton snapper that account for 95.3 percent are reported by Bolivarian Republic of Venezuela (55.07 percent), the United States (30.61 percent) and Colombia (9.62 percent) (Table 3.9); for lane snapper, most of the accumulated catches are reported by Cuba (55.89 percent), Bolivarian Republic of Venezuela (25.78 percent) and Mexico (10.85 percent) (Table 3.10). The yellowtail snapper, a common snapper across the WECAFC region and abundant in the Caribbean, is widely reported, but most of the total accumulated catches for the recent period are from Mexico (46.54 percent), United States (18.07 percent) and Nicaragua (17.87 percent) (Table 3.10). It is noteworthy that the snapper fishery (*Huachinango* and *Pargo* in Mexico and *Escamas* in Nicaragua) targets multiple snapper species that are generally aggregated, but for some species, such as *pargo cola amarilla* (*Ocyurus chrysurus*) in Nicaragua, where this is the main snapper species (61.1 percent) in the Escamas, the fishery is disaggregated among other finfish species (INAPESCA, 2018). Most of the southern red snapper catch for the recent period is reported by Guyana (46.36 percent) and Bolivarian Republic of Venezuela (21.08 percent) from the NBSLME and from Cuba (16.76 percent) and the Dominican Republic (13.33 percent) from the Caribbean islands (Table 3.10). In Guyana, the southern red snapper fishery consists of three fleets: the line fleet, trap fleet and an incidental line fishery for shark carried out by trap boats, all of which are mixed fisheries targeting a variety of species. Recently, Guyana has encouraged the use of handline gear for the red snapper fishery (Government of Guyana, 2019). Catches of southern red snapper by the Bolivarian Republic of Venezuela mostly come from its mid- and long-range *pargo-mero* artisanal fleets that have operated in the southeastern Caribbean and in the NBSLME off the EU (FR Guiana) and Suriname (Mendoza and Lárez, 2004; FAO, 2019b).

Table 3.10 Part 2: Snappers catch by country for the period 2015–2019 (tonnes)

Group: Reef and slope species – snappers. Species: *Lutjanus synagris* – lane snapper. Species code: SNL								
Country	**2015**	**2016**	**2017**	**2018**	**2019**	**Rank**	**%**	**%cum**
Cuba	1 369	1 212	924	817	971.8	1	55.89	
Venezuela (Bolivarian Republic of)	0	597	615	615	615	2	25.78	81.68
Mexico	192	202	213	226	195	3	10.85	92.53
Colombia	2	27	181	76	102.56	4	4.10	96.63
Puerto Rico	56	29	22	27	38.9	5	1.83	98.46
Bermuda	16	15	17	12	12	6	0.76	99.22
United States of America	21	18	21	14	0	7	0.78	100.00
Group: Reef and slope species – snappers. Species: *Ocyurus chrysurus*– yellowtail snapper. Species code: SNY								
Mexico	1 777	2 433	1 972	2 725	1 953	1	46.54	
United States of America	997	1050	1278	891	0	2	18.07	64.61
Nicaragua	705	908	734	939	882.66	3	17.87	82.48
British Virgin Islands (the)	250	250	250	250	250	4	5.36	87.84
Cuba	174	158	170	187	171.5	5	3.69	91.53
Dominican Republic (the)	166	166	178	172	170	6	3.65	95.18
Venezuela (Bolivarian Republic of)	168	124	130	130	130	7	2.92	98.10
Puerto Rico	76	43	27	33	48.2	8	0.97	99.07
Colombia	0	3	50	8	13.01	9	0.32	99.39
Bermuda	14	20	16	12	9	10	0.30	99.70
United States Virgin Islands (the)	12	15	13	10	11	11	0.26	99.96
Saint Vincent and the Grenadines	3	2	2	1	2	12	0.04	100.00
Group: Reef and slope species – snappers. Species: *Lutjanus purpureus* – southern red snapper. Species code: SNC								
Guyana	1 095	814	950	1 016	1 736	1	46.36	
Venezuela (Bolivarian Republic of)	0	623	643	643	643	2	21.08	67.44
Cuba	378	457	429	409	356.2	3	16.76	84.20
Dominican Republic (the)	313	313	337	325	325	4	13.33	97.53
Colombia	5	6	24	171	54.06	5	2.15	99.68
Saint Vincent and the Grenadines	7	3	7	14	8	6	0.32	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

3.3.4 State of the stocks

The groupers

Red grouper. The stock status is different in three areas: northern GOM, Mexico and United States South Atlantic. No structural partitions. The northern GOM stock is not overfished and overfishing is not occurring (SEDAR, 2019b). The Mexican stock unit has been declining for years according to the stock assessment results which show a reduction in catch per unit effort (CPUE) values in the commercial fleet and lower abundance indices obtained in the joint surveys undertaken by Mexico and Cuba (Government of Mexico, 2014). The United States South Atlantic stock is overfished and overfishing is occurring (Table 3.6, page 30) (SEDAR, 2017b; Carpenter *et al.*, 2015).

Nassau grouper. There are no recent assessments, mostly because of the declining trends in landings and the classification of the species as threatened under the United States's Endangered Species Act. It is considered to be overfished in the United States Caribbean region (NOAA, 2023b), as well as in Cuba (Baisre, 2018). It is also listed as endangered on the IUCN red list (Sadovy *et al.*, 2018). Overfishing has been a major threat to this species, particularly heavy fishing on spawning aggregations.

Red hind. The most recent stock assessment conducted for this species in the United States Caribbean indicated several key data gaps, but concluded that the stock has, on average, a 32.5 percent to 60 percent risk of experiencing overfishing and therefore is being exploited unsustainably (SEDAR, 2014b).

Gag grouper. The most recent assessment for the United States South Atlantic gag grouper stock found that it is not subject to overfishing and is not overfished (SEDAR, 2021a). In the United States GOM, the most recent stock assessment for the species indicated that it is not overfished (2016 stock assessment) and is not subject to overfishing based on 2019 catch data (SEDAR, 2021b). Management measures implemented in 2009 have allowed the stock to rebuild.

Black grouper. Based on the most recent stock assessments, the stock status for the species in the waters of the United States (GOM and South Atlantic) is not overfished (SEDAR, 2010) and is not subject to overfishing based on 2019 catch data. In the United States Caribbean, black grouper is part of the Caribbean groupers complex and is not assessed. Consequently, the status of the stock is unknown, but the groupers complex is not subject to overfishing based on 2019 catch data. In Mexico, reported landings of the species are grouped with catches of other grouper species (Government of Mexico, 2012) and the Mexican grouper fishery is considered to be in an overall state of decline. In Cuba, black grouper declined by more than 50 percent in mangroves and the reef slope (Baisre, 2018). In the remainder of the region, the stock status of the species remains unknown.

The snappers

Northern red snapper. Since the late 1980s, the GOM stock was severely overfished and undergoing overfishing. However, the most recent assessment indicates that red snapper is still overfished but is no longer undergoing overfishing (SEDAR, 2018a). The latest stock assessment for the southeastern stock of the United States indicated that it remains overfished and that overfishing is occurring (SEDAR, 2017a), though at a lower rate than in 2009. This assessment estimates that since 2010 the stock has been increasing at a modest rate. In Mexico, the species is fished at MSY level at Tabasco, but the catches in the remaining fishing areas have diminished, with the species likely overexploited (Government of Mexico, 2018) (Table 3.6).

Mutton snapper. The mutton snapper population in Puerto Rico and the United States Virgin Islands is not overfished and is not undergoing overfishing (SEDAR, 2007b). The most recent assessment for the GOM and the United States' southeastern Atlantic stock indicated that it is not overfished and overfishing is not occurring (O'Hop, Muller and Addis, 2015). Noting that this species has documented spawning aggregations, in 1992 the United States GOM Fishery Management Council imposed a two-month spawning season closure (May and June) in the area off Dry Tortugas, Florida (Lindeman *et al.*, 2016b). In Cuba, mutton snapper is considered to be overfished as a result of intensive fishing during the spawning aggregation of the species; approximately 35 percent to 40 percent of the annual catch of mutton snapper were obtained during spawning aggregations between May and June (Claro *et al*., 2009; Baisre, 2018).

Grey snapper. In the GOM, the stock has been experiencing overfishing since 1976 (with few exceptions) and is currently undergoing overfishing (SEDAR, 2018b). In contrast, the South Atlantic stock of the United States is not experiencing overfishing but its overfished condition is unknown. In Cuba, where this species forms abundant spawning aggregations (June to August), the stock has declined (Claro *et al*., 2009). In Puerto Rico, grey snapper was considered overfished (with overfishing still occurring) (Ault *et al*., 2008). The stock status in Bolivarian Republic of Venezuela, where the species is common and fished by many shallow water gears, is not known.

Yellowtail snapper. Based on a recent stock assessment, this species is not overfished in the waters of the United States and is not experiencing overfishing (SEDAR, 2020a). However, it is considered to be overfished in Cuba and Brazil. In Cuba, landings declined more than 50 percent since 1995. Brazil has the largest landings of this species worldwide, a trend that began in the 1980s (Lindeman *et al*., 2016c).

Southern red snapper. The stock assessment carried out in Guyana and EU (FR Guiana) suggested that the stock was overfished and is undergoing overfishing, whereas assessments of stock status undertaken in Brazil and Suriname indicated that the stock was not overfished nor undergoing overfishing (FAO, 2021).

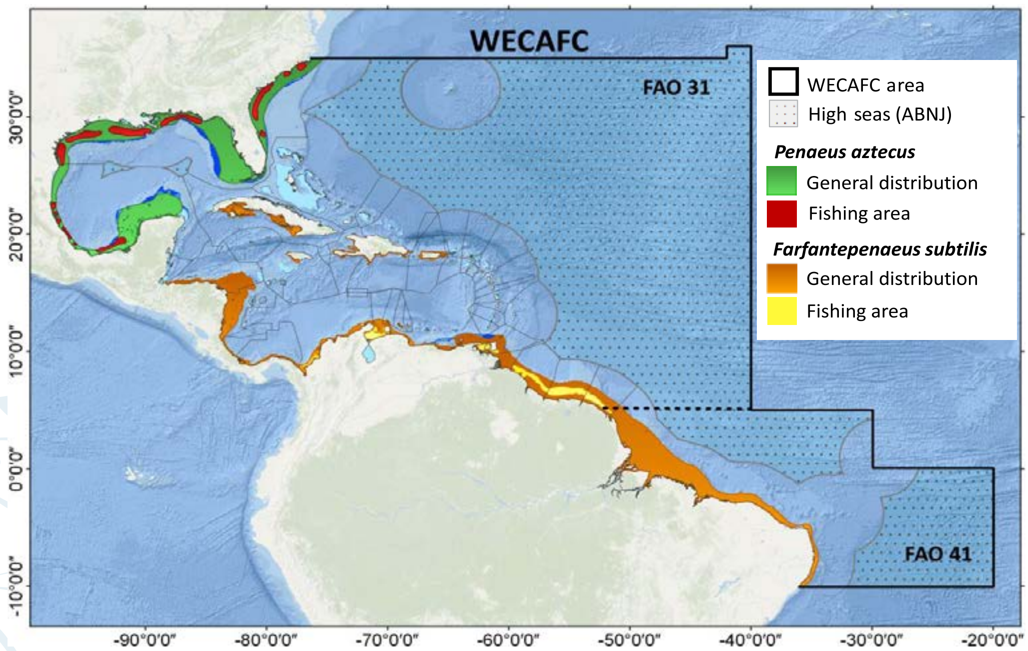
Lane snapper. Stock status in the United States GOM indicates that the stock is not undergoing overfishing, but it is not clear whether it is overfished or not (SEDAR, 2016b). In other localized areas of the region (Honduras) where a small-scale fishery targets the species, an assessment suggested that the stock is experiencing overfishing (Sierra-Castillo and Fujiwara, 2021). In Cuba, lane snapper is considered to be overfished as a result of intensive fishing during spawning aggregations; 60 percent to 70 percent of annual catches were fished in 10 to 21 days during peak spawning (Claro *et al*., 2009; Baisre, 2018). Preliminary results from older assessments conducted in several countries in the NBSLME, concluded that the stock in that area may be overfished (CRFM, 2006). From a yield per recruit perspective, the fishery appears to be operating at near optimum levels, but this assumes that future recruitment will continue at current levels. The current stock status in the southern WECAFC region is unknown.

3.4 The shelf shrimp resources

The shared shrimp species of interest in this section are those considered to be the main target species of the soft bottom fisheries in the region. The resulting selection includes three northern species, three southern species and two regional species.

Northern brown shrimp (*Farfantepenaeus aztecus*). Northern brown shrimp is distributed along the Atlantic coast of the United States, from Massachusetts to Texas and the east coast of Mexico from Tamaulipas to Campeche (Figure 3.23) (Holthuis, 1980). It occurs at depths of 4 m to 160 m and its highest densities are between 27 m and 54 m over muddy bottoms, often with sand, clay, or broken shells. The adults are marine, the juveniles estuarine and marine. Peak spawning is in spring and summer, with newly hatched shrimp entering estuaries in February and March to settle in their nursery habitat (NOAA, 2023c). The population structure of the species is not clear but there are indications that the northern GOM and northwest Atlantic distributions may constitute a single contiguous population (McMillen-Jackson and Bert, 2003) that is currently assessed and managed independently in the United States region. In Mexico it is caught in the estuaries of the Tamaulipas and Veracruz rivers (Government of Mexico, 2012). It is unclear whether the population caught in Mexico is part of the same population that occurs in the northern GOM and the United States southeast Atlantic.

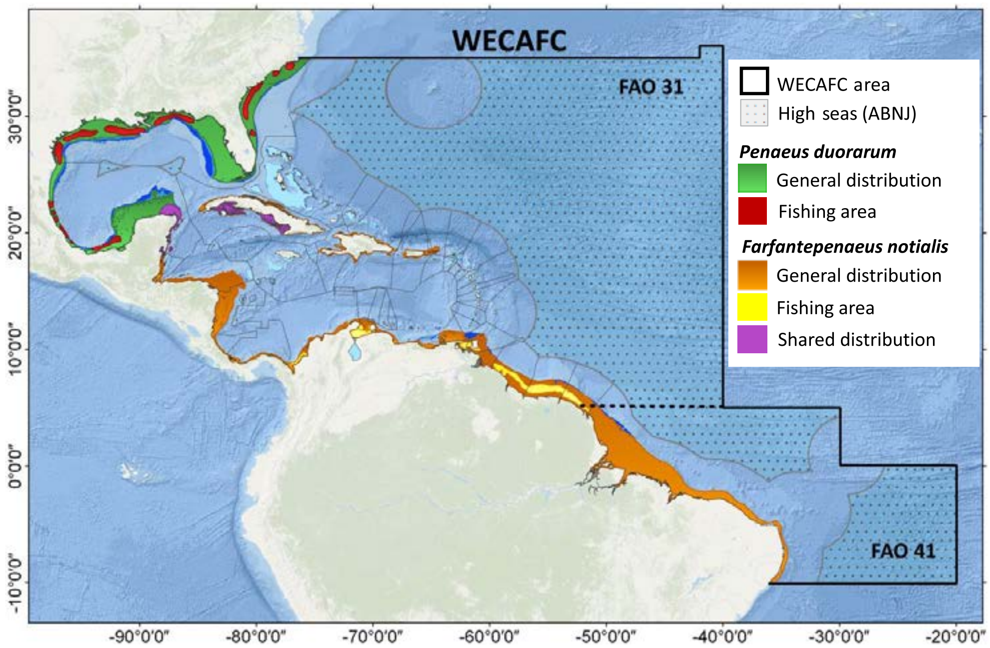
Figure 3.23. *Farfantepenaeus* (*Penaeus*) *aztecus* (northern brown shrimp, ABS) and *F. subtilis* (Southern brown shrimp, PNU) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Northern pink shrimp (*Farfantepenaeus duorarum*). Northern pink shrimp is distributed from southern Chesapeake Bay and Bermuda to the Florida Keys and around the coast of the GOM to Quintana Roo (Figure 3.24) (Holthuis, 1980). The species is most abundant in the Tortugas area and in the Gulf of Campeche. It inhabits depths of 2 m to 70 m over muddy bottoms, sometimes with sand or clay. Adults are marine and juveniles estuarine. Off North Carolina, northern pink shrimp spawn in May to July (NOAA, 2023d) whereas in Florida they spawn multiple times, peaking from April to July when the water is warmest. Newly hatched shrimp travel to their estuarine nursery habitats in late spring and early summer, propelled by shoreward currents. As with northern brown shrimp, the population structure of this species is unclear but there are indications that the northern GOM and the United States southeast Atlantic distributions may constitute a single contiguous population (McMillen-Jackson and Bert, 2003) that is currently assessed and managed independently in the United States region. Pink shrimp is caught along with brown and white shrimp throughout the area.

Figure 3.24. *Farfantepenaeus* (*Penaeus*) *duorarum* (northern pink shrimp, APS) and *F. notialis* (southern pink shrimp, SOP) general distribution and fishing areas in the Western Central Atlantic Fishery Commission region

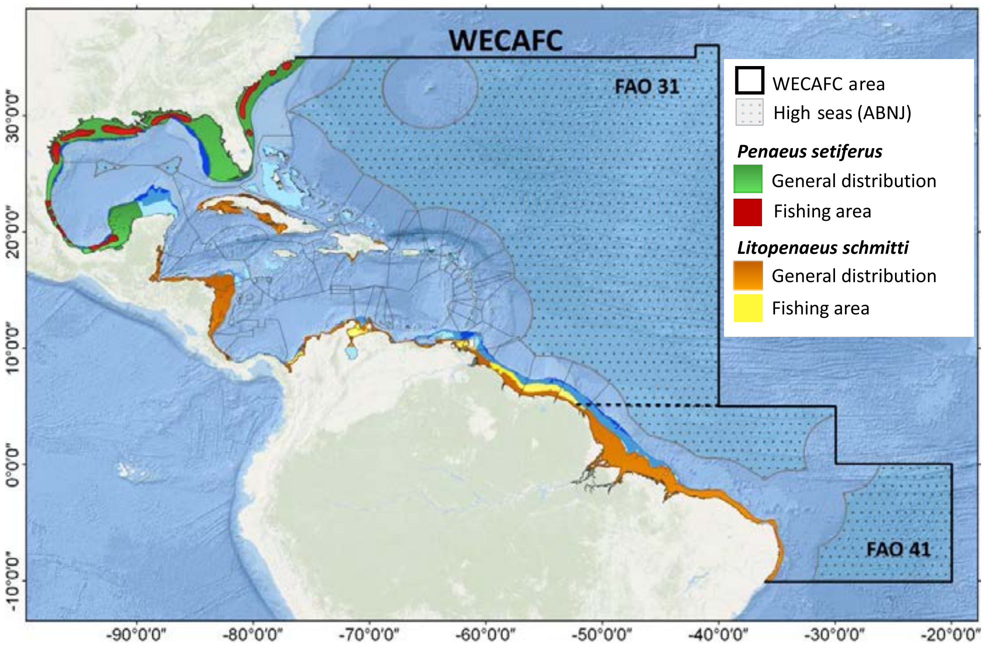


Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Northern white shrimp (*Litopenaeus setiferus*). Northern white shrimp is distributed from southern Chesapeake Bay to the Florida Keys and around the coast of the GOM to the Yucatan south of Cabo Catoche, Mexico (Figure 3.25) (Holthuis, 1980). The species is most abundant off southwestern Florida and the southeastern Gulf of Campeche. It inhabits depths of 2 m to 90 m over muddy bottoms, sometimes with sand or clay. Adults are marine and juveniles estuarine. White shrimp spawns when offshore ocean bottom water temperatures increase, generally from May to September in North Carolina and South Carolina, and from March to September in the GOM (NOAA, 2023e). Newly hatched shrimp travel to their estuarine nursery habitats in April and early May. The population structure of this species is formed by a population from the Atlantic coast of the United States and another from the GOM, based on some evidence of genetic separation (Ball and Chapman, 2003).

Southern brown shrimp (*Farfantepenaeus subtilis*). Southern brown shrimp is distributed from the Greater Antilles in the Caribbean Sea and south of Yucatan, Mexico along the coast of Central America and the northern coast of South America to northern Brazil (Figure 3.23). The biology and ecology of this species is like its northern counterpart and most of its biological traits are adapted to its distribution and habitat. The species inhabits depths of 1 m to 190 m, over bottom mud, often with sand or broken shells. The adults are marine and the juveniles estuarine and marine. They are omnivorous and feed on worms, algae, microscopic animals and various types of organic debris (Holthuis, 1980). Stock structure in the WECAFC region has not been addressed.

Figure 3.25. *Litopenaeus* (*Penaeus*) *setiferus* (northern white shrimp, PST) and *Farfantepenaeus schmitti* (southern white shrimp, PNT) general distribution and fishing areas in the Western Central Atlantic Fishery Commission region

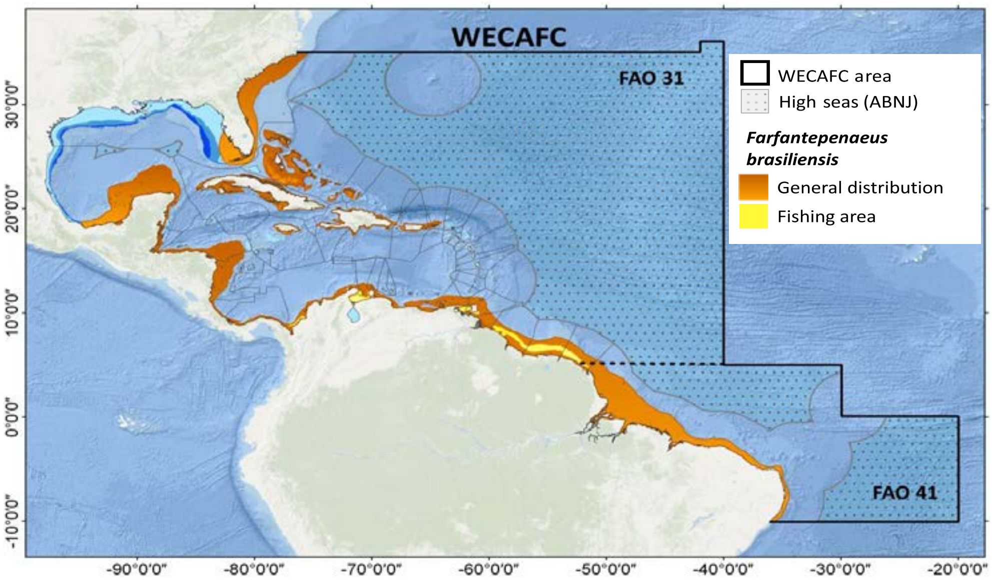


Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Southern pink shrimp (*Farfantepenaeus notialis*). Southern pink shrimp in the western Atlantic is distributed from the Greater Antilles in the Caribbean Sea and south of Yucatan, Mexico along the coast of Central America and the northern coast of South America to southern Brazil, Rio de Janeiro (Figure 3.24). This species usually inhabits depths of 3 m to 50 m, over bottom mud, often with sand and sandy patches among rocks. The adults are marine and the juveniles estuarine. Off northern Colombia, spawning occurs all year round, but peaks were observed between October to December and April to June (Páramo, Pérez and Wolff, 2014). In Guatemala, peak spawning was observed from January to June (de León, 2016). Stock structure in the WECAFC region has not been addressed. Most countries that fish for this species in the region consider it to be a single stock unit in their jurisdictional waters.

Redspotted shrimp (*Farfantepenaeus brasiliensis*). Redspotted shrimp is distributed along the Atlantic coast of the United States, from North Carolina to Rio Grande do Sul in Brazil, including Bermuda and the southern GOM and the Caribbean Sea (Figure 3.26). However, its highest densities seem to occur in the NBSLME area. It inhabits depths of 3 m to 365 m, and its highest densities are between 45 m and 65 m over bottom mud or sand. The adults are marine and the juveniles estuarine and marine (Holthuis, 1980). Stock structure in the WECAFC region has not been addressed. Most countries that fish for this species in the region consider it to be a single stock unit in their jurisdictional waters.

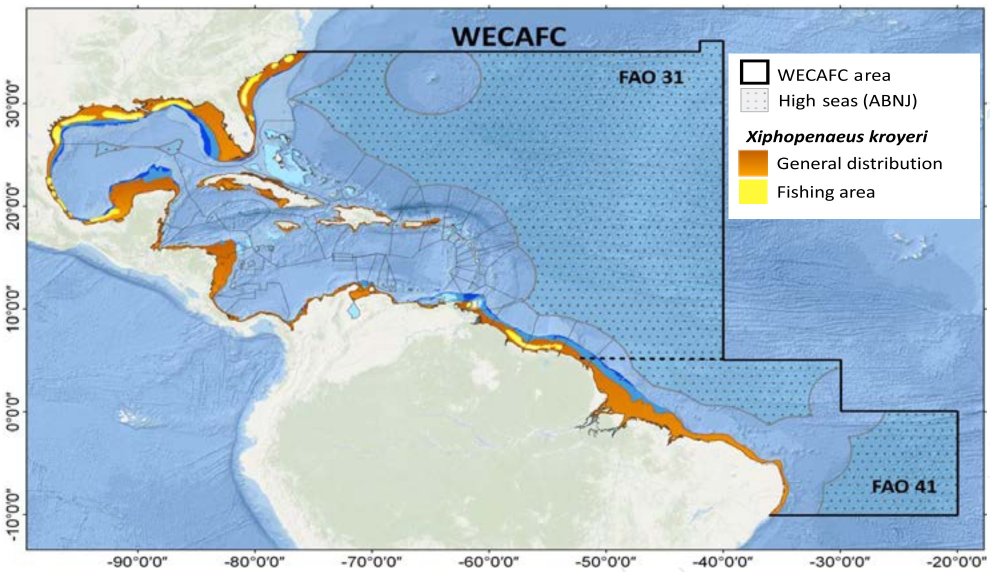
Figure 3.26. *Farfantepenaeus brasiliensis* (redspotted shrimp, PNB) general distribution and fishing areas in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Southern white shrimp (*Litopenaeus schmitti*). The geographical distribution of southern white shrimp in the WECAFC region is from the Greater Antilles (Cuba to the United States Virgin Islands) and from Belize to the northern coast of South America and the NBSLME (Figure 3.25). The species' common habitat is soft mud bottom or silt, sometimes with sand, at depths from 2 m to 47 m. It is most abundant between 15 m and 30 m. Juveniles are estuarine and adults are marine (Holthuis, 1980). In Guatemala, a high number of spawning females were present from July to October (de León, 2016). Stock structure in the WECAFC region has not been addressed and most countries that fish for this species consider it to be a single stock unit in their jurisdictional waters.

Figure 3.27. *Xiphopenaeus kroyeri* (Atlantic seabob, BOB) general distribution and fishing areas in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Atlantic seabob (*Xiphopenaeus kroyeri*). Atlantic seabob is distributed from North Carolina, United States, to Santa Catarina in Brazil, including the GOM and the Caribbean Sea (Figure 3.27). However, its highest densities seem to occur in the NBSLME area. It inhabits depths of 1 m to 70 m, but its highest densities are in depths less than 30 m over bottom mud or sand. Atlantic seabob is a marine and brackish species, most abundant near estuaries. Nursing areas are estuarine or inshore waters and adults spawn in marine waters (Holthuis, 1980). A recent genetic study on the population structure of Atlantic seabob in the NBSLME indicated that only one single population is present there, although there is no conclusive evidence that Atlantic seabob from Trinidad and Tobago and Colombia were part of the same population (Kerkhove *et al.*, 2019; FAO, 2021b). It is plausible that Atlantic seabob from the northern part of the WECAFC region forms part of the same population (Gusmão *et al.*, 2006).

3.4.1 The fishery

The shared shrimp resources of the region are members of the Penaeid family, which are short-lived species, having a life span of about 1 to 2 years. This family contains some of the most valuable commercial species of shrimps. Their life cycle is spent between estuaries, coastal lagoons, river deltas and offshore waters. Larvae and post larvae migrate to nursery grounds in estuaries and other wetlands, and during the juvenile stage they migrate to offshore waters where they attain sexual maturity. In the WECAFC region, shared shrimp resources are fished across the range of their life cycles, in estuaries, coastal lagoons, river deltas and offshore waters, by a variety of coastal artisanal and subsistence fisheries, as well as by industrial fisheries in offshore waters.

Shrimp fishery statistics reported to FAO are species-specific for the Atlantic seabob and the northern shrimp resources fished by Cuba, Mexico and the United States. The shrimp resources fished in the Caribbean LME and the NBSLME are reported grouped as *Penaeus* spp. (*Penaeus* shrimp NEI), except for southern white shrimp in recent years.

The total accumulated catch for northern brown shrimp and northern white shrimp for the period 2015 to 2019 is reported by the United States and Mexico, and most of the catch is attributed to the United States (72.65 percent for northern brown shrimp and 97.29 percent for northern white shrimp). Mexico landed the remaining portion of the reported catch (Table 3.11). For northern pink shrimp, the United States is responsible for over half of the total accumulated catch for the same period. Mexico landed about a third of the total accumulated catch and Cuba landed the remainder (9.01 percent).

Table 3.11 Shrimp and Atlantic seabob catch by country for the period 2015–2019 (tonnes)

Group: Shelf shrimps. Species: *Penaeus aztecus* – northern brown shrimp. Species code: ABS								
Country	**2015**	**2016**	**2017**	**2018**	**2019**	**Rank**	**%**	**%cum**
United States of America	50 969	37 821	45 284	51 110	71	1	72.65	
Mexico	13 179	14 433	14 629	16 165	11 329	2	27.35	100.00
Group: Shelf shrimps. Species: *Penaeus duorarum* – northern pink shrimp. Species code: APS								
United States of America	4 360	4 330	7 976	9 332	0	1	56.08	
Mexico	4 127	2 314	4 581	2 592	2 571	2	34.91	90.99
Cuba	918	764	701	1 121	672.1	3	9.01	100.00
Group: Shelf shrimps. Species: *Penaeus setiferus* – northern white shrimp. Species code: PST								
United States of America	43 645	54 767	54 007	39 733	2 864	1	97.29	
Mexico	1 120	1 020	1 243	1 142	904	2	2.71	100.00
Group: Shelf shrimps. Species: *Litopenaeus schimitti* (=*Penaeus schmitti*) – southern white shrimp. Species code: PNT								
Venezuela (Bolivarian Republic of)	0	2 493	2 570	2 570	2 570	1	100.00	100.00
Group: Shelf shrimps. Species: *Penaeus* spp. – *Penaeus* shrimp NEI. Species code: –								
Mexico	3 563	1 352	3 955	1 514	3 932	1	36.25	
Nicaragua	1 556	1 155	1 035	1 086	1 020.84	2	14.82	51.07
Honduras	1 000	1 000	1 000	1 000	979	3	12.61	63.67
Trinidad and Tobago	776	776	776	776	776	4	9.82	73.50
Guyana	500	411	600	421	478	5	6.10	79.60
Venezuela (Bolivarian Republic of)	2 276	5	5	5	5	6	5.81	85.41
French Guiana	759	625	400	250	255	7	5.80	91.21
Suriname	511	377	315	379	305	8	4.78	95.99
Colombia	125	117	315	0	113.89	9	1.70	97.69
Guatemala	138	126	109	122	93	10	1.49	99.17
Dominican Republic (the)	66	64	69	62	60	11	0.81	99.99
Costa Rica	5	0	0	0	0	12	0.01	100.00
Group: Shelf shrimps. Species: *Xiphopenaeus kroyeri* – Atlantic seabob. Species code: BOB								
Guyana	17 641	20 334	21 765	19 946	14 040	1	66.51	
Suriname	6 310	7 674	8 272	9 886	6 456	2	27.39	93.91
Mexico	864	1 357	959	1 520	1 565	3	4.45	98.35
United States of America	507	724	263	213	0	4	1.21	99.56
Colombia	0	0	0	0	375.87	5	0.27	99.83
Venezuela (Bolivarian Republic of)	0	58	60	60	60	6	0.17	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Almost all the northern brown shrimp and northern white shrimp harvested in the United States comes from the GOM, mainly from Texas and Louisiana (NOAA, 2023f) while over half of the northern pink shrimp harvested in the United States comes from the west coast of Florida. Northern brown shrimp is the most important species in the GOM shrimp fishery of the United States, with most catches made from June to October (GMFMC, 2017). The fishery operates at about 70 m and is highly dependent on environmental factors such as temperature and salinity. In the southeastern United States northern brown shrimp occurs in commercial quantities in areas where water depth is as great as 110 m, but northern brown shrimp and northern white shrimp are most abundant in areas less than 55 m deep (SAFMC, 2004).

Northern white shrimp is found in nearshore waters to about 36 m from Texas to Alabama, where most of the catch is fished from August to December, in addition to a small spring and summer fishery (GMFMC, 2017). In the southeastern United States, the northern white shrimp is more common off South Carolina, Georgia and northeast Florida. Northern white shrimp is generally concentrated on the continental shelf where water depths are 27 m or less (SAFMC, 2004).

Northern pink shrimp is fished off all GOM states but is most abundant off Florida's west coast, particularly in the Dry Tortugas grounds off the Florida Keys. Most landings occur from October to May and pink shrimp are caught in waters of 55 m (GMFMC, 2017). In the northern and western GOM states, northern pink shrimp are sometimes mistakenly counted as northern brown shrimp. Northern pink shrimp are of major commercial significance only in North Carolina and the Florida Keys on the Atlantic side, where the highest abundance occurs at water depths of 11 m to 37 m, although in some areas they may be abundant at depths of 65 m (SAFMC, 2004).

In 2016, there were 1 440 valid or renewable federal GOM shrimp permits in the GOM fishery of the United States. There has been a moratorium on the issuance of new GOM shrimp permits since 2007. Permits are fully transferable and renewal of the permit is contingent upon compliance with reporting requirements. For state commercial shrimping licenses, there are approximately 9 500, more than half of which are licensed through Louisiana (GMFMC, 2017). Therefore, it is likely that there are less than 9 500 vessels fishing commercially for shrimps in state waters of the GOM.

The harvesting sector is composed of two fleets: i) a small vessel fleet that is predominantly active in inshore and state offshore waters, and diverse with respect to gear and other operating characteristics; and ii) a large vessel fleet predominantly active in offshore waters, particularly the EEZ, and almost always using otter trawl gear with various modifications (including turtle excluder devices [TEDs] and BRDs). More than half the vessels fall into a size range of 17 m to 23 m across both fleets (GMFMC, 2017). The small vessel fleet operating inshore and in state offshore waters uses various types of gears including cast nets, haul seines, stationary butterfly nets, wing nets, skimmer nets, traps and beam trawls.

A recreational shrimp trawl fishery occurs seasonally inside state waters. However, not all states have a permitting system for recreational shrimping, and not all states track the amount of bait shrimp landed (GMFMC, 2017).

The GOM Penaeid shrimp fishery of the United States is subject to several cooperative management regulations that include simultaneous closure in both state and federal waters off the coast of Texas, the Tortugas Shrimp Sanctuary, and seasonally closed zones for the shrimp and stone crab fisheries off the coast of Florida (GMFMC, 2017).

In the South Atlantic shrimp fishery of the United States, each state has its own regulatory gear restrictions. The commercial fishing area for Penaeid shrimp (northern white, brown and pink) species in the Atlantic is mainly concentrated from Florida to North Carolina. There is another fishery off the Florida Keys where the main target is pink shrimp (SAFMC, 2004). In North Carolina, the important shrimping areas are off major river deltas and off the southern coast. The most important fishing area in Florida is the northeastern part of the state. In Georgia, shrimping takes place along the entire coast. In South Carolina, the most important shrimping areas are south from Georgetown (Winyah Bay). Commercial shrimp catches in all four states are taken from internal waters, state waters out to 3 NM and from the EEZ. Most of the shrimp in these states is caught using otter trawl gear with modifications. However, in Biscayne Bay, Florida, shrimps are harvested with wing nets. A wing net is a net in the form of an elongated bag kept open by a rigid frame that is attached to either side of a vessel and is not towed behind a vessel or dragged along the bottom. This is a top water fishery and shrimp is harvested as they leave the bay.

The recreational shrimp harvest on the Atlantic side of the United States occurs almost exclusively in state waters and is comprised mostly of Penaeid shrimp (white, brown and pink) species. A variety of gear types are employed for recreational food shrimp activities and recreational shrimping for bait. Recreational fishers catch brown shrimp seasonally and almost always in state waters where regulations vary between states. In addition, there is a commercial bait shrimp fishery on the Atlantic side where Florida has the largest operation of the area (SAFMC, 2004).

In Mexico, most of the shrimp catch consists of northern brown shrimp that is caught off the coast from the Rio Bravo in Tamaulipas, south to Rio Coatzacoalcos in Veracruz in depths of 9 m to 109 m by the artisanal and industrial fleets (Government of Mexico, 2012). The industrial fleet of about 722 vessels uses bottom trawl gear with exclusion devices similar to those used in the Penaeid shrimp fishery of the United States (FAO, 2021c). Other fishing areas include the Campeche Sound off Tabasco and Campeche, and the Mexican side of the Caribbean in Quintana Roo (Wakida-Kusunoki *et al*., 2006). In the area of the Campeche Sound, most of the shrimp catch consists of northern pink shrimp. The shrimp fishery on the Mexican side of the Caribbean consists mainly of redspotted shrimp. The artisanal fishery in the coastal lagoons like Laguna Madre in Tamaulipas uses set gillnets called *charangas*. a total of 3 064 nets were operating in 2001, of a total of 2 540 licensed nets (Ramírez López, 2003; Fernández and Escartín Hernández, 2003).

The shrimp fishery off Campeche Sound consists of two fleets: 1) an artisanal fleet that targets juveniles of northern pink shrimp in coastal areas; and 2) an industrial vessel fleet active in offshore waters using otter trawl gear with various modifications (including TEDs and BRDs). The main interest of this fleet is northern white shrimp, although high proportions of northern brown and northern pink shrimps are also caught. However, a shift in fleet operations (day versus night fishing) can reverse the proportion of species caught (Wakida-Kusunoki *et al*., 2006).

The Mexican Penaeid shrimp fishery is subject to several management regulations, including spatial and seasonal closures and no take areas. For the industrial fleets fishing in Mexican waters there is a seasonal closure from May to September. Spatial closures for the industrial shrimp fleet occur from Campeche to the limits with Belize of a no take zone between 0 miles and 15 miles. For the artisanal fleets operating in estuaries and coastal lagoons, seasonal closures are from May to July and from May to September, depending on the area, and there is a permanent closure in Términos and Campeche lagoons (CONAPESCA, 2018).

The shrimp fishery in Cuba operates off the southeastern coasts of the island, from Cienfuegos to Manzanillo. The shrimp fleet comprises 30 vessels that use otter trawl gear with escapement devices (FAO, 2022). Most of the shrimp catch consists of northern pink shrimp (about 98 percent), the remainder is southern white shrimp (Pérez Marrero, 2016). The fleet fishes from depths of 5 m to 15 m and up to 50 m depending on the fishing area. Fishing operations can last between 10 and 20 days, but the shrimp catch is transshipped daily to the local plant on the island (Pérez Marrero, 2016). A seasonal closure from July to October is used as a management action.

Most of the total accumulated catch of *Penaeus* shrimp (95.99 percent) in the region for the period 2015 to 2019 is attributed to eight countries (Table 3.11). Mexico is the major producer of *Penaeus* shrimps with 36.25 percent, followed by Nicaragua and Honduras with a combined reported catch of 27.43 percent. The remainder of the five countries with important *Penaeus* shrimp catches (32.31 percent) share most of the shrimp resources along the Atlantic northern coast of South America where important estuaries and river deltas are the major fishing areas. In Central America, the majority of the shared *Penaeus* shrimp species are caught off the shelf of Honduras and Nicaragua by artisanal and industrial fleets, while the remainder are likely caught by small-scale coastal fleets in the estuaries of Guatemala and Costa Rica. The estimated catch from Guatemala is made up of the northern brown and northern pink shrimp (most likely to be southern brown and southern pink shrimps, based on the geographical distribution of the species) and the southern white shrimp (Lindop *et al*., 2015b); whereas the small catch from Costa Rica is confusing because the country does not report Caribbean shrimp landings on the official website (INCOPESCA, 2023). In Nicaragua, the main *Penaeus* shrimp species caught by the artisanal and industrial fleets are the southern pink and the southern white shrimp, and it is possible that southern brown and redspotted shrimps are also caught, but in smaller quantities (CIPA, 2008). The artisanal fleet operating in coastal lagoons normally catches southern white shrimp with cast nets. In 2017, the number of operational industrial shrimp vessels was 14, all of which operate with bottom trawl gear with exclusion devices (INAPESCA, 2018). In Honduras, the species breakdown is similar to that of Guatemala (Funes *et al*., 2015). In the Dominican Republic, the artisanal and subsistence fisheries catch southern white shrimp and likely southern pink shrimp in the northeastern part of the island. Most of the shrimp catches are made up of southern white shrimp (85 percent to 95 percent) and the main gears used are gillnets and cast nets (Herrera *et al*., 2011).

From Colombia and along the northern coast of South America and the NBSLME, the shrimp caught are southern *Penaeus* spp. In Colombia, most of the *Penaeus* shrimp species caught are southern pink shrimp, redspotted shrimp, southern brown shrimp and southern white shrimp. The shrimp fishery off Colombia in the Caribbean is operated by what is called a shallow water fleet, with vessels operating in the area south of Cartagena, mainly between the Gulf of Urabá and the Gulf of Morrosquillo, and another area north of Colombia (La Guajira) (Bustos Montes *et al*., 2012). In 2004, there were 53 vessels dedicated to *Penaeus* shrimp fishing; 30 were from Colombia, the remainder were foreign flagged. The fleet's vessels are Florida-type of 13 m to 25 m with 165 HP to 520 HP engines. Each vessel operates with otter trawl gear, with exclusion devices for turtles, and fishing operations take place at night at depths of between 21 m and 81 m (Zúñiga, Altamar and Majarrés, 2006).

In Bolivarian Republic of Venezuela, *Penaeus* shrimp species are caught in three main areas: i) in the west, shrimp fisheries take place in the Gulf of Venezuela and in Lake Maracaibo; ii) in the northeastern shelf shrimps are caught off the coastal lagoons of Tacarigua, Unare-Píritu and around Margarita Island (mostly in the southern area); and iii) in the Gulf of Paria and northern Orinoco River delta (Marcano *et al*., 2001; Alió, *et al*., 2010). In 2009, prior to the ban on industrial trawling, the fleet in Bolivarian Republic of Venezuela landed a significant proportion of the *Penaeus* shrimp species in the country and the species composition by fishing area was the following: i) in the west, in the Gulf of Venezuela, all southern *Penaeus* shrimp species were caught but 50 percent of the catch consisted of southern brown shrimp, while in Lake Maracaibo it was mostly southern white shrimp, along with some juveniles of the other species; ii) in the northeastern shelf, off the coastal lagoons, southern white and redspotted shrimps were most common in the landed catches, while around Margarita Island southern brown, southern pink and redspotted shrimps were most common;

iii) in the Gulf of Paria, the most common species caught were southern white, southern brown and redspotted shrimps, but off the Orinoco River delta, southern white shrimp was the species most commonly caught (Novoa, 2000; Marcano *et al*., 2001; Alió *et al*. 2010).

In recent years, following the departure of the industrial trawling fleet, the Venezuelan artisanal fishing fleets have operated in the different shrimping areas of the country. Bolivarian Republic of Venezuela´s major reported catches for *Penaeus* shrimp for the period 2015 to 2019 are split between *Penaeus* shrimp NEI in 2015 and southern white shrimp from 2016 to 2019 (Table 3.11). A plausible explanation is that since the take-over of the *Penaeus* shrimp fishery by the artisanal fleets, which operate mainly in estuaries, coastal lagoons and river deltas, the predominant shrimp catch is of southern white shrimp, while the low catches of *Penaeus* shrimp NEI are a combination of all other species, depending on the location of the fishing operations. For instance, in the artisanal fishery that operates in the southern area of Margarita island, the main species caught is the southern pink shrimp, whereas in the Gulf of Paria/Orinoco River delta, southern brown shrimp makes up almost half of the *Penaeus* shrimp catch (Novoa, 2000; Ferreira and Medley, 2006; Marval *et al*., 2015). The artisanal fleets operate with 7 m to 10 m wood or fibreglass boats powered by one or two outboard engines of 48 HP to 75 HP. In the eastern part of the Gulf of Venezuela, fishing operations are with drift gillnets called *tendedor derivante*, while in the northeastern shelf coastal areas and in the Gulf of Paria, the gear used is a single small otter trawl-type net called red *arrastre chica* with exclusion and bottom net modifications (Alió *et al*., 2010; Díaz *et al*., 2014). In Lake Maracaibo and in the southern Gulf of Paria and northern Orinoco River delta, the predominant fishing gear is a type of beach purse seine called *mandinga* or *jala pa'tierra*, with a mesh size ranging between 1 cm to 2 cm, while cast nets are used in the coastal lagoons of Tacarigua, Unare-Píritu. Bottom set nets and the *suripera*-type net are used in the area of the Gulf of Venezuela (Novoa, 2000; Alió *et al*., 2010; Díaz *et al*., 2014).

There is no information on the total number of artisanal boats operating in the Venezuelan shrimp fisheries but the number of permits authorized by the National Fishery Administration for the small otter trawl fishery is 359: 162 for the shrimping grounds off the coastal lagoons of Tacarigua, Unare-Píritu; 122 for the southern area of Margarita Island; and 75 for the Orinoco River delta (Government of the Bolivarian Republic of Venezuela, 2016). There is no information available on the number of beach purse seine nets called *mandinga* or *jala pa'tierra* that target shrimp commercially across Bolivarian Republic of Venezuela. Nonetheless, the Venezuelan *Penaeus* shrimp fishery is subject to several management regulations which include seasonal closures that vary for the different shrimping grounds. In the northeastern and Atlantic shelf areas, two seasonal closures are imposed and each has a duration of 45 days (Government of the Bolivarian Republic of Venezuela, 2016), whereas the two seasonal closures in the western shrimping grounds have a duration of 10 days each. However, the seasonal closures appear to be directed towards southern white shrimp and Atlantic seabob (González, 2021).

Trinidad and Tobago report close to 10 percent of the *Penaeus* shrimp accumulated catches in the recent period, made up of all the southern shrimp species selected in this review (Table 3.11). The shrimp fishing grounds are in the western and southern coasts of Trinidad. There are three types of fleets targeting shrimps: i) the artisanal type II fleet with 103 boats of 8 m to 12 m that use an inboard engine and fish in the Gulf of Paria and catch mainly southern brown shrimp; ii) the semi-industrial type III fleet with eight boats of 10 m to 12 m that use inboard engines, operate a single stern net and fish in the Gulf of Paria close to shore, also landing predominantly southern brown shrimp; and iii) the industrial type IV fleet consisting of 36 double rigged trawlers of 17 m to 22 m (GOM-type), fishing in the north, west and south of Trinidad and catching mainly southern brown and southern pink shrimp (FAO, 2017; Ferreira, 2019).

Guyana landed 6.1 percent of the total accumulated *Penaeus* shrimp catches over the period 2015 to 2019 (Table 3.11). The industrial prawn trawl fleet targets all the southern *Penaeus* shrimp species (southern brown, southern pink, southern white and redspotted shrimps). The fleet consists of 12 active vessels (out of 24 licenses available). They use otter trawl gear with various modifications (including excluder devices like TEDs and BRDs) (Government of Guyana, 2019). Fishing is deeper than 27 m. Approximately 10 percent of *Penaeus* shrimp catches are landed as bycatch in the Atlantic seabob fishery, which lands southern brown and southern pink shrimps.

The *Penaeus* shrimp catches of the EU (FR Guiana) during the period 2015 to 2019 amounted to 5.8 percent of the total accumulated catches for the time series reviewed (Table 3.11). The area most exploited is between 30 m and 90 m, due to a regulation that bans shrimp trawling on grounds shallower than 30 m. The main shrimp species exploited on the continental shelf is southern pink shrimp which represents close to 95 percent of the total *Penaeus* shrimp landings. The other species landed is the redspotted shrimp, which is not specified in the landings (FAO, 2017). All the vessels are Florida-style shrimp trawlers which each use two trawls at the same time with TEDs and BRDs. The number of licenses issued in 2010 was 49 but currently the number of active shrimp trawlers is less than the number of licenses (Sanz *et al*., 2017).

Suriname catches the smallest proportion of *Penaeus* shrimps in the area (4.78 percent) for the period 2015 to 2019 (Table 3.11). As in other areas, the fleet consists of Florida-style shrimp trawlers using otter trawls with exclusion devices. Licensing limits the number of vessels to 20, with a maximum length of 28 m and maximum engine power of 500 HP. Fishing is restricted to areas deeper than 32 m (Government of Suriname, 2021a).

The northern part of Brazil is part of the WECAFC region, but no reports are available for FAO Major Fishing Area 31 because the country's catch within the WECAFC region is reported as FAO Major Fishing Area 41. The information available is sourced from national scientists who submit reports to WECAFC meetings. The shrimp fishery in northern Brazil is one of the most important fisheries in the country. The main fishing area is between the mouth of the Parnaiba River and the border of EU (FR Guiana), along the coast of the states of Maranhão, Pará and Amapá. Fishers use artisanal, small-scale and industrial fishing vessels, outfitted with trawls (*puca-de-arrastro* or *guizo*), cast nets (*tarrafa*) and fixed traps (*zangaria*). The main species caught are southern brown and southern white shrimps, as well as Atlantic seabob. The small-scale fishery is concentrated in the Maranhão area. It operates in coastal waters with small, motorized trawlers (8 m to 13 m) commonly used to catch southern white shrimps and Atlantic seabob. The industrial shrimp trawlers are the Florida type, from 17 m to 23 m, powered by 325 HP to 425 HP engines, deploying otter trawls with exclusion devices. The total number of shrimp trawlers in 2021 was 70 (out of 110 licenses issued in 2019). Trip duration is 40 to 50 days at sea and daily trawl operations last 5 to 6 hours. The area of operation of the industrial shrimp fleet is limited to 40 m to 80 m water depth (FAO, 2017; Negreiros Aragao, 2019). The Brazilian *Penaeus* shrimp fishery is subject to several management regulations, including seasonal closures and no take areas, as well as depth limitations for trawling operations (artisanal and industrial).

The Atlantic seabob fishery is important in the NBSLME area. Most of the accumulated catch for the period 2015 to 2019 was landed by Guyana and Suriname; about 94 percent of the catch is landed by these two countries (Table 3.11). In both countries, the Atlantic seabob fisheries are Marine Stewardship Council-certified. Mexico catches a noteworthy proportion of the Atlantic seabob catch in the region, most of it taken by artisanal fishers in coastal lagoons and estuaries, whereas the artisanal and industrial fleets operate in Guyana and Suriname. Both countries have specific fishery management plans that limit Atlantic seabob fishing operations. In Guyana, the Guyana Atlantic seabob fisheries operate in a habitat extending from the coastal lagoons and river mouths to depths of about 30 m. The shallow water areas are reserved for artisanal fishers, and the industrial trawl fishery is restricted to a zone extending from the 14 m to the 32 m isobath. The industrial seabob trawl fleet currently comprises 81 operational vessels (Government of Guyana, 2019).

In Suriname, the Atlantic seabob industry uses twin-rig shrimp trawlers, which land the shrimp on ice to processing companies, while artisanal fishers catch Atlantic seabob in river mouths using Chinese seines (Government of Suriname, 2021b). Industrial vessels are equipped with the standard twin-rig method (two trawls on either side of the vessel), with exclusion devices, and maximum engine power is limited to 500 HP. Waters deeper than the 18 m isobath are closed to Atlantic seabob fisheries and the number of available licenses is limited to 26. Effort limitation in the fishery is monitored under a harvest control rule (HCR).

3.4.2 State of the stocks

Northern brown shrimp. The current stock status of northern brown shrimp in the United States GOM is not overfished nor undergoing overfishing (Hart, 2016a); the stock in the southeastern Atlantic of the United States is not overfished and overfishing is not occurring (NOAA, 2013). The stock status of the species managed by Mexico is currently unknown, but in the ten years after 2010 it was described as fully exploited with no signs of recovery in catches (Government of Mexico, 2012) (Table 3.6).

Northern pink shrimp. According to the latest stock assessment, the stocks managed by the United States are not overfished nor undergoing overfishing (Hart, 2017). The stock status of the species managed by Mexico is currently unknown, but between 2010 and 2020, it was overexploited with no signs of recovery of the catches (Government of Mexico, 2012).

Northern white shrimp. According to the latest stock assessment, the managed stocks in the United States are not overfished nor undergoing overfishing (Hart, 2016b; NOAA, 2013). Like the northern pink shrimp managed by Mexico, the stock status for northern white shrimp is currently unknown. However, in the decade 2010 to 2020 it was fully exploited with no signs of recovery of the catches (Government of Mexico, 2012).

Southern brown shrimp. In EU (FR Guiana), southern brown shrimp is the main species targeted by shrimp trawlers. The most recent stock assessment of southern brown shrimp indicated that the stock is at historically low levels and probably below the management target. The current total allowable catch (TAC) and number of licenses are ineffective because they potentially allow for overexploitation of the stock (FAO, 2021b).

For the remainder of the shrimp species, the most recent stock status is derived from the *Case study on shared stocks of the shrimp and groundfish fishery of the Guianas-Brazil shelf* (UNGF/INT/001/OPS) (CLME, 2013). For southern pink shrimp in Trinidad and Tobago and Guyana, stock status and exploitation was at medium risk of the stock being overfished and experiencing overfishing. For the redspotted shrimp in Guyana and Suriname, stock status and exploitation was at low risk of the stock being overfished and experiencing overfishing in Suriname, with data up to 2012; for Guyana, the stock was at high risk of overfishing occurring and stock status was likely overfished. In Trinidad and Bolivarian Republic of Venezuela, for all shrimp species combined, the risk of the stock being overfished and experiencing overfishing was at medium levels, taking into account some uncertainty.

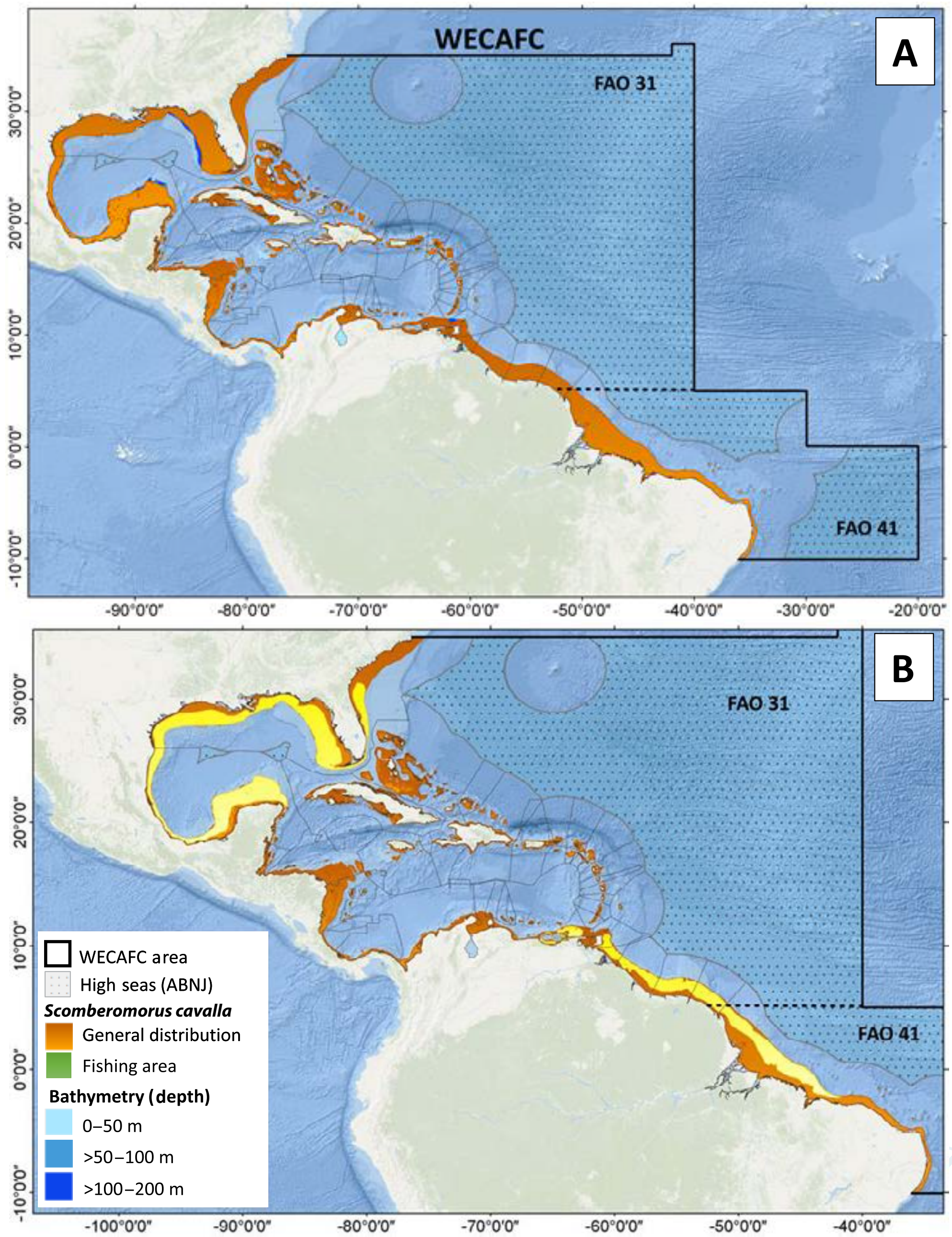
Atlantic seabob. The most recent stock status is available from FAO/FIRMS and indicates that the stock fished by Guyana and Suriname is not overfished, and overfishing is not occurring (CRFM, 2019; FAO, 2020–2023d). Based on the stock assessment and HCR parameters, the performance of both fisheries is reasonable, with low probability (<5 percent) of the stock being below 50 percent SSB_{MSY} (spawning stock biomass capable of producing MSY). Catches are measured as a relative loss of opportunity and for Suriname around 14 percent of monthly catches are less than 50 percent of the MSY level, compared to 8 percent for Guyana (CRFM, 2019).

3.5 The pelagic resources

In the WECAFC region, some of the most economically valuable resources of the large pelagic fish species are *Scomberomorus* species: king mackerel (*Scomberomorus cavalla*), Atlantic Spanish mackerel (*Scomberomorus maculatus*), serra Spanish mackerel (*Scomberomorus brasiliensis*) and cero (*Scomberomorus regalis*).

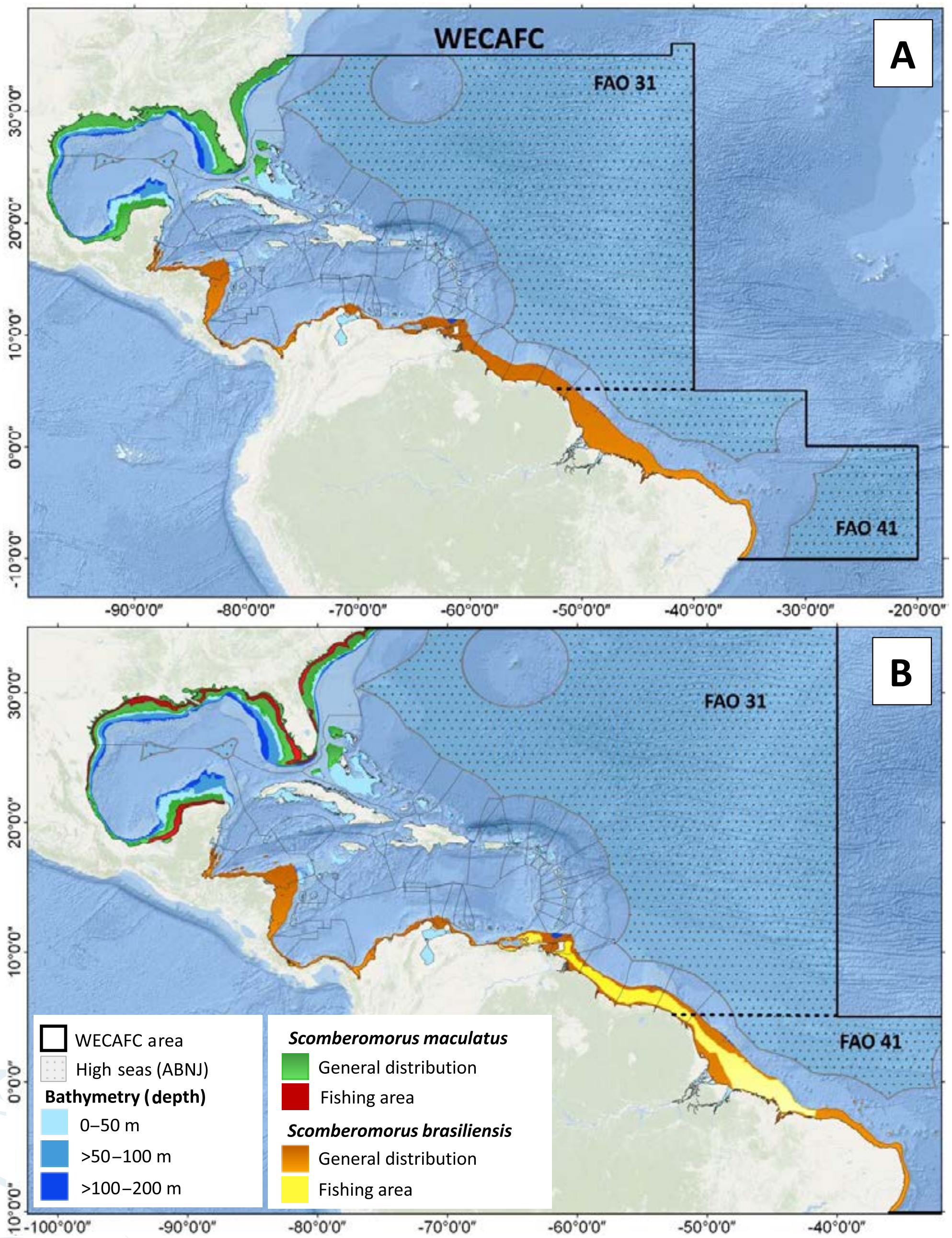
The four mackerel species are epipelagic, neritic, often found in outer reef areas and in estuaries, with characteristics specific to each species. The king mackerel and to some extent the cero, are more oceanodromous and common in outer reef areas and move in small groups or as single individuals. Atlantic Spanish and serra Spanish mackerel are more coastal and are often found entering estuaries and moving in schools across their distribution range. All species display seasonal migrations within the region (Strum, 1978; Strum, Julien and Salter, 1984; Clardy *et al.*, 2008; Collette *et al.*, 2011a, 2011b, 2011c, 2011d), although, there are some resident populations of king mackerel in the northern GOM and northeastern Brazil (Strum and Salter, 1989). King mackerel is widely distributed across the region (Figure 3.28A), while the most important fishing areas are in the GOM, southeastern United States (in the northern WECAFC region) in the NBSLME and northeastern Bolivarian Republic of Venezuela and in the southern part of the region (Figure 3.28B). In contrast, Atlantic Spanish mackerel is distributed from the northern limit of the WECAFC region through to the Yucatan Peninsula and northern Cuba, while serra Spanish mackerel is distributed along the Caribbean shelf through to northeastern Brazil (Figure 3.29A). Fishing areas for Atlantic Spanish mackerel are mostly in the GOM and southeastern United States, while those for serra Spanish mackerel are in the NBSLME and northeastern Bolivarian Republic of Venezuela (Figure 3.29B). Cero fishing is mostly limited to the islands across the Caribbean Sea (Figure 3.30). Spawning occurs seasonally for king, Atlantic Spanish and serra Spanish mackerels within their distribution range; for king mackerel it occurs in the GOM, Caribbean Sea and northeastern Brazil; while for Atlantic Spanish mackerel it takes place in the northern GOM and the southeastern United States (Collete *et al.*, 2011a, 2011d). Spawning of the serra Spanish mackerel takes place over a protracted period in estuaries (Strum, 1978).

Figure 3.28. ***Scomberomorus cavalla*** **(king mackerel, KGM) general distribution (A: general view; B: including fishing areas) in the Western Central Atlantic Fishery Commission region**



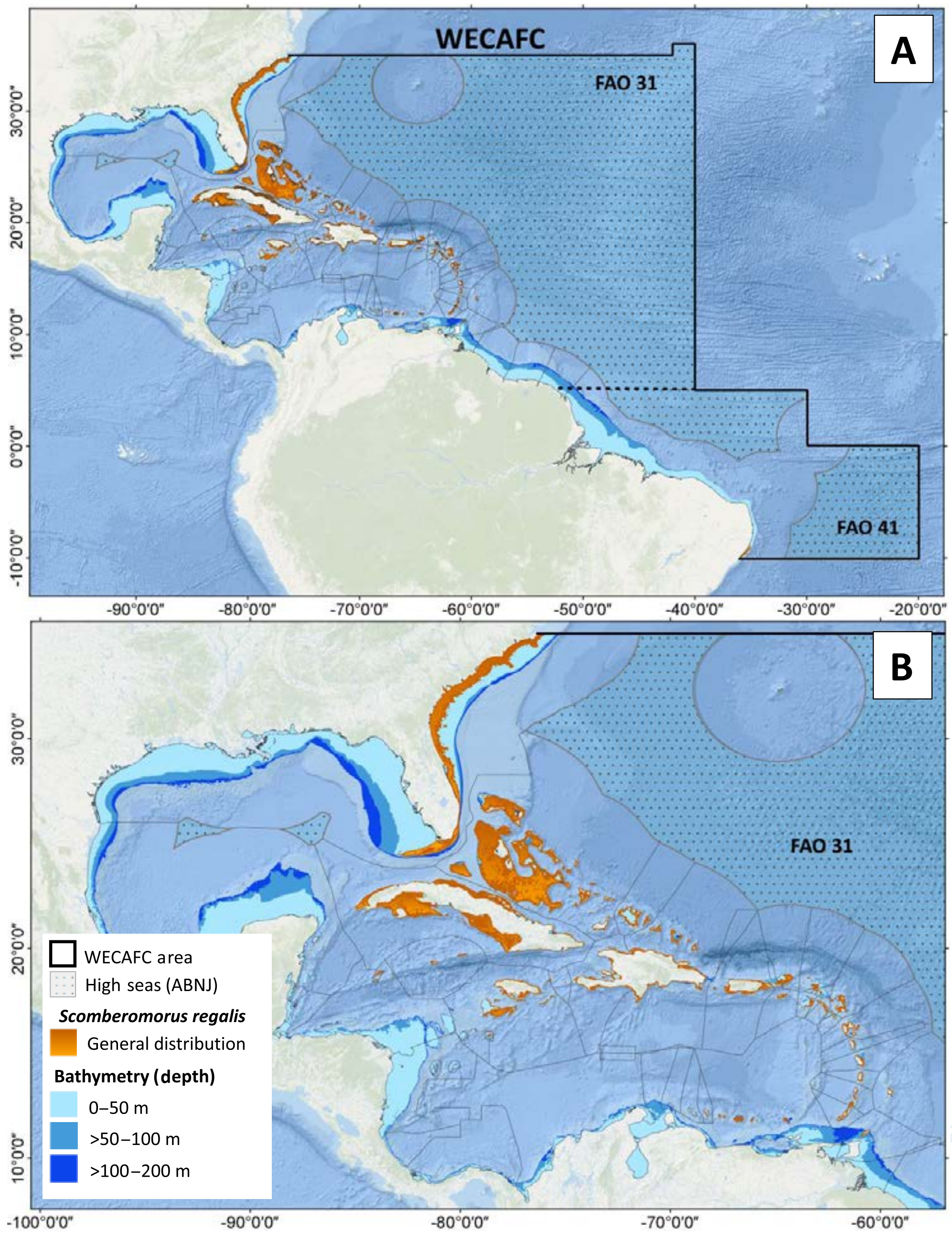
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 3.29. ***Scomberomorus maculatus*** **(spotted Spanish mackerel, SSM) and** ***S. brasiliensis*** **(serra Spanish mackerel, BRS) general distribution (A: general view; B: including fishing areas) in the Western Central Atlantic Fishery Commission area**



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 3.30. ***Scomberomorus regalis*** **(cero, CER) general distribution (A: general view; B: detailed view) in the Western Central Atlantic Fishery Commission region**



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The stock structure for king mackerel in the northern WECAFC region appears to display four stock units, based on tagging efforts, but there are no genetic differences between the two GOM populations and the species is managed by the United States as two migratory stocks: GOM and the southeastern United States coast (Gold, Pak and DeVries, 2002). Another potential stock unit is located off northeastern Bolivarian Republic of Venezuela – where an important fishery has existed since 1950 – and Trinidad and Tobago to Suriname (Marcano, Lárez and Carrion, 1998; Hogarth and Martin, 2006). Finally, the most southern stock unit in the region is in northern Brazil (Nobrega and Lessa, 2009). Stock structure for serra Spanish mackerel consists of three stock units: two in the southeastern Caribbean Sea (Gold *et al.*, 2010) and one in northeastern Brazil (Nobrega and Lessa, 2009). For Atlantic Spanish mackerel, the stock structure comprises a single intermingling genetic stock (Buonaccorsi, Starkey and Graves, 2001). There is no information on the stock structure of Cero.

3.5.1 The fishery

As these resources are part of the ICCAT species group and several ICCAT Member States have important directed fisheries, most of the reported catch is species-specific.

King mackerel. Recent FAO statistics indicate that 99.75 percent of the accumulated catch of king mackerel for the period 2015 to 2019 was landed by six countries in the WECAFC region (Table 3.12). Mexico accounts for over 63 percent of the accumulated catch, followed by the United States with over 19 percent of the total accumulated catch in the region. Bolivarian Republic of Venezuela accounts for over 7 percent of the accumulated catch, but attention is drawn to the last three years of the reporting period which each report very similar catch numbers. Noting that the fishery for king mackerel is one of the most important large pelagic fish resources for the mid- and long-range artisanal fleet in northeastern Bolivarian Republic of Venezuela (Marcano, Lárez and Carrión, 1998; Mendoza, 2015), the possibility exists that those numbers reflect a carry-over of previous years due to incomplete reporting. A similar problem may exist in the numbers reported by Trinidad and Tobago, noting that the reported catch remains the same for the last four years of the period and 1 tonne is reported for 2015. Recognizing that the combined catch from these two countries can account for 11 percent or more of the total accumulated catch in the region, efforts should be made to reconcile the estimated catch for the recent period.

Table 3.12 Pelagic resources (mackerels) catch by country for the period 2015–2019 (tonnes)

Group: Pelagic species. Species: *Scomberomorus cavalla* – king mackerel. Species code: KGM								
Country	**2015**	**2016**	**2017**	**2018**	**2019**	**Rank**	**%**	**%cum**
Mexico	6 150	5 517	6 827	6 179	5 170	1	63.10	
United States of America	1 948	2 246	2 499	2 375	11	2	19.20	82.30
Venezuela (Bolivarian Republic of)	1 092	574	590	590	590	3	7.27	89.57
Trinidad and Tobago	1	494	494	494	494	4	4.18	93.75
Dominican Republic (the)	277	288	309	275	285	5	3.03	96.78
Guyana	358	314	192	143	398	6	2.97	99.75
Grenada	12	12	12	12	12	7	0.13	99.88
Puerto Rico	14	11	7	13	8.84	8	0.11	99.99
Saint Kitts and Nevis	0	0	0	1	1	9	0.004	100.00
Saint Vincent and the Grenadines	0	0	0	1	1	10	0.004	100.00
Group: Pelagic species. Species: *Scomberomorus maculatus* – Atlantic Spanish mackerel. Species code: SSM								
Mexico	7 750	8 422	8 603	9 433	7 433	1	86.63	
United States of America	1 328	1 747	1 501	1 844	0	2	13.36	99.99
Grenada	1	1	1	1	1	3	0.01	100.00
Group: Pelagic species. Species: *Scomberomorus brasiliensis* – serra spanish mackerel. Species code: BRS								
Venezuela (Bolivarian Republic of)	747	881	910	910	910	1	46.52	
Trinidad and Tobago	0	695	695	695	695	2	29.68	76.20
Guyana	387	399	307	313	701	3	22.49	98.69
Colombia	0	0	0	0	122.75	4	1.31	100.00
Group: Pelagic species. Species: *Carite chinigua* (*Scomberomorus regalis*) – cero. Species code: CER								
Venezuela (Bolivarian Republic of)	0	171	175	175	175	1	70.20	
Dominican Republic (the)	57	75	81	3	25	2	24.31	94.51
Puerto Rico	14	4	3	5	12.46	3	3.88	98.39
United States of America	3	3	4	6	0	4	1.61	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Serra Spanish and Atlantic Spanish mackerel. Most of the recent catches (98.69 percent) for serra Spanish mackerel are shared by three countries: Bolivarian Republic of Venezuela, Trinidad and Tobago and Guyana (Table 3.12). Based on the information reported to FAO, Bolivarian Republic of Venezuela accounts for almost half of the accumulated catch for the period 2015 to 2019, while the other half is shared by Trinidad and Tobago and Guyana. A small fraction of the accumulated catch is reported by Colombia in the last year of the series. This species represents an important coastal large pelagic shared resource for these countries and it appears that the same potential reporting problem identified for king mackerel in the case of Bolivarian Republic of Venezuela and Trinidad and Tobago occurs, i.e. a carry-over of reported catches for several years, potentially masking the actual volume of serra Spanish mackerel caught in the region. In the case of Atlantic Spanish mackerel, the species is shared by two countries, Mexico and the United States (Table 3.12). Mexico is responsible for most of the accumulated catch (86.63 percent) for the period 2015 to 2019, the remainder is reported by the United States. Grenada also reported some catches of Atlantic Spanish mackerel for the period but this is likely due to species misidentification because the geographical distribution of the species is limited to the GOM and the United States (Figure 3.29).

Cero. Bolivarian Republic of Venezuela and the Dominican Republic account for most of the recent accumulated catches (94.51 percent) in the region; the remainder is shared by Puerto Rico and the United States (Table 3.12). The reported catch values from Bolivarian Republic of Venezuela seem to be carry-over estimates, as occurred with the previous species. This species is common in the Venezuelan offshore islands, particularly around Los Roques Archipelago (Cervigón, 2005). It is commonly fished by the local small-scale fishers and landing information is not reported to the mainland on a timely basis, often leading to the generation of catch estimates based on previous reports.

There are several countries that do not report species-specific catches for this group of pelagic species, instead reporting them as *Scomberomorus* spp. or seerfishes NEI. Within this group, three countries account for most of the accumulated catch (94.82 percent) for 2015 to 2019: Colombia, Cuba and Nicaragua (Table 3.13). The remainder of the catch is shared by several small Caribbean islands, notably EU (FR Guiana). It is not clear what catches are reported as European Union, noting that Martinique, Guadalupe and French Guiana are all French overseas departments.

Tuna © Unsplash

Table 3.13 Pelagic resources (Scombroidei and *Scomberomorus* spp.) catch by country for the period 2015–2019 (tonnes)

Group: Pelagic species. Species: Scombroidei (suborder) – tuna-like fishes NEI. Species code: –								
Country	**2015**	**2016**	**2017**	**2018**	**2019**	**Rank**	**%**	**%cum**
Trinidad and Tobago	369	369	369	419	423.53	1	41.78	
Costa Rica	112	161	160	160	160	2	16.14	57.91
Dominican Republic (the)	145	21	13	300	200	3	14.55	72.46
Guyana	3	229	10	102	312	4	14.06	86.52
Venezuela (Bolivarian Republic of)	28	39	64	0	0	5	2.81	89.33
Guatemala	1	107	0	0	0	6	2.31	91.64
Antigua and Barbuda	20	20	20	20	20	7	2.14	93.78
Colombia	0	7	7	0	75.84	8	1.93	95.71
Saint Lucia	23	15	17	13	15.6	9	1.79	97.50
United States of America	15	0	0	0	36	10	1.09	98.59
Dominica	2	3	10	5	5	11	0.54	99.13
Saint Kitts and Nevis	14	2	5	0	0	12	0.45	99.58
United States Virgin Islands (the)	0	2	0	5	5	13	0.26	99.83
Puerto Rico	3	1	1	1	1.73	14	0.17	100.00
Group: Pelagic species. Species: *Scomberomorus* spp.– seerfishes NEI. Species code: –								
Colombia	12	85	515	0	80.89	1	38.98	
Cuba	145	120	108	108	90	2	32.12	71.10
Nicaragua	110	124	79	56	52.64	3	23.72	94.82
French Guiana	9	8	10	9	9	4	2.53	97.35
United States Virgin Islands (the)	6	9	6	4	0	5	1.41	98.75
France	0	10	10	0	0	6	1.13	99.88
Saint Lucia	1	0	0	0	0.17	7	0.07	99.94
British Virgin Islands (the)	1	0	0	0	0	8	0.06	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

In the WECAFC region there are four countries that have directed fisheries towards this group of species. In the northern part of the region, the United States has directed commercial fisheries and recreational fisheries for king mackerel and Atlantic Spanish mackerel, while Mexico has directed commercial fisheries for the same two species. In the southern part of the region, Bolivarian Republic of Venezuela and Trinidad and Tobago have directed commercial fisheries for king mackerel and serra Spanish mackerel. The rest of the countries in the region catch this group of species as part of their seasonal multispecies fisheries for large pelagic fishes, using a variety of handline gear that includes hook and line and trolling, and gillnets. Apart from the United States, this group of species is caught by artisanal fisheries for which some countries have specific gear configurations, particularly those that use gillnets (Guyana, Mexico, Trinidad and Tobago).

In Mexico, king mackerel, Atlantic Spanish mackerel and cero are fished with bottom gillnets over depths of 10 m to 40 m and by trolling. Gillnets are 300 m long with a 9 cm to 10 cm mesh size (Fernández *et al.*, 2011; Government of Mexico, 2018). In Trinidad, serra Spanish mackerel – the most important mackerel species landed – and king mackerel are targeted by the artisanal multigear fleets operating off all the coasts of Trinidad and Tobago using gillnets (340 m long) (Fernández *et al.*, 2011) and pelagic handline methods that include *a-la-vive* (fishing with live bait), switchering (handline with baited hooks deployed while vessel is stationary), and trolling/towing (4 to 6 lines are towed from bamboo outriggers off the vessel) (Arocha, 2019). In Tobago, king mackerel is mostly caught by trolling (Mohammed and Lindop, 2015a).

In Bolivarian Republic of Venezuela, king mackerel is caught throughout the year in the northeast by trolling using live bait (round sardinella, *Sardinella aurita*) (Marcano, Lárez and Carrión, 1998). Both mackerel species are also caught by the country's offshore artisanal fleet operating off the NBSLME, although most of the catch from that area consists of serra Spanish mackerel. Cero is mostly caught with handline gear around the Venezuelan offshore islands, mainly off Los Roques Archipelago. In the United States, king mackerel commercial landings are grouped into three gear categories: handline, gillnet and other. Handline gear includes hook and line, electric/hydraulic bandit reels and trolling, the dominant gear. Gillnet catches prior to the mid-1980s accounted for more than half of the landings, but since then gillnet landings have accounted for 10 to 20 percent of the landings. Small catches of king mackerel are also reported from the shrimp trawl fishery in the GOM. King mackerel represents an important recreational fishery resource in the southeastern United States and GOM, mainly Florida (SEDAR, 2014c). For Atlantic Spanish mackerel, commercial fishers in the United States use cast nets, gillnets and hook-and-line gear to harvest the species, but cast nets account for most of the landings. There is also an important recreational fishery (SEDAR, 2013a).

In the Dominican Republic, most of the catch of king mackerel and cero is associated with moored fish aggregating devices (mFADs) and live bait fishing. When fishing on mFADs, handline gear is trolled around the fish aggregating device (FAD). Each boat carries two fishers and each handle two hooked lines. Dead bait (sardine or similar) is used to catch live bait (small jacks) that are used to catch large pelagic fishes on the mFADs (Arocha, 2019). In Guyana, the artisanal fleet consists of 1 147 boats, of which 15 are equipped with different types of gillnets (Chinese seine/fyke net, pin seine, gillnet [nylon and polyethylene]). Mackerel species (king and serra Spanish) are mostly caught by the nylon and polyethylene gillnet boats that account for 45 percent of Guyana's catch by gear type (MacDonald *et al.*, 2015; Arocha, 2019).

3.5.2 State of the stocks

King mackerel, Atlantic Spanish mackerel, serra Spanish mackerel and Cero. An ecological risk analysis (ERA) for the small tuna caught by longline and purse seine fisheries in the Atlantic, including all four *Scomberomorus* species, was conducted in 2016 (ICCAT, 2017). The assessment found that king and Atlantic Spanish mackerel were two of the top three stocks estimated to be the most vulnerable species caught in the region, with a high risk of overfishing. The assessment found that the serra Spanish mackerel stock off north-northeastern Brazil was at "moderate" risk[2] although it was indicated that the data quality

[2] There are three levels of risk: high, moderate and low.

score for the estimation was moderate (Frédou *et al.*, 2017). In the case of cero, assessment results indicated there was at low risk of overfishing (Table 3.5).

For the stock units of king and Atlantic Spanish mackerel under the management of the United States, the most recent stock assessments (SEDAR, 2013a, 2014c, 2014d) suggest that none of the stocks in the Atlantic (GOM and southeastern United States) are overfished or subject to overfishing. The stock status assessment for the potential king mackerel southern Caribbean stock unit (off Bolivarian Republic of Venezuela, Trinidad and Tobago and Guyana) – conducted in 2006, reviewed and updated in 2007 – remained inconclusive (CRFM, 2006, 2007). The updated assessment concluded that it is not known whether the stock is overfished or not, thus the current exploitation level may be sustainable, but may not be the level desired by management. Therefore, the precautionary approach recommended to managers was that current (2007) levels of fishing effort should not be increased and participation at CRFM assessment meetings of scientists from other countries that collect information on the same stock should be encouraged, with the aim of contributing additional assessment data which would significantly reduce the uncertainty in the evaluation of the stock status.

For the two potential stocks of serra Spanish mackerel (Trinidad and Tobago and Bolivarian Republic of Venezuela), only Trinidad and Tobago carried out a stock assessment in 1991 and categorized this species as fully exploited (Henry and Martin, 1992). The more recent assessment (Martin and Nowlis, 2004) indicated that the biomass of serra Spanish mackerel was below MSY and that fishing mortality (F) was above F_{MSY}. However, this most recent stock assessment was based on two different models, with some conflicting results. In general, there was uncertainty and the recommendation for the stock unit of Trinidad and Tobago was to continue fishing at current levels. However, based on historical catches, the stocks were categorized as overfished in 2012 (FAO WECAFC, 2018).

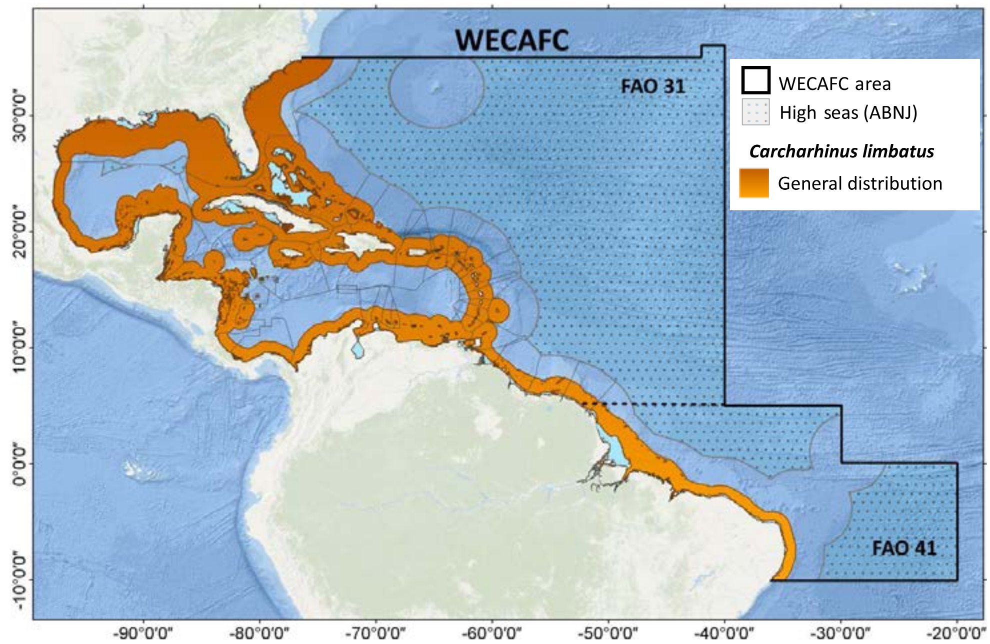
3.6 The elasmobranch resources

There is limited information available on the status of elasmobranch stocks in the WECAFC area. Historically, these species were not deemed economically important in most countries of the region and there was little incentive to collect data on population sizes or other demographics. However, there is consensus that sharks and rays in the region have experienced a sharp decline in the past decades (FAO, 2018b).

The transboundary elasmobranch resources considered in this section are those species that fall into the group of coastal sharks which include four requiem sharks (Carcharhinidae), two hammerhead sharks (Sphyrnidae) and one houndshark (Triakidae). Most requiem sharks included in this review are shelf or slope dwellers, mostly littoral and semi-pelagic with variations, depending on the species.

Blacktip shark (*Carcharhinus limbatus*). The blacktip shark is cosmopolitan in tropical to subtropical coastal, shelf and island waters (Figure 3.31). In the Atlantic during its seasonal migration, it ranges from Massachusetts to Brazil, but its centre of abundance is the GOM and Caribbean Sea. The blacktip shark inhabits inshore and offshore waters but is not a truly pelagic species. It is often seen close to shore around river mouths, bays, mangrove swamps and in estuaries, though it does not penetrate far into freshwater (Burgess and Branstetter, 2009). Neonates and juveniles are common in several distinct areas in the southern Caribbean, such as the Gulf of Venezuela, Los Roques Archipelago and in nearshore areas of Trinidad and Tobago (Tavares, 2008; Shing, 2006; Tavares and Sánchez, 2012). This species commonly occurs in loose aggregations, it uses coastal bays and estuaries throughout the southeastern United States of America, distinct areas of the southern Caribbean and the NBSLME as nursery grounds (Castro, 1996; F. Arocha, direct observation). The blacktip shark is targeted by several commercial and artisanal fisheries in the region, by the longline fishery in the northern part of the region and by semi-industrial multigear fleets off the NBSLME. The meat is used for fishmeal or sold in local markets for human consumption. The fins are sold to Asia and the hides are used for leather.

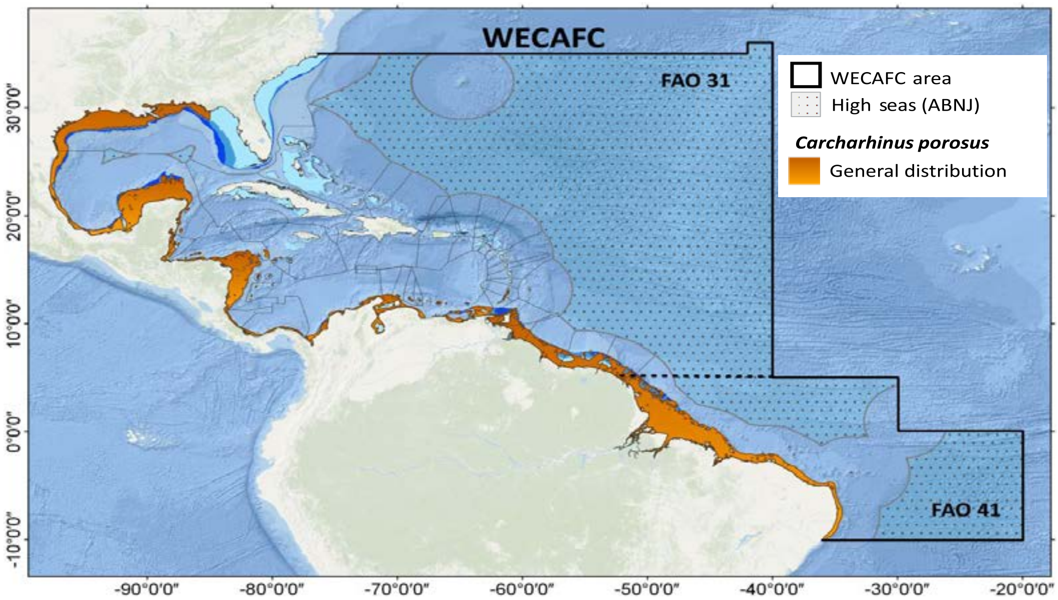
Figure 3.31. *Carcharhinus limbatus* (blacktip shark, CCL) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Smalltail shark (*Carcharhinus porosus*). The smalltail shark is distributed in the western Atlantic Ocean from the northern GOM to southern Brazil but is absent from the Caribbean islands (Figure 3.32). Common in waters over continental shelves, the smalltail shark prefers muddy bottoms in estuarine habitats (Feitosa *et al.*, 2020). It swims along the bottom to depths of 36 m. The smalltail shark is primarily caught as incidental bycatch in the gillnets of artisanal fisheries. The flesh is marketed fresh for human consumption while the fins are valuable exports. This shark is also processed into fishmeal and the oil is extracted from the liver.

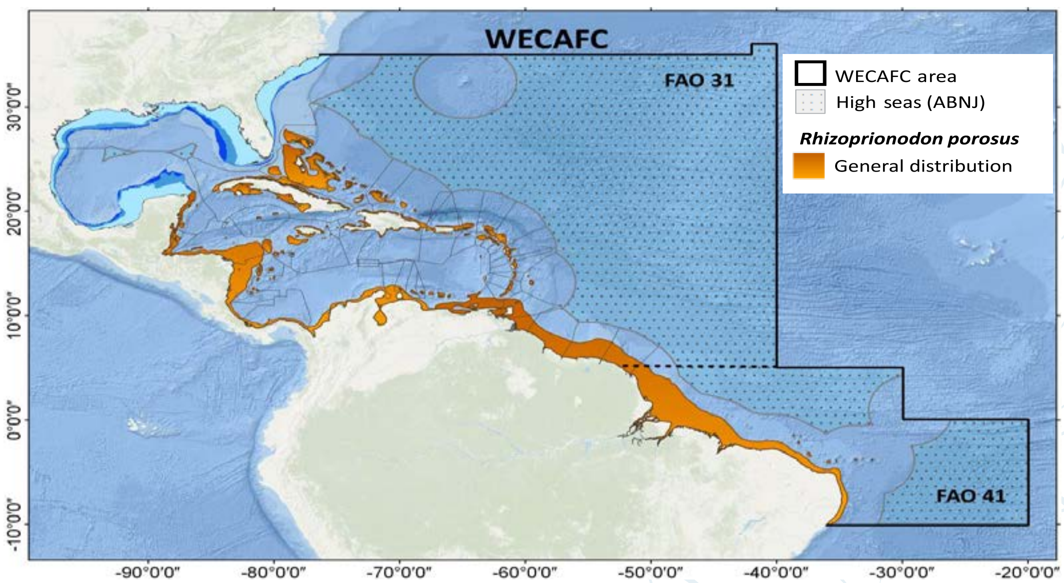
Figure 3.32. *Carcharhinus porosus* (smalltail shark, CCR) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Caribbean sharpnose shark (*Rhizoprionodon porosus*). The Caribbean sharpnose shark is a small (<110 cm total length) coastal shark that has a limited distribution in the WECAFC region. It occurs from the Bahamas, Caribbean Islands and Quintana Roo, Mexico, south into northeastern Brazil and beyond (Figure 3.33) (Carlson *et al.*, 2021). It inhabits continental and insular shelves from close inshore to a depth of 500 m (Ebert, Fowler and Compagno, 2013). The species is targeted and taken as bycatch in gillnet, longline and commercial trawl fisheries, which are intense and inadequately managed in key parts of its range. Population structure is not defined for the Caribbean area, but there seem to be two genetically distinct populations between northeastern Brazil and the south (Mendonça *et al.*, 2011).

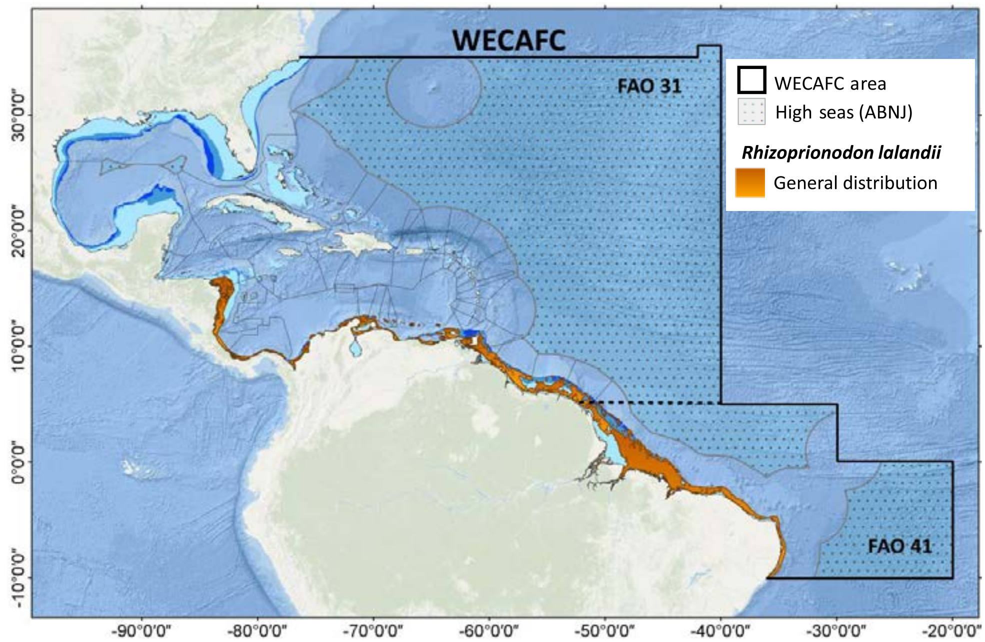
Figure 3.33. *Rhizoprionodon porosus* (Caribbean sharpnose shark, RHR) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Brazilian sharpnose shark (*Rhizoprionodon lalandii*). The Brazilian sharpnose shark is another small (<80 cm total length) shark that has limited distribution in the WECAFC region. It is found from north of South America in the Caribbean Sea, including Panama and the southern Caribbean islands, south to northeastern Brazil and beyond (Figure 3.34) (Pollom *et al.*, 2020a). It occurs over sand and mud on the inshore continental shelf at depths of 3 m to 149 m (Ebert, Fowler and Compagno, 2013; García, 2017). The species is captured in intensive artisanal gillnet fisheries throughout most of its geographic range and is consumed and sold locally. It is subject to intense exploitation in Colombia (García *et al.*, 2007). In Bolivarian Republic of Venezuela, the shark is among the most captured in artisanal fisheries (Tagliafico *et al.*, 2015), but it has likely declined in numbers due to the absence of management and increasing demand.

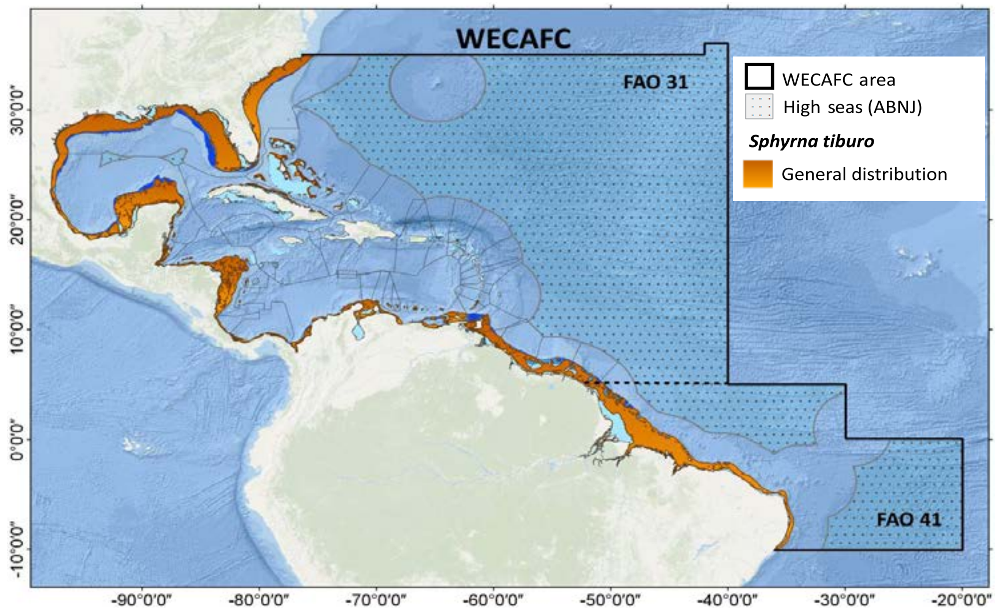
Figure 3.34. *Rhizoprionodon lalandii* (Brazilian sharpnose shark, RHL) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Bonnethead shark (*Sphyrna tiburo*). The bonnethead shark is a small sized shark (maximum of 150 cm) that occurs over continental and insular shelves from the intertidal zone to 90 m across the WECAFC region (Figure 3.35). The species normally occurs in small schools of up to 15 individuals, but during migration events they are seen in large groups. During pupping season, females congregate in shallow waters where they give birth (Lombardi-Carlson *et al.*, 2003). Its remarkably high rate of population growth makes this species one of the most productive shark species (Cortés, 2002). In the region, the bonnethead shark has been identified as a complex of two geographically discrete species: the northwest and western central Atlantic (United States, the Bahamas and Mexico) and the Caribbean Sea and southwest Atlantic (Belize south to Brazil) (Pollom *et al.*, 2020b). In the United States, highly significant genetic differences were observed among bonnethead sharks from the Atlantic coast of Florida, Gulf Coast of Florida and southwestern GOM (Escatel-Luna *et al.*, 2015). The species' population in the northern part of the region is relatively stable due to management actions (SEDAR, 2013b) but, in other areas where fisheries for this species exist and management measures are absent, it is likely that the abundance of Bonnethead sharks is low.

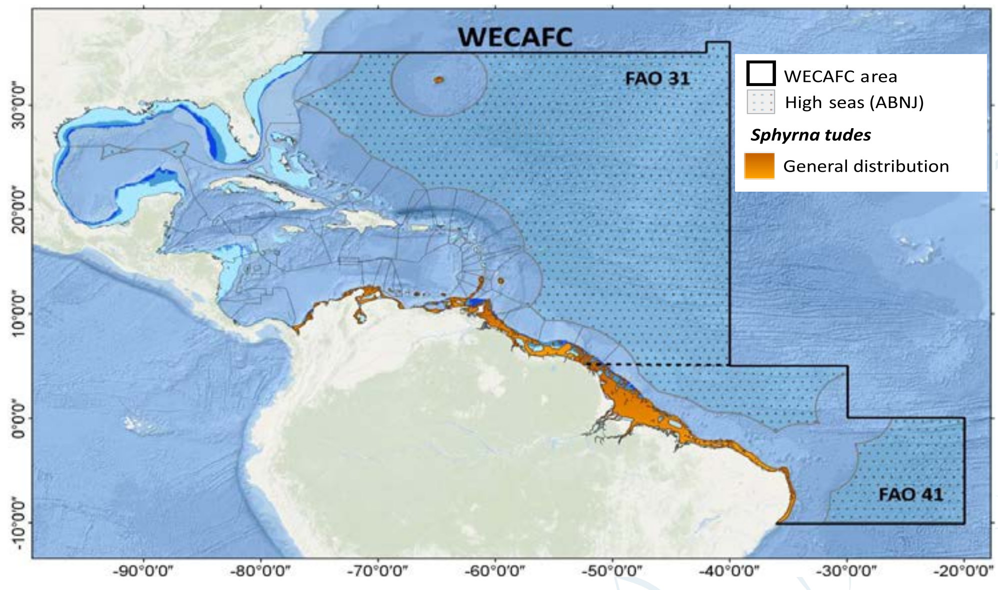
Figure 3.35. *Sphyrna tiburo* (bonnethead shark, SPJ) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Smalleye hammerhead shark (*Sphyrna tudes*). The smalleye hammerhead is a medium-sized (to 150 cm total length) shark that occurs in the subtropical waters off the east coast of South America from Colombia to Uruguay (Figure 3.36). There is almost no data from the southern Caribbean Sea. The Orinoco River delta (NBSLME) seems to have a large population, where it is thought to be the dominant species of hammerhead shark as well as in the waters of northeastern Trinidad and Tobago where it is caught by small-scale fisheries (Shing, 2006). The species inhabits inshore waters over the continental shelf at depths of 5 m to 80 m. It is captured in intense and largely unmanaged commercial and artisanal fisheries throughout its range using beach seines, gillnets, longlines and trawls (Pollom *et al*., 2020c).

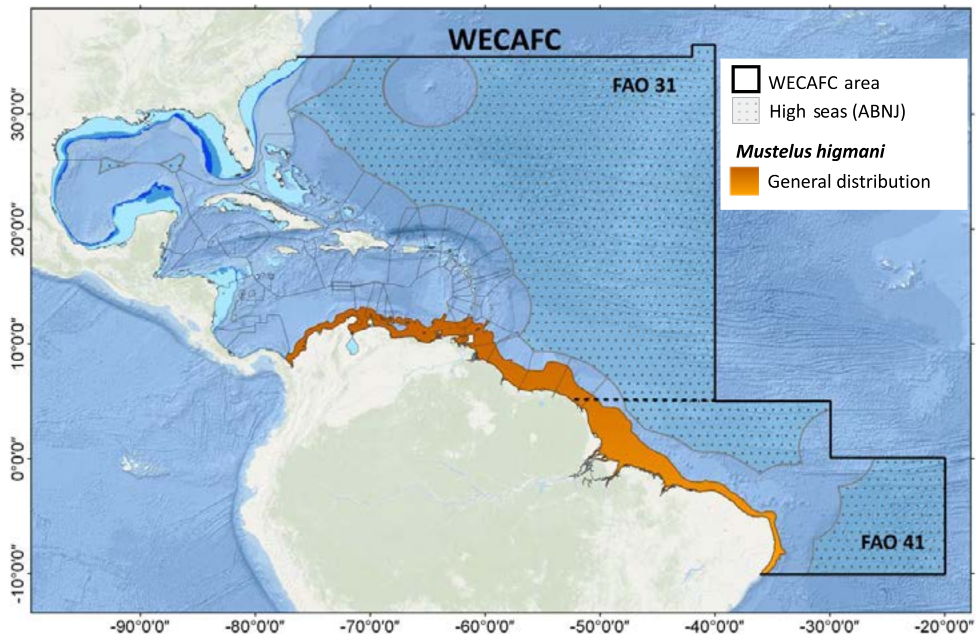
Figure 3.36. *Sphyrna tudes* (smalleye hammerhead, SPQ) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Smalleye smoothhound (*Mustelus higmani*). The smalleye smoothhound is a small (to 64 cm total length) houndshark that occurs from Colombia to southern Brazil (Figure 3.37) and inhabits mud, sand and shell debris on the continental shelves and upper slopes from close inshore to 130 m depth (Pollom *et al.*, 2020d). It is captured in commercial trawl fisheries and in commercial and artisanal driftnets, gillnets and longlines. Artisanal fisheries are intense across much of coastal Atlantic South America and there are largely unmanaged commercial trawl and longline fisheries in many areas (Tavares, Sánchez and Medina, 2009). This species is rare in Caribbean Colombia but there are no baseline data. In Bolivarian Republic of Venezuela, this species is targeted in intensive fisheries and there were already reported declines in abundance around Los Roques Archipelago in the 1990s (Tavares, 2005).

Figure 3.37 *Mustelus higmani* (smalleye smoothhound, CTJ) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

3.6.1 The fishery

Shark fisheries most likely pre-date recorded history in the region and it is probable that every part of these resources has been used for some purpose. In some countries in the region shark meat is an important food, consumed fresh or salted (FAO, 2018b). In many communities with ties to Asia, the fins of sharks are traded and exported. Shark cartilage and other products are increasingly sought for medicinal purposes. Few fisheries use the whole shark, however: some use only the meat, others only use the fins, or liver for oil, or cartilage for medicines, or jaws/teeth for tourism. In most cases where only a portion of the shark is used, the rest is discarded, which makes identification of the catch species difficult.

The fishery for elasmobranch species in this section can be taken as the commercial part of the bycatch from other coastal fisheries. In a recent survey in the WECAFC region, six countries reported directed fisheries for sharks (Antigua, Barbados, Belize, Cuba, Panama and the United States) but none of those countries provided information on the number of fishers involved in the fishery (FAO, 2018b). In countries where directed fisheries exist, the types of fisheries are diverse and most elasmobranchs are taken by small-scale fisheries using drift and bottom gillnets, pelagic and bottom longline (rigged with specific leaders and hooks for sharks), harpoons and bottom trawls. In addition, a sport fishery for large coastal sharks exists in the United States, although is mostly limited to one shark per vessel/trip (SEDAR, 2006).

Most of the elasmobranch catches in the region are reported in the following groupings: Elasmobranchii (sharks, rays, skates, etc. NEI); Sphyrnidae (hammerhead sharks, etc. NEI); Rajiformes (rays, stingrays, mantas NEI); generic such as *Sphyrna* spp., *Mustelus* spp. and transboundary specific like blacktip shark, smalltail shark, Caribbean sharpnose shark and smalleye hammerhead shark. Most of the shark species caught by small-scale fisheries in the region are likely reported under the Elasmobranchii group and this is also the case for shark species caught as bycatch by the pelagic longline tuna fisheries that do not fall under a specific management action of a RFMO (i.e. ICCAT). Most of the Elasmobranchii reported catches in recent years are attributed to seven countries in the region, of which Mexico was responsible for 61.54 percent of the accumulated catch during the period 2015 to 2019 (Table 3.14). The remaining six countries with important shark catches vary between 2.4 percent and 8.5 percent of the accumulated reported catches. In the case of Mexico, with the largest accumulated catch in recent years, most of the country's shark catches are from the small-scale fisheries using bottom gillnets and pelagic longlines, and a variety of requiem and hammerhead sharks, among them blacktip shark, smalltail shark and bonnethead shark are targeted (Government of Mexico, 2012). The Atlantic sharpnose shark (*Rhizoprionodon terranovae*) was known to represent close to 50 percent of the shark catches in the 1990s (Castillo-Géniz, 2001), but it not known whether the species represents a similar proportion of the shark catch in recent times. The reported catches from Bolivarian Republic of Venezuela are likely to be requiem sharks and coastal hammerhead sharks landed in the dressed form in communities where species identification is not possible. It seems likely that the same occurs in Nicaragua and Trinidad and Tobago. The shark catch of Cuba seems to consist of small coastal and large requiem sharks (FAO, 2018b).

In the case of hammerhead sharks, Mexico reports them separately and is responsible for most of the catch of hammerhead sharks in the region, with 82 percent of the total accumulated catch for 2015 to 2019 (Table 3.14). This catch consists primarily of bonnethead shark, and to a lesser extent the scalloped hammerhead (Government of Mexico, 2012). The bonnethead shark is caught as target and bycatch in coastal gillnet and longline fisheries and as bycatch in shrimp fisheries (Pollom *et al.*, 2020b). In the western central Atlantic, bonnethead shark is captured primarily in gillnets, demersal trawls and recreationally on hook and line. There is a directed fishery in Quintana Roo (Mexico) where the species is the third most important catch. It is present in landings in Belize, Cuba and Panama. In the southern Caribbean through to Brazil, artisanal fisheries are intense in most coastal areas, and there are largely unmanaged commercial trawl and longline fisheries in many areas. In Bolivarian Republic of Venezuela, although not specified in the catches, commercial and artisanal fisheries are intense, lack management and have exhibited peaks in catches followed by declines, indicative of sequential overfishing (Mendoza *et al.*, 2015). In Trinidad and Tobago, the smalleye hammerhead is the second most important shark species, followed by the bonnethead shark in the inshore artisanal fisheries (Shing, 2006). Groundfish fisheries on the Brazil-Guyanas shelf were already fully exploited by 2000; these fisheries are multigear, multispecies and multinational, with vessels crossing national maritime borders (Booth *et al.*, 2001; Tavares, 2005). Therefore, most coastal sharks are likely to be heavily exploited.

Table 3.14 Elasmobranchii and hammerhead sharks catch by country for the period 2015–2019 (tonnes)

Group: Elasmobranch. Species: *Elasmobranchii* – sharks. rays. skates. etc. NEI. Species code: –								
Country	**2015**	**2016**	**2017**	**2018**	**2019**	**Rank**	**%**	**%cum**
Mexico	3 743	5 074	4 155	5 683	3 955	1	61.90	
United States of America	906	711	485	693	328	2	8.55	70.45
Guyana	569	748	623	329	774	3	8.33	16.88
Cuba	550	460	408	407	390	4	6.06	14.39
Venezuela (Bolivarian Republic of)	1 303	162	165	165	165	5	5.37	11.43
Trinidad and Tobago	293	276	301	301	302.02	6	4.03	9.40
Nicaragua	232	234	196	114	107.16	7	2.42	6.45
Colombia	0	30	427	1	0	8	1.25	3.67
Costa Rica	107	86	85	85	85	9	1.23	2.48
Antigua and Barbuda	22	22	22	22	22	10	0.30	1.53
Barbados	23	15	18	11	10	11	0.21	0.51
Grenada	15	15	15	15	15	12	0.21	0.42
Martinique	4	4	4	4	4	13	0.05	0.26
Puerto Rico	4	3	2	4	3	14	0.04	0.10
Saint Lucia	3	1	3	1	0.59	15	0.02	0.07
Belize	0	5	0	0	0	16	0.01	0.04
Saint Vincent and the Grenadines	2	1	0	0	0	17	0.01	0.02
Bermuda	0	1	0	0	0	18	0.00	0.01
Group: Elasmobranch. Species: Sphyrnidae (family) – hammerhead sharks. etc. NEI. Species code: –								
Mexico	147	199	163	223	171	1	82.09	
Trinidad and Tobago	40	40	39	39	38.98	2	17.91	100.00
Group: Elasmobranch. Species: *Sphyrna* spp. – hammerhead sharks NEI. Species code: –								
Colombia	0	0	0	0	0.13	1	100.00	100.00
Group: Elasmobranch. Species: *Sphyrna tudes* – smalleye hammerhead. Species code: SPQ								
Colombia	0	0	0	0	0.4	1	100.00	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Among the requiem sharks, one of the most common species landed across the region for which catch specific landings exist is the blacktip shark (Table 3.15). Most of the accumulated reported catch for 2015 to 2019 is reported by three countries, of which two (the United States and Bolivarian Republic of Venezuela) account for 97.84 percent of the total reported catch, and the remaining fraction is reported by Trinidad and Tobago. In the United States, commercial bottom longline and gillnets are used to catch southeast Atlantic blacktip sharks; recreational fishers typically use rod and reel. In the southern Caribbean along the Venezuelan coast and offshore islands, blacktip sharks are caught by artisanal fisheries off the northwestern coasts and in Los Roques archipelago (off central Bolivarian Republic of Venezuela). However, research in these areas indicated that the catch consisted of juvenile specimens (average size of 90 cm total length) and noted that few adults (> 150 cm total length) are seen in the landings of blacktip sharks in the Venezuelan Caribbean ports; although small quantities were caught as bycatch in the tuna longline fishery operating in the Caribbean (Tavares, 2005; Tavares, 2008; Tavares and Sánchez, 2012). In Trinidad and Tobago, the inshore artisanal fishery that catches most of the sharks (60 percent) is the gill net fishery for king and serra Spanish mackerels. The inshore artisanal catch and beach seine catches of blacktip sharks comprise both neonates and adults, depending on the fishing location (distance from shore) at different times, which suggests that pups may stay in nearshore waters; the semi-industrial longline fishery also catches adult specimens (Shing, 2006). In the area of the NBSLME, blacktip sharks are caught by the small-scale, semi-industrial and industrial fleets that use trawl nets and gillnets, pelagic and bottom longline. Venezuelan industrial operations targeting sharks with drift gillnets off EU (FR Guiana) in the mid 1990s landed larger blacktip sharks (>100 cm total length) (Tavares, 2005).

Table 3.15 Requiem and *Mustelus* spp. sharks catch by country for the period 2015–2019 (tonnes)

Group: Elasmobranch. Family: *Carcharhinidae* – requiem sharks NEI. Species code: –								
Country	**2015**	**2016**	**2017**	**2018**	**2019**	**Rank**	**%**	**%cum**
Mexico	1 352	1 103	1 501	1 235	1 277	1	87.75	
Venezuela (Bolivarian Republic of)	862	6	6	6	6	2	12.02	99.77
Bermuda	3	3	2	2	2	3	0.16	99.93
Saint Vincent and the Grenadines	0	0	0	3	2	4	0.07	100.00
Group: Elasmobranch. Species: *Carcharhinus limbatus* – blacktip shark. Species code: CCL								
United States of America	102	84	101	69	58	1	58.54	
Venezuela (Bolivarian Republic of)	0	68	70	70	70	2	39.31	97.84
Trinidad and Tobago	2	2	4	5	2.25	3	2.16	100.00
Group: Elasmobranch. Species: *Carcharhinus porosus* – smalltail shark. Species code: CCR								
United States of America	102	84	101	69	58	1	58.54	
Venezuela (Bolivarian Republic of)	0	99	100	100	100	1	94.54	
Colombia	0	4	4	3	12.03	2	5.46	100.00
Group: Elasmobranch. Species: *Rhizoprionodon porosus* – Caribbean sharpnose shark. Species code: RHR								
Venezuela (Bolivarian Republic of)	0	260	265	265	265	1	92.65	
Colombia	0	3	32	18	30.69	2	7.35	100.00
Group: Elasmobranch. Species: *Mustelus* spp. – smooth-hounds NEI. Species code: –								
Venezuela (Bolivarian Republic of)	0	335	345	345	345	1	61.10	
Trinidad and Tobago	172	172	173	173	173.15	2	38.50	99.60
Bermuda	1	2	1	1	1	3	0.27	99.87
Colombia	3	0	0	0	0	4	0.13	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Catches of the other three requiem sharks (smalltail, Caribbean sharpnose and Brazilian sharpnose sharks) are only reported by Bolivarian Republic of Venezuela, which accounts for more than 90 percent of the accumulated catch of each species, and Colombia (Table 3.15). The artisanal fisheries in northeastern Bolivarian Republic of Venezuela land a significant amount of the Caribbean and Brazilian sharpnose shark catch, while an important part of the shark catch from artisanal fisheries in northwestern Bolivarian Republic of Venezuela is of Caribbean sharpnose shark (Tavares, Sánchez and Medina, 2010; Tavares and Sánchez, 2012).

There are few reports for smalltail sharks, but confirmed reports come from the pelagic longline fishery targeting tunas operating in the Caribbean (Tavares, 2005). It is possible that coastal fisheries land smalltail sharks, but they may be misidentified in the reports. In Trinidad and Tobago, the smalltail shark is the most common species, representing about 30 percent of landed sharks, followed by the Brazilian sharpnose shark (Shing, 2006). Catches of the Caribbean sharpnose shark are reported by Trinidad and Tobago.

Catches of smalleye smoothhound sharks are reported as *Mustelus* spp. (smoothhound NEI) and almost all the recent catch (99.60 percent) is reported from Bolivarian Republic of Venezuela and Trinidad and Tobago (Table 3.15). In northeastern Bolivarian Republic of Venezuela, the smalleye smoothhound shark is one of the most common species landed by the artisanal coastal fisheries and can account for up to 40 percent of the landed catch of sharks (Tavares, Sánchez and Medina, 2010; Márquez, Tavares and Ariza, 2019). Landings from Trinidad and Tobago are likely from the same fisheries, using the same gears as described for the other requiem sharks (Shing, 2006).

3.6.2 State of the stocks

Blacktip shark. Stock status for the blacktip shark has been measured in the United States where the species is managed as two stock units: the United States GOM and the United States South Atlantic. The USGOM stock assessment used a state space age-structured production model and the benchmarks included estimates of spawning stock fecundity, F and abundance for the year 2016 (SSF_{2016}, F_{2016}, N_{2016}); reference points based on MSY (SSF_{MSY}, F_{MSY}); spawning stock fecundity (SSF) at the minimum spawning stock threshold (SSF_{MSST}), status relative to SSF_{MSY} and/or SSF_{MSST}, and F_{MSY} levels. All model runs indicated that the stock was not overfished (SSF_{2016}/SSF_{MSY}=2.68) and overfishing (F_{2016}/F_{MSY}=0.024) was not occurring (SEDAR, 2018c). For the United States South Atlantic, the base model configuration (stock synthesis model) predicted that the stock was not overfished ($SSF_{2018} > MSST$) and that it was not experiencing overfishing ($F_{2018} > F_{MSY}$) in the terminal year of the assessment (SEDAR, 2020b).

Bonnethead shark. In the United States there has been and still is some directed commercial fishing for bonnethead sharks, and they are also frequently caught in recreational fisheries. Catches of this species are dominated by bycatch in the GOM shrimp trawl fishery. Based on the benchmarks for the MSY reference points for bonnethead sharks in the United States, the base model estimated that the stock was not overfished, and overfishing was not occurring, but that it had been near or even in an overfished condition for several years between 1996 and 2003 (SEDAR, 2013b).

Other than the stock assessments and data review conducted by the United States for the blacktip shark and the bonnethead shark above, there is no other information on the stock status of the region's transboundary sharks selected for this review, noting that waters between Bolivarian Republic of Venezuela and northern Brazil are considered the global center of abundance for smalltail shark. After 2004, the total biomass decreased by 85 percent in northern Brazil (Feitosa *et al.*, 2020) and consequently it is likely that this species is overfished. The only reference available for an estimate of the conservation status of the selected transboundary sharks is the information published by the International Union for Conservation of Nature's (IUCN's) Shark Specialist Group for the IUCN Red list assessments for sharks (Kyne *et al.*, 2012). The conservation status assessments published in the IUCN's web site (IUCN, 2023) for the selected transboundary sharks are from 2019, with the exception of blacktip shark in which the assessment dates are 2005, reviewed in 2009 (Burgess and Branstetter, 2009). The subpopulation of the northwest Atlantic was estimated to be vulnerable with no indication of population trends. For the remainder of the species, all population trends are decreasing but their conservation status varies from vulnerable to critically endangered, depending on the species (Table 3.16).

Table 3.16 Transboundary stock status in elasmobranchs (northwest Atlantic subpopulation)

	Other sources (after 2010) FIRMS				FAO categorization		Reference year	IUCN	Assessment year	
Common name/ species name	**Stock unit**	**Year**	**Overfished**	**Overfishing**	**Abundance Level**	**Exploitation rate**	**WECAFC/SAG/IX/2018/3**		**IUCN, 2023**	
Blacktip shark, *Carcharhinus limbatus*	USGM SEUS	2020	No	No	–	–	–	–	VU/ unknown*	2005
Smalltail shark, *Carcharhinus porosus*	NBRAZ	2020	Yes	–	–	–	–	–	CR/ decreasing	2019
Caribbean sharpnose shark, *Rhizoprionodon porosus*	–	–	–	–	–	–	–	–	VU/ decreasing	2019
Brazilian sharpnose shark, *Rhizoprionodon lalandii*	–	–	–	–	–	–	–	–	VU/ decreasing	2019
Smalleye hammerhead, *Sphyrna tudes*	–	–	–	–	–	–	–	–	CR/ decreasing	2019
Bonnethead shark, *Sphyrna tiburo*	USGM SEUS	2013	No	No	–	–	–	–	EN/ decreasing	2019
Smalleye smoothhound, *Mustelus higmani*	–	–	–	–	–	–	–	–	EN/ decreasing	2019

Notes: USGM= United States GOM; SEUS= Southeast United States; NBRAZ= North Brazil; VU= vulnerable; EN: endangered; CR: critically endangered

Source: Authors' compilation.

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4

Straddling stocks

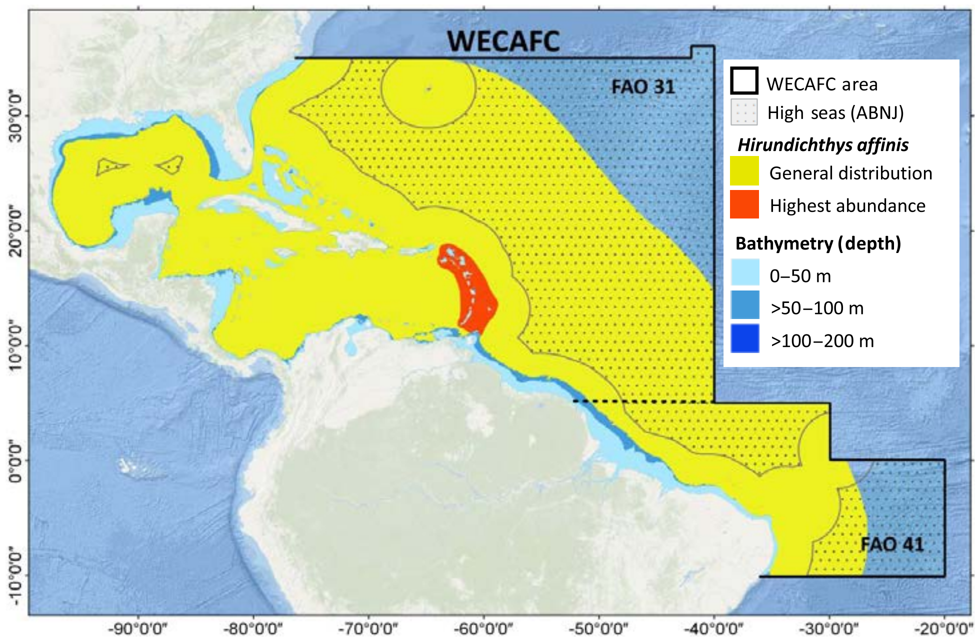
4. Straddling stocks

For the purpose of this review, straddling stocks are those defined in Section 2. They include one group of small pelagic fishes, the flyingfishes (Exocoetidae), the tuna and tuna-like species, and a selected group of elasmobranchs (sharks and rays) that are commercially exploited, threatened and/or protected in the WECAFC region.

4.1 The flyingfish resources

Three species of flyingfish – margined flyingfish (*Cypselurus cyanopterus*), fourwing flyingfish (*Hirundichthys affinis*) and sailfin flyingfish (*Parexocoetus brachypterus*) – are economically exploited through direct harvesting, mainly in the eastern Caribbean Sea (Oxenford, Mahon and Hunte, 1995). However, the target species of the offshore flyingfish fisheries of the eastern Caribbean (accounting for approximately 99 percent of all flyingfish landed) is the fourwing flyingfish (CRFM, 2019). The fourwing flyingfish is a nerito-oceanic species that prefers the waters above the shelf and slope but is often found in open ocean waters (Shakhovskoy, 2018) (Figure 4.1). In the eastern Caribbean, the species displays a north–south migration from Dominica to Tobago (Trinidad and Tobago) (Oxenford, 1994).

Figure 4.1. *Hirundichthys affinis* (flyingfish, FFV) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The fourwing flyingfish is a short-lived species (~18 months) with a strong interannual variability (Oxenford *et al.*, 2007). It spawns throughout the year with two peaks, one in December to January and another in April to May (Oxenford, 1994; Khokiattiwong, Mahon and Hunte, 2000), when its highest seasonal abundance occurs. It is seasonally targeted by the fisheries in the southern end of the eastern Caribbean (Medley *et al.*, 2010). Eggs are highly adhesive and are spawned on natural flotsam, as well as on floating fishing gear. The amount of natural flotsam in the eastern Caribbean, particularly sargassum, can vary according to flows from source rivers and prevailing ocean currents which may constrain flyingfish population size (CRFM, 2019). This species is consumed by large pelagic fishes, particularly common dolphinfish, and it is also the preferred bait used in longline fisheries in the eastern Caribbean Islands (Fanning and Oxenford, 2011). In the region, the areas of major abundance (based on spatial distribution of the catches) are in the eastern Caribbean countries, mostly around Barbados, Grenada and Saint Vincent and the Grenadines.

There are three genetically discrete subregional stocks identified and acknowledged within the WECAFC region. A genetic study on the fourwing flyingfish indicated a lack of gene flow between three areas within the WECAFC region, the eastern Caribbean Islands (Barbados, Dominica, Trinidad and Tobago), Curaçao and off Caiçara do Norte (Brazil), suggesting the existence of at least three stock units of fourwing flyingfish (*Hirundichthys affinis*) in the central western Atlantic (Gomes, Oxenford and Dales, 1999).

4.1.1 The fishery

Flyingfish fisheries are concentrated in the southern end of the Lesser Antilles island chain. Barbados, EU [FR Martinique] and Trinidad and Tobago all have historically important directed flyingfish fisheries and to a lesser extent Dominica, Grenada and Saint Lucia (CRFM, 2019). They are likely exploiting a single stock unit that at least extends from Dominica to Trinidad and Tobago.

The fourwing flyingfish supports important small-scale fisheries in the region in terms of employment generation, food security and supply of bait for fisheries targeting large pelagic fish species. As with other fisheries in the Caribbean, fishers involved in flyingfish fisheries often belong to the lower socioeconomic strata of society (CRFM, 2012).

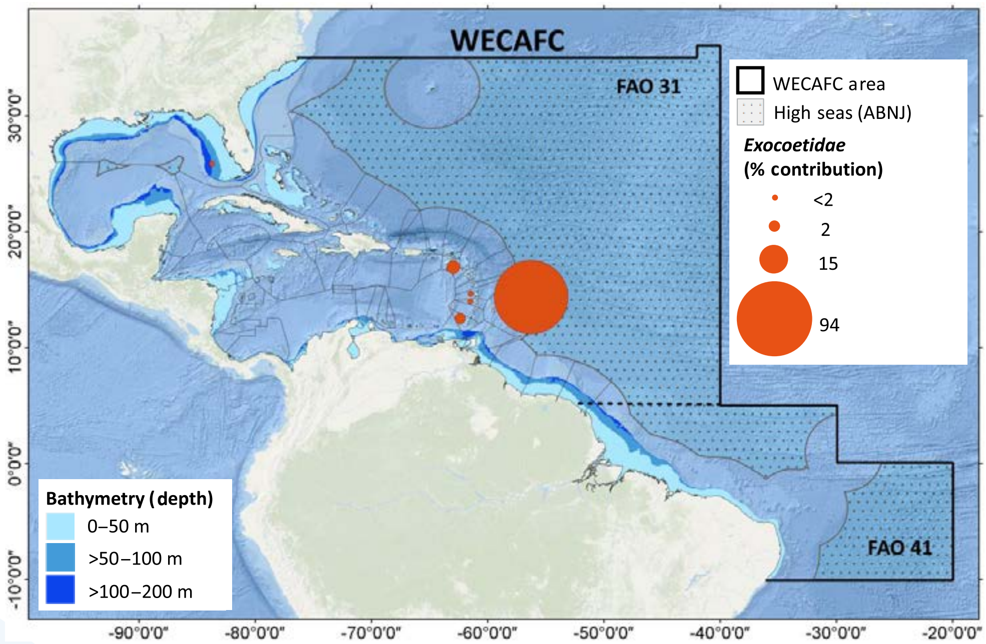
Historical landings of flyingfishes NEI (in which fourwing flyingfish is the dominant species in the reported landings) fluctuate throughout the time series – around 2 000 and 3 000 tonnes per year between 1950 and 1983. Landings reached their highest levels in 1983, 1985 and 1988, amounting to over 4 000 tonnes each year. After 1988, landings dropped and fluctuated at around 1 500 tonnes, until recently when landings dropped to around 500 tonnes in 2016, largely due to the decrease in landings in Barbados. Over 93 percent of flyingfish landings were caught by Barbados between 2015 and 2019 (Table 4.1; Figure 4.2), the remaining landed catch was from Saint Kitts and Nevis, Grenada, EU [FR Martinique], United States and Saint Lucia over the same period.

Table 4.1 Flyingfish catch by country for the period 2015 to 2019 (tonnes)

Country	2015	2016	2017	2018	2019	Rank	%	%cum
Group: Pelagic species. Species: flyingfish – Exocoetidae. Species code: FFV								
Barbados	378	469	777	775	775	1	93,79	
Saint Kitts and Nevis	33	17	9	22	8	2	2,63	96,42
Grenada	16	16	16	16	16	3	2,36	98,78
Martinique	7	7	7	7	7	4	1,03	99,82
United States of America	0	0	4	0	0	5	0,12	99,94
Saint Lucia	0	1	1	0	0,02	6	0,06	100,00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Figure 4.2. *Hirundichthys affinis* (flyingfish, FFV) percentage contribution to total catch in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

There were more than 1 700 boats of small to medium size engaged in flyingfish fisheries in the early 2000s. In recent times, there have been more than 1 850 registered boats in Barbados capable of targeting flyingfish and more than 2 800 in the region (CRFM, 2019). In Trinidad and Tobago, the flyingfish fishery is located on the Caribbean Sea coast of the island of Tobago. In Saint Lucia, 331 vessels were engaged in the flyingfish fishery in 2007 (FAO, 2010). There are no targeted flyingfish fisheries in Saint Vincent and the Grenadines. In Dominica, there has been a shift from the flyingfish fishery to the large pelagic fishery within the last eight years due to the increased use of FADs.

The fishing effort for flyingfish is highly seasonal (December to June), driven by the seasonal availability of both flyingfish and the large pelagic species, particularly dolphinfish. The most recent estimates of fishing effort in the subregion – in terms of the number of fishing trips during which flyingfish were caught – were assembled by Medley *et al.* (2010) for Barbados, Saint Lucia and Trinidad and Tobago for the period 1988 to 2008. The mean total number of fishing trips conducted per year by the fleets of these three countries over this period was 78 200. Barbados day boats account for most fishing trips, averaging 43 300 per year, followed by Barbados ice boats averaging around 21 800. Tobago day boats contribute on average 10 800 fishing trips, while Saint Lucia dayboats make some 2 300 trips per year.

The socioeconomic information available for the flyingfish fishery is mostly related to a diagnostic study to determine poverty and vulnerability levels in CARICOM fishing communities (CRFM, 2012). The study was conducted in some countries that have directed flyingfish fisheries including Barbados and Grenada, and other countries that do not make an important contribution to the flyingfish fishery. The study identified poverty and vulnerability with reference to unsatisfied basic needs. Households with more than one unsatisfied basic need were classified as poor households. Households with one unsatisfied basic need were classified as vulnerable. In Grenada, about 6 percent of fisher households were classified as poor, while in Barbados, poverty was not a problem. However, vulnerability was an important issue for both countries; 25.62 percent of households in Grenada and 7.37 percent of households in Barbados were determined to be vulnerable. The study indicated that vulnerability statistics correlate with the degree of development of flyingfish value chains across the eastern Caribbean. The best example is Barbados which has the most complex value chain that begins with an active commercial harvest and ends in value-added products processed for local and export markets.

4.1.2 State of the stocks

The fourwing flyingfish stock recruitment model and associated risk assessment approach, with decision rules to facilitate management decision-making, was applied in the most recent stock assessment for the fourwing flyingfish in the eastern Caribbean (Medley *et al.*, 2010). The results of the stock assessment suggested that the stock was not overfished, and that overfishing was not occurring (Table 4.2; FAO, 2017–2023). Catch rates had remained stable overall in the time series as catches increased. Given the potential stock area and estimates of a relatively large stock size from tagging and survey estimates, it is likely that the potential yield exceeds total catches taken throughout the history of the fishery. There is no immediate action required by management to conserve the stock unless there is a significant increase in catches. In the proposed subregional management plan for fourwing flyingfish (CRFM, 2014), a catch trigger point of 5 000 tonnes was to be established to ensure the stock does not become overfished.

The major gap in the flyingfish resource is the significant uncertainty in the most recent assessments that continue to stem from the poor data available on catches and effort (CRFM, 2019). However, in recent years, massive sargassum influxes that occurred throughout the southeastern Caribbean in 2011 to 2012, 2014 to 2015 and 2018 appear to have affected the availability of flyingfish and may have affected the catch composition of the pelagic fishery. Thus, declines in recent flyingfish catches in years of sargassum influx may be primarily due to reductions in catchability rather than stock abundance. Research will be needed to determine the impacts of sargassum on flyingfish population dynamics in the eastern Caribbean fishery or if there is a catchability/connectivity effect between open ocean waters and the waters around the Lesser Antilles island-chain (Figure 4.2).

Table 4.2 **Stock status of key regional species, major tunas, small tunas and tuna-like species in the Western Central Atlantic Fishery Commission region**

Common name/species name	ICCAT (or CRFM#)				FIRMS		FAO categorization	Reference year
	Stock unit	Assessment year	Overfished	Overfishing	Abundance level	Exploitation rate	WECAFC/SAG/IX/2018/3	
Key regional species								
Flyingfishfish/ *Hirundichthys affinis*	Subregional stock	2007*	No	No	Pre- exploitation biomass	No or low fishing mortality	–	–
Major tunas								
Yellowfin tuna/*Thunnus albacares*	Atlantic	2019	No	No	Intermediate abundance	Moderate fishing mortality	O	2015
Skipjack tuna/ *Katsuwonus pelamis*	West	2014	No	No	Not applicable	Not applicable	F	2013
Northern bluefin tuna/ *Thunnus thynnus*	Atlantic	2020	–	No	Not assessed	Moderate fishing mortality	?	2015
Albacore/*Thunnus alalunga*	West Atlantic	2020	No	No	Intermediate abundance	No or low fishing mortality	F	2014
Bigeye tuna/*Thunnus obesus*	North Atlantic	2021	Yes	No	Low abundance	High fishing mortality	O	2014
Small tunas								
Blackfin tuna/*Thunnus atlanticus*	West Atlantic	2016	-	Vulnerability: high*	-	-	-	-
Little tunny/*Euthynnus alletteratus*	NW Atlantic	2014–2016	No**	Vulnerability: moderate***	-	-	-	-
Frigate tuna/*Auxis thazard*	NW Atlantic	Not assessed	-	Vulnerability: low**	-	-	-	-
Bullet tuna/*Auxis rochei*	NW Atlantic	Not assessed	-	Vulnerability: Low**	-	-	-	-
Atlantic bonito/*Sarda sarda*	NW Atlantic	2016	-	Vulnerability: Low**	-	-	F–O	2016
Tuna-like species								
Swordfish/*Xiphias gladius*	North Atlantic	2017	No	No	Intermediate abundance	Moderate fishing mortality	F	2015
Atlantic sailfish/ *Istiophorus albicans*	West Atlantic	2016	Not likely	Not likely	Intermediate abundance	No or low fishing mortality	F	2014
Blue Marlin/*Makaira nigricans*	Atlantic	2018	Yes	Yes	Low abundance	High fishing mortality	O	2016
Atlantic white marlin/ *Tetrapturus albidus*	Atlantic	2019	Yes	No	Intermediate abundance	High fishing mortality	-	-
Longbill spearfish/ *Tetrapturus pfluegeri*	West Atlantic	Not assessed	-	-	-	-	-	-
Roundscale spearfish/ *Tetrapturus georgii*	Not defined	Not assessed	-	-	-	-	-	-
Common dolphinfish/ *Coryphaena hippurus*	NW Atlantic	Not assessed	-	-	-	-	-	-
Wahoo/*Acanthocybium solandri*	NW Atlantic	2014–2016	Yes**	-	-	-	-	-

Notes: F= fully exploited; O= overexploited; U= non-fully exploited.
* ICCAT. 2017b. Report of the 2016 Small Tunas Species Group Intersessional Meeting, 4–8 April 2016. ICCAT Collective Volume of Scientific Papers, 73(8): 2591–2662.
** ICCAT. 2016b. Report of the 2015 Small Tunas Species Group Intersessional Meeting, 10–13 June 2015. ICCAT Collective Volume of Scientific Papers, 72(8): 2120–2185.
*** Pons, M., Lucena-Fredou, F., Fredou, T. & Mourtao, B. 2019. Exploration of length-based and catch-based data limited assessments for small tunas. ICCAT Collective Volume of Scientific Papers, 76(5): 78–95.
Source: Authors' compilation.

4.2 The tunas and tuna-like resources

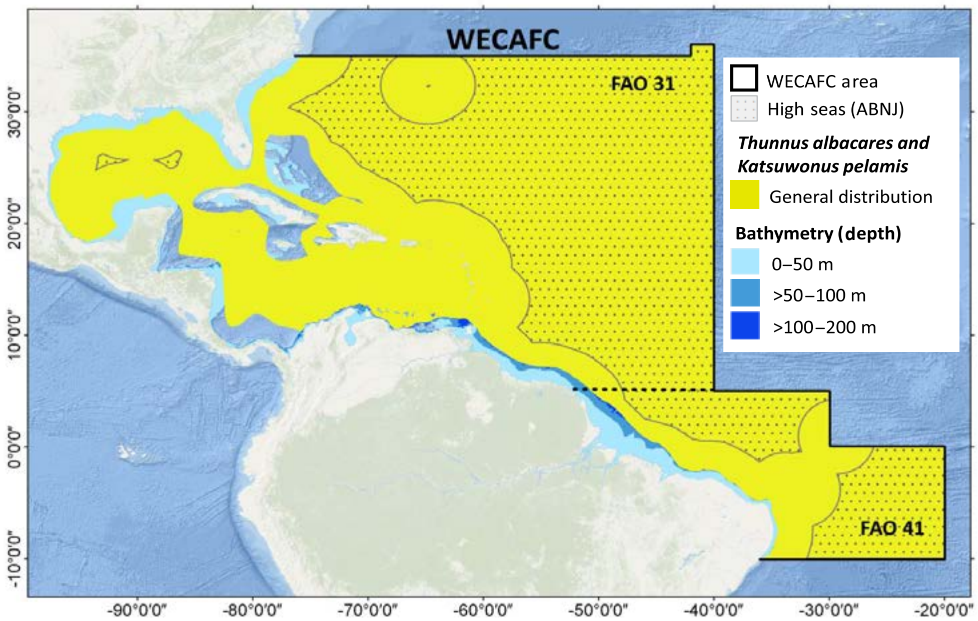
The tunas and several tuna-like species include the most economically important species because of their global and regional economic importance and their intensive international trade. For the purpose of this report, the tunas are classified into major tunas, all of which belong the *Thunnus* and *Katsuwonus* genera, and small tunas, which include three genera (*Euthynnus, Auxis* and *Thunnus*). The tuna-like species consists of istiophorid species occurring in the WECAFC region: swordfish, wahoo and common dolphinfish.

4.2.1 Major tunas

The major tunas include albacore tuna (*Thunnus alalunga*), bluefin tuna (*Thunnus thynnus*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*) and skipjack tuna (*Katsuwonus pelamis*). In the WECAFC region, the most important major tunas are the yellowfin tuna, skipjack tuna and bluefin tuna; the first two because of the volume of catches and the latter because of its high economic value.

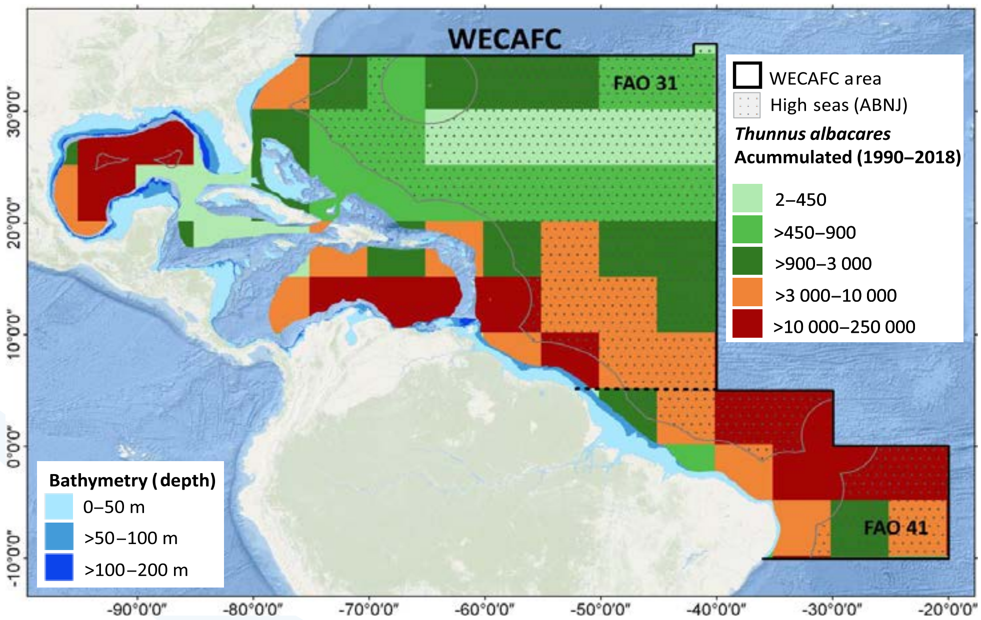
Yellowfin tuna is considered to be a single Atlantic-wide stock and a cosmopolitan open-water pelagic and oceanic species. It occurs above and below the thermocline to depths of up to 400 m throughout the WECAFC region (Figure 4.3). However, a recent study on population genomics at a global scale challenges current stock delineation (Pecoraro *et al.*, 2016, 2018) indicating that there is a strong genetic differentiation between populations in the eastern and western Atlantic. Yellowfin tuna is sensitive to low concentrations of oxygen and therefore it is not usually caught below 250 m in the tropics and is found in waters warmer than 18 °C. The species schools primarily by size, either in monospecific or multispecies groups. In the region, particularly in the Caribbean Sea, yellowfin tuna is associated with whale sharks and whales, with a certain seasonality depending on the presence of these mammals (Gaertner and Medina-Gaertner, 1999). Spawning in the WECAFC region consistently takes place from May to November in the GOM and to a lesser extent in the southeastern Caribbean Sea (Arocha *et al.*, 2000) at sea surface temperatures above 24 °C. In the region, the areas of major abundance (based on spatial distribution of the catches) are the GOM, the southern Caribbean Sea, off the NBSLME and the southern limit of the region off Brazil (Figure 4.4).

Figure 4.3. *Thunnus albacares* (yellowfin tuna, YFT) and *Katsuwonus pelamis* (skipjack tuna, SKJ) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.4. *Thunnus albacares* (yellowfin tuna, YFT) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)

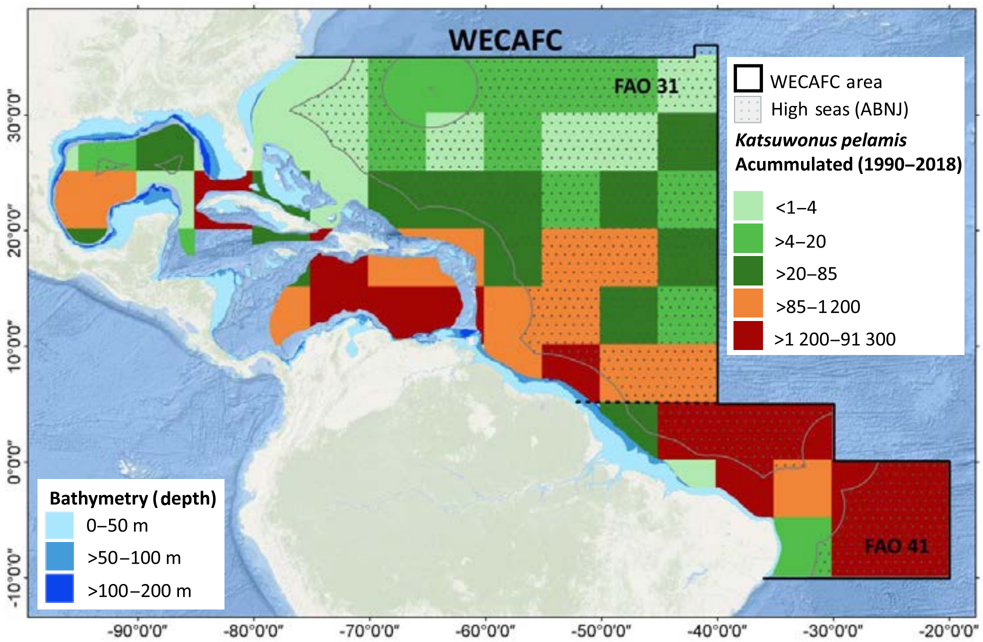


Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Skipjack tuna, like yellowfin tuna, is a cosmopolitan open-water pelagic and oceanic species occurring in offshore waters to depths of 260 m, normally found in highly oxygenated waters between 20 °C and 30 °C. In the WECAFC area, it is commonly found in mixed schools with yellowfin tuna and associated with birds, drifting objects, whale sharks and whales (Gaertner and Medina-Gaertner, 1999). The skipjack tuna distributed throughout the

WECAFC region is considered to belong to the western Atlantic stock (Figure 4.3), although a recent review based on movement patterns in the Atlantic suggested that due to the low north–south mixing in the western Atlantic (Fonteneau, 2015), the mixing rates of remote fractions of skipjack between GOM/Caribbean Sea and southern Brazil were probably very low or absent, suggesting that current stock structure is not a fully valid one for assessments and management of the resource. Skipjack tuna has a short lifespan, with high fecundity. It spawns opportunistically and seasonally throughout the year in warm waters above 25 °C (Cayré and Farrugio, 1986; Andrade and Santos, 2004) in the GOM and the southeastern Caribbean Sea (Brenner and McNulty, 2018; Pagavino, 1997). In the region, the areas of major abundance (based on spatial distribution of the catches) are the southern Caribbean Sea and, to a lesser extent, the southwestern GOM (Figure 4.5).

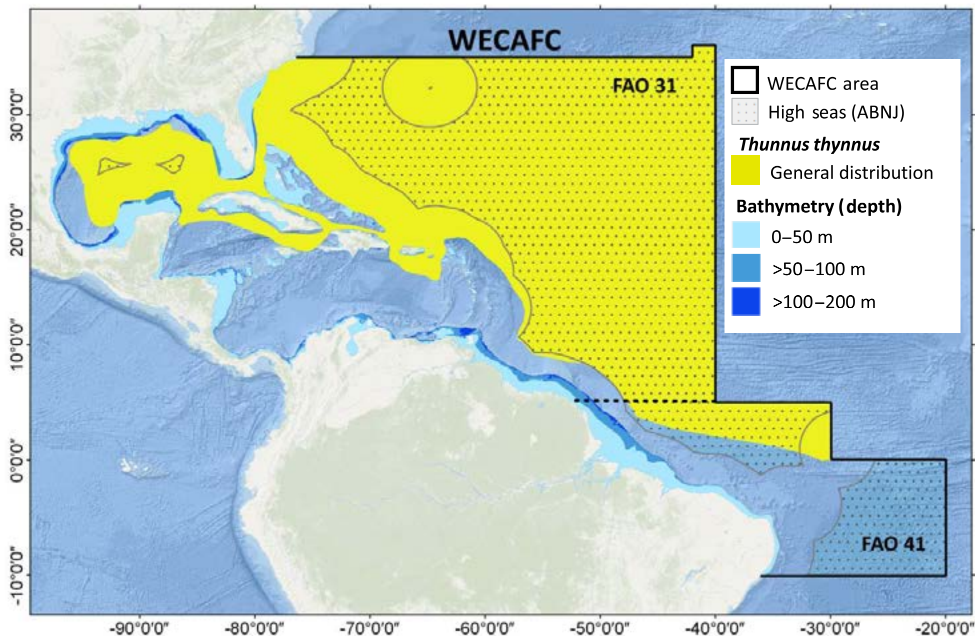
Figure 4.5. *Katsuwonus pelamis* (skipjack tuna, SKJ) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

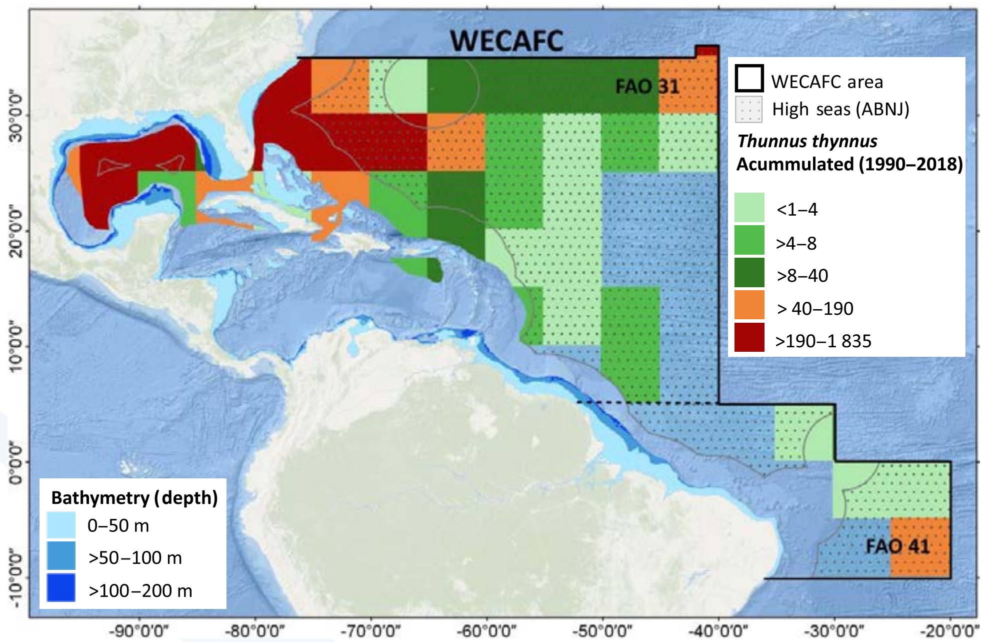
Bluefin tuna, the most economically valuable tuna, is long-lived with a wide geographical distribution. It lives permanently in the temperate waters of the North Atlantic and aggregates along ocean fronts to feed (ICCAT, 2006–2016). The bluefin tuna in the WECAFC region is part of the metapopulation that occurs in the western North Atlantic, occupying distinct and patchy suitable habitats, displaying late maturation and with distinct spawning grounds in the GOM (Fromentin and Powers, 2005) (Figure 4.6). In the region, the areas of major abundance (based on the spatial distribution of catches) in recent years are in the northern GOM (ICCAT, 2020a) (Figure 4.7).

Figure 4.6. *Thunnus thynnus* (northern bluefin tuna, BFT) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

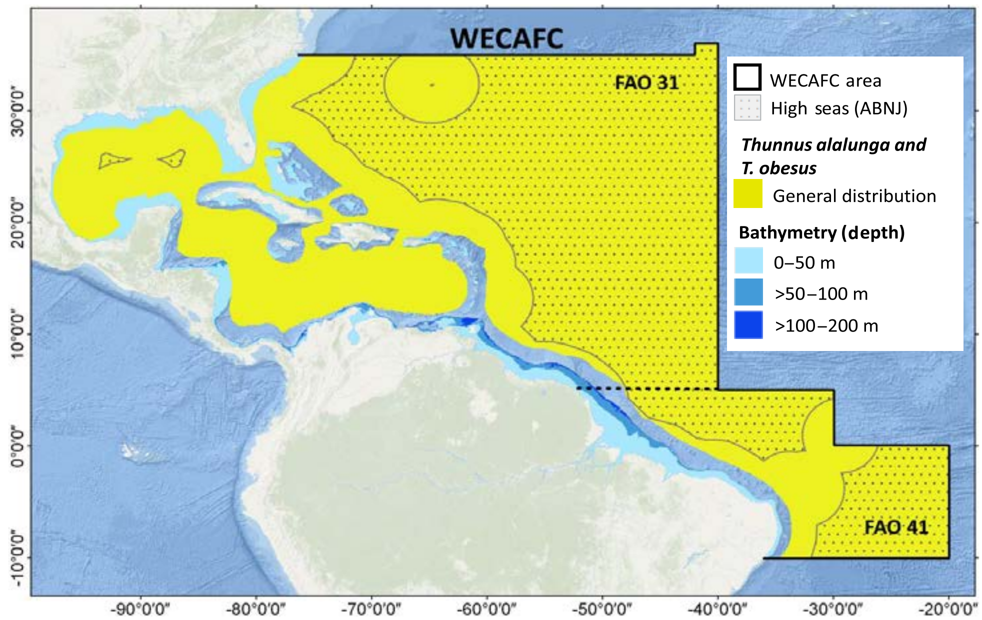
Figure 4.7. *Thunnus thynnus* (northern bluefin tuna, BFT) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

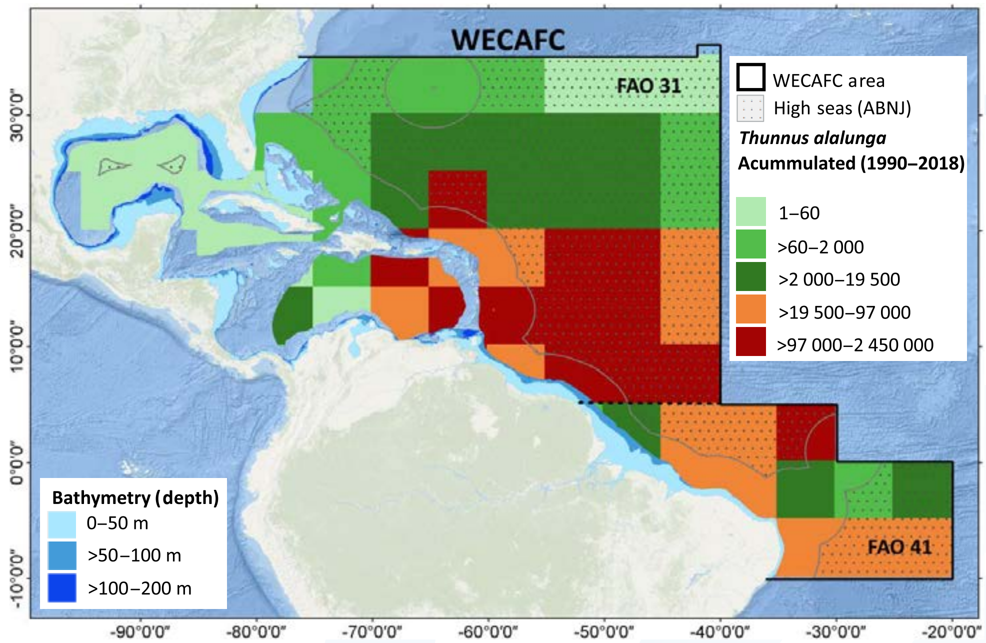
The other two major tuna species, albacore, and bigeye tuna, are widely distributed throughout the Atlantic Ocean, including the WECAFC region (Figure 4.8). Albacore tuna is considered a temperate species, while bigeye tuna is mostly a tropical species. Albacore tuna is longer lived (15 years) than bigeye tuna (9 years). Both species spawn in tropical waters off the NBSLME (ICCAT 2006–2016; Arocha, 2020) and southwest of the Sargasso Sea (Luckhurst and Arocha, 2016). Albacore in the WECAFC region is part of the North Atlantic stock, although some studies support the hypothesis that various subpopulations may exist within the northern stock. Bigeye tuna occurring in the region is part of an Atlantic-wide stock (ICCAT 2006–2016). The areas of major abundance (based on the spatial distribution of catches) for albacore tuna in recent years include the southern Caribbean Sea, off the NBSLME and the area of the high seas within the WECAFC region (Figure 4.9), while for bigeye tuna major abundances are in the southern Caribbean Sea and the area of the high seas within the WECAFC region (Figure 4.10).

Figure 4.8. *Thunnus alalunga* (albacore, ALB) and *T. obesus* (bigeye tuna, BET) general distribution in the Western Central Atlantic Fishery Commission region



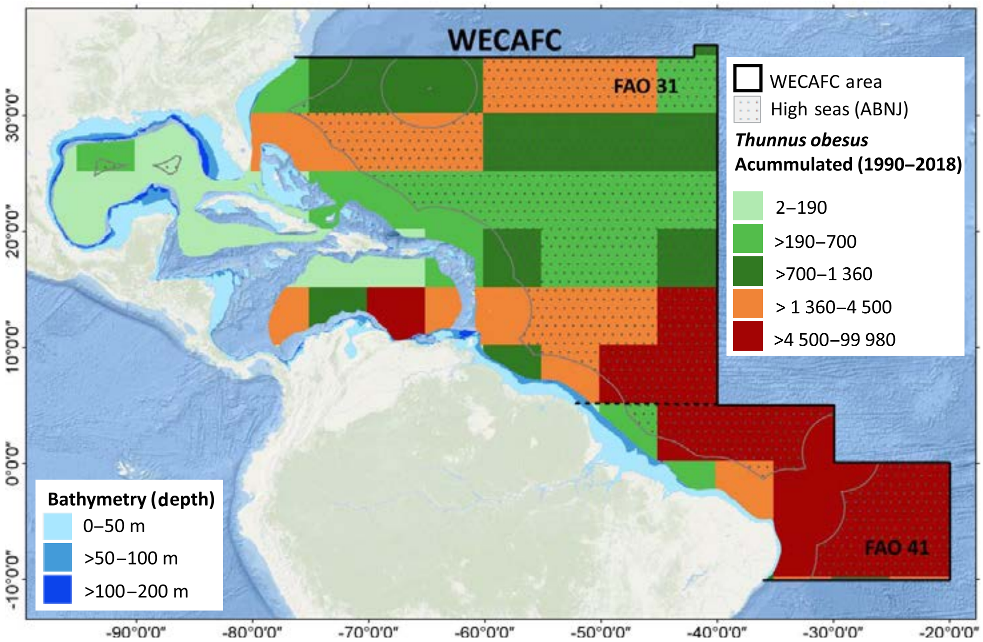
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.9. *Thunnus alalunga* (albacore, ALB) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.10. ***Thunnus obesus*** **(bigeye tuna, BET) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)**

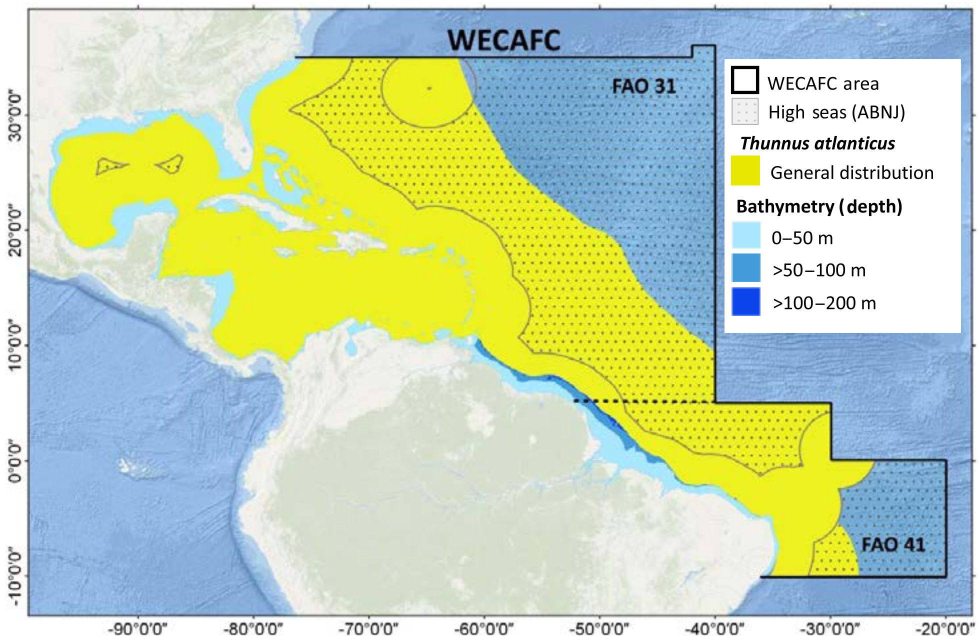


Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

4.2.2 Small tunas

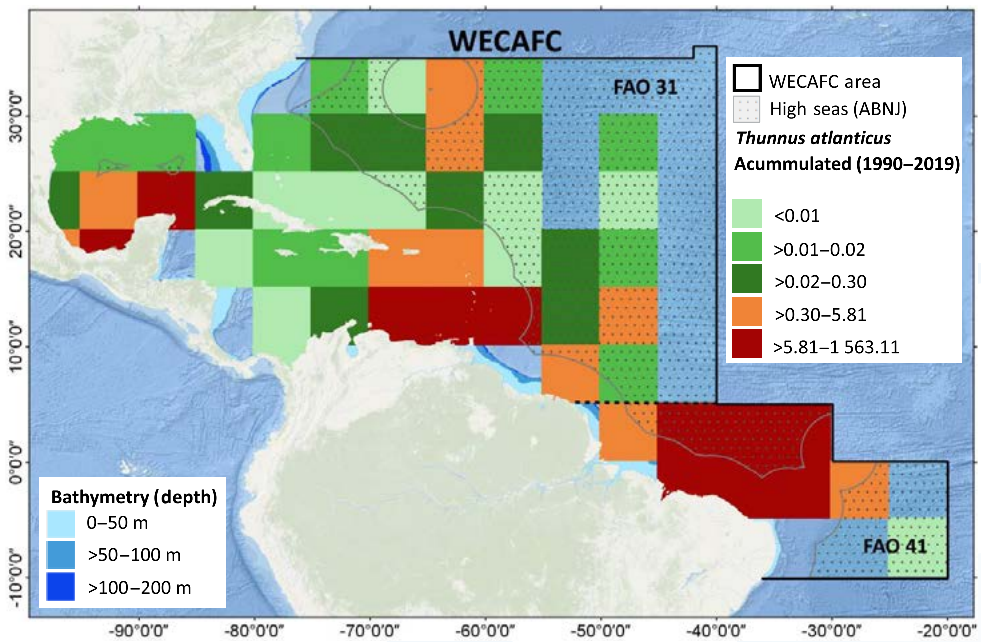
The small tunas include blackfin tuna (*Thunnus atlanticus*), little tunny (*Euthynnus alleteratus*), frigate and bullet tuna (*Auxis thazard, Auxis rochei*). The Atlantic bonito (*Sarda sarda*) is also included in the small tuna subgroup due to its presence in the tuna purse seine fishery in the Caribbean Sea. Blackfin tuna exists only in the western Atlantic, limited to most of the WECAFC region and is the most relevant and common species within the small tunas group (Figure 4.11). It is an epipelagic species, often found over reefs, in bays, offshore and the high seas. It sometimes occurs in large schools, often with yellowfin tuna and skipjack tuna. A recent study on the genetic structure of blackfin tuna in the region (Saillant *et al.*, 2016), suggests the occurrence of a weak pattern of isolation by distance where genetic distance increases as a function of geographic distance (i.e. southern United States versus Bolivarian Republic of Venezuela–northern Brazil). In the region, the areas of major abundance (based on spatial distribution of the catches) for blackfin tuna in recent years are in the Caribbean Sea, mostly associated with catches of the purse seine and pole and line fisheries off Bolivarian Republic of Venezuela (Narváez *et al.*, 2017) and in the southeastern GOM (Figure 4.12). Little tunny, frigate tuna, bullet tuna and Atlantic bonito are less oceanic and more associated with continental shelves than other tunas. All species are mostly distributed across the region, except for Atlantic bonito, which seems to have a more limited distribution in the GOM, southeast United States and the southern Caribbean Sea (figures 4.13, 4.14 and 4.15). In the region, the areas of major abundance (based on the spatial distribution of catches) for this group of small tunas were aggregated for the four species and are in the south central Caribbean and off the NBSLME in the boundary between the EEZs and the ABNJ (Figure 4.16).

Figure 4.11. *Thunnus atlanticus* (blackfin tuna, BLF) general distribution in the Western Central Atlantic Fishery Commission region



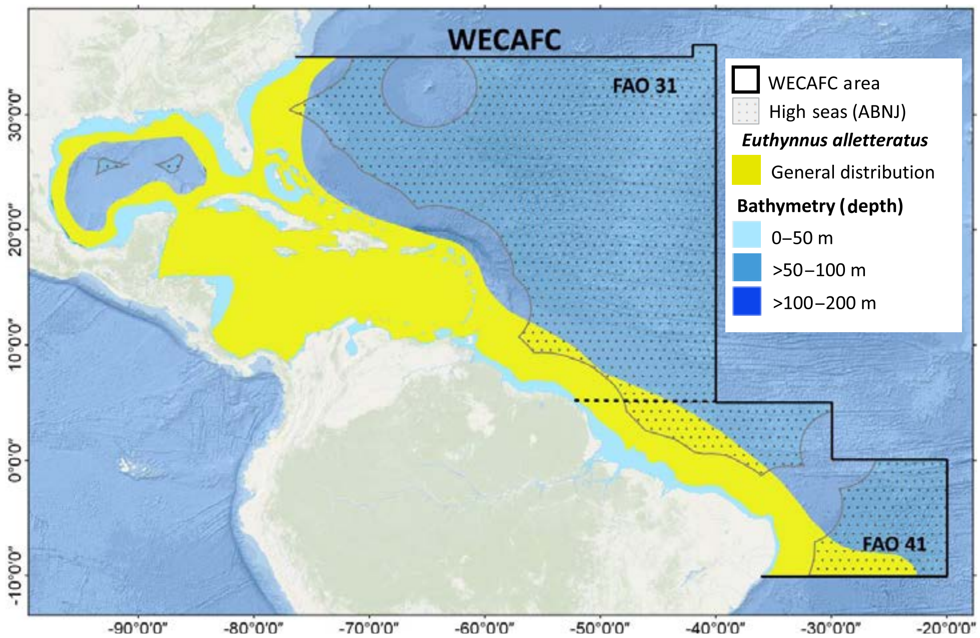
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.12. *Thunnus atlanticus* (blackfin tuna, BLF) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)



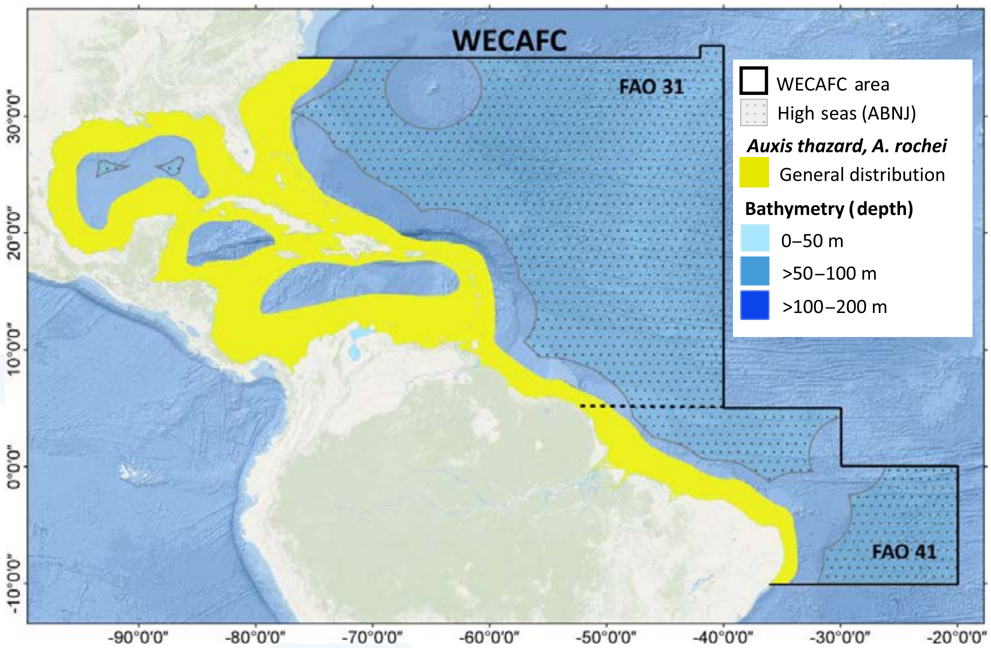
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.13. ***Euthynnus alleteratus*** **(little tunny, LTA) general distribution in the Western Central Atlantic Fishery Commission region**



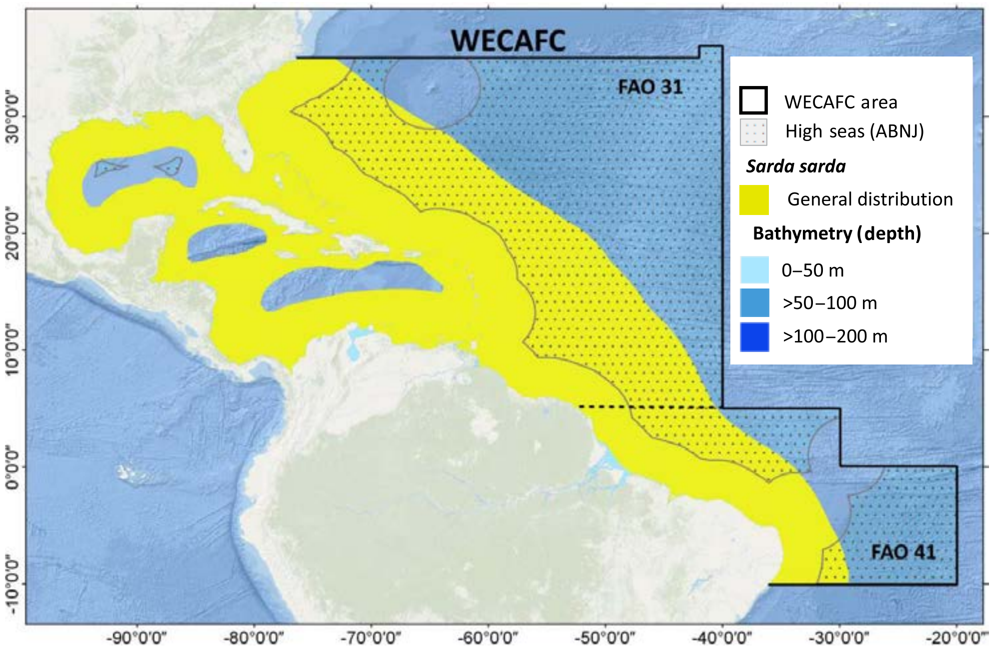
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.14. ***Auxis thazard*** **(frigate tuna, FRI) and *A. rochei* (bullet tuna, BLT) general distribution in the Western Central Atlantic Fishery Commission region**



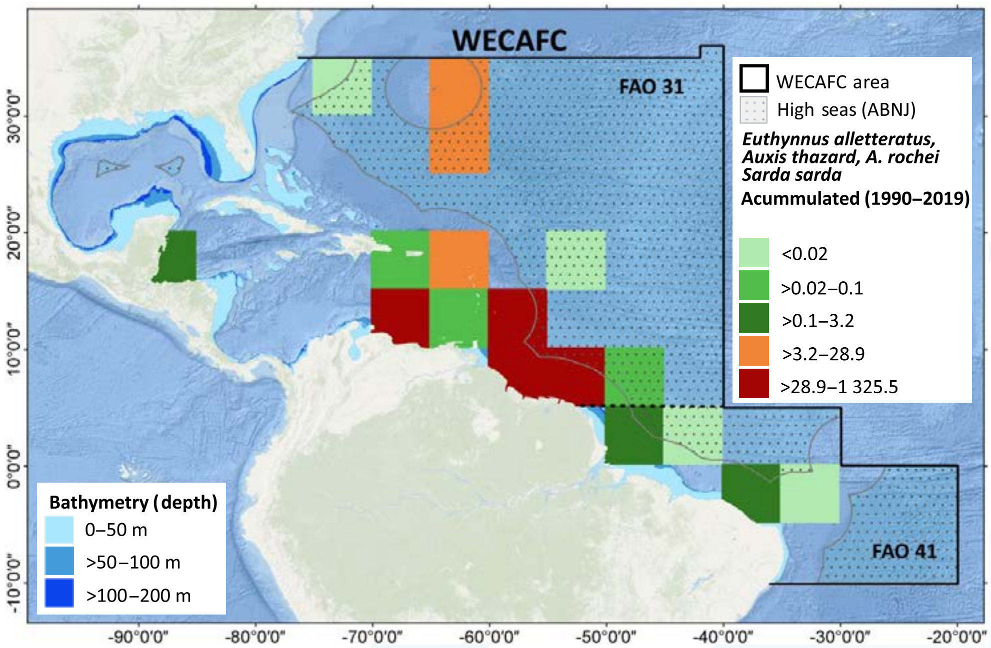
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.15. *Sarda sarda* (Atlantic bonito, BON) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.16. *Euthynnus alleteratus* (little tunny, LTA), *Auxis thazard* (frigate tuna, FRI), *A. rochei* (bullet tuna, BLT) and *Sarda sarda* (Atlantic bonito, BON) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)

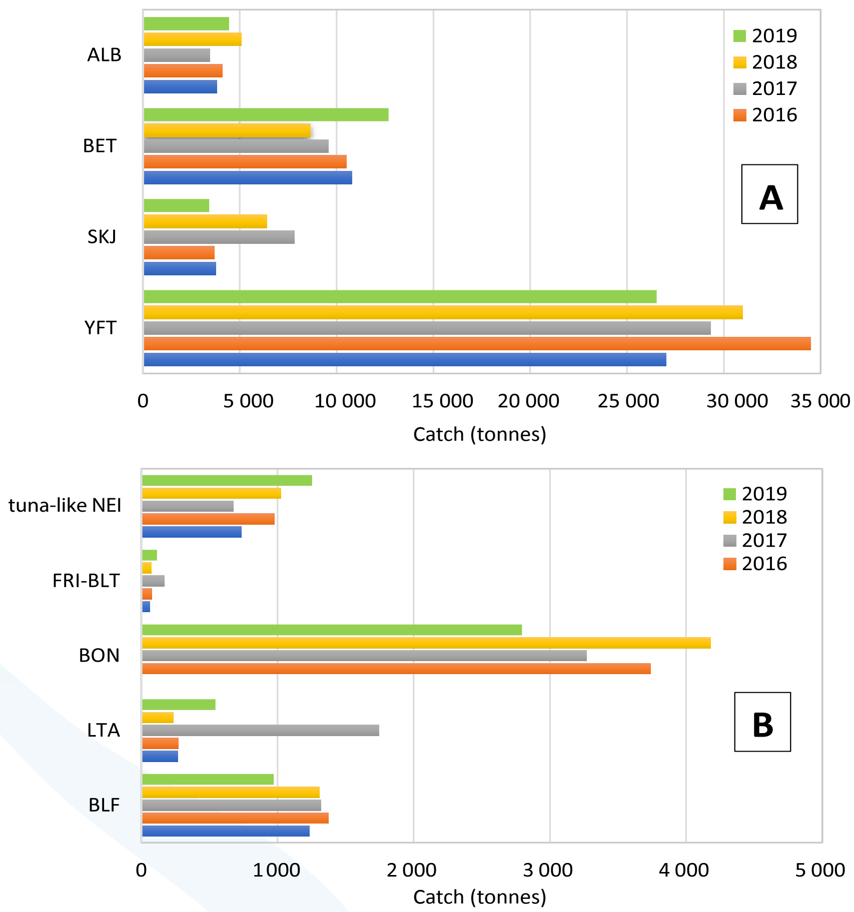


Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

4.2.3 The fishery for tunas

The tuna fishery started in the western Atlantic Ocean during the late 1950s. Several Japanese longliners conducted commercial feasibility operations in the Caribbean Sea between 1955 and 1958. The encouraging results led to a substantial increase in the number of vessels operating in the area and the establishment of a Venezuelan–Japanese-based longline fishing operation in Cumaná in 1957 (Kawaguchi, 1974). The main targets of the fishery were yellowfin tuna and albacore tuna. About the same time (1957), Cuba also started longline operations with Japanese vessels in the GOM, the Atlantic Ocean and the Caribbean Sea, targeting tunas, marlins and bluefin tuna off Florida. The purse-seine fishery in the western Atlantic is opportunistic. It was started in the late 1970s by Venezuelan purse seiners that fished mostly in the eastern Pacific (Miyake, Miyabe and Nakano, 2004). The vessels that fish in the WECAFC region were generally from the Pacific and only a few smaller vessels remain in the area, operating with the baitboat fishery that started in the late 1970s.

Figure 4.17. Recent trend in the WECAFC region catches of: A) major tunas (ALB: albacore tuna, BET: bigeye tuna, SKJ: skipjack tuna, YFT: yellowfin tuna); and B) tuna-like and small tunas (FRI: frigate tuna, BLT: bullet tuna, BON: bonito, LTA: little tunny, BLF: blackfin tuna) (tonnes)



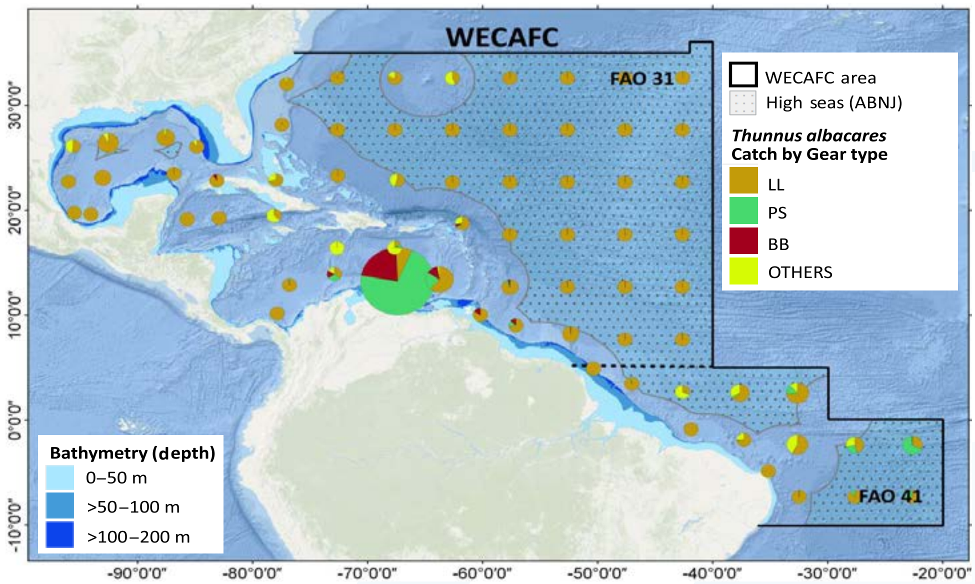
Note: Data for this study came from statistical data sources revised in 2021.

Source: FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en; ICCAT. 2023. Access to ICCAT statistical databases. In: *ICCAT*, Madrid. [Cited 19 July 2023]. www.iccat.int/en/accesingdb.html

In the WECAFC region, the catches of the initial target species – yellowfin and albacore tunas – increased very rapidly and were the most important species caught by both longlines and surface gears for a period of time. However, since 1972, with the development of the surface fishery (baitboats and purse seines), the yellowfin and skipjack catch increased, while the albacore catch has stabilized. The yellowfin catch was the greatest until 1991, when it was exceeded by the skipjack catch (ICCAT, 2020b). Over the most recent period (2015 to 2019), yellowfin tuna has been the species with the highest reported landings in the region, with over 25 000 tonnes, while the remainder of the major tuna species were below 10 000 tonnes over the same period, with the exception of bigeye tuna which exceed 10 000 tonnes (Figure 4.17A). For the tuna-like species (swordfish, Atlantic blue marlin, Atlantic sailfish, Atlantic white marlin) combined catches are rarely over 1 000 tonnes in the region. As for small tunas, bonito is by far the species that represents the largest catches of this group, followed by blackfin tuna (Figure 4.17B).

The dominant major tuna species caught in the region belong the group known as tropical tunas: yellowfin tuna, bigeye tuna and skipjack tuna. These species are the main target of the tuna fisheries in the region. For yellowfin tuna, a little over 90 percent of the reported landings in the WECAFC region come from eight countries, of which Brazil, Suriname and Bolivarian Republic of Venezuela account for close to 70 percent of the reported landings over the period 2015 to 2019 (Table 4.3). In the case of bigeye tuna, four countries in the WECAFC region account for close to 90 percent of the reported landed catch for the same period; however, distant water fishing nations, like Japan and China combined, account for 20 percent of the landed catch and Brazil 54 percent (Table 4.4). For skipjack tuna, about 90 percent of the landed catch comes from five WECAFC countries, of which Brazil and Bolivarian Republic of Venezuela accounted for 82 percent of the landed catch for the same period (Table 4.5).

Figure 4.18. *Thunnus albacares* (yellowfin tuna, YFT) proportional catch in 5°x5° by major gear in the Western Central Atlantic Fishery Commission region



Notes: LL= longline; PS= purse seine; BB= baitboats.

Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Table 4.3 Yellowfin tuna catch by country for the period 2015–2019 (tonnes)

Country	2015	2016	2017	2018	2019	Rank	%	%cum
Group: Pelagic species. Species: *Thunnus albacares* – yellowfin tuna. Species code: YFT								
Brazil	13 080	14 216	11 996	15 741	1 1875	1	45.11	
Venezuela (Bolivarian Republic of)	3 127	4 204	5 059	2 743	2 029	2	11.57	56.68
Suriname	2 632	2 384	3 050	3 370	3 538	3	10.10	66.77
Panama	1 580	1 683	1 620	2 104	2 382	4	6.32	73.09
Mexico	1 176	1 574	1 305	1 763	1 376	5	4.85	77.94
Grenada	1 167	1 607	1 257	1 391	1 300	6	4.53	82.47
Trinidad and Tobago	1 179	1 057	890	1 214	981.59	7	3.59	86.06
United States of America	669	742	718	448	323	8	1.96	88.02
France	632	403	346	488	864	9	1.84	89.86
Belize	0	2163	359	8.96	0	10	1.71	91.57
Japan	612	454	410	144	685	11	1.55	93.12
Colombia	0	1911	24	25	0	12	1.32	94.44
Saint Vincent and the Grenadines	153	434	772	373	105	13	1.24	95.68
Barbados	262	324	270	248	121	14	0.83	96.50
Dominican Republic (the)	70	350	376	111	195	15	0.74	97.25
Saint Lucia	175	191	232	199	171.85	16	0.65	97.90
Dominica	194	179	209	116	120	17	0.55	98.45
El Salvador	31	381	91	21	18	18	0.37	98.82
Taiwan Province of China	68	67	60	180	110	19	0.33	99.14
Martinique	86	89	90	90	91.10	20	0.30	99.45
China	0	13	22	35	130	21	0.13	99.58
Guatemala	0	18	71	40	13	22	0.10	99.68
Bermuda	10	9	25	32	50	23	0.08	99.76
Guyana	14	0	1	52	48	24	0.08	99.84
Spain	31	10	21	9	3.04	25	0.05	99.89
Vanuatu	64	0	0	0	0	26	0.04	99.93
Saint Kitts and Nevis	1	5	30	12	1	27	0.03	99.96
Republic of Korea (the)	11.01	11.64	2.93	5.93	0	28	0.02	99.99
Puerto Rico	5	2	1	2	1.78	29	0.01	99.99
United States Virgin Islands	2	5	2	0	0	30	0.01	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

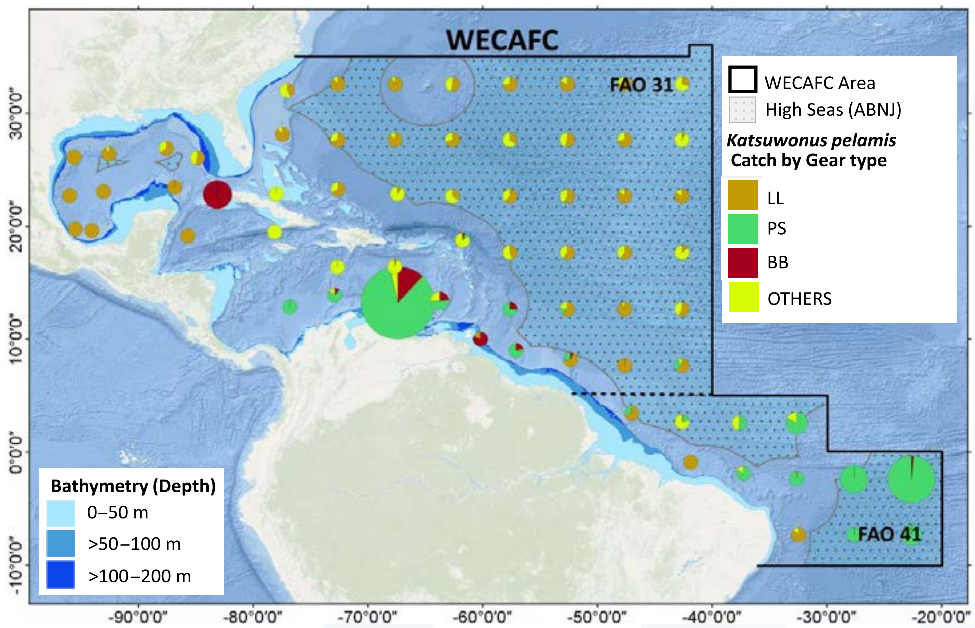
The other two tuna species, bluefin tuna and albacore tuna, are considered temperate tunas. Bluefin tuna caught in the WECAFC region has been under strict catch quota regulations since the early 1980s, and of the coastal states and islands within the WECAFC region, only three countries have catch quotas, namely, Bermuda, Mexico and the United States. Between 2015 and 2019, only the United States and Mexico reported catches (Table 4.4); the United States has landed around 1 000 tonnes annually (of the 1 247.86 tonne TAC), Mexico has landed under 100 tonnes annually (of the 128.44 tonnes TAC), and Bermuda has a catch quota of 5.31 tonnes (ICCAT, 2020b, 2021a).

Table 4.4 Bigeye tuna and bluefin tuna catch by country for the period 2015–2019 (tonnes)

Country	2015	2016	2017	2018	2019	Rank	%	%cum
Group: Pelagic species. Species: *Thunnus obesus* – bigeye tuna. Species code: BET								
Brazil	6 792	6 537	5 277	4 168	5 417	1	54.00	
Japan	1 337	1 038	1 106	1 235	1 737	2	12.36	66.36
China	5	443	281	659	3 104	3	8.60	74.97
Saint Vincent and the Grenadines	496	622	889	428	504	4	5.63	80.59
Suriname	495	2	229	303	759	5	3.42	84.02
Panama	301	355	109	419	497	6	3.22	87.24
Belize	28	640	223	353	225	7	2.81	90.05
Spain	218	209	499	300	8.93	8	2.37	92.42
Venezuela (Bolivarian Republic of)	132	156	318	165	28	9	1.53	93.95
Taiwan Province of China	63	80	108	238	229	10	1.38	95.32
Republic of Korea (the)	484.87	24.35	15.07	60.39	0	11	1.12	96.44
United States of America	149	87	123	79	66	12	0.97	97.41
El Salvador	166	57	36	45	46	13	0.67	98.08
Guyana	6	0	180	3	2	14	0.37	98.45
France	0	49	48	81	0	15	0.34	98.79
Trinidad and Tobago	77	37	25	17	13.17	16	0.32	99.11
Guatemala	0	65	42	33	0	17	0.27	99.38
Barbados	30	19	16	29	14	18	0.21	99.59
Grenada	16	16	16	16	16	19	0.15	99.74
Saint Lucia	6	10	25	13	12.89	20	0.13	99.87
Colombia	0	53	0	1	0	21	0.10	99.97
Mexico	2	2	2	2	2	22	0.02	99.99
Saint Kitts and Nevis	0	4	1	0	0	23	0.01	100.00
Group: Pelagic species. Species: *Thunnus thynnus* – bluefin tuna. Species code: BFT								
ICCAT United States	877	1 002	986	1 014	1 185	1	95.10	93.79
ICCAT MEX	53	55	34	80	39	2	4.90	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Figure 4.19. *Katsuwonus pelamis* (skipjack tuna, SKJ) proportional catch in 5°x5° by major gear in the Western Central Atlantic Fishery Commission region



Notes: LL= longline; PS= purse seine; BB= baitboats.
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Albacore tuna, the other tuna to be considered a temperate species, is caught in the region as a bycatch of the targeted fishery for tropical tunas by WECAFC countries. However, about 55 percent of the reported landed catch during the period 2015 to 2019 is from the seasonal targeted fishery of Taiwan Province of China, which operates mainly in the high seas of the WECAFC region (Table 4.5). Of the main four WECAFC Member States landing albacore tuna, the landed catch of the Dominican Republic is unlikely. In this case, catches probably come from fishing on mFADs.

Most of the yellowfin tuna and skipjack tuna catch in the region since the 1990s is attributed to the industrial surface fleet (purse seine and baitboat/pole and line) from Bolivarian Republic of Venezuela which operated mostly in the southern Caribbean Sea, with occasional excursions off the NBSLME (ICCAT, 2020b; figures 4.18, 4.19). The purse seine fishery in the southern Caribbean has been opportunistic, mostly conducted from Venezuelan purse seiners that fished occasionally in the Caribbean Sea when in transit from the eastern Pacific fishing grounds. However, a fleet of about four purse seiners normally operates in the southern Caribbean. The Venezuelan baitboat/pole and line fleet consists of five vessels that operate individually or in company of the purse seine vessels. The catch from the industrial surface fleet is destined for the canning industry, although in recent years it also commercialized a frozen segment in the local market. Purse seine catches also occur, at smaller volumes, at the southern limit of the WECAFC region where handline gear is also used.

The distribution of tuna abundance is represented from the spatial distribution of catches for each species from all gears combined in 5x5 degrees squares in the WECAFC region. The highest abundance of yellowfin tuna within the EEZs occurs in the GOM, the southeastern Caribbean and off the NBSLME, as well as in the high seas at the southern end of the WECAFC region, within a part of Brazil's EEZ, around its offshore archipelago islands of Sao Pedro and Sao Paulo (Figure 4.4). Skipjack tuna shows a similar distribution pattern because it is caught mostly with surface gears. Its highest abundance is in the central and southeastern Caribbean, the eastern part of Cuba and (as with yellowfin tuna) in the high seas at the southern end of the region as well as in a part of Brazil's EEZ around its offshore archipelago islands (Figure 4.5).

According to the spatial distribution of catches of bluefin tuna by gear, longline and handline are the preferred gears used to catch the species (Figure 4.20). The highest concentration is found in the GOM and along the southeast United States, within that country's EEZ, with some high seas hot spots occurring west of the United States (Figure 4.7).

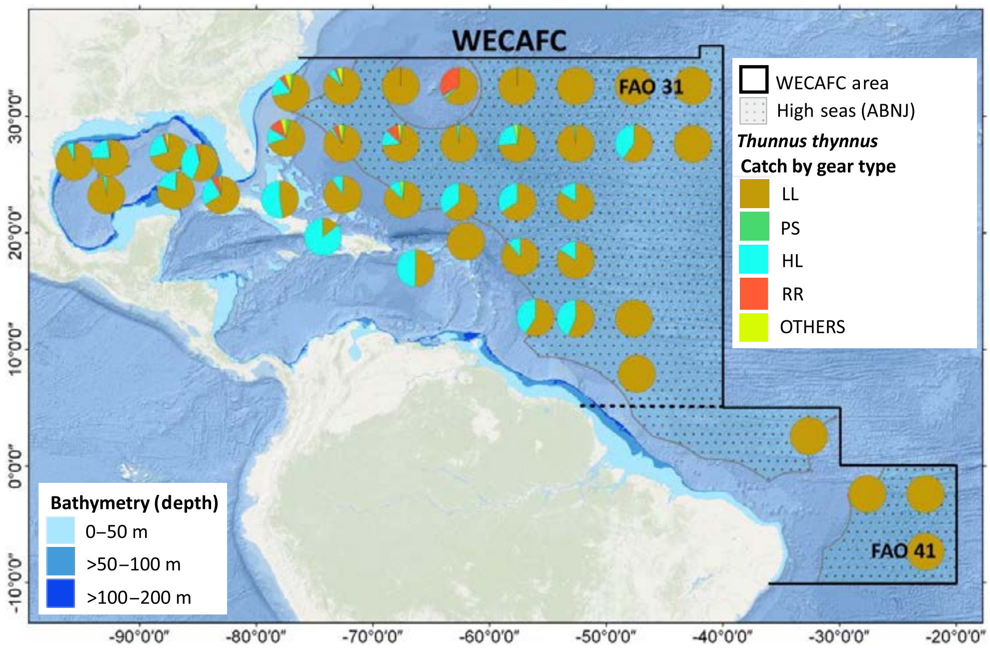
Lancha margariteña, Venezuelan long-range artisanal boat © FAO

Table 4.5 Skipjack and albacore tuna catch by country for the period 2015–2019 (tonnes)

Country	2015	2016	2017	2018	2019	Rank	%	%cum
Group: Pelagic species. Species: *Katsuwonus pelamis* – skipjack tuna. Species code: SKJ								
Brazil	465	459	4 693	4 461	2 195	1	48.85	
Venezuela (Bolivarian Republic of)	2 019	1 914	2 222	1 267	927	2	33.23	82.08
Suriname	841	155	60	6	0	3	4.23	86.31
Colombia	0	599	5	1	0	4	2.41	88.72
Saint Lucia	87	138	142	122	77.66	5	2.26	90.97
France	0	25	221	282	4	6	2.12	93.09
Cuba	120	89	99	87	58.5	7	1.81	94.89
Panama	89	185	0	0	8	8	1.12	96.02
Saint Vincent and the Grenadines	47	0	86	36	35	9	0.81	96.83
Dominican Republic (the)	54	60	64	4	20	10	0.80	97.63
Guatemala	0	11	86	54	44	11	0.78	98.41
Spain	0	0	71	26	0	12	0.39	98.79
Dominica	16	27	28	11	10	13	0.37	99.16
Grenada	17	17	17	17	17	14	0.34	99.50
Mexico	7	10	8	11	8	15	0.18	99.67
Taiwan Province of China	2	4	13	12	10	16	0.16	99.84
Puerto Rico	5	4	4	7	6.83	17	0.11	99.94
Barbados	1	1	1	1	1	18	0.02	99.96
Saint Kitts and Nevis	0	1	1	1	0	19	0.01	99.98
United States of America	0	1	1	1	0	20	0.01	99.99
United States Virgin Islands	1	1	1	0	0	21	0.01	100.00
Group: Pelagic Species. Spe—cies: *Thunnus alalunga* - albacore tuna. Species code: ALB								
Taiwan Province of China	2 375	2 496	1 823	2 265	2 639	1	55.44	
Suriname	211	275	598	637	587	2	11.03	66.48
Saint Vincent and the Grenadines	405	399	398	271	211	3	8.05	74.53
Dominican Republic (the)	102	102	110	592	430	4	6.39	80.91
Venezuela (Bolivarian Republic of)	351	287	301	165	221	5	6.33	87.25
Spain	0	0	0	759	0.06	6	3.63	90.88
Panama	0	200	0	196	198	7	2.84	93.71
United States of America	95	105	91	64	90	8	2.13	95.84
Trinidad and Tobago	95	71	48	33	19	9	1.27	97.11
Grenada	47	47	47	47	47	10	1.12	98.24
Barbados	16	38	32	15	7	11	0.52	98.75
Japan	50	55	0	0	0	12	0.50	99.26
China	0	26	17	33	0	13	0.36	99.62
Vanuatu	64	0	0	0	0	14	0.31	99.92
Mexico	1	2	1	2	1	15	0.03	99.96
Saint Lucia	0	2	1	1	0.66	16	0.02	99.98
Puerto Rico	1	1	0	0	0.16	17	0.01	99.99
Bermuda	0	1	0	0	1	18	0.01	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Figure 4.20. ***Thunnus thynnus*** **(northern bluefin tuna, BFT) catch in 5°x5° by major gear in the Western Central Atlantic Fishery Commission region**



Notes: LL= longline; PS= purse seine; BB= baitboats.
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Bigeye and albacore tunas are mostly caught by pelagic longline gear and most of the spatial distribution is based on catches from pelagic longline gear. Most of the bigeye abundance is southwest of the region, in the high seas off Brazil, in part of the EEZ of Brazil around the offshore archipelago islands (Figure 4.10), as well as off the central coast of the Bolivarian Republic of Venezuela. However, the bigeye tuna caught in that area comes from the Venezuelan surface fleets operating there. The highest abundance of albacore tuna is in the high seas off the NBSLME, but also inside the EEZs of the countries in the northern part of the NBSLME and in the eastern Caribbean (Figure 4.9). Another important area of abundance of albacore tuna is the northwest corner of the Antillean Island Arc, between the high seas and the EEZs of several Small Island Developing States (SIDS).

The second group of species in the tuna fisheries is the small tunas, which includes blackfin tuna, little tunny, frigate and bullet tuna, and the Atlantic bonito. The latter species yielded the highest average landed catch for the period of 2015 to 2019 (3 380 tonnes), most of which was reported by Mexico (Table 4.6). Although there is no indication of a directed fishery in Mexico, it appears that the Atlantic bonito is caught in trammel nets used for the mackerel fishery off the Yucatan Peninsula when large schools migrate through the area during the warmer months (Government of Mexico, 2018). Blackfin tuna also yielded a high average landed catch (1 242 tonnes) for the period 2015 to 2019, with 91.16 percent of the landed catch reported by four countries in the region: Cuba landed 68.11 percent of the accumulated catch, followed by Saint Lucia, Grenada and Bolivarian Republic of Venezuela (Table 4.6). The landings of Cuba come from that country's longline fishery off the western side of the island around the Yucatan Channel. Most of the landed catch from Saint Lucia and Grenada comes from the small-scale fisheries associated with FADs (CRFM, 2015). In contrast, the landings of blackfin tuna by the Bolivarian Republic of Venezuela are part of the bycatch of the tuna surface fleets (Narváez *et al.*, 2017). The other small tuna species – little tunny, frigate and bullet tuna – were mostly caught by small-scale fishers from Colombia (little tunny) and Bolivarian Republic of Venezuela (frigate and bullet tuna) using trammel nets during their runs along the southern Caribbean coasts of both nations. Colombia accounted for 70.16 percent of the accumulated landed catch of little tunny, and Bolivarian Republic of Venezuela for 73.29 percent of the landed catch of frigate and bullet tuna (Table 4.6).

Table 4.6 Atlantic bonito, blackfin tuna, little tunny, frigate and bullet tuna catch by country for the period 2015–2019 (tonnes)

Country	2015	2016	2017	2018	2019	Rank	%	%cum
Group: Pelagic species. Species: *Sarda sarda* – Atlantic bonito. Species code: BON								
Mexico	2 915	3 685	3 236	4 127	2 705	1	98.60	
Trinidad and Tobago	0	16	16	16	15.68	2	0.38	98.98
Colombia	0	2	8	3	49.8	3	0.37	99.35
France	0	22	2	16	18	4	0.34	99.69
Grenada	5	5	5	5	5	5	0.15	99.84
Belize	0	0	0	10	0	6	0.06	99.90
Dominica	2	7	1	0	0	7	0.06	99.96
Saint Kitts and Nevis	0	0	0	3	1	8	0.02	99.98
United States of America	1	1	1	0	0	9	0.02	100.00
Group: Pelagic species. Species: *Thunnus atlancticus* – blackfin tuna. Species code: BLF								
Cuba	830	786	941	1 004	669.80	1	68.11	
Saint Lucia	80	156	119	96	127.48	2	9.31	77.43
Grenada	107	100	100	100	100	3	8.16	85.59
Venezuela (Bolivarian Republic of)	81	197	25	39	4	4	5.57	91.16
Dominica	24	34	32	17	25	5	2.13	93.28
Dominican Republic (the)	41	31	33	0	10	6	1.85	95.14
Bermuda	20	17	17	16	10	7	1.29	96.42
United States of America	19	17	17	0	1	8	0.87	97.29
Puerto Rico	16	10	6	12	9.16	9	0.86	98.15
France	12	14	14	6	0	10	0.74	98.89
Trinidad and Tobago	0	5	5	10.01	5.01	11	0.40	99.29
Mexico	4	5	4	6	5	12	0.39	99.68
Saint Vincent and the Grenadines	0	0	5	0	9	13	0.23	99.90
United States Virgin Islands	1	1	2	0	0	14	0.06	99.97
Saint Kitts and Nevis	0	0	0	1	1	15	0.03	100.00
Group: Pelagic species. Species: *Euthynnus alletteratus* – little tunny. Species code: LTA								
Colombia	0	53	1 533	66	499.12	1	70.16	
United States of America	205	184	178	106	0	2	21.95	92.10
Saint Vincent and the Grenadines	33	11	15	44	23	3	4.11	96.21
Cuba	10	9	7	7	5	4	1.24	97.45
United States Virgin Islands	8	10	8	4	4	5	1.11	98.56
Puerto Rico	7	2	3	6	10.68	6	0.94	99.50
Bermuda	4	3	2	1	2	7	0.39	99.89
Saint Lucia	2	0	0	0	1.43	8	0.11	100.00
Group: Pelagic species. Species: *Auxis thazard/Auxis rochei* – frigate and bullet tuna. Code: FRI/BLT								
Venezuela (Bolivarian Republic of)	64	70	115	67	26	1	73.29	
Colombia	0	6	53	0	58.65	2	25.21	98.50
France	0	0	0	7	0	3	1.50	100.00
Group: Pelagic species. Species: *Auxis thazard* – frigate tuna. Species code: FRI								
Belize	0	0	0	0	31	1	96.88	
Bermuda	0	0	1	0	0	2	3.13	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

The main fishing effort directed at the major tunas is from industrial and semi-industrial fleets, as well as small-scale fisheries and those associated with FADs in the region. The number of industrial and semi-industrial vessels operating in the region targeting major tunas is not clearly known, but it is estimated that there are about 440 vessels in this category. (Table 4.7). The largest category is the longline fleet with an estimated 330 vessels, in addition to 87 vessels from Japan. The surface industrial fleet consists of four baitboat/pole and line vessels (Bolivarian Republic of Venezuela) and 23 purse seiners, of which most operate outside the WECAFC region but have opportunistic and seasonal sets within the region´s EEZs and in the high seas.

Table 4.7 Estimated number of vessels (longliner, purse seiner, baitboat) operating in the Western Central Atlantic Fishery Commission region

WECAFC Member State	LL	LOA (m)	PS	LOA (m)	BB	LOA	SSF	LOA (m)	Source
Antigua and Barbuda							332		CRFM (2018)
Barbados	32	12,8							ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)
Belize	12	20–30	7	<30					ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)
Bermuda							106	15	ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)
Brazil	83	13–28					300	10–20	ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)
Cuba							2 344		FAO (2019a)
Curaçao			5				91	7–2014	ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)
Dominica							199		FAO (2019b)
Dominican Republic (the)	36	20–27							Gentner *et al.* (2018)
European Union*							405	5–20	Reynal *et al.* (2015)
Grenada			2	79					Gentner *et al.* (2018)
Guatemala	7								ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)
Guyana							11 036	5–7	ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)
Haiti	87								USAI-MARNDR (2019)
Mexico	27								ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)
Panama	25	21–33	6	44–72					ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)
Saint Kitts and Nevis							260		FAO (2020–2023)
Saint Lucia							87	<40	FAO (2018b)
Saint Vincent and the Grenadines							928		CRFM (2018b)
Suriname**	4	47–49					900		CRFM (2018)
Trinidad and Tobago							1 369		ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)
United States of America	24						136		ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)
Venezuela (Bolivarian Republic of)	78	24–29	4	50–70	5	25	700	11–20	ICCAT Annual Reports Part I (2018) Vol.3 (ICCAT, 2023)
Japan (Atlantic)	87								ICCAT Annual Reports Part II (2019) Vol.3 (ICCAT, 2023)

Notes: LL= longliner; PS= purse seiner; BB= baitboat; LOA= length overall. *(EU [FR Guadeloupe and FR Martinique]). **vessels from Panama, Saint Vincent and the Grenadines and Belize land ICCAT species.
Source: Authors' compilation.

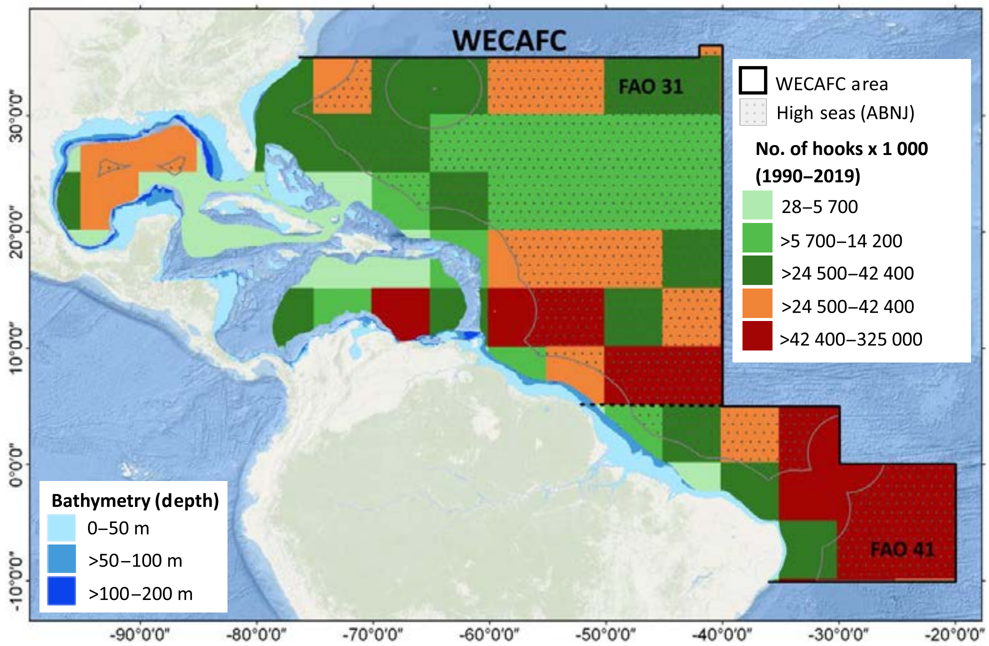
Across the WECAFC region, the gear of preference is pelagic longline gear for which yellowfin tuna is the main target species, but the target changes seasonally according to preferences of the fleet and/or fishing nation and the market value of the species. The estimated longline effort in number of hooks x 1 000 (Taylor *et al.*, 2020) is mainly concentrated in the high seas, particularly off the NBSLME and the southeastern corner of the WECAFC region (Figure 4.21). Areas of high fishing effort within the region's EEZs are in the southern central Caribbean (off Bolivarian Republic of Venezuela), around Barbados and offshore of Brazil´s archipelagic islands. Another area of important pelagic longline effort distribution is the GOM and off the northeastern United States within the region's limit.

The amount of fishing effort directed at tunas by small-scale fishers is not possible to quantify for several reasons. One of them is the multispecific nature of the small-scale fisheries targeting large pelagic fishes in the region. In SIDS, as well as in countries with very narrow continental shelves exposed to the migration routes of large pelagic fishes, the species targeted by small-scale fishers varies on a seasonal basis. Similarly, the effort (i.e. number of boats) directed at large pelagic fishes varies at any given time. The countries that report to ICCAT and have semi-industrial or small-scale fisheries are likely to report fishing effort at least as the number of vessels involved in the fishery of large pelagic fishes. However, countries like Mexico, Saint Vincent and the Grenadines, Trinidad and Tobago and Bolivarian Republic of Venezuela, that are members of ICCAT and have important small-scale fisheries that target large pelagic species, do not report fishing effort on a regular basis to ICCAT or any other RFB. In most cases, when catches are reported, they have been the product of specific research projects (e.g. Arocha *et al.*, 2015). A rough potential estimate of boats involved in the small-scale fishery for large pelagic fishes, including tunas and tuna-like species, is about 8 877 boats with overall lengths of less than 20 m (Table 4.7). However, the number of vessels indicated in the table should be viewed with caution because there is no clear indication from some countries about the number of boats directly involved in the fishery. Another reason is the variety of gears used to capture large pelagic fishes. Some gears are very selective, such as line gear (longline, handline and trolling) and others are non-selective, such as trammel and drift gillnets. In some countries, such as Bolivarian Republic of Venezuela, some boats carry several types of gear at any given time and switch between them. It is presumed that fleets from other countries in the region may utilize a similar practice.

Another issue related to fishing effort is the development of FAD fisheries, triggered by the depletion of the islands' nearshore fishery resources and the resulting economic stress created among small-scale fishers (Ehrhardt, Brown and Pohlot, 2017). Fishers in the region utilize a combination of moored and drifting FADs (dFADS); most of the effort on dFADs is targeted toward flyingfish, while fishing on moored FADs (mFADs) is heterogeneous, although mostly directed at large pelagic fishes (Doray, 2007). The effort definition for this type of fishing will become a challenge because the boat to FAD ratio can be highly variable across the region -- from several boats fishing on a single FAD, to a one-on-one ratio. The development of FAD fishing has been highly variable across the region, although one commonality is that all nations lack either financial resources or human resources for proper data collection; most of the information that has been collected varies considerably according to when projects begin and/or end. However, efforts continue towards the development of a subregional plan that would enhance FAD fisheries (CRFM, 2015).

Venezuelan long-range artisanal longliners at port © FAO

Figure 4.21. Estimated longline effort in number of hooks x 1 000 in 5°x5° for the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

4.2.4 State of the stocks

Yellowfin tuna. The most recent stock assessment conducted for yellowfin tuna was undertaken in July 2019 and applied two production models and one age-structured model to the catch data available to the year 2018 (ICCAT, 2020b). The combined results of all models used to develop management advice resulted in the median estimate of B/B_{MSY} (spawning stock biomass that results from fishing at F_{MSY} for a long time) is 1.17 and the median estimate of F/F_{MSY} is 0.96. The median MSY estimated is 121 298 tonnes. The results point to a stock status of not overfished, with no overfishing occurring (Table 4.2). Current management advice is an Atlantic-wide TAC of 110 000 tonnes, with area closures in the eastern Atlantic, limitations on the deployment of FADs, vessel authorization and limits on the number of vessels and gears.

Open water longline vessels operating in Grenada © FAO

Skipjack tuna. A full stock assessment was conducted for western Atlantic Skipjack tuna in 2014. Four models were used for this assessment: a mean length-based mortality estimator, a catch-only model, a Bayesian surplus production model and a stock production model incorporating covariates (ICCAT, 2015). The stock was determined to most likely not be overfished ($B_{2013}/B_{MSY}>1$) or undergoing overfishing ($F_{2013}/F_{MSY}<1$). Catches in 2013 (17 996 tonnes) were well below the estimated MSY (30 000 tonnes to 32 000 tonnes).

Bluefin tuna. The western stock assessment was conducted in 2020 as a strict update from the last stock assessment. Both sets of results from the virtual population analysis and stock synthesis models were equally weighted to formulate advice. Current F (average of 2015 to 2017) relative to the F0.1 reference point was 0.8 virtual population analysis and 0.84 (stock synthesis), indicating that overfishing is not occurring (ICCAT, 2021a). Under the updated models, the current TAC is likely to have led to overfishing relative to F0.1 beginning in 2018. The updates of the virtual population analysis and stock synthesis model used were informative. They found evidence of stock decline and provided a range of options for TAC advice for 2021, 2022 and 2023.

Albacore tuna. The northern stock assessment was conducted in 2020. The biomass dynamic model used in the assessment included data up to the year 2018. Assessment results indicated that the stock is in the green quadrant of the Kobe plot, i.e. not being overfished nor experiencing overfishing (ICCAT, 2021a). Management advice for the 2021 to 2023 period, following the interim HCR adopted by the Commission in 2017, was a recommended TAC of 37 801 tonnes (in which several WECAFC countries have a specific TAC) which is

Grenadian longliner ©FAO

expected to maintain the stock levels above BMSY until 2033 with a probability higher than 60 percent.

Bigeye tuna. The most recent stock assessment for bigeye tuna was conducted in July 2021. Two surplus production models and a stock synthesis model were chosen to provide stock status. It was recommended that final management advice be developed from the distribution of the projections for the 27 stock synthesis runs of the uncertainty grid (ICCAT, 2021b). The results of the assessment, based on the median of the entire uncertainty grid show that in 2019 the Atlantic bigeye tuna stock was overfished (median SSB_{2019}/SSB_{MSY}=0.94 and 80 percent confidence interval [CI] of 0.71 and 1.37) and was not undergoing overfishing (median F_{2019}/F_{MSY}=1.00 and 80 percent CI of 0.63 and 1.35). The average of MSY was estimated to be 86 833 tonnes with (80 percent CI of 72 210 and 106 440) from the uncertainty grid deterministic runs.

Blackfin tuna. ICCAT's Standing Committee on Research and Statistics (SCRS) Small Tunas Species Group decided to apply an ERA on a selected group of species for which available life history data existed (ICCAT, 2016a). The approach consisted of defining the risk to a population of being depleted as a function of i) population productivity, which determines the rate at which the population can recover from depletion; and ii) population susceptibility, which defines its exposure to fishing activity. Productivity and susceptibility were used to produce a single risk score and risk categories – high, moderate and low were assigned. As a result, considering only the small tuna in the WECAFC area of the Atlantic Ocean, the 2016 ERA indicated that blackfin tuna was one of the most vulnerable species caught by the longline fleet in the region, with high risk (ICCAT, 2017a). However, CRFM's technical group concluded that on a qualitative basis there was no evidence that overfishing was occurring on the blackfin tuna stock, indicating that trends of annual nominal landings for the data used (Dominica, Grenada, Saint Lucia and Saint Vincent and the Grenadines) indicated a general increasing trend (CRFM, 2013). Strong caution is warranted based on recent preliminary findings on stock structure (Saillant *et al.*, 2016) in which blackfin tuna caught in the southeastern Caribbean is likely to share the same genetic affinity with those specimens caught by the eastern Caribbean islands.

The remaining small tunas – little tunny, frigate and bullet tuna and Atlantic bonito were assessed with an ERA also known as a productivity and susceptibility analysis. Results indicated that frigate and bullet tuna from the North Atlantic were the most productive, thus with a low vulnerability to overfishing. In contrast, little tunny showed moderate vulnerability to overfishing (ICCAT, 2016b). However, a recent assessment using data-limited assessment methods that included northwest Atlantic little tunny indicated that the stock was above stock status target (Pons *et al.*, 2019) and therefore not overfished.

4.2.5 The tuna-like species

Tuna-like species include five billfish species: Atlantic blue marlin (*Makaira nigricans*), Atlantic sailfish (*Istiophorus albicans*), Atlantic white marlin (*Tetrapturus albidus*), longbill spearfish (T*etrapturus pfluegeri*), roundscale spearfish (*Tetrapturus georgii*) and swordfish (*Xiphias gladius*), all of which are long-lived species with high fecundity. It is noted that Atlantic sailfish and Atlantic white marlin are presently recognized as *Istiophorus platypterus* and *Kajikia albida* by ICCAT, but not the Aquatic Sciences and Fisheries Information System. Other tuna-like species include the wahoo (*Acanthocybium solandri*) and the common dolphinfish.

Barbados longliner deck © FAO

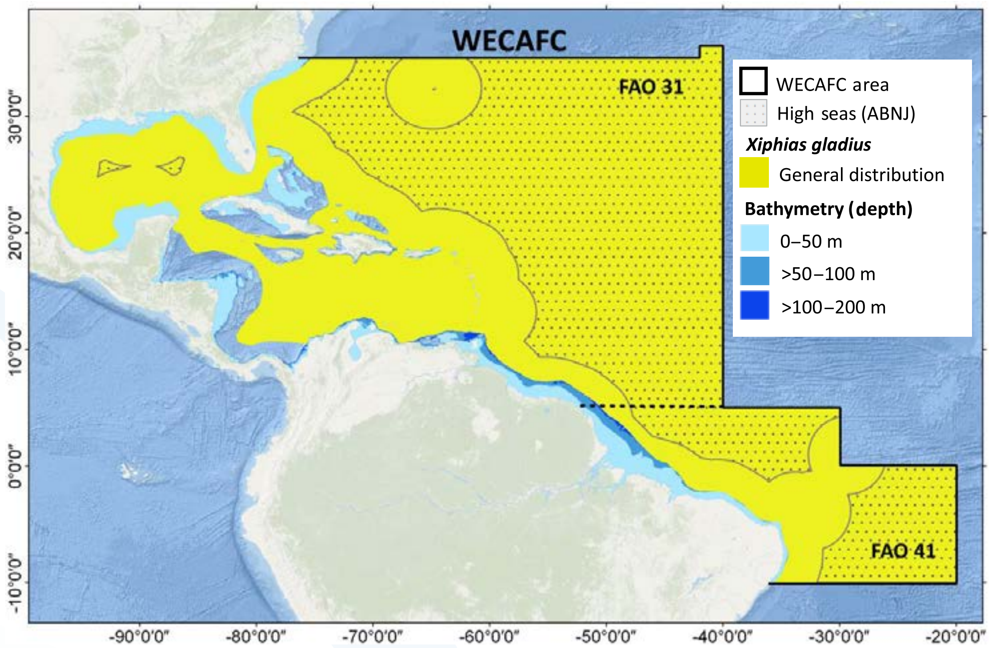
Pole and line boats in Trinidad and Tobago © FAO

Longline vessel at Cumaná fishing port © FAO

In the WECAFC region, swordfish is an economically valuable resource. Of the billfishes, Atlantic blue marlin and Atlantic sailfish represent important fishery resources for SIDS, as well as for some coastal communities in developing countries which depend on them for food security. In developed countries, all billfish species are highly valuable for the recreational fishery sector (Gentner *et al.*, 2018).

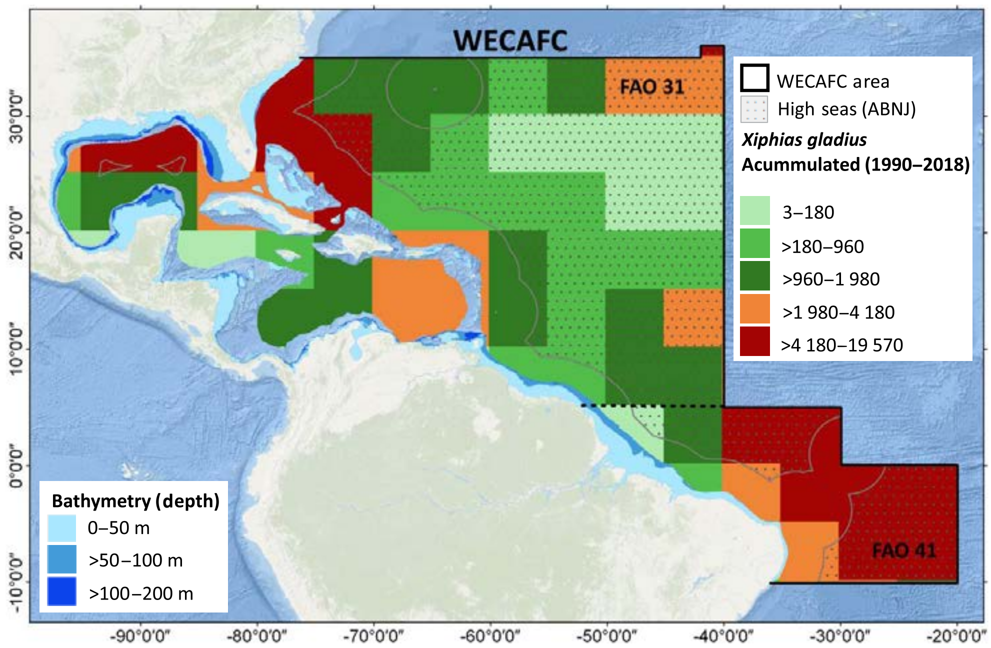
Swordfish is considered an oceanic meso-pelagic species and is widely distributed throughout tropical and temperate waters. It does not form schools or dense aggregations (Ward, Porter and Elscot, 2000). The species is widely distributed across the region and is part of the North Atlantic stock. It occurs in open waters and close to coastal areas where the slope drop is steep (Figure 4.22). Swordfish spawns within the WECAFC region in the high seas as well as in the GOM and in the southeastern United States over a protracted season (Arocha, 2007). Some areas of the Caribbean Sea, GOM and southeastern United States are considered important nursery grounds for the species (Neilson *et al.*, 2009). Swordfish is known to display north–south migratory movements between spawning and nursery grounds in the region, and major feeding grounds off New England (United States) and Grand Banks (Canada), where the fish remain or return to the same feeding grounds at least after one year, and juveniles remain in the nursery area at least for one year (Arocha and Prince, 1999; Stone, 2000; Neilson *et al.*, 2013). In the region, the areas of major abundance (based on spatial distribution of the accumulated catches) for swordfish in recent decades (1990 to 2018) include the GOM, southeastern United States, west of the Bahamas and to a lesser extent off northeast Puerto Rico, the eastern Caribbean Sea and east of the Lesser Antilles (Figure 4.23). Another area of high abundance is found in the southern limits of the WECAFC area in the high seas and around Brazil's offshore archipelagic islands.

Figure 4.22. *Xiphias gladius* (swordfish, SWO) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.23. *Xiphias gladius* (swordfish, SWO) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)

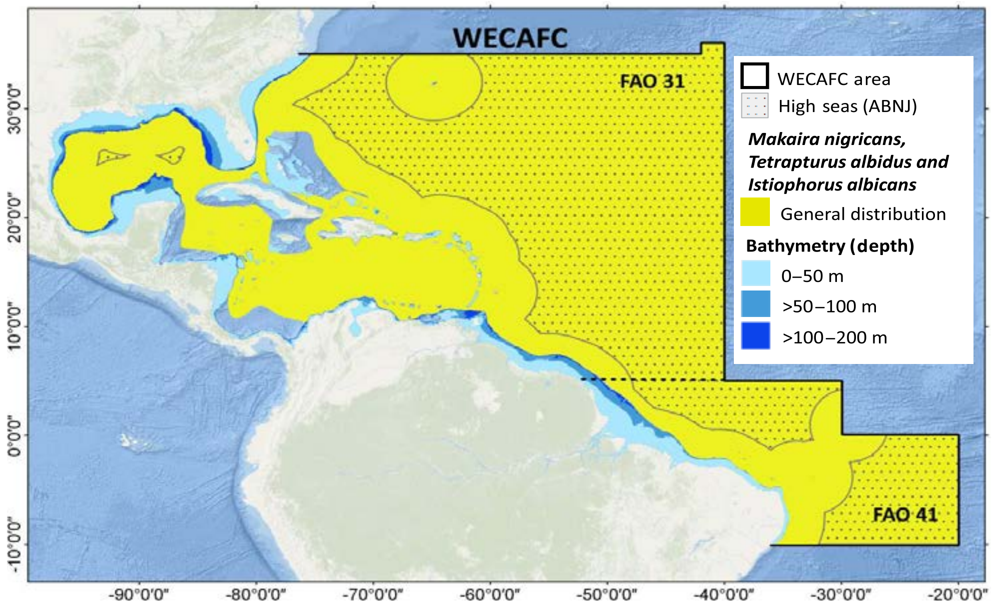


Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Atlantic blue marlin is an epipelagic oceanic species widely distributed across the region, often over open waters of the Caribbean EEZs and the high seas (Figure 4.24). It is commonly found in open seas with surface temperatures between 22 °C and 31 °C. As with swordfish, Atlantic blue marlin in the region is a single Atlantic-wide stock. The species does not form schools or dense aggregations. Spawning is thought to occur in the GOM (Kraus, Wells and Rooker, 2011) in the Mona Passage (the Dominican Republic), north of Puerto Rico and in the southern Bahamas (Rooker *et al.*, 2012; Prince *et al.*, 2005; Serafy *et al.*, 2003). Migratory movements in the WECAFC region show important horizontal displacement within and between the GOM and southern Caribbean Sea, and between the southern Caribbean and the southeastern United States (Ortiz *et al.*, 2003). However, fish tagged outside the GOM and the Caribbean Sea (e.g. the Bahamas, Bermuda and Puerto Rico) show that most of the migratory movements are into the Atlantic Ocean (IGFA, 2023), with incursions into the southern Caribbean Sea. It has been hypothesized that the southern Caribbean Sea is a feeding ground and the GOM is a spawning and nursery area. The areas of major abundance (based on spatial distribution of the accumulated catches) for Atlantic blue marlin in recent decades (1990 to 2018) is the Caribbean Sea and to a lesser extent the GOM and off the NBSLME (Figure 4.25).

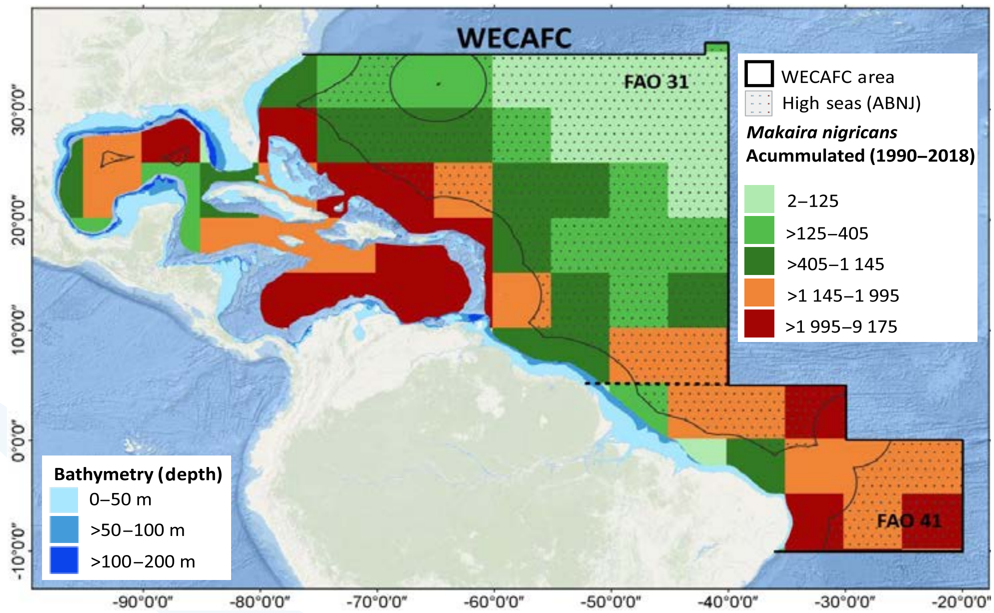
The Atlantic sailfish is the least oceanic of the Atlantic billfishes, displaying a strong tendency to approach continental coasts, islands and reefs (de Sylva, 1974; Nakamura, 1985) (Figure 4.24). In the region, Atlantic sailfish are considered part of the western stock where they normally form groups of several individuals and are occasionally found in schools when feeding and seasonally in hot spots such as Isla Mujeres (Mexico) and La Guaira (Bolivarian Republic of Venezuela) (Kurvers *et al.*, 2017; Lam *et al.*, 2016; Arocha *et al.*, 2016).

Figure 4.24. ***Makaira nigricans* (blue marlin, BUM) *Tetrapturus albidus* (Atlantic white marlin, WHM) and *Istiophorus albicans* (Atlantic sailfish, SAI) general distribution in the Western Central Atlantic Fishery Commission region**



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

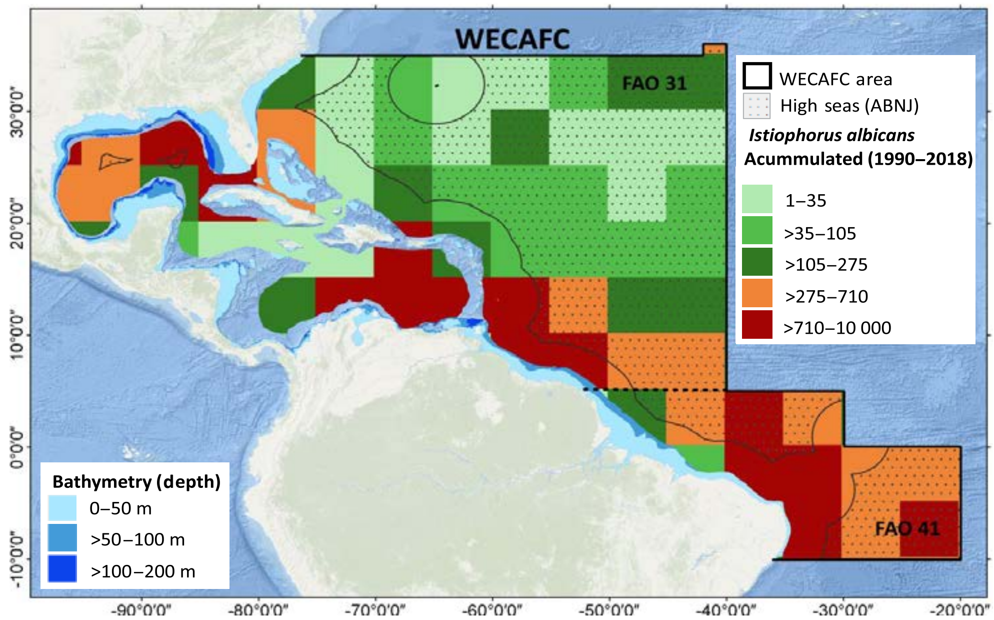
Figure 4.25. ***Makaira nigricans* (blue marlin, BUM) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)**



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Atlantic sailfish in the WECAFC region spawn in several areas between 5° north and 30° north, derived from information on larval surveys and reproductive biology of spawning fish (Simms *et al.*, 2010; Mourato *et al.*, 2018). Larval surveys indicate spawning in the GOM and the southeastern United States, while spawning fish occur in the southeastern Caribbean Sea around the La Guaira–Bolivarian Republic of Venezuela hot spot. Occasional spawning takes place off the NBSLME between June and October (Mourato *et al.*, 2018). The areas of major abundance (based on spatial distribution of the accumulated catches) for Atlantic sailfish in recent decades (1990 to 2018) include the southern and eastern Caribbean Sea and off the NBSLME, the eastern GOM and around western Cuba (Figure 4.26). There are also localized areas of high accumulated catch in the western GOM and north of Puerto Rico, possibly attributed to sport fishing catches. The southern limits of the WECAFC are also an area of high abundance of Atlantic sailfish, both within the EEZs and in the high seas.

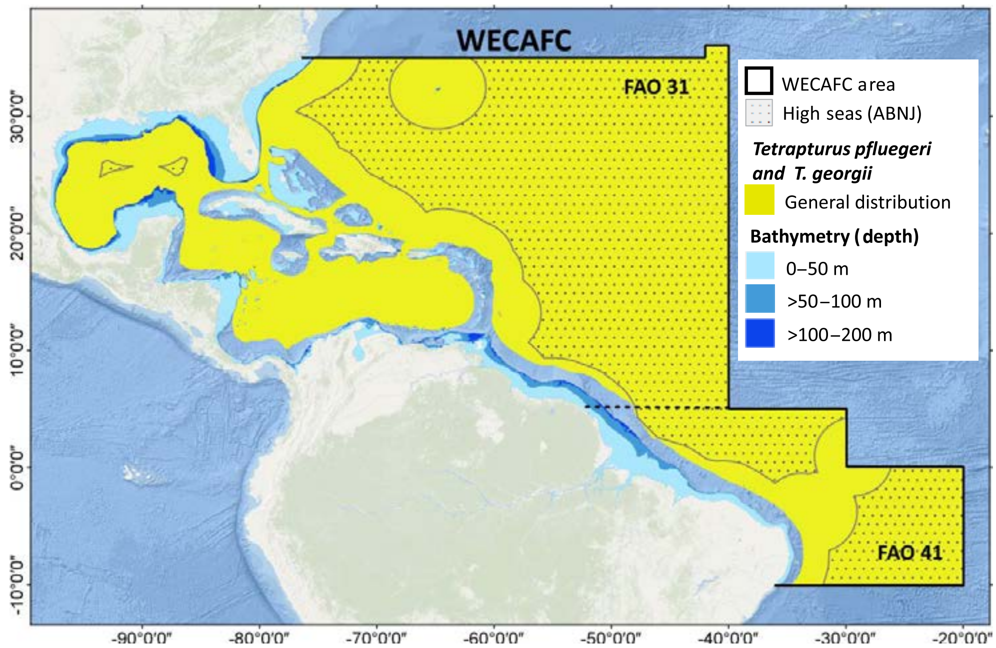
Figure 4.26. *Istiophorus albicans* (Atlantic sailfish, SAI) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

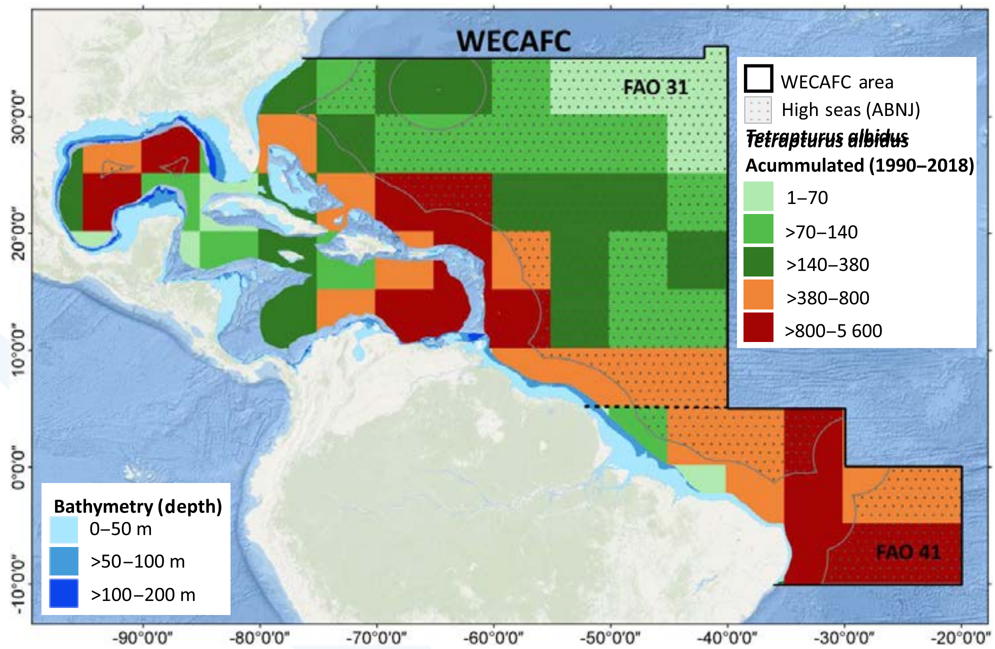
The remaining three billfish species, Atlantic white marlin, longbill spearfish, and the roundscale spearfish, have not attracted a high degree of interest from commercial fisheries, although they are commonly caught as bycatch in tuna and coastal large pelagic fisheries and are highly attractive to the recreational sector. Atlantic white marlin has a similar spatial distribution as Atlantic blue marlin within the region (Figure 4.24), while the two spearfishes have a more open "blue water" spatial distribution that has made these two species relatively uncommon in the commercial catches (Figure 4.27). White marlin in the region is part of the Atlantic-wide stock, which has suffered a steep population decline, mostly as a result of tuna fisheries and some small-scale fisheries. In the WECAFC region, Atlantic white marlin spawns seasonally in two localized areas northeast of the Greater Antilles (northeast of the Dominican Republic, and north-northeast of the Puerto Rico Trench) (Arocha and Barrios, 2009). As is the case with Atlantic blue marlin, migratory movements in the WECAFC region show strong horizontal displacement between the southern Caribbean and the southeastern United States (Ortiz *et al.*, 2003). However, fish tagged with pop-up satellite archival tags north of the WECAFC region show that the migratory movements are into the Atlantic Ocean, with incursions into the southern Caribbean Sea, and fish tagged in the southern Caribbean Sea remain in the area for a limited time (Hoolihan *et al.*, 2015). The areas of major abundance (based on spatial distribution of the catches) for Atlantic white marlin in recent decades include the southeastern Caribbean Sea, some areas of the GOM, and an area east of the EEZs of the Antilles Islands and the high seas (Figure 4.28). Another area of major abundance is the southern limit of the WECAFC region, within the EEZ of Brazil and the high seas in that area. The NBSLME offshore area is another relatively abundant area for Atlantic white marlin. This area borders the EEZs of several countries and the high seas.

Figure 4.27. *Tetrapturus pfluegeri* (longbill spearfish, SPF) and *T. georgii* roundscale spearfish, RSP) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

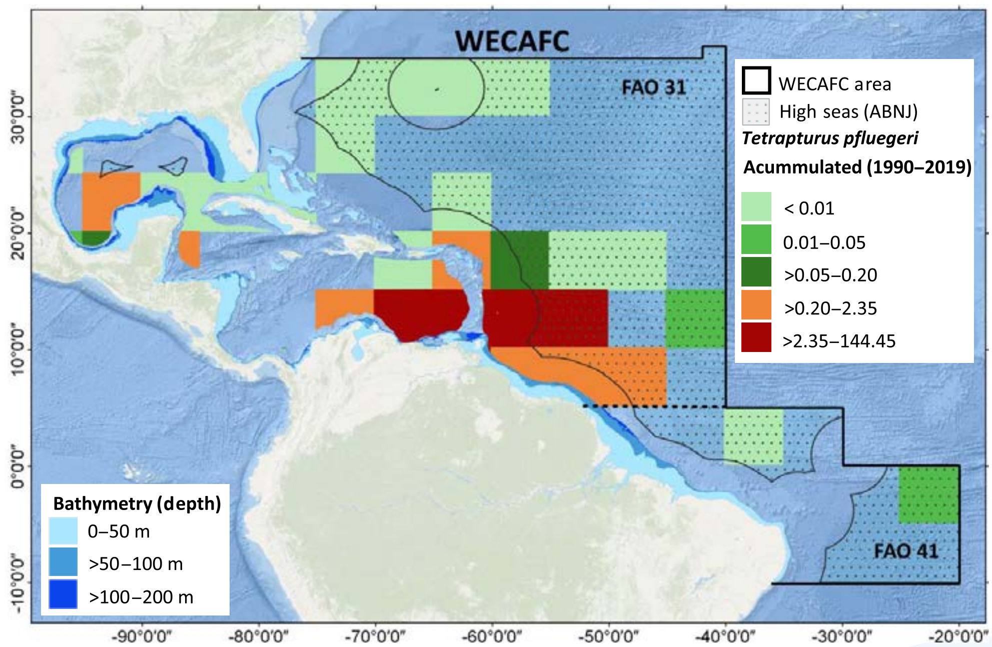
Figure 4.28. *Tetrapturus albidus* (Atlantic white marlin, WHM) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The two spearfish species, longbill spearfish and roundscale spearfish, are oceanodromous and mostly found in open ocean waters within the WECAFC region. There is no defined stock structure for either species, although ICCAT separates them into western and eastern stocks. The longbill spearfish is more commonly caught as bycatch in the tuna fisheries and as directed catch of some offshore artisanal fisheries of the region (Arocha, Barrios and Lee, 2007; Arocha *et al.*, 2015). Of the two species, only the longbill spearfish is known to spawn in open waters of the eastern-central Caribbean Sea (Arocha, 2007). Limited information exists for roundscale spearfish, other than it is easily confused with Atlantic white marlin by untrained fishers and is widely caught as bycatch of the tuna longline fisheries in the region (Arocha and Silva, 2011; Beerkircher *et al.*, 2009). The areas of known major abundance (based on spatial distribution of the catches) for the longbill spearfish in recent decades (1990 to 2018) include the southeastern Caribbean Sea and southeast of the Lesser Antilles to east of Barbados and into the area of the high seas along that latitude (Figure 4.29). There are other important areas of abundance around the aforementioned areas, and in the northwest and southwest of the Yucatan Peninsula. In the case of the roundscale spearfish, the few countries in the region that can identify the species started reporting it separately in recent times; therefore, spatial catch distribution is not sufficient to develop a spatial distribution map.

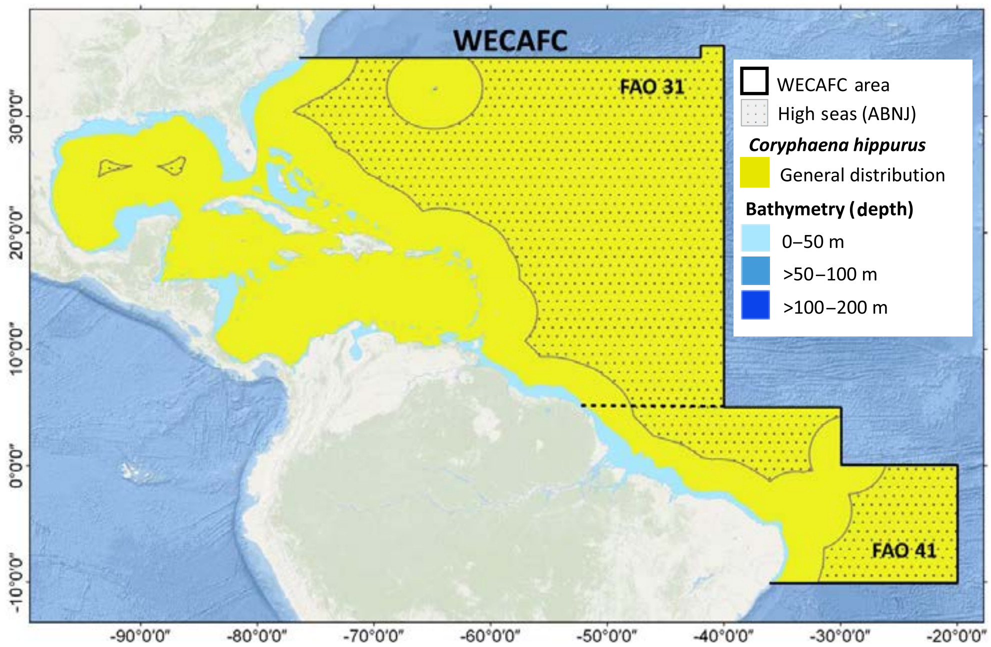
Figure 4.29. *Tetrapturus pfluegeri* (longbill spearfish, SPF) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

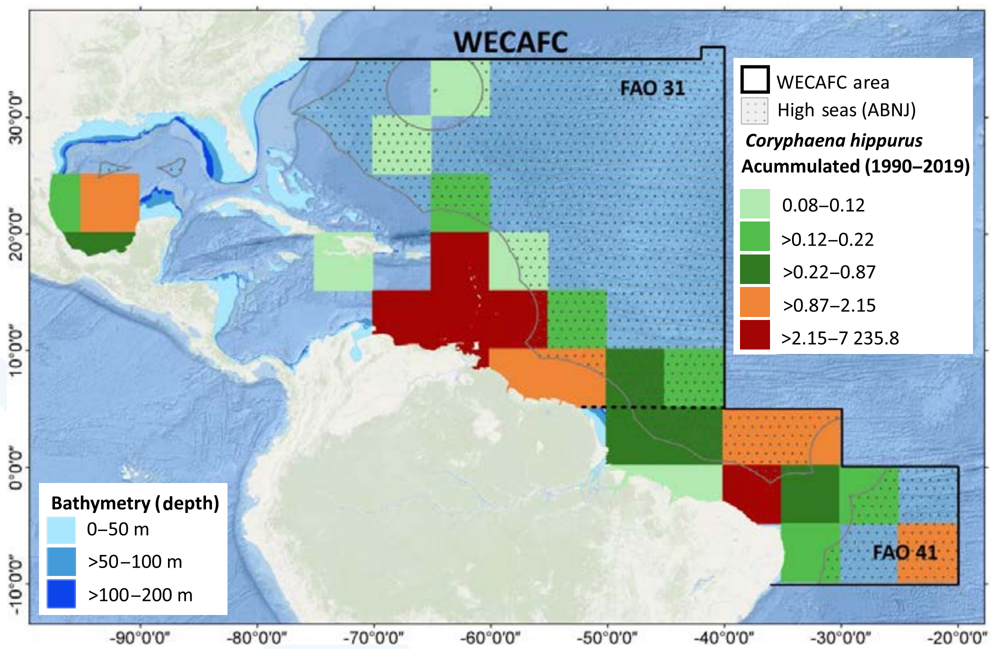
The common dolphinfish is widely distributed in surface oceanic waters and near coastal areas across the region (Figure 4.30). It is common in northern area of the southeastern United States, throughout the GOM and from the Caribbean Sea to the northeastern coast of Brazil, although the species is only seasonally abundant in these areas (Oxenford, 1999). In the region, the common dolphinfish is considered a single panmictic population (Merten *et al.*, 2015). It is found offshore under floating objects, such as sargasso mats, logs and FADs; it displays a protracted spawning behaviour, with multiple spawns during the spawning period and the peak spawning period varying across the region (Arocha *et al.*, 1999; Oxenford, 1999). The areas of highest abundance of common dolphinfish based on reported catches occur in the southeastern Caribbean and around the eastern Caribbean islands through to Barbados and Trinidad and Tobago (Figure 4.31). Other important areas of abundance include northeastern Brazil and the western GOM.

Figure 4.30. *Coryphaena hippurus* (common dolphinfish, DOL) general distribution in the Western Central Atlantic Fishery Commission region



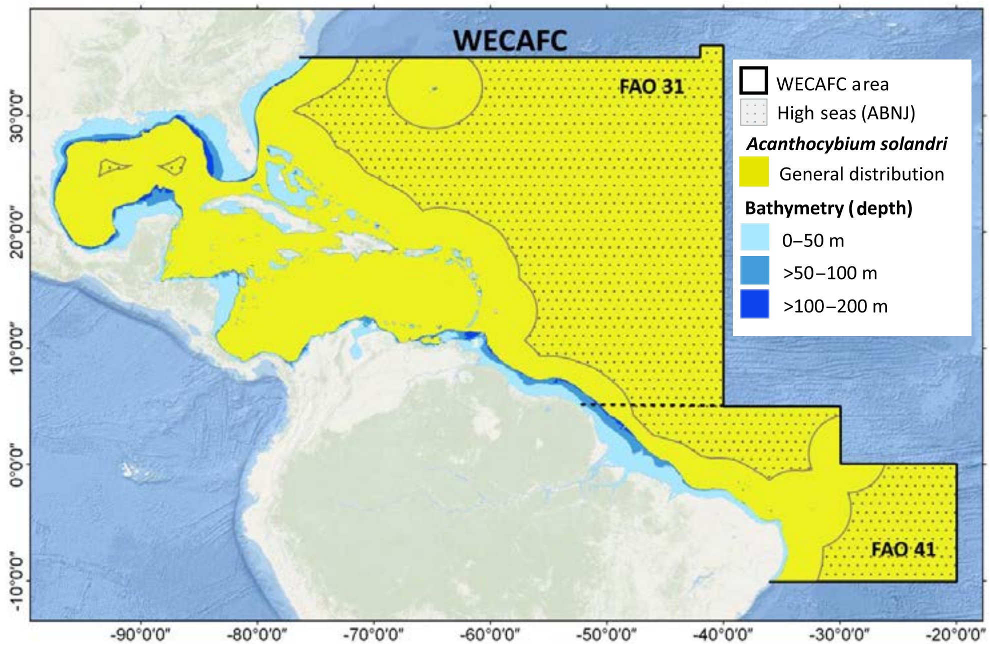
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.31. *Coryphaena hippurus* (common dolphinfish, DOL) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)



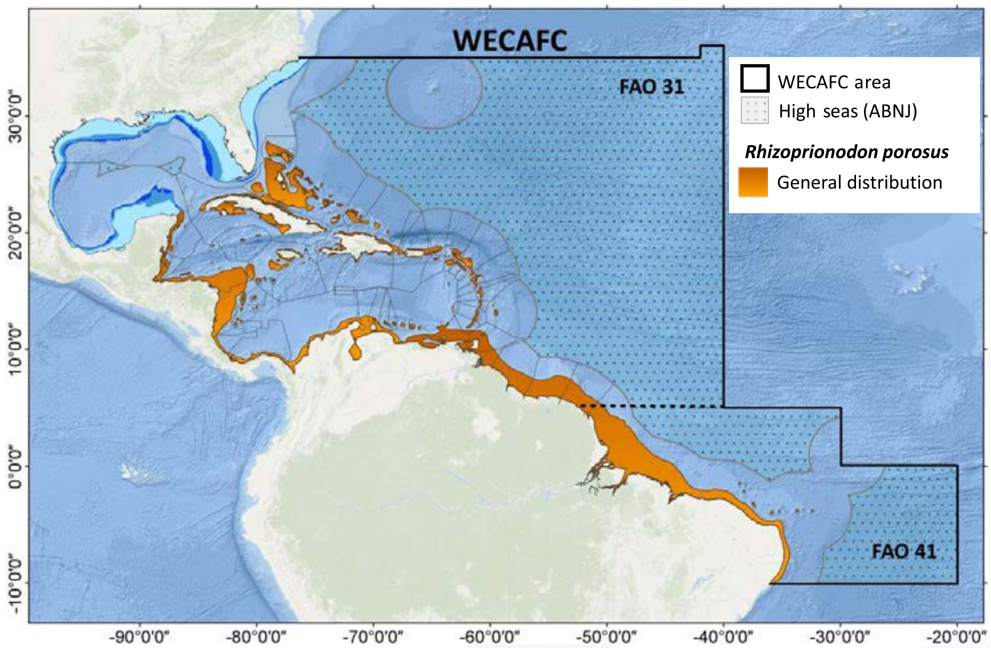
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.32. *Acanthocybium solandri* (wahoo, WAH) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.33. *Acanthocybium solandri* (wahoo, WAH) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The wahoo is an oceanic, epipelagic species frequently found solitarily or forming small, loose aggregations rather than compact schools. In the WECAFC region, it is widely distributed and seasonally abundant in most locations (Figure 4.32). Periods of peak abundance occur from the autumn through to spring in the southeastern and northern

Caribbean islands and are restricted to the warmer months (late spring through to early autumn) in the northern areas of the GOM, southeastern United States and Bermuda (Oxenford *et al.*, 2003). The limited information on stock structure in the region suggests a single stock hypothesis, with the stock boundary beyond the WECAFC region (Constantine, 2002). As is the case with the common dolphinfish, the wahoo is found offshore in the vicinity of drifting objects, such as sargasso mats and FADs. Spawning information is mostly limited to the northern areas of the region where it appears to take place during the warmer months (May to October) (Oxenford, Murray and Luckurst, 2003), although at-sea observers from the Venezuelan Pelagic Longline Observer Program have identified spawning wahoo in the central- eastern Caribbean during the spring months. The areas of highest abundance are in the high seas around Bermuda, in the southeastern Caribbean and around the eastern Caribbean islands through to Barbados and Trinidad and Tobago, and in the southern part of the NBSLME, eastward to the high seas off Brazil (Figure 4.33).

4.2.6 The fishery

The swordfish fishery is a specialized longline-directed fishery that involves setting the longline gear at dusk, fishing during the night and using light-sticks attached near the baited hook to attract the target species.

The fishery for swordfish in the northwestern Atlantic orginally began as a seasonal fishery off the northeastern United States and Canada, with harpoons used initially and longlines later, as well as some gillnets. In the mid-North Atlantic within the WECAFC region, swordfish were caught as bycatch by the Japanese longline fleet targeting bigeye tuna. In 1978, after the easing of the United States' Food and Drug Administration regulations on mercury content in swordfish, the United States' fishery expanded south to the Straits of Florida, GOM, Caribbean Sea and into the Atlantic off Puerto Rico. By the late 1980s the fishery for swordfish had expanded to the waters of the NBSLME (Arocha, 1997). Also in the 1980s, Bolivarian Republic of Venezuela initiated an exploratory fishery that developed into a formal swordfish-directed fishery, operational throughout the year until the mid-1990s, after which it shifted operations towards tuna, landing swordfish as bycatch (Arocha and Marcano, 2005).

Signs of swordfish being overfished began to appear in the early 1990s and several management measurements were implemented by ICCAT to reduce fishing mortality and rebuild the North Atlantic stock (Neilson *et al.*, 2013). During that time, fishing operations were reduced, nursery areas were defined and protected and minimum size limits for trade were enforced. The Venezuelan swordfish operation ceased entirely by 1999 due to the enforcement of minimum size limits by the United States (the destination of almost the entire catch) and because the southern Caribbean was mostly a nursery area for North Atlantic swordfish (Arocha, Marcano and Silva, 2013; Arocha and Prince, 1999). Presently, the North Atlantic swordfish stock is considered to be recovered and is under country-specific catch quota management (Neilson *et al.*, 2013).

Most of the reported landed catch for swordfish (91.84 percent) in recent years comes from four countries operating within the WECAFC region (Table 4.8). Over half of the reported landed catch is from a foreign fleet likely operating in the high seas of the WECAFC region, while the United States has the highest reported landed catch (32.1 percent) of the WECAFC Member States. The remaining proportion of the landed catch is distributed between regional fleets and foreign fleets operating in the region, of which Saint Vincent and the Grenadines, Bolivarian Republic of Venezuela, Mexico and Grenada account for slightly over 7 percent of the catch, which is likely taken as bycatch by the tuna longline fisheries of those countries.

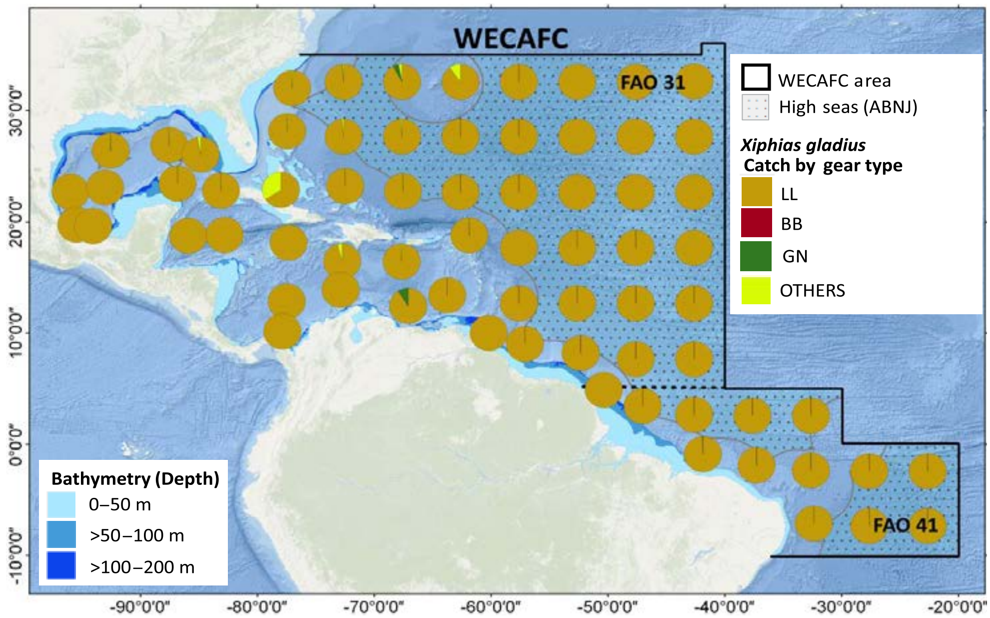
Table 4.8 Swordfish and Atlantic blue marlin catch by country for the period 2015–2019 (tonnes)

Country	2015	2016	2017	2018	2019	Rank	%	%cum
Group: Pelagic species. Species: *Xiphias gladius* – swordfish. Species code: SWO								
Spain	1 451	1 608	1 592	1 525	113.73	1	55.76	
United States of America	594	825	635	709	858	2	32.10	87.86
Saint Vincent and the Grenadines	103	38	55	30	27	3	2.24	90.10
Venezuela (Bolivarian Republic of)	29	53	52	31	31	9	1.74	91.84
Mexico	32	37	36	41	36	4	1.61	93.45
Grenada	37	29	36	36	35	5	1.53	94.98
Costa Rica	22	22	20	20	20	6	0.92	95.90
Barbados	29	20	21	18	10	7	0.87	96.77
Japan	22	19	19	5	20	8	0.75	97.53
Trinidad and Tobago	17	13	36	3	5.91	10	0.66	98.19
Taiwan Province of China	7	8	12	25	15	11	0.59	98.78
China	1	17	12	23	0	12	0.47	99.25
Guyana	0	6	34	10	2	13	0.46	99.72
Portugal	0	0	7	3	0	14	0.09	99.80
Republic of Korea (the)	1	1	3	1	0	15	0.05	99.86
Bermuda	1	2	0	0	1	16	0.04	99.89
France	0	0	0	4	0	17	0.04	99.93
Cuba	1	1	1	0	0	18	0.03	99.95
Saint Kitts and Nevis	0	0	0	2	0	19	0.02	99.97
Puerto Rico	0	0	0	0	1.13	20	0.01	99.98
Dominica	0	0	1	0	0	21	0.01	99.99
Vanuatu	1	0	0	0	0	22	0.01	100.00
Group: Pelagic species. Species: *Makaira nigricans* – blue marlin. Species code: BUM								
Dominican Republic (the)	73	170	183	176	175	1	19.49	
France	117	106	138	126	215	2	17.61	37.11
Venezuela (Bolivarian Republic of)	130	164	181	120	107	3	17.59	54.69
Saint Lucia	53	91	134	93	81.87	4	11.36	66.05
Mexico	73	67	81	75	79	5	9.41	75.46
Grenada	60	60	60	60	60	6	7.53	82.99
Dominica	62	49	70	54	55	7	7.28	90.27
Japan	22	28	28	7	37	8	3.06	93.33
Barbados	34	11	24	21	13	9	2.58	95.91
Trinidad and Tobago	35	19	0	0	0	10	1.35	97.27
China	0	4	6	5	16	11	0.78	98.04
Saint Kitts and Nevis	2	2	8	14	4	12	0.75	98.80
Taiwan Province of China	1	3	3	5	4	13	0.40	99.20
Bermuda	3	2	1	2	2	14	0.25	99.45
Spain	2	1	4	0	0	15	0.18	99.62
Saint Vincent and the Grenadines	2	2	2	0	0	16	0.15	99.77
Belize	0	0	2	2	1	17	0.13	99.90
Belice	2	1	1	0	0	18	0.10	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Across the WECAFC region, the preferred gear for targeting swordfish is pelagic longline gear (Figure 4.34). Pelagic drift gillnets were used in the early 1990s by fishers from the United States in the northern limits of the WECAFC region (Arocha, 1997), which may be responsible for the catches west of Bermuda. Artisanal drift gillnets off central Bolivarian Republic of Venezuela, which target billfishes, have also landed incidental catches of swordfish. The "other" gear category is likely from troll fisheries off northern Cuba and southern Haiti (possibly around mFADs).

Figure 4.34. *Xiphias gladius* (swordfish, SWO) accumulated catch by major gear in 5°x5° for the Western Central Atlantic Fishery Commission region (1990–2019)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The fishery for billfish species in the WECAFC region began as a recreational fishery in the 1930s in the United States (Ehrhardt and Fitchett, 2016) and in the 1940s off the central coast of Bolivarian Republic of Venezuela. When fishing started, Atlantic white marlins were caught with handline and the first Atlantic blue marlin was caught with rod and reel under sport fishing regulations in 1947 (Alió, 2013). By the 1950s, recreational billfish tournaments were taking place in the region (Rodríguez-Ferrer, Rodríguez-Ferrer and Lilyestrom, 2005). Some billfish species have also been part of the commercial bycatch of Japanese longliners fishing in the Caribbean Sea since the early days of commercial operations off Bolivarian Republic of Venezuela in the late 1950s. At that point in time, Atlantic white and blue marlins were seasonally abundant during yellowfin tuna fishing operations (Kawaguchi, 1974).

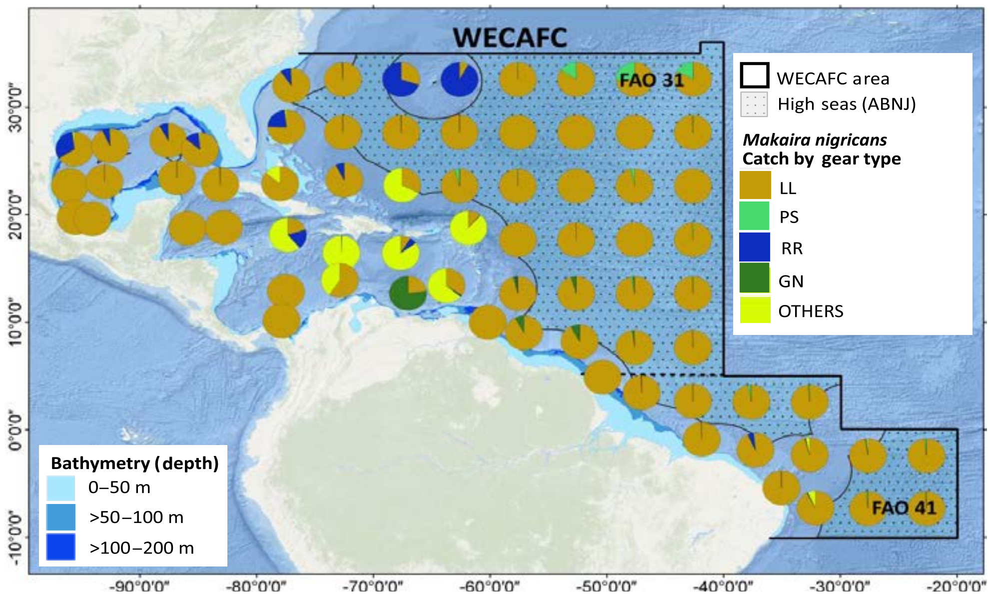
Concerns were raised in the 1970s, 1980s and again in the 1990s when trends in abundance indices from recreational fisheries in the region began to drop for all three major species (Atlantic blue marlin, white marlin and sailfish). This was attributed to the increased catch of billfishes from tuna fishing operations as a consequence of increased fishing effort in the Atlantic (ICCAT, 1994; Babcock and Arocha, 2016; Ehrhardt and Fitchett, 2016). In the 2000s, stock assessment results led to the implementation of Atlantic-wide management actions by ICCAT to limit catches of all major billfish species and recommend the release of all billfish caught by tuna fisheries (ICCAT, 2020b).

The billfishes are mostly caught by pelagic longline gear as bycatch of yellowfin tuna-directed fisheries across WECAFC region, although there are exceptions. For example, in some areas where they are targeted by the small-scale fisheries of several countries, other gears are also used. In addition, some trophy-size catches are landed, although the sport fishery for billfish is mostly catch-and-release. In the most recent years, the landed billfish catch consists of four species: blue and Atlantic white marlin, Atlantic sailfish and longbill spearfish.

Most of the region's Atlantic blue marlin accumulated landed catch (90.27 percent) for the period 2015 to 2019 was reported by seven countries (Table 4.8). Over half of the landed catch (55.75 percent) came from small-scale fisheries and opportunistic/seasonal fisheries in Dominica, the Dominican Republic, EU (FR Martinique and FR Guadeloupe) and Saint Lucia which utilize mFADs to attract the fish and line gear to land it (Reynal *et al.*, 2015; CRFM, 2015; Gentner *et al.*, 2018; Arocha, 2019; FAO, 2021–2023). The remainder of the landed catch (44.25 percent) was mostly taken as bycatch in the tuna directed fisheries, but in the case of Bolivarian Republic of Venezuela, almost half of the Atlantic blue marlin reported catch came from the artisanal drift gillnet fishery which fishes off La Guaira's billfish hot spot (Arocha, Ortiz and Marcano, 2011).

In the high seas, Atlantic blue marlin is mostly caught by longlines, but within the EEZs the species is caught by rod and reel around Bermuda and along the coast of the United States (Figure 4.35). In the GOM and northwestern Caribbean, it is mostly caught with longline gear. In central and eastern Caribbean, Atlantic blue marlin is caught with a variety of gears other than longline. The "other" gears category includes troll fishing, as well as drop lines with live bait around mFADs off the Dominican Republic (Gentner *et al.*, 2018) and drop lines with live bait in Haiti (Valles, 2016), as well as in the eastern Caribbean in EU (FR Guadeloupe and FR Martinique) and Saint Lucia. In the central Caribbean off Bolivarian Republic of Venezuela, in addition to the longline, most of the Atlantic blue marlin catch is taken by the artisanal fishery operating in the billfish hot spot (La Guaira) using drift gillnets. Off the NBSLME, some fisheries use driftnets from semi-industrial fisheries, which can occasionally catch Atlantic blue marlin in the area. In the southern part of the WECAFC region, some rod and reel and other types of line gear are used, in addition to longlines.

Figure 4.35. *Makaira nigricans* (blue marlin, BUM) accumulated catch by major gear in 5°x5° for the Western Central Atlantic Fishery Commission region (1990–2019)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Atlantic sailfish is mostly caught by seven countries in the WECAFC region, which accounted for 92.57 percent of the accumulated landed catch for the period 2015 to 2019 (Table 4.9). Six of the countries operate longline gear and Atlantic sailfish is considered part of the bycatch of directed fisheries, i.e. for yellowfin tuna; while the catch of the other country (Dominican Republic) comes entirely from trolling around mFADs or using drop lines with live bait (Gentner *et al.*, 2018; Arocha, 2019). In the case of Bolivarian Republic of Venezuela, 20 percent to 30 percent of the landed catch came from the artisanal drift gillnet fishery fishing off La Guaira's billfish hot spot; but (as with Atlantic white marlin) the recent catch history of Atlantic sailfish from the Venezuelan artisanal offshore longline fleet is on average almost twice the combined landed catch of the artisanal drift gillnet and the commercial bycatch from the longline fleets (Arocha *et al.*, 2015). This historical comparison shows the impact of the Venezuelan artisanal offshore longline fleet on total removals of Atlantic sailfish in the southwestern Caribbean Sea and off the NBSLME. However, due to the lack of reporting from the Venezuelan fleet in recent years (2015 to 2019) the impact is unknown. The reported catches from the other two most important catching countries (Suriname and Panama), are likely from the high seas and the EEZs off the NBSLME. The fleets that operate in the area are from Belize, Panama and Saint Vincent and the Grenadines and they land Atlantic sailfish as part of an agreement with Suriname (ICCAT, 2020c).

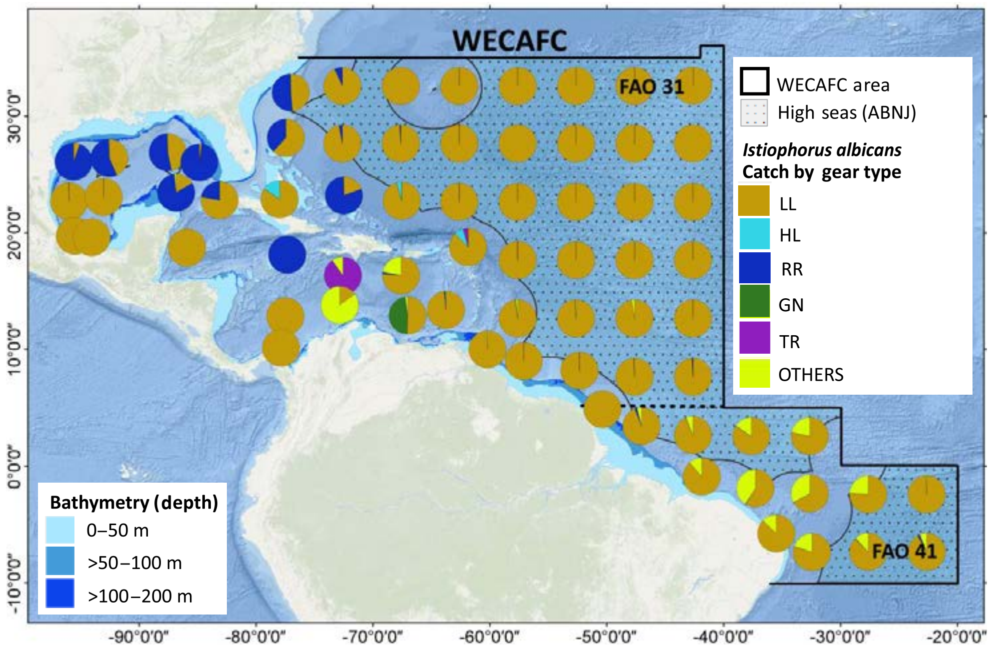
Table 4.9 Atlantic sailfish, Atlantic white marlin and longbill spearfish catch by country for the period 2015–2019 (tonnes)

Country	2015	2016	2017	2018	2019	Rank	%	%cum
Group: Pelagic species. Species: *Istiophorus albicans* – sailfish. Species code: SAI								
Suriname	195	481	442	480	447	1	25.87	
Venezuela (Bolivarian Republic of)	213	295	517	508	463	2	25.26	51.13
Panama	0	415	0	461	378	3	15.87	67.00
Grenada	200	186	186	186	186	4	11.94	78.94
Dominican Republic (the)	91	119	128	124	125	5	7.43	86.37
Trinidad and Tobago	51	53	63	51	51	6	3.40	89.77
Mexico	35	47	39	53	47	7	2.80	92.57
Barbados	54	56	42	21	15	8	2.38	94.95
Saint Vincent and the Grenadines	1	85	10	10	5	9	1.40	96.35
Cuba	22	19	16	16	10	10	1.05	97.40
Spain	26	10	21	13	1.27	11.00	0.90	98.30
Japan	11	13	7	3	18	12	0.66	98.96
Colombia	0	6	10	6	0	13	0.28	99.24
Martinique	4	4	4	4	4	14	0.25	99.49
Taiwan Province of China	4	3	3	4	3	15	0.22	99.71
Dominica	3	3	3	2	2	16	0.16	99.87
Saint Lucia	1	1	4	2	0	17	0.10	99.97
France	0	0	0	1	0	18	0.01	99.99
Saint Kitts and Nevis	0	0	0	1	0	19	0.01	100.00
Group: Pelagic species. Species: *Tetrapturus albidus* – Atlantic white marlin. Species code: WHM								
Venezuela (Bolivarian Republic of)	117	167	158	101	115	1	52.78	
Costa Rica	33	53	50	50	50	2	18.98	71.76
Mexico	26	20	29	22	26	3	9.89	81.65
Barbados	10	14	17	22	11	4	5.95	87.60
Grenada	26	15	9	11	10	5	5.71	93.31
Trinidad and Tobago	32	20	0	0	0	6	4.18	97.49
Saint Vincent and the Grenadines	0	0	8	8	5	7	1.69	99.18
Spain	0	3	4	0	0	8	0.56	99.75
Saint Lucia	1	0	1	1	0.15	9	0.25	100.00
Group: Pelagic species. Species: *Tetrapturus pfluegeri* – longbill spearfish. Species code: SPF								
Saint Vincent and the Grenadines	1	7	63	84	12	1	61.53	
Venezuela (Bolivarian Republic of)	32	35	6	10	4	2	32.06	93.59
Mexico	0	4	0	4	1	3	3.32	96.90
Spain	1	0	1	1	3.4	4	2.36	99.26
Dominica	0	1	1	0	0	5	0.74	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Atlantic sailfish in the high seas is entirely caught with longline gear. Some of the catch landed in the region's EEZs is taken by longline gear (Figure 4.36). In the EEZ of the United States and other areas of the northwestern Caribbean around Jamaica, Atlantic sailfish is largely caught with rod and reel by the sport fishery. In the central Caribbean, important catches occur south of la Española (the Dominican Republic and Haiti) (Valles, 2016; Gentner *et al.*, 2018). These are mostly from small-scale fisheries associated with the mFADs fishery and catches are taken by troll and/or baited drop line gear. In the south-central Caribbean, catches are taken by the artisanal billfish-directed drift gillnet fishery operating off central Bolivarian Republic of Venezuela and by small-scale fishers operating with line gear off northeastern Colombia. In the southern limits of the WECAFC region, Atlantic sailfish catches are important to the small-scale fisheries operating with handlines, identified as "other" gear.

Figure 4.36. *Istiophorus albicans* (Atlantic sailfish, SAI) accumulated catch by major gear in 5°x5° for the Western Central Atlantic Fishery Commission region (1990–2019)



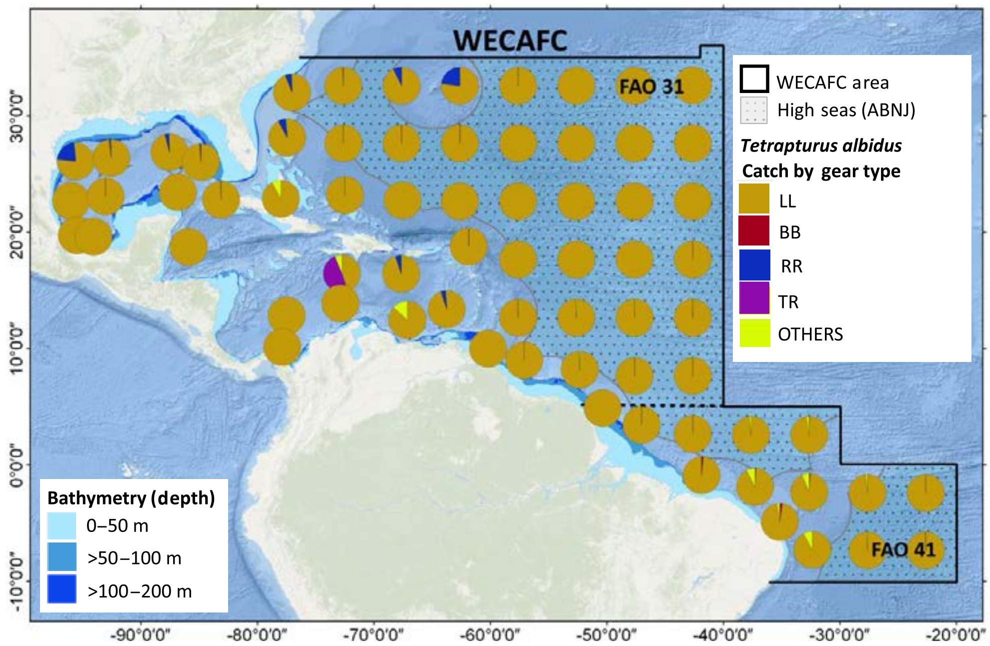
Notes: LL= longline; HL= handline; RR= rod and reel; GN= gillnet; TR= trolling.
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors

Most of the accumulated landed catch of Atlantic white marlin (92.57 percent) is bycatch of the tuna-directed fisheries of Barbados, Grenada, Mexico and Bolivarian Republic of Venezuela; the catch landed in Bolivarian Republic of Venezuela accounts for over 50 percent of the reported catch in the region and, as with Atlantic blue marlin, about 20 percent of the landed catch came from the artisanal drift gillnet fishery operating off La Guaira's billfish hot spot (Arocha *et al.*, 2012) (Table 4.9). However, recently, the highest catch of Atlantic white marlin in Bolivarian Republic of Venezuela came from the Venezuelan artisanal offshore longline fleet (Arocha *et al.*, 2015). For the period 2015 to 2019, Atlantic white marlin catches from this fleet were not reported to ICCAT or to FAO. In the case of Barbados and Grenada, the catch is mostly taken by their different types of boats operating with longline gear (Gentner *et al.*, 2018; Arocha, 2019). Costa Rica is the country with the second highest accumulated landed catch of Atlantic white marlin in the region (18.98 percent), even though the country has declared it does not have vessels targeting large pelagics in the WECAFC region (FAO, 2019; ICCAT, 2020c). There are reported landings of large pelagic fish species in the national fishery statistics of Costa Rica's Caribbean landing port of Limón (INCOPESCA, 2023) but it is not clear if this important catch of Atlantic white marlin has its origin in the WECAFC region.

As with the other billfish species, Atlantic white marlin is taken almost entirely by longlines in the high seas of the WECAFC region, as well as in most of the EEZs (Figure 4.37).

However, there are some exceptions, such as off Bermuda, along the coast of southeastern United States and northern GOM, where a small proportion of the Atlantic white marlin catch is taken by sport fisheries (including the eastern Caribbean where billfish tournaments take place in Grenada and Puerto Rico). South of la Española (the Dominican Republic and Haiti) an important take of Atlantic white marlin is reported from troll and baited drop line gear. In both cases, these are likely catches from small-scale fisheries associated with the mFADs fishery. In the southern limits of the WECAFC region, within Brazil's EEZ, some catches of Atlantic white marlin are taken by the artisanal fishery operating with line gear.

Figure 4.37. *Tetrapturus albidus* (Atlantic white marlin, WHM) accumulated catch by major gear in 5°x5° for the Western Central Atlantic Fishery Commission region (1990–2019)

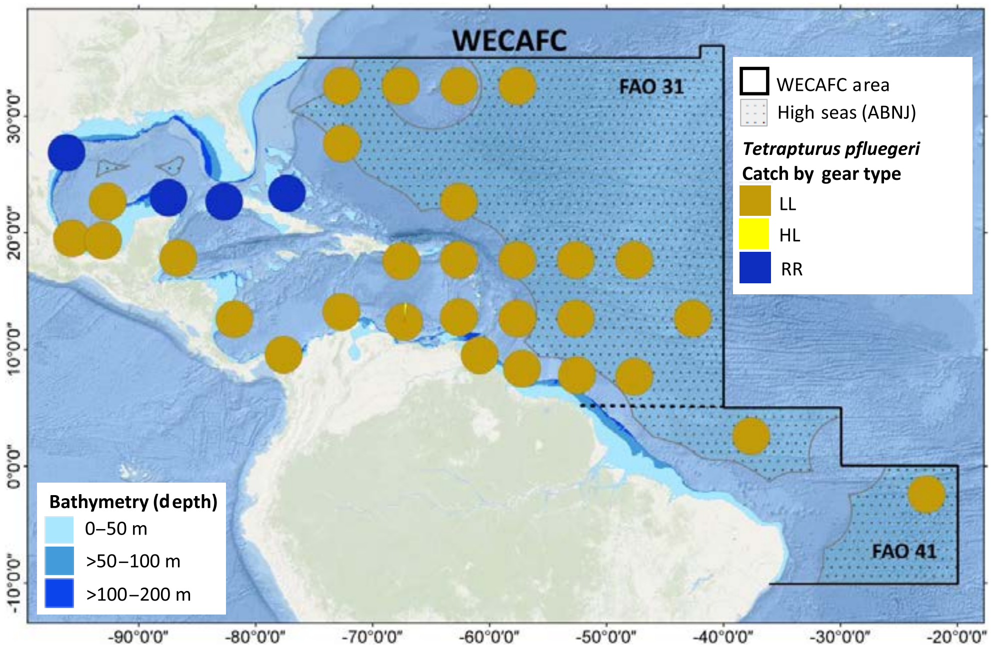


Notes: LL= longline; BB= baitboat; RR= rod and reel; TR= trolling.

Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The total accumulated landed catch of longbill spearfish in the WECAFC region came from five countries, two of which are likely catching longbill spearfish in the high seas (Saint Vincent and the Grenadines and Spain). The remainder of the catch is mostly caught within the EEZs (Table 4.9). Over 93 percent of the reported accumulated catch is bycatch of the yellowfin tuna targeted by Saint Vincent and the Grenadines and Bolivarian Republic of Venezuela. This is likely the same for Mexico and Spain, but in the case of Dominica, the longbill spearfish catch is likely a bycatch ofthe mFAD fishery which targets yellowfin tuna and common dolphinfish (Sidman *et al.*, 2014; CRFM, 2015). The available spatial information on the catches of longbill spearfish comes from the commercial operations of pelagic longliners, most of which operate in the high seas and the Caribbean Sea and south to some locations in the high seas in FAO Major Fishing Area 41 (Figure 4.38). However, in the northwestern GOM, Yucatan Channel, Straits of Florida and the Bahamas, the reported catch is entirely from rod and reel fishing by sport fishers.

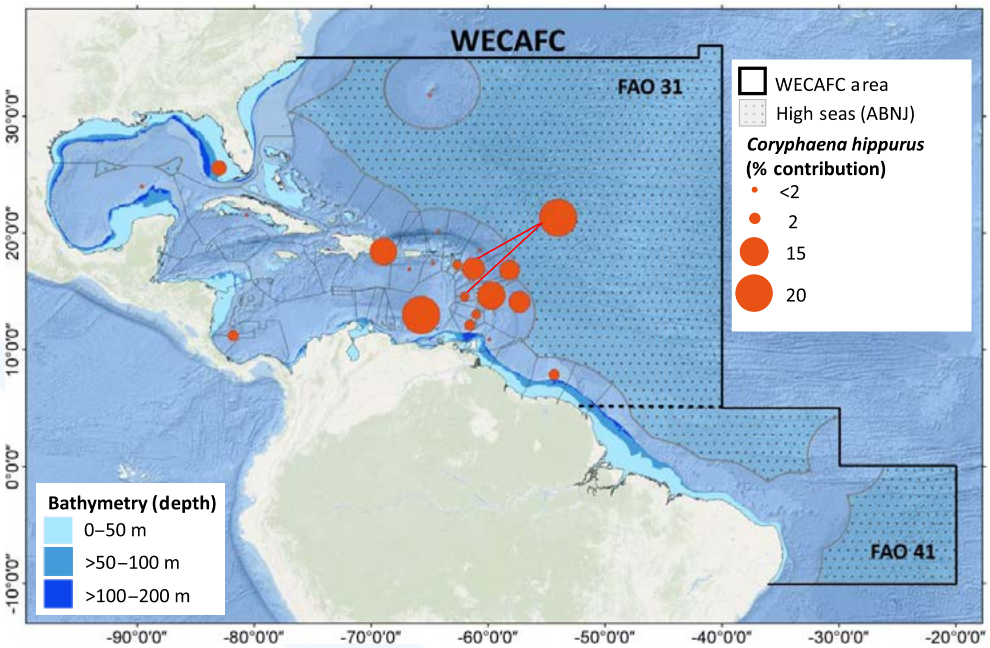
Figure 4.38. ***Tetrapturus pfluegeri*** **(longbill spearfish, SPF) accumulated catch by major gear in 5°x5° for the Western Central Atlantic Fishery Commission region (1990–2019)**



Notes: LL= longline; HL= handline; RR= rod and reel.

Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.39. ***Coryphaena hippurus*** **(common dolphinfish, DOL) percentage of contribution to total catch**



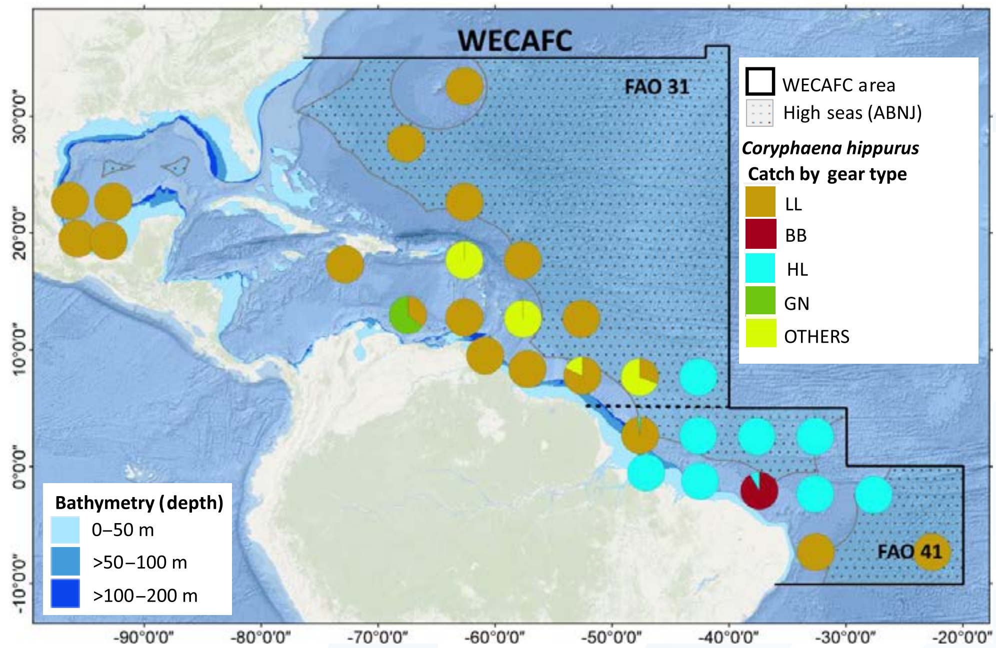
Note: The Catch of the European Union is linked to FR Martinique and FR Guadeloupe bubbles.

Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The directed fishery for common dolphinfish is mostly from the small-scale and recreational fisheries across the region, and a limited proportion is taken as bycatch in the tuna longline fishery. About 92 percent of the common dolphinfish accumulated landed catch for 2015 to 2019 is from 11 countries in the WECAFC region which makes it an important fishery resource across the region (Table 4.10, Figure 4.39). Of those countries, the reported catches from Barbados and Bolivarian Republic of Venezuela are almost entirely from small-scale longline fleets operating within several EEZs and in the margin with the high seas (Arocha *et al.*, 2015; Arocha, 2019; ICCAT, 2020b). In the United States, including Puerto Rico, the common dolphinfish landed within the WECAFC region is from the sport fishery (commercial and recreational) and from the pelagic longline fishery (directed and bycatch of fisheries directed at other migratory species) in almost equal proportions (SAFMC, 2003; CFMC, 2019). An important catch of common dolphinfish, which amounts to 50.21 percent of the total accumulated landed catch, comes from the mFAD fishery of the European Union (FR Guadeloupe and FR Martinique), Saint Lucia, the Dominican Republic, Dominica and Grenada, in which the main gear is handline gear (trolling or drop lines) (CRFM, 2015; Arocha, 2019). The common dolphinfish catches of Suriname are likely a bycatch of the longline fishery operating within the country's EEZ, whereas the catch of Costa Rica is unclear for the same reason expressed above.

The spatial distribution of common dolphinfish catches by gear (excluding the recreational fishery) shows that the species is caught by pelagic longline gear in the western GOM, likely by the Mexican fleets targeting large pelagic species, and in the high seas north of Puerto Rico and around Bermuda (Figure 4.40). In the Caribbean Sea, common dolphinfish is caught by artisanal drift gillnet, commercial pelagic longline, and likely by "other" type of line gear (i.e. trolling) around the eastern Caribbean islands. In the NBSLME the species is caught by commercial pelagic longline and other undefined gear. In the southern part of the WECAFC region, off Brazil, most of the catch is by handline gear, possibly by the recently developed small-scale fishery that targets large pelagic fishes (ICCAT, 2020b) with some coming from commercial pelagic longline and baitboats.

Figure 4.40. *Coryphaena hippurus* (common dolphinfish, DOL) accumulated catch by major gear in 5°x5° for the Western Central Atlantic Fishery Commission region (1990–2019)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Wahoo is not part of a fishery but is caught seasonally by several countries in the region when it becomes available in an area where there is a fishery for large pelagic fishes. Most of the landed catch of wahoo (91.22 percent) is reported by 12 countries in the region which means it is another important resource for SIDS (Table 4.10). The primary method for catching wahoo is by trolling (commercial and recreational) and with longline gear targeting pelagic migratory species. Within the 12 countries, 20.62 percent of the accumulated reported catch for the period 2015 to 2019 comes from longline fisheries targeting pelagic migratory species (Panama, Mexico, Saint Vincent and the Grenadines and Bolivarian Republic of Venezuela). The catch landed by the United States is mostly from the recreational fishery and a small proportion is bycatch of the common dolphinfish-directed fishery or other pelagic migratory species (SAFMC, 2003). Another group of countries that land wahoo reports catches from small-scale fisheries in SIDS that use line gear by trolling around mFADs or in open water.

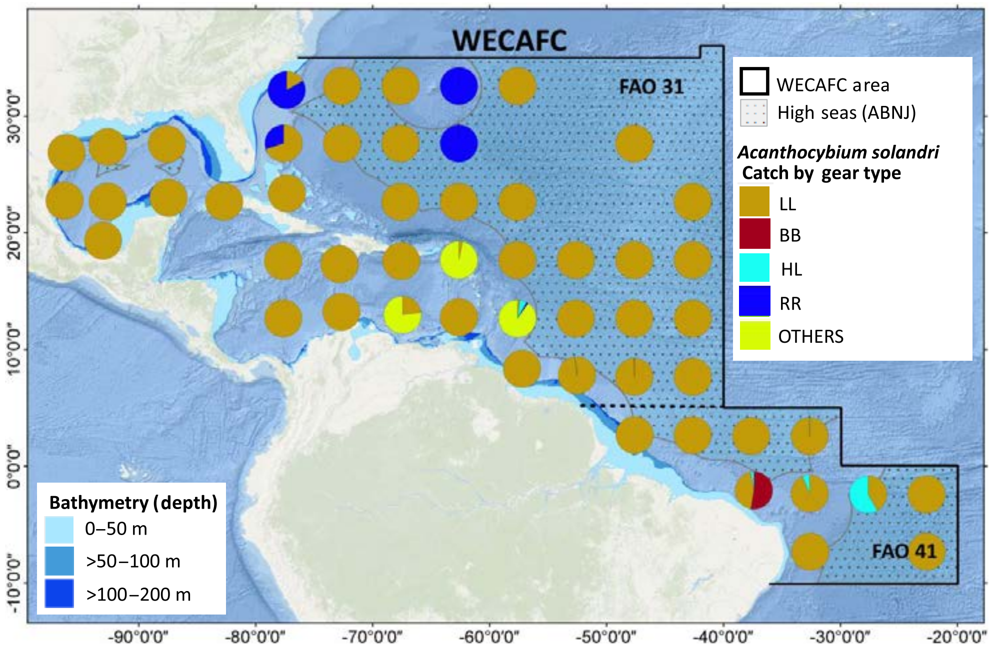
Table 4.10 Common dolphinfish and wahoo catch by country for the period 2015–2019 (tonnes)

Country	2015	2016	2017	2018	2019	Rank	%	%cum
Group: Pelagic species. Species: *Coryphaena hippurus* – common dolphinfish. Species code: DOL								
France	1 566	1	0	958	1 338	1	20.26	
Venezuela (Bolivarian Republic of)	968	812	836	836	386	2	20.12	40.38
Saint Lucia	505	435	403	390	388	3	11.12	51.50
Dominican Republic (the)	199	393	422	485	460	4	10.27	61.77
Guadeloupe	230	270	270	270	270	5	6.87	68.64
Barbados	373	405	185	155	151	6	6.65	75.30
Dominica	295	186	228	209	210	7	5.91	81.21
United States of America	148	99	85	173	103	8	3.19	84.40
Suriname	182	79	82	89	99	9	2.78	87.19
Grenada	105	100	100	100	100	10	2.65	89.83
Costa Rica	27	108	105	105	105	11	2.36	92.19
Saint Vincent and the Grenadines	0	6	105	126	99	12	1.76	93.95
Saint Kitts and Nevis	52	64	65	68	30	13	1.46	95.42
Martinique	44	46	46	46	90.3	14	1.43	96.85
Puerto Rico	60	26	17	38	42.46	15	0.96	97.81
Antigua and Barbuda	22	22	22	22	22	16	0.58	98.38
United States Virgin Islands	25	28	28	9	9	17	0.52	98.90
Cuba	22	19	16	16	10	18	0.44	99.34
Trinidad and Tobago	24	21	8	6	5.1	19	0.34	99.67
Mexico	7	7	8	8	6	20	0.19	99.86
Bermuda	4	3	4	5	5	21	0.11	99.97
British Virgin Islands	1	1	1	1	1	22	0.03	100.00
Group: Pelagic species. Species: *Acanthocybium solandri* – wahoo. Species code: WAH								
Suriname	360	139	143	132	148	1	24.27	
Saint Lucia	87	147.	110	76	126.64	2	14.39	38.67
Bermuda	86	96	92	69	82	3	11.19	49.85
Panama	0	109	0	77	123	4	8.14	57.99
Saint Vincent and the Grenadines	9	11	126	82	27	5	6.71	64.70
Aruba	47	47	40	40	45	6	5.77	70.47
Grenada	40	40	40	40	40	7	5.27	75.73
Venezuela (Bolivarian Republic of)	30	64	51	0	0	8	3.82	79.55
France	45	38	41	13	0	9	3.61	83.16
United States of America	38	45	39	10	4	10	3.58	86.74
Dominican Republic (the)	92	2	2	0	0	11	2.53	89.27
Mexico	12	18	13	20	11	12	1.95	91.22
Spain	1	3	1	61	0.03	13	1.74	92.95
United States Virgin Islands (the)	13	17	14	4	4	14	1.37	94.32
Saint Kitts and Nevis	6	9	15	12	6	15	1.26	95.59
Barbados	10	11	10	7	9	16	1.24	96.82
Trinidad and Tobago	9	10	8	7	6	17	1.05	97.88
Dominica	10	10	5	3	6	18	0.90	98.77
Puerto Rico	8	5	3	7	6.5	19	0.78	99.55
Colombia	0	2	7	0	6.66	20	0.41	99.96
British Virgin Islands (the)	1	0	0	0	0	21	0.03	99.99
Belize	0	0	0	0.48	0	22	0.01	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

The spatial abundance of wahoo in the region is well represented because of the fishery's interaction with the pelagic longline fishery targeting migratory fishes, and because of improved reporting in the past 20 years. Most of the reported catch of wahoo is taken by pelagic longline gear throughout the region (Figure 4.41) and in some areas, such as around Bermuda and off the southeastern coast of the United States, the species is taken by recreational fishers using rod and reel. In the eastern Caribbean it is mostly caught with "other" line gear like trolling and handline and in the southern WECAFC area wahoo is caught with handline and baitboats, in addition to pelagic longline gear.

Figure 4.41. *Acanthocybium solandri* (wahoo, WAH) accumulated catch by major gear in 5°x5° for the Western Central Atlantic Fishery Commission region (1990–2019)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Sailfish hauled by Venezuelan artisanal longline boat © FAO

4.2.7 State of the stocks

Swordfish. The last assessment for swordfish in the North Atlantic was conducted in 2017 (ICCAT, 2020b). The population of swordfish in the North Atlantic is estimated to be at or above levels needed to produce MSY (B/B_{MSY}=1.04) and is not overfished (F/F_{MSY}=0.78) (Table 4.2). Management advice up to 2021 is a TAC of 13 200 tonnes, in which several WECAFC Member States have a specific TAC, as well as a minimum size limit.

Atlantic blue marlin. A full stock assessment was conducted for Atlantic blue marlin in 2018, using data available to the year 2016 and applying both surplus production and age-structured models (ICCAT, 2019). The results of the 2018 assessment indicated that the estimated MSY (median = 3 001 tonnes), the estimated relative biomass (B/B_{MSY}=0.69) and relative fishing mortality (F/F_{MSY}=1.03) were such that the current stock status is overfished and undergoing overfishing. Current management advice is a TAC of 2 000 tonnes, in which several WECAFC Member States have a specific TAC.

Atlantic sailfish. A full stock assessment was conducted for western Atlantic sailfish in 2016, using the data available to the year 2014, and applying a surplus production, stock reduction analysis (catch only) and stock synthesis model (ICCAT, 2017a). Models could not provide stock status due to the large uncertainty in benchmark estimates, and generally poor model convergence. Therefore, based on point estimates of the surplus production and stock synthesis models, ICCAT indicated that the stock is neither overfished nor experiencing overfishing. Current management advice is a western Atlantic sailfish catch limit of 67 percent of the MSY that was estimated, i.e. between 1 438 tonnes and 1 636 tonnes.

Atlantic white marlin. A full stock assessment was conducted for the combined Atlantic white marlin/roundscale spearfish in 2019 using data available to the year 2017 and applying both surplus production and age-structured models (ICCAT, 2019). The results of the 2019 assessment indicated that the estimated relative biomass (B/B_{MSY}=0.58) and relative fishing mortality (F/F_{MSY}=0.65) were such that the current stock status is overfished but not undergoing overfishing. Current management advice is a TAC of 400 tonnes, in which several WECAFC Member States have a specific TAC.

Spearfishes. No stock assessments have been conducted on individual species, only for roundscale spearfish when it is combined with Atlantic white marlin. However, efforts continue to estimate the proportion of the two species in the catches that would allow a potential separation over the time series. In the case of the longbill spearfish, no assessments have been conducted.

Common dolphinfish. The CRFM 2010 stock assessment analysed data from the eastern Caribbean islands, Bolivarian Republic of Venezuela, northeastern Brazil and the United States (CRFM, 2010). The standardized CPUE indices for the eastern Caribbean corroborated that the stock was not declining. In Brazil, the stock assessment in the northeast indicated that the stock was fully exploited (Lessa *et al.*, 2009), although there is uncertainty in the data. The one stock assessment reported for this stock in the southeast waters of the United States, produced highly uncertain results due to the absence of reliable data in many sectors over many years (Prager, 2000).

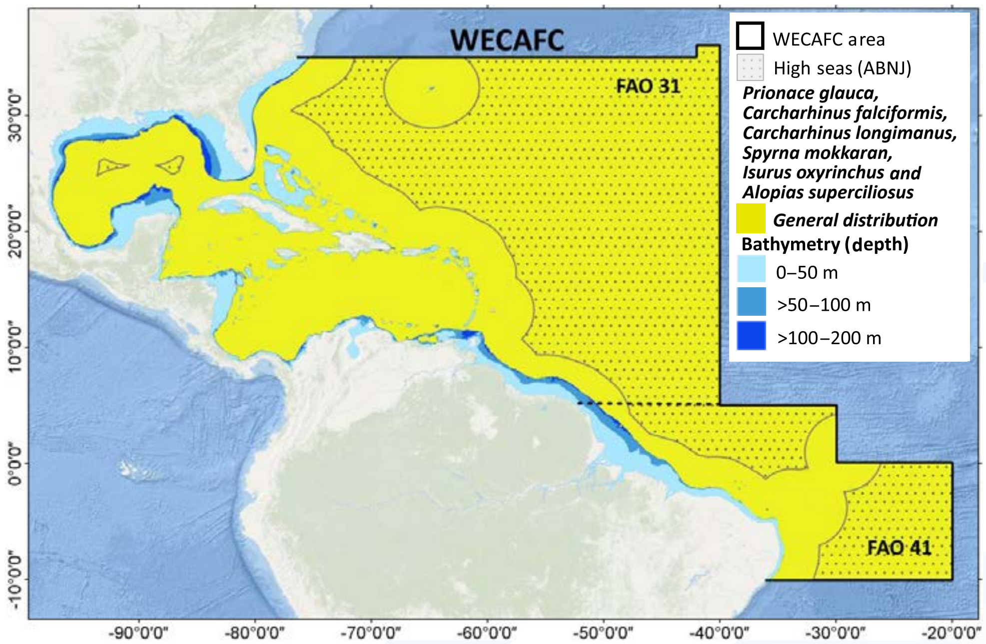
Wahoo. Data-limited assessment methods that used biological information and fisheries data to estimate proxies of stock status of wahoo in the northwest Atlantic indicated that both models used (length-based spawning potential ratio and length-based integrated mixed effects) estimated low spawning potential ratio values for the northwest stock, suggesting that this stock is overfished (Pons *et al.*, 2019). A recommendation was that, when the data are available, length-based models should be applied to the length data coming from the fleet that targets the broadest range of sizes.

4.3 The elasmobranch resources (sharks and rays)

The elasmobranch resources in this section are considered to be pelagic and mostly open water species which include four requiem sharks (Carcharinidae), three hammerhead sharks (Sphyrnidae), one mackerel shark (shortfin mako, *Isurus oxyrinchus*), one thresher shark (bigeye thresher, *Alopias superciliosus*), one whale shark (*Rhincodon typus*), one stingray (pelagic stingray) and one devil ray (giant oceanic manta ray, *Mobula birostris*).

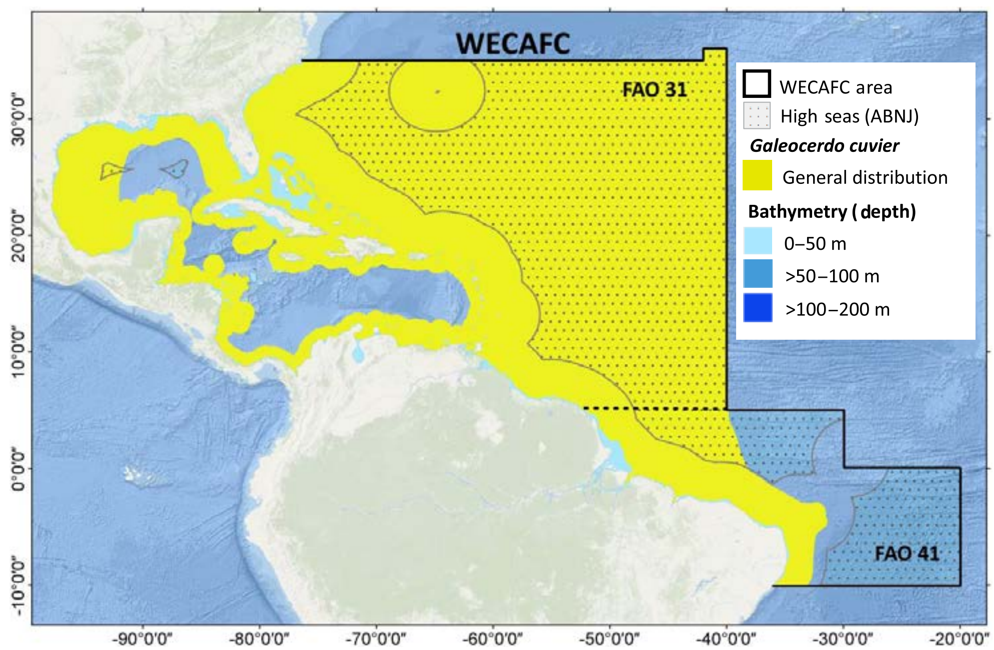
The main requiem shark species from a fisheries point of view in the WECAFC region are blue shark (*Prionace glauca*), silky shark (*Carcharhinus falciformis*), oceanic whitetip shark (*Carcharhinus longimanus*) and tiger shark (*Galeocerdo cuvier*). Most requiem sharks included in this section are oceanic (blue shark, silky shark and oceanic whitetip shark) (Figure 4.42). The tiger shark is mostly littoral and semipelagic but is known to move into open ocean waters (Figure 4.43).

Figure 4.42. *Prionace glauca* (blue shark, BSH), *Carcharhinus falciformis* (silky shark, FAL), *Carcharhinus longimanus* (oceanic whitetip shark, OCS), *Sphyrna mokarran* (great hammerhead, SPK), *Isurus oxyrinchus* (shortfin mako, SMA) and *Alopias superciliosus* (bigeye thresher shark, BTH) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.43. *Gaeleocerdo cuvier* (tiger shark, TIG) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The **blue shark** is distributed throughout the region. It is found from the surface to at least 1 160 m depth (Queiroz *et al.*, 2012). The shark occasionally occurs in inshore waters where the continental shelf is narrow, preferring temperatures of 12 °C to 20 °C. It is found at greater depths in tropical waters. A behavioural characteristic of this species is its tendency to segregate temporally and spatially by size and/or sex, during feeding, mating, gestation and birth processes (Nakano and Stevens, 2008; Coelho *et al.*, 2018). In the Caribbean Sea, blue sharks displayed temporal and spatial sexual segregation dominated by immature and mature males, but with a seasonal occurrence of mature females with advanced pregnancy in the area (Tavares, Ortiz and Arocha, 2012). Genetically, blue shark in the WECAFC region likely belongs to an Atlantic-wide population (Veríssimo *et al.*, 2017), although it is managed under the North Atlantic stock unit by ICCAT.

The **silky shark** has an oceanic and coastal distribution, found near the edge of continental and insular shelves, as well as far from land in the open sea, to depths of 500 m. It is widely distributed throughout the region but is commonly caught as bycatch in pelagic longline fisheries across the WECAFC region. There is no indication of a regional stock structure, although most catches consist of adult specimens in the northern and southern range of the WECAFC region, while off the NBSLME and southeastern Caribbean Sea the catch consists of juvenile and small specimens (Rigby *et al.*, 2017; Arocha *et al.*, 2015).

The **oceanic whitetip shark** is a wide-ranging oceanic species of tropical and temperate seas worldwide, with a preference for surface waters. The shark is usually found far offshore in the open sea, but it sometimes occurs in water as shallow as 37 m inshore, particularly off oceanic islands or in continental areas where the shelf is very narrow (Rigby *et al.*, 2019a). The species is caught globally as target and bycatch in pelagic large- and small-scale longline, purse seine and gillnet fisheries and is often retained for the meat and fins, unless regulations prohibit its retention. It has a high catchability due to its preference for surface waters and its inquisitive nature. Steep population declines have occurred in all oceans. The oceanic whitetip shark was once one of the most abundant pelagic shark species in tropical seas worldwide but is now rare in some regions including the WECAFC region (Young *et al.*, 2017).

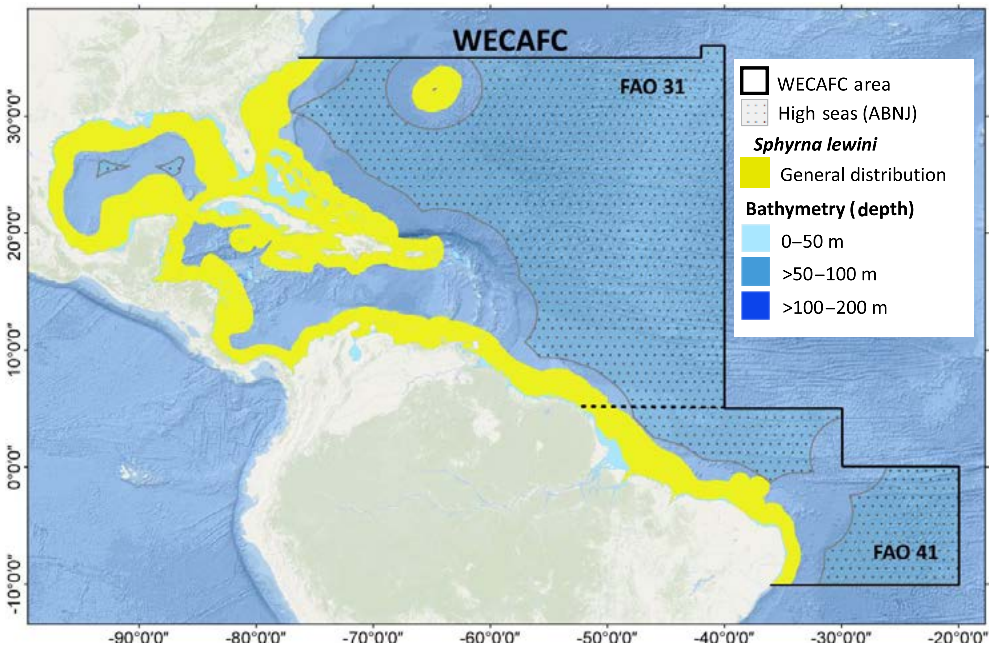
The **tiger shark** is a wide-ranging oceanic species that inhabits shelf, reef and slope habitats, is sometimes associated with coral reefs, and makes long-distance excursions into the high seas (Assael, 2016). This species has relatively fast growth rates and large litters (on average 26 to 33 pups) but the likely triennial reproductive cycle reduces its ability to recover from fishing pressure (Ferreira and Simpfendorfer, 2019). The species is caught by commercial and artisanal fisheries in the WECAFC region. Off the central coast of Bolivarian Republic of Venezuela the species is caught as bycatch of the billfish artisanal drift gillnet fisheries, and off the NBSLME it is caught by bottom gillnets by the Venezuelan multigear fleet. In the latter fishery, most of the catch consists of juvenile tiger sharks.

The members of the family Sphyrnidae are generally considered coastal, occasionally occurring in brackish water with a global distribution, mostly in warm waters, although the species reviewed in his section are known to occur in open ocean waters of the high seas (ICCAT, 2013). Three species are commonly caught within the WECAFC region.

The **scalloped hammerhead** occurs globally and is generally a coastal and semi-oceanic pelagic shark, found over continental and insular shelves and nearby deep water, ranging from the intertidal area and surface waters, usually to a depth of 275 m depth (Rigby *et al.*, 2019b). However, there are records of the scalloped hammerhead in open ocean waters around sea mounts and rises (Bessudo *et al.*, 2011). Additionally, the species has been observed close to shore and even entering estuarine habitats. It is caught globally as a target species and as bycatch in pelagic commercial and small-scale longline, purse seine and gillnet fisheries, and is retained for the meat and fins. Scalloped hammerhead shark is found across the WECAFC region, except for the Caribbean Sea basin and the Lesser Antilles (Figure 4.44). The species is common in inshore small-scale fisheries, as well as offshore operations. It is caught with pelagic longlines, fixed bottom longlines and fixed bottom nets. Adults spend most of the time offshore in midwater and females migrate to the coastal areas to pup (Klimley, 1987). Genetic data reveal that the global population structure varies between males and females. Only males move across ocean basins, while females move regionally and not between discontinuous continental coastlines (Duncan *et al.*, 2006).

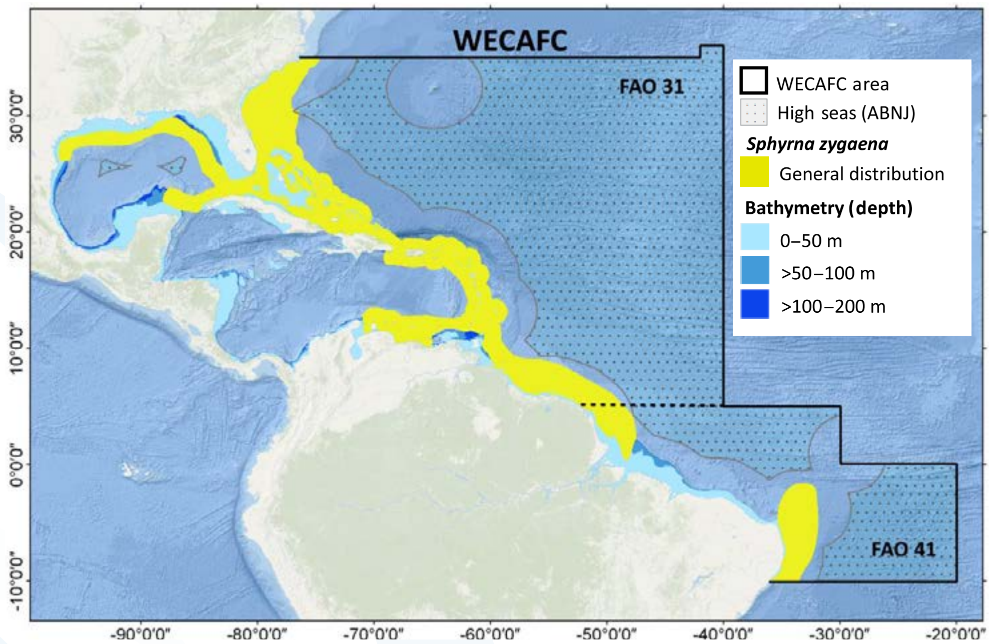
The **smooth hammerhead** is generally a coastal and semi-oceanic pelagic shark that occurs on the continental shelf to at least 200 m, and possibly deeper. It is the most oceanic of the hammerhead species and capable of travelling long distances over open ocean in the high seas (Santos and Coelho, 2018) commonly leaving coastal habitats at 2 to 3 years of age (Clarke *et al.*, 2015). In the WECAFC region, the smooth hammerhead is caught as bycatch in pelagic industrial and small-scale longline and gillnet fisheries and is often retained for the fins and sometimes the meat (Tavares and Arocha, 2008). In the region this species is found from Canada south to the Virgin Islands and from off the NBSLME south to Argentina. It is absent from the GOM and the Caribbean Sea (Figure 4.45). Smooth hammerhead sharks occasionally venture into freshwater and estuaries. Juveniles form large aggregations, while adults occur individually or in small groups (Rigby *et al.*, 2019c). There are no data available on the global population size of the smooth hammerhead. Genetic studies reveal structure between the Atlantic and Indo-Pacific, but contrasting results may indicate female philopatry and male mediated gene flow (Testerman, 2014). Despite its widespread occurrence, biological data on this species are limited. It attains a maximum size of about 400 cm total length (Ebert, Fowler and Compagno, 2013; Weigmann, 2016).

Figure 4.44. *Sphyrna lewini* (scalloped hammerhead shark, SPL) general distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.45. *Sphyrna zygaena* (smooth hammerhead, SPZ) general distribution distribution in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The great hammerhead (*Sphyrna mokarran*) is a large (600 cm total length), semi-oceanic pelagic shark which is generally solitary and found in coastal areas, but does move to open ocean waters in the high seas (Hammerschlag *et al.*, 2011). Generally, the species occurs close inshore and well offshore at depths ranging from near surface to 300 m. It is commonly seen in shallow coastal areas, such as over continental shelves and in lagoons at depths of 80 m (Rigby *et al.*, 2019d). The great hammerhead is targeted globally and landed as bycatch in pelagic large- and small-scale longline fisheries and in gillnet fisheries. It is often retained for its fins. The species has a long lifespan of up to 44 years and only breeds once every two years. These factors, when combined with high bycatch mortality, make it susceptible to depletion where it is taken in unmanaged fisheries. There are no data available on the global population size of the great hammerhead. Genetic studies support two subpopulations, the Atlantic and Indo-Pacific. No genetic structure was found within the Atlantic (Testerman, 2014). In the WECAFC region it ranges from North Carolina (United States) south to Uruguay, including the GOM and Caribbean Sea (Figure 4.42).

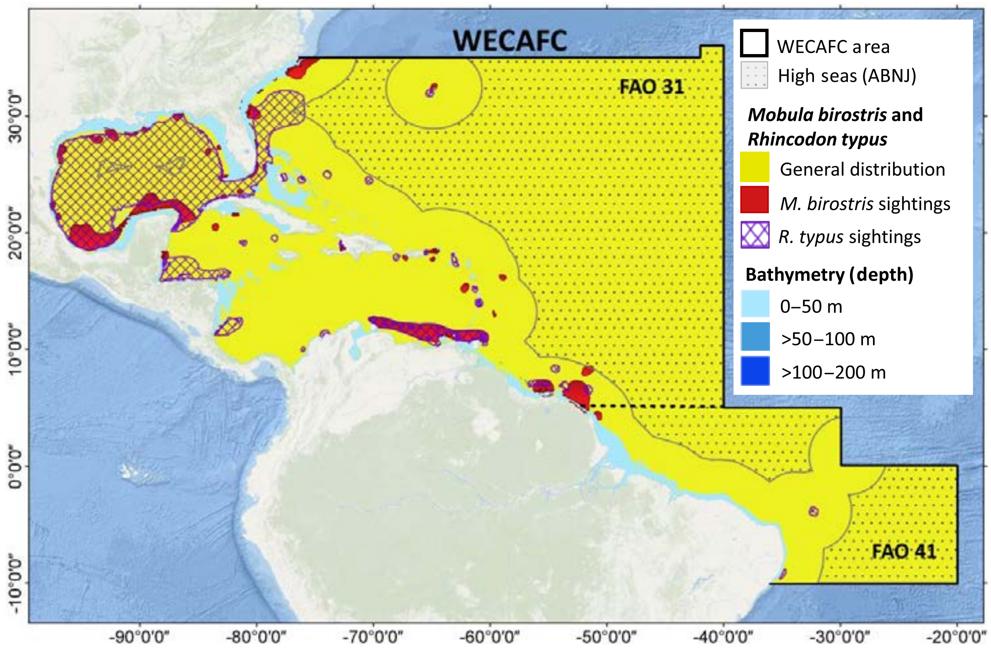
The **shortfin mako** is a large (to 445 cm total length) neritic, epipelagic, and mesopelagic species, widespread in temperate and tropical oceans and widely distributed across the WECAFC region (Figure 4.42). It occurs from the surface to depths of 888 m (Rigby *et al.*, 2019e). Like the blue shark´s behavioural characteristic to segregate spatially, shortfin mako seems to display some latitudinal distribution in the Atlantic, with the larger specimens tending to occur along the equatorial and tropical regions and the smaller sizes occurring mainly towards higher latitudes, both in the North and Southern hemispheres (Coelho *et al.*, 2018). It is occasionally found close to inshore waters where the continental shelf is narrow. Shortfin mako is caught globally as target and bycatch in coastal and pelagic commercial and small-scale longline fisheries and gillnet fisheries and is generally retained for the high-value meat and fins. The species reaches a maximum size of about 445 cm total length. It has low biological productivity with a triennial reproductive cycle and late age at maturity. There are no data available on the absolute global population size of the shortfin mako. Genetic studies indicate one global population, but there is some genetic structuring between ocean basins such as in the Atlantic where there is some indication that the North Atlantic population appears to be isolated from the South Atlantic (Schrey and Heist, 2003).

The **bigeye thresher** is a large (to 484 cm total length) pelagic shark, occurring worldwide in tropical and temperate seas from the surface to depths of 955 m; it is found in coastal waters over continental shelves, sometimes close inshore in shallow waters, and on the high seas in the epipelagic and mesopelagic zones far from land. It is also caught near the bottom in deep water on continental slopes (Rigby *et al.*, 2019). It is present near the surface at night and makes deep dives during the day (Clarke *et al.,* 2015). In the WECAFC region, the bigeye thresher is found in the southeastern United States, some parts of the GOM and around Cuba, and in the southern Caribbean Sea and off the NBSLME (Arocha *et al.*, 2017) (Figure 4.42). It has low fecundity (average two pups per litter) and the lowest intrinsic rebound potential of the thresher shark species. It is caught globally as target and bycatch in pelagic commercial and small-scale longline fisheries and gillnet fisheries. Genetic results indicate one global population, but there is some genetic structuring between the northwest Atlantic and the Pacific Oceans (Morales *et al.*, 2018).

The **whale shark** is a cosmopolitan tropical and warm temperate species. Genetic results indicate that two major subpopulations exist, in the Atlantic Ocean and Indo-Pacific, respectively. Pronounced size- and sex-based segregation is present in most of the species' known coastal feeding areas, with coastal sites typically dominated by juvenile male sharks

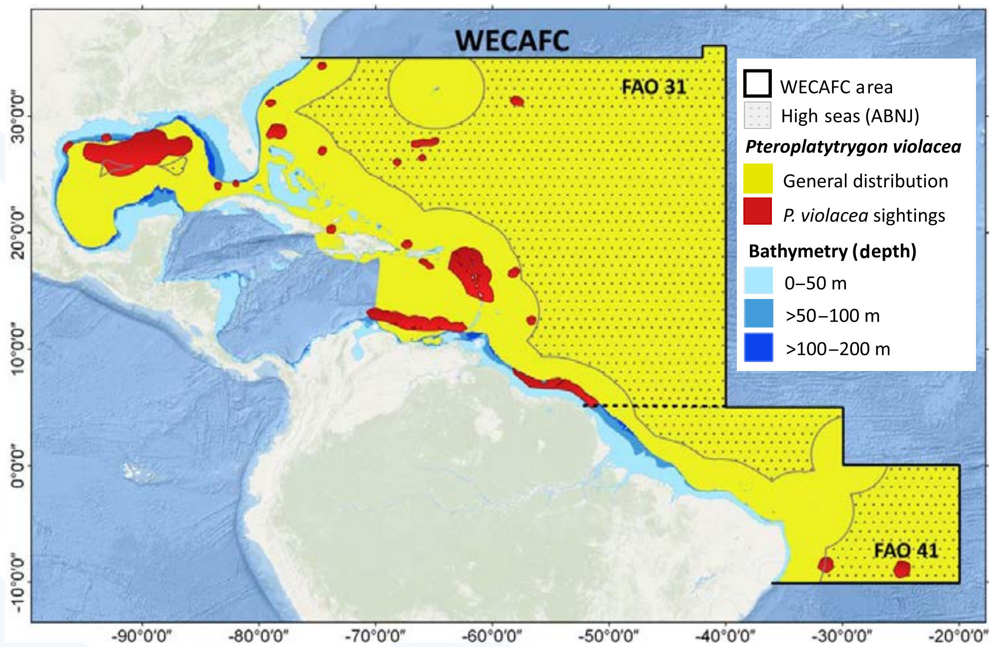
(Pierce and Norman, 2016). Whale sharks are found in both coastal and oceanic habitats (Figure 4.46) (Rowat and Brooks, 2012). They spend most of the time in the epipelagic zone, but dive to at least 1 928 m (Tyminsky *et al.*, 2015). Most whale shark sightings occur at a small number of known coastal feeding areas for the species (Sánchez *et al.*, 2020) where the sharks aggregate on the surface to exploit seasonal productivity such as fish spawning events or zooplankton blooms (Rowat and Brooks, 2012).

Figure 4.46. *Mobula birostris* (giant oceanic manta ray, RMB) and *Rhincodon typus* (whale shark, RHN) general distribution and sightings in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.47. *Pteroplatytrygon violacea* (pelagic stingray, PLS) general distribution and sightings in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The **pelagic stingray** is a medium-sized ray (to 80 cm disc width) that is circumglobal throughout the tropical and temperate oceans. It occurs in the epipelagic zone, mostly to depths of 100 m, although it has been recorded to 381 m (Kyne *et al.*, 2019). The pelagic stingray is perhaps the only species of stingray that occurs in the pelagic zone (Neer, 2008). In the WECAFC region it is found off Bermuda, the southern Caribbean Sea, around the Lesser Antilles and off the NBSLME (Figure 4.47). The species is taken as bycatch in pelagic longline fisheries around the world. It is mostly discarded but in some areas it is retained and utilized. Parturition (birth) was seen to occur in July off the island of La Tortuga (Bolivarian Republic of Venezuela) detected from a significant volume of catches in the area (Arocha *et al.*, 2013).

The **giant oceanic manta ray** is a large ray with a circumglobal distribution in tropical and temperate waters throughout major oceans. It is a neritic and oceanic pelagic ray, common in areas with regular upwelling along coastlines, oceanic islands and offshore pinnacles and seamounts. The species can exhibit diel patterns in habitat use, moving inshore during the day to clean and socialize in shallow waters, and then moving offshore at night to feed to depths of 1 000 m. It can also spend long periods of time offshore without visiting shallow coastal waters (Marshall *et al.*, 2020). In the WECAFC region the species is often found in areas relatively close to land formations, i.e. continental slope, rises/seamounts, islands and reefs (Figure 4.46). The giant oceanic manta ray may be the largest living ray species, attaining a maximum size of 700 cm disc width (DW) with anecdotal reports up to 910 cm (Compagno, 1999). The global population size is not known, but local and regional abundance has been estimated and is mostly small, numbering less than 500 individuals, with exceptions. The species has an extremely slow life history, producing only one pup on average every 4 to 5 years. It is targeted or taken as bycatch in artisanal small-scale fisheries and taken as bycatch in large-scale tuna fisheries.

4.3.1 The fishery

The fishery for elasmobranch species in this section can be directed, or the species are taken as bycatch in the longline fishery for tuna and swordfish. In countries where directed fisheries exist, the pelagic elasmobranch catches are mostly taken by the small-scale fisheries of several countries in the region. In addition, a sport fishery for large coastal sharks exists in the United States, although it is mostly limited to one shark per vessel/trip (NOAA, 2006).

As is the case for transboundary elasmobranch species, most of the elasmobranch catches in the region are reported in groupings: Elasmobranchii (sharks, rays, skates, etc. NEI), Carcharhinidae (requiem shark NEI), Sphyrnidae (hammerhead sharks, etc. NEI), Rajiformes (rays, stingrays, mantas NEI); generic such as *Carcharhinus* spp., *Sphyrna* spp., *Alopias* spp., *Isurus* spp., and straddling-specific such as blue shark, shortfin mako, silky shark, tiger shark, great hammerhead and scalloped hammerhead. In this section, the fishery descriptions will focus initially on the species for which specific catch data and fishery information exist, such as the blue shark and shortfin mako.

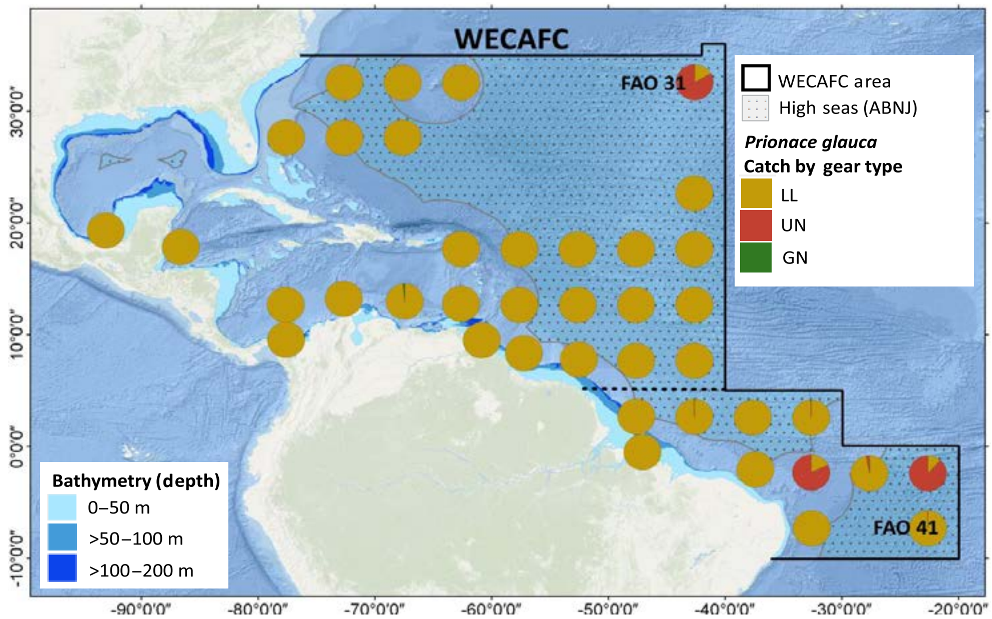
For blue shark, most of the accumulated landed catch (93.17 percent) during the period 2015 to 2019 is from commercial bycatch of the tuna longline fishery of three WECAFC Member States, and from Spain which is responsible for over 50 percent of the blue shark catch reported for the WECAFC region (Table 4.11). Other than Panama, Suriname and Bolivarian Republic of Venezuela, that account for 39.72 percent of the WECAFC blue shark reported catch in recent years, the other Member States that report blue shark catches (Saint Vincent and the Grenadines, Colombia and Trinidad and Tobago) account for 1.78 percent of the accumulated recent catch. The remainder (5.05 percent) is reported by non-WECAFC Member States. The spatial distribution of blue shark accumulated catches by gear for the period 1990 to 2019 is mostly from the pelagic longline gear that targets tuna, in the case of the Asian fleets and WECAFC countries, and swordfish, in the case of European countries (Portugal and Spain) that fish in the high seas of the WECAFC region and its adjacent areas (Figure 4.48). Most of the reported catch by longline gear is from the high seas and to some extent in the southern Caribbean and along the NBSLME, through to the southern limits of the region. A small fraction of the catches off central Bolivarian Republic of Venezuela come from the artisanal drift gillnet fishery targeting billfishes. Significant fractions of the catch in the high seas are from unclassified gear, and most likely from the longline fishery targeting swordfish, but the catches may not have been reported in the early years of the period. Limited catches are observed in the upper WECAFC region (Yucatan Channel and off Florida, United States). The areas of significant abundance of blue shark within the EEZs of the region are off central Bolivarian Republic of Venezuela and Suriname, the remainder are in the areas of the high seas (Figure 4.49).

Table 4.11 Blue shark, shortfin mako, silky shark, bigeye thresher shark, tiger shark and other sharks catch by country for the period 2015–2019 (tonnes)

Country	2015	2016	2017	2018	2019	Rank	%	%cum
Group: Elasmobranch. Species: *Prionace glauca* – blue shark. Species code: BSH								
Spain	1 585	1 330	448	747	487.77	1	53.45	
Suriname	195	344	496	541	383	2	22.77	76.22
Panama	0	262	0	437		3	10.94	87.16
Venezuela (Bolivarian Republic of)	129	116	105	112	55	4	6.01	93.17
Taiwan Province of China	184	136	56	0	0	5	4.37	97.54
Saint Vincent and the Grenadines	0	136	0	0	0	6	1.58	99.13
Portugal	0	0	15	34	0	7	0.57	99.69
China	0	5	0	2	2	8	0.10	99.80
Colombia	0	0	0	0	8.95	9	0.10	99.90
Trinidad and Tobago	4	2	2	0	0.29	10	0.10	100.00
Group: Elasmobranch. Species: *Isurus* spp. – mako sharks. Species code: –								
Trinidad and Tobago	0	0	0	0	0.15	1	100.00	100.00
Group: Elasmobranch. Species: *Isurus oxyrinchus* – shortfin mako. Species code: SMA								
Spain	72	100	81	59	35.14	1	65.40	
Venezuela (Bolivarian Republic of)	13.97	11.1	15.74	14.26	12.12	4	12.66	78.06
United States of America	12	17	14	7	2	2	9.80	87.86
Mexico	4	5	4	6	5	3	4.52	92.38
Saint Vincent and the Grenadines	2	3	4	2	3	5	2.64	95.02
Taiwan Province of China	9	2	1	0	0	6	2.26	97.28
Trinidad and Tobago	1	1	2	2	1.16	7	1.35	98.63
Portugal	0	0	0	5	0	8	0.94	99.57
Colombia	0	0	0	0	1.28	9	0.24	99.81
Costa Rica	0	1	0	0	0	10	0.19	100.00
Group: Elasmobranch. Species: *Carcharhinidae* – requiem sharks NEI. Species code: –								
Mexico	1 352	1 103	1 501	1 235	1 277	1	87.75	
Venezuela (Bolivarian Republic of)	862	6	6	6	6	2	12.02	99.77
Bermuda	3	3	2	2	2	3	0.16	99.93
Saint Vincent and the Grenadines	0	0	0	3	2	4	0.07	100.00
Group: Elasmobranch. Species: *Carcharhinus* spp.– Carcharhinus sharks NEI. Species code: –								
Colombia	0	0	0	0	11.36	1	100.00	
Group: Elasmobranch. Species: *Carcharhinus falciformis* - silky shark. Species code: FAL								
Costa Rica	71	124	120	120	120	1	99.80	
United States of America	1	0	0	0	0	2	0.18	99.97
Colombia	0	0	0	0	0.14	3	0.03	100.00
Group: Elasmobranch. Species: *Alopias* spp – thresher sharks NEI. Species code: –								
Trinidad and Tobago	1	1	1	1	0.63	1	100.00	100.00
Group: Elasmobranch. Species: *Alopias superciliosus* – bigeye thresher shark. Species code: BTH								
Mexico	0	0	0	0	64	1	80.00	
Venezuela (Bolivarian Republic of)	0	4	4	4	4	2	20.00	100.00
Group: Elasmobranch. Species: *Galeocerdo cuvier* – tiger shark. Species code: TIG								
Venezuela (Bolivarian Republic of)	0	31	32	32	32	1	36.60	
United States of America	11	0	30	28	40	2	31.41	68.02
Mexico	12	22	13	25	17	3	25.65	93.67
Colombia	0	0	0	0	6.91	4	1.99	95.66
Trinidad and Tobago	1	1	1	1	1.01	5	1.44	97.10
Saint Lucia	1	0	1	2	0.82	6	1.39	98.49
Puerto Rico	2	0	0	0	2.24	7	1.22	99.71
Bermuda	0	0	1	0	0	8	0.29	100.00

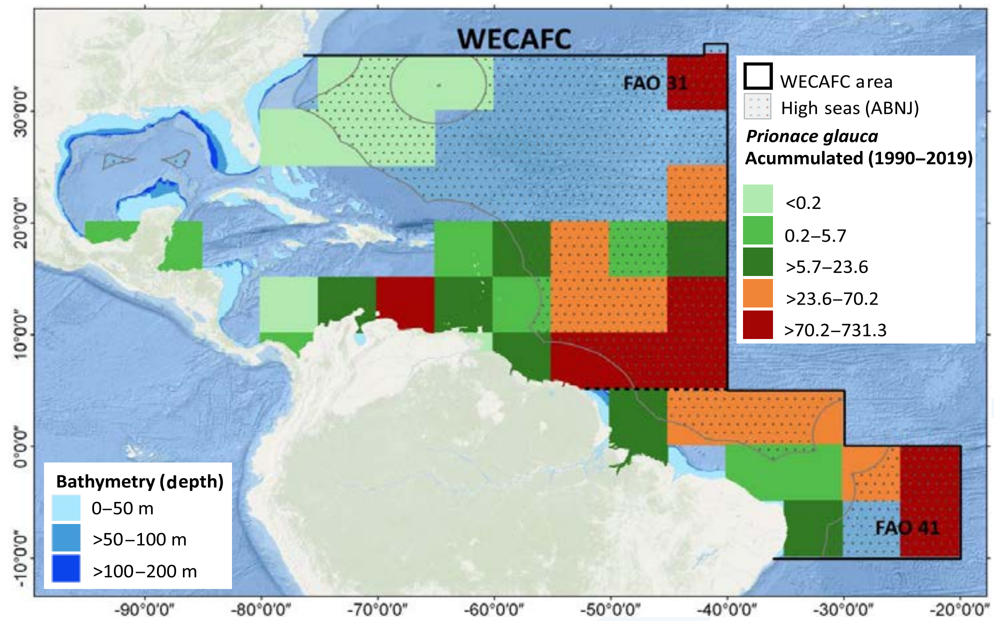
Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Figure 4.48. *Prionace glauca* (blue shark, BSH) accumulated catch by major gears in 5°x5° in the Western Central Atlantic Fishery Commission region (1990–2019)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.49. *Prionace glauca* (blue shark, BSH) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)



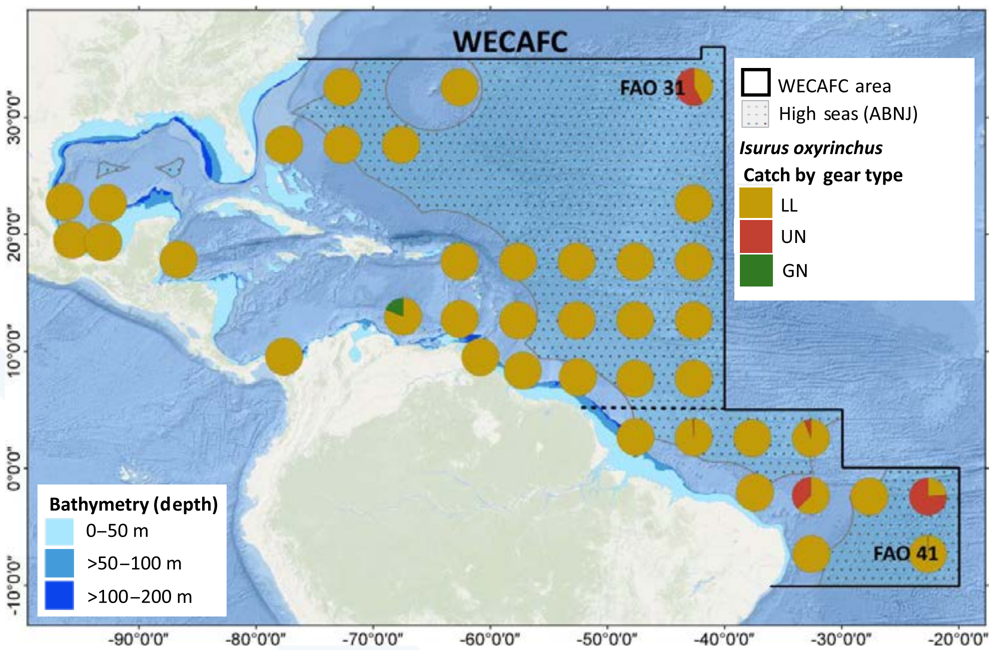
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

In the WECAF region, shortfin mako shark is mostly caught by four countries which account for 92.38 percent of the accumulated landed catch for the period 2015 to 2019 (Table 4.11). Spain is responsible for 65.40 percent of the total accumulated catch, followed by Bolivarian Republic of Venezuela with 12.66 percent, the United States with 9.80 percent and Mexico with 4.52 percent. As with blue shark, most of the reported catches of shortfin mako are made with longline gear, generally associated with fisheries for tuna and/or swordfish

(Figure 4.50). However, a significant fraction of the catch in the south-central Caribbean is taken by the artisanal drift gillnet fishery targeting billfishes off Bolivarian Republic of Venezuela. As with blue shark, in the high seas some localized fractional catches from unclassified gear likely come from the longline fishery targeting swordfish and may not have been reported and/or reclassified. In the Caribbean Sea there are two areas of important abundance based on accumulated catches: one is the southeast off Bolivarian Republic of Venezuela and the other is northwest, off Yucatan and Belize (Figure 4.51). Other areas of important abundance in the EEZs of the WECAFC region include the southwestern GOM and off Guyana and Suriname. The remaining abundance is mostly found in the high seas.

This section, on the fishery for straddling elasmobranch species, will focus first on the species-specific fisheries and then the generic and higher groups. The requiem sharks (silky shark, oceanic whitetip), bigeye thresher sharks and pelagic stingrays are mostly taken by the pelagic longline tuna and swordfish fisheries in the region – both industrial and small-scale fleets – but there are several small-scale fisheries in the region that catch these species with drift gillnets. Tiger shark and hammerhead shark are mostly taken by bottom longline gear and drift and set gillnets, and occasionally as bycatch of the pelagic longline fishery for tuna. The large pelagic elasmobranchs such as the whale shark and giant oceanic manta ray are mostly entangled in nets or accidentally hooked. In most cases, when caught in tuna commercial fisheries they are released, but when they become entangled in the gears of small-scale fisheries, in some coastal communities the animal will be landed and processed for its meat.

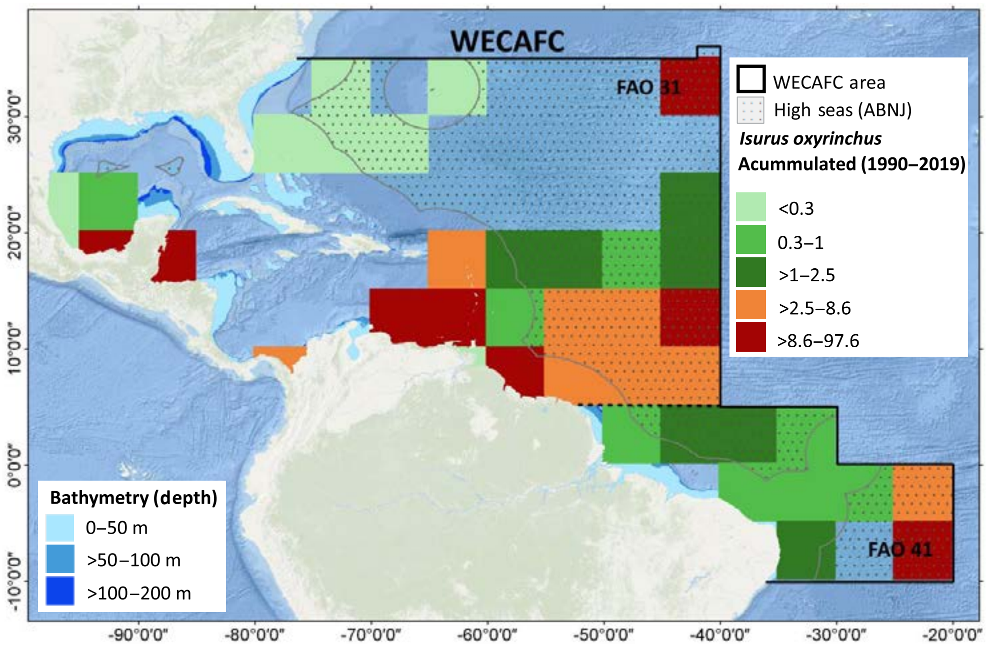
Figure 4.50. *Isurus oxyrinchus* (shortfin mako, SMA) accumulated catch by major gears in 5°x5° in the Western Central Atlantic Fishery Commission region (1990–2019)



Notes: LL= longline; UN= unclassified; GN= gillnet.

Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 4.51. *Isurus oxyrinchus* (shortfin mako, SMA) accumulated catch in 5°x5° in the Western Central Atlantic Fishery Commission region (tonnes)



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Catches of specific sharks like tiger shark, silky shark, hammerhead sharks (great, and scalloped) and thresher shark have been reported by very few countries in recent years (Table 4.11). The tiger shark is one of the most reported species, with 93.67 percent of reported catches coming from three WECAFC countries, namely Mexico, United States and Bolivarian Republic of Venezuela. Silky shark is mostly reported (99.80 percent) by Costa Rica, while the bigeye thresher shark is reported by Mexico in the last year of the series, and by Bolivarian Republic of Venezuela. Most of the reported catches of the two hammerhead species (85.18 percent for scalloped hammerhead, and 81.55 percent for great hammerhead) are from Bolivarian Republic of Venezuela (Table 4.12), and the remainder of the reported catches are shared by the United States and Colombia. At the generic level, only Colombia reports *Carcharhinus* spp. and *Sphyrna* spp. for the last year of the recent catch (tables 4.11 and 4.12). Trinidad and Tobago is the only reporting country for *Isurus* spp. and *Alopias* spp., also for the last year of the time series. At the family level (Carcharrinidae and Sphyrnidae), known as requiem sharks NEI and hammerhead sharks NEI, Mexico accounts for most of the recent catch (over 80 percent) in both groups (tables 4.11 and 4.12). The remainder of the reported catches of sharks and rays for the region are in the form of two general groups: Rajiformes (rays, stingrays, mantas NEI) and a broader group, Elasmobranchii that includes all sharks, skates and rays. In Rajiformes, most of the reported catches (96.85 percent) are attributed to five countries (Table 4.12), which collectively represent a significant volume of catches by fisheries targeting batoid fishes, although as indicated in the section on transboundary species, those catches most likely come from coastal fisheries.

Table 4.12 Hammerhead sharks, great hammerhead shark, scalloped hammerhead shark and other sharks and rays catch by country for the period 2015–2019 (tonnes)

Country	2015	2016	2017	2018	2019	Rank	%	%cum
Group: Elasmobranch. Species: *Elasmobranchii* – sharks. rays. skates. etc. NEI. Species code: –								
Mexico	3 743	5 074	4 155	5 683	3 955	1	61.54	
United States of America	906	711	485	693	328	2	8.50	70.04
Guyana	569	748	623	329	774	3	8.28	78.32
Cuba	550	460	408	407	390	4	6.03	84.35
Venezuela (Bolivarian Republic of)	1 303	162	165	165	165	5	5.33	89.68
Trinidad and Tobago	293	276	301	301	302.02	6	4.01	93.69
Nicaragua	232	234	196	114	107.16	7	2.40	96.10
Colombia	0	30	427	1	0	8	1.25	97.34
Costa Rica	107	86	85	85	85	9	1.22	98.56
Japan	44	66	17	17	15	10	0.43	98.99
Antigua and Barbuda	22	22	22	22	22	11	0.30	99.29
Barbados	23	15	18	11	10	12	0.21	99.50
Grenada	15	15	15	15	15	13	0.20	99.71
Spain	0	0	33	0	0	14	0.09	99.80
Martinique	4	4	4	4	4	15	0.05	99.85
Taiwan Province of China	0	0	16	0	3	16	0.05	99.90
Puerto Rico	4	3	2	4	3	17	0.04	99.95
Saint Lucia	3	1	3	1	0.59	18	0.02	99.97
Belize	0	5	0	0	0	19	0.01	99.98
Saint Vincent and the Grenadines	2	1	0	0	0	20	0.01	99.99
Republic of Korea	2	0	0	0	0	21	0.01	100.00
Bermuda	0	1	0	0	0	22	0.00	100.00
Group: Elasmobranch. Species: *Rajiformes* – rays. stingrays. mantas NEI. Species code: –								
Cuba	1 343	1 216	1 320	1 257	1 078.10	1	57.80	
Venezuela (Bolivarian Republic of)	2 184	209	215	215	215	2	28.26	86.06
Mexico	18	62	20	69	192	3	3.36	89.42
Colombia	0	5	117	51	93.01	4	2.47	91.89
Nicaragua	124	172	124	58	54.52	5	4.95	96.85
Dominican Republic (the)	103	45	48	2	15	6	1.98	98.83
French Guiana	11	11	14	13	10	7	0.55	99.38
Martinique	1	1	1	1	1	8	0.05	99.42
United States of America	2	7	46	7	0	9	0.58	100.00
Group: Elasmobranch. Species: *Sphyrnidae* – hammerhead sharks. etc. NEI. Species code: –								
Mexico	147	199	163	223	171	1	82.09	
Trinidad and Tobago	40	40	39	39	38.98	2	17.91	100.00
Group: Elasmobranch. Species: *Sphyrna* spp. hammerhead sharks. etc. NEI. Species code: –								
Colombia	0	0	0	0	0.13	1	100.00	
Group: Elasmobranch. Species: *Sphyrna mokarran* – great hammerhead. Species code: SPK								
Venezuela (Bolivarian Republic of)	0	32	35	35	35	1	81.55	
United States of America	13	0	0	18	0	2	18.45	100.00
Group: Elasmobranch. Species: *Sphyrna lewini* – scalloped hammerhead shark. Species code: SPL								
Venezuela (Bolivarian Republic of)	26	11	12	12	12	1	85.18	
United States of America	0	1	7	2	1	2	12.84	98.02
Colombia	0	0	0	0	1.70	3	1.98	100.00

Source: Authors' analysis; FAO. 2021. Estadísticas de pesca y acuicultura. Producción mundial por origen de producción 1950–2019 (FishStatJ) [Fisheries and aquaculture statistics. World production by origin of production 1950–2019 (FishStatJ) updated 2021]. In: *Fisheries and Aquaculture Division*. Rome. [Cited 19 July 2023]. www.fao.org/fishery/en/topic/166235?lang=en

Finally, the group Elasmobranchii that aggregates all sharks, rays, skates, etc. NEI and other species not elsewhere included (NEI) is the one in which most of the region´s catches of sharks and rays are reported (Table 4.12). Most of the reported catches of Elasmobranchii (96.10 percent) are caught by seven countries, five of which have important large pelagic fisheries for, e.g. tunas, swordfish and common dolphinfish, in which sharks form part of the catch, or they have directed shark fisheries but do not discriminate by species. In Guyana, sharks are caught by the large nearshore artisanal fleet that is multispecific using gillnets, trawl nets and pelagic longlines. All shark specimens are landed dressed (headless and gutted). Over the years, it has been difficult to record the shark catch by species, but the species identified when landed whole are hammerhead sharks, tiger sharks and other small coastal sharks (ICCAT, 2020b). In Trinidad and Tobago, the scalloped hammerhead is likely the only straddling shark species caught by that country's small-scale fishers, in addition to other small coastal sharks (Shing, 2006). In Cuba and Nicaragua, the reported catches will most likely be from small-scale/artisanal coastal fisheries, with occasional catches from tuna longline fisheries (FAO, 2018a).

The fishery for whale sharks in the region is very limited and is likely to be due to incidental encounter with small-scale fisheries, notably coastal fisheries where the shelf is very narrow, as in some areas along the Venezuelan coasts where annual encounters were frequent and most of which consisted of juveniles sharks (<7 m). Most encounters were due to entanglement with drift gillnets or the animals were harpooned and captured (Sánchez *et al.*, 2020). However, a local non-governmental organization began interacting with fishing communities, offering seminars that helped to transform some of those communities to monitor and report whale shark sighting and reduce whale shark deaths in the area.

4.3.2 State of the stocks

The elasmobranch resources in this section subject to direct fishing pressure and for which formal stock assessments have been conducted include the blue shark and shortfin mako shark. The stock assessment results presented are those for the North Atlantic only as they are relevant to the WECAFC region. In the case of the elasmobranchs for which no formal stock assessments have been conducted, their stock status is based on an ERA, also known as a PSA, which is a common tool used to provide information for data-limited shark populations (Cortés *et al.*, 2010). Only two species have not been assessed by RFMOs: the whale shark and giant oceanic manta ray, but they are threatened by open water fisheries. In this case, the assessment information provided is from the IUCN red list (IUCN, 2023) The IUCN red list also provides assessments for the elasmobranch species reviewed in this section and the assessments are included in Table 4.13 for comparative purposes.

Table 4.13 Stock status of elasmobranchs in the Western Central Atlantic Fishery Commission region

Common name/ species name	ICCAT				FIRMS		FAO categorization/ reference year		IUCN – assessment year
	Stock unit assessment year		Overfished	Overfishing	Abundance level	Exploitation rate	WECAFC/SAG/IX/2018/3		IUCN, 2023
Tiburón azul (*Prionace glauca*)	North Atlantic	2015	Not likely	Not likely	Intermediate abundance	Moderate fishing mortality	F	2016	NT/decreasing 2018
Tiburón jaquetón (*Carcharhinus falciformis*)	North Atlantic	2012	–	Vulnerability: moderate*	–	–	–	–	VU/decreasing 2017
Tiburón oceánico (*Carcharhinus longimanus*)	North Atlantic	2012	–	Vulnerability: moderate*	–	–	–	–	CR/decreasing 2018
Tintorera tigre (*Galeocerdo cuvier*)	North Atlantic	2012	–	Vulnerability: moderate*	–	–	–	–	NT/decreasing 2018
Cornuda común (*Sphyrna lewini*)	North Atlantic	2012	–	Vulnerability: low*	–	–	–	–	CR/decreasing 2018
Cornuda cruz (*Sphyrna zygaena*)	North Atlantic	2012	–	Vulnerability: low*	–	–	–	–	VU/decreasing 2018
Cornuda gigante (*Sphyrna mokarran*)	North Atlantic	2012	–	Vulnerability: moderate*	–	–	–	–	CR/decreasing 2018
Marrajo dientuso (*Isurus oxyrinchus*)	North Atlantic	2017	Yes	Yes	Low abundance	High fishing mortality	O	2016	EN/decreasing 2018
Zorro ojón (*Alopias superciliosus*)	North Atlantic	2012	–	Vulnerability: high*	–	–	–	–	VU/decreasing 2018
Raya-látigo violácea (*Pteroplatytrygon violacea*)	North Atlantic	2012	–	Vulnerability: low*	–	–	–	–	LC/unknown 2018
Manta gigante (*Mobula birostris*)	Atlantic	No evaluado	–	–	–	–	–	–	EN/decreasing 2019
Tiburón ballena (*Rhincodon typus*)	Atlantic	No evaluado	–	–	–	–	–	–	EN/decreasing 2016

*ICCAT 2020b. LC= least concern; NT= near threatened; VU= vulnerable; EN= endangered; CR= critically endangered.

Source: Authors' compilation.

Blue shark. A full stock assessment was conducted for North Atlantic blue shark in 2015, using data available to the year 2014, applying a Bayesian surplus production and a stock synthesis model (ICCAT 2016a). All scenarios considered by both models indicated that the stock was not overfished, and that overfishing was not occurring. However, ICCAT recognizes that there remains a high level of uncertainty in data inputs and model structural assumptions. Thus, the possibility of the stock being overfished, and that overfishing was occurring, could not be ruled out.

Shortfin mako. The 2017 assessment of the status of North and South Atlantic stocks of shortfin mako shark was conducted with updated time series of relative abundance and annual catches to the year 2015 (ICCAT, 2020b). For the North Atlantic stock, several stock assessment model runs were selected to provide stock status and management advice.

Although all results indicated that stock abundance in 2015 was below B_{MSY}, results of the production models were more pessimistic (B/B_{MSY}: 0.57 to 0.85) and those of the age-structured model (stock synthesis) were less pessimistic (SSF/SSF_{MSY}=0.95). F was above F_{MSY}. The combined 90 percent probability from all the models is that the the North Atlantic stock is overfished and experiencing overfishing. It was noted that it could take about 25 years to rebuild mako shark stocks, even if fishing mortality rates were cut to zero (ICCAT, 2020b).

The 2012 ERA conducted by ICCAT was a quantitative assessment consisting of a risk analysis to evaluate the biological productivity of the shark stocks and a susceptibility analysis to assess their propensity to capture and mortality in pelagic longline fisheries. One stock with the lowest productivity was the bigeye thresher. The highest susceptibility values corresponded to shortfin mako, North Atlantic blue shark and bigeye thresher. Based on the results, the bigeye thresher and shortfin mako sharks were the most vulnerable stocks to overfishing. In contrast, North Atlantic pelagic stingray had the lowest vulnerability. The remaining species – silky shark, oceanic whitetip shark, tiger shark and great hammerhead in the North Atlantic – had moderate vulnerability to overfishing (ICCAT, 2020b).

Whale shark. For the WECAFC region, the Atlantic subpopulation trend is based on whale shark sightings in the area off Belize, which dropped from a mean of 4 to 6 sharks per day between 1998 and 2001 to less than two per day in 2003, with reports from diving guides and from feeding aggregations in the GOM (Pierce and Norman, 2016) indicating that numbers remained low until 2016. The IUCN Species Survival Commission Shark Specialist Group has classified this species as endangered and with a decreasing population trend, based on the declining numbers of mature individuals.

Giant oceanic manta ray. The IUCN Species Survival Commission Shark Specialist Group suspects that the giant oceanic manta ray at a global level has undergone a population reduction of 50 percent to 79 percent over the past three generation lengths (87 years); further population reduction is predicted for the next three generation lengths (2018 to 2105) due to ongoing levels of exploitation and a reduction in area of occupancy due to suspected local and regional extinctions. The species is assessed as an endangered and decreasing population (Marshall *et al.*, 2020).

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5

Stocks managed by regional fisheries management organizations overlapping with the Western Central Atlantic Fishery Commission

5. Stocks managed by regional fisheries management organizations overlapping with the Western Central Atlantic Fishery Commission

5.1 Regional fisheries management organizations and regional fisheries advisory bodies in the Western Central Atlantic Fishery Commission region

The main organizations and groups involved in the governance of fisheries in the region include one RFMO – the ICCAT – and four regional fisheries advisory bodies, namely WECAFC, CRFM, OSPESCA and the Commission for Small-scale and Artisanal Fisheries and Aquaculture of Latin America (COPPESAALC) (Table 5.1). The CRFM is a regional fisheries advisory body for the CARICOM Member States, while the OSPESCA is part of the Central American Integration System (SICA) that works with the Spanish speaking Central American countries, Belize and the Dominican Republic. The work of the COPPESAALC is mostly related to the planning and development of artisanal fisheries and aquaculture in Latin America and the Caribbean. WECAFC covers additional countries and thus has thus a mandate to create cohesion and involvement in its region.

Table 5.1 Membership of countries and overseas territories in the Western Central Atlantic Fishery Commission region (green) in the main fisheries-related international bodies

Country	COPACO	ICCAT	CRFM	OSPESCA	COPPESAALC
Anguilla*			■		
Antigua and Barbuda	■		■		
Bahamas (the)	■		■		
Barbados	■	■	■		
Belize	■	■	■	■	
Brazil	■	■			
Canada		■			
Colombia	■				
Costa Rica	■			■	■
Cuba	■				
Curaçao		■			
Dominica	■		■		
Dominican Republic (the)				■	■
El Salvador	■				
European Union	■	■			
France	■	*St-P_M*			
Grenada	■	■	■		
Guatemala	■			■	■
Guinea	■				
Guyana	■	*CnCP*	■		
Haiti	■		■		
Honduras	■	■		■	■
Jamaica			■		
Japan	■		■		■
Mexico	■	■			
Monserrat*	■	■			■
Netherlands			■		
Nicaragua	■	■		■	■
Panama	■				
Republic of Korea	■	■		■	■
Saint Kitts and Nevis	■	■			
Saint Lucia	■	■			
Saint Vincent and the Grenadines	■			■	■
Spain	■		■		
Suriname	■		■		
Trinidad and Tobago	■	■	■		
Turk and Caicos Islands*	■	*PnCC*	■		■
United Kingdom of Great Britain and Northern Ireland*	■	■	■		
United States of America	■	■			
Venezuela (Bolivarian Republic of)	■	■			■

Notes: Orange/yellow color indicates a type of participation.
St-P_M= Saint Pierre and Miquelon; CNCP= Cooperating Non-Contracting Party.
*The Government of the United Kingdom of Great Britain and Northern Ireland deals with all international relations on behalf of these territories.

Source: Authors' compilation.

ICCAT was established by the International Convention for the Conservation of Atlantic Tunas, which was signed in 1966 and entered into force in 1969 (ICCAT, 2023a). The objective of the Convention is to conserve tuna and tuna-like species in the Atlantic Ocean and to maintain the populations of these fishes at levels that will permit the maximum sustainable catch. The Commission has established three subsidiary bodies, i.e. the Standing Committee on Finance and Administration, the Standing Committee on Research and Statistics, and the Compliance Committee. It also appoints the executive secretary who manages the ICCAT Secretariat. ICCAT currently has 52 contracting parties represented by three members for each country. Five countries have been granted the status of cooperating non-contracting party. Of ICCAT's contracting and non-contracting parties, 18 are also members of WECAFC. Noting that the Convention text does not specifically refer to the precautionary or ecosystem approaches, ICCAT has evolved in redefining the list of ICCAT target species under its mandate, which now include several species of elasmobranchs (sharks and rays). It has also established several binding measures for mitigating bycatch and for conserving non-target species, including multiple measures for shark species as well as measures for seabirds and sea turtles (ICCAT, 2023b). In addition, ICCAT has established minimum standards for the vessel monitoring system in the ICCAT Convention area and adopted several measures to combat IUU fishing.

The WECAFC was established in 1973 by Resolution 4/61 of the FAO Council under Article VI, Paragraph 1 of the FAO Constitution. Its general objective is to promote the effective conservation, management and development of the living marine resources in the Western Central Atlantic, in accordance with the FAO Code of Conduct for Responsible Fisheries (FAO WECAFC, 2023). It assists Member States in:

i) implementing relevant international fisheries instruments;

ii) promoting, coordinating and undertaking the collection, exchange, dissemination, analysis and study of statistical, biological, environmental and socioeconomic data and other marine fishery information;

iii) promoting and facilitating the harmonization of relevant national laws and regulations and the compatibility of conservation and management measures; and

iv) assisting its Member States, at their request, in the conservation, management and development of transboundary and straddling stocks under their respective national jurisdictions.

WECAFC covers national waters and the high seas, and applies to all living marine resources, irrespective of the management responsibilities and authority of other management organizations or arrangements addressing fisheries and other living marine resources in the area. WECAFC has 34 Member States; its governing body is the Commission which meets every two years. The Commission established a Scientific Advisory Group which provides it with scientific advice; it consists of no more than five scientists with suitable scientific qualifications and experience. The Scientific Advisory Group assesses and reports to the Commission on the status of stocks in the area covered by the Commission and assesses the situation, trends and prospects of fisheries in the region. The Commission has to date established and confirmed 11 working groups that normally function in collaboration with other regional partner institutions. Fishery management advice and recommendations are provided to Member States for their implementation by specific working groups. The WECAFC Secretariat is provided by FAO. It is based in the Subregional Office for the Caribbean.

The CRFM was officially inaugurated on 27 March 2003, in Belize City, Belize, where it is headquartered, following the signing of the "Agreement Establishing the CRFM" on February 4, 2002. It is an intergovernmental organization with the mission "to promote and facilitate the responsible utilization of the region's fisheries and other aquatic resources for the economic and social benefits of the current and future population of the region". The CRFM consist of three bodies – the Ministerial Council; the Caribbean Fisheries Forum; and the CRFM Secretariat. Its members are Anguilla, Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago and the Turks and Caicos Islands (CRFM, 2023). The Ministerial Council is the highest decision-making body of the CRFM and is responsible for formulating the policy of the Mechanism. It comprises the ministers responsible for fisheries in each Member State. The CRFM is made up of one representative from each Member State, an associate member and an observer from each Member State. The CRFM Secretariat comprises a permanent body of technical, scientific and support staff. The staff is located at two offices: one in Belize, the headquarters of the CRFM, and the other in the eastern Caribbean.

OSPESCA was established in 1995 within the SICA, which is the institutional framework for the integration of the Central American region. SICA has 25 secretariats and specialized institutions responsible for different topics of high regional interest – OSPESCA being one of them. The establishment of SICA was endorsed by the General Assembly of the United Nations, allowing its regional bodies and institutions, including OSPESCA, to relate to the UN system. OSPESCA is a regional fisheries advisory body responsible for coordinating strategies, policies and projects for the regional governance and sustainable development of fisheries and aquaculture in Central America. OSPESCA's work is guided by the "Fisheries and Aquaculture Integration Policy 2015–2025" and covers the inland waters, territorial seas and EEZs of its eight members: Belize, Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua and Panama. OSPESCA has three levels of higher authorities representing its eight Member States: the Council of Ministers, the Committee of Vice Ministers, and the Commission of Directors of Fisheries and Aquaculture. Two regional organizations representing small-scale fisherfolk and the fishing and aquaculture industry function as advisory bodies and participate in OSPESCA's activities. OSPESCA coordinates actions of regional impact, offering national authorities, fisherfolk and aquaculture organizations and other actors in the value chain a space to exchange experiences and to work together in favour of the Central American region.

COPPESAALC, formerly COPESCAALC, was established in 1976 by Resolution 4/70 of the FAO Council (FAO, 2023a). Its statutes were updated in 2019 during its 16th meeting in La Habana, Cuba (FAO, 2023b) to include all small-scale and artisanal fisheries (inland and marine) and aquaculture. COPPESAALC is a member of the Regional Fishery Body Secretariats Network and its main objective is to promote the sustainable development and management of small-scale and artisanal fisheries and aquaculture, according to the norms and principles of the FAO Code of Conduct for Responsible Fisheries, the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries and other applicable complementary instruments adopted by FAO. The area of competence of this Commission is the inland waters and marine national waters of Latin American countries, Jamaica and Suriname. The main body is the Commission, which normally meets every two years, with the Secretariat provided by FAO and based at the Regional Office for Latin America and the Caribbean in Santiago de Chile, Chile.

The Commission assists its Member States to promote the strengthening and sustainability of small-scale and artisanal fisheries and the development of aquaculture as sectors that sustain food and nutritional security in rural territories and contribute to boosting local economies. To this end it establishes cooperative relationships with other international organizations in areas of common interest.

5.2 Existence of arrangements that address the governance of pelagic fisheries at the regional/subregional level

Of the fishery resources considered in this report, only the highly migratory pelagic fish species associated with fisheries for tuna and tuna-like species are under the binding mandate of ICCAT. The remaining resources are under the specific national management and conservation measures of each country within the region.

However, under WECAFC, fishery management advice and recommendations are based on the best available scientific information provided to Member States for their implementation by dedicated working groups, established by the Commission. These groups for the purpose of the present report are: i) WECAFC/OSPESCA/CRFM/CFMC Working Group on Recreational Fisheries; and ii) CRFM/WECAFC Working Group on Flyingfish in the Eastern Caribbean. It is from these working groups that one fishery management plan has been developed and adopted by the Commission: the Subregional Fisheries Management Plan for Flyingfish in the Eastern Caribbean (CRFM, 2014; FAO WECAFC, 2016).

5.3 Structure and operation of the International Commission for the Conservation of Atlantic Tunas

5.3.1 Structure

Overall, ICCAT is formed by contracting parties and cooperating non-contracting parties, several subsidiary bodies and the secretariat (ICCAT, 2023a).

Contracting Parties. The Commission may be joined by any government that is a member of the United Nations, any specialized United Nations agency, or any intergovernmental economic integration organization constituted by States that have transferred to it competence over the matters governed by the ICCAT Convention. The Commission has also created a special status known as Cooperating Non-Contracting Party, Entity or Fishing Entity. Parties, entities or fishing entities that are granted this status have many of the same obligations, and are entitled to many of the same privileges, as the Contracting Parties.

The subsidiary bodies established by the Commission analyse an array of information and refer their conclusions and recommendations back to the Commission for final decision-making. These include the Standing Committee on Finance and Administration, the Standing Committee on Research and Statistics, and the Compliance Committee. The Commission has also established two permanent working groups, one to improve ICCAT statistics and conservation measures, and another to enhance dialogue between fisheries scientists and managers.

The Secretariat coordinates and facilitates the work of the Commission. This includes managing the Commission's budget, coordinating research programmes, maintaining databases, preparing the collection and analysis of data necessary for stock assessments, preparing publications and organizing the meetings of the Commission and subsidiary bodies.

The Standing Committee on Finance and Administration reviews all financial and administrative matters and prepares a budget.

The SCRS is the technical body that recommends all policy and procedures for fishery data collection. It is the task of the SCRS to provide the Commission with the most complete and current statistics concerning fishing activities in the Convention area, as well as biological information on the stocks that are fished. The SCRS is composed of other subsidiary bodies that examine distinct species or different topics.

Four panels are responsible for keeping under review the species, group of species, or geographic area under its purview: Panel 1: Tropical Tunas (yellowfin, skipjack and bigeye); Panel 2: Northern Temperate Tunas (albacore and bluefin); Panel 3: Southern Temperate Tunas (albacore and southern Bluefin); and Panel 4: Other species (swordfish, billfishes, sharks). The panels review scientific and other information and make recommendations for joint action by the Contracting Parties aimed at maintaining the stocks at levels that will permit maximum sustainable catches. The panels may also recommend to the Commission studies and investigations necessary for obtaining information relating to its species, group of species, or geographic area, as well as the coordination of research programmes by the Contracting Parties.

Compliance matters are reviewed by two different bodies: the Conservation and Management Measures Compliance Committee (reviews matters related to Contracting Parties) and the Permanent Working Group on ICCAT Statistics and Conservation Measures (reviews matters related to Non-contracting Parties).

5.3.2 Operation

All the Commission's scientific work and data collection efforts are accomplished by the Contracting Parties themselves. The Secretariat's role is to be a focal point for data collation/assimilation and coordinating access by scientists to the common databases.

Fishery data

The core of the scientific advice to the Commission is the fishery data. The main types of data used by ICCAT could be classified according to two criteria: the source of the data and the intended use of the data.

Most of the fishery data used by ICCAT is fishery-dependent, where the main sources are logbooks, observer programmes, port sampling, factory/market sampling and international trade (import/export) statistics. The mandatory fishery data according to the ICCAT Convention and other international agreements is the most basic type: total annual catch by species, flag, stock area and gear. Other types of data, such as catch/effort samples and size samples, also need to be collected and reported to ICCAT.

ICCAT also collects fishery-independent data, mostly studies on tunas and tuna-like species that are conducted with tagging programmes. There are, however, a few examples of surveys conducted under ICCAT sponsorship (e.g. larval surveys).

Fishery data may be used for stock assessments and scientific advice and for compliance purposes. In the case of compliance, the data used is to ensure that the recommendations for the management of stocks are being implemented adequately. For example, if a recommendation establishes catch quotas and minimum sizes for a given stock, the compliance information required will be in the form of total catches and the size composition of those catches.

The fishery data to be used for stock assessments and scientific advice can be classified according to two criteria: statistical data and biological data.

The statistical data compiled by the ICCAT Secretariat for scientific purposes cover tuna, tuna-like species and shark catches in the ICCAT Convention area and include:

i) fleet characterization (e.g. flag, gear, target species, size and tonnage);

ii) task I nominal catches (nominal catch estimates of target and bycatch species and dead discards);

iii) task II catch and effort (catch by species effort statistics, classified by fishing fleet, gear, time strata and area);

iv) task II size samples (size frequencies of the samples measured for each species classified by fishing fleet, species, gear, sample units, time strata and area); and

v) task II catch-at-size (catch-at-size estimates classified by fishing fleet, gear, time strata, and area (and by sex in the case of swordfish) for the major ICCAT species.

The biological data used in ICCAT come from scientists of the Contracting Parties who present the latest results of their studies to the pertinent Species Working Groups and to the SCRS. The advances made by individual scientists are "adopted" as the most up to date information and become part of the knowledge base used in stock assessments. These scientific studies are published annually in the *ICCAT Collective Volume of Scientific Papers*.

The Standing Committee on Research and Statistics

All members of the Commission are represented on the SCRS. The Committee is responsible for developing and recommending to the Commission all policy and procedures for the collection, compilation, analysis and dissemination of fishery statistics. The SCRS also coordinates various national research activities, develops plans for special international cooperative research programmes, conducts stock assessments, and advises the Commission on the need for specific conservation and management measures.

The SCRS' subsidiary bodies are: i) the Subcommittee on Statistics; and ii) the Subcommittee on Ecosystems. In addition, there are seven species working groups, a Working Group on Stock Assessment Methods and the Ad hoc Working Group on coordination of tagging information.

The Sub-Committee on Statistics oversees the process of data procurement and analysis conducted by the Secretariat and the various stock assessment groups. Any updates and revisions of historical and recent catch data by Contracting Parties are to be presented to this body for revision and adoption.

The Sub-Committee on Ecosystems deals with a wide range of issues, including an ecosystem approach to fisheries and oceanographic factors affecting tuna biology and fisheries. It also oversees the advances on mitigation measurements and bycatch assessments of species associated with the tuna fisheries in the Convention area. As indicated earlier, the Convention text does not specifically refer to the precautionary or ecosystem approaches but ICCAT has recognized that bycatch issues have become particularly important for long-lived marine megafauna such as sharks, sea turtles, seabirds and marine mammals. It has made efforts to improve the knowledge on bycatch species by creating a meta-database under the supervision of a bycatch coordinator (a professional Secretariat staff member) to harmonize and analyse fishery datasets related to bycatch species of tuna fisheries in the ICCAT area. As part of his or her tasks, the bycatch coordinator oversees the updating and maintenance of the ICCAT bycatch meta-database.

The Working Group on Stock Assessment Methods implements quality management procedures for stock assessment methodologies, leading to the review, testing and documentation of assessment methods used by the SCRS. Currently it is advancing work on HCRs, limit reference points, and management strategy evaluation; standard diagnostics for stock assessment models; and CPUE standardization/incorporation of oceanographic and environmental changes into the assessment process.

The objective of the ad hoc working group on coordination of tagging information is to channel and make use of the experience of the scientists for new tagging activities.

There are seven species working groups responsible for the revision and update of the fishery data specific to one species or species group; the revision and discussion of the latest results of biological and/or methodological studies; and the stock assessments pertinent to each of the species groups (Table 5.2). It is within the species working groups that the stock assessments and the state of the resource reports are originated and these provide management advice.

The species working groups hold intersessional and/or annual meetings prior to the plenary meeting of the SCRS. Intersessional meetings are mostly related to data preparation in advance of a stock assessment, and for the stock assessments themselves. There are also intersessional meetings called by specific species working groups that need to address specific issues in relation to upcoming stock assessments, such as technical meetings on management strategy evaluation for a specific species working group, or the Joint Tuna-RFMO FAD working group associated with the Tropical Tunas Working Group, among other relevant issues. The annual meeting of the species working groups is held a week prior to the SCRS plenary and this is when the most recent fishery data compiled by the ICCAT Secretariat is reviewed by each species working group; the executive summaries of each major species or group of species are revised and updated; annual working plans are developed, recommendations with and without financial implications are made to the Commission; and responses to the Commission (if any) are addressed and responded to. All the information compiled and updated by each species working group is presented by the respective species working group chairperson to the SCRS Plenary, where it is discussed and adopted by the SCRS Plenary. The SCRS Plenary reviews and adopts the report that will form the basis of the scientific advice to the Commission. The Commission will then act on the conservation and management advice provided by the SCRS, in the form of recommendations or resolutions that are binding for all contracting and cooperating non-contracting parties.

Table 5.2 List of the Species Working Groups of the International Commission for the Conservation of Atlantic Tunas' Standing Committee on Research and Statistics

Species working groups	Species	Stocks	Observations
Tropical tunas (TUN)	*Thunnus albacares* (YFT), *Thunnus obesus* (BET), *Katsuwonus pelamis* (SJK)	YFT: one stock (Atlantic-wide) BET: one stock (Atlantic-wide) SKJ: two stocks (East and West Atlantic)	
Albacore tuna (ALB)	*Thunnus alalunga* (ALB)	ALB: three stocks (North, South Atlantic, and Mediterranean)	
Bluefin tuna (BFT)	*Thunnus thynnus* (BFT)	BFT: two stocks (East [including Mediterranean] and West Atlantic)	
Billfishes (BIL)	*Makaira nigricans* (BUM), *Istiophorus albicans* (SAI), *Tetrapturus albidus* (WHM), *Tetrapturus pfluegeri* (SPF), *Tetrapturus georgii* (RSP), *Tetrapturus belone* (MSP)	BUM: one stock (Atlantic-wide) WHM: one stock (Atlantic- wide) SAI: two stocks (East and West Atlantic) SPF: two stocks (East and West Atlantic) MSP: one stock (Mediterranean)	RSP is considered part of the WHM species complex in WHM stock assessments, due to historical misidentification with WHM. Therefore, RSP is considered Atlantic-wide for assessment purposes.
Swordfish (SWO)	*Xiphias gladius* (SWO)	SWO: three stocks (North, South Atlantic, and Mediterranean)	
Sharks (SHK)	*Prionace glauca* (BSH), *Isurus oxyrinchus* (SMA), *Lamna nasus* (POR)	BHS: two stocks (North and South Atlantic) SMA: two stocks (North and South Atlantic) POR: three stocks (Northwest, Southwest, and Northeast Atlantic)	There are 21 elasmobranch species, other than those listed, that are under ICCAT's mandate but are evaluated when the SHK group considers it necessary.
Small tunas (SMT)	*Thunnus atlanticus* (BLF), *Euthynnus alletteratus* (LTA), *Auxis rochei* (BLT), *Auxis thazard* (FRI), *Sarda sarda* (BON), *Orcynopsis unicolor* (BOP), *Scomberomorus cavalla* (KGM), *Scomberomorus brasiliensis* (BRS), *Scomberomorus maculatus* (SSM), *Scomberomorus regalis* (CER), *Scomberomorus tritor* (MAW), *Acanthocybium solandri* (WAH)	No stock boundaries have been defined for any of the species within this Group. However, the SMT WG agreed that the ICCAT Statistical Areas Map #4, that separates the Atlantic into four areas (NW, SW, NE, SE) and the Mediterranean, was adequate for the species in this group. Therefore, studies should be carried based on those spatial areas.	Uncertainties continue regarding the accuracy and completeness of reported landings in all areas. There has been improvement in applying a range of data-limited models, but robustness still needs to be evaluated before they can be used to provide management advice to the Commission.

Sailfish © Michael-Worden

6

The ecological connectivity between the areas beyond national jurisdiction and the exclusive economic zones in the Western Central Atlantic Fishery Commission region

6. The ecological connectivity between the areas beyond national jurisdiction and the exclusive economic zones in the Western Central Atlantic Fishery Commission region

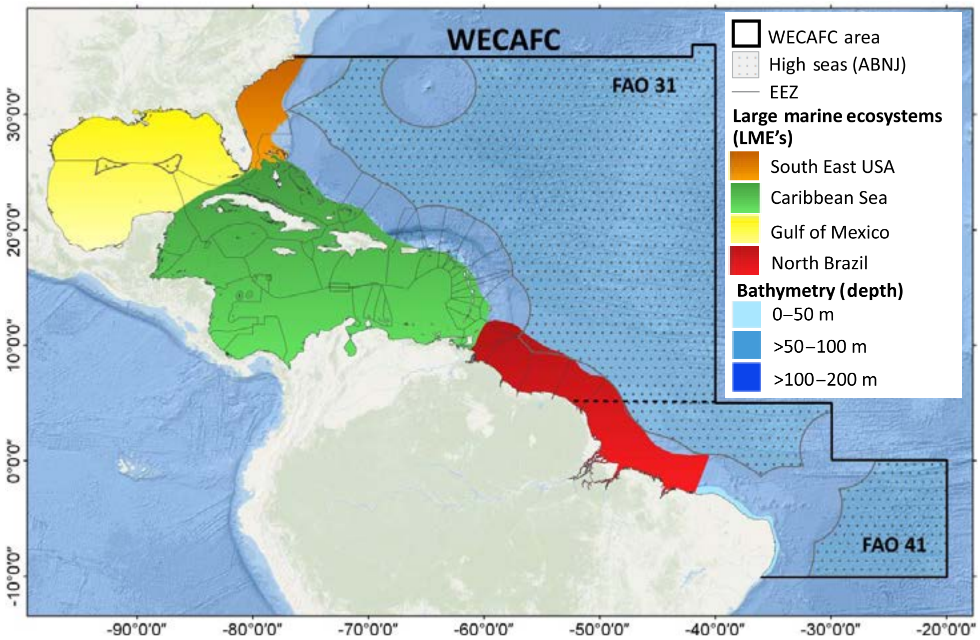
6.1 Ecological connectivity between distant marine ecosystems

The WECAFC region includes FAO Major Fishing Area 31 and the northern part of FAO Major Fishing area 41. It also contains the EEZs of 28 nation states and 16 territories belonging to the Netherlands, the United Kingdom of Great Britain and Northern Ireland, France and the United States. Twenty-nine of the Member States are considered to be SIDS, making this one of the most geopolitically complex and vulnerable regions of the world (Singh-Renton and McIvor, 2015).

The region encompasses four distinct LMEs and a large ABNJ linked by major ocean currents (Figure 6.1). It occupies of an area of 14 644 544 km^2, of which 10.5 percent is continental and island shelf; incorporates two of the world's largest semi-enclosed seas; and is influenced by the discharge of some of the world's largest rivers (e.g. the Amazon, Orinoco and Mississippi rivers).

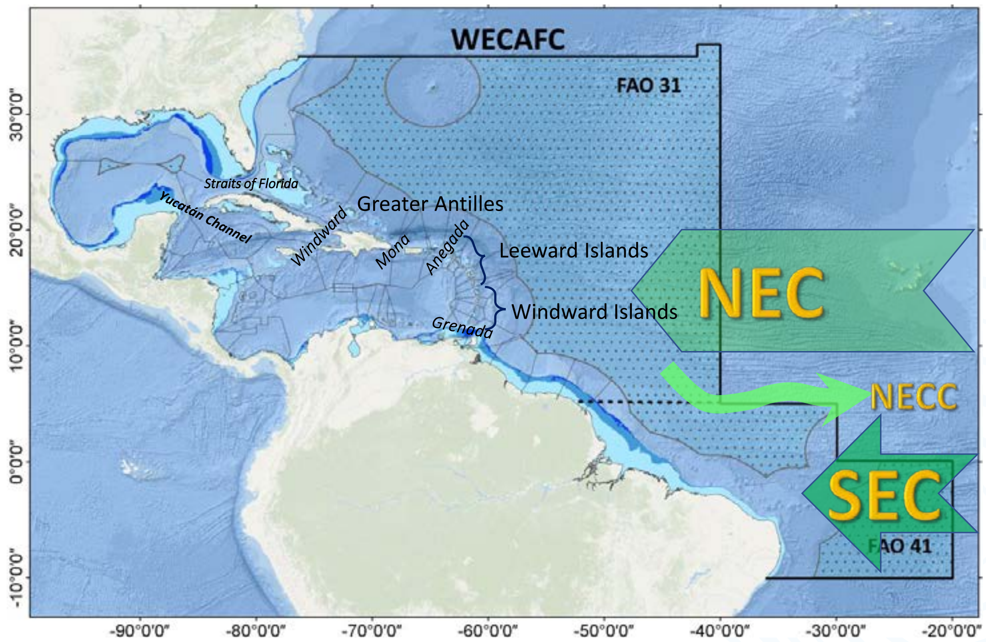
Marine ecological connectivity is viewed as the most complex type of ecological spatial connectivity linking various components of marine ecosystems in time and space. Therefore, ecological connectivity between distant marine ecosystems (e.g. EEZs and ABNJ) is affected by two types of connections: circulation (passive) connectivity facilitated by the ocean currents, and migratory connectivity achieved by active swimming by marine species. However, it not only involves the movement of species, but also the movement of chemicals (e.g. nutrients and pollutants), materials (e.g. sediments and debris) and energy (in the form of organisms, e.g. sargasso) which are part of the passive connectivity through ocean currents (Carr *et al.*, 2017).

Figure 6.1. Large marine ecosystems and areas beyond national jurisdiction in the Western Central Atlantic Fishery Commission region



Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 6.2. Large-scale westward currents (North Equatorial Current, South Equatorial Current) and eastward countercurrent (North Equatorial Countercurrent) in the Western Central Atlantic Fishery Commission region, and major passages into the Caribbean Sea and Gulf of Mexico

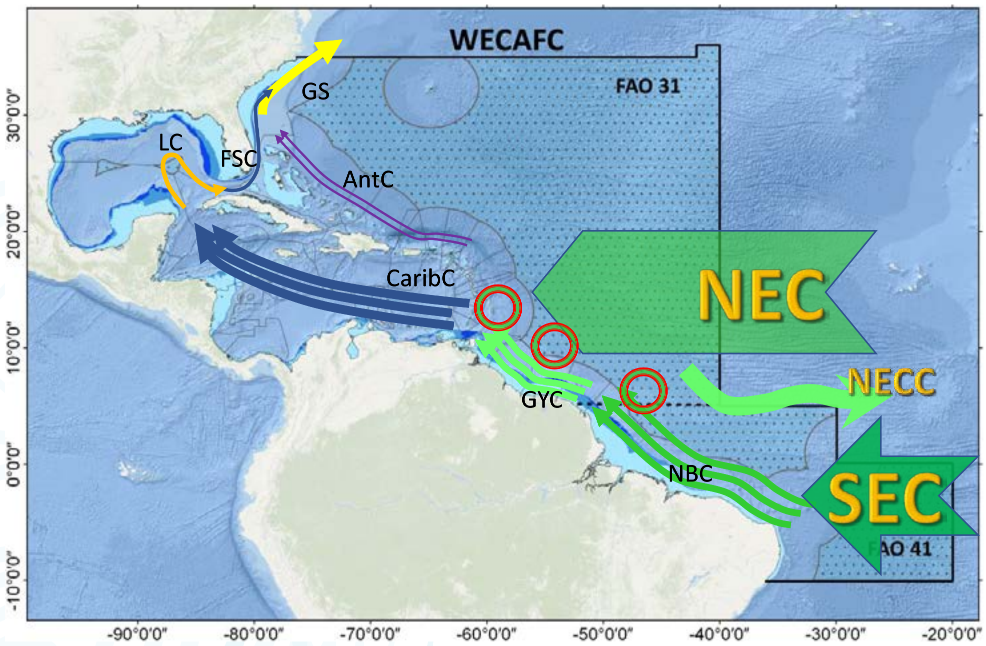


Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

6.2 Circulation connectivity mediated by the ocean currents

Energetic ocean currents are the key medium by which distant ocean regions are connected to each other, including the connectivity of the EEZ to the ABNJ. In the case of the WECAFC region, the connection between the EEZs and the ABNJ is influenced by two large-scale westward currents (North Equatorial Current [NEC] and South Equatorial Current [SEC]) and one eastward counter current (North Equatorial Counter Current [NECC]) (Figure 6.2). The NEC is found in the North Atlantic from about 7° north to about 20° north, is a broad westward flowing current that forms the southern limb of the North Atlantic subtropical gyre (Ocean Surface Currents, 2023). It is fortified by the Atlantic trade wind belt, with an annual mean transport of 8.5 Sverdrups (Sv). The SEC is a broad, westward flowing current that extends from the surface to a nominal depth of 100 m. Its northern boundary is usually near 4° north, while the southern boundary is usually found between 15° south to 25° south (Ocean Surface Currents, 2023). The SEC flows westward toward the Brazilian shelf, and splits at Cabo de Sao Roque (Brazil), near 16° south with one branch, the stronger of the two, heading northwards as the NBC and the other, weaker southwards branch, as the Brazil Current. The SEC northern branch transport in the upper layer is about 12 Sv. The northern branch of the SEC feeds the NBC, retroflects and feeds the NECC, which in turn, helps feed the northern branch of the SEC. The NECC lies between 3° north and 10° north and is considered to roughly serve as the northern boundary for the SEC (Ocean Surface Currents, 2023). The main source of the NECC is the retroflection of about 16 Sv from the upper layers (100 m) of the NBC, starting at between 5° north and 8° north. Temperature and circulation of the tropical Atlantic have strong seasonal signals and this results in a transient but regular appearance of the NECC.

Figure 6.3. Link currents between areas beyond national jurisdiction and exclusive economic zones of boundary states with the high seas



Notes: LC = Loop Current; FSC = Florida Straits Current; GS = Gulf Stream; AntC = Antilles Current; CaribC = Caribbean Current; GYC = Guyana Current and NBC = North Brazil Current.

Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The three large-scale currents described above have direct influence in several currents that are the oceanographic link between the ABNJ of the WECAFC region and the EEZs of boundary states with the high seas (Figure 6.3). In a northerly poleward direction, the linkage starts with a well-established western boundary current, the NBC, which is fed by the SEC. The NBC is the dominant surface circulation feature in the western tropical Atlantic Ocean. It plays a dual role: firstly, it closes the wind-driven equatorial gyre circulation and feeds a system of zonal countercurrents; and secondly, it provides a conduit for cross-equatorial transport of upper ocean waters as part of the Atlantic meridional overturning cell (Ocean Surface Currents, 2023). One of the major features of the NBC is the large anticyclonic rings shed by the current which swirl northwestwards along the South American coast.

As the NBC flows north along the northeastern coast of South America, it reaches EU (FR Guiana), where part of it separates from the coast and retroflects to join the NECC (Wilson *et al*., 1994). The remainder of the NBC continues flowing northwestward to form the Guiana Current (Condie, 1991). At this point (near 6° north to 8° north), the NBC retroflection is present year-round – on occasion it retroflects so severely that it pinches off large, isolated warm-core rings exceeding 450 km in overall diameter. Over a 24-year study (1993 to 2016), the NBC formed, on average, five NBC rings per year; with an average lifetime of 15.3 weeks (Aroucha *et al*., 2020). The study indicated that NBCRs are larger, rotate faster, live less, and carry more energy in boreal winter months (December to February), while during boreal summer (July to August) and early autumn (September), they last longer, have smaller diameters and carry less energy.

An important feature observed in NBCRs is the influence of the Amazon River's discharge after its maximum in August, when the Amazon plume completely surrounds the NBC retroflection on the west and in the north (Ffield, 2005). The surface layer characteristics of the NBCRs reveal the varying influence of the Amazon plume. The fresher and typically warmer surface waters associated with the Amazon plume are buoyant relative to the saltier and typically colder surface waters carried by the NBC, therefore the varying position of the Amazon plume may seasonally influence the surface dynamics in the region.

As the NBCRs move northwestward towards the Caribbean Sea on a course parallel to the South American coastline during a period of about 3 to 4 months, the NBCRs stall and decay off the Lesser Antilles (Fratantoni and Richardson, 2006). These islands become a barrier to the translation of the NBCRs and the topography east of the island arc contributes to the termination of the NBCRs and only filaments of core water enter the eastern Caribbean. However, NBCRs are observed to move northward as they reach the island arc, and they surround the island of Barbados for a period of several days, leading to fluctuations in temperature and salinity near the island. A study demonstrated that the overall impact of NBCRs on recruitment of coral reef fishes to the island appears to be that of increasing variability (Cowen *et al*., 2003). The regular passage of NBCRs in the vicinity of Barbados seems to have conflicting impacts on larval fish around the island, depending both on species-specific behaviour and NBCR type. The physical retention of larvae may be enhanced (concentration at fronts with flows bringing larvae closer to shore) or decreased because of flushing/advection away from the island.

In summary, the NBC and NBCRs contribute to the dispersal of fresh, nutrient-rich outflow from the Amazon River and provide a mechanism for transport of this water northwestward towards Trinidad and Tobago and the Lesser Antilles.

The other surface currents that are an oceanographic link between the ABNJ of the WECAFC region and the EEZs of boundary states are the Guianas, Antilles and Florida currents (Figure 6.3). The Guiana Current (GC) is fed by the NBC; in the spring the current can extend as far as 300 NM offshore (Febres-Ortega and Herrera, 1976). In the mid 1970s, it was concluded that the GC does not flow uniformly northwestward because it forms seasonal meanders (Febres-Ortega and Herrera, 1976). It has been shown that GC surface water enters the Caribbean primarily between the Windward Islands and between Grenada and the South American continent (Figure 6.2). However, some authors have indicated that the inflow to the Caribbean is fed by the main NBC and from NBCRs that collide with the continental margin near Tobago (near 11.2° north) (Johns *et al.*, 2002).

The Atlantic inflow into the Caribbean (or the connectivity between the ABNJ and the Antilles Island chain) has been divided among three main groups of passages: the windward islands passages (south of EU [FR Martinique]), the leeward islands passages (between EU [FR Martinique] and the United States Virgin Islands and British Virgin Islands) and the Greater Antilles passages (between Puerto Rico and Cuba) (Figure 6.2). The inflow to the Caribbean by the main NBC and from NBCRs enters through the largest individual contributor in the south, the Grenada Passage (6 Sv). The subtropical gyre (NEC) inflow to the Caribbean Sea is about 17 Sv and it enters mainly through the Greater Antilles and leeward islands passages in the northern Caribbean (Johns *et al.*, 2002).

Another important feature in the southern area of the region is the influence of the dispersal of freshwater from the Amazon and Orinoco rivers, which is discharged into the tropical Atlantic and advected into the Caribbean Sea. Two inflows of freshwater enter the Caribbean Sea (Cherubin and Richardson, 2007). The first is south of 12° north, where the Orinoco plume, some NBC water and some NBCR water enter the Caribbean through the Grenada passage, where the swiftest currents of the Caribbean Current are observed. The second inflow of freshwater is between 14° north and 18° north, partly provided by NBCRs, which stall and decay east of the Lesser Antilles, and partly by the NEC, which advects water westward. The freshwater flux from NBCRs exerts a strong forcing on the reef ecosystem as noted by Cowen *et al.* (2003). Changes in the vertical distribution of fish larvae were observed with the intrusion of freshwater, potentially affecting survival rates and recruitment success.

The other two passages by which Atlantic water (NEC) enters the Caribbean are the leeward islands passages and the Greater Antilles passages (Figure 6.2). Of all the passages in the leeward, the Anegada Passage is relevant because its depth (1 900 m) allows for exchange between the Caribbean Sea and Atlantic Ocean at levels below the direct influence of the subtropical gyre circulation and the flow of Atlantic deep water (of high salinity, high oxygen and low nutrients from between about 1 500 m and 3 500 m) into the Caribbean and Colombian basins (Johns *et al.*, 2002). The transport of Atlantic water into the Caribbean Sea is mostly concentrated in the northern part of the leeward islands (Anegada and Antigua passages). In the northern Caribbean, the transport of Atlantic water into the Caribbean is through the Mona and windward passages.

In summary, the three different passage groups (windward, leeward and Greater Antilles) in the eastern and north Caribbean are the major connection pathways by which Atlantic water enters the Caribbean Sea and encounters in its path the different islands.

Moving northward along the ABNJ boundary and the Greater Antilles through to the Bahamas, the next linkage is the Antilles Current (Figure 6.3), a western boundary current that flows northward, east of the Greater Antilles and then northwestward along and around the northern islands of the Bahamas in the subtropical North Atlantic before joining the Florida Current and subsequently the Gulf Stream. The Antilles Current is not a continuous flow along the Bahamas and Antilles island chain, it appears more as an eddy field along the Bahamas–Antilles arc rather than as a continuous jet (Gunn and Watt, 1982; Lee *et al.*, 1996). A recent study on seasonal variability shows a maximum northward transport in August to September but the seasonal component of the variability is weak (Meinen *et al.*, 2019). The study finds that on average, this current is carrying 4.7 ×106 m^3 of water per second northward and that this flow can vary by more than 100 percent from day to day (i.e. some days the flow can reverse and go southward). This variability may be the cause of the difficulties in detecting a continuous flow.

Continuing northward, as the Antilles Current joins the Florida Current at around 27° north, the Florida Current becomes the next and last northern boundary between the ABNJ and the EEZ in the WECAFC region (Domingues, Johns and Meinen, 2019). The Florida Current can be considered the "official" beginning of the Gulf Stream system. It is defined here as that section of the system that stretches from the Straits of Florida to Cape Hatteras. The Florida Current receives its water from two main sources: the Loop Current and the Antilles Current (Baringer and Larsen, 2001). The Loop Current is the most significant of these sources and can be considered the upstream extension of the Gulf Stream system. The transport increases downstream to a maximum of about 85 Sv near Cape Hatteras. The Gulf Stream begins upstream of Cape Hatteras (35° north), where the Florida Current ceases to follow the continental shelf. The position of the Gulf Stream as it leaves the coast changes throughout the year. Noting that the Gulf Stream leaves the WECAFC region, it will not be considered in this review.

In the area away from the direct influence of the waters in the ABNJ, two major currents contribute to the connectivity between organisms in the Caribbean Sea and GOM, namely, the Caribbean Current and the Loop Current. Noting that the ecosystem connectivity of interest is between the ABNJ and bordering the EEZs in the WECAFC region, the direction of the connectivity is considered poleward – the NBC and the NBCR are the upstream source of the waters reaching a particular location and influencing it – that is, the NBSLME and the eastern part of the CLME, notwithstanding the influence that the Antilles Current can have in the northern part of the CLME. The connectivity between the ABNJ and the SEUSALME is mostly influenced by the Gulf Stream system that may likely have more effect on the northern area outside the WECAFC region.

In general, knowledge of the different currents by which pelagic larvae are moved is usually compiled into physical oceanographic models. The use of the Lagrangian particle-tracking method in conjunction with high-resolution ocean circulation models, allows oceanographers to estimate the passive (oceanographic) connectivity between the EEZs of coastal nations and the ABNJ (Popova *et al.*, 2019). Recent advances have made it possible to develop a multiscale biophysical modeling system, based on an individual-based model and Lagrangian framework (Paris *et al.*, 2013). The connectivity modeling system (CMS) was developed to study complex larval migrations and give probability estimates of population connectivity. The CMS can also provide a Lagrangian description of oceanic phenomena of advection, dispersion and retention with great precision.

6.3 Migratory connectivity achieved by active swimming of marine species

Information on the migratory connectivity between marine ecosystems is achieved by regular movement of marine species from one place to another, often from breeding to feeding (non-breeding) grounds and back. On the scale of a single species or region, connectivity can be analysed empirically through genetic testing, but for analyses on larger scales, dispersal patterns can be estimated using biophysical models that combine oceanographic data with an understanding of the biology of the stocks (Cowen, Paris and Srinivasan, 2006; Paris *et al*., 2013).

In the late 1990s, the use of higher resolution spatial and temporal measurements of the flow regime surrounding Barbados provided a comprehensive view of the local surface circulation (0 m to 100 m), revealing that external forcing by NBCR played a dominant role in the near-field flow variability surrounding the island. The study by Cowen *et al.* (2003) on the interaction of NBCR with coastal flow dynamics and the biological response of the system, was measured by recruitment of coral reef fishes. The study showed that the flow direction and associated residence time in the vicinity of the island appeared to vary depending on the orientation of the NBCR as they collided with the island. During some of the events, larval fishes appeared to be rapidly advected away, resulting in a failure of larval settlement, whereas under other conditions larval retention was enhanced and was followed by a settlement pulse. In other observations, where the depth of chlorophyll_a (Chl a) maximum was influenced by the NBCR, changes were observed in the vertical distribution of fish larvae, affecting their growth and survival rates and ultimately their recruitment success. Cowen *et al.* (2003) concluded that that NBCR interfere with the island-scale flow dynamics around Barbados and add considerable variability to the local recruitment signal of coral reef fishes.

Another study on linking spawning aggregations of red hind to oceanographic processes in the eastern Caribbean indicated that the timing of red hind spawning aggregations was synchronized across large spatial scales, based on similar oceanographic features (Nemeth *et al*., 2008). The study revealed that changes in the lunar cycles and seasonal declines in seawater temperatures and current speeds appear to initiate migration and synchronize the arrival of red hind to the spawning aggregation sites. This results in spawning over brief periods between December and the end of February when annual seawater temperature and current speed reach their minimum. The authors suggested that the presence of slower across-shelf currents in all sites analysed might indicate the maximum retention of eggs and larvae and therefore enhance self-recruitment. These red hind spawning aggregations are located in the vicinity of the Anegada Passage and the passages of the leeward islands, by which a second inflow of freshwater into the Caribbean Sea is partly provided by NBCR – which stall and decay east of the Lesser Antilles – and partly by the NEC which advects water westward (Cherubin and Richardson, 2007). Hence, the next questions would be: how much of that influx of freshwater that occurs before or at the time of the spawning aggregations of red hind on those sites is responsible for the slower across-shelf currents that enhance self-recruitment? And, would that influx of freshwater have any influence in larval retention, growth and survival, in a similar way as was observed around Barbados? Questions like these are what science needs to address to better understand connectivity over a broader scale.

Efforts have been made within the wider Caribbean, such as those of Cowen, Paris and Srinivasan (2006) who modeled the connectivity of reef fish species using an individual-based model of dispersing larvae in a hydrodynamic field, replicating five years of history in the Caribbean and with coral reef habitat identified as 260 nodes (10 km x 50 km) in the region. The study noted the variation across the region, but overall, the high levels of self-recruitment. Demographically meaningful immigration was effectively limited to distances of less than 100 km. On average, about 21 percent of recruiting larvae came from within the node, and recruitment from more than 100 km away was marginal.

Other research studies have indicated the need to consider vertical distribution of nutrients, salinity and temperature when developing hydrodynamic oceanographic models for predicting reef fish larval dispersal and connectivity of Caribbean coral reefs, especially in strongly vertically stratified waters. It was found that pelagic surgeonfish (Acanthuridae) larvae are capable of significant offshore dispersal, probably in association with the NBCRs that typically pass northward along the eastern edge of the Lesser Antilles (Oxenford, Fanning and Cowen, 2008). This study showed accumulations of surgeonfish larvae deeper (100 m to 150 m) than previously known, and coincident with, or slightly above, the depth of the Chl a maximum and a high-salinity layer.

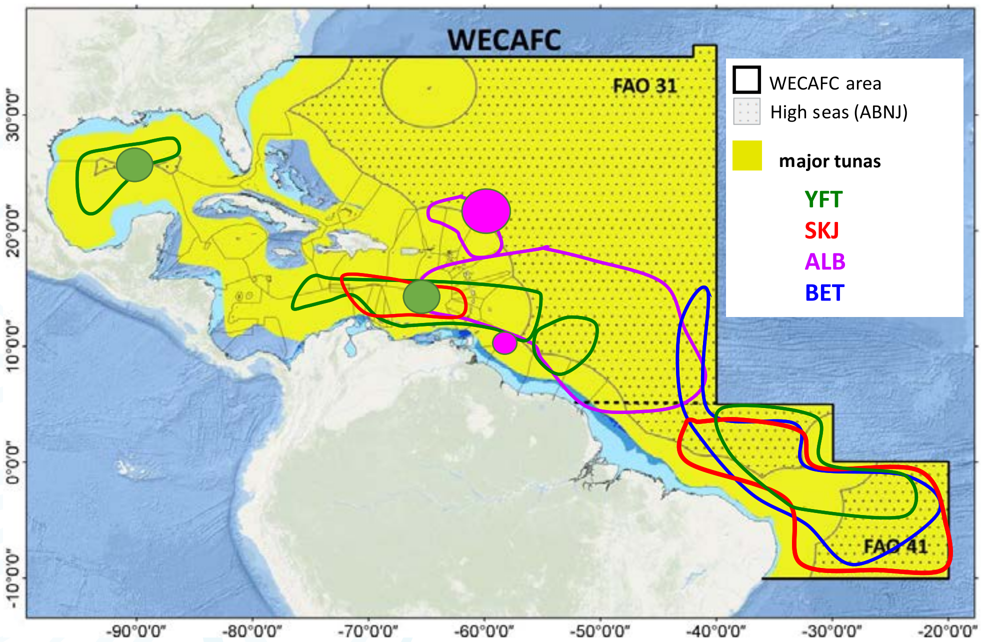
Generally, fish larvae and juveniles reside in the epipelagic zone (0 m to 200 m), where planktonic food occurs at concentrations acceptable for fast-growing fishes with discrete movement capability (Fuiman and Wegner, 2002; Houde, 2009). As larval fish grow and detection probability by epipelagic predators increases, individuals will descend to meso and bathypelagic depths, or in the case of deep-demersal species even to the seafloor. Recent data suggest that occupation of multiple depth zones by large pelagic fishes is much more widespread than previously thought (e.g. whale shark to 1 200 m; bluefin tuna to 1 000 m and swordfish to 900 m). Some wide vertical distributions result from active vertical movements away from a center of distribution, either upwards or downwards, while others appear to simply result from tolerance of a wide range of environmental conditions (probably as with the surgeonfish example). In the case of the pelagic species mentioned above, which are to be considered primarily epipelagic specimens, they represent examples of active downward fluxes. Likewise, if the center of distribution of mesopelagic fishes is between 200 m and 1 000 m, most species will likely occur between these depths during daylight, then their nocturnal migration would be considered an upward active flux into the epipelagic zone.

Therefore, the connectivity of both active fluxes is for feeding, suggesting that the deep pelagic zone is a fundamental element of the ecology of many large epipelagic fishes (including several of the straddling species reviewed in Section 4), and the epipelagic zone is certainly integral to the ecology of nearly all mesopelagic fishes. A recent study in the tropical South Atlantic (the offshore waters of Ascension Island) showed that several top pelagic predators, like swordfish, bigeye tuna and blue shark make extensive use of the epipelagic and mesopelagic biomes, while other pelagic predators, such as tiger shark, oceanic whitetip shark, yellowfin tuna and wahoo, can make limited use of the mesopelagic biome (Madigan *et al.*, 2021). Consequently, it appears that there is considerable vertical connectivity between the species in the epipelagic and mesopelagic biomes by an active (migration) and passive (ontogenetic descent, and/or oceanographic processes) movement. These aspects need to be considered when reviewing the ecological connectivity between the EEZs of the WECAFC region and the ABNJ, particularly if much of the connectivity is linked to straddling and highly migratory species that are of high commercial and food security value to the countries of the region.

Fisheries are typically managed at the scale of national EEZs, but many fish populations are connected beyond EEZ boundaries (Popova *et al*., 2019). Generally, pelagic species can be tracked across international borders as adults (e.g. Block *et al*., 2005; Luckhurst, 2007). In the WECAFC region, the straddling species would likely represent a good example of migratory connectivity of adult species between the ABNJ and the EEZs in the region.

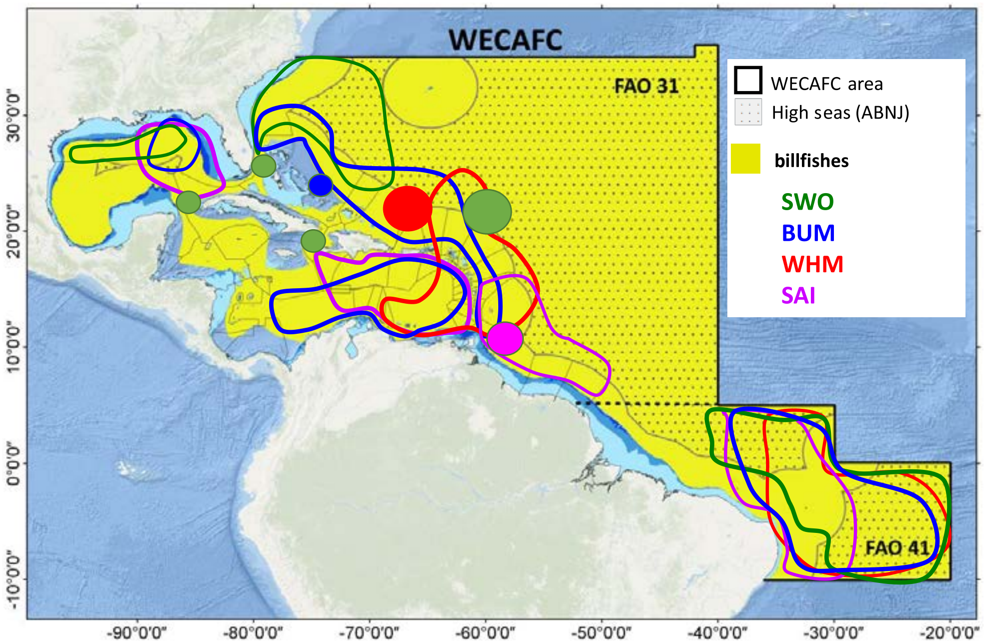
Information from Section 4 on the geographical distribution and catch areas of straddling species was used to map the distribution and/or movement of the most relevant straddling species in the western central Atlantic within the WECAFC region (figures 6.4, 6.5 and 6.6). It is evident that the tuna, billfishes and other large pelagic resources are distributed throughout the WECAFC region and span the ABNJ and the EEZs of all countries in the region. It is also noticeable that most of the major tuna catches are distributed across the southeastern Caribbean Sea and along the northern part of South America up to the lesser Antilles, covering several EEZs and parts of the ABNJ (Figure 6.4). In contrast, major billfish catches are distributed in the southern part of the region (FAO area 41), in the central and eastern Caribbean and east of the Lesser Antilles, and in the GOM and northern part of the region (Figure 6.5). The three large pelagic species (dolphin fish, wahoo and bluefin tuna) are mostly caught in the central and eastern Caribbean and east of the Lesser Antilles, including in the vicinity of the ABNJ, notwithstanding the presence of important localized areas across the region for individual species, with the exception of Brazil (Figure 6.6). Most of these species live much of their life-cycle within the WECAFC region and beyond into the ABNJ (within and outside the WECAFC region), migrating between spawning and feeding grounds, for example yellowfin tuna, albacore tuna (ICCAT, 2006–2016; Arocha, 2020), swordfish (ICCAT, 2006–2016; Arocha, 2007), Atlantic white marlin (ICCAT, 2006–2016), Atlantic sailfish (ICCAT, 2006–2016; Mourato *et al*., 2018), and dolphinfish (Merten, Appeldorn and Hammond, 2016; Schlenker *et al*., 2021).

Figure 6.4. Distribution and/or movement of major tunas (YFT: yellowfin tuna, SKJ: skipjack tuna, ALB: albacore tuna, BET: bigeye tuna) in the Western Central Atlantic Fishery Commission region



Notes: Filled circles indicate spawning grounds for each species.
Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

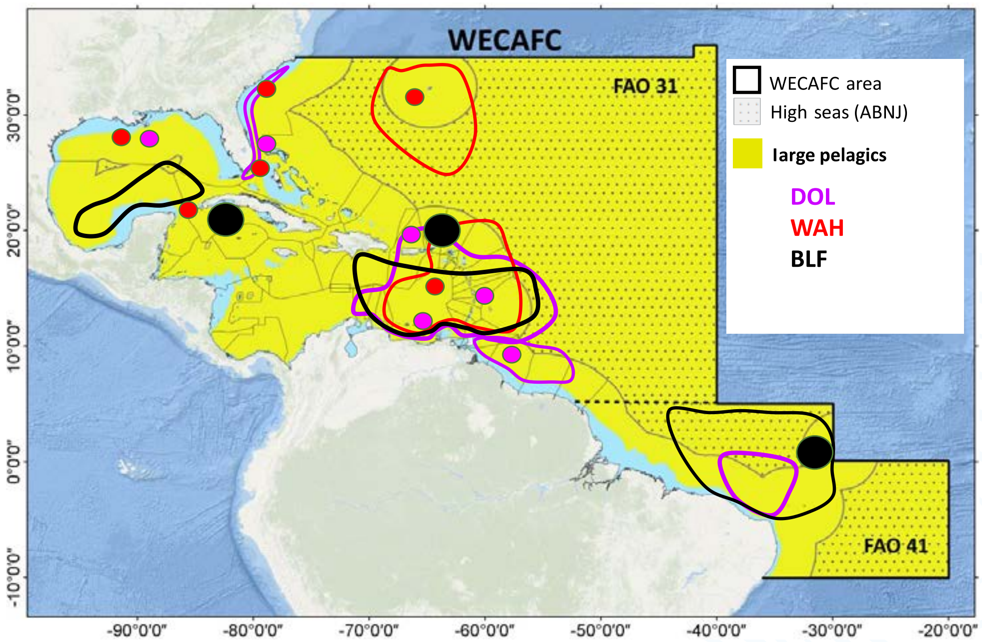
Figure 6.5. Distribution and/or movement of billfishes (swordfish, blue marlin, white marlin and sailfish) in the Western Central Atlantic Fishery Commission region



Notes: SWO = swordfish; BUM = blue marlin; WHM = white marlin; SAI = sailfish. Filled circles indicate spawning grounds for each species.

Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

Figure 6.6. Distribution and/or movement of large pelagic fish in the Western Central Atlantic Fishery Commission region



Notes: DOL= dolphinfish; WAH= wahoo; BLF= blackfin tuna. Filled circles indicate spawning grounds for each species.

Source: Esri. 2021. World Ocean Base [Shapefile]. Redlands, USA, modified by authors.

The major tunas, billfishes and large pelagics, such as common dolphinfish and blackfin tuna, are an important resource for many people in the region, both as a food source with nutritional importance and as an important source of income (Guillotreau *et al.*, 2017; Oxenford and Monnereau, 2018). This is particularly the case in several developing countries and SIDS throughout the Caribbean Sea and NBSLME, where fishing for tuna (and other large pelagic fishes) provides food, employment and income for artisanal fishers, as well as commercial and recreational fishers (Gentner, 2016; Gentner and Whitehead, 2018). The presence of these large pelagic fishes also presents the potential for growth in terms of recreational fisheries. Several developing countries in the area have recognized recreational fisheries as a growing industry with the potential to contribute to economic growth, especially with regards to the associated growth of local tourism (CRFM, 2016).

Larval connectivity patterns have been analysed at both the regional (Cowen and Sponaugle, 2009) and global levels and have been used to suggest changes for spatial management and conservation (O'Leary and Roberts, 2018). However, studies of demographic connectivity have largely focused on species with short pelagic larval duration, like reef fishes, that have a pelagic larval state and a demersal settlement, and on invertebrates (e.g. queen conch) that have a pelagic larval state and a benthic settlement (Grober-Dunsmore and Keller, 2008). Demographic connectivity among distant populations and between distant marine ecosystems is not detected by current tagging methods and genetic techniques, which inhibits understanding of connectivity at larger spatial scales for the management of important fishery resources (e.g. tunas, billfishes, large pelagic fishes and lobster).

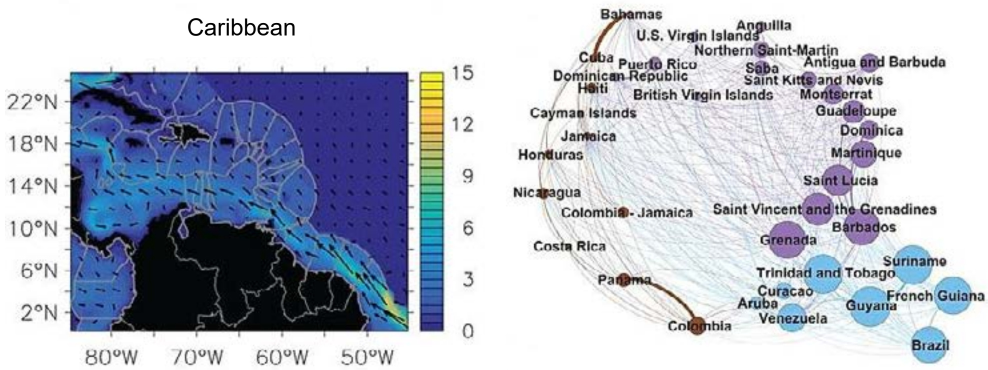
In the case of the Caribbean spiny lobster, connectivity and dispersal pathways throughout the Caribbean were identified by using multiscale biophysical modeling techniques coupled with empirical estimates of larval behaviour and gamete production (Kough, Paris and Butler, 2013). The spiny lobster has a long 5- to 9-month pelagic larval duration time and it matures in the open sea, engaging in diurnal and vertical ontogenetic migration during dispersal before returning to coastal nursery areas (Yeung and Lee 2002). The study was able to predict and empirically verify spatio-temporal patterns of larval supply and describe the Caribbean-wide pattern of larval connectivity for the Caribbean spiny lobster.

However, demographic connectivity between distant marine ecosystems of large pelagic fishes (such as straddling species) have not been explored in a similar way (Kough, Paris and Butler, 2013). The migratory connectivity of large pelagic fishes has been based on inferences of the biology and ecology of the spawning population and its connection to the oceanographic processes and conditions occurring on the spawning grounds (i.e. Serafy *et al.*, 2003; Luckhurst and Arocha, 2016; Duncan, 2017). The available information on the spawning grounds of some large pelagic fishes (with the presence of larval fish) located within the boundaries of several EEZs and the ABNJ of the WECAFC region, warrants future study with similar tools (multiscale biophysical modeling techniques coupled with empirical estimates of larval behaviour and gamete production), similar to that used for species with long pelagic larval duration (e.g. Caribbean spiny lobster). What is known about the spawning adults and larval concentration of albacore tuna, swordfish, Atlantic blue marlin and Alantic white marlin within the boundary of EEZs and the ABNJ is that pre-juvenile or young of the year (YOY) of most of these species inhabit specific areas within the WECAFC region before migrating outside it as adult fish to feed in more productive waters. Therefore a connection exists between these two distant marine ecosystems. The use of high resolution, three-dimensional oceanographic circulation models and larval behaviour can contribute towards understanding the connectivity between larval areas and YOY nursery areas of these species in the WECAFC region. Presently, the connection is evident, but what is not known is how it works and how it affects the countries in the region.

Ecological connectivity between distant marine ecosystems can also be explored as the dependence of coastal nations on their neighbours for recruitment. In other words, the risk of losing part of their catch if the fisheries in the EEZs outside their jurisdiction are poorly managed. A recent study examined the international connectivity of more than 700 species by building a global network of fish larval dispersal (Ramesh, Rising and Oremus, 2019). The study combined oceanographic and life history data of commercially harvested fish to estimate their connectivity across several hundred (249) EEZs and constructed a network representing the larval flows between nations. Economic risks were quantified and regional hotspots of risk were identified for catch, fishery employment and food security. The study showed that for the area called the Caribbean (from the southern limit of the WECAFC region through to northern Cuba [24° north]), the NBC flows northwestward along the South American coast, and consequently many of the EEZs lying along this current act as sources for the Lesser Antilles (Figure 6.3). Within the Lesser Antilles, the density of small EEZs gives rise to a highly interconnected, complex network structure (Figure 6.7). The effect of the northward flow along this island chain can be inferred from the larger node sizes among the EEZs lying in its southern portion. The study showed that the most vulnerable countries that depend the most on the spawning grounds of their neighbours in terms of their total catch, gross domestic product, number of jobs in the fishery industry, and a fishery food security dependence index, are concentrated in the hot spot area of the Caribbean islands (Ramesh, Rising and Oremus, 2019). In summary, the study highlights the role of larval connectivity across international boundaries and the need for multilateral cooperation for sustainable management of shared resources. Nonetheless, the role of adult fish migration in driving international connectivity remains unclear.

The straddling species included in this review cross many EEZ boundaries and move into ABNJ (ICCAT, 2006–2016). As such, there is a need to increase efforts across the WECAFC region to collect and report fishery data on these straddling species to the responsible RFMO and other RFBs. This may contribute to reducing uncertainties around stock assessments and increase multilateral cooperation for the sustainable management of shared resources.

Figure 6.7. Ecological connectivity network structure for the Caribbean region



Source: Ramesh, N., Rising, J. & Oremus, K. 2019. The small world of global marine fisheries: The cross-boundary consequences of larval dispersal. *Science*, 364 (6446): 1192-1196.

7

Discussions and conclusions

7. Discussions and conclusions

Fisheries targeting resources that straddle political boundaries are likely to complicate fisheries management and potentially reduce the effectiveness of policies to achieve conservation and sustainability objectives. Therefore, having an accurate understanding of the distribution and scale of transboundary and straddling fish stocks and associated fisheries is important for their sustainable management.

This review shows that shared fisheries in the WECAFC region involve fish that are caught in the waters of more than one country and in the high seas. These shared fisheries are economically and biologically significant, making their management and conservation a priority for the sustainability of the region's fisheries (Acosta *et al*., 2020).

In the review of the species, 38 were classified as transboundary and 31 as straddling/highly migratory species. However, current research does not support the inclusion of the queen conch (that is very important to the region) with the group of species that were classified as transboundary. A couple of studies on the potential replenishment of nursery areas in the Mexican Caribbean and the southern GOM and their connection to the Florida Keys have proved that the connection is weak (Delgado *et al*., 2008, Paris *et al*. 2008). One study showed that the small fraction of larval dispersal of queen conch reaching the Florida Keys might not be sufficient to replenish downstream populations. However, there are other areas in the Caribbean where queen conch is commonly fished and studies on the connectivity of larval dispersal are not known to science. For example, what is the potential connectivity between queen conch in the Antillean Islands and the populations off Jamaica and Nicaragua? Are these concentrations self sustained or is there connectivity between them? The possibility that the nature of queen conch larvae and ocean currents could cause panmixis over relatively large spatial scales, and prevent the isolation of populations, continues to be likely. However, it is evident that queen conch has been severely overexploited in the region for centuries, thus it is likely that the panmixis potential has been reduced over time. Nonetheless, queen conch in the Caribbean should be considered a shared stock with transboundary issues, if not a transboundary species.

The remainder of the species classified as transboundary show no relevant discrepancies. One characteristic is that several groups of species show clear relevance within and between the LMEs in the region. The spiny lobster is widely distributed and exploited across all LMEs, although the population off Yucatan in the GOM appears to be undefined. It is evident that the management of the Caribbean spiny lobster will require the cooperation of all countries exploiting the resource.

The group of groundfish stocks is most intensively exploited in the NBSLME and parts of the southern coast of the CLME, with the exception of the whitemouth croaker that is widely distributed in the coastal areas of the southern GMLME, CLME and NBSLME. Management effort would likely be focused in this area by countries that share these transboundary stocks.

The transboundary species of reef and slope species selected in this review include some critically overexploited and endangered species that are shared by several countries. Of the eleven reef and slope species selected, five are distributed across all EEZs of the region, while the remainder are limited to two or three LMEs. Noting that many of these species aggregate to spawn, the need to protect spawning aggregations is critical for the conservation and sustainability of these resources. Therefore, a priority for these stocks is to support the Regional Fish Spawning Aggregation Fishery Management Plan for the WECAFC region.

The transboundary stocks of shelf shrimps can be separated into two groups: those corresponding to the GMLME and SEUSALME, and those of the CLME and NBSLME, with a couple of species that are broadly distributed across all LMEs of the region (redspotted shrimp and Atlantic seabob). Although classified as transboundary species, in most cases these stocks are managed as stock units by individual countries across the region and not as shared stocks. However, some recent progress has been made towards possible collaboration in the management of some shared stocks by countries in the NBSLME that exploit these southern stocks, even though some countries have established individual management actions for specific stocks. More advances are needed for species-specific reporting to enhance future collaboration in the conservation and sustainability of these shrimp resources.

The four large pelagic fish classified as transboundary species are under the mandate of the only RFMO operating in the region (ICCAT) and are to be reviewed and assessed by the Small Tuna Species Working Group. However, ICCAT has not been able to conduct formal assessments on any of these species. Responsibility lies with ICCAT Member States to provide catch and effort data regularly and contribute the biological information necessary for the assessments. Noting that two species (king mackerel and serra Spanish mackerel) are of great importance to many countries in the region, regional ICCAT members and non-ICCAT members should be encouraged to report catch and effort data to ICCAT, with the aim of supporting regional ICCAT members in their efforts to conduct formal stock assessments of these shared resources and contribute to region-wide CMMs.

Of the seven transboundary shark species, only one (blacktip shark) is distributed across all the EEZs of the region and is probably one of the most heavily fished. One of the major issues associated with elasmobranchs is the misidentification of shark species in catches, with a few exceptions such as small coastal hammerhead sharks (smalleye hammerhead and bonnethead shark) where they are commonly fished and relatively easily identified. Most of the shark species are landed dressed at sea and grouped; this practice hinders proper identification and reporting of the catches. This review has demonstated that most of the shark catches come from multispecific fisheries and small-scale fisheries off the NBSLME and the southern coasts of the CLME, except for bonnethead shark that seems to be more common in the GMLME. Small individuals of several shark species are common in areas of the NBSLME and the possibility that the area is a nursery area for some shark species is high. Therefore, improved efforts to identify the species that may be using it as a nursing ground is a critical one for the conservation of shark species in the region.

Of the 31 species classified as straddling/highly migratory stocks, two are not under the mandate of ICCAT. These are fourwing flyingfish and common dolphinfish. The flyingfish species complex that consists of mainly fourwing flying fish is mostly caught at the boundary between the high seas in the Atlantic EEZs of the southeastern Caribbean islands.

The fishery for this species complex is localized within the WECAFC region but supports the social, economic and traditional values of several islands. It is considered to be managed under the CRFM. In contrast, the common dolphinfish, which in some cases is also mixed with the pompano dolphinfish, *Coryphaena equiselis*, is widely distributed across the region and targeted by many countries. It is also part of the commercial bycatch of the regional tuna fisheries. For a brief period in recent years, and under the petition of ICCAT's SCRS, the common dolphinfish was placed under ICCAT's species of interest and efforts were made to create and construct historical catch and effort datasets for the species. Several countries in the region contributed to that dataset, facilitating the fisheries mapping of common dolphinfish provided in this review. After 2021 the common dolphinfish was dropped off ICCAT's species of interest and is currently not under ICCAT but it would be in the region's best interest to build on the existing ICCAT regional database for future regional assessments, to ensure the conservation and management of the common dolphinfish, a highly important pelagic resource in the WECAFC region.

Within the straddling stocks that are under ICCAT's mandate, two species are of particular interest to the region's small-scale pelagic fisheries, but are not fully assessed by ICCAT: blackfin tuna and wahoo. These two stocks are under the responsibility of the SCRS's Small Tuna Species Working Group and the scientists of the Member States. Therefore, if interested parties have provided data to revise the state of the stocks, it is within this working group that a decision to conduct a stock assessment is considered, based on the data available to the working group. It would be to the benefit of the region's Member States with an interest in these two species or any other species under ICCAT's mandate that are not regularly assessed, to contribute the minimum data requirements and help regional ICCAT members to request the necessary data review and potential assessments in species of interest to all members WECAFC. Without regional input to ICCAT scientific meetings, it is unlikely that specific assessments will be conducted.

Of the all the species that appear in the *WECAFC Reference list of aquatic species* presented in the iDCRF (Version 2021.0.7, Appendix 3.1), a group of 26 fish and crustacean species that were considered as high seas and deep-sea species falling under a possible mandate of WECAFC as a regional fisheries management entity or arrangement were not included in the present review due to several factors, the most relevant of which was the limited reported catches in FAO catch statistics, with a few exceptions such as the United States and Mexico for the vermelion snapper (*Rhomboplites aurorubens*), which can be considered a transboundary species. The remainder of the species were either grouped with other species or have not been reported. If any of the species listed in this group are to be the focus of a RFMA in the WECAFC region, efforts should be made by countries targeting them (like vermelion snapper) or willing to exploit any of the fish resources listed, to record and collect fishery data for future CMM.

Data describing fisheries (what, where and how much is caught, and how fisheries are conducted, including effort by gear type) are fundamental to fishery management. Such data are required for scientific assessments of the state of fish stocks and to estimate sustainable yields. The present review showed that information on reported catches and fishing effort across the region's fisheries is unbalanced, incomplete and outdated. Regardless of the country's development status, the level of fishery data relevant to the WECAFC region is, at the very least, incomplete. The most notable is the limited information on basic fishing effort, i.e. fleet characteristics, number of vessels dedicated to a fishery, number of fishers, gear type by fleet(s), among other issues.

The review of the most recent reported catches (2015 to 2019) by countries showed two outstanding issues: the first is that in species-specific reported catches there were discrepancies between those reported to FAO and those reported to other official databases (national databases or ICCAT) for the same species and year. The second is the use of carry-over catch values over several years in some species-specific reported catches. Other specific issues were also noted, such as the reporting of catches for the same species by overseas territories in the WECAFC region and the country that oversees those territories. This raises the question of whether double reporting is taking place. A further issue is the claim by a Member State that no pelagic fishing is occurring in its Caribbean waters, yet catches of large pelagic species being caught there are reported. This raises the question of whether those catches are misreported from other oceans. This type of misreporting will have undesirable effects on the catch matrix for a given species when trying to conduct a stock assessments and Member States should make a concerted effort to review and update such records accordingly.

Regarding the basic information on fishing effort, it was clear that – with very few exceptions – in least developed countries with large coastal areas and multiple fisheries, the information on fishing effort is limited, aggregated and most of the time not up to date. In contrast, countries with small and limited coastal areas tend to be more organized. Nonetheless, in both cases information on fishing effort is limited and unbalanced, at best. It also became evident that relatively complete and detailed information on fishing effort is available for most of the straddling stocks reviewed because this is reported by WECAFC Member States targeting these species to ICCAT, either because they are ICCAT members (Contracting Parties and Cooperating Non-Contracting Parties) or because they are non-member countries that abide by the United Nations Fish Stocks Agreement. This information made it possible to produce detailed fishery maps specifically for the WECAFC region. The limited information on catch and effort in the region is due to the absence of a regional DCRF. The 17th WECAFC session convened in 2019 adopted a recommendation on the iDCRF, which would be the first instrument to establish a foundation for comprehensive fisheries data and statistics collection in the WECAFC region. This is an ongoing process that may take years to accomplish. Efforts should be made to develop a simple structure in order to capture the basic information required for the main species of interest that need constant monitoring, surveillance and compliance to effectively manage regional fishery resources.

Noting that most countries in the region are targeting or have an interest in expanding their large pelagic fisheries towards tuna species and or tuna-like species, it would be in their best interest to get involved in the ICCAT process for reviewing the state of resources under its mandate. This would involve the participation of national scientists in the species working group meetings where fishery data is revised and updated, and relevant biological and ecological information for a species of interest are discussed and updated in order to move towards the analysis of the state of a particular stock. Such participation would be a starting point in getting regional scientists from WECAFC countries involved in the stock assessment process in the immediate future.

The ecological connectivity between the high seas and the region's EEZs is largely dominated upstream by the NBC and NBCR and downstream by the NEC which seem to have inferred influence in some of the straddling stocks (tuna and tuna-like species) exploited in the region. Without direct empirical evidence of this potential connectivity between the two distant ecosystems, any assertion that poor management around the boundary of either side of the ecosystems will result in the loss of catches downstream (i.e. within the WECAFC region) is precluded. However, the results of the study by Ramesh *et al.* (2019) revealed that the most vulnerable countries, that depend the most on the spawning grounds of neighbouring countries, are concentrated in the Caribbean islands; although the study did not specify the species that were responsible for that effect in the Caribbean region.

7.1 Concluding remarks

Sixty-nine species were examined: one mollusc, nine crustaceans, six groundfish species, 11 reef and slope fish species, 23 pelagic species and 19 elasmobranch species. Thirty-eight were classified as transboundary and 31 as straddling/highly migratory. The classification of only one species, the queen conch, remains unclear.

Fisheries mapping by species with spatial information on fishing effort and catch by gear type was possible for most of the straddling/highly migratory stocks that are targeted or part of the commercial bycatch of the tuna fisheries operating in the WECAFC region. The fisheries mapping information for the transboundary species was possible only for the spatial distribution of catch areas. Large-scale spatial effort data for the transboundary species reviewed are very limited in the WECAFC region.

The absence of a regional DCRF for the WECAFC region represents a handicap when evaluating the state of the stocks at the regional level. For several stocks, mostly transboundary, localized fishery information may be available to conduct stock assessments, but for most straddling/highly migratory stocks (whether under the ICCAT mandate or not) is insufficient. For several straddling/highly migratory stocks in region, the limited information of fishery data has had an adverse effect in some of the stock assessment results for species of interest in the region (e.g. marlin species).

Data on social and economic aspects of fisheries is rarely collected in a systematic and comprehensive manner in the region. Efforts to address the issue of social and economic data collection are being developed by the iDCRF for which specific tasks are defined, along with the characterization of the scale of fishing units for small-scale fisheries to assist national/regional management. This is led by the FAO Coordinating Working Party on Fishery Statistics. The approach uses a matrix scoring approach to address the multicharacter complexity and inter-regional diversity of small-scale fishing operations. Several countries in the WECAFC region have conducted survey trials in some of their fisheries with interesting results. The use of this instrument for valuable regional resources would provide benefits towards policy development, as well as providing a common framework of intercomparability of fishing units between countries and regions. It would also enable greater clarity and objectivity over the scope of management or policy measures that are applied to large- or small-scale fishing units.

Stock status of the straddling/highly migratory stocks that were reviewed indicated that flyingfish is not overfished. Of the major tunas, only one stock is overfished (bigeye tuna); Atlantic blue marlin and Atlantic white marlin are under strict conservation and recovery measures; and the stock status of two spearfishes and dolphinfish are unknown. Of the elasmobranch species caught by tuna fisheries, shortfin mako is overfished and experiencing overfishing. The remainder are in a relatively stable condition, although there are a number of recommendations to reduce fishing mortality on several oceanic shark species.

The ecological connectivity between the high seas and the region's EEZs is largely dominated upstream by the NBC system and downstream by the NEC. These two major currents are largely responsible for the connection of the straddling/highly migratory stocks (tuna and tuna-like species) exploited in the region. However, the connectivity is less evident for some transboundary species. For slope stocks in the NBSLME and reef stocks in the eastern CLME a connection may exist, but no empirical studies are available to confirm that possibility.

The information presented in this review will serve as the basis of an actionable process for transforming the WECAFC into a regional fisheries management entity or arrangement in the region. There are several ways that an actionable process can be approached to facilitate the decisions that need to be addressed by the WECAFC. Some of them are highlighted in Appendix A.

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Appendix A

Appendix A. Future considerations

From the discussions that took place during the First Preparatory Meeting of the WECAFC for the Transformation into a RFMO, there appeared to be general agreement on the creation of an entity/arrangement with a mandate within the ABNJ and a possible extension to stocks within the EEZs of the coastal states concerned. The approach would be short, medium and long term, starting with the ABNJ where binding measures can be implemented, and perhaps including selected straddling and transboundary stocks, or highly migratory stocks within the EEZs without prejudice to the sovereign rights of WECAFC Member States.

This review revealed that most of the economically important resources for which there are directed fisheries, and those valued for food security within the ABNJ of the WECAFC region, are straddling/highly migratory stocks under the mandate of the existing RFMO in the region, namely ICCAT, with the exception of two species: flyingfish and common dolphinfish. In the case of transboundary stocks, the review showed that most occur within the EEZs of neighbouring states.

In the case of the straddling/highly migratory stocks not under an ICCAT mandate (flyingfish and dolphinfish), exploitation of the fourwing flyingfish resource is mostly limited to an area that is under the regional advisory body CRFM, that can contribute with binding CMMs among the coastal states that target the resource. However, there may be other elements that may affect the stock status of the fourwing flyingfish resource that may not be attributed to fishing mortality, but rather to environmental variations in the species' critical habitat. Considering that fourwing flyingfish prefer floating objects for spawning, there is a lack of knowledge about whether the influx of sargassum to the fishing areas has had an adverse effect on recruitment, and whether there is strong existing connectivity between the sargassum and the population dynamics of the fourwing flyingfish. Therefore, to understand the ecosystem impacts of pelagic sargassum in the population dynamics of numerous species (possibly including fourwing flyingfish) that depend on it as habitat is mostly addressed at a broad regional level.

Common dolphinfish is a straddling/highly migratory stock, widely fished across the region by commercial (small-scale, semi-industrial and industrial) and recreational fisheries. The species would be an excellent candidate for testing region-wide CMM, noting that dolphinfish in the WECAFC region is considered a single panmictic population. This would require States to take the necessary measures to collect, record and report fishery statistics to a regional entity with a regional mandate that would analyse and report on the stock status of dolphinfish region-wide.

Almost all the transboundary species reviewed are shared resources within the EEZs of several neighbouring states. Shelf shrimps and groundfish resources in the southern part of the WECAFC region, which includes the Gulf of Paria (with similar ecosystem characteristics to the NBSLME) and the NBSLME, are shared by six States that are responsible for the collection and reporting of fishery statistics to determine the stock status of several species caught by fisheries in the area. Without a clear stock definition or delimitation of the species of interest, the health of the shared stocks cannot be guaranteed, regardless of State-specific CMMs. In addition, there is a need to estimate indices of abundance in an unbiased way for all the species of interest.

The transboundary species in the northern part of WECAFC are shared by two neighbouring states. Most stocks of northern shelf shrimp are managed as State-specific stock units.

However, for the transboundary species within the group of reef and slope species (groupers and snappers) there is a need to define a series of indicators that would help to determine stock units for each species of interest. For these stocks there appear to be subareas of groups of reef and slope species that would require clear stock definition/delimitation. There is the group of species in the northern and eastern GOM and southeastern United States which are managed as stock units by the United States. Another subarea is off the Yucatan Peninsula and the western Caribbean (the Mesoamerican reef area and the Nicaragua shelf area). A better understanding of the connectivity between the different subareas of the western Caribbean LME and Yucatan Peninsula is required. This would provide a better understanding of stock definition/delimitation of the species of interest, and guarantee the health of the shared stocks in cooperation with State-specific CMMs. Another subarea that requires similar studies is the Caribbean Islands (Greater and Lesser Antilles). Finally, the slope resources of the NBSLME would also require similar studies, but such studies would likely need to be extended to the Lesser Antilles and the southern Caribbean as reef and slope resources in those two subareas are downstream of the major ocean currents that are responsible for the connection of several stocks in the region.

A final major step would be to advance a multiple-scale approach to enhance understanding of the interaction between the key physical and biological processes driving the connectivity and/or isolation between habitats and populations of key species or groups of species in the region. Such an effort would require validated biophysical models that consider ocean circulation and larval dispersal.

Deep-sea fishing in the ABNJ of the WECAFC region is very limited. Seven years have passed since the first meeting of the Working Group on the Management of Deep-sea Fisheries of the Western Central Atlantic Fishery Commission (FAO WECAFC, 2015). The available information on the high seas fisheries of the WECAFC area noted that deep-sea fisheries had been and were occurring, and that they were likely to increase in the future. However, it was noted that there were few deep-sea fisheries being undertaken by the countries represented at the workshop, and the deep-sea fisheries known to occur were normally an extension of shallower-water fisheries into deeper waters, typically within the EEZ of the country operating them.

In 2016 WECAFC issued a recommendation "On the management of deep-sea fisheries in the high seas" (Recommendation WECAFC/16/2016/4) that:

i) asked members to develop data and information collection programmes and research projects to assess current practice and scope for socially and economically viable and ecologically sustainable investments in deep-sea fisheries in the WECAFC mandate area;

ii) asked members and non-members of the WECAFC involved in experimental, exploratory and established deep-sea fisheries in the high seas of the WECAFC area to report annually to the WECAFC Secretariat on their activities; and

iii) asked members and non-members of WECAFC to submit to the WECAFC Secretariat any plans to engage in deep-sea fisheries, including exploratory fishing and/or research on deep-sea resources, in the high seas areas of the WECAFC area prior to implementation (FAO WECAFC, 2016).

Presently, no published literature or reports indicate the existence of deep-sea fishing operations in the ABNJ area of the WECAFC region in the past decade. The available published information showed that there were deep-sea fishing operations targeting Alfonsino (*Beryx splendens* and *Beryx decadactylus*) species common in temperate and subtropical seas, in FAO Major Fishing Area 31 and 41 during the late 1990s and mid-2000s by foreign fleets (FAO WECAFC, 2015; Shotton, 2016). It seems that those catches were made at the same time around Corner Rise Seamounts which are located at the northern limit of the WECAFC region and overlap with FAO Major Fishing Area 21 (Shotton, 2016).

Potential deep-sea fishing in the ABNJ of the WECAFC region is likely to be conducted by bottom and midwater trawl and squid jigger fleets. Available published information reveals that bottom trawl fishing in the WECAFC region is limited mainly to the United States and EU (FR Guiana) EEZs, based on Automatic Identification System (AIS) data and Global Fishing Watch algorithms (Kroodsma *et al*., 2018). There are other nations operating bottom trawls within their EEZs, but not recorded by AIS in the WECAFC region (Arrizabalaga *et al*., 2019a). Although there are operations of squid jigger fleets in FAO Major Fishing Area 41, they appear to be outside the WECAFC area (Arrizabalaga *et al*., 2019b). A recent study on the economics of fishing in the high seas showed that most of the fishing effort by gear type likely operating in deep-sea fisheries (i.e. trawlers and squid jiggers) is outside the WECAFC region (Sala *et al*., 2018). Some experimental squid jigging was conducted in Grenada with poor results due to the high costs of fishing gear and a limited market (Anon., 2009). No other offshore/high seas squid jigging experimental or commercial fisheries are known from the WECAFC region in the past decade.

There were several vulnerable marine ecosystems identified in the first meeting of the Working Group on the Management of Deep-sea fisheries of the Western Central Atlantic Fishery Commission. These were included in a WECAFC recommendation on the management of deep-sea fisheries in the high seas. It appears that a way forward in all aspects of deep-sea fisheries in the ABNJ of the WECAFC region would be to act on the Commission's recommendation (WECAFC/16/2016/4) which would likely be possible if there are binding agreements on CMM and only possible through a RFMO.

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The Western Central Atlantic Fishery Commission (WECAFC) endorsed the roadmap towards a model for a regional fisheries management entity or arrangement in the region and asked for preliminary work to be undertaken to gather information, best practices and options for the development of such an entity or arrangement. This review was developed in response. Its objectives were to revise the available data and identify information gaps for fish stocks considered to be transboundary and/or straddling stocks, occurring exclusively in the exclusive economic zones (EEZs) of WECAFC Member States and in the areas beyond national jurisdiction (ABNJ); to map the fisheries of the region; identify fisheries and stocks managed by other organizations; and to explore the ecological connectivity between the EEZs and ABNJ. A group of species considered to be highly important to Member States was selected and reviewed and the ecological connectivity between the EEZs and ABNJ was revised.

The review demonstrates that reported catches and fishing effort across the WECAFC are unbalanced, incomplete and outdated. Of the species reviewed, the four-wing flyingfish and the common dolphinfish are not under the mandate of any regional fisheries management organization operating in the WECAFC region. The ecological connectivity between the EEZs and ABNJ is dominated by two major currents, the North Equatorial Current and the North Brazil Current. These major currents are largely responsible for the connectivity of the straddling/highly migratory species exploited regionally. The review reveals that the most vulnerable countries in the region that depend on the spawning grounds of neighbouring states are concentrated in the Caribbean islands. It concludes with a number of recommendations that may assist with the transformation of the WECAFC into a regional fisheries management entity or arrangement.

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