FAO
FISHERIES AND
AQUACULTURE
TECHNICAL
PAPER

ISSN 2070-7010

569

Review of the state of world marine fishery resources

Cover illustration:
Emanuela D'Antoni

Review of the state of world marine fishery resources

FAO
FISHERIES AND
AQUACULTURE
TECHNICAL
PAPER

569

Marine and Inland Fisheries Service
Fisheries and Aquaculture Resources Use and Conservation Division
FAO Fisheries and Aquaculture Department

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2011

ISBN 978-92-5-107023-9

Preparation of this document

This document, the *Review of the state of world marine fishery resources*, was prepared by the Marine and Inland Fisheries Service, Marine and Aquaculture Resources Use and Conservation Division, FAO Fisheries and Aquaculture Department. It is part of the regular programme activities and a partial fulfilment of the Organization's role with regards to the monitoring and reporting on global marine resources and relevant environmental and ecological changes. The main objective of this review is to provide the FAO Committee on Fisheries (COFI), policy-makers, fishers, civil society and managers of world fishery resources with a comprehensive, objective and global review of the state of the living marine resources. This document updates the information provided in FAO Fisheries Technical Paper No. 457, *Review of the state of world marine fishery resources*, issued in 2005, and also updates and expands the information provided in relevant fishery resources sections of the more recent FAO publications on *The state of world fisheries and aquaculture* (SOFIA). It is intended that this *Review of the state of world marine fishery resources* will be completely revised every five years, with briefer updates provided biennially.

Relevant sections of this review have been compiled by FAO and selected invited experts, as indicated by the authorship of each chapter. Yimin Ye was responsible for the general coordination and final technical editing of this document, with the valuable assistance of David Milton. Fabio Carocci prepared tables and illustrations for this report.

Abstract

Marine fisheries are very important to the economy and well-being of coastal communities. Maintaining the long-term prosperity and sustainability of marine fisheries is not only of political and social significance but also of economic and ecological importance. This review presents an updated assessment of the current status of the world's marine fishery resources. Its aim is to provide the FAO Committee on Fisheries, policy-makers, civil society, fishers and managers of world fishery resources with a comprehensive, objective and global review of the state of the living marine resources of the oceans. The review was based mainly on official catch statistics up until 2009 and relevant stock assessment and other complementary information available until 2010.

This review consists of four major components. The first is a global overview of marine fishery production and the state of marine fish resources. The second part is divided into chapters that summarize and compile the information available for each FAO major fishing area, together with a discussion of the major trends and changes that have occurred with the main fishery resources exploited in each area and comments on the stock assessment work undertaken in support of fisheries management in each region. The third section is allocated to special topics that attract great attention in the international community, including tuna and tuna-like species, sharks, the Pacific islands region, deep-sea fisheries, and fisheries and long-term climate variability. The final part lists all the tables that provide details about historical and recent catches for the major marine resources and, where possible, assessments of the most current state of exploitation of fish stocks.

FAO
Review of the state of world marine fishery resources.
FAO Fisheries and Aquaculture Technical Paper No. 569. Rome, FAO. 2011. 334 pp.

Contents

List of tables, figures and boxes

LIST OF TABLES

LIST OF FIGURES

Appendix

LIST OF BOXES

Acknowledgements

This publication is one of the initiatives of the Marine and Inland Fisheries Service to assess and monitor the state of world marine fishery resources. In addition to the authors listed in each chapter, many staff members, both inside and outside the Service, made valuable contributions to the assessment and preparation of this review report. The Statistics and Information Service assisted with catch statistic data, Luca Garibaldi in particular. The library of the Fisheries and Aquaculture Department provided valuable service for references. Michel Lamboeuf, Juan Ignacio de Leiva Moreno, and Jean-Jacques Maguire assisted with analyzing FAO's catch statistic data. Tina Farmer provided various assistances with the publication of this report. A large number of regional fishery management organizations/authorities have provided data, information, comments and suggestions and are gratefully acknowledged. The final revisions and inputs of the report were provided by technical editor David Milton and FAO editor Julian Plummer. The graphic layout was prepared by Jose Luis Castilla Civit. Thanks are also expressed to many others who with our regrets are not being listed due to the large number. Nevertheless and while fully recognizing the assistance received from different sources, the full responsibility for what is presented in this review lies entirely with the Organization and the authors of each chapter.

Abbreviations and acronyms

ABF	Angola-Benguela Front
ACE	annual catch entitlement
ACOM	Advisory Committee (ICES)
ACS	Association of Caribbean States
AFMA	Australian Fisheries Management Authority
APEC	Asia-Pacific Economic Cooperation
APFIC	Asia-Pacific Fishery Commission
ASEAN	Association of Southeast Asian Nations
CalCOFI	California Cooperative Ocean Fisheries Investigation Program
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CDS	catch documentation scheme
CECAF	Fishery Committee for the Eastern Central Atlantic
CFMC	Caribbean Fisheries Management Council
CFP	Common Fisheries Policy
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLME	Caribbean Large Marine Ecosystem
CMM	conservation and management measure
Code	Code of Conduct for Responsible Fisheries
COFI	Committee on Fisheries
CPUE	catch per unit of effort
CRFM	Caribbean Regional Fisheries Mechanism
CTMFM	Joint Technical Commission for the River Plate Maritime Front
CTS	Commonwealth trawl sector (Australia)
DEPM	Daily egg production method
DFO	Department of Fisheries and Oceans, Canada
EA	Eastern Arctic
EEZ	exclusive economic zone
ENSO	El Niño-Southern Oscillation
EU	European Union
F	fishing mortality
FAD	fish aggregating device
FFA	Forum Fisheries Agency
FMA	Fisheries Management Act 1991 (Australia)
FMP	Fishery Management Plan
GCC	Cooperation Council
GEF	Global Environment Facility
GFCM	General Fisheries Commission for the Mediterranean
GSA	geographical subarea (GFCM)
HSP	Commonwealth Fisheries Harvest Strategy: policy and guidelines (Australia)
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
IOTC	Indian Ocean Tuna Commission

IPOA-Sharks	FAO International Plan of Action for the Conservation and Management on Sharks
ISSCAAP	International Standard Statistical Classification of Aquatic Animals and Plants
ISSF	International Seafood Sustainability Foundation
ITQ	individual transferable quota
IUCN	International Union for Conservation of Nature
IUU	illegal, unreported and unregulated (fishing)
IWC	International Whaling Commission
MCS	monitoring, control and surveillance
ML-TZ	Mid-Latitude "Transition Zone"
MPA	marine protected area
MSY	maximum sustainable yield
NAFO	Northwest Atlantic Fisheries Organization
NASCO	North Atlantic Salmon Conservation Organization
NEAC	Northeast Atlantic Commission (NASCO)
NEAFC	North East Atlantic Fisheries Commission
NEI	not elsewhere included
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPAFC	North Pacific Anadromous Fish Commission
NPOA	national plan of action
OECS	Organization of Eastern Caribbean States
OLDEPESCA	Latin American Organization for fishery Development
OMZ	oxygen minimum zone
ORCP	Orange Roughy Conservation Programme
OSPESCA	Central American Organization for the Fisheries and Aquaculture Sector
QMA	quota management area
QMS	quota management system
RAC	Regional Advisory Council
RBC	recommended biological catch
RECOFI	regional Commission for Fisheries
RFMO/A	regional fisheries management organization/arrangement
SAC	Scientific Advisory Committee (GFCM)
SEAFDEC	Southeast Asian Fisheries Development Centre
SciCOM	Science Committee (ICES)
SEAFO	South East Atlantic Fisheries Organisation
SICA	Sistema de la Integración Centroamericana
SIOFA	Southern Indian Ocean Fisheries Agreement
SlopeRAG	Slope Resource Assessment Group
SP-NWA	Sub-Polar Northwest Atlantic
SPC	Secretariat of the Pacific Community
SPRFMO	South Pacific Regional Fisheries Management Organisation
SSB	spawning stock biomass
SST	sea surface temperature
STECF	Scientific, Technical and Economic Committee for Fisheries
SWIOFC	South West Indian Ocean Fisheries Commission
TAC	total allowable catch
TACC	total allowable commercial catch
TAFIRI	Tanzania Fisheries Research Institute
TMP	Tuna management plan
t-RFMO	tuna regional fisheries management organization

UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNFSA	United Nations Fish Stocks Agreement
UNGA	United Nations General Assembly
VME	vulnerable marine ecosystem
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WECAFC	Western Central Atlantic Fisheries Commission
WFC	World Fish Center
WSSD	World Summit on Sustainable Development
WWF	World Wide Fund for Nature

PART A

Global overview

Global overview of marine fishery resources

Yimin Ye
Senior Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: yimin.ye@fao.org

Kevern Cochrane
Director
Fisheries and Aquaculture Resources Use and Conservation Division
FAO Fisheries and Aquaculture Department
E-mail: kevern.cochrane@fao.org

INTRODUCTION

Marine fisheries are very important to the economy and well-being of coastal communities, providing food security, job opportunities, income and livelihoods as well as traditional cultural identity. They produced 80 million tonnes of fish in 2009 and directly employed 34 million people in fishing operations in 2008 (FAO, 2010). Fish and fishery products are a vital and affordable source of high-quality protein, especially in the world's poorest nations – in 2008, fish supplied more than 3 billion people with at least 15 percent of their average animal protein intake (FAO, 2010). Therefore, maintaining the long-term prosperity and sustainability of marine fisheries is not only of political and social significance but also of economic and ecological importance. The United Nations Convention on the Law of the Sea (UNCLOS), the United Nations Fish Stocks Agreement (UNFSA [UN, 1995]) and the FAO Code of Conduct for Responsible Fisheries (FAO, 1995a) all require maintaining or restoring fish stocks at levels that are capable of producing their maximum sustainable yield (MSY). To fulfil the objectives of these international treaties, fishery management authorities need to undertake assessment of the state of fish stocks and develop effective policies and management strategies. As the United Nations (UN) Agency with a mandate for fisheries, FAO has an obligation to provide the international community with the best information on the state of marine fishery resources.

FAO undertook an assessment of marine fishery resources in 1973, originally at the request of the Sea Bed Committee in preparation for the UN Conference on the Law of the Sea. The FAO Committee on Fisheries (COFI) in its Eighth Session report expressed the view that such an appraisal of the world's fishery resources should be updated with the most recent statistics and presented at future COFI meetings (FAO, 1974). This effort to assess and report on the state of global marine fishery resources was then followed up through a series of brief summary updates (FAO, 1974, 1978, 1979, 1981, 1983, 1985, 1987, 1989, 1990, 1992). These reports were prepared as background information documents for the regular sessions of COFI. This reporting became a series of regular stand-alone publications (FAO, 1994, 1995b, 1997a) and later as contribution sections to the FAO flagship publication *The State of World Fisheries and Aquaculture* (FAO, 1997b, 1999, 2000, 2002, 2004). *The State of World Fisheries and Aquaculture* also has a primary objective of providing updated information to COFI. It also provides an update, more generally, to policy-makers, civil society and all those who derive their livelihood from fisheries and aquaculture, while covering a much broader range of issues affecting these sectors.

FIGURE A1
FAO marine major fishing areas for statistical purposes

This paper presents a major assessment and update since the last comprehensive review in 2005 (FAO, 2005). It is an update on the state of world marine fishery resources provided in the most recent biennial updates for *The State of World Fisheries and Aquaculture 2010* (FAO, 2010). While the general focus and outlay of previous major reviews have been maintained to the extent possible, several changes have been introduced in this volume in response to comments and suggestions received from readers and collaborators. It is also the intention of FAO to make better use of hard-copy and electronic Web-based publishing possibilities.

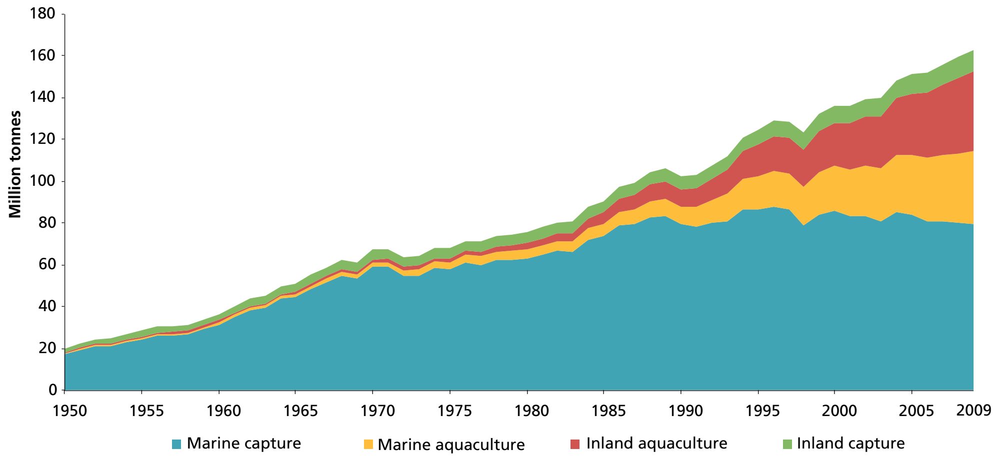
This review consists of four major components. The first part provides a global overview of marine fishery production and the state of marine fish resources (Chapter A1). The second part is divided into chapters (Chapters B1–B16) that summarize and compile the information available for each FAO major fishing area for statistical purposes (Figure A1). The third part focuses on special topics that attract great attention in the international community, including tuna and tuna-like species, sharks, the Pacific islands region, deep-sea fisheries, and fisheries and long-term climate variability (Chapters C1–C5). The final part lists all the tables that provide details about trends in catches and, where feasible, on the state of exploitation of stocks. The final set of tables in Part D summarize and complement the reviews by major fishing areas and main species groups organized according to the International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) grouping.

PROFILE OF CATCHES

The world's fisheries and aquaculture sectors have gone through a dramatic development in the last 60 years, and there have been large increases in their production. Total world fish production was only 19.3 million tonnes in 1950, but it increased dramatically to 163 million tonnes in 2009 (Figure A2). Marine capture fisheries have always been the largest contributor to world fish production. In 1950, marine captures were 16.7 million tonnes and accounted for 86 percent of total world fish production. In the last two decades, marine and inland aquaculture has expanded rapidly, and the relative contribution of marine capture fisheries to the growing total world fish production has shrunk. Nevertheless, marine capture fisheries still contributed 49 percent of the world's fish production in 2009, the largest sector in comparison with mariculture (21 percent), freshwater aquaculture (23 percent) and inland capture fishery (6 percent) (Figure A2).

Marine fisheries have experienced different development stages, increasing from 16.7 million tonnes in 1950 to a peak of 87.7 million tonnes in 1996, and then declining to stabilize at about 80 million tonnes, with interannual fluctuations. Global recorded

FIGURE A2
World production from different sectors of fisheries and aquaculture



production was 79.5 million tonnes in 2009 (Figure A2). Rapid development was seen in the late 1950s and 1960s and between 1983 and 1989. The first boom was believed to be caused mainly by the post-war shipbuilding expansion in the 1950s, the new technologies such as steam and motor trawlers in the 1960s, and the extension of jurisdiction to 12 nautical miles by most costal States – this is the region that encompassed the ocean's most productive upwelling and continental shelves (Sanchirico and Willen, 2007; Engelhard, 2008). The second rapid expansion was associated with the extension of jurisdictions from 12 to 200 nautical miles with the establishment of exclusive economic zones (EEZs) under the legal foundation of the UNCLOS (Sanchirico and Willen, 2007).

After reaching a peak in 1996, global landings decreased gradually, dropping by about 10 percent by 2009. Subsequent fluctuations mainly reflect the variation in catches from a few highly productive areas, particularly in the Northwest Pacific (Area 61) and the Southeast Pacific (Area 87). These areas account for a large portion of landings from pelagic species.

Regional patterns in landings

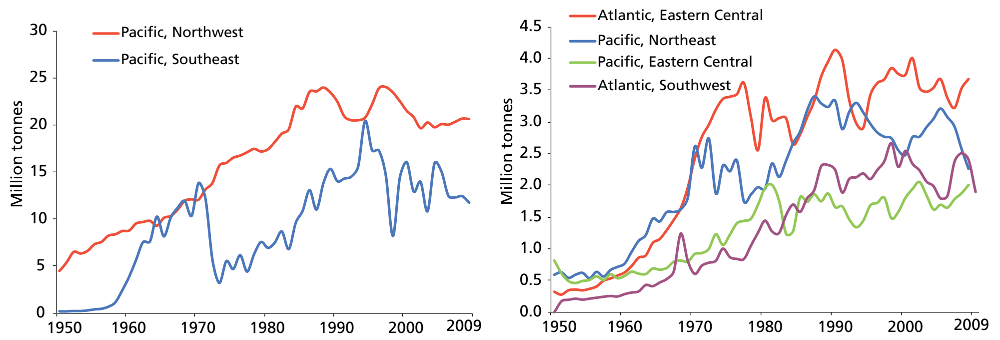
Based on the average catches in 2005–09, the Northwest Pacific is the largest contributor (25 percent) to the global catch, followed by the Southeast Pacific (16 percent), Western Central Pacific (14 percent), Northeast Atlantic (11 percent) and Eastern Indian Ocean (7 percent). All other FAO areas contribute less than 5 percent of the global total catch.

World marine fisheries have gone through significant development and changes since 1950 when FAO started collecting fisheries statistics data. Accordingly, the levels of exploitation of fish resources and their landings have also varied over time. The temporal pattern of landings differs from area to area, depending on the level of urban development and changes that countries surrounding that area have experienced. In general, they can be grouped into three types. The first group are those FAO areas that have demonstrated oscillations in total catch (Figure A3). They are the Eastern Central Atlantic (Area 34), Northeast Pacific (Area 67), Eastern Central Pacific (Area 77), Southwest Atlantic (Area 41), Southeast Pacific (Area 87), and Northwest Pacific (Area 61). These areas provide about 53.5 percent of the world's total catch. Some areas in this group may have shown a clear drop in total catch in the last few years, e.g. Northeast Pacific, but, over the longer period, a declining trend is not evident.

The second group consists of areas that have demonstrated a decreasing trend in catch since reaching a peak at some time in the past. This group contributes 19.9 percent of global catch on average in the last five years, and includes the Northeast Atlantic (Area 27), Northwest Atlantic (Area 21), Western Central Atlantic (Area 31),

FIGURE A3

FAO Statistical Areas showing fluctuations in fish landings



Mediterranean and Black Sea (Area 37), Southwest Pacific (Area 81), and Southeast Atlantic (Area 47). It is interesting and noteworthy that such declines occurred at different times: in the Northwest Atlantic in the late 1960s; in the Northeast and Southeast Atlantic in the mid-1970s; in the Western Central Atlantic and Mediterranean and Black Sea in the mid-1980s; and in the Southwest Pacific in the early 1990s (Figure A4). This sequence largely reflects the fact that areas surrounded by the most-developed countries experienced the earliest decline in catches.

The largest decline was seen in the Northwest Atlantic, where landings dropped by 55 percent from their peak to 2009. The second-largest drop was in the Western Central Atlantic with 46 percent, followed by the Southwest Pacific with 37 percent and the Northeast Atlantic with 35 percent. The total catches in the Mediterranean and Black Sea dropped by 28 percent.

FIGURE A4

FAO Statistical Areas showing a decreasing trend in fish landings

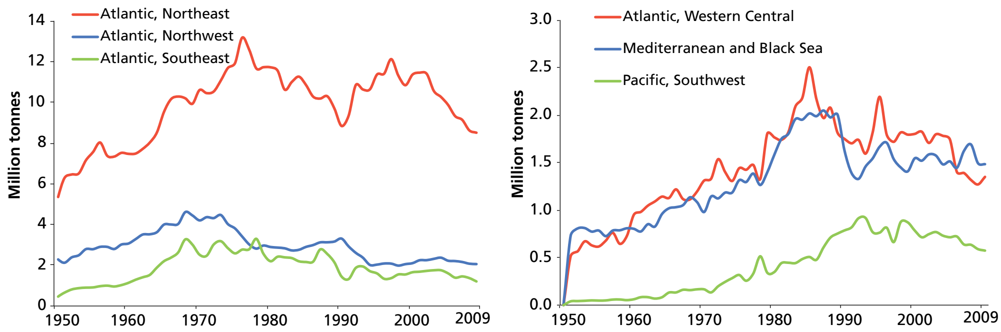
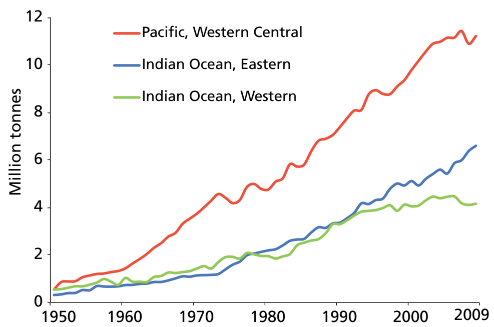


FIGURE A5

FAO Statistical Areas showing an increasing trend in fish landings



The third group comprises the FAO areas that have shown a continual increase in catch since 1950 (Figure A5). There are only three areas in this group: Western Central Pacific (Area 71), Eastern (Area 57) and Western Indian Ocean (Area 51). They have contributed 26.4 percent of the total catch on average in the last five years. Minor drops in catch have also been seen in Western Central Pacific and Western Indian Ocean in the last two years. However, considering the uncertainty involved in catch reporting and natural fluctuation in fish stock abundance, such declines might have been caused by environmental "white noise" and need to be monitored over the next few years.

Major characteristics and significant changes

Fluctuations in the abundance of a fish stock are a common phenomenon, particularly for low-trophic-level species. As a result, the catch of this stock also usually oscillates in a similar manner. However, at a regional level, fluctuations in catch often appear to be less marked. This is because: (i) fish stocks within an ecosystem often compensate for one another as they increase and decrease in abundance; and (ii) aggregation over catches of all species usually smoothes out the variations of low-trophic-level and short-lived species. This is because the abundance and catch of high-trophic-level and long-lived species often vary less.

In the three groups defined above for analysing overall catch trends, the first group – Eastern Central and Southwest Atlantic, and Southeast, Northeast and Eastern Central Pacific, and Northwest Pacific – had large fluctuations in landings (Figure A3). The largest fluctuation is seen in the Southeast Pacific (Area 87; Figure A3). A drop of about 10 million tonnes occurred between 1970 and 1973. The fish stocks then recovered and produced an all-time high catch of more than 20 million tonnes in 1994. The catch from this area dropped by 12 million tonnes again in the subsequent five years (between 1994 and 1998) and was at about 12 million tonnes in 2009, almost as high as its first peak in 1970. The large interannual variation in catch from the Southeast Pacific is caused by the large proportion of pelagic species in catches from the area. The top three species were anchoveta (*Engraulis ringens*), Chilean jack mackerel (*Trachurus murphyi*) and South American pilchard or sardine (*Sardinops sagax*); together, they account for more than 80 percent of the current and historical catches. They have had alternating periods of high and low abundance in recent decades. Large catch fluctuations are common in this region and are mostly a consequence of the periodic climatic events known as El Niño. El Niño events affect fishing success as well as longer-term stock abundance and productivity. These and other changes in fisheries production from Area 87 are described in further detail in Chapter B15 of this volume.

Significant fluctuations were also reported for other regions, although their combined effect on global catches was less noticeable. For example, in the Northeast Pacific (Area 67, Chapter B11), fish production reached a peak of 3.6 million tonnes in 1987 and declined to 2.2 million tonnes in 2009, following a slight recovery to 3.2 million tonnes in 2005 (Figure A3). The Northwest Pacific has shown an oscillation between 20 and 24 million tonnes since the late 1980s (Figure A3). The fluctuations were caused by catch and, presumably, abundance changes of Japanese pilchard or sardine (*Sardinops melanostictus*) and Alaska pollock (*Theragra chalcogramma*). These and other changes in total catch and state of resources are further described in Chapter B10.

In the Eastern Central Pacific (Area 77), described in Chapter B13, catches have fluctuated between 1.2 and 1.8 million tonnes since 1981 (Figure A3).The 2009 catch was at a peak of about 2 million tonnes, probably because of the recovery of California pilchard or sardine (*Sardinops caeruleus*). They yielded 0.8 million tonnes in 2009, an all-time record high and slightly higher than the high catch of 720 000 tonnes in 1936, which occurred during the previous high "regime" of this species. This previous peak period lasted from the late-1920s throughout the early-1940s. The total landings of the Southwest Atlantic (Chapter B6) have also fluctuated around 2 million tonnes since the late 1980s (Figure A3). Argentine hake, Argentine anchovy, Argentine short-fin squid and Argentine red shrimp are the species that show strong fluctuations in this area.

Temporal fluctuations in the landings of the second group (declining landings) are weaker (Figure A4). The landings from the Northeast Atlantic (Chapter B2) have continued the declining trend seen since the mid-1970s. This has mainly been caused by the decline in Atlantic cod (*Gadus morhua*) since the late 1960s, with a bounce back in the 1990s. It is noteworthy that landings of blue whiting (*Micromesistius poutassou*), which increased gradually since the 1970s and reached a peak of about 2 million tonnes in 2003, dropped back to below 1 million tonnes in 2009. Sandeels (*Ammodytes* spp.) also experienced a striking and marked drop to below 0.4 million tonnes in 2009 after peaking at more than 1.2 million tonnes in the mid-1990s.

In the Northwest Atlantic (Area 21), fish production declined to a low of 2 million tonnes in 1994 (Figure A4), following the collapse of groundfish stocks off eastern Canada. However, the catch has since stabilized at about 2 million tonnes. The collapse in Atlantic cod in the 1970s and of American plaice in the early 1990s has been balanced out by the increase in catches of low-trophic- level species such as American sea scallop and American lobster.

The Western Central Atlantic (Area 31), Mediterranean and Black Sea (Area 37) and Southwest Pacific (Area 81) have also experienced a period of declining catches, but to a lesser extent (Figure A4). Large reductions in catches have been seen in the last decade for round sardinella, ocean catfish NEI (not elsewhere included) and requiem sharks NEI in the Western Central Atlantic, and for mullets, blue whiting and common octopus in the Mediterranean and Black Sea, and for blue grenadier and oreo dories NEI in the Southwest Pacific.

Of the three areas showing a continuously increasing trend in catch, the West Indian Ocean (Area 51) and Western Central Pacific (Area 71) have shown some signs of decline in the last few years (Figure A5), though these may be natural fluctuations. When examining this trend at the species level, large declines are clear for skipjack and yellowfin tuna, and for natantian decapods NEI in the West Indian Ocean. However, decreases in those species were balanced out by increases in the catches of other redfishes, Indian oil sardine, and giant tiger prawn. Similarly, reductions in sharks, rays, skates etc NEI and in penaeid shrimps NEI, from these areas was compensated by an increase in skipjack tuna, threadfin breams NEI and natantian decapods NEI in the Western Central Pacific. Standing out from all other areas, the East Indian Ocean is the only FAO area that has not shown any sign of decline in total catch, and no clear decline in catch has been seen in major fish species (Chapter B9).

Tunas and tuna-like species are collectively the most valuable fishery resources exploited in the high seas. Their total production is highest in the Pacific Ocean followed by the Atlantic and Indian Oceans. As discussed in Chapter C1, catches of tuna and tuna-like species increased from less than 0.5 million tonnes in the early 1950s to an all-time high of 5.5 million tonnes in 2006. The catch has stabilized at about 5.4 million tonnes since 2003. Among the species, skipjack tuna (*Katsuwonus pelamis*) accounts for about 47 percent, at 2.6 million tonnes in 2009. Yellowfin tuna contributed 20 percent of the catch (1.1 million tonnes) followed by bigeye tuna at 7 percent (0.4 million tonnes) and kawakawa at 6 percent (0.3 million tonnes) in 2009.

Total recorded catches from deep-sea fisheries reached a peak of about 3.6 million tonnes in 2004 and then dropped back to 1.9 million tonnes in 2009 (Chapter C4). The Atlantic Ocean supports the largest deep-sea fishery, contributing about 80 percent of the total deep-sea catch between 2000 and 2005, followed by the Pacific Ocean and Indian Ocean. The dramatic decline can largely be attributed to the decrease in reported catches of blue whiting in the Atlantic Ocean. The catch of blue whiting decreased from 2.4 million tonnes in 2004 to about 65 000 tonnes in 2009, owing to a decline in recruitment, spawning stock biomass and a reduction of quotas (ICES, 2011). The species that have yielded a high average catch in the last five years (2005–09) in the Atlantic Ocean include Patagonian grenadier (*Macruronus magellanicus*), Greenland halibut (*Reinhardtius hippoglossoides*), southern blue whiting (*Micromesistius australis*) and ling (*Molva molva*).

The top five species are blue whiting (= poutassou), contributing 1.5 million tonnes in 2009 and accounting for 35 percent of the total catch of deep-sea fisheries, followed by hairtails and scabbardfishes NEI (135 000 tonnes, 7 percent), Patagonian grenadier (132 000 tonnes, 7 percent), blue grenadier (112 000 tonnes, 5 percent) and

Greenland halibut (97 000 tonnes, 5 percent). Patagonian grenadier, Greenland halibut, blue grenadier, southern blue whiting, orange roughy, and oreo dories NEI have all experienced clear declines in catch.

A recurring pattern in some areas is the medium- to long-term change in catch composition following the decline of some fish stocks that had traditionally been dominant. For example, in the Northwest Atlantic (Chapter B1), catches of molluscs and crustaceans have increased noticeably following the declines of demersal fishes. In the Northeast Atlantic (Chapter B2) the reduction in catches from the continuous decline in Atlantic cod since the late 1960s has been balanced out by the increase in catches of formerly low-value species, such as blue whiting and sandeels. In the Northwest Pacific (Chapter B10), the decline in catches of Japanese pilchard or sardine and Alaska pollock has been somewhat offset by the increasing catches of Japanese anchovy (*Engraulis japonicus*), largehead hairtail (*Trichiurus lepturus*) and squids (mostly *Todarodes pacificus*). The causes for these medium- to long-term changes in the species composition of marine commercial catches can be multifold. These causes include adaptation of industry and markets to previously unattractive low-valued species, and the effect of fishing on the abundance of target species and on the structure of other marine communities. At the same time, environmental changes or regime shifts affecting the long-term abundance of the various wild fish stocks have occurred. Often, these effects are confounding and in many cases they are difficult to discern. This is particularly the case in areas where research and monitoring of fishery resources and environmental processes are not well developed.

Catch composition

Pelagic species comprise the largest proportion of the global marine catches. Small pelagics (ISSCAAP Group 35: herrings, sardines, anchovies, etc.) contributed about 22 percent (19.9 million tonnes) of the total catch in 2009 (Figure A6). This share is down from 29 percent in the 1950s and 27 percent in 1970s. The large pelagics (ISSCAAP Groups 36 and 37: tunas, bonitos, billfishes and miscellaneous pelagics) accounted for 19 percent (16.6 million tonnes) of the total catches in 2009. This is an increase in their share from 13 percent in the 1950s. Demersal fishes (ISSCAAP Groups 31, 32 and 34: flounders, halibuts, soles, cods, hakes, haddocks and miscellaneous demersals) contributed 12 percent of the total catches in 2009 (10.9 million tonnes), compared with almost 26 percent in the 1950s and 1970s. Miscellaneous coastal fishes (ISSCAAP Group 33) increased slightly to 8 percent (7.2 million tonnes) from 7 percent in 2009. Catches of crustaceans (ISSCAAP Groups 42, 43, 44, 45, 46 and 47: crabs, lobsters, shrimps, prawns, krill, etc.) contributed 6 percent (5.4 million tonnes) in 2009, slightly lower than 7 percent in 2002. Molluscs (ISSCAAP Groups 52, 53, 54, 55, 56, 57 and 58: abalones, conchs, oysters, mussels, scallops, clams, squids, octopus, etc.) increased slightly from 6 percent in the 1950s and 1970s to 7 percent (6.2 million tonnes) in 2009. The proportion of unspecified fish (ISSCAAP Group 39) decreased slightly with 11 percent of the total catches (9.9 million tonnes) in 2009.

In world fish production, pelagic – defined here as those belonging to ISSCAAP Groups 34–37 (following Grainger and Garcia [1996]) is defined to include jacks, mullets, sauries, herrings, sardines, anchovies, tunas, bonitos, billfishes, mackerels, snooks and cutlassfishes. Demersal

FIGURE A6
World marine catch by main species groups in 2009 (million tonnes and percentages)

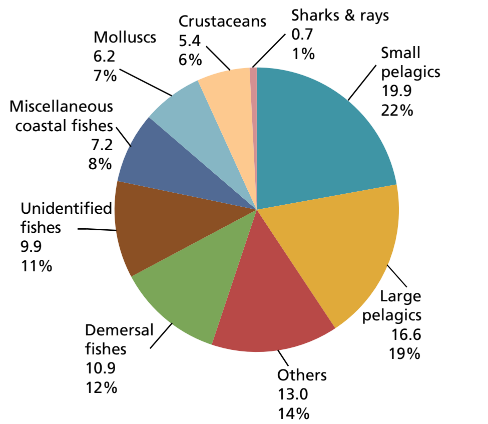
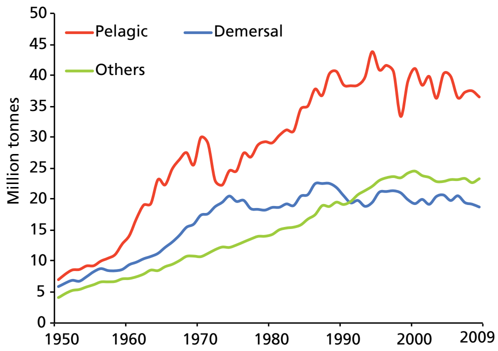


FIGURE A7
Catches over time by three groups – pelagic, demersal and others



species (ISSCAAP Groups 31–33 and 38) include flounders, halibuts, soles, cods, hakes, haddocks, redfishes, basses, congers, sharks, rays and chimaeras. These groups contributed similar proportions of total marine fisheries production in 1950, 41 percent and 35 percent, respectively. The remaining 24 percent of the total catch came from other species, including shrimps, prawns, crabs, clams, mussels, and marine fishes not identified. While the total marine fish landings increased with the development of the fishing industry, landings from demersal species reached, and in some cases exceeded, the limit of their potential production in the early 1970s. Subsequently, catches of demersal species levelled off below 20 million tonnes (Figure A7). Production from pelagic species increased over time, with large fluctuations reflecting both natural variations in species productivity as well as boom and bust harvesting strategies. Production of pelagic species peaked at 40 million tonnes in the early 1990s that has been followed by a decreasing trend. The production of other species continued to increase until 2000 and has since stabilized at about 22 million tonnes. In 2009, pelagic, demersal and other species represented 46 percent, 24 percent, and 30 percent, respectively (Figure A7).

The distribution of landings among species is highly skewed. Among the 221 pelagic species recorded, the top ten were anchoveta, Atlantic herring, chub mackerel, Chilean jack mackerel, Japanese pilchard, South American pilchard, capelin, skipjack tuna, European pilchard (= sardine), and Japanese anchovy, in sequence of the average catch from 1950 to 2009. Together, they contributed about 50 percent of the total pelagic landings in 2009 and about 22.5 percent of total global landings.

All the top ten pelagic species have experienced substantial declines in catch, except skipjack tuna (Figure A8). The most dramatic boom–bust catch patterns have been seen in Japanese pilchard, South American pilchard, and capelin. Their historical peak catches were 4–6 million tonnes, but were negligible in 2009. Peruvian anchovy has recorded the largest catches of pelagic species and demonstrated the most dramatic variations. It had a peak catch of 12 million tonnes in 1969, very low catches between 1970 and 1990, and resurging back to about 12 million tonnes in 1994, and was still 7 million tonnes in 2009. Skipjack tuna has been the only species that has shown a continuous growth in total catch, from 0.16 million tonnes in 1950 to 2.6 million tonnes in 2009. This is a 16-fold expansion in catch over this 59-year period.

FIGURE A8
Temporal catch patterns of the top ten demersal species

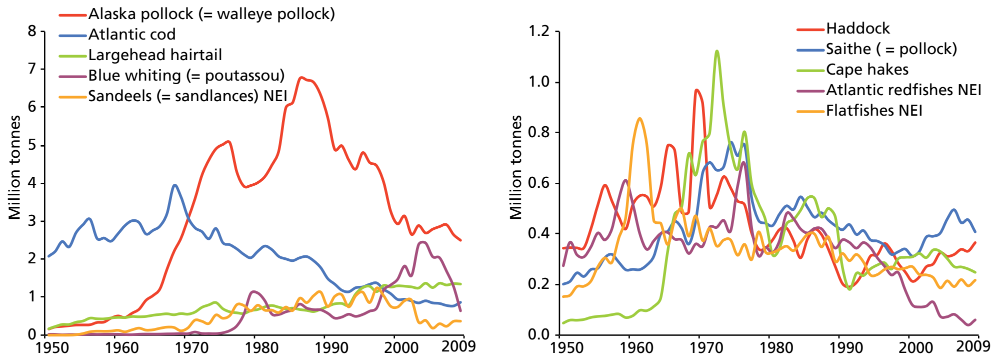
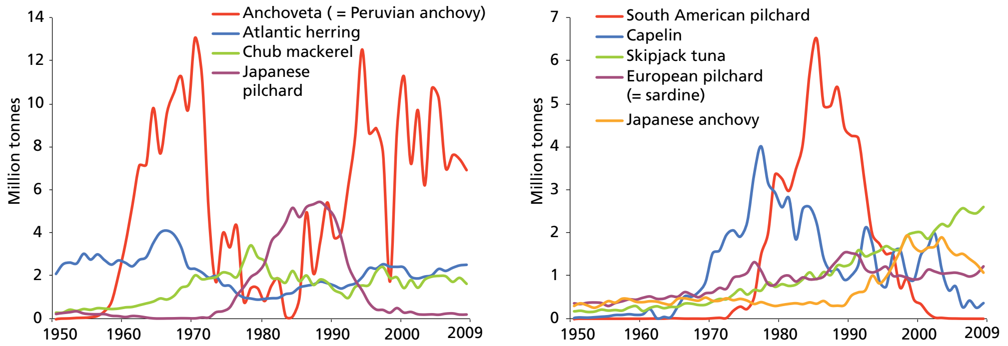


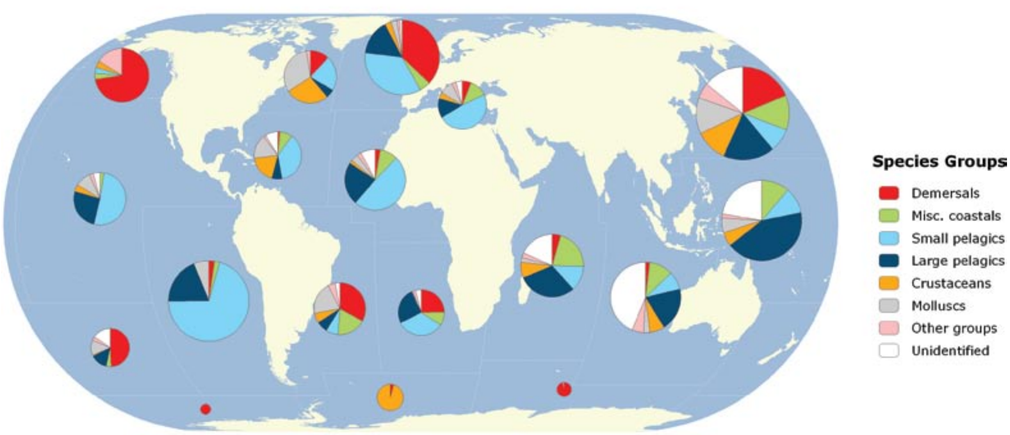
FIGURE A9
Temporal catch patterns of the top ten pelagic species



For demersal species, the top ten species were Alaska pollock (= walleye pollock), Atlantic cod, largehead hairtail, blue whiting (= poutassou), sandeels (= sandlances) NEI, haddock, saithe (= pollock), Cape hakes, Atlantic redfishes NEI, and flatfishes NEI, ordered in terms of average annual landings from 1950 to 2009. In general, production of the top ten demersal species is not as high as that of pelagic species, nor do they exhibit variations in catch of the same extent. These ten species produced 37 percent of the total demersal landings in 2009 (Figure A9). The most common pattern across these ten species has been a decreasing trend in catch. Nine of the ten species produced a much lower catch in 2009 than their historical highs. Most of them had a peak catch in the 1960s or 1970s. Largehead hairtail is the only species that has not experienced a decline, but a levelling off in catch since the mid-1990s.

Species composition varies from area to area around the world. All the major species groups were represented more or less equally in the Northwest Pacific (Area 61) (Figure A10). Small pelagics (mostly anchoveta) dominate catches in the Southeast Pacific (Area 87). In the Northeast Atlantic (Area 27), demersal fishes were the most abundant, followed by larger pelagics and small pelagics. In the Western Central Pacific, catches were dominated by larger pelagics, which were also the most abundant group in the Western Indian Ocean (Area 51). Small pelagics were also dominant in the Eastern Central Atlantic (Area 34), Mediterranean and Black Sea (Area 37), Western Central Atlantic (Area 31) and Eastern Central Pacific (Area 77). In contrast, demersal fishes were the dominant species group in the Northeast Pacific (Area 67) and Southwest Pacific (Area 81).

FIGURE A10
Cath species composition by main species groups in major fishing areas in 2009



STATE OF EXPLOITATION

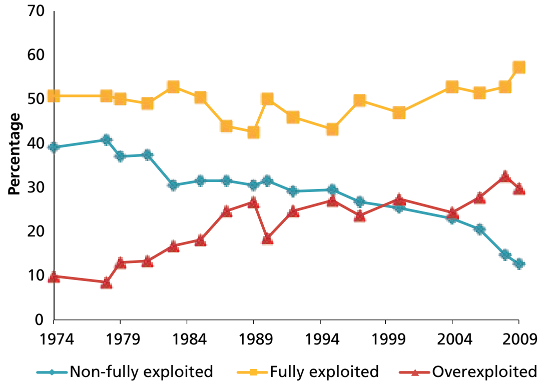
Since its first publication of the global review of marine fish stocks in 1971 (Gulland, 1971), the FAO Fisheries and Aquaculture Department has been regularly assessing and monitoring the state of world marine fish resources. Assessment methodologies used in its reviews are described in Appendix. As explained there and in the last paragraph of this section, a modified approach has been adopted for this review. This includes the reduction of the number of categories of state of exploitation from five to three. A primary goal of this change has been an attempt to ensure greater standardization in the assessment methods between regions. At the same time, it also recognizes the large differences in the amount and quality of data and information available in different regions. This new method will probably have led to slight differences in the regional assessments of state of exploitation compared with the result that would have been obtained with the previously used approach. This could mean that the two approaches may not be directly comparable. However, this issue should not affect the aggregated global estimates. These should be comparable, taking into account the large uncertainties that are an unavoidable feature of any global assessment of the state of stocks.

The assessment data available to FAO in 2009 from the 17 FAO Statistical Areas plus the "Tuna" category has been summarized in Tables D1–D19. These tables address 584 "stock" items, of which 395 stocks were assessed in 2009, representing 70 percent of global catch. The remaining 189 stocks had either insufficient information for status assessment or catches with no proper identification, even at the family level, that was provided in official national statistics. Some species, even where properly identified in the official statistics, were not monitored or investigated because of the inadequacy of other data requirements. Species in this group usually correspond to less-abundant and lower-value species on which research effort tends to be limited. However, there are also some major stocks and fisheries with limited data, including stocks of mullets, mussels, shrimps and prawns in several areas, bonga shad (*Ethmalosa fimbriata*) and European anchovy (*Engraulis encrasicolus*) in the Eastern Central Atlantic, Pacific cod (*Gadus macrocephalus*) in the Northeast Pacific, and various newly exploited deep-sea resources.

FAO has always made efforts to standardize the number of marine stocks or species groups monitored and described for each major fishing area. However, the uneven availability of information and distribution of catch volumes have limited the number of stock groups able to be considered per area. In addition, in some parts of the world, there are relatively large numbers of stocks or species groups whose state of exploitation is undetermined or not known. The Western Indian Ocean (Area 51) and Western Central Atlantic (Area 31) are fishing areas with the highest incidence of stocks or species groups for which the state of exploitation is reported as not known or uncertain in the regional reviews presented in Part B of this paper.

With the development of world fisheries, both the assessment methods and the data available for such assessment have changed significantly. It is noteworthy that this review uses three categories: non-fully exploited, fully exploited and overexploited (Figure A11). This decision was made following recommendations from an external review panel on the FAO method and FAO's internal review. It reflects the fact that the data currently available to FAO for most stocks do not provide sufficient information for the

FIGURE A11
Global trends in marine fish stock status from 1974 to 2009



differentiation between recovery and depleted and between underfished and moderately exploited. The category of "fully exploited" represents stocks with an abundance that falls within a band around the level that can produce MSY. Provided these stocks are being carefully monitored and managed in a precautionary manner, this is a desirable status. In comparison with the five categories used in the previous assessments, the underfished and majority of the "moderately exploited" stocks have been merged and now roughly correspond to the new "non-fully exploited" category. Parts of the "moderately exploited" and "overexploited" stocks under the earlier approach may have been classified as "fully exploited" in this new approach and merged with those classified as "fully exploited" by both the old and new methods. Finally, both "depleted" and "recovering" stocks are merged into "overexploited" (for details, see Appendix 1).

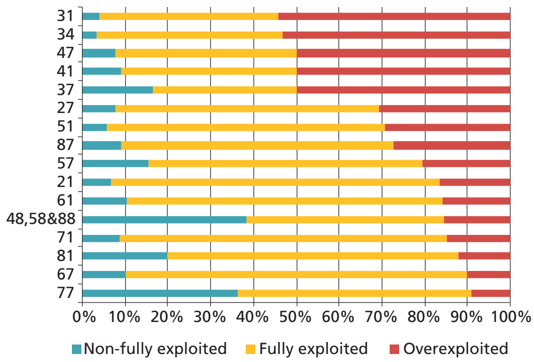
Global stock status

Of the fish stocks assessed, 57.4 percent were estimated to be fully exploited in 2009. These stocks produced catches that were already at or very close to their maximum sustainable production. They have no room for further expansion in catch, and even some risk of decline if not properly managed. Among the remaining stocks, 29.9 percent were overexploited, and 12.7 percent non-fully exploited in 2009. The overexploited stocks produced lower yields than their biological and ecological potential. They require strict management plans to rebuild their stock abundance to restore full sustainable productivity. The World Summit on Sustainable Development (WSSD) goal demands that all these overfished stocks be restored to the level that can produce MSY by 2015. This review suggests that this goal is very unlikely to be achieved, notwithstanding the good progress made in some countries and regions (Worm *et al*., 2009). The non-fully exploited stocks were under relatively low fishing pressure and have a potential to increase their production. However, these stocks often do not have high production potential. The potential for increase in catch may be generally limited. Nevertheless, proper management plans should be established before increasing the exploitation rate of these non-fully exploited stocks in order to avoid following the same track of overfishing.

The proportion of non-fully exploited stocks has decreased gradually since 1974, when the first FAO assessment was accomplished (Figure A11). In contrast, the percentage of overfished stocks has since increased, especially in the late 1970s and 1980s from 10 percent in 1974 to 26 percent in 1989. After 1990, the number of overfished stocks continued to increase, but the rate of increase slowed, until the last two assessments, reaching about 30 percent in 2009. The fraction of fully exploited stocks demonstrated the smallest change over time. The percentage dropped from about 50 percent at the start of the series to 43 percent in 1987 and has increased to 57.4 percent in 2009 (Figure A11).

A primary fishery management goal is to control fishing at a level that allows the fishery to produce sustained annual yields. This yield should be as close to MSY as allowed by responsible management within the context of an ecosystem approach. This goal should lead to keeping the proportion of overexploited stocks at zero, as required by the WSSD goal set in 2002. At the same time, it allows for increasing exploitation rates on non-fully exploited stocks. This would maximize the sustained contribution of fisheries to global food security and human well-being. The increasing trend in fully exploited stocks after 1990 indicates the positive impact of fishery management towards maximizing production. However, close attention is required to all fully exploited stocks to ensure that they are not overexploited in the future. Moreover, the increase in overfished stocks is a cause for concern. It indicates that, at the global level, the WSSD targets for rebuilding the overfished stocks and implementing an ecosystem approach are not being met. Nevertheless, the deceleration in the rate of increase of overfished stocks after 1990 in comparison with the 1980s may indicate some progress in improved

FIGURE A12
Percentages of fish stocks in different status by major fishing areas in 2009



management. It suggests that some fish resources have benefited from the management efforts of coastal States and the international community.

Regional stock status

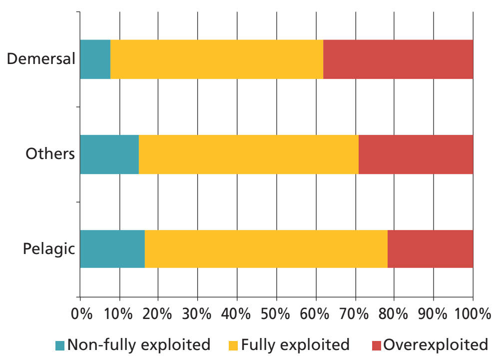
Development of the fishing industry and management of fishery resources vary with country and region. The Western and Eastern Central Atlantic (Areas 31 and 34) had the highest proportion of overfished stocks, about 54 percent in 2009 (Figure A12). The Southeast (Area 47), Southwest Atlantic (Area 41), and Mediterranean and Black Sea (Area 37) had 50 percent of fish stock overfished. The lowest proportion of overfished stocks was about 10 percent, seen in the Eastern Central Pacific (Area 77), Northeast Pacific (Area 67) and Southwest Pacific (Area 81). Other Areas had 15–30 percent of fish stocks overexploited (Figure A12).

In terms of potential for further expansion, the Eastern Central Pacific (Area 77) and Southern Oceans (Areas 48, 58 and 88) had the highest proportion of non-fully exploited stocks, about 38 percent in 2009 (Figure A12). However, these areas are not major fishery production areas and contributed only 2.3 percent and 0.2 percent of global catch, respectively, in 2009. The Southwest Pacific (Area 81) and Eastern Indian Ocean (Area 57) and Mediterranean and Black Sea had about 20 percent of stocks underexploited and may provide opportunities for further fishery expansion. All the remaining areas had a very low percentage of fish stocks that have room for expansion in catch.

Differences can also be found in stock status between pelagic and demersal fish stocks. Demersal stocks had the highest percentage of overfished stocks and the lowest proportion of non-fully exploited stocks, at 38 percent and 7 percent, respectively, in 2009 (Figure A13). In contrast, pelagic species had only 22 percent of stocks overfished, but 16 percent non-fully fished in 2009. The percentage of fully exploited species was 54 percent for demersal and 62 percent for pelagic. Overall, these percentages indicate that pelagic stocks are in better shape than demersal species, with more stocks being sustainably fished and fewer stocks overfished. The results seem associated with the biological and ecological characteristics of pelagic and demersal species and with the history of fishery development. The "Others" group had percentages for both overfished and non-fully fished stocks in between those for demersal and pelagic (Figure A13).

For the top ten pelagic species, 30 percent of stocks were estimated to be overfished in 2009, which is higher than the 20 percent for all pelagics (Figure A13). In contrast, the top ten demersal species had 43 percent of their stocks overfished, similar to the average for all demersal species. However, both pelagic and demersal top-ten groups had no underexploited stocks, which is not surprising as large stocks are more likely to become the target of fishing. They also attract more effort for management so that they have a greater percentage of stocks fully exploited. The above-average percentage of overfished stocks for the top ten pelagic species probably reflects the widespread risk of overfishing taking place even when there are good management systems in place. This is because of social and economic pressures to maintain catches even when they may exceed sustainable levels.

FIGURE A13
Percentages of fish stocks in different status by three groups in 2009



Tuna stock status

Tuna and tuna-like species have high commercial values and support fisheries of a global, multigear and multispecies nature. All the world's tuna and tuna-like species are the subject of research and management by regional fisheries management organizations (RFMOs). There are five main tuna fishery management bodies: the Western and Central Pacific Fisheries Commission, the Inter-American Tropical Tuna Commission, the Indian Ocean Tuna Commission, the International Commission for the Conservation of Atlantic Tunas and the Commission for the Conservation of Southern Bluefin Tuna. Tuna RFMOs cover a large part of the world's oceans, and they involve many countries. Tuna fisheries are characterized by high commercial value, global nature, and complex management. They involve many different types of stakeholders, and this frequently makes management scientifically and politically complex. International management of tuna and tuna-like species is governed by several legal instruments such as the binding UNCLOS, the UNFSA (UN, 1995) and the voluntary FAO Code of Conduct for Responsible Fisheries (the Code) (FAO, 1995a).

FAO has been monitoring the state of principal market tuna stocks as part of its initiative to assess the stock status of the world's marine fishery resources. Principal market tunas include: albacore (*Thunnus alalunga*), Atlantic bluefin tuna (*T. thynnus*), bigeye tuna (*T. obesus*), Pacific bluefin tuna (*T. orientalis*), southern bluefin tuna (*T. maccoyii*), yellowfin tuna (*T. albacares*), and skipjack tuna (*Katsuwonus pelamis*). They represented about 80 percent of the total catch of tuna and tuna-like species in 2009. Because of their wide distributions, the state of each of these seven tuna species was assessed at the stock level, rather than by FAO Statistic Area as is done for other species. FAO's classification is based on a variety of data and information including those from tuna RFMOs and may not necessarily be the same as those of the RFMOs.

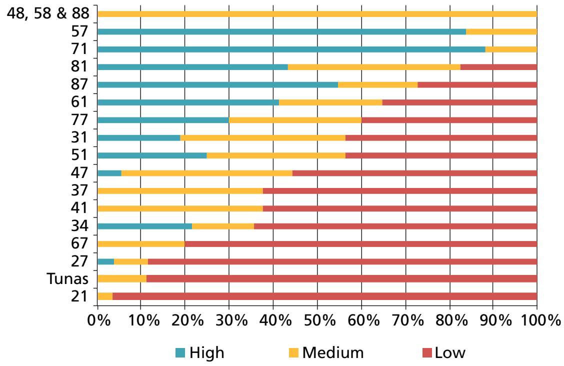
The global annual catch of tuna and tuna-like species has shown an increasing trend from less than 1 million tonnes in 1950 to about 6.5 million tonnes in 2009. The global production of the principal market tunas increased relatively steadily from less than 0.5 million tonnes in the early 1950s to a maximum of about 4.4 million tonnes in 2005 and has since stabilized at this level (Chapter C1). In particular, catches of skipjack have continued to increase up to 2009. Albacore has shown a much weaker increasing trend since the 1970s, with greater interannual variations. In contrast, yellowfin, bigeye, Atlantic bluefin, Pacific bluefin and southern bluefin tunas have all shown a gradual decline in catch after reaching their historical peaks.

Among the seven major tuna species, one-third were estimated to be overfished in 2009, close to the 30 percent for all monitored stocks. Of the remainder, 37.5 percent were fully exploited and 29 percent non-fully exploited in 2009. This compares favourably with 57.5 percent and 12.7 percent of the global average.

Uncertainty

All stock assessments involve uncertainty, and uncertainty arises from three different sources: data, methods and the process of applying the methods to the data. Awareness of the degree of such uncertainty helps to understand the reliability of the results and their interpretation. In the 2009 assessment, the uncertainty of each assessment was scored according to one of three categories: "high", "medium" and "low" (for more information, see Appendix 1). In general, the Northwest Atlantic (Area 21), tunas, Northeast Atlantic (Area 27), and Northeast Pacific (67) had the lowest uncertainty, with 80–96 percent of assessed stocks having low uncertainty. These were followed by the Eastern Central (34) and Southwest Atlantic (Area 41) and Mediterranean and Black Sea (Area 37) with about 63 percent of stocks having low uncertainty (Figure A14). In contrast, the Eastern Indian Ocean (Area 57) and Western Central Pacific (Area 71) have the highest uncertainty (84–88 percent), with no stocks assessed as having low uncertainty about their status. This high uncertainty results from a combination of limited data available, the existence of

FIGURE A14
Percentages of assessed stocks involving different uncertainty levels by major fishing areas in 2009



many small stocks for many species and other complexities of assessment in tropical waters. The Southwest (Area 81), Southeast (Area 67) and Northwest Pacific (Area 61) also have a relatively high percentage of stocks for which the assessment was highly uncertain.

DISCUSSION

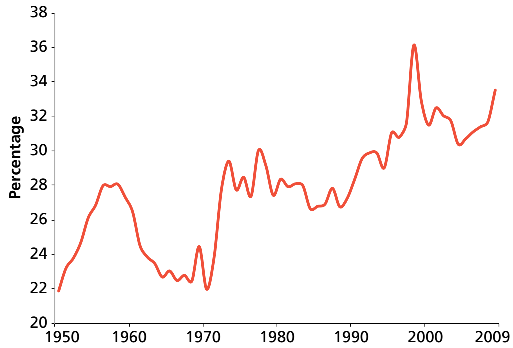
The total production of marine fishery resources has declined gradually after reaching a peak in landings in 1996. Is it possible to increase global fishery production any further? One way in which yields could be increased is to rebuild the 30 percent overfished stocks so that they can produce close to their MSY. This should lead to a net increase in landings. However, it is difficult to estimate the extent of this increase because it is not only related to the current abundance of overfished stocks but also depends on the biological and technical interactions between species. Nevertheless, the top ten demersal species have 43 percent of stocks overfished. As a result, their 2009 production was only 51 percent of their peak level. This may give some indication of the scale of catch loss caused by overfishing. However, better estimates of the lost production will require a combination of stock assessments and ecosystem modelling. A second approach for increasing global production would be to intensify exploitation of the non-fully exploited stocks (13 percent of the monitored stocks). To avoid the same pattern of overfishing that has been experienced with other species in the past, any attempt to intensify exploitation on non-fully exploited stocks should be accompanied by precautionary management plans.

This updated assessment suggests that the state of global marine fish stocks is continuing along its historical trend. There has been a slow but apparently ongoing increase in the proportion of overexploited stocks and a decreasing percentage of non-fully exploited stocks, while the number of fully exploited stocks has increased slightly. However, it must also be noted that progress is being made in some regions, which should serve both as encouragement and as examples of successful management. For example, the number of stocks classified as overfished and/or subject to overfishing showed a fall in Australia from 24 in 2005 to 18 in 2008 (Wilson *et al.*, 2009). Fisheries in large marine ecosystems such as the California Current and the Eastern Bering Sea have reduced exploitation rates and rebuilt biomass to or above the level that produces multispecies MSY (Worm *et al.*, 2009).

Of the three categories describing stock status, the percentage of overfished stocks is the one of greatest concern. Not only can overexploitation cause negative ecological consequences, it can also reduce fish production with resulting negative social and economic consequences (World Bank and FAO, 2009). The need to improve management of stocks is widely recognized. The WSSD set a target to restore all overfished stocks to the level that can produce maximum sustainable yield by 2015. The strategic goal of the 2010 Conference of the Parties to the Convention on Biological Diversity is: "by 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem approaches" (UNEP, 2010). The UN Millennium Development Goals (UN, 2010) is also monitoring the proportion of fish stocks within "safe" biological limits as an indicator of environmental sustainability. The successful cases highlighted above demonstrate that effective management is possible. Member States, the general international community and all relevant stakeholders need to work together to achieve the agreed goals.

Assessing stock status usually requires quantitative analysis either through modelling or monitoring key indicators. Catch data alone are often insufficient, although they may allow the use of catch-only methods. It is a common practice in fisheries that stock assessment is undertaken to provide the information necessary for designing management regulations. This is still true, even when they may range from qualitative to quantitative assessments. However, assessment results are not always available to the public. The RAM Legacy Database compiled the results of classic assessments on 234 stocks of 124 species that accounted for about 20 percent of global catch (Branch *et al*., 2011). FAO has adopted a spectrum of methods and extended the coverage to 70 percent of the global catch. There is still 30 percent of the global catch without any formal assessment. This is mainly because these catches are taken from stocks or species groups with insufficient information to assess their state of exploitation. Moreover, within the above, there is a high proportion of the total marine catch without reliable information on what species are being caught. This catch was recorded in the FAO database as "miscellaneous fishes" or "marine fish NEI". These landings are termed here as the "NEI" group, and the share of global catch statistics attributed to this group increased to 33 percent in 2009 (Figure A15). Assessing stock status for the "NEI" group is often difficult, although not completely impossible. Therefore, greater effort needs to be made at all levels and stages of fisheries research and management. These actions should range from improving the identification of species being caught and landed to improving the information base for the proper assessment of fish stocks as required by the Code. This code requires that "States should ensure that timely, complete and reliable statistics on catch and fishing effort are collected and maintained in accordance with applicable international standards and practices and in sufficient detail to allow sound statistical analysis" (Article 7.4).

FIGURE A15
Temporal variation in the percentage of catches reported as "NEI" in the FAO statistical database



ACKNOWLEDGEMENTS

We wish to thank all the authors in Section B - the regional reviews of marine fisheries resources in FAO statistical areas for their contribution to the data and information presented in this chapter. We are also grateful to Luca Garibaldi and Fabio Carocci for their input in the preparation of data and graphs. Finally, David Milton and Jacek Majkowski are thanked for their valuable comments and suggestions to an earlier version of this manuscript.

REFERENCES

Branch, T.A., Jensen, O., Ricard, E., Ye, Y. and Hilborn, R. 2011. Contrasting global trends in marine fishery status obtained from catches and from stock assessments. *Conservation Biology* 25: 777–786.

Engelhard, G.H. 2008. One hundred and twenty years of change in fishing power of English North Sea trawlers. *In* Payne, A., Cotter, J., Potter, T. eds. *Advances in fisheries science: 50 years on from Beverton and Holt*, pp.1-25. Blackwell Publishing Ltd, Oxford, UK.

Grainger, R.J.R. & Garcia, S.M. 1996. *Chronicles of marine fishery landings (1950–1994): trend analysis and fisheries potential*. FAO Fisheries Technical Paper No. 359. Rome, FAO. 51 pp.

Gulland, J.A. 1971. *The fish resources of the ocean*. West Byfleet, UK, Fishing News Books. 255 pp.

FAO. 1974. *Review of the status of exploitation of the world fish resources*. FAO Fisheries Circular No. 328. Rome. 30 pp.
FAO. 1978. *Review of the state of world fishery resources*. FAO Fisheries Circular No. 710. Rome. 47 pp.
FAO. 1979. *Review of the state of world fishery resources*. FAO Fisheries Circular No. 710 (Rev. 1). Rome. 46 pp.
FAO. 1981. *Review of the state of world fishery resources (marine areas and inland waters)*. FAO Fisheries Circular No. 710 (Rev. 2). Rome. 60 pp.
FAO. 1983. *Review of the state of world fishery resources*. FAO Fisheries Circular No. 710 (Rev. 3). Rome. 47 pp.
FAO. 1985. *Review of the state of world fishery resources*. FAO Fisheries Circular No. 710 (Rev. 4). Rome. 64 pp.
FAO. 1987. *Review of the state of world fishery resources*. FAO Fisheries Circular No. 710 (Rev. 5). Rome. 64 pp.
FAO. 1989. *Review of the state of world fishery resources*. FAO Fisheries Circular No. 710 (Rev. 6). Rome. 58 pp.
FAO. 1990. *Review of the state of world fishery resources*. FAO Fisheries Circular No. 710 (Rev. 7). Rome. 89 pp.
FAO. 1992. *Review of the state of world fishery resources*. FAO Fisheries Circular No. 710 (Rev. 8). Rome. Part 1: 114 pp; Part 2: 28 pp.
FAO. 1994. *Review of the state of world marine fishery resources*. FAO Fisheries Technical Paper No. 335. Rome. 136 pp.
FAO. 1995a. *Code of Conduct for Responsible Fisheries*. Rome. 41 pp.
FAO. 1995b. *Review of the state of world marine fishery resources: marine fisheries*. FAO Fisheries Circular No. 884. Rome. 105 pp.
FAO. 1997a. *Review of the state of world marine fishery resources: marine fisheries*. FAO Fisheries Circular No. 920: 173 pp.
FAO. 1997b. *The State of World Fisheries and Aquaculture 1996*. Rome. 125 pp.
FAO. 1999. *The State of World Fisheries and Aquaculture 1998*. Rome. 112 pp.
FAO. 2000. *The State of World Fisheries and Aquaculture 2000*. Rome. 142 pp.
FAO. 2002. *The State of World Fisheries and Aquaculture 2002*. Rome. 150 pp.
FAO. 2004. *The State of World Fisheries and Aquaculture 2004*. Rome. 153 pp.
FAO. 2005. *Review of the state of world marine fishery resources*. FAO Fisheries Technical Paper No. 457. Rome. 235 pp.
FAO. 2010. *The State of World Fisheries and Aquaculture 2010*. Rome. 197 pp.
ICES. 2011. Advice September 2010. Blue whiting in subareas 1-IX, XII and XIV (combined stock)
Sanchirico, J.N. & Wilen, J.E. 2007. Global Marine fishery resources: status and prospectus. *International Journal of Global Environmental Issues*, 7: 106–118.
The World Bank & FAO. 2009. *The sunken billions*. Washington, DC, World Bank. 100 pp.
United Nations (UN). 1995. *The Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks*. New York, USA. 40 pp.
United Nations (UN). 2010. *The Millennium Development Goals Report 2010*. 21 pp.
United Nations Environment Programme (UNEP). 2010. *Report of the 10th Meeting of the Conference of the Parties to the Convention of Biological Diversity*. 339 pp.
Wilson, D., Curtotti, R., Begg, G. & Phillips, K. 2009. *Fishery status report 2008*. Canberra. 395 pp.
Worm, B., Hilborn, R., Baum, J.K., Branch, T.A., Collie, J.S., Costello, C., Fogarty, M.J., Fulton, E.A., Hutchings, J.A., Jennings, S., Jensen, O.P., Lotze, H.K., Mace, P.M., McClanahan, T.R., Minto, C., Palumbi, S.R., Parma, A.M., Ricard, D., Rosenberg, A.A., Watson, R. & Zeller, D. 2009. Rebuilding global fisheries. *Science*, 325: 578–585.

PART B

Regional reviews

B1. Northwest Atlantic

FAO STATISTICAL AREA 21

David Kulka
FAO Consultant
Canada
E-mail: dave.kulka@dfo-mpo.gc.ca

INTRODUCTION

Area 21 extends over 6.5 million km^2 and covers 43 degrees of latitude from Greenland to the Carolinas off the United States of America (Figure B1.1). It encompasses an extensive continental shelf and slope out to 1 000 m that covers 1.3 million km^2. It comprises the mid-Atlantic Bight of the United States of America, Georges Bank/Gulf of Maine, the Scotian Shelf, the Gulf of St Lawrence, the Grand Banks, the northeast Newfoundland and Labrador Shelves, Davis Strait and Baffin Bay bordering the Arctic Basin. It is one of the few places in the world where the continental shelf extends into international waters beyond 200 nautical miles from land – this occurs on both the Grand Banks and the Flemish Cap. As a result, some of the fisheries are managed by an RFMO, namely, the Northwest Atlantic Fisheries Organization (NAFO).

The marine environment of the region encompasses the extremes, from Arctic to subtropical conditions. It includes three large oceanographic regions identified by the International Council for the Exploration of the Sea (ICES, 2011). The first is the Eastern Arctic (EA), which comprises Baffin Bay and allows Arctic waters to flow south (Dickson *et al*., 2007). The second region is the Sub-Polar Northwest Atlantic (SP-NWA), which extends from Davis Strait south to the Tail of the Grand Bank. This region is strongly influenced by a subpolar gyre (Loder, Petrie and Gawarkiewicz, 1998) and the cold Labrador Current (Colbourne *et al*., 2010), which carries subpolar water south along the shelf to mid-latitudes in the upper ocean. The third region is

FIGURE B1.1
The Northwest Atlantic (Area 21)

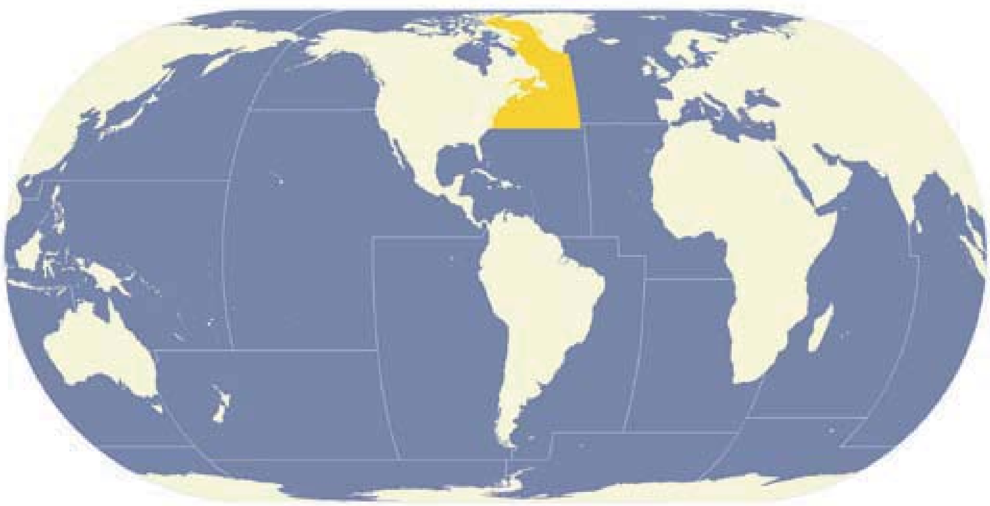
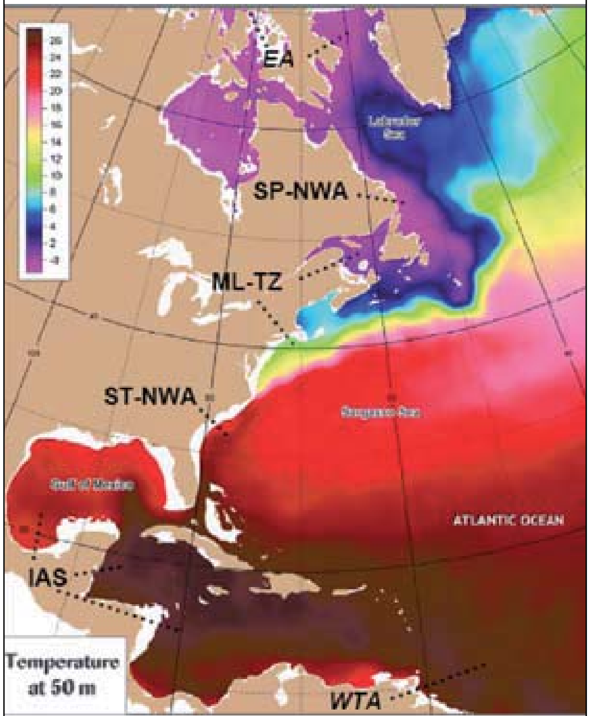


FIGURE B1.2
Long-term annual-mean temperature



Sources: From Yashayaev (1999)

Notes:
Major oceanographic region: EA = Eastern Arctic;
SP-NWA = Sub-Polar NW Atlantic; ML-TZ = Mid-Latitude Transition Zone; ST-WNA = Sub-Tropical Western North Atlantic.
IAS = Intra-Americas Sea; WTA = Western Tropical Atlantic.

the Mid-Latitude "Transition Zone" (ML-TZ) from Cape Hatteras north to the largely enclosed Gulf of St Lawrence, eastward to the Tail of the Grand Bank. This region is affected by competing influences of the counter-flowing subpolar, subtropical and slope waters (Loder, Petrie and Gawarkiewicz, 1998). Warm tropical Gulf Stream waters come into close proximity to subpolar (Labrador Current) waters at the southern edge of the Grand Banks. Here, subsurface temperatures change from subzero to over 20 °C within a few kilometres (red to purple transition in Figure B1.2). Subpolar waters have generally dominated much of the shelf in this zone in recent history (Wanamaker *et al*., 2007), but there are increasing influences of subtropical waters towards Cape Hatteras.

In 1497, the historical expedition led by John Cabot discovered abundant resources of Atlantic cod (*Gadus morhua*) off Newfoundland. For a period of almost five centuries, this fishery supplied the world's population with about 200 million tonnes of fish (www.nafo.int/about/frames/history.html). Cod was referred to as "Newfoundland currency" and constituted a large proportion of the fishery in the Northwest Atlantic until well into the twentieth century.

The late 1800s and early 1900s saw the development of new fisheries for haddock (*Melanogramus aeglefinus*), mackerel (*Scomber scombrus*) and lobster (*Homaris americanus*). It also saw the beginning of fishery management in Area 21. Fishery research institutions at Woods Hole in the United States of America and the St Andrews Biological Station in Canada were the first to be established under the direction of new government departments (services) with a mandate of fishery management. The United States of America began to record the fishing ground of landings at major Atlantic coast ports in 1891. The first attempt at promoting and coordinating international marine fisheries research in the Northwest Atlantic was taken by the North American Council on Fishery Investigations in 1921. The first subdivision of the Northwest Atlantic for the purpose of collecting fishery statistics by area of capture was made in the early 1930s.

The most profound development in Northwest Atlantic fisheries occurred from the 1950s to the 1970s, when European and Asian distant-water fleets expanded into Northwest Atlantic waters. It resulted in a massive increase in effort and the development of numerous offshore fisheries. This prompted the formation of the International Convention for the Northwest Atlantic Fisheries to manage these emerging fisheries (Anderson, 1998). The number of contracting parties (countries) to this organization increased from the initial five (Canada, Denmark, Iceland, the United Kingdom of Great Britain and Northern Ireland, and the United States of America) in 1951 to a high of 18 by 1975. This reflected the large increase in fishing capacity and diversification of exploited species. These distant-water fleets were capable of fishing for months at a time without landing product. Fishing had previously been constrained near shore. Now, it was extended out to great depths for many new fisheries including deepwater species such as redfish (*Sebastes* sp.), Greenland halibut (*Reinhardtius hippoglossoides*), witch flounder (*Glyplocephalus cynoglossus*), and grenadiers (Macrouridae). As early as the 1960s, it was recognized that overfishing was taking place, but controls were limited because the harvest was taking place in international waters. In the late 1970s, as in other parts of the world, the coastal States in Area 21 extended jurisdiction out to 200 miles in order to gain control of the harvest.

After supporting a sustainable fishery for more than five centuries, cod became severely depleted by the early 1990s. Catches were affected by a combination of factors besides heavy fishing that started in the 1960s. Environmental factors hypothesized to be involved included cold conditions linked to stronger Labrador Current flows, and a reduction in their key food (capelin [*Mallotus villosus*]). Seal predation and possibly low oxygen concentration have also been implicated in the decline of cod. In fact, cod were virtually gone on the northern extent of the Labrador Shelf (referred to as 2GH cod). This region had been unfished prior to the 1960s. A host of other demersal fish species such as American plaice (*Hippoglossoides platessoides*), redfish, Greenland halibut, witch flounder and grenadier species also collapsed in the same period. This indicated that environmental influences as well as overfishing played a role in the reduction of many commercial fish species.

Cod, American plaice, witch flounder, cusk (*Brosme brosme*), white hake (*Urophycis tenuis*) and grenadiers remain in low abundance in most parts of their range, even under moratoria or strict regulatory limitations. However, not all demersal fish underwent a decline in the early 1990s and some have recovered in recent years. For example, yellowtail flounder (*Limanda ferruginea*), particularly on the Grand Banks, has fully recovered to near virgin biomass. Populations of Atlantic halibut (*Hippoglossus hippoglossus*) and haddock (*Melanogrammus aeglefinus*) on the Scotian Shelf to Georges Bank have also grown in recent years. On the Georges Bank, declining gadoid resources that were replaced by elasmobranchs such as skates (*Rajidae*) and dogfish (*Squalus acanthias*) in the 1980s have begun to recover. Pelagic fish resources, primarily menhaden (*Brevoortia tyrannus*), herring (*Clupea harengus*) and Atlantic mackerel (*Scomber scombrus*) have continued to support fairly stable fisheries since the mid-1970s. They constitute about 23 percent of total reported landings in Area 21 since 2001. The key Georges Bank herring stock recovered in the 1990s from the overfishing in the 1970s.

In contrast, invertebrate species, primarily shrimp (*Pandalus* sp.) and snow or queen crab (*Chionoecetes opilio*) both greatly increased their abundance and range in the 1980s and 1990s, particularly off Newfoundland and Labrador. Lobster (*Homarus americanus*) and sea scallop (*Placopecten magellanicus*) have increased slightly in the long term. These increases in shrimp and crab resources have supported emerging fisheries that have driven the total landed values to record highs in recent years. This has been despite the reduction in traditional demersal fish stocks. Shrimp and sea scallop fisheries have had the largest catch in Area 21 since 2001. This change in an ecosystem dominated by demersal fish species to one dominated by invertebrate species may have constituted a regime shift (Lilly, Parsons and Kulka, 2000, ICES, 2009).

PROFILE OF CATCHES

Nominal catches in Area 21 doubled from 2.3 million tonnes in 1950 to peak at 4.6 million tonnes in 1968 (Figure B1.3; Table D1). Catches subsequently declined from 4.4 million tonnes in 1973 to 2.8 million tonnes in 1978. They stabilized at about 2.7 million tonnes until 1984 then increased slowly, reaching 3.3 million tonnes in 1990. Catches subsequently declined steeply to about 2 million tonnes in 1994, as a result of the groundfish collapse off eastern Canada. A slight recovery has been evident since 1998, when 1.96 million tonnes were reported. Total catch increased to 2.3 million tonnes in 2001 and has fluctuated around that value since then.

Historic patterns in catch in Area 21 are primarily affected by changes in cod (decrease) and shrimp (increase) stocks. Cod catches dominated the fisheries catches prior to the

FIGURE B1.3
Annual nominal catches by ISSCAAP species groups in the Northwest Atlantic (Area 21)

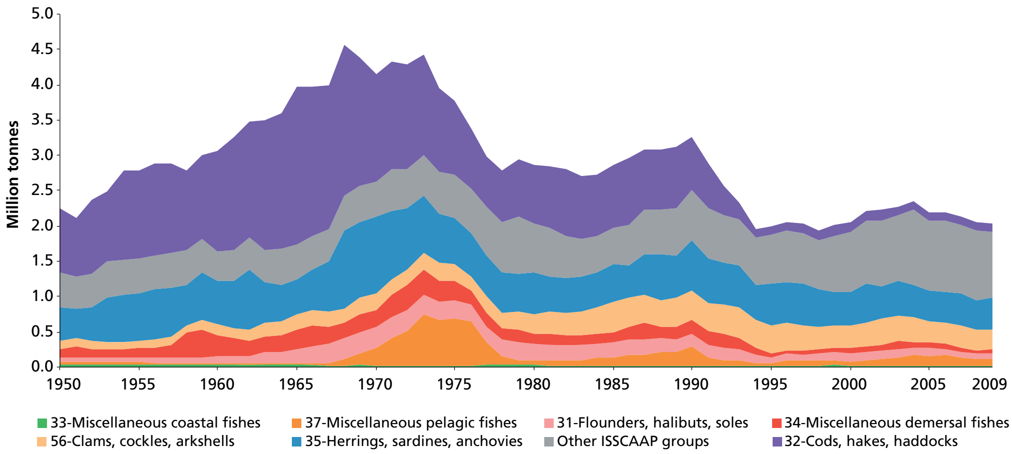


FIGURE B1.4
Annual nominal catches of selected species in ISSCAAP Group 32, Northwest Atlantic (Area 21)

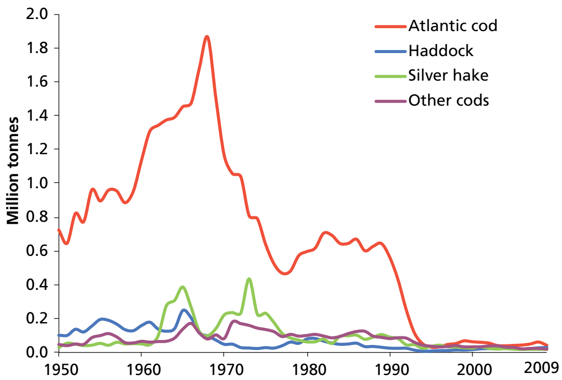
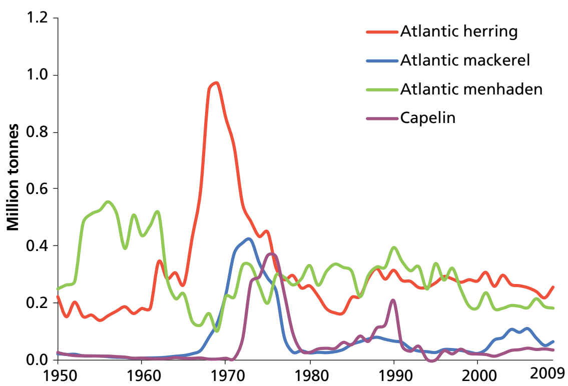


FIGURE B1.5
Annual nominal catches of selected species in ISSCAAP Group 35, 37, Northwest Atlantic (Area 21)



1950s and increased in the 1960s to a peak of almost 2 million tonnes. They then declined to below 500 000 tonnes in 1977 as a result of overfishing and other factors noted above. The catches from the southern Labrador – eastern Newfoundland stock (northern cod) contributed significantly to the overall cod catches in the period 1953–1987 and accounted on average for almost 40 percent of the total. Catches of cod then declined precipitously in the early 1990s, dropping to 40 000 tonnes by 2003–2005. They then increased to 60 000 tonnes by 2008. In contrast, shrimp, previously fished in small amounts, less than 10 000 tonnes prior to the 1980s now constitutes the largest nominal catch of any species in Area 21 (287 000 tonnes in 2009).

Catches of Atlantic herring, redfish, silver hake (*Merluccius bilinearis*), haddock, Atlantic menhaden and sea scallop also increased in the 1950s and 1960s (Figure B1.4). These were followed by increased catches of Atlantic mackerel (*Scomber scombrus*) and capelin (*Mallotus villosus*) (Figure B1.5) as a result of increasing distant-water fleet effort. Flatfish catches peaked at 303 000 tonnes in 1968 (Figure B1.6), then declined to 78 600 tonnes by 1995. By 2002, catches of flatfish had recovered to 116 400 tonnes. However, the catch composition had changed with just over half being made of Greenland halibut (*Reinhartius hippoglossoides*). Fisheries for invertebrates have fared better (Figure B1.7), showing increases from the mid-1970s to the early 1990s, when more than 600 000 tonnes were caught. Catches of shellfish, primarily sea scallops (*Placopecten magellanicus*), ocean quahog

(*Arctica islandica*) and surf clams (*Mactromeris polynyma*) decreased during most of the 1990s, but have increased in recent years.

In the 1960s, the major species fished in order were: cod, Atlantic herring, Atlantic redfishes, silver hake, haddock, Atlantic menhaden, sea scallop, surf clam and American oyster (*Crassostrea virginica*). These species accounted for 80 percent of the total reported landings. In the period from 2001 to 2009, catches were dominated by invertebrate and pelagic fish species. The largest catches have been made of shrimps (average 311 297 tonnes), sea scallop (average 285 402 tonnes), Atlantic herring (average 261 932 tonnes), Atlantic menhaden (average 194 101 tonnes), Atlantic surf clam (average 151 783 tonnes), snow crab (average 102 424 tonnes), American lobster (average 86 942 tonnes), Atlantic mackerel (average 77 285 tonnes), Greenland halibut (average 60 156 tonnes), cod (average 48 416 tonnes), blue crab (*Callinectes sapidus*, average 39 664 tonnes) and Atlantic redfish NEI (average 38 903 tonnes). Those 13 species made up 80 percent of the reported catch in that period.

FIGURE B1.6

Annual nominal catches of selected species in ISSCAAP Group 31, Northwest Atlantic (Area 21)

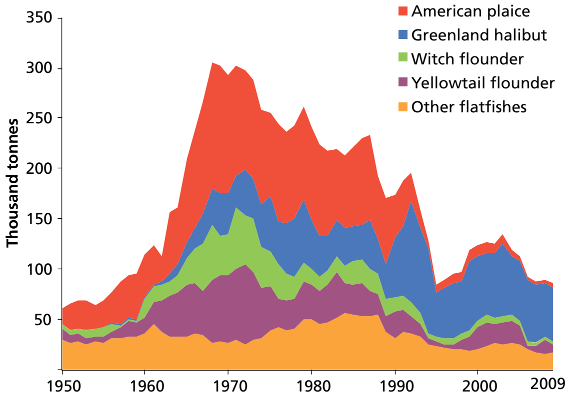
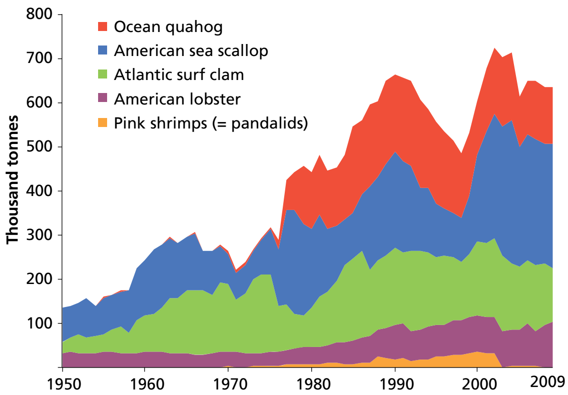


FIGURE B1.7

Annual nominal catches of selected species in ISSCAAP Groups 43, 45, 55, 56, Northwest Atlantic (Area 21)



RESOURCE STATUS AND FISHERY MANAGEMENT

Greenland

The main commercial fish species are Greenland halibut, Atlantic cod, lumpfish, Greenland cod, redfish and wolffish (Anarhichidae). Annual landings of these species have shown major changes in the past century. The current status of exploitation and trend in catch in the region are shown in Table D1. Historically, cod was the most important commercial fish species in Greenland waters, with annual catches peaking between 400 000 and 500 000 tonnes in the 1960s. Low recruitment and overfishing have played an important role in the collapse of the cod fishery since the 1960s. This stock has shown some recovery and catches increased from 1 700 tonnes in 2001 to 20 000 tonnes in 2008. The presence and abundance of cod in offshore waters off Greenland is believed to be related to environmental conditions and the periodic influx of larvae from Iceland that subsequently migrate back to spawn (Buch, Hirsted and Hovgård, 1994).

Shrimp are the principal invertebrate resource in this region in terms of landings. Fisheries for snow crab and Icelandic scallops are small compared with shrimp. Shrimp biomass increased in the 1970s to 1990s, and it currently supports by far the largest fishery off Greenland. It has undergone a continuous increase from 1 791 tonnes in 1960 to 145 233 tonnes in 2008 (71 percent of the total landings), surpassing cod landings in 1984. Given the importance of this fishery, the West Greenland Shrimp Fishery Plan was developed as a result of the new purposes section of the Greenland Fishery Act introduced in 2010. This plan states: “In the administration of this Act, emphasis must be placed on the conservation and reproduction of resources and on keeping the fishery’s impact on the ecosystem at an acceptable level”.

Greenland halibut currently represents the second largest fishery, although it made up only 10 percent of total landings in 2008. Historically, Greenland halibut were only a minor portion of the landings. However, catches increased from 1 159 tonnes in 1971 to 20 064 tonnes in 2008. From 2000 to 2008, Greenland halibut was the principal groundfish caught and averaged 29 605 tonnes. Annual catches of cod averaged 6 677 tonnes between 1999 and 2008 and were well below the catches of the 1960s and 1970s. Landings of lumpfish have only constituted a significant portion of the landings in recent years and wolffish (striped) has been increasing since 2000.

Canada

For much of the past five centuries, the predominant fishery product from what are now Canadian waters was salted cod. The fish were originally caught by hook and line and gillnets from small vessels, and salted ashore. Starting in the seventeenth century, salting was also done at sea. It allowed fishing to be expanded offshore and resulted in a more efficient and widespread harvest (Fiedler, 1940).

However, it was external influences, the development of steamer and trawler technology starting in the 1900s, that ultimately changed the nature of fisheries off Canada. In 1954, the United Kingdom of Great Britain and Northern Ireland introduced the factory stern trawler, allowing the vessel to fish long distances from home, and this technology was rapidly taken up by other countries. The banks off Canada were viewed as a prime target by the long-distance fleets, and the arrival of large numbers of factory trawlers from European and Asian countries resulted in a doubling of the catches in the 1960s. Although Canada had already implemented controls on the Canadian fleet, catches were largely unregulated for other countries, leading to decreased stock sizes. This prompted the extension of Canadian jurisdiction out to 200 miles in 1977.

At that time, there was considerable optimism that Canadian catches would increase substantially under the national management system. Canada started to develop its own fleet of wet-fish trawlers in the late 1960s. After the extension of their jurisdiction, many of the trawl fisheries for cod, redfish and flatfish once prosecuted by the long-distance fleets, were taken over by Canadian interests. Non-Canadian fleets continued to be allocated a share of the quota but were phased out by the late 1980s. The Department of Fisheries and Oceans (DFO) expanded its management of the fisheries out to 200 miles. Straddling stocks were comanaged through NAFO (see NAFO section below). Stock assessments are used as the basis for providing scientific advice for quota management. Under the Fisheries Act, vessel licensing, seasonal permitting and quotas are enforced and monitored through fishery officer boardings and dockside inspections, quota monitoring and a fishery observer programme.

Demersal fish species

Following extension of jurisdiction, some improvements in stock status of demersal fish, including cod were seen up to the mid-1980s. Thereafter, a combination of expanding Canadian offshore fishing capacity (which drove increased effort despite the supposedly conservative management system), overfishing by the distant-water fleets on the grounds outside the 200 miles jurisdiction and a succession of weak year classes in many fish stocks led to increases in fishing mortality and precipitous declines in stock sizes in the late 1980s and early 1990s. Many of the demersal finfish stocks, including cod, American plaice, witch flounder, yellowtail flounder and redfish collapsed, and fisheries for these species were closed or underwent sharp reductions in catch quotas in 1992 or 1993 (Murawski *et al*., 1997).

Conservative management measures since the collapse have had mixed results. In its 2003 report, the Fisheries Resource Conservation Council noted that the spawning biomass of cod in NAFO Divisions 2J3KL (northern cod) continued to be very low. It had poor recruitment, high mortality from seals and exposure to bycatch. Until recently, northern cod remained at less than 3 percent of its 1980s biomass, with few fish older than five years. However, from 2004 to 2008, the spawning stock biomass (SSB) increased by 83 percent per year. This is the first positive trend since the collapse in the early 1990s. However, the SSB still remains low: the average 2007–09 SSB offshore is 10 percent of the average in the 1980s. Whether this constitutes the start of recovery is unclear. Grand Bank cod (Div. 3NO, contiguous with northern cod) has not shown any sign of recovery. One of the possible causes is the relatively high fishing mortality on this depleted stock from bycatch in overlapping fisheries. The main fisheries where cod are taken as bycatch are the yellowtail flounder fishery inside 200 miles and in several fisheries in the NAFO Regulatory Area. Recruitment of this stock has also remained low for years, although from 2005–07, they have been similar to that seen in the 1980s.

Catches of northern Gulf of St. Lawrence cod stock (Div. 3Pn4RS) exceeded 100 000 tonnes in 1983 and constituted overfishing. The abundance of fish aged more than three years declined from 1980 to 1994. The fishery was closed in 2003 but was reopened the following year as the SSB increased to 76 million in 2009 owing to a strong 2006 year class. The stock now supports a limited fishery with a total allowable catch (TAC) of 7 000 tonnes in 2008. Natural mortality remains high, with seal predation attributed as the major cause (Fisheries Resource Conservation Council, 2003a, 2003b, 2003c). The southern Gulf of St. Lawrence cod stock (Div. 4T) sustained a catch exceeding 50 000 tonnes annually as recently as the early 1990s when the stock collapsed and has remained low since. The 2005–08 SSBs were the lowest observed since 1971. Natural mortality is high (~ 0.6), so recovery in the near term is very unlikely. The present TAC of 2 000 tonnes and a catch of 1 500 tonnes are considered too high to allow recovery.

The cod stocks off southern Newfoundland (Subdiv. 3Ps) sustained catches that varied about 60 000 tonnes prior to the mid-1970s, but that resulted in decline of the stock. The fishery was closed from 1994–96 but reopened in 1997. The abundance has fluctuated without an obvious trend since the 1980s. The SSB declined between 2004 and 2008, increased in 2009 and is now near the 1998–2009 average. Low recruitment continues to be an issue. The TAC now stands at 11 500 tonnes, which is down from 20 000 tonnes in 2000. This stock now supports the largest cod fishery off Canada.

To the south, cod stocks on the northeast Scotian Shelf (Div. 4VsW and Div. 4Vn) have been under a moratorium since 1993. They continue to be at or near the lowest spawning biomass ever recorded, with recruitment, growth and condition all below average. For the southwest Scotian Shelf and Bay of Fundy (Div. 4X5Y) cod stock, recruitment has improved. This started with the 1998 year class and although biomass has increased since the late 1990s, it remains low.

All commercial populations of the cod of Canada's northern (Div. 2J3KL), Laurentian (Div. 4RST and 3Ps) and southern cod (Div. 4X5YZjm) were assessed as "endangered" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2011). This was because of their substantial declines in abundance and a lack of recovery. Although assessed at risk of extinction, these populations have not been placed on Schedule 1 of the Species at Risk Act, which would offer protection against harm. They continue to be managed under the Fisheries Act.

Prior to the late 1960s, haddock was the second-most important demersal fish resource after cod and was the first stock to collapse. Div. 3NO haddock (southern Grand Bank) catches peaked at 76 000 tonnes in 1961 but declined rapidly to a remnant population and have been under moratorium since 2001. The Div. 4TVW stock (Gulf of St. Lawrence/Scotian Shelf) has also been under moratorium since 1989. It shows little or no sign of improvement. The Div. 4X5Y stock (southern Scotian Shelf/Bay of Fundy) has been stable since the 1990s and its SSB has increased in the past decade. The present TAC is 7 000 tonnes. Canada fishes part of the eastern Georges Banks stock, which had an increasing TAC of 29 600 tonnes in 2010. Its SSB has more than doubled since the mid-2000s. The 2003 year class is exceptional and the largest on record. This stock is now the largest haddock population in Area 21.

Redfish was one of the early targets of the new Canadian wet-fish trawler fleet. Canadian catches peaked briefly at close to 160 000 tonnes in 1973, but are currently averaging about 20 000 tonnes. The stock in Div. 2+3K (Labrador Shelf) was once one of the largest. It now remains under moratorium and shows no sign of recovery. The stock in Div. 3LNO (Grand Bank) was closed in 1998. It was reopened in 2009 with a small TAC of 3 500 tonnes. Div. 3O redfish (southern Grand Bank) has been more stable in the long term and the current TAC is 20 000 tonnes. Unit 1 and Unit 2 (Gulf of St. Lawrence/Scotian Shelf) are now considered to be a single stock that has a TAC of 10 300 tonnes. This stock is rebuilding at present. One of the complicating factors in managing redfish fisheries is that they comprise a mix of three closely related species *Sebastes marinus, S. mentella* and *S. fasciatus*. The most recent assessments treat the species separately although catch statistics remain problematic.

Pollock supports limited fisheries on the Scotian Shelf. Catches have increased in recent years to about 15 000 tonnes, which is half the average between 1960 and 1970. Witch flounder biomass and commercial catch have remained low (average 1 800 tonnes annually) since the decline of the various stocks in the early 1990s. Of the five stocks, three are under moratorium and one is only taken as bycatch. Yellowtail flounder on the Grand Banks (Div. 3LNO) stands out as it has undergone a full recovery to near virgin biomass. Other small fisheries for demersal fish species include white hake, cusk (currently under moratorium), winter flounder, silver hake, Atlantic halibut (recent assessments of this valuable species indicate that partial recovery has taken place), thorny skate and spiny dogfish.

The failure of many demersal stocks to recover fully in the 18 or more years since they collapsed has puzzled those working on and interested in these fisheries. The stocks of these species have failed to recover despite most being closed to fishing. When the moratoria were placed on these stocks in the early 1990s, recovery was anticipated to take only a few years. Possible explanations have been proposed for cod by a Fisheries and Oceans review (Fisheries and Oceans Canada, 2003) but are also more broadly applicable to other fish stocks. Cod in northern Canada have lower productivity than elsewhere because they live in colder environments. In the 1990s, the ocean climate was unusually cold and unfavourable to productivity. Harsh conditions in the 1990s reduced survival and growth of cod. When the stocks collapsed, they underwent a severe reduction in SSB that resulted in a high proportion of first-time spawning fish. This reduced the reproductive potential of the stocks. Cod were small for their age and in poor condition with little energy reserves to survive critical stages. These reduced cod stocks were preyed upon by increasing numbers of seals, mackerel and herring. This combined mortality was sufficient to have affected recovery. While catches from fishing have been greatly reduced in comparison with the 1970s and 1980s, fishing mortality appears to have remained sufficiently high to hinder recovery. There was also evidence of under-reporting of catch, discarding of small fish and poaching.

Invertebrate species

At about the time that demersal fish stocks were declining or collapsing, the biomass of two invertebrate species, shrimp (primarily *P. borealis*) and snow crab, were increasing. The increase in biomass was widespread and fisheries for these two species were expanding. The shrimp fishery in the Gulf of St. Lawrence began in the late 1960s, when landings rose gradually until a significant increase after 1990. Currently, the TAC for shrimp is 36 900 tonnes. In the 1970s and 1980s, a shrimp fishery was opened off Nova Scotia. However, it was closed on several occasions because of bycatch issues and currently has a TAC of 5 000 tonnes. It was elsewhere that the large shrimp resource was developed. In the 1970s, an exploratory fishing programme confirmed dense, widespread shrimp concentrations from Baffin Island to the northeast coast of Newfoundland. Canada bought a number of large factory freezer trawlers in the 1980s that were designed to trawl for shrimp. Between 1978 and 1991, 17 Canadian licences for an offshore fleet were issued and quotas established with an enterprise allocation regime. In the 1990s, as the abundance of the shrimp stocks grew and the groundfish moratorium came into effect, the fishery became increasingly lucrative. Inshore licences were introduced giving priority access to the < 65 ft (about 20 m) fleet and to first-nations fishers. The TAC rose from 85 000 tonnes in 1998 to more than 160 000 tonnes in 2007 and the fishery was extended south to the Grand Banks. Canadian catches of shrimp had been almost non-existent in the 1960s, yet they were now providing the largest catch in Canadian waters. Along with snow crab, shrimp now yield the greatest market value for the Canadian fishing industry. One of the issues that developed as the shrimp fishery expanded was the incidental capture of many of the declining demersal fish stocks. A fish exclusion device, the Nordmore grid, proved effective at reducing bycatch of adults of commercially important demersal fishes. In 1993, the device was made mandatory in the shrimp fishery. A full description of this fishery can be found on the Web site of Fisheries and Oceans Canada (2011).

Snow crab started to undergo a large increase in biomass throughout its range in the 1970s. Catch had been almost non-existent in the 1960s but increased rapidly to peak in the 1980s before declining. Between 1990 and 2002, landings quadrupled from just over 26 000 tonnes to almost 107 000 tonnes. Snow crab catches were 83 584 tonnes in 2010 with a TAC of 87 952 tonnes. The management of the snow crab fisheries was developed in the 1980s and 1990s. It is based on annual TACs, quotas, effort controls, minimum legal size, minimum mesh size of traps, seasons, areas, and soft-shelled (also known as white crab) protocols. Although market issues affected prices in the mid-2000s, crab is the most lucrative east coast fishery and even surpasses lobster.

Lobster has been a mainstay of inshore fisheries in Atlantic Canada since the late 1800s. The fishery started to increase its catches in the 1980s and these reached near-record levels in the 1990s after being depleted for half a century. Ecological changes may have led to the increased lobster production, although there is no agreement on the specific cause. Increased fishing efficiency has also played a role in increasing catch rates. Lobster catches reached a peak of 48 500 tonnes in 1991, declined through the following decade and are now at record high catches in excess of 50 000 tonnes. However, the Fisheries Resource Conservation Council warned in 2007 that, although the stocks are in good shape at present, they are overexploited with insufficient larger females to spawn and release their eggs to ensure long-term sustainability. Larger ships and more efficient technology are thought to present increased risks to Atlantic Canada's lucrative lobster industry.

Canadian participation in the offshore scallop fishery first began in the south on Georges Bank in the mid-1940s. When the 200-mile limit was introduced and the Canada/United States border was defined, Canada's access to this stock was restricted. In 1973, management in the form of limited entry was introduced. The fishery is now under an integrated fishery management plan. Management measures include limited entry (no new licences), TACs, meat counts, electronic vessel monitoring, dockside monitoring of all landings and industry-managed closures to protect juvenile scallops. The offshore scallop fishery was recently certified as a sustainable fishery against the Marine Stewardship Council criteria. This indicates that scallop fisheries ranging from Georges Bank to St. Pierre Bank off southern Newfoundland are healthy and appropriately managed (Marine Stewardship Council, 2011). By value, scallop is the third-ranked species (behind lobster and crab) in Nova Scotia although the catch is small compared with shrimp, crab and lobster (7 000 tonnes).

Other invertebrates fished off Canada include surf clam, soft clam, rock and Jonah crab, oyster, sea urchin, Icelandic scallop, hard clam, periwinkle and whelk. These are all relatively minor fisheries compared with the industrial fisheries described above.

Pelagic species

The fishery for herring is the largest small pelagic fishery and one of the largest fisheries in eastern Canada with a catch of 166 000 tonnes and an export value of more than US$110 million in 2008. Historically, it ranks second after cod in terms of long-term catch. Several gear types are used, primarily gillnet, purse seine and weir. Many different types of management have been applied, including TAC, individual transferable quotas (ITQs) and limited entry. Most herring stocks are well below their historical averages, and two stocks are below or near the critical levels. The overall economic return from the fishery is limited as the price has changed little in the last 30 years. Despite this, the fishery is important to many fishers and processors. The long-term prospects for the fishery are uncertain given the status of the resource and the systemic problems of the industry. Nonetheless, the Fisheries Resource Conservation Council is convinced that greater benefit could be derived from the herring fishery (Fisheries Resource Conservation Council, 2009).

Capelin fisheries occur on the Labrador Shelf and Grand Banks and have fluctuated in the long term. Catches rose rapidly in the 1970s and 1980s peaking in 1988–1990. The species was taken in large amounts by non-Canadian fleets and overfishing resulted in the collapse of various stocks. Some recovery in the fishery has been observed in recent years.

Atlantic mackerel is a highly migratory species that arrives in May and occurs as far north as northeast Newfoundland. Catches are unpredictable in many areas, depending on the migration patterns that may change depending on water conditions. The largest catches of Atlantic mackerel were recorded between 2003 and 2007. The overall TAC was 80 000 tonnes for 2010, in spite of the apparent drop in biomass and uncertainty around stock status. The main gear types used in the mackerel fishery including traps, gillnets, handlines, bar seines and purse seines. For more information on the mackerel fishery, refer to Fisheries and Oceans Canada (2010). Other small pelagic species fished off Canada include alewife (*Alosa pseudoharengus*) and American shad but these constitute minor inshore fisheries.

Summary

Canadian fisheries now exist in Area 21 for about 35 fish and invertebrate species. They comprise a multitude of stocks and management units that are all managed under the Fisheries Act. Some of the recently developed fisheries, primarily in the 1990s and thereafter, exploit underutilized species. These fisheries have been developed in an attempt to replace fisheries for the depleted demersal fish stocks. They include skate, spiny dogfish, white hake, wolffish, sea urchins, whelks, periwinkles, offshore bivalves, krill and marine worms. These new target fisheries have been successful to varying degrees but most remain a minor component of the overall production. The lack of recovery, or limited recovery, for some historical fisheries such as cod, witch flounder and redfish was concluded to be the result of several factors working simultaneously or in turn. These factors appeared to have affected fish growth, reproduction and fish survival. Prompt recovery in any of these stocks has not occurred. Conversely, invertebrates remain at near record levels of abundance.

Descriptions of stock status are derived mainly from stock status reports located on the Web site of Fisheries and Oceans Canada at www.isdm-gdsi.gc.ca/csas-sccs/applications/publications/index-eng.asp and www2.mar.dfo-mpo.gc.ca/science/trac/tsr.html. Materials pertaining to quotas and management can be found at www.dfo-mpo.gc.ca/fm-gp/index-eng.htm.

The United States of America

The largest fisheries in the northeast of the United States of America catch mainly pelagic and invertebrate species in the following order: menhaden, surf clam, ocean quahog, sea scallop, oyster, herring, blue crab, hard clam and lobster. The oyster fishery has the longest history, taken in intertidal areas by aboriginal peoples and later in the seventeenth century by early European settlers. It now lands a fraction of the amount observed in the 1970s owing to a collapse in the 1980s. The menhaden fishery was developed in the 1950s and 1960s and has sustained the largest fishery off the eastern United States of America. Scallop, quahog and lobster are at or near peak production. Except for a period of intense distant-water fleet fishing from the 1960s and 1970s, the demersal fish fishery in United States waters has been domestic.

The current United States harvest strategy must comply with the provisions of the Magnuson–Stevens Fishery Conservation and Management Act. Since the mid-1990s, particularly with the adoption of stronger management actions, fishing mortality has been reduced on most demersal fish stocks. Some stocks have started to rebuild relatively quickly (www.nefmc.org/press/press_releases/2010/GFStock%20Status2010%20(4).pdf). Management is based on a limit reference point framework. Accordingly, managers are required to maintain exploitation below $F_{REBUILD}$ that would lead to SSB reaching or exceeding the B_{MSY} proxy within a ten-year rebuilding horizon. The SSB that is thought to result in the maximum projected recruitment, SSB_{MAX}, is often used as a B_{MSY} proxy. The recently formed Transboundary Resources Assessment Committee (www2.mar.dfo-mpo.gc.ca/science/trac/tsr.html) is a Canada/United States of America committee that assesses stock status of species that straddle the boundary of the two countries. Fisheries that are assessed by the committee include herring, cod, haddock, mackerel, yellowtail flounder and dogfish.

Much of the following information on stock status in the waters of the United States of America is derived from the Web site of the National Oceanic and Atmospheric Administration (NOAA) at www.nefsc.noaa.gov/nefsc/saw/ and www.nefsc.noaa.gov/publications/crd/ and information on fishery management can be found at the Web site of the New England Fishery Management Council (www.nefmc.org).

Demersal species

Demersal species have been the traditional mainstay of the fisheries off the United States northeast coast. Redfish, haddock, silver hake and yellowtail flounder were the dominant demersal fish fisheries in the 1960s with catches reaching 40 000 tonnes to 60 000 tonnes for each of those species. The abundance of demersal fish species declined by 70 percent between 1963 and 1974 as a consequence of overfishing by distant-water fleets. Some recovery occurred in the late 1970s following catch and effort reductions implemented by the International Commission for the Northwest Atlantic Fisheries prior to 1977 and the establishment of the United States EEZ in 1977. However, the recovery was short-lived owing to increased fishing pressure by the United States fleet. Overall abundance of commercially important demersal fish species reached a record low in 1992. Since the mid-1990s, fishing mortality rates have been reduced and rebuilding begun for stocks such as haddock, yellowtail flounder and summer flounder (*Paralichthys dentatus*). This improvement in the status of these species was a result of stringent management measures (including a moratorium on new vessel entrants, drastic reductions in days at sea for trawl and gillnet vessels, increased mesh sizes, several large year-round closed areas).

There are about 35 species (stocks) of demersal fish species caught off the northeast coast of the United States of America. Catches are dominated by goosefish (*Lophius americanus* also known as monkfish), gadoids (cod, haddock, pollock [*Pollachius virens*], silver and white hake), flounders (winter flounder [*Pleuronectes americanus*] and yellowtail flounder), spiny dogfish (*Squalus acanthias*), and skates. These species of skate are managed under the Skate Complex Fishery Skate Management Plan. The Northeast skate complex includes seven species: winter skate, barn-door skate, thorny skate, smooth skate, little skate, clear-nose skate, and rosette skate in the New England region. In the Mid-Atlantic region, catches consist mostly of summer flounder, scup (*Stenotomus chrysops*), goosefish and black sea bass (*Centropristis striata*). The average yield in the last decade of the principal demersal fish species, which includes goosefish, skates, Atlantic cod, silver hake, haddock, pollock, summer flounder, winter flounder and yellowtail flounder, scup, white hake, bluefish, witch, spiny dogfish and American plaice averaged 94 136 tonnes between 2001 and 2008. This amount is considerably less than their combined long-term potential yield. Some of these species have started to show some improvement in recent years as management has improved. Haddock catches had recovered to 8 242 tonnes by 2004, up from 328 tonnes in 1994 but declined again to 3 360 tonnes in 2007. However, cod catch was the lowest on record in 2006 at 5 724 tonnes, but showed a slight recovery to 8 659 tonnes in 2008.

Pelagic species

Atlantic menhaden (*Brevoortia tyrannus*) is taken mainly by purse seiners off the mid-Atlantic states of the United States of America. This is the largest fishery resource in the Atlantic waters of the United States of America and the dominant pelagic species. The catch in 2008 was 189 000 tonnes, which was down from a peak of more than 400 000 tonnes in 1990–91. The catch history shows fluctuations without any major trends and it is considered not to be overfished. This is largely a reduction fishery, but the species also plays an important role in the ecosystem as forage for many species and as a major consumer of plankton.

Herring and mackerel were heavily exploited by distant-water fleets in the late 1960s and early 1970s. Abundance declined in the mid-1970s and early 1980s before subsequently rebuilding in the absence of intensive fishing. Since 1983, the index has markedly increased, with the 1994 value the highest in the time series. The Georges Bank herring stock biomass increased from about 111 600 tonnes in 1982 to 830 000 tonnes in 1997 and was estimated to be 652 000 tonnes in 2008 (more information available on the Web site of the NOAA at www.nefsc.noaa.gov/sos/agtt/). Combined herring landings for Canada and the United States of America increased from 106 000 tonnes in 2005 to 116 000 tonnes in 2006, then declined to 90 000 tonnes in 2008. United States catches comprised 26.1 percent of total herring harvest, the remainder being taken by Canada. Mackerel catches increased in the early-to-mid-2000s but declined in 2007 and 2008. Catches in 2002 were 70 456 tonnes (61.2 percent Canada, 38.8 percent the United States of America) and, although at the high end for the decade, they remain still far below the long-term estimated potential of 383 000 tonnes. The combined mackerel catch for Canada and the United States of America was 50 685 tonnes in 2008.

Anadromous species

This is a diverse group including river shads such as alewife and blueback (*Alosa aestivalis*), American shad (*Alosa sapidissima*), striped bass (*Morone saxatilis*), Atlantic salmon (*Salmo salar*), Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and shortnosed sturgeon (*Acipenser brevirostrum*). The composite average yield from 2000 to 2002 was only about 3 978 tonnes. This was far below the historic maximum of 32 443 tonnes in 1959. All of these species, except striped bass, are overexploited and their abundance is low. The combined commercial and recreational catches of striped bass reached a record low of 423 tonnes in 1989 and highly restrictive regulatory measures were imposed in the mid-1980s. Stock rebuilding followed good recruitment and the stock was declared restored in 1995. The catch of striped bass was 5 020 tonnes in 2008.

The last two decades have marked a period of decline in stock status for all Atlantic salmon populations of the North Atlantic. Population estimates indicate that survival plummeted as much as fivefold for some stocks. This decline in survival has intensified concern over the additive effects of natural mortality in the marine environment and habitat issues that persist in United States rivers. The US Atlantic Salmon Assessment

Committee report indicated one of the lowest long-term returns in 1999 when only 1 452 adults returned to United States rivers (NOAA, 2011).

Invertebrate species

Offshore fisheries for invertebrate species including lobsters, surf clams (*Spisula solidissima*), ocean quahogs (*Arctica islandica*), longfin squid (*Loligo pealeii*), shortfin squid (*Illex illecebrosus*), sea scallops, northern shrimp and red crab (*Chaceon quinquedens*) are among the most valuable in the northeast of the United States of America. Fisheries for invertebrate species in nearshore and estuarine waters include blue crabs (*Callinectes sapidus*), oysters (*Crassostrea virginica*), hard clams (*Mercenaria mercenaria*), sea urchins (*Strongylocentrotus* spp.), and softshell clams (*Mya arenaria*). Sea worms (including primarily sandworm [*Nereis virens*], and bloodworm [*Glycera dibranchiata*]), whelks (*Busycotypus canaliculatus*, *Busycon carica* and *B. sinistrum*), and blue mussels (*Mytilus edulis*) are commonly harvested for use as bait in recreational fisheries.

United States catches of the valuable lobster fishery increased after 1940 and peaked at 39 832 tonnes in 2008. The recent increases have resulted from both increased effort as well as apparent increases in abundance, probably owing to favourable environmental conditions. However, fishing mortality is two to three times in excess of overfishing reference limits, and catches are dependent on newly moulted and sexually immature animals. Recent regulatory measures (limits on the number of traps per fisher) may not be sufficiently stringent to achieve the required reduction in fishing mortality.

Since 1982, the Atlantic Sea Scallop Fishery Management Plan (FMP) has regulated the fishery. Initially, regulations required vessels to land scallops that averaged fewer than 35 to 40 meats (the adductor muscle) per pound (about 450 g) or a minimum shell width of 3–3.5 inches (7.5–9.0 cm). However, fishing effort increased to unsustainable levels in the late 1980s and 1990s. This prompted the New England Fishery Management Council to develop Amendment 4 that became effective in 1994. Amendment 4 changed the management of scallop to achieve a maximum fishing mortality threshold equal to F5 percent. This threshold was believed to ensure recruitment by keeping SSB above 5 percent of virgin conditions. Also implemented were limited-access permits, day-at-sea allocations, dredge ring-size minima, gear configuration restrictions to improve small scallop escapement, and a minimum mesh size to improve finfish escapement. United States sea scallop catches from the Georges Bank – Mid-Atlantic region have averaged 88 896 tonnes in the last decade with a high of 186 336 tonnes in 2002, indicating a recovery in the stocks. Large areas closed to protect demersal fish stocks have also contributed greatly to the recovery of sea scallops.

Surf clams and ocean quahogs, regulated by an individual transferable quota (ITQ) system implemented in 1990, are harvested by dredges primarily in the Mid-Atlantic and Southern New England region. These species are currently underexploited. Catches of both species have remained relatively stable in recent years with 1999–2008 averages of 151 430 tonnes and 135 475 tonnes, respectively.

Fisheries for longfin and shortfin squid have existed since the 1800s. In the early years, they were primarily used for bait. The fishery generated catches of about 1 000 tonnes or less per year for each species until the 1970s. The fishery expanded greatly in the 1980s and 1990s in response to growing markets for human consumption. Longfin squid are fished primarily between North Carolina and the Gulf of Maine, while shortfin squid have been fished from North Carolina to Newfoundland and are assumed to constitute a unit stock. Distant-water fisheries for these two species existed between 1964 and 1986, with catches from United States waters peaking for longfin squid at 36 500 tonnes in 1973 and for shortfin squid at 24 700 tonnes in 1976. The average yields of squid for 1999–2008 were 15 095 tonnes for longfin and 10 486 tonnes for shortfin.

NAFO area

Following extension of jurisdiction to 200 miles in 1977, the principal northwest Atlantic fishing grounds came under coastal State jurisdiction. However, a significant portion of these fishing grounds also lies in international waters on the “nose” and “tail” of Grand Bank and on the Flemish Cap. This region comes under the jurisdiction of NAFO. There are 21 fisheries, including transboundary stocks that are managed by the 12 contracting parties of NAFO.

Only 10 percent of the stocks under the mandate of NAFO are caught in the international waters. In the last decade, average catches within the national EEZs were of the order of 1.4 million tonnes per year whereas annual catches in the NAFO Regulatory Area averaged about 120 000 tonnes. Eleven species, namely Atlantic cod, American plaice, witch flounder, yellowtail flounder, Greenland halibut, capelin, squid, shrimp, thorny skate (the first time an elasmobranch species has been managed by an RFMO), white hake, redfish in Div. 3O and pelagic redfish in Subarea 2, Div. 1F+3K (south of Greenland), are managed mainly through TAC and quota allocation. Systems to monitor, control and survey the fisheries have been developed by NAFO. A precautionary framework has been developed to address uncertainties in the assessment of fish stocks. Long-term management and rebuilding plans are in place for stocks post-moratoria. There is joint inspection and surveillance conducted by contracting parties on behalf of NAFO. These consist of at-sea inspections, air surveillance and port inspections. An amended convention includes an ecosystem approach to fisheries management, and NAFO has closed five seamounts, a coral protection zone and 12 regions of significant coral and sponge concentration to demersal fishing.

Further information on stocks under the NAFO mandate can be found in NAFO annual reports (NAFO, 2009, 2010) and on the NAFO Web site at www.nafo.int/publications/frames/science.html

Stock status

The transboundary stocks comanaged with Greenland and Canada are described above. Stocks lying fully outside of the EEZs include species on the Flemish Cap (Div. 3M). In 2010, the fishery for cod in Div. 3M was reopened with a TAC of 5 500 tonnes following SSB growth since 2004. For redfish in Div. 3M, the SSB is increasing, but is still low – the TAC for 2011 was set at 10 000 tonnes. For American plaice in Div. 3M, the 2008 assessment concluded that the stock biomass and the SSB remain very low and there is no sign of recovery. Greenland halibut biomass increased from 2004 to 2008. From 2008 to 2010, weaker year classes have recruited and caused a decrease in biomass. The TAC for 2011 is 17 185 tonnes in Div. 3LMNO. In 2003, a rebuilding plan for Greenland halibut was adopted with an objective of allowing a stable yield in the long term by setting prescribed quotas in future years. The state of the thorny skate stock is unclear, but the biomass was low and stable from 1996 to 2009. The TAC for thorny skate in Div. 3LNO for 2011 is set at 12 000 tonnes. In 2009, Div. 3M shrimp biomass decreased sharply to below B_{lim} even though exploitation has been low since 2005. The stock has entered the collapse zone defined in the precautionary approach framework and recruitment prospects remain poor.

ACKNOWLEDGEMENTS

This work comprises an update of the work done by Ross Shotton who wrote the previous version of this chapter. I thank him for providing the basis for what is presented here. I would also like to thank Barbara Marshall (Northwest Atlantic Fisheries Organization) who helped to put together the section on NAFO, and compiled other fisheries data.

REFERENCES

Anderson, E.D. 1998. The history of fisheries management and scientific advice – the ICNAF/NAFO history from the end of World War II to the present. *Journal of Northwest Atlantic Fishery Science*, 23: 75–94.

Buch, B.E., Horsted, S.A. & Hovgård, H. 1994. Fluctuations in the occurrence of cod in Greenland waters and their possible causes. *ICES Marine Science Symposia*, 198: 158–174.

Colbourne, E.B., Craig, J., Fitzpatrick, C., Senciall, D., Stead, P. & Bailey, W. 2010. *An assessment of the physical oceanographic environment on the Newfoundland and Labrador Shelf in NAFO Subareas 2 and 3 during 2009*. NAFO Scientific Council Research Document, 10/16 Serial No. N5770.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2011. Wildlife species search. *In COSEWIC* [online]. [Cited 20 December 2011]. www.cosewic.gc.ca/eng/sct1/SearchResult_e.cfm?commonName=cod&scienceName=&Submit=Submit

Dickson, R., Rudels, B., Dye, S., Karcher, M., Meincke, J. & Yashayaev, I. 2007. Current estimates of freshwater flux through Arctic and subarctic seas. *Progress in Oceanography*, 73: 210–230.

Fiedler, R.H. 1940. Fisheries of North America: with special reference to the United States. *Geographical Review*, 30: 201–214.

Fisheries and Oceans Canada. 2010. *Atlantic mackerel in the northwest Atlantic* [online]. [Cited 20 December 2011]. www.mafmc.org/meeting_materials/SSC/2011-05/Atlantic%20mackerel/TSR_2010_01_E.pdf

Fisheries and Oceans Canada. 2011. Northern Shrimp - Shrimp Fishing Areas (SFAs) 0-7 and the Flemish Cap. In *Fisheries and Oceans Canada* [online]. [Cited 20 December 2011]. www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/ifmp-gmp/shrimp-crevette/shrimp-crevette-2007-eng.htm

Fisheries and Oceans Canada. 2003. *Why the cod stocks haven't recovered?* [online]. [Cited 20 December 2011]. www.dfo-mpo.gc.ca/media/back-fiche/2003/cod-3-eng.htm

Fisheries Resource Conservation Council. 2003a. *2003/2004 conservation requirements for groundfish stocks on the Scotian Shelf and in the Bay of Fundy (4VWX5Z), in Subareas 0, 2 + 3 and redfish stocks*. Report to the Minister for Fisheries and Oceans. FRCC R.1. 107 pp.

Fisheries Resource Conservation Council. 2003b. *2003/2004 conservation requirements for 2J3KL cod stocks*. Report to the Minister for Fisheries and Oceans. FRCC R.2. 18 pp.

Fisheries Resource Conservation Council. 2003c. *2003/2004 conservation requirements for groundfish stocks in the Gulf of St. Lawrence*. Report to the Minister of Fisheries and Oceans. FRCC R.3. 47 pp.

Fisheries Resource Conservation Council. 2009. *Fishing into the future: the herring fishery in eastern Canada* [online]. [Cited 20 December 2011]. www.frcc.ca/2009/herring_2009.pdf

International Council for the Exploration of the Sea (ICES). 2009. *Report of the Working Group on Fish Ecology (WGFE), 26–30 October 2009, ICES, Copenhagen, Denmark*. ICES CM 2009 SSGEF/SciCom/:04.

International Council for the Exploration of the Sea (ICES). 2011. *Report of the Study Group on Designing Marine Protected Area Net-works in a Changing Climate (SGMPAN), 15–19 November 2010, Woods Hole, Massachusetts, USA*. ICES CM 2011/SSGSUE:01. 155 pp.

Lilly, G.R., Parsons, D.G. & Kulka, D.W. 2000. Was the increase on shrimp biomass on the Northeast Newfoundland Shelf a consequence of a release in predation pressure from cod? *Journal of Northwest Atlantic Fishery Science*, 27: 45–62.

Loder, J.W., Petrie, B. & Gawarkiewicz, G. 1998. The coastal ocean off northeastern North America: a large-scale view. *In* A.R. Robinson & K. H. Brink, eds. *The global coastal ocean: regional studies and synthesis*, pp. 105–133. The Sea, Vol. 11. John Wiley & Sons, Inc.

Marine Stewardship Council. 2011. Eastern Canada offshore scallop fishery. In: *Marine Stewardship Council* [online]. [Cited 20 December 2011]. www.msc.org/track-a-fishery/certified/north-west-atlantic/Eastern-Canada-offshore-scallop-fishery

Murawski, S.A., Maguire, J.-J., Mayo, R.K. & Serchuk, F.M. 1997. Groundfish stocks and the fishing industry. *In* J. Boreman, B.S. Nakashima, J.A. Wilson & R.L. Kendall, eds. *Northwest Atlantic groundfish: perspectives on a fishery collapse*, pp. 27-70. Bethesda, USA, American Fisheries Society. xxii + 242 pp.

National Oceanic and Atmospheric Administration (NOAA). 2011. Status of fishery resources off the northeastern US. In: *NOAA* [online]. [Cited 20 December 2011]. www.nefsc.noaa.gov/sos/spsyn/af/salmon/

Northwest Atlantic Fisheries Organization (NAFO). 2009. *NAFO perspectives*. NAFO Secretariat with Damon Loomer. 18 pp.

Northwest Atlantic Fisheries Organization (NAFO). 2010. *NAFO Scientific Council Report 2010*. 371 pp.

Yashayaev, I. 1999. Computer Atlas of the Northwest Atlantic, Atlas of Ocean Sciences CD-ROM.

Wanamaker, Jr, A.D., Kreutz, K.J., Schone, B.R., Petigrew, N., Borns, H.W., Introne, D.S., Belknap, D., Maasch, K.A. & Feindel, S. 2007. Coupled North Atlantic slope water forcing on Gulf of Maine temperatures over the past millennium. *Climate Dynamics*, 31: 183–194.

B2. Northeast Atlantic

FAO STATISTICAL AREA 27

Paul Medley
FAO Consultant
United Kingdom
E-mail: paulahmedley@yahoo.co.uk

INTRODUCTION

The total area of the Northeast Atlantic is 14.3 million km^2 with about 2.7 million km^2 of continental shelf. The main oceanographic features in the Northeast Atlantic are a subpolar and a subtropical gyre, which are driven predominantly by the North Atlantic current originating from the Caribbean. It also has an extended shelf area off northern Europe, the semi-enclosed Baltic Sea, and summer upwellings off the coast of Spain and Portugal (Figure B2.1).

The fisheries of the Northeast Atlantic expanded rapidly in the late nineteenth and early twentieth centuries. During this time, fishing became increasingly industrialized and applied more advanced technology. This expansion was only interrupted by the First and Second World Wars, which provided periods of little fishing activity, enabling stocks to rebuild. Since the 1950s, fisheries in the Northeast Atlantic region have undergone a significant reduction in numbers of vessels and employment. Despite this, a corresponding increase in fishing power of vessels has meant that fishing mortality has continued to increase. More recently, fishing mortality has levelled off or decreased (Sparholt and Cook, 2009).

Most of the traditional fishery resources of the Northeast Atlantic are fully exploited or overexploited, and new fisheries have been developed for some non-traditional stocks. There have been notable improvements in the status of some larger stocks, such as Northeast Arctic cod, Northeast Arctic haddock, mackerel, and the larger herring

FIGURE B2.1
The Northeast Atlantic (Area 27)

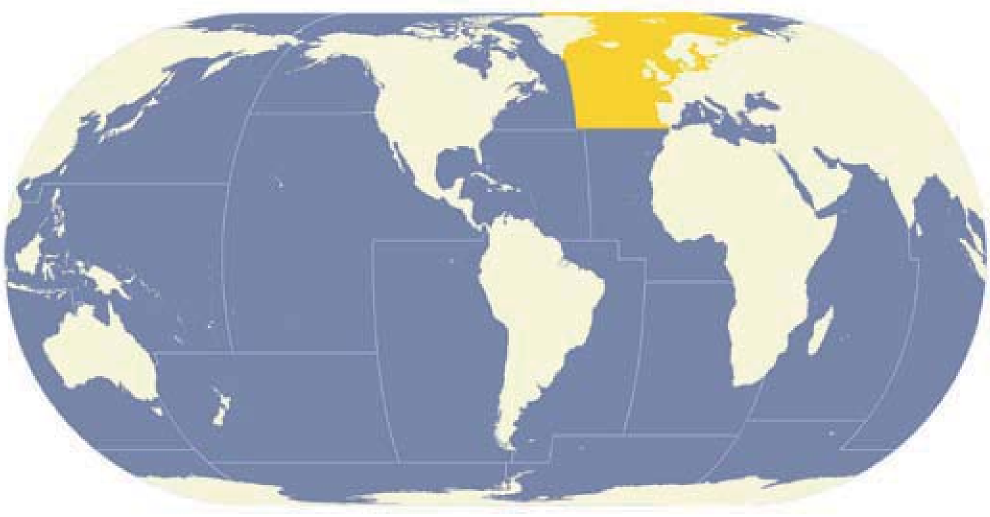
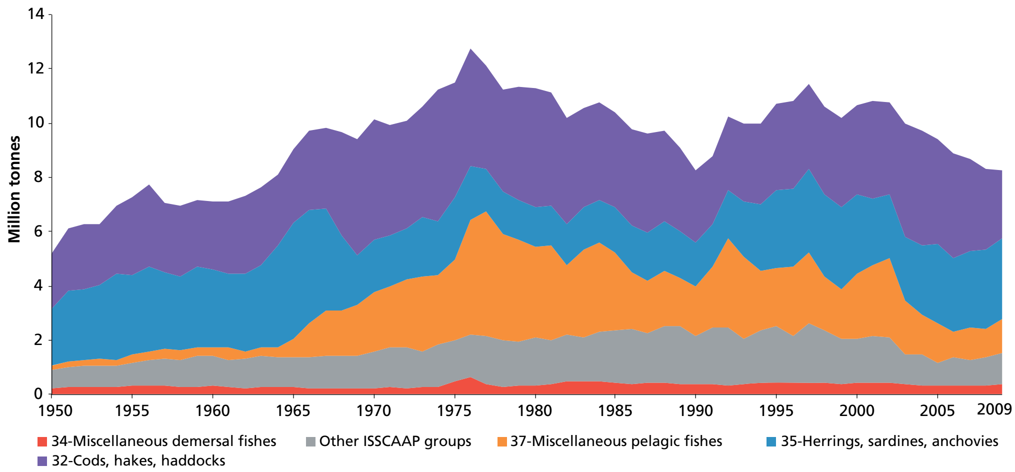


FIGURE B2.2
Annual nominal catches by ISSCAAP species groups in the Northeast Atlantic (Area 27)



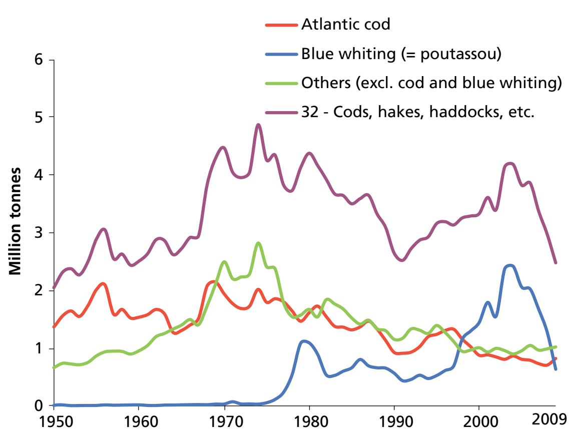
stocks. Other stocks, such as North Sea plaice and cod, are still in recovery although demonstrable progress has been made in their rebuilding. Overall, real progress is being made in the sustainable management of the fisheries in this region despite many challenges in international cooperation, fishing overcapacity and environmental change.

PROFILE OF CATCHES

Total marine catch in the Northeast Atlantic has increased from an average of about 6 million tonnes in the 1950s to an average of about 11 million tonnes in the period 1970–2000. Since 2005, the total catch has fallen to between 8 and 9 million tonnes (Figure B2.2; Table D2).

The composition of the total catch has changed over time, smoothing out some of the more dramatic fluctuations. Overall, declines in fisheries for traditional species, such as North Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and herring (*Clupea harengus*), have been compensated by the development of fisheries for formerly lower-valued species such as sandeels (*Ammodytes* spp.) and blue whiting (*Micromesistius poutassou*). In addition, a number of stocks that had previously been depleted have recovered.

FIGURE B2.3
Annual nominal catches of selected species in ISSCAAP Group 32, Northeast Atlantic (Area 27)



Catches of North Atlantic cod made the largest contribution to the total of cods, hakes and haddocks until 1998 (ISSCAAP Group 32). Since then, blue whiting landings have become the most important species in this group (Figure B2.3). A persistent downward trend in cod catches is evident from the peak in the late 1960s. The lower catches in recent years can be attributed in part to the rebuilding programme for North Sea cod, and a small recovery is evident in 2009. Catches of blue whiting have been greater than those of cod since 1999, reaching a peak in 2004. However, the catch has declined in recent years owing to reduced recruitment and lower fishing mortality. The total Northeast Atlantic catches of species other than cod and blue whiting in ISSCAAP Group 32 peaked in the early 1970s and then showed a general decline (Figure B2.4). Saithe (*Pollachius virens*) and haddock have formed an increased proportion of the catch, whereas whiting and Norway pout have declined alongside cod.

Both North Sea and Norwegian spring-spawning herring have recovered from overfishing and have sustained the growth in catches of herring through to the mid-2000s (ISSCAAP Group 35; Figure B2.5). The North Sea herring catch has largely stabilized despite low recent recruitment. Catches of European sprat (*Sprattus sprattus*) have been relatively stable in the last 15 years.

Capelin (*Mallotus villosus*) catches are affected by environment changes and, thus, show high short-term variability (ISSCAAP Group 37; Figure B2.5). Capelin catches were highest in 1970–1985, fluctuated dramatically between 1985 and 2005, and were at their lowest level between 2005 and 2009. Atlantic mackerel (*Scomber scombrus*) now makes the largest contribution to ISSCAAP Group 37, and, after a dip in 2006, its catch has returned to around the long-term average maintained since the mid-1970s.

Flatfish catches, primarily made up of plaice (*Pleuronectes platessa*), show a decline since 1990, primarily due to overfishing (ISSCAAP Group 31; Figure B2.6). Atlantic redfish fisheries (various deep-sea and oceanic stocks of *Sebastes mentella* and *S. marinus*; ISSCAAP Group 34) are predominantly in international waters in the Irminger Sea. The redfish catches declined overall between 2000 and 2009 partly owing to depletion and partly management action.

The small-mesh fishery for sandeels (ISSCAAP Group 33) has expanded substantially since the 1970s, supplying the market for fishmeal. Catches for 1985–2002 showed no trend and varied between 0.65 and 1.24 million tonnes (Figure B2.6). However, since 2002, sandeel catches have declined to below 500 000 tonnes owing to environmental change and the introduction of management measures.

Catches of shrimps and prawns (ISSCAAP Group 45), which include the valuable *Nephrops norvegicus* fisheries, increased between the early 1980s and 2000 (Figure B2.6). Since then, the fishery has declined to levels observed before 1980. These changes in total catch are mostly attributable to declines in northern prawn (*Pandalus borealis*) catch. Unlike northern prawn, the combined

FIGURE B2.4
Annual nominal catches of selected species in ISSCAAP Group 32, Northeast Atlantic (Area 27)

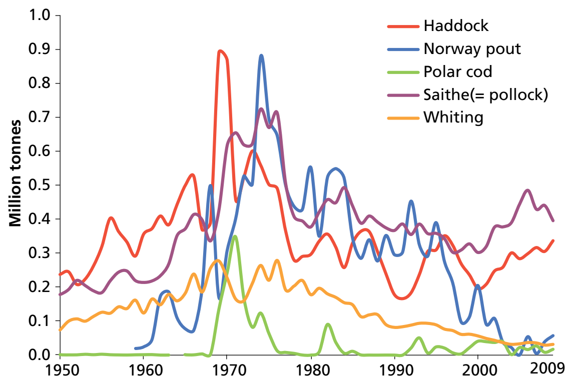


FIGURE B2.5
Annual nominal catches of selected species in ISSCAAP Group 35, 37, Northeast Atlantic (Area 27)

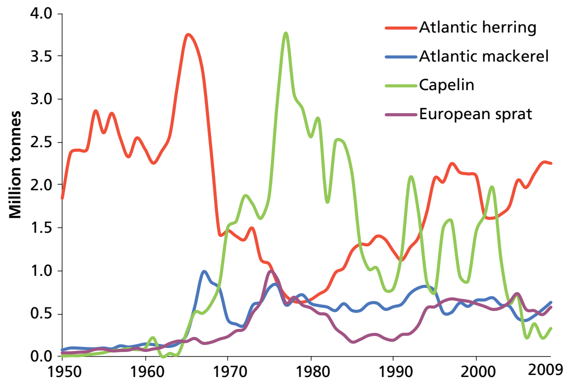
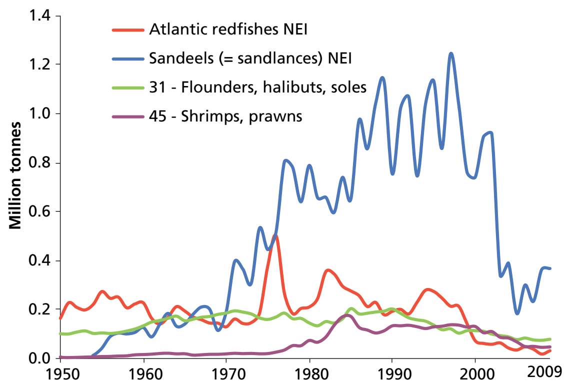


FIGURE B2.6
Annual nominal catches of selected species in ISSCAAP Groups 31, 33, 34, 45, Northeast Atlantic (Area 27)



catches of other shrimp and prawn in ISSCAAP Group 45 species declined slowly from the mid-1950s to 1990s. However, since 2000, their catch has risen to become stable at 40 000–50 000 tonnes.

RESOURCE STATUS AND FISHERY MANAGEMENT

The ICES provides scientific advice for fisheries in the Northeast Atlantic through its Advisory Committee (ACOM). This committee oversees the production of scientific advice for the management of coastal and ocean resources, and ecosystems on behalf of the ICES. Scientific research is coordinated with ACOM through the Science Committee (SciCOM). The scientific advice is based upon peer-reviewed analyses prepared in the ICES expert groups. The ACOM advice is used by the relevant management authorities, which include government institutions, particularly the European Commission, and multilateral organizations, notably the North East Atlantic Fisheries Commission (NEAFC).

In 2009 and 2010, ICES provided advice on 129 stocks. The majority of larger stocks are assessed annually with age-structured stock assessments. For most other species, the advice is constrained to suggesting limits on catches and identifying further information that is required for more precise recommendations on management measures. Lack of data, or unreliable data, is the main constraint on the precision and accuracy of these assessments. For several stocks, catches have been misreported, and many lack a reliable abundance index to apply standard assessment techniques. Current status of exploitation and trend of catch in the region is shown in Table D2.

Through limit and precautionary reference points for SSB and fishing mortality (F), ICES has attempted to implement the precautionary approach in a consistent way. However, for a large number of stocks, reference points remain undefined because the management authority has either yet to agree on the basis for defining them or the necessary data are lacking. More recently, MSY has been adopted as the standard basis for reference points (e.g. Iceland, European Union [EU] Common Fisheries Policy [CFP]) in line with other countries (e.g. the United States of America). In addition, the EU policy paper on fisheries management (COM (2010) 241 Annex III) defines the fishery categories that form the basis for TAC estimation. This is particularly useful where information and stock assessments are lacking. Better definition of fishery categories should lead to improvements over time in standardizing definitions of stock status.

The resource status described here is based upon the 2009 and 2010 advice (ICES, 2009, 2010a). The advice and working group reports are published on the ICES Web site (www.ices.dk).

Northeast Arctic fisheries (ICES Subareas I and II)

The main demersal and pelagic fisheries all show a similar pattern of depletion and recovery. Northeast Arctic cod and haddock are generally caught together in trawl fisheries under a joint agreement between Norway and the Russian Federation. Both stocks were depleted in much of the period from the 1950s to the 1980s. Since then, they have recovered through reduced fishing mortality and are currently considered to be harvested sustainably. Recent high biomass of both species is the result of the management controls that have limited fishing mortality very effectively. Saithe has recovered to a level on a par with the estimated spawning stock size in the 1960s. Stock condition for capelin is considered good with catches remaining at or below sustainable limits. This is important as capelin is an important prey for many predators in the region, including cod and haddock.

In contrast, Greenland halibut, Norwegian coastal cod and redfishes appear depleted. A rebuilding plan has been proposed by Norwegian authorities for their coastal cod, which is being evaluated by ICES. Greenland halibut (*Reinhardtius hippoglossoides*) has no recovery plan, and the 2010–12 TAC was set above that recommended for recovery. The scientific recommendation for redfishes (*Sebastes marinus* and *S. mentella*) is to keep catches as low as possible. This is not surprising given their current status, low productivity and the high fishing pressure in the region.

There is evidence that northern shrimp catches in the Barents Sea have been below their MSY. Similarly, there is no targeted fishery for polar cod (*Boreogadus saida*), and catches are low compared with the likely resource size of 1.2 million tonnes (Anon., 2009). However, polar cod, like capelin and sandeel, is an important prey for many arctic species, and safe levels of exploitation may be low under an ecosystem approach to fisheries.

The Baltic (ICES Divisions IIIb-d)

The Baltic ecosystem is heavily influenced by environmental conditions that result from the semi-enclosed nature of the sea. Freshwater inflows to the Baltic tend to lower salinity and oxygen levels. These can often raise temperature and nutrients, and can affect cod recruitment in particular. However, intermittent inflows of oceanic water from the North Sea with higher salinity and oxygen levels refresh the environmental state. This makes fishery management in the Baltic particularly difficult as sustainable exploitation levels will vary in response to the environmental conditions.

A major period of ecological stress in the Baltic appears to have occurred between 1987 and 1993 (Diekmann and Möllmann, 2010). In this period, low salinity, low dissolved oxygen, high temperatures and high nutrient levels occurred. At the same time, there was high cod fishing pressure, which may have pushed the biotic part of the ecosystem into a new state with reduced cod productivity. The abundance of cod as the main predator of sprat and herring has an important effect on the whole Baltic ecosystem.

Western and eastern Baltic cod (Subareas 22–24 and 25–32) appear currently fully exploited in 2009. Both stocks, but particularly eastern Baltic cod, have been through periods of prolonged depletion. Eastern Baltic cod has only recently (2008–09) been rebuilt, mainly by management achieving a significant reduction in fishing mortality. In addition, the Baltic cod fishery has had considerable problems with monitoring and control. Under-reporting of catches was a particular concern in 1993–96, and 2000–07. This problem appears to have reduced more recently.

There are several herring stocks in the Baltic that are fully exploited or whose status is unknown owing to a lack of data. The largest stock, central Baltic herring, is overexploited. Sprat is fully exploited and the stock has appeared stable in the last decade despite a trend in fishing mortality to above the precautionary level. However, the recovery in the main predator, cod, may require a reassessment of management objectives for these stocks.

The North Sea (ICES Subarea IV), Skagerrak (Divisions IIIa) and Eastern Channel (Division VIId)

The North Sea cod stock assessment now includes cod caught in Skagerrak, the Eastern Channel and the North Sea. Based on the estimated status in 2009, ICES classifies the stock as having "reduced reproductive capacity and as being at risk of being harvested unsustainably". The stock has increased in size since the lowest observed biomass in 2006, but rebuilding is not complete. Controlling fishing mortality has been difficult mainly owing to discarding practices and the mixed species composition of the demersal fishery. A major limitation on catches for many small-scale fisheries in this region is due to cod bycatch limits. However, there is a stronger 2005 cod year class, which, together with controls on fishing effort, will support the current rebuilding plan.

Haddock and saithe, in contrast to cod, are at full reproductive capacity and harvested sustainably, despite recent recruitments being poor. Whiting status in the region is unclear. Recruitment has been very low since 2002, with an indication of a modest improvement recently. However, ICES is currently recommending reduced whiting catches to reverse the long-term decline in population size.

With reduced importance of cod, smaller fisheries have increased as a proportion of the value of fisheries landings. Of these, the nephrops (Norway lobster, *Nephrops norvegicus*) are a resource that has increased in importance relatively recently. There are nine management units for nephrops in the North Sea and Skagerrak/Kattegat region with catches averaging between 1 000 and 10 000 tonnes. All of these units are fully exploited.

Plaice (*Pleuronectes platessa*) and sole (*Solea solea*) are the major species in the mixed flatfish fishery. Although still under a rebuilding plan in 2009, North Sea sole and plaice are classified as having full reproductive capacity and as being harvested sustainably. The status of smaller stocks of Eastern Channel sole and plaice is less certain. Both stocks are at greater risk of overfishing. Other flatfish species have not been assessed, but the reduction in directed effort on plaice and sole is likely to have had a positive effect on them as well.

The main herring stock, autumn-spawning North Sea herring, consists of a number of spawning components. The landings from these components cannot be separated and are therefore treated as a single stock. Recruitment of these stocks has been very poor since 2002. This poor recruitment has been taken into account in developing the EU–Norway agreement that sets exploitation levels on these species. There are some other small spring-spawning herring stocks associated with gravel beds and river estuaries that are managed locally.

The shorter-lived species such as the three sandeel stocks are considered at risk of reduced reproductive capacity. A reduction in their TAC was thus advised (ICES, 2011). The Norway pout (*Trisopterus esmarkii*) stock is considered at full reproductive capacity. Less is known about the state of sprat, but survey trends indicate the stock size has increased from the 1980s and has varied around an average level since 1998 with no trend. The population sizes of all these species are generally more influenced more by the environment than by longer-lived species. Temperature and salinity affects processes such as natural mortality and recruitment. This causes significant changes in population size even in the absence of fishing. In addition, they are important prey species for a number of other fish stocks (cod, saithe, haddock and mackerel), marine mammals and seabirds. Consideration of these issues makes management of the relevant fisheries difficult, and well-defined reference points are as yet unavailable.

Iceland (ICES Divisions Va), the Faeroe Islands (Vb), the Irminger Sea and Greenland (Subareas XII and XIV)

Cod is the most important resource in this region in terms of volume. Icelandic cod is the largest fishery. Although the current biomass remains low compared with levels observed in the 1950s, the stock is increasing in size and is above the limit reference point. A management plan is being implemented that should keep fishing mortality to levels more consistent with the MSY. The state of the slightly smaller Iceland and East Greenland cod stock is uncertain. The ICES recommendation was that no fishery should take place in 2011 to improve the likelihood of establishing offshore spawning stocks. The smaller Faroese cod stocks are also in a more parlous state than Icelandic cod; and ICES has recommended that the Faroe bank cod fishery be closed to allow stock recovery. Faroe plateau cod is in a better state, although its biomass is still below the target level.

Cod is often caught with haddock, but the haddock stock in the same area is probably in a better state, with its biomass as high as that observed in 1980s. However, haddock lacks a management plan, which is currently under development. Faroe haddock is also considered to be at risk, and ICES recommends catches should be as low as possible to allow rebuilding. The two stocks of saithe, in Faroe Islands and Iceland, are both considered at risk, and ICES recommends a reduction in fishing mortality on these stocks as well.

Greenland halibut stock in this region has remained close to its limit reference point. Despite recommendations to the contrary, fishing mortality on this stock has risen. The recommendation of ICES has been to set the TAC below 5 000 tonnes, which is substantially lower than the 2009 landings of just under 30 000 tonnes.

There are five management units for redfish (*Sebastes* sp.) identified in the region. These are slow-growing species that are likely to be vulnerable to overexploitation. Three of the stocks are considered fully exploited, whereas the Iceland and eastern Greenland shallow and deep water pelagic stocks of beaked redfish (*S. mentella*) are considered overexploited.

The status of Iceland–East Greenland–Jan Mayen capelin is unclear owing to the lack of reference points. The spawning stock left in spring 2009 was estimated to be below the management target, suggesting that the stock is at risk. Icelandic summer-spawning herring face a different problem. The stock increased from 2003 to well above the precautionary level owing to a reduction in fishing mortality. However, the stock has fallen dramatically since 2008, coinciding with an outbreak of *Ichthyophonus* infection, which continued in 2009. As it progresses, the disease will require the stock assessment to rely on the annual survey to obtain estimates of stock status.

The West of Scotland and Rockall (ICES Divisions VIa–b), the Irish and Celtic Seas (Divisions VIIa–c and VIIe–k), and the Bay of Biscay (Division VIIIa-b)

The ICES Divisions VI–VIII (excluding the Eastern Channel), covering areas to the west and south of the British Isles, contain upwards of 42 stocks monitored by ICES. The fisheries in this region have been under stress and present significant challenges for management. Many of these stocks are overexploited and others lack data to provide any scientific advice. Most stocks are relatively small with landings of less than 10 000 tonnes. Some stocks, for example haddock in Division VIa, are biologically part of the North Sea.

Western horse mackerel (*Trachurus trachurus*) is probably the largest fishery in terms of volume in this region. The fishery is considered fully exploited, although the exact status is unknown. The cod stocks form most of the other major landings. West of Scotland and Irish Sea cod are considered to have reduced reproductive capacity. The status of Celtic Sea and Rockall cod is unknown. However, precautionary advice for Celtic Seas suggests a reduction in fishing. Catches of the small Rockall stock appear to have declined without management intervention.

Many of the demersal fisheries are part of a mixed trawl fishery and are affected by discarding and misreporting. West of Scotland haddock and whiting are overexploited, whereas Rockall haddock appears fully exploited. There are inadequate data to assess Celtic Sea and Irish Sea haddock stocks. Irish Sea whiting is overexploited. Northern shelf anglerfish (*Lophius* spp.) and megrim (*Lepidorhombus* spp.) and West of Britain whiting are considered fully exploited.

There are separate plaice and sole stocks in the Western Channel, Irish Sea, West of Ireland, Southwest of Ireland and the Celtic Sea, all of which with the exception of Celtic Sea sole and Irish Sea plaice are considered at risk or harvested unsustainably. Irish Sea, West of Ireland and Scotland, and North of Scotland herring probably form a complex of stocks, which are at significant risk of overexploitation. The Celtic Sea/South of Ireland stock, however, has recently recovered and the stock is at full reproductive capacity.

The non-finfish fisheries in the region mainly target nephrops. There are 10 management units in the region with landings of between 500 and 7 000 tonnes. Of these, six are considered overexploited or at risk of reduced reproductive capacity. As with other small-scale fisheries, assessments are severely limited by data.

The Bay of Biscay sardine and sole fisheries are not likely to be overexploited, but assessments are severely data-limited. In contrast, the larger anchovy fishery is thought to be at risk. There is almost a 50 percent chance that the stock is below its limit reference point, where the risk to the reproductive capacity is considered unacceptable.

This region also includes the larger of the two hake stocks (*Merluccius merluccius*) in the Northeast Atlantic. The northern hake stock, which also extends into the North Sea, is at full reproductive capacity and is being harvested sustainably.

Iberian Region (ICES Division VIIIc and Subareas IX and X)

The main demersal species in the Iberian Region are hake (*Merluccius merluccius*), anglerfish (*Lophius* spp.) and megrim (*Lepidorhombus* spp.). In contrast to the northern hake stock, the southern hake is at reduced reproductive capacity and at increased risk of overfishing. Spanish and Portuguese megrim (*L. boscii* and *L. whiffiagonis*) are fully exploited. Anglerfish status is uncertain, but one of the two species is likely to be overfished. Scientific advice recommends reduction in catches to build the stocks to their MSY. There are also two small nephrops stocks, one of which, the North Galicia and Cantabrian Sea management unit, is considered to be overexploited.

The Spanish and Portuguese sardine (*Sardina pilchardus*) fishery, which is the largest by volume, the anchovy (*Engraulis encrasicolus*) fishery and the southern horse mackerel fishery are considered fully exploited and stable. While the sardine biomass has recently declined, this is due to poor recruitment, probably caused by chance or environmental effects.

North Atlantic and Baltic salmon stocks

There are more than 1 500 rivers with salmon (*Salmo salar*) stocks in the Northeast Atlantic Commission (NEAC) Area of the North Atlantic Salmon Conservation Organization (NASCO). Overall, data from monitored rivers suggest that there has been no trend in smolt production.

Salmon is divided broadly into three stock complexes. The smaller Northern European (Scandinavia and the Russian Federation) 1 sea-winter (1SW) and multi-sea-winter (MSW) stock complex is considered to be fully exploited, but at full reproductive capacity. The larger Southern European (Ireland, the United Kingdom of Great Britain and Northern Ireland, and France) 1SW stock is considered to be at reduced reproductive capacity, and the Southern European MSW stock complex is considered to be at risk of reduced reproductive capacity. The current estimates for the sizes of both stock complexes are among the lowest in the time series.

Although estimated exploitation rates have generally been decreasing over time for all stock complexes, there has been little improvement in the status of stocks. This is mainly because of continuing poor survival in the marine environment, probably because of climate effects.

Baltic salmon is assessed separately. The natural smolt production of salmon populations in the Baltic has continued to increase and is now about 70 percent of the overall potential wild production. However, in common with other salmon populations, survival of post-smolt fish has remained low, and has suppressed recovery of wild salmon stocks.

Widely distributed, deepwater and migratory stocks

Blue whiting are caught from the Barents Sea to the Straits of Gibraltar. Based on the 2009 estimates of biomass and fishing mortality, ICES classifies the stock as having full reproductive capacity and being harvested sustainably. Recently (in 2008), a new management plan has been implemented by Norway, EU, Faroe Islands and Iceland.

Mackerel is assessed as a single stock for the Northeast Atlantic, although it is made up of distinct spawning components, of which the Western is by far the largest. The SSB has increased from a low of 1.8 million tonnes in 2002 to about 2.5 million tonnes in 2008, a level similar to that seen in the 1990s. At present, the stock as a whole is at full reproductive capacity. However, the North Sea component is still depleted and, hence, catches in the North Sea are prohibited at appropriate times to encourage its recovery.

Despite the recent increased SSB, the fishery has a number of problems. Catches have generally exceeded the levels recommended by ICES. Misreporting has been a serious problem in this fishery, especially in international waters, although the problem has been very much reduced in recent years. There is an agreed management plan, but this has not been followed since 2007 owing to disagreements among the fishing nations. Problems are partly due to the summer mackerel distribution extending farther north in recent decades, so that the stock is being commercially fished in areas where it was previously not fished, particularly in the Icelandic EEZ.

Deepwater species such as the Argentine (*Argentina sphyraena*), greater silver smelt (*Glossanodon leioglossus*), roundnose grenadier (*Coryphaenoides rupestris*) and Atlantic orange roughy (*Hoplostethus atlanticus*), along with more than 20 other species of bony fish and more than 10 species of sharks are now caught in deepwater fisheries. The productivity of these stocks is often low even where the population sizes are initially large. This makes them particularly vulnerable to overfishing. The advice of ICES is that effort in these fisheries be kept as low as possible until the response of these species to fishing is better understood. Therefore, appropriate data need to be collected from these fisheries if they are to be continued. Indeed, ICES goes so far as to recommend that some stocks, for example, orange roughy, should not be fished at all. For others such as tusk (*Brosme brosme*), ling (*Molva molva*) and red seabream (*Pagellus bogaraveo*), the fisheries may have long-term potential, depending on the area fished.

ENVIRONMENTAL ISSUES

A report by ICES (2010b) outlined the main physical oceanographic events that occurred in 2009:

- The upper layers of the northern North Atlantic and the Nordic Seas were warm and saline in 2009 compared with the long-term average.
- A strong cold anomaly developed in the surface of the central North Atlantic in the summer.
- Warming and salination of deep waters has continued.

Evidence suggests multidecadal changes in ocean climate have been driving changes in recruitment and productivity in the North Atlantic and Pacific Ocean (Klyashtorin, 2001). Long-term climate change may make stocks more vulnerable to fishing by reducing the overall carrying capacity of the stock. This will mean that past exploitation rates might not be sustained (Jennings and Blanchard, 2004) and reference points based on historical data may be invalid. Therefore, s main concern is how climate change affects the way fisheries should be managed (Rijnsdorp *et al.*, 2010).

The effects of climate change are potentially complex and difficult to predict (Rijnsdorp *et al.*, 2010). Climate will affect not only average temperatures, but the frequency of very cold or hot seasons, changes in sea ice cover, CO_2 levels, pH, salinity, wind and rainfall patterns. Changes in these can affect physiology, behaviour and population dynamics of species, and hence affect whole ecosystems. Separating these effects from the more direct effects of pollution and fishing is difficult. One of the problems for fisheries science is the complex life history of fishes. They have a factor of ten increase in body size throughout life that leads to major changes in ecology (Rothschild, 1986). Pre-recruits, in particular, may be in life stages that are more vulnerable to changes in climate.

Productivity of fish populations is determined by recruitment, growth and mortality, all of which can be affected by changes in climate. For example, in a comparative study of 15 cod stocks, the large differences in productivity corresponded to differences in water temperature (Dutil and Brander, 2003). In the Bay of Biscay and Mediterranean, changes in river runoff are expected to alter the productivity of sole (Rijnsdorp *et al*., 2010). Climate change may also affect management controls. Closed areas may not achieve their objectives because species or life stages shift outside the boundaries of the protected area (e.g. the North Sea "Plaice Box" – van Keeken *et al*., 2007).

Another concern is the effect on benthic habitats of bottom trawls, particularly beam trawls. Beam trawls have been shown to affect the benthic community on sand (de Groot, 1984) and gravel beds (Kaiser and Spencer, 1996). There is little doubt among fisheries managers that many fishing gear types are affecting benthic habitats. The problem facing fisheries managers is to quantify and manage this impact, as the interaction is complex. The primary problem is the physical impact of the gear on the animals on or close to the substrate surface. The degree of impact will depend on the weight and speed of the trawl, frequency of trawling, and the bottom type as well as the characteristics of the animals themselves (OSB, 2002). Management of these impacts involves a multistep process:

- Identifying an acceptable impact as many of the fisheries had been operating for many years before baseline data were collected. This makes the basis for determining the acceptable ecological impact on habitat and the ecosystem unclear.
- Assessing the impact for different gear types and minimizing impacts through technical changes to the gear and the way it is used.
- Controlling the fishery operation over the various marine habitats (the fishery "footprint"), which involves overlaying the fishery activity on a habitat map, and limiting the area of the fishery or frequency at which specific areas are fished.
- Applying overall control on fishing activity, such as limits on capacity and fishing effort. This forms the more usual fishery management intervention and is necessary to conserve the target stock.

The Marine Strategy Framework Directive (EU, 2008) provides the policy for dealing with this sort of issue in the EU. However, obtaining the necessary information to implement the effective management may still take time.

Other environmental concerns arise out of the expansion of mariculture in the Northeast Atlantic region. Extensive farming exists for Atlantic salmon, which may have environmental impacts through local eutrophication. Potential negative impacts on wild populations from salmon farming can occur through interbreeding and introduction of disease.

MANAGEMENT ISSUES

Until the late 1970s and early 1980s, the principal RFMO in Area 27 was the NEAFC. However, the declaration of 200-mile EEZs and the establishment of the CFP of the EU have changed the management landscape. For fish stocks occurring exclusively within the jurisdiction of the coastal State, it is that State that manages the resource exploitation. This applies to the majority of marine stocks in the region. For States that are members of the EU competency for fishery managements lies with the European Commission and is administered by DG MARE. Fisheries on stocks shared between Norway and the Russian Federation are managed through the Norwegian–Russian Fishery Commission. This means that the role of the NEAFC is now largely confined to shared stocks that also occur in international waters such as mackerel, blue whiting and redfish. The NEAFC recommends and coordinates measures to maintain the rational exploitation of fish stocks in its convention area with scientific advice from ICES. Measures are implemented by the contracting parties that include the EU, as well as Denmark (in respect of Faroe Islands and Greenland), Iceland, Norway and the Russian Federation. The NEAFC not only harmonizes measures in the region, but coordinates the management of shared stocks, and perhaps most importantly, manages fisheries in international waters. If requested, it will also recommend measures for regions under national jurisdiction.

Most fisheries are managed with stock-specific TACs. Therefore, ICES is typically requested to provide catch advice on a stock-by-stock basis. However, other fishery management measures are frequently used as well. Advice is modified to take account of technical interactions (e.g. bycatch in mixed species fisheries) or of biological interactions (e.g. predator–prey) where appropriate.

The majority of the commercial fish resources of the Northeast Atlantic have been overexploited or depleted despite substantial investment in fishery science, monitoring, control and surveillance. Critical components for good management were lacking. These include effective consultation with all stakeholders, enforcement and a clear, understandable process for dealing with risk and uncertainty. However, the signs are positive that management is now improving.

The CFP of the EU, and other fisheries policies in the region, continue to be developed and improved. The latest EU policy is being revised from one that focused on fish production to one concerned much more with sustainable use. This is being complemented with a more effective monitoring, control and surveillance (MCS) system implemented in 2009.

Currently, seven Regional Advisory Councils (RACs) have been established after the revision of the EU CFP in 2002 (EU, 2004, 2007). The objective of the RACs is to work towards integrated and sustainable management of fisheries, based on the ecosystem and precautionary approaches. They provide a way for stakeholders to discuss issues and develop management plans.

Another related and important ongoing development has been the implementation of testable, explicit and transparent harvest control rules. These now form the core of a number of management plans. Fisheries where such management plans appear successful include Northeast Arctic cod and haddock, North Sea herring, sole and plaice. The harvest control rules have aided dialogue between industry (through, for example, the RACs) and ICES (through management plan evaluations). Even where management plans are not being implemented successfully, such as with mackerel, the harvest control rule still provides a clear way to measure management performance and a focus for improvement.

In developing management plans, ICES and relevant management authorities are incorporating MSY as the default basis for reference points, along with ecosystem and precautionary approaches. The transition to the ecosystem approach (ICES, 2004) and MSY-based management will be gradual (COM, 2006).

ACKNOWLEDGEMENTS

Robin Cooks and Jean-Jacques Maguire reviewed an earlier version of the text and their constructive comments have greatly improved the manuscript.

REFERENCES

Anon. 2009. *Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea August-October 2008 Volume 1*. IMR/PINRO Joint Report Series, No. 1/2009. ISSN 1502-8828. 103 pp.

Commission of the European Communities (COM). 2006. *360 final. Implementing sustainability in EU fisheries through maximum sustainable yield*. Communication from the Commission to the Council and the European Parliament. Brussels.

de Groot, S.J. 1984. The impact of bottom trawling on benthic fauna of the North Sea. *Ocean Management*, 9: 177–190.

Diekmann, R. & Möllmann, C., eds. 2010. *Integrated ecosystem assessments of seven Baltic Sea areas covering the last three decades*. ICES Cooperative Research Report No. 302. 90 pp.

Dutil, J. D. & Brander, K. 2003. Comparing productivity of North Atlantic cod (*Gadus morhua*) stocks and limits to growth production. *Fisheries Oceanography*, 12: 502–512.

European Union (EU). 2004. Council Decision of 19 July 2004 establishing Regional Advisory Councils under the Common Fisheries Policy (2004/585/EC). *In*: *Official Journal of the European Union*.

European Union (EU). 2007. Council Decision of 11 June 2007 amending Decision 2004/585/EC establishing Regional Advisory Councils under the Common Fisheries Policy (2007/409/EC). *In*: *Official Journal of the European Union*.

European Union (EU). 2008. Council Decision of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) (2008/56/EC). *In*: *Official Journal of the European Union*.

International Council for the Exploration of the Sea (ICES). 2004. *Report of the Thirteenth ICES Dialogue Meeting: Advancing scientific advice for an ecosystem approach to management: collaboration amongst managers, scientists, and other stakeholders Dublin, Ireland, 26–27 April 2004*. ICES Cooperative Research Report No. 267.

International Council for the Exploration of the Sea (ICES). 2009. *Report of the ICES Advisory Committee, 2009*. ICES Advice, 2009. Books 1–10.

International Council for the Exploration of the Sea (ICES). 2010a. *Report of the ICES Advisory Committee, 2010*. ICES Advice, 2010. Books 1–10.

International Council for the Exploration of the Sea (ICES). 2010b. *Report of the Working Group on Oceanic Hydrography (WGOH) 9–11 March 2010, Brest, France*. ICES CM 2010/SSGEF:08. 157 pp.

International Council for the Exploration of the Sea (ICES). 2011. *Advice February 2011. Ecoregion North Sea Sandeel in Division IIIa and Subarea IV*. Book 6: 6.4.21

Jennings, S. & Blanchard, J.L. 2004. Fish abundance with no fishing: predictions based on macroecological theory. *Journal of Animal Ecology*, 73: 632–642.

Kaiser, M.J. & Spencer, B.E. 1996. The effects of beam-trawl disturbance on infaunal communities in different habitats. *Journal of Animal Ecology*, 65: 348–358.

Klyashtorin, L.B. 2001. *Climate change and long-term fluctuations of commercial catches: the possibility of forecasting*. FAO Fisheries Technical Paper No. 410. Rome, FAO. 86 pp.

Ocean Studies Board (OSB). 2002. *Effects of trawling and dredging on seafloor habitat. Committee on Ecosystem Effects of Fishing: Phase 1—effects of bottom trawling on seafloor habitats*. Washington, DC, National Academy Press.

Rijnsdorp, A.D., Peck, M.A., Engelhard, G.H., Möllmann, C. & Pinnegar, J.K. 2010. Resolving the effect of climate change on fish populations. *ICES Journal of Marine Science*, 66: 1570–1583.

Rothschild, B.J. 1986. *Dynamics of marine fish populations*. Cambridge, USA, Harvard University Press.

Sparholt, H. & Cook, R.M. 2009. Sustainable exploitation of temperate fish stocks. *Biology Letters*, 6: 124–127.

van Keeken, O.A., van Hoppe, M., Grift, R.E. & Rijnsdorp, A.D. 2007. The implications of changes in the spatial distribution of juveniles for the management of North Sea plaice (*Pleuronectes platessa*). *Journal of Sea Research,* 57: 187–197.

B3. Western Central Atlantic

FAO STATISTICAL AREA 31

Tarûb Bahri
Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: tarub.bahri@fao.org

INTRODUCTION

The area covered by the Western Central Atlantic Fisheries Commission (WECAFC) extends from Cape Hatteras in North Carolina, the United States of America (35°N), to just south of Cape Recife in Brazil (10°S). It includes an area of almost 15 million km^2, of which approximately 1.9 million km^2 is shelf area (Stevenson, 1981). The major subdivisions in this region are the southeast coast of the United States of America, the Gulf of Mexico, the Caribbean Sea and the northeast coast of South America, which includes the Guyanas (French Guiana, Guyana and Suriname) and Brazil.

The WECAFC area includes FAO Statistical Area 31 and a portion of Area 41 offshore of northern Brazil. This chapter deals only with Area 31 (Figure B3.1 and Table B3.1). The region is geographically one of the most complex regions of the world. It is split up into a number of deep ocean basins separated by shallow zones. There are also a large number of island platforms, offshore banks and the continental shelf. The major island groups in Area 31 are the Bahamas and adjacent banks and islands. These account for more than half of the islands and banks shelf area and include the Greater Antilles (Cuba, Puerto Rico, Jamaica and Hispaniola), and the Lesser Antilles (Stevenson, 1981).

The North Equatorial Current flows west slightly north of the equator. It meets the Guiana Current before splitting in two branches: the Caribbean Current that enters

FIGURE B3.1
The Western Central Atlantic (Area 31)

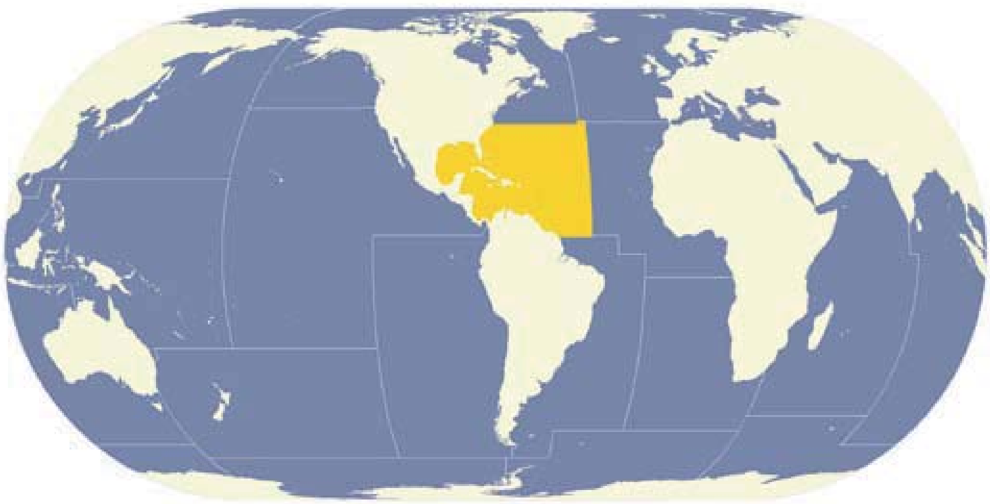


TABLE B3.1
Locality and area of the major coastal shelf zones in the WECAF area

Location	Area (thousand km²)	FAO Area
Continental shelf		
United States east coast	110	31
Gulf of Mexico	600	31
Yucatan – eastern Venezuela (Bolivarian Republic of)	250	31
Guyana, Suriname, French Guiana	200	31
Northern Brazil	360	41
Total Continental shelf	1 520	
Islands		
Islands and offshore banks	380	31
Grand total	1 900	

Source: Stevenson (1981).

the Caribbean Sea, and the Antilles Current that flows northwards along the Antilles and joins the Florida Current to form the Gulf Stream. The Caribbean Current flows northwest through the Caribbean Sea, with a number of meanders, filaments and eddies that show spatiotemporal variability. Eventually, the water flows through the Yucatan Channel into the Gulf of Mexico, where it becomes the Loop Current that flows clockwise through the Gulf of Mexico and through the Straits of Florida to become the Florida Current.

Freshwater discharges from the Mississippi, Orinoco and Amazon Rivers have an important influence on sediment discharge and ocean circulation in the region. The productivity of the waters is recognized to be influenced by these major rivers, even though the runoff is seasonal.

The productivity of the region is heterogeneous with alternating areas of high and low productivity. Areas of high productivity are typically the plumes of the main rivers, coral reefs, mangroves and seagrass beds. These last three are the coastal habitats of main interest, as they provide coastal protection against waves and storm surges. They also host the spawning and nursery grounds of a number of living marine species (Heileman, 2007). Seasonal upwelling is also a source of high productivity, especially between January and June in the southern Caribbean (Muller-Karger and Aparicio-Castro, 1994).

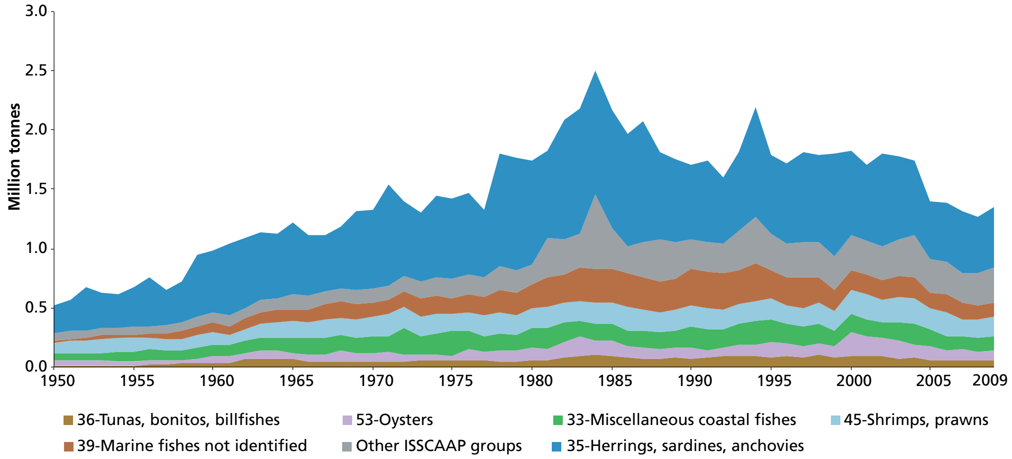
The WECAFC area has a high diversity of species, particularly around southern Florida, eastern Bahamas and northern Cuba. There is also a high level of species endemicity within the Caribbean. The Caribbean Sea has the highest level of species diversity in the tropical Atlantic and is considered a global hotspot of marine biodiversity (Roberts *et al.*, 2002; Miloslavich *et al.*, 2010). Species of interest to fisheries include molluscs, crustaceans (lobster, penaeid shrimps, crabs), coastal fishes occupying various substrata (soft bottom or reefs), large migratory fish species and deep-slope fish species.

PROFILE OF CATCHES

The total landings in Area 31 increased steadily from about 0.5 million tonnes in 1950 to a peak of near 2.5 million tonnes in 1984. This was followed by a rapid decline between 1984 and 1992, and catches stabilized subsequently at about 1.5 million tonnes until 2003 (Figure B3.2). They then declined further to 1.3 million tonnes in 2009. This decrease is mainly due to the diminished catches of ISSCAAP Groups 33 (miscellaneous. coastal fishes that include groupers, snappers, mugilidae) and 35 (small pelagic fish, herrings, sardines and anchovies).

The proportion of non-identified species remained stable throughout the years (between 15 and 20 percent), indicating that no or limited progress was made in the identification of the species in the landings. ISSCAAP Group 39 (marine fishes not identified) accounted for 124 000 tonnes and 117 000 tonnes of the total landings in 2008 and 2009, respectively (about 10 percent of the catches).

FIGURE B3.2
Annual nominal catches by ISSCAAP species groups in the Western Central Atlantic (Area 31)



ISSCAAP Group 35 (herrings, sardines, anchovies) makes the largest contribution in the catches, with 44 percent of the total catches in Area 31 in 2009. This is mostly due to the Gulf menhaden (*Brevoortia patronus*) caught mainly by the United States of America. Catches of this species increased irregularly from about 200 000 tonnes in 1950 and reached a peak in 1984 at 1 million tonnes. After 1984, the catches declined, dropping to 433 000 tonnes in 1992. In recent years, the landings have been relatively stable, fluctuating between 450 000 tonnes and 500 000 tonnes, with a minimum recorded in 2005 at 370 000 tonnes (Figure B3.3). The most recent declines in landings are in part because of the active tropical storm season in 2004 and the two major hurricanes, Katrina and Rita, in 2005 that damaged vessels and processing plants (Vaughan, Shertzer and Smith, 2007). Atlantic menhaden (*B. tyrannus*) is the other species that used to be important in terms of landings in the United States of America. However, the fishery has experienced a continuous decline in catch in the last few years, reaching a historical low of 120 tonnes in 2009.

Six families dominate the small pelagic catches from ISSCAAP Groups 35 (herrings, sardines, anchovies) and 37 (Other miscellaneous pelagic fishes): Exocetidae (flyingfishes); Clupeidae (herrings and sardines); Engraulidae (anchovies and anchovetas); Carangidae (jacks, bumpers and scads); and Hemiramphidae (halfbeaks).

The round sardinella (*Sardinella aurita*) still accounts for important catches in weight. However, the landings show wide fluctuations, with a spectacular increase in the 1990s, reaching a maximum of 191 000 tonnes in 1998. This was followed by a steep decrease from 160 000 tonnes in 2002 to 37 000 tonnes in 2009, mostly reported by Venezuela (Bolivarian Republic of) (Figure B3.4). As for the previous years, the flathead grey mullet (*Mugil cephalus*), unidentified mullets and the Atlantic thread herring (*Opisthonema oglinum*) represent a significant proportion of the catches, accounting for 21 000 tonnes in 2009. The flathead grey mullet catches decreased by nearly two-thirds from 16 700 tonnes in 1996 to 6 000 tonnes in 2009, and was only reported by

FIGURE B3.3
Annual nominal catches of selected species in ISSCAAP Group 35 in the Western Central Atlantic (Area 31)

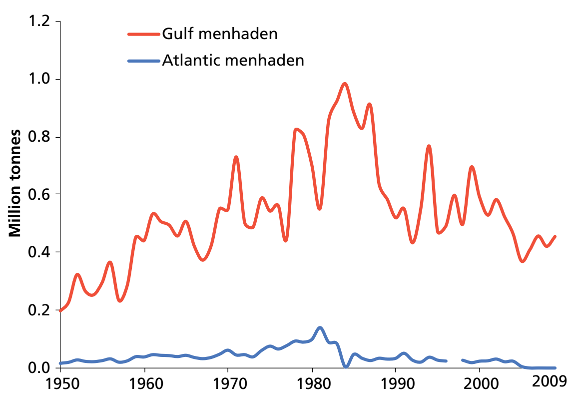
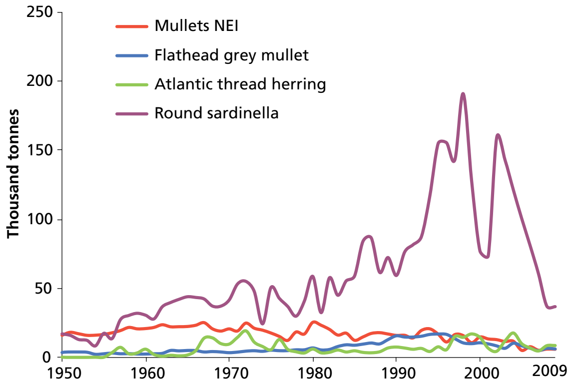


FIGURE B3.4
Annual nominal catches of selected species in ISSCAAP Groups 33, 35 in the Western Central Atlantic (Area 31)



Venezuela (Bolivarian Republic of) and Mexico. The countries declaring Atlantic thread herring are mainly Venezuela (Bolivarian Republic of), Cuba and the United States of America. The landings show wide fluctuations in the last 15 years, with a minimum of 4 500 tonnes in 2002 and a maximum of 17 700 tonnes in 2004. The most recently reported catch was 9 000 tonnes in 2009. Whereas the Atlantic thread herring catches have fluctuated over the years, with successive high and low catches, those of the mullets show an overall decreasing trend in the last two decades.

The catches of unidentified jacks and trevallies of the genus *Caranx* are reported mainly by Venezuela (Bolivarian Republic of), Mexico and Trinidad and Tobago. They show a regular increase from 3 000 tonnes in 1950 to a maximum of 12 800 tonnes in 1997 and then a steep decrease from 12 400 tonnes in 2003 to 5 400 tonnes in 2009. This most recent decline was mainly due to a reduction in the landings declared by Mexico. This decrease actually corresponds to a change in the reporting system in 2005, when Mexico started reporting blue runner (*Caranx crysos*). If the landings of *Caranx* spp. and *Caranx crysos* are summed, the trend actually shows fluctuations around an annual average of 10 800 tonnes in the period 2003–09. This illustrates that the changes are due to improved species identification rather than any underlying change in the fishery or ecosystem.

The four-winged flyingfish (*Hirundichthys affinis*) is known to support important local fisheries in the eastern Caribbean for bait fish and human consumption. The landings statistics are poor, but were recently corrected for Barbados, Tobago, Grenada, Saint Lucia, Saint Vincent and Grenadines, Martinique and Dominica. These corrected catch statistics show landings fluctuating around 3 500 tonnes in the period 1985–2004. This was followed by a decrease in the last few years when catches reached 2 500 tonnes (FAO, 2010). As for the common dolphinfish (*Coryphaena hippurus*), the countries reporting the highest catches recently have been Venezuela (Bolivarian Republic of), Barbados, France (Guadeloupe), Saint Lucia and the United States of America. The catches of this species have increased regularly since the 1950s. They reached 4 500 tonnes in 1997, then decreased to 2 600 tonnes in 2005, before increasing again to more than 5 000 tonnes in 2009. Venezuelan catches accounted for one-third of the total in 2008 and 2009.

The ISSCAAP Group 33 (miscellaneous coastal fishes) continues to contribute a significant proportion of the landings (Figure B3.2). This group accounted for about 9 percent of the catches in the region in 2009. The species or families that contribute the most to this group are: marine catfishes (Ariidae); groupers, seabasses (Serranidae), especially the groupers (*Epinephelus* spp.); grunts, sweetlips (Haemulidae); snappers, jobfishes (Lutjanidae), especially the northern red snapper (*Lutjanus campechanus*), the yellowtail snapper (*Ocyrus chrysurus*) and the vermilion snapper (*Rhomboplites aurorubens*), croakers, drums (Sciaenidae), especially the weakfishes (*Cynoscion* spp.) and the whitemouth croaker (*Micropogonias furnieri*); and the snooks (Centropomidae), especially the common snook (*Centropomus undecimalis*). Overall, the catches of this Group are lower than in the previous decade, despite a peak in 2003–05; the current catches are about 119 000 tonnes (Table D3).

The subdivision of the miscellaneous coastal fish (soft substrata and reef fishes) of the previous review (Cochrane, 2005) has been retained in this analysis. The sea catfish catches increased from 1950 reaching almost 30 000 tonnes in 2004 but then decreased sharply, dropping below 7 000 tonnes in 2009, only one-quarter of their 2004 peak (Figure B3.5). The main fishing countries remain Mexico and Venezuela (Bolivarian Republic of). The weakfish catches alternated between a peak of more than 19 000 tonnes in 2004 and a low of 9 000 tonnes in 2007, before increasing again to 13 000 tonnes in 2009. The 2009 catch corresponds to the average value in the period 1970–2009. Weakfish are mainly landed by Venezuela (Bolivarian Republic of) and to a lesser extent by Mexico and French Guiana. Spotted weakfish (*Cynoscion nebulosus*) catches dropped significantly from more than 6 000 tonnes in 2002 to less than 400 tonnes in 2009. Similarly, landings of common snook decreased substantially from more than 9 000 tonnes in 2004 to 1 500 tonnes in 2009, mainly because of the decrease in the catches declared by Mexico. In contrast, unidentified snook catches in Mexico almost doubled from 2 000 tonnes in 2003 to more than 3 800 tonnes in 2009. This indicates deterioration in species identification of the reported catches. Although catches vary widely, whitemouth croaker catches have also demonstrated a clear decline from about 6 000 tonnes in 2004 to 2 700 tonnes in 2009 (Figure B3.5). This species is mainly fished by Venezuela (Bolivarian Republic of).

FIGURE B3.5
Annual nominal catches of selected soft-bottom species, Western Central Atlantic (Area 31)

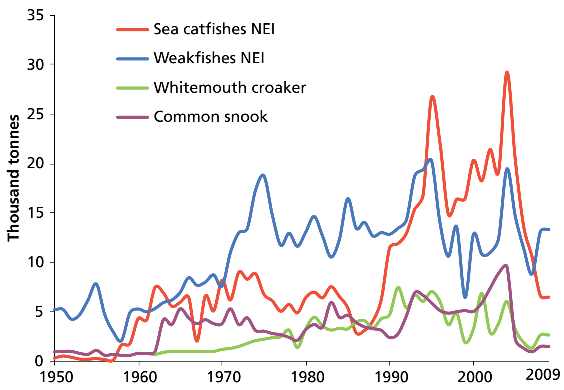
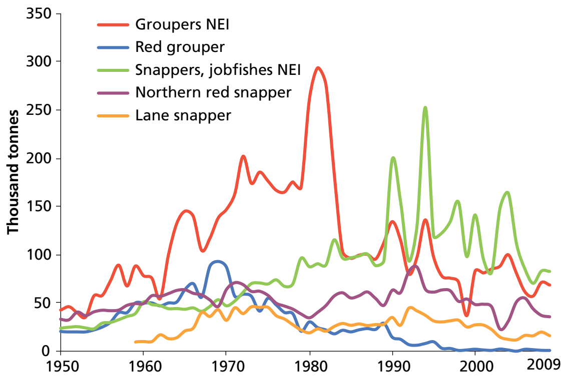


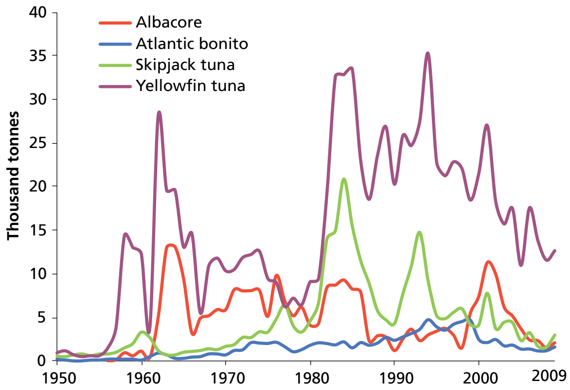
FIGURE B3.6
Annual nominal catches of selected reef species in the Western Central Atlantic (Area 31)



Catches of unidentified groupers show an important decreasing trend since their peak of 29 000 tonnes in 1981, reaching 7 000 tonnes in 2009. Red grouper (*Epinephelus morio*) landings have decreased more or less continuously from the maximum of 9 300 tonnes observed in 1970. However, the catches reported for red grouper only reflect landings by Cuba and the Dominican Republic and not those of the major producers in the region: Mexico and the United States of America. In Mexico average catches during the period 2002-2006 amount to about 6 500 tonnes (Burgos-Rosas *et al.* 2008) while in the USA for the same period the average was about 3 200 tonnes (SEDAR, 2009a). Landings of unidentified snappers and jobfishes increased throughout the recording period until 1990 and then started showing wide oscillations. Despite the fluctuations, there seems to be a decreasing trend since the 1990s, with 8 000 tonnes being landed in 2009. Venezuela (Bolivarian Republic of), Mexico and the Dominican Republic are the countries that declare the highest landings of unidentified snappers and jobfishes. The northern red snapper (*Lutjanus campechanus*) and the lane snapper (*L. synagris*) landings show fluctuations throughout the period, with a decreasing trend since the early 1990s (Figure B3.6).

The decreasing trend for Nassau grouper (*Epinephelus striatus*) has continued, with a minimum of 246 tonnes caught in 2009, most of which was declared by the Bahamas. Nassau groupers have been severely depleted by fishing and the species was listed on the International Union for Conservation of Nature (IUCN) Red List of Threatened

FIGURE B3.7
Annual nominal catches of selected species in ISSCAAP Group 36 in the Western Central Atlantic (Area 31)



Species in 2003. Many of the remaining spawning aggregations are protected; this may account for the decrease in the landings in recent years, among other things.

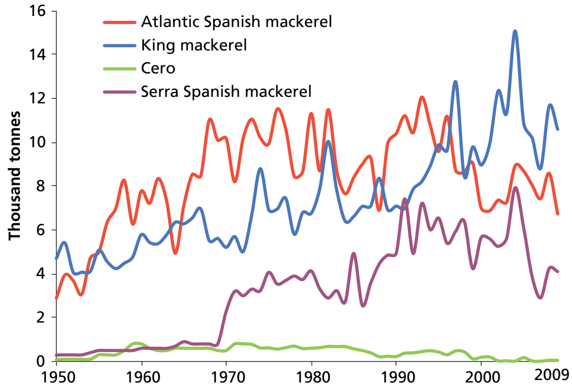
Vermillion snapper (*Rhomboplites aurorubens*) started to be declared in 1997, with an average of 800 tonnes per year until 2004. However, in the last five years, the landings have reached an average of 3 700 tonnes per year. This is due mainly to the fact that Mexico started reporting higher landings in 2005, as well as to a slight increase in the catches of the United States of America. More than an increase in catches, this is probably due to an improved identification of the species and, hence, more correct reporting of the landings. This is also reflected in the statistics on other coastal species, such as yellowtail snapper (*Ocyurus chrysurus*), unidentified snappers and jobfishes, grey snapper (*Lutjanus griseus*), cubera snapper (*Lutjanus cyanopterus*), white grunt (*Haemulon plumierii*), unidentified snooks (*Centropomus* spp.), sea catfishes (Ariidae), unidentified porgies and seabreams (Sparidae). For example, Mexican landings show wide variations between 2004 and 2005, with some landings doubling or even tripling from one year to the next. This reallocation of the catches would explain why some species show a spectacular decline in 2005 in Mexico, as for example common snook (*Centropomus undecimalis*) (5 400 tonnes in 2004 to 20 tonnes in 2005).

The catches of the ISSCAAP Group 36 (tunas, bonitos and billfishes) fluctuate widely between years. The major species show a clear declining trend, although the starting year of the decline varies among species (Figure B3.7). The overall catch of the group averaged 87 000 tonnes in the 1990s and 71 000 tonnes in the 2000s.

Yellowfin tuna (*Thunnus albacares*) remains the most landed species. Two distinct periods could be identified while analysing the catches of this species: from 1950 to 1980, the catches increased up to a maximum of 28 000 tonnes in 1962, before decreasing to 6 400 tonnes in 1979. A notable increase occurred between 1980 and 1985 (33 500 tonnes) and then catches show an overall decrease until 2009, when they reached 12 700 tonnes. The decrease is attributed to reduced fishing effort on yellowfin. However, in some areas, environmental conditions may have affected abundance (ICCAT, 2009). The albacore (*Thunnus alalunga*) catches have continued to decrease, falling from 10 000 tonnes in 2002 to 2 000 tonnes in 2009. This is probably because of a reduction in effort by the fleet from Taiwan Province of China. Skipjack tuna (*Katsuwonus pelamis*) landings fluctuated, but with a decreasing trend, between 3 700 tonnes in 2002 and 3 000 tonnes in 2009. The main fishing countries are Venezuela (Bolivarian Republic of) and, to a lesser extent, Cuba. The Atlantic bonito (*Sarda sarda*) landings increased regularly from the 1950s, reaching a maximum of 4 700 tonnes in 1994. Landings then started decreasing, reaching 1 600 tonnes in 2009, when the catches were mainly reported by Mexico.

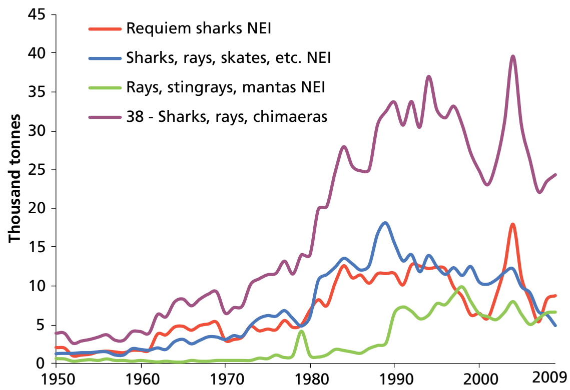
The coastal large pelagic catches are dominated by the same species as in previous years: king mackerel (*Scomberomorus cavalla*), declared mainly by Mexico, the United States of America, Venezuela (Bolivarian Republic of) and Trinidad and Tobago; Atlantic Spanish mackerel (*Scomberomorus maculatus*), in Mexico and the United States of America; serra Spanish mackerel (*Scomberomorus brasiliensis*) in Venezuela (Bolivarian Republic of) and Trinidad and Tobago; and cero (*Scomberomorus regalis*), (Figure B3.8). The catches of all four species are characterized by wide fluctuations. In the last few years, there seems to be an overall decreasing trend for Atlantic Spanish mackerel, with catches as low as 6 700 tonnes in 2009. There has been an overall increasing trend for king mackerel since records began. In 2009, the catches of king mackerel and serra Spanish mackerel were 10 600 tonnes and 4 100 tonnes, respectively. The recorded Cero catches show low values in the years 2000s compared to the 1990s. Catches fluctuated around an average of 50 tonnes in the period 2002–09. In light of the most recent landings statistics, it appears that landings of cero have a totally different pattern compared with the historical data (1950–1984). The 1990s and 2000s were characterized by a sharp decrease in landings, and the most recent catches represent only 5 percent of what the catches used to be at the time of the historical maximum of 800 tonnes in the 1960s and 1970s. The species has been reported only by the Dominican Republic and Puerto Rico since then.

FIGURE B3.8
Annual nominal catches of selected species in ISSCAAP Group 36 in the Western Central Atlantic (Area 31)



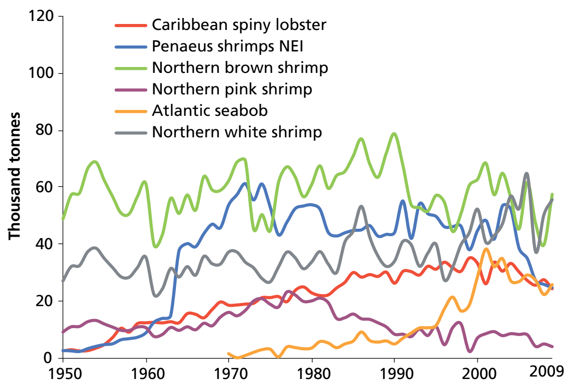
After an overall increase until the mid-1990s, the catches of ISSCAAP Group 38 (sharks, rays, chimaeras) seem to have been decreasing since 1994. Yet, in 2004, the catches suddenly increased and reached a historical peak at 39 600 tonnes (Figure B3.9). The 2004 peak seems to be due mainly to an increase in catches of requiem sharks by Venezuela (Bolivarian Republic of) (catches increased by more than twofold between 2002 and 2004). Larger catches of unidentified rays, stingrays and mantas were also reported by Venezuela (Bolivarian Republic of) and the ISSCAAP Group 38 landings from Guyana.

FIGURE B3.9
Annual nominal catches of selected species in ISSCAAP Group 38 in the Western Central Atlantic (Area 31)



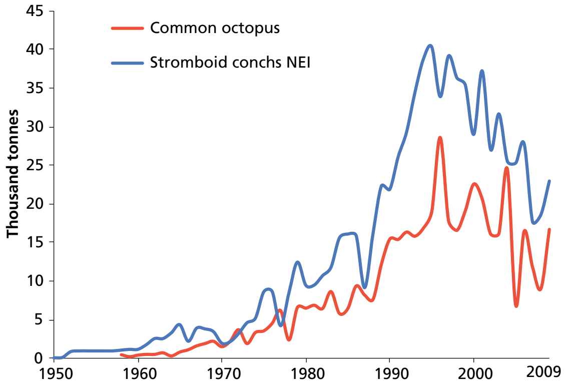
The Caribbean spiny lobster (*Panulirus argus*) catches decreased from 34 000 tonnes in 2002 to 24 000 tonnes in 2009 (Figure B3.10). Caribbean spiny lobster landings are declared by 26 countries, but Nicaragua, Honduras, Cuba and the Bahamas together accounted for 70 percent of the catches in Area 31 in 2009. The spiny lobster stocks are known to be under heavy exploitation in the region and to have been depleted in some areas. The fact that landings have been maintained at reasonably constant levels up until recently probably reflects the fact that fisheries in some countries have progressively extended to deeper waters, for example Jamaica, Dominican Republic, Honduras and Nicaragua.

FIGURE B3.10
Annual nominal catches of selected species in ISSCAAP Groups 43, 45 in the Western Central Atlantic (Area 31)



In the same period, landings of unidentified penaeid shrimps dropped from a peak of more than 50 000 tonnes in 2003 and 2004 to 25 000 tonnes in 2009. The northern brown shrimp (*Penaeus aztecus*) and the northern white shrimp (*Litopenaeus setiferus*) are the two most productive shrimp species, with

FIGURE B3.11
Annual nominal catches of common octopus and stromboid conchs in the Western Central Atlantic (Area 31)



similar landings of more than 55 000 tonnes in 2009 (Figure B3.10). However, they seem to show opposite trends over recent years, with an increase for the northern white shrimp and a decrease for the northern brown shrimp. Both species are mainly reported by the United States of America. The trend in Atlantic seabob (*Xiphopenaeus kroyeri*) landings seems to have reversed in – after a continuous increase until 2001 (38 000 tonnes), the catches decreased continuously to 26 000 tonnes in 2009. The bulk of the landings are reported by Guyana and Suriname, with more than 90 percent of the catches of Area 31. Landings of northern pink shrimp declined more or less continuously from when they peaked at 22 000 tonnes in 1978 to 4 000 tonnes in 2009. Catches by the United States of America have accounted for about 70 percent of the total.

Among the molluscs landed, oysters remain the main catches of the group in Area 31. The most important is the American cupped oyster (*Crassostrea virginica*), which is declared by the United States of America and Mexico. The landings halved from the historical peak of 195 000 tonnes in 2000 to 84 000 tonnes in 2009, owing to a sharp decline in the United States landings. Production of ark clams (*Arca* spp.) shows a continuous increase throughout the period of record collection and reached a historical maximum at 71 000 tonnes in 2009, mainly reported by Venezuela (Bolivarian Republic of).

Although catches of stromboid conchs (*Strombus* spp.) fluctuate widely, they appear to have declined since their historical maximum of 40 000 tonnes in 1995 down to 23 000 tonnes in 2009 (Figure B3.11). This apparent decline is partly in response to the listing of queen conch (*Strombus gigas*) on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1992. This listing has controlled its export and enabled national management efforts to reduce harvests. The countries declaring the highest landings are Mexico, Jamaica, Turks and Caicos Islands, Belize, Dominican Republic and Nicaragua, but conchs are also declared by a number of other countries. Landings of common octopus (*Octopus vulgaris*) have shown important interannual fluctuations in the last five years between a maximum of 24 000 tonnes in 2004 and a minimum of 7 000 tonnes in 2005. The most recently reported catch was 17 000 tonnes in 2009, which was mainly caught by Mexico. Landing of Mexican four-eyed octopus (*Octopus maya*) have been reported since 2005. They account for one-third of octopus catches in Mexico, with an average of 5 400 tonnes per year.

Reported landings of turtles decreased steadily from 2002 and practically disappeared from the statistics in 2009. Landings of green turtle (*Chelonia mydas*) decreased from 14 tonnes in 2002 to 1 tonne in 2008, but no landings were reported in 2009. All of the Caribbean Sea turtle species are considered endangered or critically endangered (IUCN Red List of Threatened Species) and all are listed on Appendix I of CITES, preventing export trade in these species.

An interesting feature is the recent inclusion of unidentified sea cucumbers (Holothurioidea) in the landings. These are mainly reported by Nicaragua, and show that 5 tonnes were caught in 2006 and 720 tonnes in 2009. This is despite an indication that the fishery has been operating since 1994 (Toral-Granda, 2008). This increase in reported landings is probably due to new markets for this group opening up in China.

RESOURCE STATUS AND FISHERY MANAGEMENT

A number of institutional arrangements promote and facilitate the responsible utilization of the fisheries and other aquatic resources within Area 31. Each organization has a different geographical coverage and mandate: Western Central Atlantic Fisheries Commission (WECAFC) of FAO, the International Commission for the Conservation of Atlantic Tuna (ICCAT), the Caribbean Regional Fisheries Mechanism (CRFM), the Caribbean Fisheries Management Council (CFMC), the Latin American Organization for Fishery Development (OLDEPESCA), the Central American Organization for the Fisheries and Aquaculture Sector (OSPESCA), the Association of Caribbean States (ACS), the Organization of Eastern Caribbean States (OECS), and the National Oceanic and Atmospheric Administration (NOAA). The different institutions within Area 31 adapt to the informal arrangements that are agreed upon by these arrangements. Some of them take the lead in the assessment and management of particular fisheries resources. For example, the WECAFC undertakes the assessment for shrimp, groundfish and flyingfish, the CRFM for other regional pelagics, conch, lobster and shrimp, and OSPESCA for lobster resources (Fanning and Mahon, 2011). However, despite the relatively large number of existing arrangements, information that can be used for management purposes still needs to be improved in Area 31. The launching of the Caribbean Large Marine Ecosystem (CLME) Project (Web site: www.clme.iwlearn.org/) funded by the Global Environment Facility (GEF) in 2009 will probably provide valuable assistance to the Caribbean countries to improve the knowledge on and the management of their shared fisheries resources.

The stock abundance of Gulf menhaden (*Brevoortia patronus*) was estimated to be between its target and limit reference points and, thus, not considered to be overfished nor subject to overfishing. However, the stock will approach its limit reference points if the population fecundity decreases and fishing mortality continues to increase (Vaughan, Shertzer and Smith, 2007). Atlantic menhaden (*Brevoortia tyrannus)* was not considered to be overfished nor was overfishing occurring in 2008, although uncertainties in the assessment led to the conclusion that overfishing was potentially occurring in 2008 (ASMFC, 2011).

Following a survey carried out in 2009 along the Venezuelan eastern coasts, the biomass of round sardinella (*Sardinella aurita*) was estimated to have decreased significantly in the last few years. This is probably because of a combined effect of natural and fishing mortality coupled with unfavourable environmental conditions that hampered recruitment. The stock currently shows signs of overexploitation, if not depletion (López, personal communication). In the United States of America, despite the reduction in commercial landings of round sardinella on the west coast of Florida since 1995, fishery independent surveys undertaken in 2003 indicated that there had been no increase in abundance in recent years. The surveys suggest that factors other than fishing may be responsible for changes in abundance (Mahmoudi *et al.*, 2002).

For flyingfish (*Hirundichthys affinis*), analysis of data until 2008 suggests that the eastern Caribbean stock is not experiencing overfishing, but because of the poor regional data available, the assessment could not determine whether local depletion is taking place (FAO, 2010). As part of the CLME Project, a case study is currently focusing on the improvement in availability of fisheries catch and effort data. It is hoped that this will lead to more reliable assessments in the future (CRFM, 2010a). No formal stock assessment of Atlantic thread herring (*Opisthonema oglinum*) seems available in the region.

Assessments of flathead grey mullet carried out in Mexico show that, depending on the province, the species is either exploited at the MSY (Tamaulipas) or deteriorating (Veracruz), as evidenced by the sharp decrease in catches. Current management measures include a minimum landing size of 31 cm as well as a minimum mesh size of 101 mm (SAGARPA, 2010). The most recent assessment of flathead grey mullet in

Florida waters indicates that the stock was not overfished and that nor was overfishing occurring (Mahmoudi, 2008).

Greater amberjack, together with a number of highly migratory species (blue marlin, white marlin, sailfish, albacore, and bluefin tuna), were found to be subject to high fishing mortality, with biomass below the biological threshold specified in the fishery management plan. Sailfish in the Western Atlantic is no longer overfished, but is still subject to overfishing (NMFS, 2011).

As for the common dolphinfish, any decline in the stock seems impossible to detect because of incomplete information available. Therefore, no status could be clearly attributed from the last assessment undertaken with data from Caribbean, Venezuela, USA and Brazil (CRFM, 2010b). The standardized CPUE indices for the eastern Caribbean seem to show that the stock is not declining; however this may not be reflective of the whole Western Central Atlantic stock and precaution is required in interpreting this data.

Yellowfin tuna in the Atlantic was assessed with data up to 2006 (ICCAT, 2009). The stock was neither overfished nor subject to overfishing in 2006. However, the yellowfin tuna in the Atlantic Ocean is treated as a unit stock. The last assessment available for North Atlantic albacore stock indicates that the stock is likely to be overexploited and it recommended a reduction in its TAC (ICCAT, 2010). The assessment of the western stock of skipjack tuna, based on the data up to 2006 (ICCAT, 2009), concludes that the current catch is unlikely to be higher than the replacement yield, but no clear status was assigned.

Assessment of the king mackerel fishery in United States waters estimated that the species was not overfished in the Gulf of Mexico and Atlantic Ocean. However, uncertainty in stock assessments made it difficult to identify whether overfishing was occurring (SEDAR, 2009b). In the southern Caribbean, there has not been a significant change in king mackerel fishing mortality in the last ten years. Yet, it is not known whether the stock is overfished or not (CRFM, 2007). For Spanish mackerel on the South Atlantic coast of the U.S. results indicated that overfishing was not occurring, but there was uncertainty regarding the overfished status of the stock (SEDAR, 2008).

The shrimp trawl fishery in Venezuela (Bolivarian Republic of) has been closed since March 2009. Mendoza *et al.* (2009) analysed available information on landings of different taxonomic groups and their nominal fishing effort. This assessment examined the status of each group by fleet between 1970 and 2008 in eastern Venezuela (Bolivarian Republic of). They estimated biomass trajectories, MSY and the fishing effort corresponding to MSY, thus providing retrospective information on the status of different stocks. Except for the red spotted shrimp (*Penaeus brasiliensis)*, all stocks analysed seemed to show signs of overfishing in 2008. Signs of slight recovery in abundance were seen for whitemouth croaker (*Micropogonias furnieri)*, king weakfish (*Macrodon ancylodon*) along the Orinoco Delta or the Jamaica weakfish (*Cynoscion jamaicensis*) on the Margarita-Sucre platform. However, the authors cautioned the use of the results, owing to considerations of data limitations and inconsistencies in the measurement of fishing effort.

In its annual report to the United States Congress, the National Marine Fisheries Service (NMFS) indicated that several species of snappers and groupers are either subject to overfishing, overfished or both in the South Atlantic, Gulf of Mexico and Caribbean regions. Northern red snapper, misty grouper, Nassau grouper, red grouper, yellowedge grouper, yellowfin grouper and black seabass were indicated as both subject to overfishing and overfished in the waters of the United States of America. The status of gag grouper was previously unknown in the United States of America, but evidence was found that it was subject to overfishing in the South Atlantic and overfished and subjected to overfishing in the Gulf of Mexico (NMFS, 2011). In Mexico, the red grouper is overfished and effort reductions have been recommended (SAGARPA, 2010).

Only general indications are available for some fish stocks or species. For example, in Mexico, there are insufficient data to assess stock status of various coastal fishes stocks. However, many species are considered to be deteriorating (SAGARPA, 2010). Another example is the southern red snapper (*Lutjanus purpureus*) in French Guiana, where a large recruitment has been recorded in recent years, along with a large adult biomass. This may indicate that the stock might be improving, at least in the short term, but the status is still unknown because no formal assessment has been undertaken (IFREMER, 2011).

The status of shark stocks does not seem to be dealt with in a systematic way and, hence, only limited and scattered information is available. The exploitation status of sharks and rays in Venezuela (Bolivarian Republic of) was analyzed on the basis of data collected until 2006 (Tavares, 2009). They were found to sustain an important artisanal fishery along most of the coast and islands of the country. The author underlined the difficulty of collecting data on sharks at landing sites scattered along the coast. A total of 97 species (62 shark and 35 ray species) were recorded in the landings, with a predominance of the genera *Mustelus* and *Rhizoprionodon*. In the islands, the catch composition was dominated by *Carcharhinus limbatus*, *C. perezi* and *Ginglymostoma cirratum*. In contrast, catches of the industrial fishery were dominated by *Prionace glauca* and *C. signatus*. No stock assessment was carried out owing to the lack of detailed data and information. Loss of biodiversity and declines in abundance of several species were described (Tavares and Arocha, 2008), but there were still large uncertainties regarding the status of these stocks.

In Mexico, some rays (*Dasyatis americana*, *D. sabina*, *Aetobatus narinari*, *Gymnura micrura* and *Rhinoptera bonasus*) are known to be target species. Their populations were estimated to be exploited at their MSY. However, it was recommended that there be further increase in fishing effort (SAGARPA, 2010).

Sandbar shark, dusky shark and blacknose shark are subject to overfishing and overfished, while the shortfin mako is subject to overfishing (NMFS, 2011). Other species assessed such as finetooth shark, Atlantic sharpnose and bonnethead are neither overfished nor subject to overfishing, as were blacktip shark stocks in the Gulf of Mexico (SEDAR, 2006, 2007).

Spiny lobster in the Yucatan and Quintana Roo region, Mexico, was estimated to be exploited at around MSY. It was recommended that a reliable effort control system be established to prevent any further increase in fishing mortality (SAGARPA, 2010). However, in contrast, Chávez (2009) estimates that lobster populations in southern Mexico are overexploited.

In the southeast of the United States of America, the latest assessment could not establish the status of lobster stocks, as the results of the assessment models were rejected by an external review panel. However, new genetic data suggest that the southeast United States lobster population is highly dependent on external recruitment of postlarval lobsters from other spawning stocks throughout the Caribbean (SEDAR, 2010). However, Ehrhardt and Fitchett (2010) estimated that a significant proportion of recruitment was explained by the Floridian local population. This corroborates the conclusions of a CRFM working group that underlined that the spiny lobsters do not migrate over deep water as adults. Hence, there is a strong hypothesis that there are multiple distinct management units, although they might depend to an unknown extent on external recruitment (CRFM, 2009a). As a result, separate assessments were carried out by each Caribbean country.

In Jamaica, an assessment of the spiny lobster stock of Pedro Bank undertaken in 2009 with data until 2007 suggests the stock was not overfished and that current catches would not result in overfishing (CRFM, 2009a). These results were not conclusive, because of data limitations and poor reliability of the modelling results. However, a more recent assessment led to the recommendation that the current effort and catch levels be closely monitored, as there is a potential danger for the fishery if the current levels are maintained (CRFM, 2010a).

In Belize, the lobster stock was assessed to be halfway between fully exploited and overexploited. The total biomass, spawning biomass and recruitment declined as a result of high fishing mortality (FAO, 2009a). Very similar results were found for the lobster stock in Nicaragua (FAO, 2009c) where fishing mortality was found to be too high and exploitation rates were not sustainable. An assessment undertaken within the CRFM for Turks and Caicos islands concluded that overfishing was occurring in 2005 and 2006. The assessment provided baseline information for determining a TAC (CRFM, 2007). An assessment of the spiny lobster fishery in Los Roques Archipelago in Venezuela (Bolivarian Republic of) with the PARFISH approach (Hoggarth *et al.*, 2006) indicated that the stock was overexploited, and current biomass in 2008–09 was estimated at 14 percent of virgin biomass (Manzo, 2009).

The main landed shrimp species in Nicaragua (*Penaeus notialis*, *P. brasiliensis*, *Penaeus subtilis* and *Litopenaeus schmitti*) were assessed to be fully exploited in 2008. A reduction in fishing effort was reported, mainly owing to increasing operating costs (FAO, 2009b). In Mexico, status differs among species. The brown shrimp (*F. aztecus*) stock was found to be fully exploited, with fishing effort decreasing and yield increasing. The red spotted shrimp (*F. brasiliensis*) and the rock shrimp (*Sicyoria brevirostris*) show signs of deterioration, as biomass has fluctuated in the last few years, but with a decreasing trend. The northern pink shrimp (*P. duorarum*) has suffered from excessive fishing effort in the past. Other factors affecting the species included illegal fishing, habitat loss and unfavourable environmental conditions. The combined effect of these factors has led to the current historical low catches. The stock was considered as being overexploited and a reduction of fishing effort was recommended. Seabob (*Xiphopenaeus kroyeri*) in Mexico seems fully exploited, although no biomass estimate is currently available (SAGARPA, 2010). In the main fishing countries, Suriname and Guyana, it appears to be neither overfished nor subject to overfishing (CRFM, 2009b). In the United States of America, the pink shrimp was classified among the overfished stocks in the South Atlantic (NMFS, 2011), whereas brown and white shrimps were found not to be overfished (Nance, 2010).

Blue crab (*Callinectes sapidus*) sustains an important fishery in west Venezuela (Bolivarian Republic of) (Lake Maracaibo). Owing to the introduction of longlines in 2002, its landings increased steadily from 5 000 tonnes in 2001 to 10 500 tonnes in 2008. Andrade de Pasquier *et al.* (2010) report a decrease in average size and an increase in the proportion of immature individuals in the catches. This indicates that there is a higher risk of overfishing caused by the use of longlines. These longlines are less selective than the pots that were used prior to 2002. On the other hand, recent assessments of the blue crab fishery in Florida waters indicated that the species was most probably not being overfished in the period 2002–05 (Murphy, McMillan-Jackson and Mahmoudi, 2007). Similarly, *Callinectes* spp. are estimated to be exploited at the MSY level in Mexico (SAGARPA, 2010).

As in the previous report period, the queen conch has shown signs of overexploitation where data are available. This is despite its inclusion in the CITES Appendix II list and the presence of rebuilding programmes. Several management measures are currently applied to the species, such as a cap on harvest, minimum legal size limit, and seasonal and spatial closures. In the United States of America, the queen conch was found to be subject to overfishing and overfished (NMFS, 2011). In Mexico, the stock was found to be in a deteriorating state (SAGARPA, 2010), although recovery signs were detected in protected areas (Cárdenas and Aranda, 2010). In Saint Lucia, an assessment made with data to 2008 shows that the abundance of the stock continues to decline. The stock is showing signs of overexploitation and this could lead to a collapse if no management action is taken (CRFM, 2009b). Recent surveys in the Bahamas indicate that the conch fisheries at Andros Island (Stoner and Davis, 2010) and on the Berry Islands bank are not sustainable (Stoner, Davis and Booker, 2009). In contrast, the stocks of Turks and Caicos Islands seem to be stable, with an acceptable level of biomass, although recent hurricanes Hanna and Ike are likely to have caused negative effects on this species (CRFM, 2010b). In Jamaica, catches of queen conch have decreased in recent years, as the national TAC (and individual quotas in the industrial fishery) has been reduced (Aiken *et al.*, 2006). The stock seems to be neither overfished nor subject to overfishing. However, the lack of data made the results of the assessment not entirely satisfactory. Information is still badly needed in some regions for reliable assessment of the status of the stocks and there is significant concern over the continued illegal, unreported and unregulated (IUU) fishing on Pedro Bank by foreign vessels.

American cupped oyster represents the most important fishery in the Gulf of Mexico in terms of landings, but is a low-valued species. In Mexico, catches of American cupped oyster have increased in recent years in Veracruz owing to an increase in fishing effort, whereas they have been stable in Tabasco. In Tamaulipas and Campeche, catches have decreased by more than 50 percent owing to unsatisfactory sanitary conditions, and this has prevented commercialization. Recently installed depuration plants have helped improve sanitary conditions and enabled the fishery to comply with required standards. The American cupped oyster is considered to be exploited at MSY in three provinces (Veracruz, Tabasco and Campeche) and underexploited in the province of Tamaulipas (SAGARPA, 2010). In the United States of America, historic low catches of American cupped oyster on the east coast led to an assessment to establish whether the species should be listed as threatened or endangered under the Endangered Species Act. However, the review team concluded that the species was not at risk (Eastern Oyster Biological Review Team, 2007).

In Venezuela (Bolivarian Republic of), no formal assessment exists for the expanding ark shell fishery, which has recently exceeded 70 000 tonnes. It has become the country's most important fishery, but there is concern that these levels of exploitation may not be sustainable (Mendoza, personal communication).

In relation to octopus species in Mexico, *Octopus maya* is exploited at its MSY (SAGARPA, 2010). In contrast, some increases in the landings are believed to be possible for *O. vulgaris*, based mainly on the fact that the species is caught down to 36 m, whereas its habitat is likely to extend down to 150 m.

Area 31 includes 10 percent of the world's coral reefs, which have relatively low diversity but high endemicity (Burke *et al.*, 2011). Coral cover has been declining for decades and, since the 1980s, a major cause has been the declining nearshore water quality. Other factors affecting corals include the impact of diseases affecting many corals, as well as the long-spined sea urchin (*Diadema antillarum*). This urchin has an important ecological role as a herbivore on overfished coral reefs, but disease induced massive mortalities of *D. antillarum* in 1983-1984 led to macro-algal blooms in many reef areas that still persist (Bellwood *et al*., 2004). The international Year of the Reef and the 11th International Coral Reef Symposium in 2008 provided the occasion for taking stock of the status of coral reefs around the world and of major initiatives that have been undertaken. Because of unusually high temperatures in 2005, the Caribbean was one of the regions reporting the highest levels of damage to coral reefs, owing to mass coral bleaching as well as hurricanes in 2005 and 2006 (Wilkinson and Souter, 2008). Significant loss of hard coral cover from bleaching and disease outbreaks was recorded in the United States Virgin Islands and Florida, Puerto Rico, Cayman Islands, Sint Maarten, Saba, Sint Eustatius, Guadeloupe, Martinique, Saint Barthélemy, Barbados, Jamaica, Cuba, and Trinidad and Tobago. However, reefs at low risk are being still reported. These are either remote (Wider Caribbean) or well managed (Cuba) and signs of recovery have been detected in Florida and Jamaica. Nevertheless, the overall situation is still fragile. The impact of projected climate changes (mainly elevated sea surface temperatures, ocean acidification and increased storm intensities) coupled with continuing harmful human activities such as overfishing, marine construction, sediment and nutrient pollution are a serious concern for the future of the reefs in Area 31. This concern led several Caribbean countries (the Bahamas, Dominican Republic, Jamaica, Grenada, Saint Vincent and the Grenadines) to pledge to conserve 20 percent of their marine and coastal habitats by 2010. This protection will occur through the Caribbean Challenge, with the support of the GEF, the Government of Germany, and the Nature Conservancy (Wilkinson, 2008). As of today, more than 75 percent of the reefs are considered threatened, with overfishing being one of the most important threats (Burke *et al.*, 2011).

Information on seagrasses at the regional scale dates back to 2003, with a synthesis of the distribution and status of seagrass beds (Green and Short, 2003). This assessment indicated the presence of species, but did not provide details on the actual extent of seagrass beds. Research based on remotely sensed satellite images was initiated to fill this gap and has obtained promising results (Wabnitz *et al.*, 2008). However, only preliminary results at very local scales are available so far.

Mangroves are among the important coastal habitats of ecological relevance to fisheries resources. Unlike in other parts of the world, the use of mangrove for fuel is not widespread in the Caribbean. Tourism, aquaculture, urban and coastal developments have each contributed to damaging the mangrove forests. It has been estimated that around 413 000ha of mangrove forests have been lost in Central America and the Caribbean between 1980 and 2000 at a rate of about 1% of total cover per annum (CARSEA, 2007). However, nature-based tourism (boat trips, birdwatching, sport fishing) is important enough to provide an economic incentive to protect mangroves in some areas. Several countries including the United States of America, Mexico and Cuba are showing considerable interest in mangrove protection (Spalding, Kainuma and Collins, 2010).

Another important feature in the region regards the spread of invasive species, such as the Indo-Pacific lionfish (*Pterois volitans*), which is rapidly spreading throughout temperate and tropical Western Atlantic and Caribbean habitats. In several locations, lionfish abundances were described to be increasing quickly in past years (Morris *et al.*, 2009). This invasive venomous species is generating concern as it is contributing to a deep change in the ecosystem, competing with native species and causing a reduction in the recruitment of native species (Ablins and Hixon, 2008). Lionfish is having negative effects on coral reefs, and control efforts are under way or under discussion. Studies are being undertaken throughout Area 31 to monitor the spreading of, and increase the knowledge on, the species.

Uncertainty about the status of many stocks in Area 31 has remained high, and the collection and processing of fisheries-related data can be substantially improved. However, some improvements were noted, as in the case of identification of sharks in Venezuela (Bolivarian Republic of) or more detailed reporting systems by Mexico. Compared with previous years, there has been no substantial increase in the number of assessments available in the region. The information available seems to vary from one year to the next, as assessments are still not undertaken on an annual basis.

Overall catches have declined since 1984. This is probably at least partly the result of overfishing. In some cases, it is also probably due to improved responses by management to overfishing risks, thereby limiting catches. This is despite management authorities often being slow to act on scientific advice. Although overall productivity in terms of biomass may be low in the Area, the value and value per capita will probably make these resources more important in terms of socio-economic contributions at the local and national level. For example, fish resources supplying local markets for tourists in the Lesser Antilles and other tourist destinations in the Area fetch high prices.

Despite these improvements in fisheries management, a number of species still suffer from overexploitation. Moreover, coastal habitat destruction through tourism, pollution and urban development is commonly reported. These factors have led to overall ecosystem degradation, especially of coral reefs and associated fisheries (Burke *et al.,* 2011). Yet, these habitats are the basis of small-scale fisheries that have important economic, social and cultural roles in Area 31. It should be noted that this review is based on the species that are predominant in the landings reported by the countries in the Area. Therefore, it focuses on relatively large-scale fisheries owing to their higher relative contribution to those landings. Thus, it may not correctly reflect the status of the species targeted by the artisanal fisheries that dominate the insular Caribbean. Small countries with relatively low populations usually declare low nominal catches and, thus, are easily overlooked. This is particularly the case where very limited landing and stock-status information is available for those countries. However, effort levels in some insular Caribbean countries show high fishing pressure on near shore ecosystems (Dunn *et al.,* 2010). In the future, the per capita consumption of fish, as well as trade information (exports and imports) should be used to identify those countries that deserve additional attention. Efforts should be concentrated in these countries to improve the quality of data and information or undertake data collection. Moreover, the analysis of the trends of the landings should be made taking into account the context of global economy and in particular the evolution of fuel prices, as they influence directly the level of fishing in the absence of fuel subsidies for the fisheries sector (Sumaila *et al.,* 2008).

ACKNOWLEDGEMENTS

The article beneficiated from constructive suggestions provided by H. Oxenford, P. Medley and J. Mendoza who are gratefully acknowledged for their inputs. Warm thanks to all those who provided useful information and documentation: J. Alió, F. Arocha, F. Blanchard, M.-J. Cardenas, F. Carocci, K. Cochrane, P. Fanning, A. Flores, L. Garibaldi, R. Lee, D. Lopez Sánchez, S. Lluch-Cota, J. Lopez, A. Mena Millar, D. Milton, R. Puga, L. Reynal, S. Singh-Renton, Y. Ye. The participants in the fifth session of the WECAFC Scientific Advisory Group are also thanked for their comments: A. Acosta, R. Appeldoorn, N. Cummings, P. Debels, M. Haughton, L. Martínez, P. McConney, M. Perez Moreno, S. Salas Márquez, J.-C. Seijo, R. Van Anrooy.

REFERENCES

Aiken, K.A., Kong, G.A., Smikle, S.G., Appeldoorn, R. & Warner, G.F. 2006. Managing Jamaica's queen conch resources. *Ocean and Coastal Management*, 49: 332–341.

Albins, M.A. & Hixon, M.A. 2008. Invasive Indo-Pacific lionfish Pterois volitans reduce recruitment of Atlantic coral-reef fishes. *Marine Ecology Progress Series*, 367: 233–238.

Andrade De Pasquier, G., Ramírez, S., García Pinto, L., Buonocore, R. & Delgado, J. 2010. Impacto del Palangre para la Captura del Cangrejo Azul, *Callinectes sapidus* en la Composición por Tallas de los Desembarques en el Lago de Maracaibo, Venezuela. *In*: *Proceedings of the 62nd Gulf and Caribbean Fisheries Institute*, *November 2–6, 2009, Cumana, Venezuela*, pp. 415–419.

Atlantic States Marine Fisheries Commission (ASMFC). 2011. *Atlantic menhaden stock assessment and review panel reports.* Stock Assessment Report No. 10-02. 325 pp.

Bellwood, D.R. Hughes, T.P., Folke, C., Nyström, M. 2004. Confronting the coral reef crisis. *Nature*, 429: 827-833.

Burgos-Rosas, R., Pérez-Pérez, M., Mena-González, J.C., Cervera-Cervera, K., Espinoza-Mendez, J.C., Mena-Aguilar, R., Rámirez-Gil, F., Cob-Pech, E.F. 2008. Veda de la Pesquería de Mero (Epinephelus morio) en el Banco de Campeche para el 2008. SAGARPA, Instituto Nacional de Pesca. 14p.

Burke, L., Reytar, K., Spalding, M. & Perry, A. 2011. *Reefs at risk revisited*. Washington, DC, World Resources Institute. 115 pp.

Cárdenas, E.B. & Aranda, D.A. 2010. Histories of success for the conservation of populations of Queen conch (*Strombus gigas*). *In*: *Proceedings of the 62nd Gulf and Caribbean Fisheries Institute*, *November 2–6, 2009, Cumana, Venezuela*, pp. 306–312.

Caribbean Regional Fisheries Mechanism (CRFM). 2007. *CRFM Fishery Report - 2007. Volume 2. Report of Third Annual Scientific Meeting – Kingstown, St. Vincent and the Grenadines, 17-26 July 2007*. CRFM Fishery Report – 2007, Volume 2. 54 pp.

Caribbean Regional Fisheries Mechanism (CRFM). 2009a. *CRFM Fishery Report - 2009. Volume 1. Report of Fifth Annual Scientific Meeting – Kingstown, St. Vincent and the Grenadines, 09-18 June 2009*. CRFM Fishery Report – 2009, Volume 1. 167 pp.

Caribbean Regional Fisheries Mechanism (CRFM). 2009b. *CRFM Fishery Report - 2009. Volume 2. Report of Fifth Annual Scientific Meeting – Kingstown, St. Vincent and the Grenadines, 09-18 June 2009*. CRFM Fishery Report – 2009, Volume 2. 60 pp.

Caribbean Regional Fisheries Mechanism (CRFM). 2010a. *Report of Sixth Annual Scientific Meeting – Kingstown, St. Vincent and the Grenadines, 07-16 June 2010*. CRFM Fishery Report – 2010, Volume 1. 109 pp.

Caribbean Regional Fisheries Mechanism (CRFM). 2010b. *Report of Sixth Annual Scientific Meeting – Kingstown, St. Vincent and the Grenadines, 07-16 June 2010 – Fishery Management Advisory Summaries*. CRFM Fishery Report – 2010. Volume 2. 41 pp.

Chávez, E.A. 2009. Potential production of the Caribbean spiny lobster (DECAPODA, PALINURA) fisheries. *Crustaceana*, 82: 1393–1412.

Cochrane, K. 2005**.** Review of the state of world marine fishery resources. Western Central Atlantic - FAO Statistical Area 31. *FAO Fisheries Technical Paper* 457: 31-42.

Eastern Oyster Biological Review Team. 2007. *Status review of the eastern oyster (*Crassostrea virginica*). Report to the National Marine Fisheries Service, Northeast Regional Office. February 16, 2007*. NOAA Tech. Memo. NMFS F/SPO-88. 105 pp.

Ehrhardt, N.M. & Fitchett, M.D. 2010. Dependence of recruitment on parent stock of the spiny lobster, *Panulirus argus*, in Florida. *Fisheries Oceanography*, 19: 434–447.

Fanning, L. & Mahon, R. 2011. An overview and assessment of regional institutional arrangements for marine EBM of fisheries resources in the Wider Caribbean. *In* L. Fanning, R. Mahon & P. McConney, eds. *Towards marine ecosystem-based management in the Wider Caribbean*, pp. 259–269. Amsterdam, Netherlands, Amsterdam University Press.

FAO. 2009a. *Anexo 3.2 – BELIZE: Estado del recurso "langosta espinosa"* (*Panulirus argus*). Proyecto GCP/RLA/150/SWE – FIINPESCA, Fortalecimiento de la Investigación Pesquera Interdisciplinaria para la Pesca Responsable en los Países del Istmo Centroamericano. 13 pp.

FAO. 2009b. *Anexo 3.8 – NICARAGUA: Estado del recurso "Camarón" en el Caribe*. Proyecto GCP/RLA/150/SWE – FIINPESCA, Fortalecimiento de la Investigación Pesquera Interdisciplinaria para la Pesca Responsable en los Países del Istmo Centroamericano. 27 pp.

FAO. 2009c. *Anexo 3.6 – NICARAGUA: Estado del recurso "langosta espinosa"* (*Panulirus argus*). Proyecto GCP/RLA/150/SWE – FIINPESCA, Fortalecimiento de la Investigación Pesquera Interdisciplinaria para la Pesca Responsable en los Países del Istmo Centroamericano. 18 pp.

FAO. 2010. *Report of the Third Meeting of the WECAFC ad hoc Flyingfish Working Group of the Eastern Caribbean. Mount Irvine, Tobago, 21–25 July 2008*. FAO Fisheries and Aquaculture Report No. 929. Rome. 88 pp.

Green, E.P. & Short, F.T., eds. 2003. *World atlas of seagrasses*. Berkeley, USA, University of California Press. 310 pp.

Heileman, S. 2007. *Thematic report for the insular Caribbean sub-region*. A discussion paper for the CLME Synthesis Workshop. CLME-TT/3Prov. 61 pp.

Hoggarth, D.D., Abeyasekera, S., Arthur, R.I., Beddington, J.R., Burn, R.W., Halls, A.S., Kirkwood, G.P., McAllister, M., Medley, P., Mees, C.C., Parkes, G.B., Pilling, G.M., Wakeford, R.C. & Welcomme, R.L. 2006. *Stock assessment for fishery management – a framework guide to the tools of the Fisheries Management Science Programme*. FAO Fisheries Technical Paper No. 487. Rome, FAO. 261 pp.

International Commission for the Conservation of Atlantic Tunas (ICCAT). 2009. Report of the 2008 ICCAT Yellowfin and Skipjack Stock Assessments Meeting (Florianópolis, Brazil–July 21 to 29, 2008). *Collective Volume of Scientific Papers ICCAT*, 64: 669–927.

International Commission for the Conservation of Atlantic Tunas (ICCAT). 2010. Report of the 2009 ICCAT Albacore Stock Assessment Session (Madrid, Spain - July 13 to 18, 2009) *Collective Volume of Scientific Papers ICCAT*, 65: 1113–1253.

Institut français de recherche pour l'exploitation de la mer (IFREMER). 2011. *Situation en 2011 des ressources exploitées par les flottilles françaises*. Département ressources biologiques et environnement, Ifremer RBE/2011/01. 68 pp.

Mahmoudi, B. 2008. *The 2008 update of the stock assessment for striped mullet,* Mugil cephalus*, in Florida*. Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute In-House Report IHR2008. 114 pp.

Mahmoudi, B., Pierce, D., Wessel, M. & Lehnert, R. 2002. *Trends in the Florida baitfish fishery and an update on baitfish stock distribution and abundance along the central west coast of Florida*. Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute In-House Report IHR2002-014.

Manzo, N. 2009. *Análisis participativo de la pesquería de langosta espinosa en el Parque Nacional Archipiélago Los Roques*. Tesis de Grado, Universidad Simón Bolívar, Caracas. 143 pp.

Mendoza, J.J., Marcano, L.A., Alió, J.J. & Arocha, F. 2009. Autopsia de la Pesquería de Arrastre del Oriente de Venezuela: Análisis de los Datos de Desembarques y Esfuerzo de Pesca. *In*: *Proceedings of the 62nd Gulf and Caribbean Fisheries Institute, November 2-6, 2009 Cumana, Venezuela*, pp. 69–76.

Miloslavich, P., Díaz, J.M., Klein, E., Alvarado, J.J., Díaz, C., Gobin, J., Escobar-Briones, E., Cruz-Motta, J.J., Weil, E., Cortés, J., Bastidas, A.C., Roberson, R., Zapata, F., Martín, A., Castillo, J., Kazandjian, A. & Ortiz, M. 2010. Marine biodiversity in the Caribbean: Regional estimates and distribution patterns. *PLoS ONE*, 5: e11916 [online]. [Cited 20 December 2011]. doi:10.1371/journal.pone.0011916

Morris, J.A., Akins, J.L., Barse, A., Cerino, D., Freshwater, D.W., Green, S.J., Muñoz, R.C., Paris, C., Whitfield, P.E. 2009. Biology and Ecology of the Invasive Lionfishes, *Pterois miles* and *Pterois volitans*. *Proceedings of the 61st Gulf and Caribbean Fisheries Institute*, November 10-14, Gosier, Guadaloupe, French West Indies: 409-414.

Muller-Karger, F. & Aparicio-Castro, R. 1994. Mesoscale processes affecting phytoplankton abundance in the southern Caribbean Sea. *Continental Shelf Research*, 14: 199–221.

Murphy, M.D., McMillan-Jackson, A.L. & Mahmoudi, B. 2007. *A stock assessment for blue crab,* Callinectes sapidus*, in Florida waters*. Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute In-House Report IHR2007-006.

Nance, J.M. 2010. *Review of the status and health of the shrimp stocks for 2009*. Report for the Gulf of Mexico Fishery Management Council. Tab. 10 No. 3. 8 pp.

National Marine Fisheries Service (NMFS). 2011. *Annual Report to Congress on the Status of U.S. Fisheries-2010*. Silver Spring, USA, US Department of Commerce, NOAA. 21 pp.

Roberts, C.M., McClean, C.J.,Veron, J.E.N., Hawkins, J.P., Allen, J.R., McAllister, D.E., Mittermeier, C.G., Schueler, F.W., Spalding, M., Wells, F., Vynne, C. & Werner, T.B. 2002. Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science*, 295: 1280–1284.

Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA). 2010. Acuerdo mediante el cual se da a conocer la actualización de la Carta Nacional Pesquera. Estados Unidos Mexicanos. *Diario Oficial* Jueves 2 de diciembre de 2010: 319 pp.

Southeast Data, Assessment and Review (SEDAR). 2006. *Stock assessment report, large coastal shark complex, blacktip and sandbar shark*. SEDAR 11. SEDAR, NOAA National Marine Fisheries Service, Highly Migratory Species Management Division. 387 pp.

Southeast Data, Assessment and Review (SEDAR). 2007. *Stock assessment report, small coastal shark complex, Atlantic sharpnose, blacknose, bonnethead and finetooth shark*. SEDAR 13. SEDAR, NOAA National Marine Fisheries Service, Highly Migratory Species Management Division. 395 pp.

Southeast Data, Assessment and Review (SEDAR). 2008. *Stock assessment report, south Atlantic Spanish mackerel*. SEDAR 17. SEDAR, The South Atlantic Fishery Management Council. 508 pp.

Southeast Data, Assessment and Review (SEDAR). 2009a. *Stock Assessment of Red Grouper in the Gulf of Mexico*. SEDAR Update Assessment, Report of Assessment Workshop, Miami, Florida, March 30-April 2, 2009. 143p.

Southeast Data, Assessment and Review (SEDAR). 2009b. *Stock assessment report, South Atlantic and Gulf of Mexico king mackerel*. SEDAR 16 Workshop Report. SEDAR, NOAA Southeast Fisheries Science Centre. 484 pp.

Southeast Data, Assessment and Review (SEDAR). 2010. *Stock assessment of spiny lobster,* Panulirus argus*, in the southeast United States*. SEDAR 8 Update Assessment Workshop Report. SEDAR, NOAA Southeast Fisheries Science Centre. 122 pp.

Spalding, M., Kainuma, M. & Collins, L. 2010. *World atlas of mangroves*. Earthscan Ltd. 336 pp.

Stevenson, D.K. 1981. *A review of the marine resources of the WECAFC region*. FAO Fisheries Technical Paper No. 211. 132 pp.

Stoner, A. & Davis, M.S. 2010. *Queen conch stock assessment historical fishing grounds Andros Island, Bahamas*. Community Conch Report. 15 pp.

Stoner, A., Davis, M. & Booker, C. 2009. *Queen conch stock assessment proposed MPA and fishing grounds Berry Islands, Bahamas*. Community Conch Report. 57 pp.

Sumaila, U.R.,Teh, L., Watson, R., Tyedmers, P. Pauly, D. 2008. Fuel price increase, subsidies, overcapacity and resource sustainability. *ICES J. Mar. Sci*. 65:832-840.

Tavares, R. 2009. Tiburones y rayas: ¿Un recurso pesquero sobre-explotado en Venezuela?. *INIA Hoy*, 4: 71–77.

Tavares, R. & Arocha, F. 2008. Species diversity, relative abundance and length structure of oceanic sharks caught by the Venezuelan longline fishery in the Caribbean Sea and western-central Atlantic. *Zootecnia Tropical*, 26: 489–503.

Toral-Granda, V. 2008. Population status, fisheries and trade of sea cucumbers in Latin America and the Caribbean. *In* V. Toral-Granda, A. Lovatelli & M. Vasconcellos, eds. *Sea cucumbers. A global review of fisheries and trade*, pp. 213–229. FAO Fisheries and Aquaculture Technical Paper No. 516. Rome, FAO. 317 pp.

Vaughan, D.S., Shertzer, K.W. & Smith, J.W. 2007. Gulf menhaden (*Brevoortia patronus*) in the U.S. Gulf of Mexico: Fishery characteristics and biological reference points for management. *Fisheries Research*, 83: 263–275.

Wabnitz, C.C., Andréfouët, S., Torres-Pulliza, D., Müller-Karger, F.E. & Kramer, P.A. 2008. Regional-scale seagrass habitat mapping in the Wider Caribbean region using Landsat sensors: Applications to conservation and ecology. *Remote Sensing of Environment*, 112: 3455–3467.

Wilkinson, C. 2008. *Status of coral reefs of the world: 2008*. Townsville, Australia, Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre. 296 pp.

Wilkinson, C. & Souter, D., eds. 2008. *Status of Caribbean coral reefs after bleaching and hurricanes in 2005*. Townsville, Australia, Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre. 152 pp.

B4. Eastern Central Atlantic

FAO STATISTICAL AREA 34

Merete Tandstad
Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: merete.tandstad@fao.org

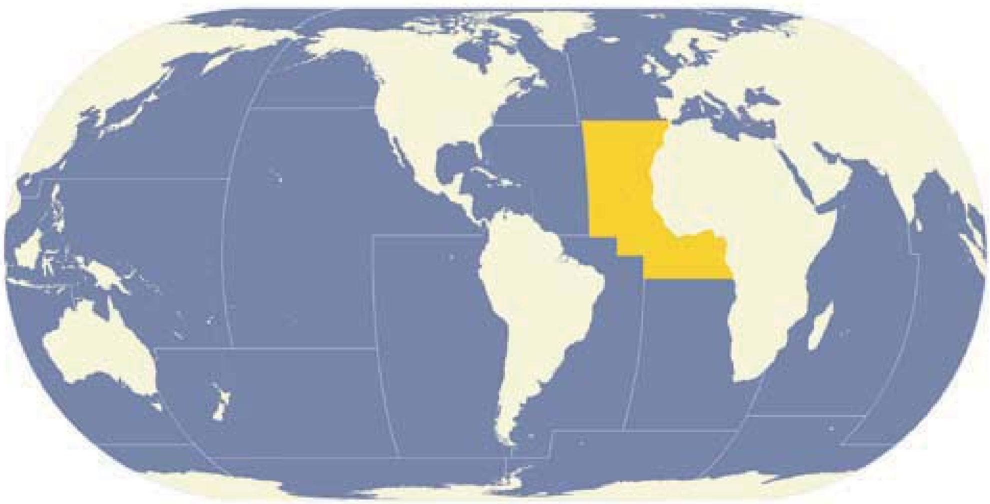
Ana Maria Caramelo
FAO Consultant
Portugal
E-mail: ana.caramelo@sapo.pt

INTRODUCTION

The Eastern Central Atlantic (Area 34) includes waters off the west coast of Africa, from the Gibraltar Strait to the mouth of the Congo River (Figure B4.1) and covers a total of 14.2 million km^2. The continental shelf along the west African coast is generally narrow, covering only 0.65 million km^2 in the entire area. Area 34 encompasses temperate, tropical and equatorial waters, lagoons and mangroves as well as oceanographic features such as major currents, upwellings and equatorial convergence. More than 250 species or groups of species were reported in fisheries landings taken by coastal States and 47 distant-water fishing nations in Area 34 in the period 1950–2009.

The fisheries in Area 34 are diverse, and many of them are typically multispecies, thus posing additional challenges for assessment and management. The type of fishing vessels used ranges from small-scale dugout canoes, through larger motorized canoes and coastal fleets to large industrial fleets of national or distant-water origin. These distant-water vessels mostly come from Europe and Asia. The catches from national fleets have

FIGURE B4.1
The Eastern Central Atlantic (Area 34)



gradually increased since the 1950s. In comparison, the distant-water fleet catches have been fluctuating, based on changes in legal regimes regulations and market forces. In the late 1980s, changes in Eastern Europe first resulted in the appearance of a number of new distant-water fishing nations that started operating in Area 34. Subsequently, increased emphasis placed on market forces and changes in management regimes resulted in a reduction in the activities of some distant-water fleets that were mainly targeting small pelagic fishes. Since 1996, fishing effort by EU fleets on small pelagics has increased in the northwest portion of Area 34. Although there have been some fluctuations, catches have remained high since that time. Other foreign fleets are also active in Area 34, targeting small pelagics, large pelagics (tuna), shrimp, cephalopods and demersal fish.

The proportion of catches originating from the artisanal fisheries has varied over time and also by subregion. Information obtained from various working group reports of the Fishery Committee for the Eastern Central Atlantic (CECAF) indicate that in the northern part of Area 34 (north of Guinea-Bissau), the percentage of catches originating from the artisanal fisheries are lower than the percentage in the southern part of Area 34.

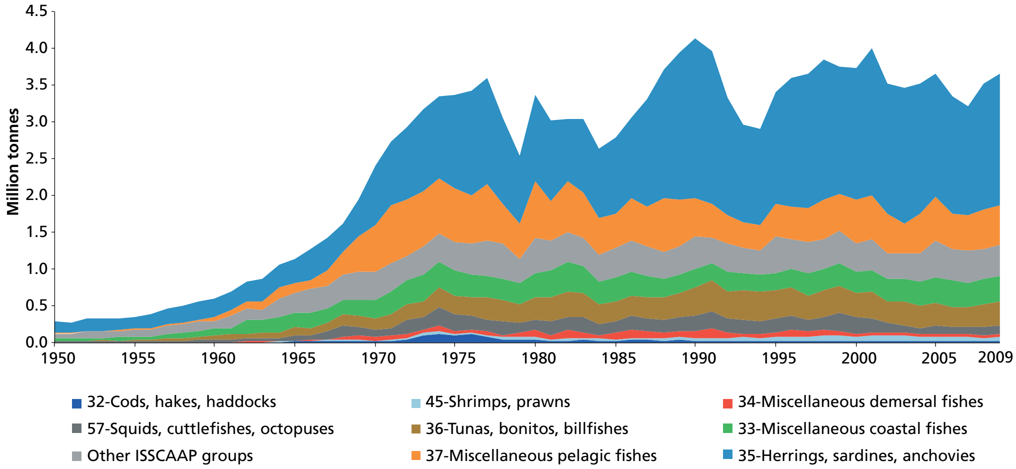
Despite the variety of fisheries in Area 34, catches are dominated by small pelagics, especially sardine (*Sardina pilchardus*) and other clupeids (ISSCAAP Group 35). The highest catches are taken in the northern part of Area 34. The group accounted for about 43 percent of total nominal catches in 2009 as compared with just over 50 percent in 2002 (FAO, 2005). The fleet exploiting these resources includes artisanal canoes, national coastal and industrial vessels and foreign industrial vessels.

PROFILE OF CATCHES

The total nominal catches reported from Area 34 increased almost twelvefold from about 300 000 tonnes in 1950 to close to 3.6 million tonnes in 1977. Since then, catches have oscillated between 2.5 million tonnes in 1979 and the peak of 4.1 million tonnes recorded in 1990. This variation appears to be due to changes in markets, fishing effort, and environmentally-induced changes that have affected stock productivity. Catches of ISSCAAP Group 35 species have shown the largest fluctuations. From 1998 to 2007, catches showed an overall decreasing trend, followed by an increase in 2008 and 2009. The catches in 2009 of 3.6 million tonnes equalled that of the average for the period 1998–2009 (Figure B4.2 and Table D4).

The major contributors to catches in Area 34 are the species of ISSCAAP Group 35 (herrings, sardines and anchovies). They account for more than 40 percent of the total

FIGURE B4.2
Annual nominal catches by ISSCAAP species groups in the Eastern Central Atlantic (Area 34)



catch reported (Figure B4.2). The landing of this group increased slightly to 1.8 million tonnes in 2009 compared with 1.5 million tonnes in 2007.

Distant-water fishing fleets, mainly catching small pelagics and tunas, have made large but irregular contributions since the early 1970s. In the late 1960s and in the 1970s, these fleets dominated the catches. However, the coastal States steadily developed their national fisheries, increasing their contribution from 43 to 72 percent of total catches in Area 34 between 1977 and 2002. Since 2003, coastal States have contributed between 75 and 80 percent of the catches (Figure B4.3).

Four species categories account for more than 80 percent of the catches in ISSCAAP Group 35 (herrings, sardines, anchovies, etc.). The European pilchard, also known as sardine (*Sardina pilchardus*), makes the largest contribution followed by the round sardinella (*Sardinella aurita*), the bonga shad (*Ethmalosa fimbriata*), the European anchovy (*Engraulis encrasicolus*) and the flat sardinella (*Sardinella maderensis*). *Sardinella* spp. also account for a sizeable portion of the group total (Figure B4.4).

Trachurus spp. are the dominant species group in ISSCAAP Group 37 (miscellaneous pelagic fishes) (Figure B4.5). Their catches increased sharply in the late 1960s, remained high throughout most of the 1970s, but declined through most of the 1980s and 1990s. Since the late 1990s the catches of this species group have been fluctuating widely, with an average of about 240 000 tonnes for the period 2000–09.

The main *Trachurus* species in Area 34 are the Atlantic horse mackerel (*Trachurus trachurus*), found mainly to the very north of Area 34, and the Cunene horse mackerel (*Trachurus trecae*), found along the coast in the tropical and subtropical regions. Few countries report to species level and most catches are reported at higher levels (Figure B4.5 and Table D4). Large catches of another important species, Chub mackerel (*Scomber japonicus*), were made in two exceptional years in 1988–89. This period was followed by a collapse of the catches in 1993, a recovery in 1997 and fluctuations since then, with an average of about 190 000 tonnes for the period 2000–09. Catches in 2009 were about 180 000 tonnes, slightly lower than the average for the last decade.

The catches from ISSCAAP Group 36 (tunas, bonitos, billfishes, etc.) show similar trends with

FIGURE B4.3
Annual nominal catches by coastal States and foreign fleets, Eastern Central Atlantic (Area 34)

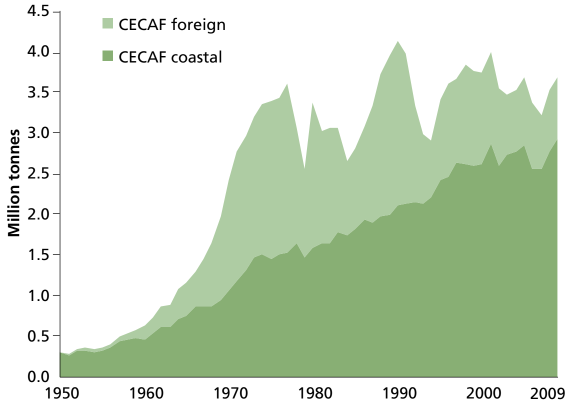


FIGURE B4.4
Annual nominal catches of selected species in ISSCAAP Group 35, Eastern Central Atlantic (Area 34)

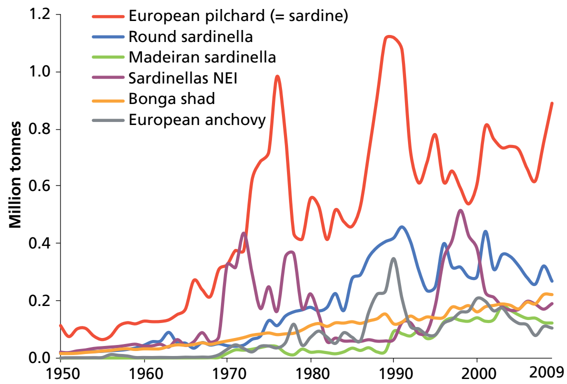


FIGURE B4.5
Annual nominal catches of selected species in ISSCAAP Group 37, Eastern Central Atlantic (Area 34)

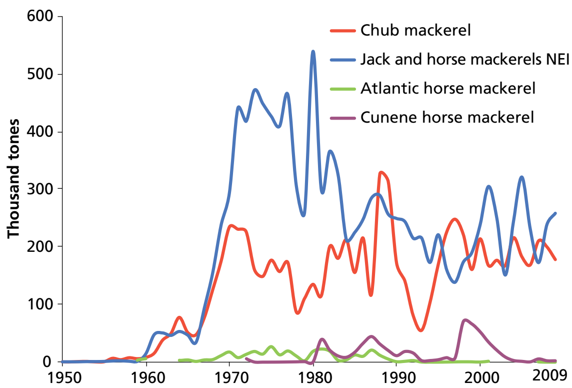


FIGURE B4.6
Annual nominal catches of selected species in ISSCAAP Group 36, Eastern Central Atlantic (Area 34)

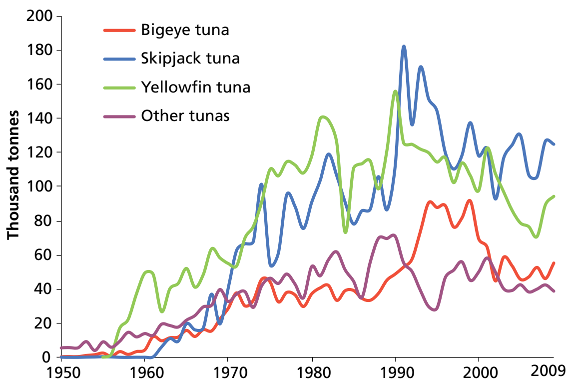


FIGURE B4.7
Annual nominal catches of selected species in ISSCAAP Group 32, Eastern Central Atlantic (Area 34)

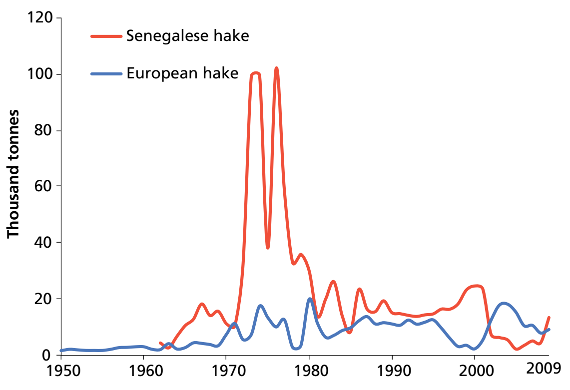
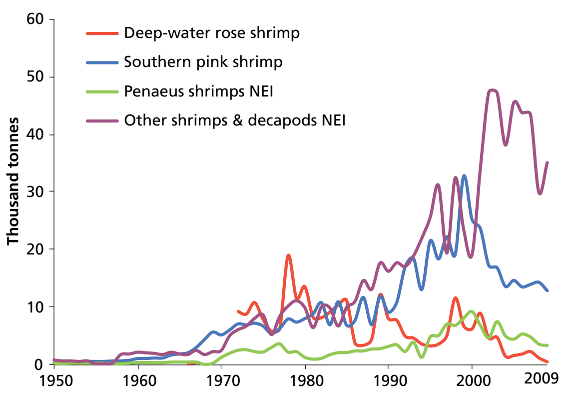


FIGURE B4.8
Annual nominal catches of selected species in ISSCAAP Group 45, Eastern Central Atlantic (Area 34)



time for the main species (Figure B4.6). The two main species are skipjack (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*). Catches of skipjack generally surpassed yellowfin tuna catches from 1991 onwards, with the exception of 2002 when yellowfin catches were slightly higher. The 2009 catches of these species were 125 000 tonnes for skipjack and about 95 000 tonnes for yellowfin. Catches of bigeye tuna have been about 40 000 tonnes since 2002.

Senegalese hake (*Merluccius senegalensis*) has been the major contributor to ISSCAAP Group 32 (cods, hakes, haddocks), with catches above 100 000 tonnes in the 1970s. Catch decreased to about 20 000 tonnes in the 1980s and remaining relatively steady at this lower level of catches until 2001, after which the catches declined (FAO/CECAF, forthcoming a, forthcoming b). With the exception of 2009, catches of European hake (*Merluccius merluccius*) have exceeded the catches of Senegalese hake since 2002 (Figure B4.7).

Figure B4.8 shows the main species catches in ISSCAAP Group 45 (shrimp and prawns). Southern pink shrimp (*Penaeus notialis*) catches started to become significant in the 1960s showing a general increasing trend, with oscillations, reaching a peak of 33 000 tonnes in 1999.

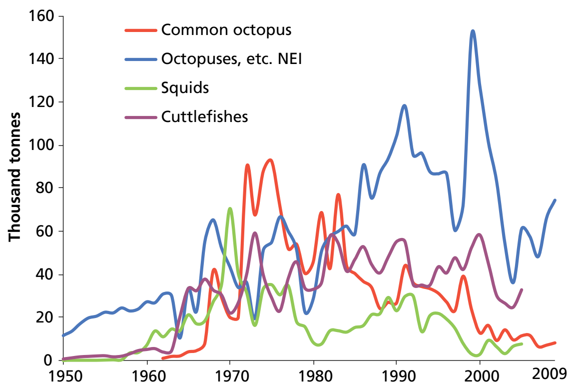
This was followed by a continued decline until 2004 and catches have remained at about 13 000–14 000 tonnes ever since. Catches of non-identified *Penaeus* shrimps have been about 3 000–5 000 tonnes since 2004. The deep-water rose shrimp (*Parapenaeus longirostris*) fishery started in 1972 and catches have been variable since then, with a high of 19 000 tonnes in 1978. The most recent peak was observed in 1998, when deepwater rose shrimp catches of 12 000 tonnes were reported from the region. Catches then decreased to 6 000 tonnes in 2000 and further to 1 500 tonnes in 2004. Since then catches have remained low and, in 2009, catches of 500 tonnes were reported to FAO.

Figure B4.9 shows the reported catches from ISSCAAP Group 57 (squids, cuttlefishes, octopuses).

The octopus (*Octopus vulgaris*) fishery in the region dates back to the 1950s. Catch reporting of this species started in 1962 to reach 93 000 tonnes in 1975, but catches have since regularly decreased to reach 9 000 tonnes in 2002 and 8 000 tonnes in 2009. However, the observed decrease in catch of the common octopus is not necessarily an indication of non-availability but could also be related to how it is reported in the catches. The group "Octopuses NEI" has shown a generally increasing trend, albeit with large interannual fluctuations up to 1993. From 1993 to 1998, catches in this category decreased followed by a record high recorded in 1999 of 150 000 tonnes. Catches dropped after this to 36 000 tonnes in 2004 before increasing to 74 000 tonnes in 2009.

Catches of cuttlefish have fluctuated with an average of 46 000 tonnes from 1986 to 2004. After 2004 (the peak of the series), catches decreased until 2007 reaching 25 000 tonnes in 2008. Catches in 2009 were 33 000 tonnes. Catches of squids have also decreased since the mid-1990s, and the average catch since 2000 is 8 000 tonnes compared with 23 000 tonnes for the period 1990–99.

FIGURE B4.9
Annual nominal catches of selected species in ISSCAAP Group 57, Eastern Central Atlantic (Area 34)



RESOURCE STATUS AND FISHERY MANAGEMENT

This review of the status of stocks is principally based on the results of assessments of the state of the major fisheries resources undertaken by the working groups of the CECAF between 2008 and 2011. The working groups assessed the state of the major fisheries resources in the region in 2008–2011. These assessments and the recommendations of the Scientific Sub-Committee of the CECAF (Accra, Ghana, 7–9 September 2011) form the basis of this section. The status of commercial species is shown in Table D4.

Fisheries are important in the CECAF region as sources of food and income, and as such support livelihoods at different levels. Most of the commercially important stocks in the region are classified as being fully exploited or overexploited, with few stocks considered non-fully exploited. In general, the situation has been more severe for the valuable demersal species, with a larger number of overexploited stocks compared with the pelagic species. Pelagic species have in general been considered fully exploited, although some important stocks have been classified as overexploited in recent assessments (e.g. round sardinella in Northwest Africa and in the Gulf of Guinea). It is noteworthy that some of the deepwater shrimp stocks in the northern part of Area 34 seem to have improved and are now considered non-fully exploited.

Many of the countries in the region do not have well-developed management systems in place. Only a few countries have management plans or regular scientific monitoring of the main resources. Research capacity to evaluate the state of stocks and their exploitation is also not always well developed. There are varying underlying causes for this, including human, institutional and financial capacity issues. Many of the main fishery resources in the region are shared among countries, posing additional challenges for the management of the fisheries exploiting these resources. Difficulties in MCS occur throughout the region. Illegal, unreported and unregulated fishing is a common phenomenon in Area 34. Nevertheless, there are several regional and national initiatives currently ongoing that are aiming to assist countries in addressing some of these key challenges for fisheries management.

Northern areas

Many of the commercially important demersal resources of Northwest Africa are heavily exploited.

With regard to finfish, hake (*Merluccius merluccius*) on the Moroccan continental shelf are considered overexploited. Of the other finfish resources assessed, the stock of white grouper (*Epinephelus aeneus*) was found to be at particular risk, and immediate action is needed (FAO/CECAF, forthcoming a, forthcoming b). The stocks of other important finfish species, such as the red pandora (*Pagellus bellottii*), axillary seabream (*Pagellus acarne*) and blue-spotted seabream (*Pagrus caeruleostictus*), are also overexploited, but not as seriously overexploited as the white grouper.

Three stocks of common octopus (*Octopus vulgaris*) are exploited by the Northwest African cephalopod fisheries, namely Dakhla, Cap Blanc and Senegal and Gambia stocks. All three are considered overexploited, with recent catches about 43 000 tonnes for the Dahkla stock, 32 000 tonnes for the Cap Blanc stock and 6 500 tonnes for the Senegal and Gambia stock (FAO/CECAF, forthcoming b). The Dakhla stock is currently managed under a management plan based on a combination of a seasonally determined TAC regime and several other measures aiming at reducing fishing pressure (fishing licences, closed seasons and minimum size). For the Cap Blanc stock, the main management measures include: closed seasons (September–October and two months in spring), freeze on licences, and minimum mesh and size restrictions as well as no-trawl zones in shallow waters less than 20 m deep (general restriction).

The exploitation of other species of cephalopods, such as squids (*Loligo vulgaris*) and cuttlefish (*Sepia officinalis*), is less intense compared with that of octopus, and their catches accounted for 33 percent of the cephalopods landed in 2008 (FAO/CECAF, forthcoming b). Management measures taken in the Moroccan EEZ, and applied to all demersal fisheries, include a two-month closed season and a reduction in the number of non-Moroccan vessels operating in the region. In Mauritania, since 2002, two closed seasons are in place for a total duration of four months, two months in spring and two months in autumn.

The 2008 catches of deep-water rose shrimp and shallow-water southern pink Shrimp (*Penaeus notialis*) in the northern CECAF area were about 17 000 tonnes (data from the 2010 Working Group on Demersal Stocks). The stocks of deep-water rose shrimp in Morocco and the shallow-water shrimp in Mauritania, Senegal and the Gambia are overexploited. However, the latest assessment has indicated an improvement in the status of the deep-water rose shrimp in the Gambia, Mauritania and Senegal. These stocks are now considered non-fully exploited (FAO/CECAF, 2011b).

The biomasses of the large stocks of small pelagics in the northern CECAF area – sardine (*Sardina pilchardus*), sardinella (*Sardinella aurita* and *Sardinella maderensis*), chub mackerel (*Scomber japonicus*) and horse mackerel (*Trachurus* spp.) – are highly variable as they are strongly influenced by environmental fluctuations. From 1995 to 2006 these stocks were regularly monitored by acoustic surveys carried out by the Norwegian research vessel *Dr. Fridtjof Nansen*. Since then, the responsibility for the regional monitoring of these stocks has been with the national research institutions using their national research vessels. However, in recent years, only the research vessels of Mauritania and Morocco have been able to keep up the monitoring work. This has meant that estimates have had to be made for the size of the populations in the southern region (FAO, 2011a, 2011b).

The sardine (*S. pilchardus*) biomass estimated by acoustic methods increased over the years 1997–2005 from a level of about 1.0 million tonnes to a record high biomass of about 8.0 million tonnes in 2005, before dropping to 3.6 million tonnes in 2006. Since then, biomass estimates have been between 4.4 and 5.9 million tonnes (FAO, 2011b). For *Sardinella aurita*, an overall general decreasing trend in the acoustic estimates from 2.1 million tonnes in 1999 to about 1.0 million tonnes in 2007 was observed. Estimates had to be made for the southern part of the *Sardinella* distribution for the two subsequent years (2008, 2009). These years resulted in the largest biomass estimates of 2.0 million tonnes in 2008 and 2.9 million tonnes in 2009. Despite this trend, this stock is considered overexploited, considering other information from the fishery. The estimated biomass of *S. maderensis* fluctuated with an average of 1.2 million tonnes for the period 1995 to 2002. Since then, the biomass increased to 2.5 million tonnes in 2004 and then fluctuated between 0.6 million tonnes and 2008 to 2.5 million tonnes in 2006. In 2009, the estimated biomass of *S. maderensis* was 1.7 million tonnes. Of the other species, the biomass estimated by acoustic surveys for mackerel, horse mackerel and other small pelagics in the region between Morocco and Senegal was about 5 million tonnes in the November–December surveys carried out between 1995 and 2009 (FAO, 2011b).

The Working Group on the Assessment of Small Pelagic Fish off Northwest Africa has been meeting on an annual basis since 2001. The latest working group recommended that the combined catch of small pelagics in Northwest Africa should not be increased above the average of the last five years, excluding the sardine in Zone C (*Sardina pilchardus*) (FAO, 2011b). The different species groups of sardinella, horse mackerels and mackerels are intensively exploited and some species are considered overexploited (FAO, 2011c).

Around Cape Verde, the national fleet has landed an annual average of 8 870 tonnes of all marine species for the last five years (2005–09). In the same period, the international fleet has reported a mean annual catch of 5 000 tonnes (Tariche, personal communications, 2011). The artisanal landings represented an average of 49 percent of the national catch. The most important fisheries are those for pelagic fishes, with a mean estimated catch of 4 400 tonnes (49 percent of the total), and those for tunas and tuna-like species, with a mean estimated catch of 2 800 tonnes (31 percent of the total).

The coastal spiny lobsters (*Panulirus regius*, *P. echinatus* and *Scyllarides lattus*) as well as pink (deep-water) lobster (*Palinurus charlestoni*) are considered to be overexploited, and a freeze of fishing effort has been recommended. With the exception of the deep-water shrimp *Plesionika edwardsii*, there are no recent assessments of the state of the fishery resources in Cape Verde. Carvalho, Morais and Nascimento (1999) provide an overview of assessments carried out in the 1990s. An assessment carried out by the CECAF in 2005 indicated that the stock of African hind (*Cephalopholis taeniops*) was fully exploited.

Southern areas

In general, multispecies fisheries are common in the southern CECAF area (south of Senegal). Artisanal fisheries are important, although differences in types of fisheries and target species are observed along the coast.

The continental shelf is characterized by coastal fish assemblages with a range of species groups including croakers, various grunts (including the big-eye grunt, *Brachydeuterus auritus*), catfishes, groupers and snappers. On the outer shelf, there are several seabreams including *Dentex* species and other species of the slope community. Of the species assessed by regional working groups, croakers (*Pseudotolithus* spp.) contributed about 26 percent of the catches in 2006 (data from FAO/CECAF Demersal South Working Group 2008).

Shrimps are also important throughout the southern region, principally in the nutrient-rich estuarine and inshore areas. The white shrimp resources off Nigeria and Cameroon are fished exclusively by artisanal fisheries, while the southern pink shrimp are exploited by different types of fleets. In Guinea, Guinea-Bissau and Ghana important catches of cephalopods (mainly cuttlefish) are also reported.

Trawl surveys carried out on the Western Gulf of Guinea continental shelf by the *Dr. Fridtjof Nansen* have shown that the estimated biomass of demersal resources varied between 1999 and 2006. For the surveys since 2002, the estimated biomass for the valuable demersal resources varied between 25 000 tonnes and 35 000 tonnes, with the 2006 biomass estimate being somewhat lower than that of 2005 (Mehl, Olsen and Bannerman, 2006). These demersal resources were found to be either fully exploited or overexploited (based on data from the 2010 Working Group on Demersal Stocks).

Owing to inconsistencies in the input data, the CECAF Demersal Working Group 2008 recommended that a precautionary approach that avoided any increase in fishing effort should be adopted for all the demersal species in the region south of Guinea-Bissau. The exploitation rate applied to cuttlefish stocks in Guinea and Ghana has been increasing since the 1990s and the stocks were considered to be overexploited (FAO/CECAF, forthcoming c).

Small pelagic species are found throughout the region, but are particularly abundant in the coastal upwelling areas, such as off Côte d'Ivoire and Ghana, further south off Gabon, the Congo, the Democratic Republic of Congo and extending down to Angola. Small pelagic resources are exploited mainly by artisanal and semi-industrial purse seine in Côte d'Ivoire, Ghana, Togo and Benin. In Nigeria and Cameroon, they are caught exclusively by small-scale fisheries and by the industrial and artisanal fisheries in Gabon, the Republic of Congo and Angola.

In the Western Gulf of Guinea (Côte d'Ivoire, Ghana, Togo and Benin), small pelagic species such as *Sardinella* species, mackerels and anchovies are important, but their catches vary widely. This further complicates the management of the fisheries exploiting them. The most recent assessments show that the round sardinella (*Sardinella aurita*) is considered overexploited in this subregion, whereas the flat sardinella (*Sardinella maderensis*) is considered fully exploited. *Sardinella* species in the southern part (Gabon, the Congo, the Democratic Republic of Congo, and Angola) is considered non-fully exploited, whereas in the northern part (Guinea-Bissau, Guinea, Sierra Leone and Liberia) this species group is considered fully exploited. Anchovy (*Engraulis encrasicolus*) is particularly important in the Western Gulf of Guinea and in the southern region, and, in general, anchovy is considered fully exploited. Bonga (*Ethmalosa fimbriata*) is very important throughout the southern region of the CECAF and is considered fully exploited, with a mean harvest level of 230 000 tonnes in 2007 (FAO/CECAF, forthcoming c).

Acoustic survey abundance estimates of pelagic species exist from 1999 to 2009. However, the data series are of varying length depending on subregion. In the case of anchovy, the time series for the Western Gulf of Guinea shows fluctuations with a generally decreasing trend for the last three years of the series (2004–06). The biomass of the two *Sardinella* species combined also fluctuates, but to a lesser extent. The biomass of *Sardinella* species was estimated at about 120 000 tonnes in 2006, showing an increase from 2005 (Mehl, Olsen and Bannerman, 2006; FAO/CECAF, forthcoming d).

REFERENCES

Carvalho, M.E.M., Morais, J. & Nascimento, J., eds. 1999. *Investigação e gestão haliêuticas em Cabo Verde. Actas da reunião realizada em Mindelo, 10 e 11 de Dezembro de 1996*. Mindelo, Cabo Verde, Instituto Nacional de Desenvolvimento das Pescas. 252 pp.

FAO. 2011a. *Report of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa. Nouakchott, Mauritania, 21–30 April 2009*. FAO Fisheries and Aquaculture Report No. 965. Rome. 256 pp.

FAO. 2011b. *Report of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa, Banjul, The Gambia, 18 to 22 May 2010*. FAO Fisheries and Aquaculture Report No. 975. Rome. 263 pp.

FAO. 2005. *Review of the state of world marine fishery resources*. FAO Fisheries Technical Paper No. 457. Rome, FAO. 235 pp.

FAO Fisheries Committee for the Eastern Central Atlantic (FAO/CECAF). (forthcoming) a. *Report of the FAO/CECAF Working Group on the Assessment of Demersal Resources – Subgroup North. Banjul, the Gambia, 6–14 November 2007*. CECAF/ECAF Series/COPACE/PACE Series No. 10/71. Rome, FAO.

FAO Fisheries Committee for the Eastern Central Atlantic (FAO/CECAF). (forthcoming) b. *Report of the FAO/CECAF Working Group on the Assessment of Demersal Resources – Subgroup North. Agadir, Morocco, 8–17 February 2010*. CECAF/ECAF Series/COPACE/PACE Series No. 11/72. Rome, FAO.

FAO Fisheries Committee for the Eastern Central Atlantic (FAO/CECAF). (forthcoming) c. *Report of the FAO/CECAF Working Group on the Assessment of Demersal Resources –Subgroup South Freetown, Sierra Leone, 9–18 October 2008*. CECAF/ECAF Series/COPACE/PACE Series No. 11/73. Rome, FAO.

FAO Fisheries Committee for the Eastern Central Atlantic (FAO/CECAF). (forthcoming) d. *Report of the FAO/CECAF Working Group on the Assessment of Small Pelagic Resources – Subgroup South. Accra, Ghana, 19–29 October 2009*. CECAF/ECAF Series/COPACE/PACE Series No. 12/74. Rome, FAO.

Mehl, S., Olsen. M & Bannerman, P. 2006. *Surveys of the fish resources of the Western Gulf of Guinea (Benin, Togo, Ghana and Côte d'Ivoire). Surveys of the pelagic and demersal resources, 19 May to 7 June 2006*. Cruise reports Dr. Fridtjof Nansen. IMR.

B5. Mediterranean and Black Sea

FAO STATISTICAL AREA 37

Pedro Barros
Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: pedro.barros@fao.org

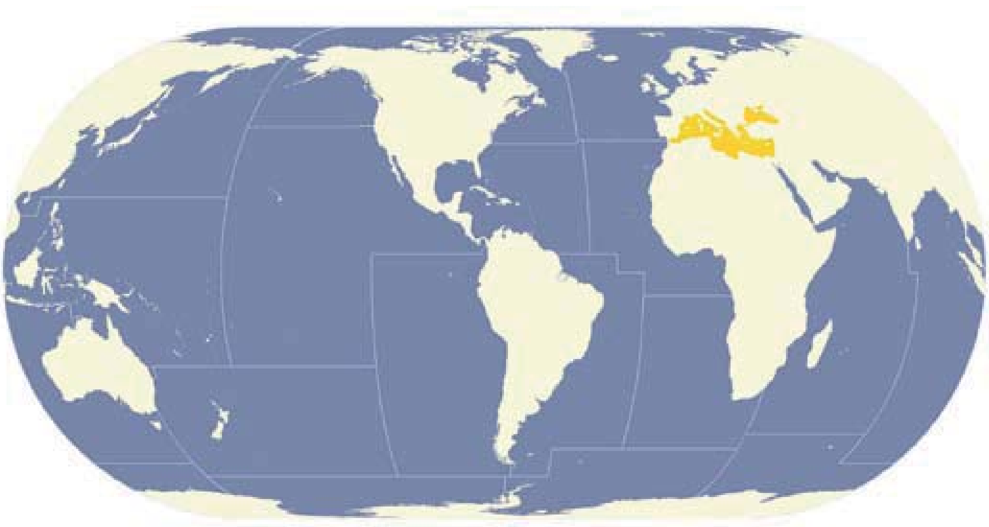
INTRODUCTION

The Mediterranean and Black Seas (Figure B5.1) are semi-enclosed seas with a surface of about 3.3 million km^2, which represents 0.8 percent of the total world marine surface. These seas are located within a relatively narrow range of latitudes (from 30°N to 46°N) in the temperate zone of the Northern Hemisphere.

The continental shelf throughout Area 37 is mostly a narrow coastal fringe with the exceptions of the Adriatic Sea, Gulf of Gabès, northern Black Sea, south of Sicily, Gulf of Lions and the Nile Delta and represents only 23 percent of the total area.

The Mediterranean Sea water masses are stratified in summer, but the temperature of the water masses below 400 m is very stable at 13 ± 0.3 °C throughout the year. The Mediterranean has a negative water budget – the loss of water through evaporation is greater than the inputs from rain and river runoff. Hence, the contribution of about 1 700 km^3/year of Atlantic water through the Strait of Gibraltar balances these losses (Bas Peired, 2005). The Mediterranean is globally considered as an oligotrophic sea (Margalef, 1985), and the gradual decline in nutrient content as the water moves from west to east leads to an overall reduction in productivity. Despite this, there are local exceptions owing to incoming nutrients from rivers and from the Black Sea.

FIGURE B5.1
The Mediterranean and Black Seas (Area 37)



The continental shelves of the Black Sea are widest in the northwest and southwest regions, and do not exceed 20 km in the remaining parts of the sea. The Black Sea is linked to the Mediterranean through the Turkish Straits System (the Bosphorus, Dardanelles Straits and the Sea of Marmara). Europe's second, third and fourth rivers (the Danube, Dnieper and Don Rivers) all flow to the Black Sea, pouring 350 km^3/year of river water into the Black Sea. This large amount of freshwater tends to stay at the surface, mixing little with the remaining water of the sea and causing a very marked stratification of the water column. Only the top 10 percent of the Black Sea is able to support aerobic organisms. The water mass below 150–200 m is devoid of dissolved oxygen and contaminated with hydrogen sulphide. The Black Sea has a positive water balance, and the outflow through the upper layer of the Bosphorus (612 km^3/year) is about twice as large as the inflow (312 km^3/year), that comes through the bottom (Ünlüata *et al*., 1990).

The Azov Sea in the northwest part of the Black Sea is the shallowest sea in the world with an average depth of 7 m. Because of the large inflow of freshwater, it has a comparatively low salinity (about 10–12 psu) in the open sea. Salinity is reduced even further in the inner areas to the east of the sea where it is almost freshwater.

Mediterranean fisheries are dominated by small-scale vessels, dispersed across a large number of landing places in most countries. Four main types of fisheries can be identified: (i) the industrial fishery for large pelagic fish, such as tunas and swordfish, that is carried out by a number of highly sophisticated and powerful vessels using purse seines and longlines; (ii) a fishery for small pelagic fish, targeting mostly anchovy, sardine and sprat, undertaken mostly by small to medium-sized purse seiners and pelagic trawlers; (iii) a multispecies demersal fishery, carried out by a multitude of small to medium-sized vessels that use a variety of gear types including trammel nets, gillnets, traps, pots, handlines, longlines and bottom trawls; and (iv) a fishery for deep-sea crustaceans (mostly deep-sea shrimps and Norway lobster) and fish (mostly hake), with a fleet of small to medium-sized bottom trawlers.

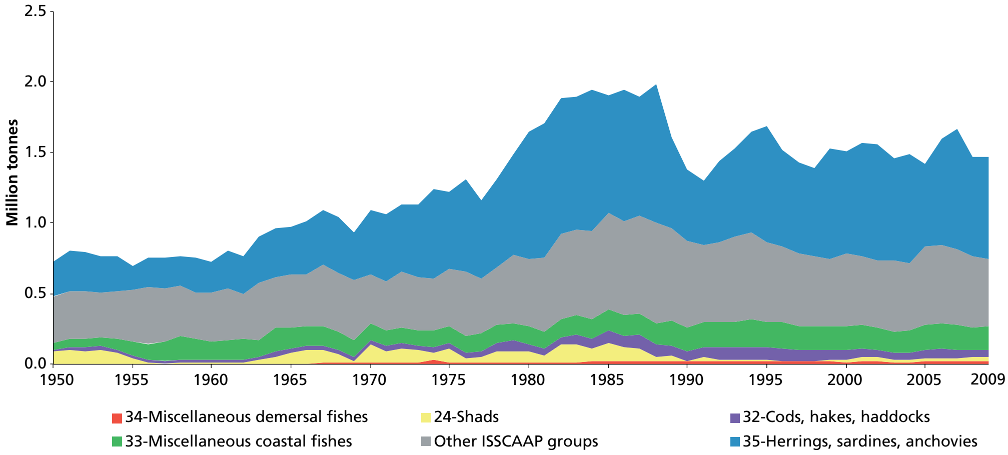
Small pelagic fish, mostly European anchovy (*Engraulis encrasicolus*), European pilchard (*Sardina pilchardus*), and sprat (European sprat [*Sprattus sprattus*] and Black and Caspian sea sprat [*Clupeonella cultriventris*]) make up 50–60 percent of total declared catch. The species classified as demersal represent about 30 percent of total reported catches in the Mediterranean and Black Sea. The most important of these are hake (*Merluccius merluccius*), red mullets (*Mullus* spp.), blue whiting (*Micromesistius poutassou*), whiting (*Merlangius merlangus*), anglerfishes (*Lophius* spp.), pandoras (*Pagellus* spp.), bogue (*Boops boops*), picarels (*Spicara* spp.) striped venus (*Chamelea gallina*), octopus (*Octopus* spp.), cuttlefish (*Sepia officinalis*), red shrimps (*Aristeus antennatus* and *Aristaeomorpha foliacea*), Norway lobster (*Nephrops norvegicus*) and deep-water rose shrimp (*Parapenaeus longirostris*).

PROFILE OF CATCHES

Total declared catches in Area 37 showed a steady increase from about 0.7 million tonnes in 1950 to about 2 million tonnes in the period 1982–88 (Figure B5.2; Table D5). They then suddenly declined to about 1.3 million tonnes following the collapse of the Black Sea fishery for sprat and anchovy (Figure B5.3), and have since recovered slightly to about 1.5 million tonnes. Total nominal catches have been fluctuating around this level since 1992.

The declared catches of species other than small pelagics increased steadily until they reached a maximum of about 700 000 tonnes in the mid-1980s. Since then, catches have declined, but with some fluctuations. The decline in catches in the last five years is a general feature for these species. The small pelagic fish show a different pattern, dominated by events in the Black Sea (Figure B5.3). After a sharp increase from 700 000 tonnes to 1.3 million tonnes in six years, they fluctuated around this level from 1983 to 1988 then

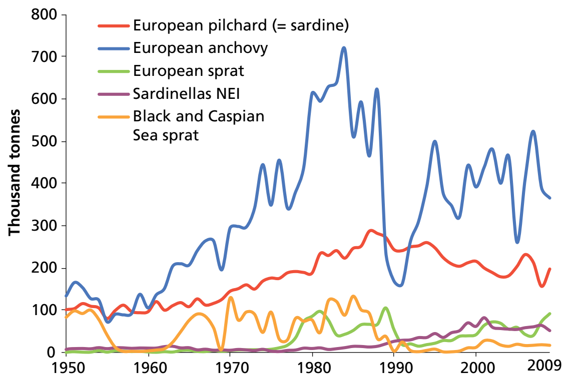
FIGURE B5.2
Total annual nominal catches from the Mediterranean and Black Seas from 1950 to 2009, grouped by major ISSCAAP groups



fell sharply to less than 620 000 tonnes in 1991. They recovered to more than 950 000 tonnes in 1995 and have fluctuated between 800 000 and 1 million tonnes since 1999.

Among small pelagic fish, anchovy (*Engraulis encrasicolus*) are the most important species landed, with about 50 percent of total, followed by sardine (*Sardina pilchardus*), with about 25 percent. The other important small pelagic fish species caught in the region are European sprat (*Sprattus sprattus*), Black and Caspian Sea sprat (*Clupeonella cultriventris*, especially important in the Azov Sea), jack and horse mackerels (*Trachurus* spp.), sardinella (*Sardinella aurita*) and chub mackerel (*Scomber japonicus*).

FIGURE B5.3
Annual nominal catches of selected species in ISSCAAP Groups 24 and 35



The large increase in catches of European anchovy until the mid-1980s was probably mainly due to the steady increase in fishing effort. However, it may also have been partly a response to the increasing eutrophication of the Black Sea in this period (Ludwig *et al.*, 2009). The collapse of the small pelagic fish fisheries in the Black Sea around 1990 has been linked to the outbreak of the ctenophore *Mnemiopsis leidyi* (Oguz, Fach and Salihoglu, 2008) as it added to the existing heavy fishing pressure. These fisheries have subsequently recovered, but catches have not reached the levels of the 1980s. This may be partly due to the decrease in nutrient input that was a result of both the successful control of fertilizer runoff by the riverine nations and the profound economic changes in the river catchments (Ludwig *et al.*, 2009). Nominal catches of jack and horse mackerels show a pattern similar to other species in the region (Figure B5.4). The catches fluctuated around 50 000 tonnes until

FIGURE B5.4
Annual nominal catches of selected species in ISSCAAP Group 37

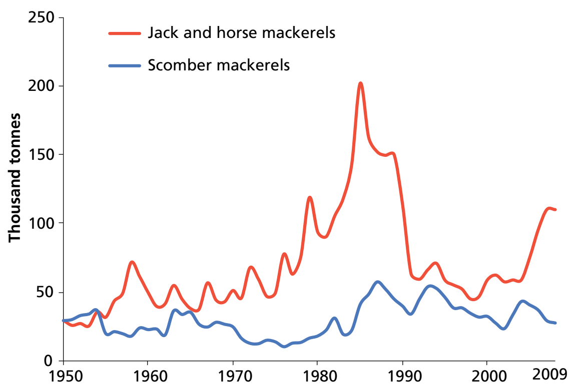


FIGURE B5.5
Annual nominal catches of selected species in ISSCAAP Groups 33 and 37

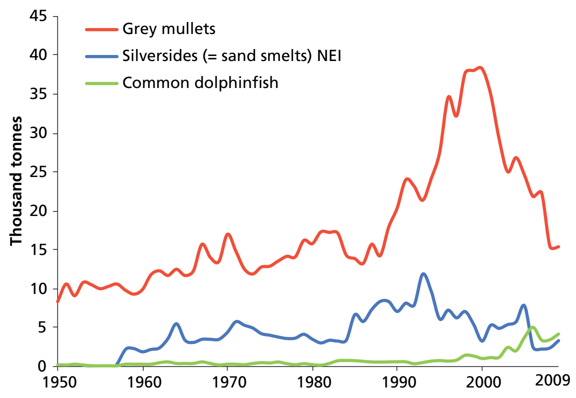


FIGURE B5.6
Annual nominal catches of selected species in ISSCAAP Groups 32 and 33

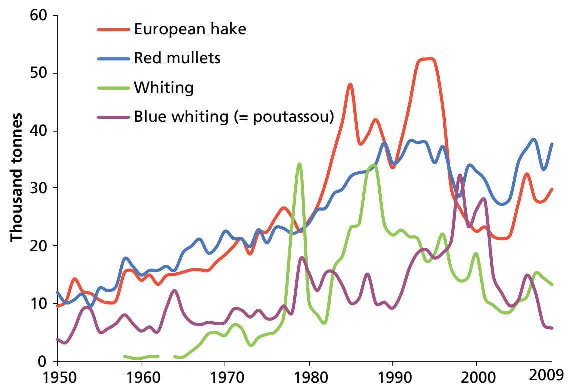
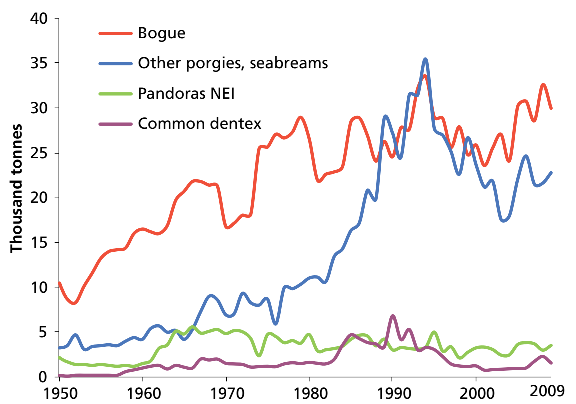


FIGURE B5.7
Annual nominal catches of selected species in ISSCAAP Group 33



1975, when catches increased rapidly until they reached 200 000 tonnes in 1985, before then declining equally rapidly to the previous level.

Reported catches of grey mullets (Mugillidae) tripled from 1988 to 2000, only to return to close to the previous values by 2008 (Figure B5.5). However, those of silversides (Atherinidae) have been relatively stable, despite a temporary increase between 1985 and 1995. The nominal catches of dolphinfish (*Coryphaena hippurus*) have always been at very low levels, but started increasing appreciably at the beginning of the 2000s and are currently at the highest level recorded. This increasing trend in catch has probably mainly been the result of increased fishing effort by some countries sharing the stock.

The declared catches of most demersal and semi-pelagic fish and crustaceans increased steadily until the period between the 1980s and the end of the 1990s. This has been followed by declines in several species in the last few years.

One of the main target species in the Mediterranean is European hake (*Merluccius merluccius*). Nominal catches of European hake increased steadily until the mid-1990s. However, after reaching their maximum (52 000 tonnes), they declined abruptly, to levels that were less than half of the maximum (about 21 000 tonnes) by 2003. Catches later recovered to levels close to those recorded in the early 1980s (Figure B5.6).

Nominal catches of red and striped mullets (*Mullus barbatus* and *M. surmuletus*) increased regularly from the 1950s until the mid-1990s. Their catches showed a small decline in the following decade before recovering to close to the maximum. The fishery begins on age group 0, and in many regions the small individuals (caught mostly in summer and early autumn) are considered a delicacy, fetching higher prices than the adults (Tserpes *et al*., 2002; Bas Peired, 2005).

Sparids and seabreams are heavily exploited across the whole region (Bas Peired, 2005). Their catches have shown a similar pattern to that of other demersal species. There was a regular increase until the mid-1990s, followed by a marked fall the following decade, and a partial recovery in the last 5–8 years (Figure B5.7).

Cephalopods are important catches from trawl fisheries and there are also directed fisheries in some regions especially with smaller vessels (Bas Peired, 2005). Catches of octopus and squid (Figure B5.8) reached a maximum at the end of the 1980s, followed by a more or less steady decline until 2009. The catches of cuttlefish, however, show a different pattern as they have been about 10 000 tonnes/year since the peak of the late 1980s.

The onset of deep-water trawling off the slope areas of the Mediterranean in the mid-1980s appears to explain the sharp rise in catches of deep-water rose shrimp and aristaeidae shrimp (Figure B5.9). The decrease in catches of rose shrimp observed in the mid-1990s is most probably the result of overexploitation of the main fishing grounds (GFCM, 2011a). Its recovery in the last three years is probably associated with a period of good recruitment. The declared catches of Norway lobster follow a similar pattern, albeit less pronounced.

The main large pelagic fishes commercially exploited in the Mediterranean, bluefin tuna (*Thunnus thynnus*) and swordfish (*Xiphias gladius*), are accompanied by albacore (*Thunnus alalunga*) and Atlantic bonito (*Sarda sarda*). Although they represent only about 4 percent of total catches, their economic value is far greater. These tuna and tuna-like stocks, whose distribution extends beyond the Mediterranean, are dealt with in detail in Chapter C1.

Nominal catches of bluefin tuna increased from the mid-1960s to reach almost 40 000 tonnes in the mid-1990s. They then dropped to below 25 000 tonnes and fluctuated around that level until 2008, when they dropped again to below 15 000 tonnes (Figure B5.10). It is possible that these declared catches do not include all those caught, especially in the last decade. This is because of the marked expansion of the farming of wild-caught fishes that are reported as part of aquaculture production instead.

FIGURE B5.8
Annual nominal catches of selected species in ISSCAAP Group 57

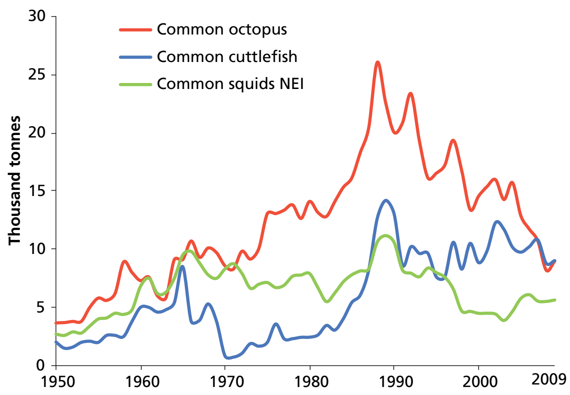


FIGURE B5.9
Annual nominal catches of selected species in ISSCAAP Groups 43 and 45

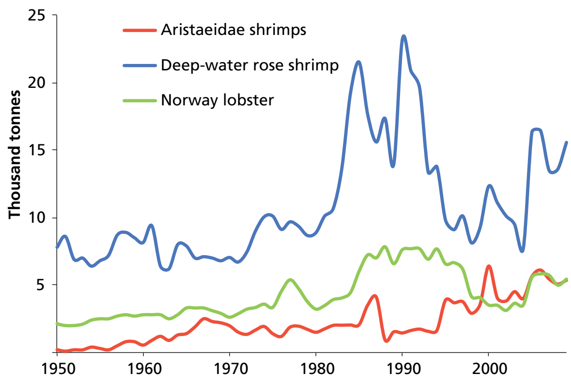
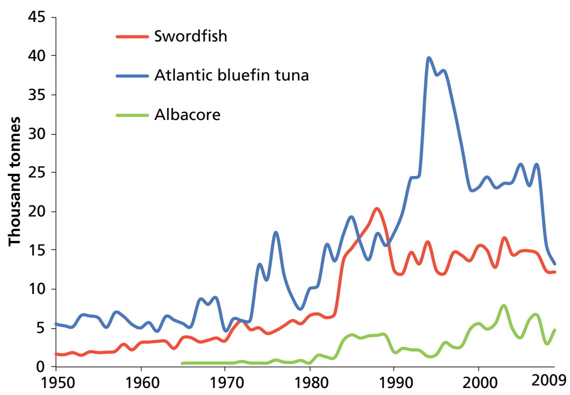


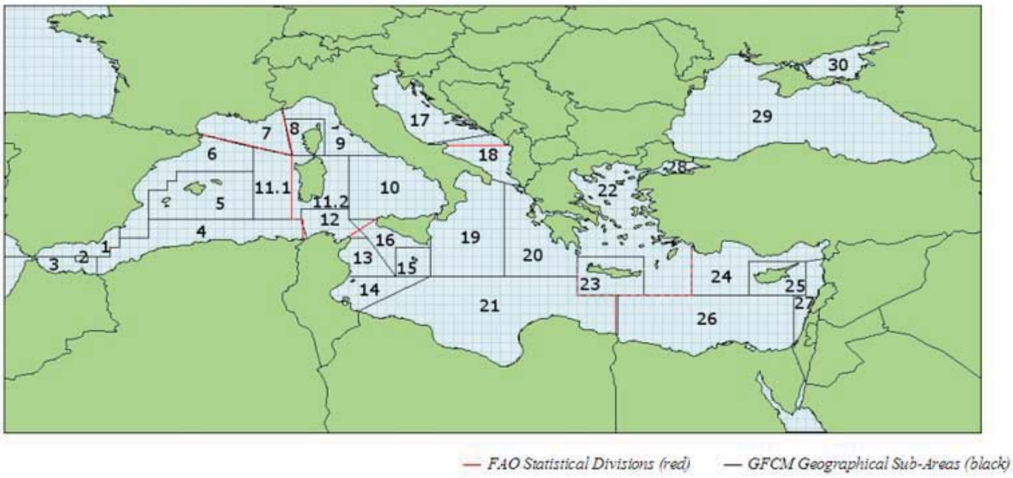
FIGURE B5.10
Annual nominal catches of selected species in ISSCAAP Group 36



RESOURCE STATUS AND FISHERY MANAGEMENT

The status of fish stocks and fisheries in the Mediterranean and the Black Sea are shown in Table D5. They are assessed and managed at several levels in Area 37. Some smaller inshore fisheries are managed at the national level. However, regional fisheries are managed within the framework of the General Fisheries Commission for the Mediterranean (GFCM), the RFMO in charge of the Mediterranean and the Black Sea, and by the EU. The exceptions to this management arrangement are mostly the tunas and tuna-like species. These species are managed within the framework of the ICCAT. For statistical reporting and management purposes, the GFCM breaks the Mediterranean and the Black Sea down into 30 different regions, called Geographical Subareas (GSAs) (Figure B5.11).

FIGURE B5.11
Definition of the GFCM Geographical Sub-Areas (GSAs)



01 - Northern Alboran Sea	07 - Gulf of Lions	13 - Gulf of Hammamet	19 - Western Ionian Sea	25 - Cyprus Island
02 - Alboran Island	08 - Corsica Island	14 - Gulf of Gabes	20 - Eastern Ionian Sea	26 - South Levant
03 - Southern Alboran Sea	09 - Ligurian and North Tyrrhenian Sea	15 - Malta Island	21 - Southern Ionian Sea	27 - Levant
04 - Algeria	10 - South and Central Tyrrhenian Sea	16 - South of Sicily	22 - Aegean Sea	28 - Marmara Sea
05 - Balearic Island	11.1 - Sardinia (west) 11.2 - Sardinia (east)	17 - Northern Adriatic	23 - Crete Island	29 - Black Sea
06 - Northern Spain	12 - Northern Tunisia	18 - Southern Adriatic Sea	24 - North Levant	30 - Azov Sea

Notes: 01 Northern Alboran Sea; 02 Alboran Island; 03 Southern Alboran Sea; 04 Algeria; 05 Balearic Islands; 06 Northern Spain; 07 Gulf of Lions; 08 Corsica Island; 09 Ligurian and North Tyrrhenian Sea; 10 South Tyrrhenian Sea; 11.1 Sardinia (west); 11.2 Sardinia (east); 12 Northern Tunisia; 13 Gulf of Hammamet; 14 Gulf of Gabes; 15 Malta Island; 16 South of Sicily; 17 Northern Adriatic Sea; 18 Southern Adriatic Sea; 19 Western Ionian Sea; 20 Eastern Ionian Sea; 21 Southern Ionian Sea; 22 Aegean Sea; 23 Crete Island; 24 North Levant; 25 Cyprus Island; 26 South Levant; 27 Levant; 28 Marmara Sea; 29 Black Sea; 30 Azov Sea.

In the most recent two sessions of the GFCM Sub-committee on Stock Assessment (GFCM, 2010, 2011b) and of the Mediterranean Subgroup of the EU's Scientific and Technical Committee for Fisheries-SGMED (Cardinale *et al.*, 2009; Cardinale *et al.*, 2010), a total of 59 stocks from 13 of the most exploited species were formally assessed mostly with analytical models. The quality of these assessments was reviewed through the formal process of the GFCM's Scientific Advisory Committee (SAC) or the EU's Scientific, Technical and Economic Committee for Fisheries (STECF) (Table B5.1).

The majority (78 percent) of the stocks assessed in the region in 2009 and 2010 were considered to be overexploited, with 22 percent fully exploited or non-fully exploited. The situation differed between demersal and small pelagic fish. Practically all demersal fish and crustaceans stocks assessed were classified as overexploited. In contrast, almost 70 percent of the small pelagic fish stocks were classified as fully exploited or non-fully exploited (Table B5.1). Given the high intensity of fishing practised across the whole region, it is reasonable to assume that this is also the general situation for most of the non-assessed fish stocks. The exceptions are possibly the stocks off some less-fished regions in the Mediterranean, such as off the southeast coast and the deep waters in the east.

Demersal resources

European hake

This is the most widely assessed species in the Mediterranean. Until the mid-1990s, high estimated juvenile mortality rates did not cause an obvious decline in recruitment. At the same time, catches were also increasing in both the east and west Mediterranean (Fiorentini, Caddy and de Leiva, 1997). It was suggested that this was because of the population of adult spawners surviving in some less exploited regions, the so-called spawning refugia (Caddy, 1990). However, after reaching their maximum (52 000 tonnes) in 1995, reported catches declined abruptly, to reach levels less than half of this maximum (about 21 000 tonnes) by 2003, recovering later to levels close to those of the early 1980s

TABLE B5.1
Summary of the exploitation status of the species assessed by the SAC-GFCM or the SGMED-STECF in the period 2009–2010

Species	Stock status				Management recommendations
	Non-fully exploited	Fully exploited	Overexploited	Total	
Merluccius merluccius	0 (0%)	0 (0%)	11 (100%)	11	Reduce fishing mortality; reduce % small individuals in catch Reduce % spawners in catch
Mullus barbatus	0 (0%)	0 (0%)	10 (100%)	10	Reduce fishing mortality; reduce % small individuals in catch
Mullus surmuletus	0 (0%)	1 (33%)	2 (67%)	3	Do not increase fishing mortality Reduce fishing mortality; reduce % small individuals in catch
Pagellus bogaraveo	0 (0%)	0 (0%)	2 (100%)	2	Reduce fishing mortality;
Pagellus erythrinus	0 (0%)	0 (0%)	2 (100%)	2	Reduce fishing mortality; reduce % small individuals in catch
Boops boops	0 (0%)	0 (0%)	2 (100%)	2	Reduce fishing mortality; reduce % small fish in catch
Solea solea	0 (0%)	0 (0%)	2 (100%)	2	Reduce fishing mortality; reduce % small individuals in catch
Parapenaeus longirostris	0 (0%)	1 (17%)	5 (83%)	6	Do not increase fishing mortality Reduce fishing mortality; reduce % small individuals in catch
Nephrops norvegicus	0 (0%)	0 (0%)	3 (100%)	3	Reduce fishing mortality; reduce % small individuals in catch
Aristeus antennatus	0 (0%)	0 (0%)	1 (100%)	1	Reduce fishing mortality; reduce % small individuals in catch
Aristaeomorpha foliacea	0 (0%)	0 (0%)	1 (100%)	1	Reduce fishing mortality; reduce % small individuals in catch
Engraulis encrasicolus	2 (25%)	3 (37.5%)	3 (37.5%)	8	Do not increase fishing mortality Reduce fishing mortality; reduce % small individuals in catch
Sardina pilchardus	2 (25%)	4 (50%)	2 (25%)	8	Do not increase fishing mortality Reduce fishing mortality; reduce % small individuals in catch Reduce % spawners in catch
Total	4 (7%)	9 (15%)	46 (78%)	59	

Notes: Number of stocks classified under each category. In parenthesis: the percentage that each category represents of all stocks of that species assessed.

(Figure B5.6). The decline was associated with the systematic introduction of deep bottom gear (longlines and gillnets) that targeted the largest and most valuable fish (e.g. AdriaMed, 2005). The most recent stock assessment Working Groups (GFCM, 2011a; Cardinale *et al.*, 2010) assessed the status of the stocks of this species in 11 GSAs. They concluded that all these stocks were being overexploited, with decreasing biomass and recruitment trends in many of these GSAs. The assessments recommended that both overall fishing mortality and the percentage of small fish in the catch should be reduced. This latter measure can be achieved through temporal closures of the nursery areas or gear modifications. Nevertheless, the importance of protecting a part of the adult spawning population has been identified several times as a way of improving the likelihood of sufficient recruitment to the population (e.g. Caddy, 1990; GFCM, 2011a).

*Red (***Mullus barbatus***) and striped (***Mullus surmuletus***) mullets*

During the latest meetings of the stock assessment Working Groups, the stocks of red mullet in 10 GSAs and of striped mullet in 3 GSAs were assessed (GFCM 2011a; Cardinale *et al.*, 2010). All stocks were considered to be suffering overexploitation, with the exception of striped mullet in Malta Island, which was diagnosed as under full exploitation. The Working Group recommended a reduction in the overall fishing pressure and in the percentage of juveniles in the catches. It also recommended pursuing these reductions through changes to the gear or the protection of nursery areas.

Sparids, seabreams and pandoras

Sparids and seabreams play an important role in Mediterranean demersal fisheries and are generally heavily exploited. Analysis of data for *Sparus aurata* in the Gulf of Lions (Farrugio and Le Corre, 1994) suggested that it was fished above F_{MSY}, and it is unlikely that this situation has improved. Pandora (*Pagellus* spp.) and groupers appear to be some of the demersal species least resistant to heavy exploitation, and catch rates have declined in a number of regions. Pandora stocks have been heavily overfished in Greek waters (Papaconstantinou, Mytilineou and Panos, 1988), and probably also in Cyprus. Other species overexploited in this region include bogue (*Boops boops*) and red mullet stocks (Hadjistephanou, 1992). In contrast, picarels (*Spicara* spp.) are considered to be exploited close to MSY. The stock of common pandora (*Pagellus erythrinus*) in GFCM GSA 09 (Ligurian and North Tyrrhenian seas) was assessed as overexploited by the SGMED WG in 2010 (Cardinale *et al.*, 2010). The stocks of blackspot seabream (*Pagellus bogaraveo*) in the Alboran Sea were assessed by a joint Moroccan–Spanish working group within the framework of the CopeMed II project. The stock was classified as overexploited, although its status on the southern side is appreciably better than that on the northern side of the Alboran Sea (GFCM, 2011b). Finally, although bogue is a bycatch in many regions, it is targeted in several others, e.g. GSAs 03 and 26, and the stocks of this species in these regions were assessed as being overexploited in 2008–09. However, the situation of the species in other GSAs is probably slightly better.

Soles

The recent assessments undertaken in the framework of the AdriaMed project and by the GFCM stock assessment Working Groups indicate that sole (*Solea solea*) stocks in the Adriatic and the South Levant regions are heavily overexploited. The catches also include a large proportion of juveniles (GFCM, 2011a). The management recommendations for these two stocks include a reduction in the overall fishing mortality and reinforcement of closed areas during the peak recruitment periods to protect juveniles.

Horse and jack mackerels

Few data exist for horse mackerels (*Trachurus trachurus* and *T. mediterraneus*) as they are not a target species for the most fisheries in Area 37. They are apparently not intensively fished, except in Turkey and maybe some southwest Mediterranean countries. Their biomass appears to be variable, presumably responding to environmental fluctuations. They are migratory, but the patterns are unclear and this makes their assessment more difficult. Similar considerations apply to mackerels (*Scomber scombrus* and *Scomber japonicus*).

Crustaceans

Norway lobster

Three stocks of this species were assessed in the most recent round of formal stock assessments (GFCM, 2011a; Cardinale *et al*., 2010). These stocks were those from GFCM GSA 05 (Balearic Islands), GSA 09 (Ligurian and North Tyrrhenian Seas) and GSA 17 (northern Adriatic, stock assessed in the framework of the AdriaMed project). All three stocks were found to be overexploited, requiring a reduction in fishing mortality, albeit to different degrees. This species is often captured by the fleets exploiting the deep-sea shrimps *Parapenaeus longirostris* and *Aristeus antennatus*, as well as larger hake (e.g. Sartor *et al*., 2003; Sbrana, Sartor and Belcari, 2003). Thus, the management of Norway lobster must take into consideration the multispecies nature of the fishery.

Rose shrimp

Rose shrimp (*Parapenaeus longirostris*) is exploited throughout the Mediterranean, and in most GSAs. During the last series of assessments, the stocks of this species in six GSAs were assessed, and the conclusion was that five (83 percent) of these were overexploited and one was fully exploited. This species is actively targeted in all these GSAs, but it is also sometimes captured as a bycatch of other fisheries (GFCM, 2011a). Therefore, management must take into consideration the multispecies nature of the fishery.

Red shrimps

Red shrimps (*Aristeus antennatus* and *Aristaeomorpha foliacea*) are intensely exploited in the western and central Mediterranean by bottom trawlers fishing the continental slope. The most recent assessments could only analyse the state of the stocks of these species in two GSAs (Balearic Islands and Northern Strait of Sicily), which were considered to be overexploited. For some countries, significant amounts of *Aristeus* and *Aristeomorpha* are probably reported to FAO simply as "natantian decapods NEI". Given the high economic value of this resource in the region (Lleonart *et al.*, 2003), and the expansion in the fisheries targeting these species (Mouffok *et al.*, 2008), special attention needs to be paid to the management of their fisheries.

Small pelagic resources

Sardine and anchovy

Monitoring of sardine and anchovy stocks with acoustic surveys has been done regularly for more than a decade in several regions. These regions include the Alboran Sea and Northwest Mediterranean, the Adriatic (with the support of the AdriaMed Project) and the Aegean and Black Seas (GFCM, 2011c). The daily egg production method (DEPM) is currently applied routinely to assess anchovy stocks in the Aegean Sea and less regularly in the Northwest Mediterranean, Tyrrhenian and Southern Adriatic. In general, the results are used as ancillary information to the acoustic surveys and the model-based stock assessments.

In the latest meeting of the different stock assessment Working Groups dealing with small pelagic fish, a total of 11 assessments were presented and discussed (GFCM, 2011c; Cardinale *et al.*, 2010). The assessments covered sardine and anchovy stocks in seven GSAs. Most stocks were found to be fully exploited. About 30 percent of the stocks were assessed to be overexploited, with those of both sardine and anchovy in the Gulf of Lions and the stock of anchovy in the Strait of Sicily considered to be in particularly poor condition. In the Gulf of Lions, this situation was associated with previous overexploitation and a current state of very low productivity. In contrast, excessive current fishing pressure is considered to be the main cause of low catch for the stock of anchovy in the Strait of Sicily.

The GFCM Small Pelagics Working Group (GFCM, 2011c) analysed the global variations of several small pelagic stocks and fisheries across the Mediterranean. It concluded that there were signs of some synchronous variations that suggested an environmental effect overlaying the effect of fisheries on the stocks. The Working Group suggested that this effect needed to be further investigated.

Large pelagic resources

Large pelagic fish, being mostly migratory fish with extensive migration patterns covering several of the FAO Fishing Areas, are dealt with in Chapter C1.

THE AZOV AND BLACK SEAS

Fisheries in the Azov and Black Seas are characterized mostly by the spectacular increase in catches of small pelagic fish from the 1970s to the mid-1980s and their subsequent collapse by the end of the 1980s. It is now reasonably accepted that the increase in catch was the result of a combination of eutrophication from the rivers draining into the seas and a reduction in predation pressure from heavy exploitation of the more important predators (Daskalov, 2002; Oguz, Fach and Salihoglu, 2008). The subsequent collapse has been linked to the invasion by the ctenophore *Mnemiopsis leidyi* coupled with heavy fishing pressure and environmentally unfavourable conditions for fish recruitment (Shiganova and Bulgakova, 2000; Oguz, Fach and Salihoglu, 2008).

Top Black Sea predators such as dolphins and porpoises have seriously declined in abundance (Birkun, 2008). Predatory fish, including mackerel (*Scomber scombrus*), blue fish (*Pomatomus saltatrix*) and bonito (*Sarda sarda*) used to enter seasonally from the Sea of Marmara. Now, these species rarely penetrate into the waters to the northwest of the Black Sea (Zengin and Dinçer, 2006). The abundance of the stocks of these species can be considered severely reduced, but not necessarily only by fishing. Pollution, especially in the northwest part of the Black Sea, is considered to have played an important part (Mee, Friedrich and Gamoiu, 2005).

Meanwhile, a species of grey mullet (the haarder [*Mugil soiuy*] has been introduced from the Pacific coast of the Russian Federation). This species breeds in shallow water and appears to be less sensitive to *M. leidyi* predation on its larval stages. This has allowed haarder stock size to increase in recent years. Several other introduced species, such as the *Mya* clam and *Rapana* sea snail appear to be tolerant of eutrophic conditions. The snail is now becoming a major export item in some countries and can be considered fully exploited (Shlyakhov and Daskalov, 2008).

In the Azov Sea, collapses of several freshwater fish stocks, such as pike, bream and roach, occurred in the 1960s (Ivanov and Beverton, 1985). These collapses were associated with progressive salination caused by damming of, and water extraction from, major inflowing rivers.

In the last decade, the amount of nutrients and pollutants entering the Black Sea through the river discharge has been appreciably reduced (BSC, 2008). This in turn has already resulted in a slight improvement in environmental conditions in the Black and Azov Seas in the last decade. This has allowed the recovery of biodiversity and marine living resources despite overfishing, degradation of vital habitats (including spawning and nursery areas) and the disturbance of the ecological balance that continues to occur.

Although the regular yearly assessment of the major fish resources has not yet become a rule in the Black Sea, some particularly important resources have been the subject of more intensive study and more information on their status is available.

Anadromous fish

Sturgeons

The estimated biomasses and catches of the most common species of sturgeon: *Acipenser gueldenstaedtii*, *Acipenser stellatus* and *Huso huso* have all declined recently. This decline has been accentuated drastically since the late 1980s. Two species of sturgeon (*Acipenser brevirostrum* and *Acipenser nudiventris*) have almost disappeared. Experts attribute these declines to the combination of a reduction in spawning habitats by damming of rivers, large-scale illegal fishing and the alteration of the flow regime of the main rivers (Shlyakhov and Daskalov, 2008). The estimated abundance of the Azov Sea sturgeon stock for 2004–05 was only 5 percent of that at the beginning of the 1990s (Shlyakhov and Daskalov, 2008). It is now considered that all the stocks of sturgeon in the Black and Azov Seas are very severely overexploited.

Shads

Biomasses of these anadromous species have declined by about 75 percent or more compared with the 1970s. Unfavourable environmental conditions in the region's rivers, especially the Danube River, may have affected the reproductive success of these species. However, overfishing on the northern and southern coasts of the Black Sea seems to have been the most important cause of the decline of these stocks (Radu, 2006). It is now considered that the stock of shad in the Black Sea is overexploited (Shlyakhov and Daskalov, 2008).

Small pelagic fish

After the heavy exploitation of the larger predators in the Black Sea, small pelagic fish, especially sprat (*Sprattus sprattus*) and anchovy (*Engraulis encrasicolus*) became the most important fish resources in the Azov and Black Seas until their collapse in the late 1980s.

European sprat

The sprat stock in the Black Sea supported intensive fishing by the former Soviet Union in the 1950s and 1970s. More recent increases in exploitation rate have caused a decline in stock biomass that has also been linked to the increase in the abundance of the predatory ctenophore *Mnemiopsis leydi* in the late 1980s (Daskalov, 1998; Shiganova and Bulgakova, 2000). After the late-1980s stock collapse, sprat recruitment, biomass and catches started to increase again. The stock had recovered to the previous peak-level recorded in the 1980s by the mid-2000s. With the recovery of fishing, fishing mortality increased from 0.1 in 1990 to 0.3 in 2000. The catch reached close to its historic levels (~70 000 tonnes) in 2001–05. The decreasing CPUE and mean catch size in Bulgarian and Romanian fisheries in 2006–07 indicate that the current level of fishing pressure might be excessive for the current stock (Shlyakov and Daskalov, 2008).

Anchovy

Anchovy is the single largest marine resource in the Black Sea. The biomass increased in the late 1970s and early 1980s at a time when catches were also increasing. This was apparently in response to increased nutrient inputs to the Black Sea (Oguz and Gilbert, 2007) and a reduction in predators due to fishing (Daskalov, Prodanov and Zengin, 2007). Anchovy stocks collapsed in the late 1980s, probably as a result of the combined effect of intensive fishing and increased predation and feeding competition with the ctenophore *Mnemiopsis leidyi* (Oguz, Fach and Salihoglu, 2008). Fishing effort was subsequently reduced and this allowed anchovies to recover somewhat. However, anchovy biomass and catches have not returned to the previous levels. Despite this partial recovery, there is still substantial overcapitalization in anchovy fisheries, especially in the south and southeast of the Black Sea. It is believed that the stock of Black Sea anchovy is still being exploited above the level of sustainability.

Demersal fish

Whiting

In the Black Sea, whiting (*Merlangius merlangus*) is caught mainly as a bycatch of trawl fisheries targeting sprat and other species. The exception is in Turkey and Romania, where it is also a target species for a part of the fleet. Catches of whiting have fluctuated markedly in the last two decades (Shlyakov and Daskalov, 2008). However, the condition of the stock varies in different parts of the Black Sea. In general, the stock seems to be more heavily exploited in the southwest Black Sea than in the northeast region, where it is apparently in a better condition. This stock may have benefited from the relative recovery of the small pelagic stocks that allowed both an increase in prey and a reduction in fishing pressure.

Turbot

Turbot (*Psetta maxima*) is the most important demersal species in the Black Sea, especially owing to its high value across the region. The stock of this species suffered very heavy exploitation in the 1970s and 1980s. It has partially recovered since then, as a result of increased restrictions on fishing being imposed by several nations, especially on the northern coasts of the Black Sea (Shlyakov and Daskalov, 2008). The latest information seems to indicate that this stock can be considered as fully exploited, although the components of the stock on the south coast may be overexploited already.

Introduced species

Among the species that have been introduced recently into the Black Sea, the So-iuy grey mullet (*Mugil soiuy*) and the sea snail *Rapana thomasiana* make the largest contribution to Black Sea fisheries. The catches of both of these species have been increasing following increased fishing effort. They are considered to be fully exploited, after the introduction of regulations limiting their exploitation on the northern coasts of the Black Sea. The intensive use of dredges for the fishery of sea snail, however, may be causing other damage to benthic habitats that should be closely monitored (Shlyakov and Daskalov, 2008).

PARTICULAR ISSUES OF RELEVANCE

Introduced species

Introductions of exotic species have caused and are causing major changes in the Mediterranean and Black Sea regions. In the Black Sea, drastic ecological changes have led to the collapse of the major anchovy fishery. These major changes have occurred following the introduction of a number of harmful exotic phytoplankton and animals that were carried in ship ballast water or attached to ship hulls. The one introduction that has had the most visible impact on fisheries has been the introduction of the ctenophore *Mnemiopsis leidyi*. In the Mediterranean, the most noteworthy of these effects is the progressive invasion of the eastern Mediterranean by a growing number of Red Sea species entering the eastern Mediterranean through the Suez Canal (Lessepsian migrants). These species now dominate the fisheries in some of the eastern Mediterranean countries, and are also likely to become important in other parts of the Mediterranean (EastMed, 2011). Even though some of the new species are highly valuable fishery targets and are welcome by fishers, others, like *Lagocephalus sceleratus*, create major problems to the fisheries in the region. This latter species damages most nets and is also highly poisonous (EastMed, 2011). The dramatic accidental introduction and spread of a species of seaweed (*Caulerpa taxifolia*) into the western Mediterranean will also probably affect demersal food chains in that region in a way that is not easily predicted (Zaitsev and Öztürk, 2001; Galil, Froglia and Noël, 2002; Golani *et al*., 2002).

FISHERY MANAGEMENT, ACHIEVEMENTS, CONCERNS OR ISSUES AND FUTURE DIRECTIONS IN THE REGION

With the exception of large pelagics and some particular fisheries (striped venus in the Adriatic, or sturgeon fisheries), fishery management in the Mediterranean is not based on catch control via TACs and quotas. The exception is the management of national fisheries in the Black Sea by the Russian Federation. Instead, the management of Mediterranean fisheries is based on regulation of total fishing effort through limited licences and technical measures such as time and area closures, gear limitations and limited landed sizes. Most countries have some form of closed-access system, through a limitation on the number of licences issued, although this is not the case in all countries and in all fleet segments. In most parts of the Mediterranean, trawlers are not allowed to operate in coastal waters (at least down to depths of 50 m and/or a distance of 3 nautical miles from the coast). These restrictions have been made in order to protect the nursery areas of several commercial species. A review of the fisheries management measures applied in the Mediterranean can be found in Cacaud (2005).

Countries neighbouring the Mediterranean have all established territorial waters up to 12 nm from the coast. However, none has actually claimed an EEZ out to 200 nm (Cacaud, 2005). Therefore, most of the Mediterranean Sea is classified as the high seas. This means that international waters are much closer to the coasts than in most other seas and oceans. This situation requires a higher level of cooperation among coastal States for the management of Mediterranean fisheries. In the Black Sea, on the other hand, all coastal countries have claimed the 200 nm EEZs. This means that most of the fishing is carried out within the national jurisdiction of bordering countries. Subject to these jurisdictional frameworks, fisheries management in the region is subject to at least three different and complementary regimens. In the Mediterranean, the overall management of all fisheries is done in the framework of the GFCM. The fisheries of the countries that are members of the EU are managed according to the CFP of the EU. In most cases for the Mediterranean, this policy is harmonized with the GFCM policy. Non-EU countries define their own fisheries management measures, although most try to ensure they are compatible with GFCM regulations. The GFCM has had a very limited role in the regulation of fisheries in the Black Sea until recently. This is because not all countries bordering the Black Sea are members of this organization.

There are a number of major difficulties for adequate fisheries management in the region. These include: the overcapacity of the fleet, widely dispersed fleets dominated by small-scale vessels, a huge number of landing points, multispecies fisheries, and insufficient compliance and cooperation among countries in fisheries management. Despite this, there have been important improvements and achievements recently in the management of Mediterranean and Black Sea fisheries.

First and foremost, most countries in the region are becoming increasingly active in fisheries management. They are introducing national measures for fisheries management and participating more actively in regional and subregional initiatives. Most countries regularly participate in the meetings of the GFCM and send representatives to the stock assessment Working Groups of the GFCM Scientific Advisory Committee and to the subregional stock assessment Working Groups organized by the FAO regional projects CopeMed, AdriaMed, MedSudMed and EastMed. The EU established a Mediterranean subgroup of its STECF in 2006 to provide fisheries management advice on the Mediterranean fisheries of its member countries. The work of this subgroup is complementing the work done by the GFCM's SAC. These recent initiatives have led to an appreciable increase in the number of the fish stocks and fisheries that are scientifically assessed. In 2009 and 2010, 59 different stocks (48 demersal and 11 small pelagic fish) were formally evaluated by the GFCM's SAC or by the STECF.

The knowledge base for the assessments has also been improving. There is an increasing recognition that many if not most of the Mediterranean and Black Sea fish stocks tend to be at least partially shared among neighbouring countries. In this context, it is easily accepted that it has been beneficial to have the assessments undertaken jointly, either at the GFCM Stock Assessment Working Groups or at subregional Working Groups. These activities are usually organized within the framework of the FAO regional projects. In 2010, at least six joint stock assessments were conducted with the support of the FAO Mediterranean projects (AdriaMed, CopeMed, EastMed and MedSudMed). These stock assessments included the stocks of rose shrimp in the Strait of Sicily, of *Pagellus bogaraveo* in the Alboran Sea, and of sardine, anchovy, hake and sole in the Adriatic Sea. In the last few years, there have also been other important efforts to improve the quality of the stock assessments. These efforts include at least the following: (i) the compilation of a database of the main biological parameters (growth, maturation and mortality) of the more-intensively exploited species in the region to facilitate the carrying out of comparable assessments with consistent parameter sets; and (ii) the introduction of a more systematic quality control and documentation system for all stock assessments, in the framework of the GFCM's SAC as well as the EU's STECF.

ACKNOWLEDGEMENTS

The authors would like to thank Enrico Arneri, Juan Antonio Camiñas, Constantina Riga, Nicoletta Milone, Luca Ceriola, Mark Dimech and Mathieu Bernardon, from the FAO Mediterranean fisheries management support projects, for their valuable comments and inputs. Special thanks also to the GFCM Secretariat and all the colleagues

from the Fisheries Research Institutes of Mediterranean and Black Sea countries, who along the years have maintained high-quality fisheries research and data management programmes providing the information this review is based on, because without their work there would still be no scientific knowledge on the status of exploited fish stocks in this region.

REFERENCES

AdriaMed. 2005. *Adriatic Sea Small-scale Fisheries. Report of the AdriaMed Technical Consultation on Adriatic Sea Small-Scale Fisheries. Split, Croatia, 14–15 October 2003*. FAO-MiPAF Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea. GCP/RER/010/ITA/TD15. AdriaMed Technical Documents, 15. 184 pp.

Bas Peired, C. 2005. *The Mediterranean Sea: living resources and exploitation*. CIHEAM-IAMZ/FAO CopeMed project. Zaragoza, Spain. 509 pp.

Birkun, A. 2008. The state of cetacean populations. *In* T Oguz, ed. *State of the environment of the Black Sea (2001-2006/7)*. Publications of the Commission on the Protection of the Black Sea Against Pollution (BSC) 2008-3. Istanbul, Turkey. 421 pp.

BSC. 2008. State of the Environment of the Black Sea (2001–2006/7). Edited by Temel Oguz. Publications of the Commission on the Protection of the Black Sea Against Pollution (BSC) 2008-3, Istanbul, Turkey, 448 pp.

Cacaud, P. 2005. *Fisheries laws and regulations in the Mediterranean: a comparative study*. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 75. Rome, FAO. 40 pp.

Caddy, J.F. 1990. Options for the regulation of Mediterranean demersal fisheries. *Natural Resource Modeling*, 4: 427–475.

Cardinale, M., Abella, A., Accadia, P., Charilaou, C., Colloca, F., Di Natale, A., Farrugio, H., Fiorentino, F., Garcia-Rodriguez, M., Giannoulaki, M., Gil-de-Sola, L., Jenko, K., Karlou-Riga, K., Knittweis, L., Lleonart, J., Martin, P., Maynou, F., Murenu M., Osio G.C., Patti B., Santojanni A., Sartor P., Scarcella G., Spedicato M.T., Ticina, V., Rätz, H.-J. & Cheilari, A. 2009. *Report of the SGMED-09-02 Working Group on the Mediterranean Part I*. Scientific, Technical and Economic Committee for Fisheries. Luxembourg. 846 pp.

Cardinale, M., Abella, A., Bellido, J., Biteto, I., Colloca, F., Fiorentino, F., Giannoulaki, M., Guijarro, B., Jadaud, A., Knittweis, L., Lloret, J., Martin, P., Murenu, M., Mustac, B., Osio, G.C., Quetglas, A., Quintanilla, F., Sbrana, M., Scarcella, G., Scott, F., Spedicato, M.T., Ticina, V., Tserpes, G., Tsikliras, A., Rätz, H.-J. & Cheilari, A. 2010. *Report of the SGMED-10-02 Working Group on the Mediterranean Part I*. Scientific, Technical and Economic Committee for Fisheries.

Daskalov, G. 1998. *Pêcheries et changement environnemental à long terme en Mer Noire*. Université de la Méditerranée (Aix-Marseille II). (thèse de doctorat)

Daskalov, G.M. 2002. Overfishing drives a trophic cascade in the Black Sea. *Marine Ecology Progress Series*, 225: 53–63.

Daskalov, G.M., Prodanov, K. & Zengin, M. 2007. The Black Seas fisheries and ecosystem change: discriminating between natural variability and human-related effects. *In* J. Nielsen, J. Dodson, K. Friedland, T. Hamon, N. Hughes, J. Musick & E. Verspoor, eds. *Proceedings of the Fourth World Fisheries Congress: Reconciling Fisheries with Conservation*, pp. 587–602. American Fisheries Society Symposium.

EastMed. 2011. *Report of the Sub-Regional Technical meeting on the Lessepsian migration and its impact on Eastern Mediterranean fishery*. Scientific and Institutional Cooperation to Support Responsible Fisheries in the Eastern Mediterranean. GCP/INT/041/EC – GRE – ITA/TD-04. Athens. 134 pp.

Farrugio, H. & Le Corre, G. 1994. *Diagnostics à l'équilibre de quelques stocks halieutiques démersaux euryhalins du Golfe de Lion: Analyses de pseudocohortes et rendements par recrue*. GFCM Consultation Sète, 19-23 Sept. 1994. (mimeo)

Fiorentini, L., Caddy, J.F. & de Leiva, J.I. 1997. *Long and short term trends of Mediterranean fishery resources*. FAO GFCM Studies and Reviews No. 69. 72 pp.

Galil, B., Froglia, C. & Noël, P. 2002. *CIESM Atlas of Exotic Species - Vol. 2. Crustaceans*. Frederic Briand, editor. CIESM Publishers. 192 pp.

General Fisheries Commission for the Mediterranean (GFCM). 2010. *Report of the twelfth session of the Scientific Advisory Committee (Budva, Montenegro, 25–29 January 2010)*. FAO Fisheries and Aquaculture Report No. 936. Rome, FAO. 167 pp.

General Fisheries Commission for the Mediterranean (GFCM). 2011a. *Report of the SCSA Working Group on stock Assessment of demersal species (Istanbul, Turkey, 18–23 October 2010)*. GFCM: SAC13/2011/Inf.19.

General Fisheries Commission for the Mediterranean (GFCM). 2011b. *Report of the 12th Session of the Sac Sub-Committee on Stock Assessment (SCSA) (Saint George's Bay Malta, 28 November–3 December 2010)*. GFCM:SAC13/2011/Inf.8.

General Fisheries Commission for the Mediterranean (GFCM). 2011c. *Report of the SCSA Working Group on stock Assessment of small pelagic species (Campobello di Mazara, Italy, 1–6 November 2010)*. GFCM: SAC13/2011/Inf.21.

Golani, D., Orsi-Relini, L., Massutí, E. & Quignard, J.-P. 2002. *CIESM Atlas of Exotic Species in the Mediterranean –Vol. 1. Fishes*. Frederic Briand, editor. CIESM Publishers. 256 p.

Hadjistephanou, N.A. 1992. Assessment of five demersal marine fish stocks of Cyprus for the year 1989. *In* FAO. *Fourth Technical Consultation on Stock Assessment in the Eastern Mediterranean. Thessaloniki, Greece, October 1991*, pp. 23–34. FAO Fisheries Report No. 477. Rome, FAO.

Ivanov, L. & Beverton, R.J.H. 1985. *The fisheries resources of the Mediterranean. Part 2: Black Sea*. GFCM Studies and Reviews, 60. 135 pp.

Lleonart, J., Maynou, F., Recasens, L. & Franquesa, R. 2003. A bioeconomic model for Mediterranean fisheries, the hake off Catalonia (western Mediterranean) as a case study. *Scientia Marina*, 67 (suppl. 1): 337–351.

Ludwig, W., Dumont, E., Meybeck, M. & Heussner, S. 2009. River discharges of water and nutrients to the Mediterranean and Black Sea: major drivers for ecosystem changes during past and future decades? *Progress in Oceanography*, 80: 199–217.

Margalef, R. 1985. Introduction to the Mediterranean. *In*: R. Margalef, ed. *Western Mediterranean*, pp. 1–16. Series Key Environments. Pergamon Press. 363 pp.

Mee, L.D., Friedrich, A. & Gomoiu, M.T. 2005. Restoring the Black Sea in times of uncertainty. *Oceanography*, 18: 100–111.

Mouffok, S., Kherraz, A., Bouras, D. & Boutiba, Z. 2008. The fishery for, and local distribution of, *Aristeus antennatus* (Risso 1816) (Crustacea: Dendrobranchiata) off western Algeria. *African Journal of Aquatic Science*, 33: 175–179.

Oguz, T. & Gilbert, D. 2007. Abrupt transitions of the top-down controlled Black Sea pelagic ecosystem during 1960–2000: evidence for regime shifts under strong fishery exploitation and nutrient enrichment modulated by climate-induced variations. *Deep-Sea Research*, 54: 220–242.

Oguz, T., Fach, B. & Salihoglu, B. 2008. Invasion dynamics of the alien ctenophore Mnemiopsis leidyi and its impact on anchovy collapse in the Black Sea. *Journal of Plankton Research*, 30: 1385–1397.

Papaconstantinou, C., Mytilineou, C. & Panos, T. 1988. Aspects of the life history and fishery of Red Pandora, *Pagellus erythrinus* (Sparidae) off Western Greece. *Cybium*, 12: 267–280.

Radu, G. 2006. *The state of main habitats important for Black Sea marine living resources*. Romanian second Fishery Report. UNDP/GEF Black Sea Ecosystem Recovery Project Phase II. 29 pp.

Sartor, P., Sbrana M., Reale, B. & Belcari, P. 2003. Impact of the deep sea trawl fishery on demersal communities of the northern Tyrrhenian Sea (western Mediterranean). *Journal of Northwest Atlantic Fishery Science*, 31: 275–284.

Sbrana, M., Sartor, P. & Belcari, P. 2003. Analysis of the factors affecting crustacean trawl fishery catch rates in the northern Tyrrhenian Sea (western Mediterranean). *Fisheries Research*, 65: 271–284

Shiganova, T.A. & Bulgakova, Y.V. 2000. Effects of gelatinous plankton on Black Sea and Sea of Azov fish and their food resources. *ICES Journal of Marine Science*, 57: 641–648.

Shlyakhov, V. & Daskalov, G. 2008. The state of marine living resources. *In* T. Oguz, ed. *State of the Environment of the Black Sea (2001-2006/7)*. Publications of the Commission on the Protection of the Black Sea Against Pollution (BSC) 2008-3. Istanbul, Turkey. 421 pp.

Tserpes, G., Fiorentino, F., Levi, D., Cau, A., Murenu, M., Zamboni, A. & Papaconstantinou, C. 2002. Distribution of *Mullus barbatus* and *M. surmuletus* (Osteichthyes: Perciformes) in the Mediterranean. *Scientia Marina*, 66 (Suppl. 2): 39–54.

Ünlüata, Ü., Oğuz, T., Latif, M.A. & Özsoy, E. 1990. On the physical oceanography of the Turkish Straits. *In* L.J. Pratt, ed. *The physical oceanography of sea straits*, pp. 25–60NATO/ASI Series. Dordrecht, Netherlands, Kluwer.

Zaitsev, Y. & Öztürk, B., eds. 2001. *Exotic species in the Aegean, Marmara, Black, Azov and Caspian Seas*. Published by Turkish Marine Research Foundation, Publication No. 8. Istanbul, Turkey. 267 pp.

Zengin, M. & Dinçer, A.C. 2006. Distribution and Seasonal Movement of Atlantic Bonito (*Sarda sarda*) populations in the Southern Black Sea Coasts. Turkish Journal of Fisheries and Aquatic Sciences, 6: 57–62.

B6. Southwest Atlantic

FAO STATISTICAL AREA 41

Marcelo Vasconcellos
FAO Consultant
Brazil
E-mail: marcelovasconcellos@furg.br

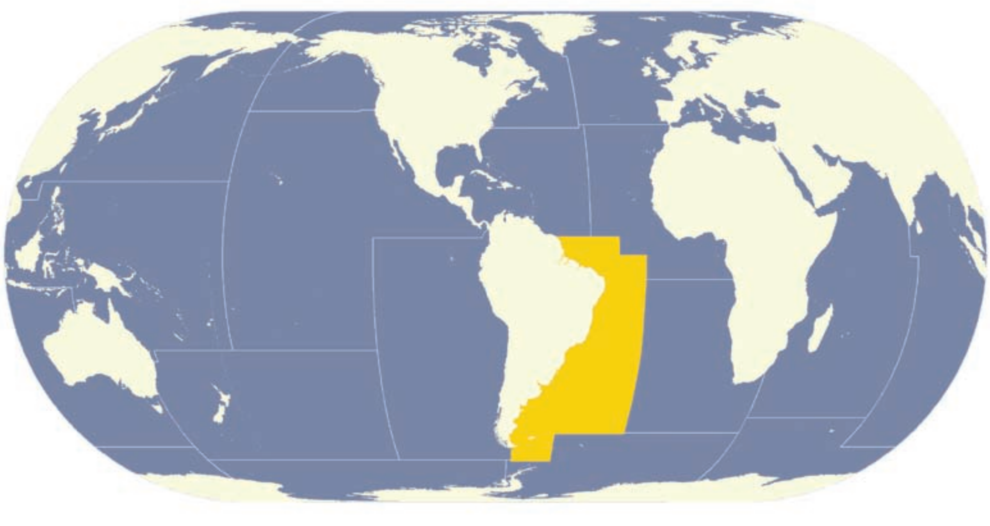
Jorge Csirke
FAO consultant
Peru
E-mail: jorge.csirke@gmail.com

INTRODUCTION

Area 41 covers a total surface of 17.65 million km^2 off the east coast of South America, between latitudes 05°00'N off northern Brazil and 60°00'S off southern Argentina, and includes a total shelf area of 1.96 million km^2 (Figure B6.1). In the north, the continental shelf may extend as far as 160 nm (320 km) offshore from the Amazon River, where the bottom is mostly river deposits and debris. As one moves south away from the influence of the Amazon River, the shelf becomes narrow, coralline and mostly unsuitable for trawling. The shelf is also narrow and mostly rocky further south off central and southern Brazil. Closer to the southern extent of Area 41, it widens and becomes more suitable for trawling. The best and largest areas for trawling are found around the Plate River and over the Patagonian shelf and the area of the Falkland Islands (Malvinas). In these regions, the shelf extends well beyond the 200-nm limit (more than 370 km) off the coastline. This makes this region the largest area of continental shelf in the Southern Hemisphere.

The variety and abundance of fishery resources and types of fisheries in Area 41 are determined by a combination of physical and environmental characteristics. The

FIGURE B6.1
The Southwest Atlantic (Area 41)



environmental conditions range from typically tropical in the north to sub-Antarctic in the south. Towards the northern part of Area 41, the marine environmental conditions are dominated by the South Equatorial Current. This current flows from the coast of Africa until it hits the South American coast. There, it branches into the North Brazil Current, which flows along the north Brazilian coast, and the Brazil Current, which flows south along the central and southern Brazilian coast. The northern part of Area 41 is further influenced by the great flow of freshwater from the Amazon River. Further south, the marine environment is dominated by the warmer southward-flowing Brazil Current and then by the colder northward-flowing Falkland Current (Malvinas Current). These currents merge into an offshore flow of subtropical convergence just off the Plate River. This is a region where there is also a large flow of freshwater into the coastal ecosystems (Emílsson, 1959; Hempel, 1971; Dias Neto and Mesquita, 1988; Bakun and Parrish, 1991; Bakun, 1993; Castro and Miranda, 1998).

Shrimps and lobsters, and to a lesser extent reef fishes and other tropical demersals, tend to be of particular relevance towards the northern part of Area 41. Further south, important populations of small pelagics are found in nutrient-rich coastal regions where water masses mix off central Brazil and off Uruguay–northern Argentina. This mostly occurs around the Plate River. Coastal demersals are particularly important off southern Brazil and in the vicinity of the Plate River. Whereas mid-water and deepwater demersals tend to dominate over most of the continental shelf in the vicinity of the Plate River, the Patagonian shelf and the Falkland Islands (Malvinas). The region of the Falkland Islands (Malvinas) is also important for squids. Large pelagics are mostly caught off central Brazil and the Plate River.

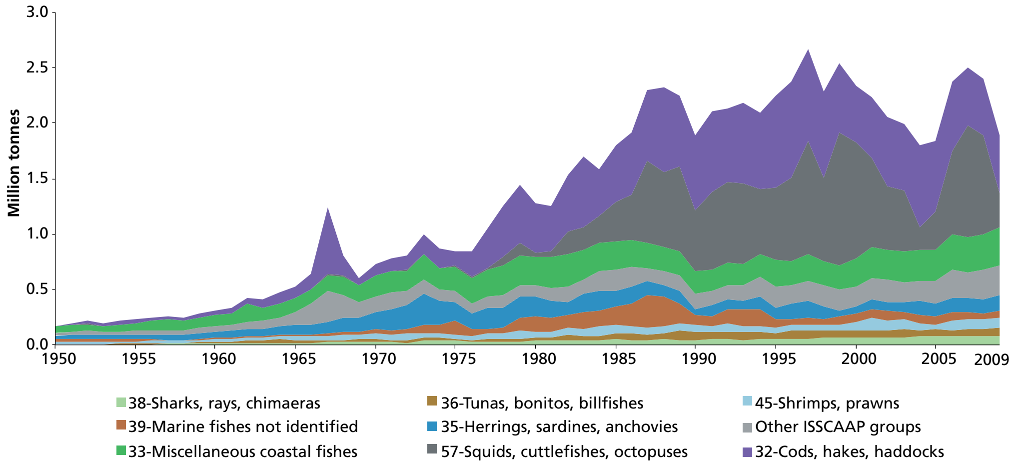
PROFILE OF CATCHES

Most capture fish production from Area 41 comes from demersals and squids. This is one of the FAO Statistical Areas where capture fisheries grew rapidly until the late 1990s. In the last decade, total catches from Area 41 have stabilized, although with marked interannual fluctuations. In 1950, the total catch for the whole of Area 41 was only 172 000 tonnes. At that time, most of the known fish stocks were only lightly or moderately exploited, and several important stocks were still virtually unexploited. A number of new fisheries have developed since, and total annual catches increased steadily at an average rate of 7.4 percent per year to reach a maximum of 2.4 million tonnes in 1987. There was an exceptional spike in catches between 1966 and 1968, with a peak catch of 599 000 tonnes in 1967 caused by an intense pulse of fishing for hake and probably other demersals by the then Soviet Union fleet (Figure B6.2). Catches declined after 1987, to a low 2.0 million tonnes in 1990 and 2.1 million tonnes in 1994. A new maximum was reached in 1997 at 2.8 million tonnes. Since then, catches have been fluctuating between 2.0 and 2.5 million tonnes (Figure B6.2 and Table D6).

Demersal species in ISSCAAP Group 32 (cods, hakes, haddocks) and molluscs in Group 57 (squids, cuttlefishes, octopuses) are the major contributors to the catches from this region. The next most-important catch groups are the coastal species in Group 33 (miscellaneous coastal fishes such as croakers and weakfishes), the small pelagics in Group 35 (herrings, sardines, anchovies), and other demersals in Group 34 (miscellaneous demersal fishes such as toothfish and cusk-eel) and Group 38 (sharks, rays, chimaeras). The dominant species in the demersals of Group 32, in terms of volume, are the Argentine hake (*Merluccius hubbsi*), the Patagonian grenadier (*Macruronus magellanicus*), and the southern blue whiting (*Micromesistius australis*). Among the other groups, the Argentine shortfin squid (*Illex argentinus*) in Group 57, and the Brazilian sardinella (*Sardinella brasiliensis*) in Group 35 contributed the largest catches.

The Argentine hake sustains one of the most important fisheries in the region of the Plate River and over most of the Patagonian shelf. Total catches of this species

FIGURE B6.2
Annual nominal catches by ISSCAAP Groups in the Southwest Atlantic (Area 41)



steadily increased from 1950 to 102 000 tonnes in 1965. Catches were at first all taken by the coastal States (Argentina, Brazil and Uruguay). Following the exceptionally high catches of hake reported by the then Soviet Union in 1967 (513 000 tonnes), catches declined to 70 000 tonnes in 1969. The total catch from this region then increased steadily to 462 000 tonnes in 1979, and then gradually increased to a record high of 682 000 tonnes in 1996. Since then, total catches of Argentine hake rapidly declined to a record low of 243 000 tonnes in 2000 and have fluctuated since. Reported catches in 2009 were 331 000 tonnes (Figure B6.3).

The Argentine hake is mostly exploited by Argentine and Uruguayan fleets. Both fleets increased in the 1980s to the early 1990s, and the Argentine fleet continued to increase in the 1990s. Other deepwater demersals in Group 32 that make a significant contribution to the total fish production in Area 41 are the Patagonian grenadier and the southern blue whiting (Figure B6.3). These species produced 135 000 tonnes and 32 000 tonnes, respectively, in 2009. They are particularly abundant in the southern Patagonian shelf and slope, where they are exploited by long-range fleets from the region as well as by distant-water fleets.

The miscellaneous demersals in Group 34 (Figure B6.4) that contribute most to total fish production in Area 41 are the pink cusk-eel (*Genypterus blacodes*) and Patagonian toothfish (*Dissostichus eleginoides*), with 21 000 tonnes and 5 000 tonnes, respectively, in 2009. These species are exploited by both

FIGURE B6.3
Annual nominal catches of selected species in ISSCAAP Group 32, Southwest Atlantic (Area 41)

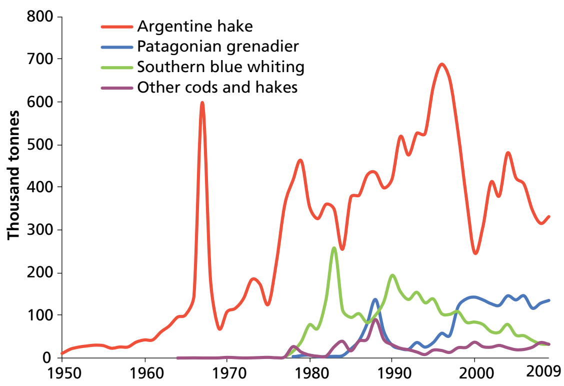


FIGURE B6.4
Annual nominal catches of selected species in ISSCAAP Groups 33 and 34, Southwest Atlantic (Area 41)

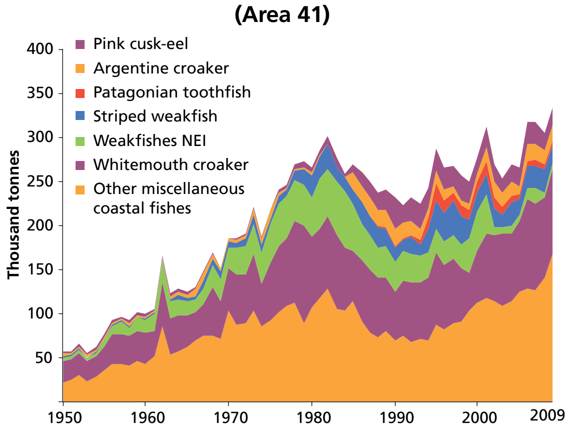


FIGURE B6.5
Annual nominal catches of selected species in ISSCAAP Groups 35 and 36, Southwest Atlantic (Area 41)

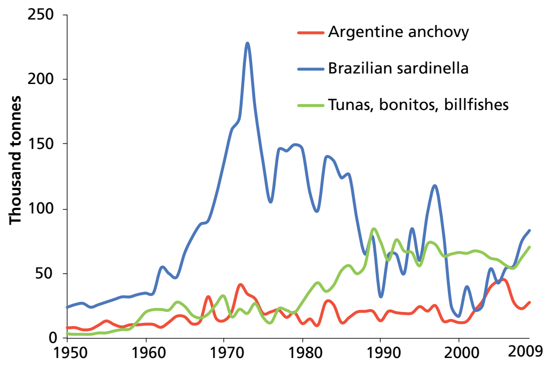
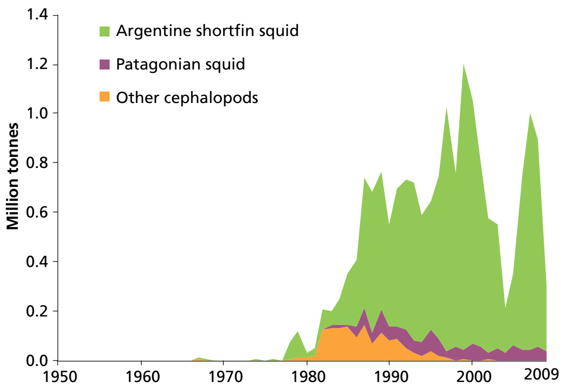


FIGURE B6.6
Annual nominal catches of selected species in ISSCAAP Group 57, Southwest Atlantic (Area 41)



coastal and long-range fleets from the region and from other FAO Statistical Areas. Coastal demersal species within Group 33 also produce significant catches within Area 41, particularly the Argentine croaker (*Umbrina canosai*), the striped weakfish (*Cynoscium striatus*), the whitemouth croaker (*Micropogonias furnieri*), and other weakfishes (*Cynoscion* spp.). These species have reported relatively high and stable catches in the past few years, with a total of 140 000 tonnes for the four species in 2009. These species are all exploited by coastal fleets.

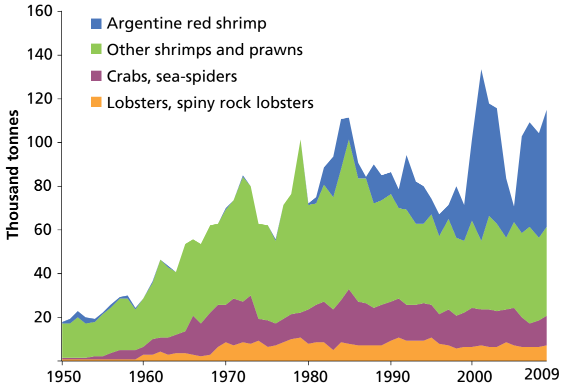
The main small pelagic species within Group 35 are the Brazilian sardinella (*S. brasiliensis*) and the Argentine anchovy (*Engraulis anchoita*). After the record catches of 228 000 tonnes of Brazilian sardinella reported in 1973, total catches of this species declined. The total catch of Brazilian sardinella hit a low of 17 000 tonnes in 2000. Since then catches have been steadily increasing, reaching 83 000 tonnes in 2009 (Figure B6.5). Catches of Argentine anchovy reached a maximum of 44 000 tonnes in 2005 and 2006, declining to 28 000 tonnes in more recent years. Catches of tunas and other large pelagics in Group 36 have been more or less stable at 50 000–70 000 tonnes per year, after reaching a maximum of 74 000 tonnes in 1996.

Another very important fishery in Area 41 is that for squids (Group 57). The main species is the Argentine shortfin squid (*Illex argentinus*). It represented 87 percent of the squid catches and 14 percent of total marine catches in Area 41 in 2009. The overall abundance and actual catches of Argentine shortfin squid have been very variable since the fisheries started in the late 1970s. After reaching 638 000 tonnes in 1993, total catches of this species declined to 506 000 tonnes in 1994, before increasing to a record high of 1.1 million tonnes in 1999. From 2000 to 2009, catches fluctuated widely between 179 000 tonnes and 955 000 tonnes. Catches in 2009 (261 000 tonnes) were among the lowest catches in the last two decades (Figure B6.6). Although less abundant, total catches of Patagonian squid (*Loligo gahi*) also fluctuated between a maximum of 89 000 tonnes in 1989 and a low of 22 000 tonnes in 1997. In 2009, the total catch of this species was 35 000 tonnes. Another squid species caught occasionally is the seven-star flying squid (*Martialia hyadesi*). Catches are usually low, ranging between 0 and 1 000 tonnes/year in most years. The exception was a record high catch of 24 000 tonnes in 1995. This exceptional catch was followed by catches of 3 800 tonnes and 8 300 tonnes in 1996 and 1997. Catches of other non-identified squids has declined sharply in recent years, suggesting great improvements in the identification at species level of squid catches from Area 41.

Shrimps, prawns, lobsters, crabs and other crustaceans in Groups 42, 43 and 45 also sustain important local fisheries throughout Area 41 from the tropics to the sub-Antarctic zone. Altogether, these species groups have yielded total catches of more than 100 000 tonnes since 2000 (Figure B6.7). These are important volumes considering their relatively high market value. The single crustacean species yielding the largest catches is the Argentine red shrimp (*Pleoticus muelleri*). It has highly variable catches ranging from 3 000 to 50 000 tonnes/year since the fishery started in the 1980s. The highest record catch of 79 000 tonnes was reported in 2001. In 2009, the total catch of this species was 54 000 tonnes.

About 3 percent of the total catches in Area 41 (55 779 tonnes in 2009) are reported as "not identified marine fishes" in the official FAO statistics. These species are grouped under ISSCAAP Group 39 (marine fishes not identified). These mostly come from small-scale fisheries, particularly in Brazil, where the variety of species and landing sites makes the recording of catches by species a difficult task.

FIGURE B6.7
Annual nominal catches of selected species in ISSCAAP Groups 42, 43 and 45, Southwest Atlantic (Area 41)



RESOURCE STATUS AND FISHERY MANAGEMENT

Until the early 1980s, Area 41 was among the few major fishing regions of the world still with a large potential for expansion. Until that time, there were abundant and potentially valuable fishery resources that were still being reported as underexploited or lightly exploited (FAO, 1979, 1981, 1983; Otero *et al.*, 1982, 1983; Csirke, 1987; Dias Neto and Mesquita, 1988). Several coastal and mostly industrialized long-range fisheries have developed since. Most of the fish stocks are now considered to be fully exploited, while some are, or have been, severely overexploited in recent years (Bezzi, Akselman and Boschi, 2000; Dias Neto, Saccardo and Bernardino, 2001; FAO, 1997, 2002; MMA, 2006). The status of commercial fish stocks is shown in Table D6.

International fisheries research, stock assessment and fisheries management activities in Area 41 are mostly dealt with through bilateral arrangements. Argentina and Uruguay cooperate mainly through the Joint Technical Commission for the River Plate Maritime Front (CTMFM, http://ctmfm.org). This organization was established in 1973 to promote bilateral cooperation between neighbouring Argentina and Uruguay regarding the assessment and management of shared stocks in the River Plate Maritime Front. In so doing, the CTMFM has been organizing or coordinating joint research surveys and other research activities in its convention area. It has also actively promoted scientific publications and meetings of regional and international relevance. At these meetings, various stock assessment and fisheries management issues of interest to the two member countries and other stakeholders are addressed. While very active in the 1980s and 1990s, the activities of this regional commission have decreased, particularly in relation the wider regional or international significance of their scientific activities. However, in November, the CTMFM signalled the start of a new, more active era by holding a scientific symposium. This symposium, titled "The ecosystem approach and its implementation in fisheries management in the Fisheries Common Zone of Argentina and Uruguay", was the first in a decade and was attended by more than 100 scientists from more than 20 institutions.

Argentina and the United Kingdom of Great Britain and Northern Ireland also cooperate in the assessment of fish stocks and management of fisheries in the region of the Falkland Islands (Malvinas). In November 1990, the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland signed a joint statement on the conservation of fisheries. This statement led to the establishment of a South Atlantic Fisheries Commission, composed of delegations from both States. The South Atlantic Fisheries Commission met regularly and provided a forum for the exchange of information on marine living resources. It discussed the implementation of measures to improve the conservation and management of commercially important fish stocks in the Southwest Atlantic, particularly those around the Falkland Islands (Malvinas). However, it has been less active in recent years.

Brazil has about ten technical working groups (Grupos Permanentes do Estudos), which have had variable degrees of activity over the years. In certain circumstances, these groups have been instrumental in coordinating research work. They have also provided technical advice on the assessment and management of important fisheries in Brazil, such as tunas, shrimps, lobsters, sardines and coastal demersals. Through some of these working groups covering the northernmost part of Area 41, there is active cooperation with the WECAFC covering Area 31 regarding the study and assessment of fish stocks in the Guyana–Brazil region.

Most of the reported expansion in production in Area 41 in the last three decades has been due to the increased catches of hake and other demersals as well as squids on the Patagonian shelf and slope. There are two well-known species of hake in this region, the Argentine hake (*Merluccius hubbsi*) and the Patagonian or southern hake (*M. australis*). A third hake species (*M. patagonicus*, sp. nov, Lloris and Matalallanas, 2003) has also recently been described. The Argentine hake is the most conspicuous and abundant of these species. The distribution and fishing grounds of Argentine hake tends to overlap with that of the other hakes in the outer Patagonian shelf and slope, and the species are difficult to identify correctly. Given the higher abundance and relative importance of the Argentine hake, it is likely that at least some of the southern hake catches are reported as Argentine hake. Reported catches of southern hake have been well under 10 000 tonnes per year in recent years, while those of Argentine hake have been in the range of 243 000–682 000 tonnes per year.

There seem to be at least two stocks of Argentine hake (*M. hubbsi*), with some authors proposing the existence of three or four or even up to five stocks (Otero and Kawai, 1981; Bezzi and Perrotta, 1983; Otero, Giangiobbe and Renzi, 1986; Perrotta and Sanchez, 1992; Bezzi, Verazay and Dato, 1995). However, the possible presence of two or more stocks is not taken into account in the official annual catch statistics. They are also not always taken into account in the assessment and management of the hake fishery within the common Argentine–Uruguayan fishing zone and in the remaining area around the Patagonian shelf.

The assessments available indicate that, until the 1980s and early 1990s, the stocks of Argentine hake were fully exploited. However, this soon developed into a state of overexploitation by the mid-1990s and stock depletion (FAO, 1983; Csirke, 1987; Bezzi, Verazay and Dato, 1995; Consejo Federal Pesquero, 1998; Aubone *et al.*, 1998; Bezzi, Aubone and Irusta, 1999; Aubone, 2000; Bezzi, Akselman and Boschi, 2000; Tringali and Bezzi, 2001; Arena and Rey, 2003; Irusta and D'Atri, 2010). At first, the overexploitation of the hake stocks was mainly caused by growth overfishing. This soon developed into recruitment overfishing, with a serious depletion of the SSB. The hake resource was declared to be in a state of emergency. Both main fishing countries, Argentina and Uruguay, had severe restrictive measures imposed in 1998. The restrictive measures are still in force and include reduced TACs and extensive seasonal and zonal closures to protect juveniles and spawners. While some signs of increased recruitment are being reported, the restrictive measures adopted so far do not seem to have reduced fishing pressure sufficiently for a more rapid long-lasting recovery of the Argentine hake stocks in Area 41.

In comparison with the Argentine hake, the southern hake (*M. australis*) stock is much smaller and is distributed further south in the southern part of the Patagonian shelf and slope. There is also evidence of a possible connection with a larger stock of southern hake in Area 87, off the southern coast of Chile (Tingley *et al.*, 1995). The stock of southern hake is considered to be fully exploited and current catches are within the recommended TAC for this species.

The Patagonian grenadier (*Macruronus magellanicus*) is usually found in deeper waters in the southern Patagonian Shelf. According to recent analyses, Patagonian grenadier is considered to be moderately exploited, with catches in recent years under the estimated TACs (Giussi and Wohler, 2009). The other main fish stock in Group 32 is the southern blue whiting (*Micromesistius australis*), which is also found in deeper waters in the southern Patagonian shelf and slope, particularly around the Falkland Islands (Malvinas). While this stock was considered to be moderately to fully exploited until the mid-1990s, more recent studies suggest that, at current catch rates, the stock of southern blue whiting is being overexploited (Bezzi, Akselman and Boschi, 2000; Cordo and Wöhler 2000; Wöhler, 2000; Consejo Federal Pesquero, 2002; Giussi and Wohler, 2010). Stock abundance has declined since 1992, reaching the lowest level in 2007, with a slight recovery in 2008 and 2009 (Giussi and Wohler, 2010). Other demersal fish stocks in Group 34, such as the Patagonian toothfish (*Dissostichus eleginoides*) and the pink cusk-eel (*Genypterus blacodes*) are also considered overexploited.

There are several stocks of coastal demersal species of Group 33 throughout the region. The main species in this ISSCAAP group are the Atlantic croaker (*Umbrina canosai*), stripped whitefish (*C. striatus*), various species of weakfishes (*Cynoscium* spp.) and the whitemouth croaker (*Micropogonias furnieri*). Most of these stocks are fully exploited, while some local stocks are showing clear signs of overexploitation (Otero and Ibañez, 1986; Arena, 1990; Dias Neto and Dornelles, 1996; Arena and Rey, 1999; Bezzi, 2000; Bezzi, Akselman and Boschi, 2000; Vasconcellos and Haimovici, 2006; MMA, 2006; Lorenzo and Scavino, 2011; Chiesa *et al*., 2011).

The Brazilian sardinella (*Sardinella brasiliensis*) is one of the main small pelagics in ISSCAAP Group 35 being exploited in Area 41. It is found over the shallower continental shelf off central Brazil between 22° and 29°S. After the record high catches of 228 000 tonnes taken in 1973, catches of this species dropped and then varied between 100 000 tonnes and 150 000 tonnes until 1986, when a further period of decline occurred. The total biomass of Brazilian sardinella declined from an estimated 350 000 tonnes in 1977 to 80 000 tonnes in , and there have been no signs of stock recovery since then (Saccardo and Rossi-Wongtschowski, 1991; Rossi-Wongtschowski, Saccardo and Cergole, 1995, 1996; Matsuura, 1998; Vasconcellos, 2001; MMA, 2006). The causes of the severe decline and lack of recovery of this sardine stock is a source of great interest and active debate among fisheries scientists and administrators (Saccardo 1983; Saccardo and Rossi-Wongtschowski, 1991; Rossi-Wongtschowski, Saccardo and Cergole, 1996; Dias Neto, Saccardo and Bernardino, 2001; Vasconcellos, 2003). All available evidence seems to indicate that the Brazilian sardine is also exposed to decadal cycles of favourable and unfavourable environmental conditions, similar to other stocks of sardines in other parts of the world. These environmental cycles drive the population size up and down more or less independently of fishing pressure. These effects comes in addition to the effects of heavy fishing, which seems to have maintained this sardine stock under a state of overexploitation almost continuously since the first recorded large catch more than four decades ago. In this respect, it has already been suggested that excessive fishing pressure could exacerbate biomass declines and delay or compromise potential natural recoveries.

Another small pelagic fish stock particularly abundant in the Southwest Atlantic is the Argentine anchovy (*Engraulis anchoita*). This anchovy is usually found off southern Brazil, Uruguay and northern Argentina. In some years, it has also been reported as far north as central Brazil, in regions usually inhabited by Brazilian sardine (Lima and Castello, 1994). This is one of the few cases worldwide of a highly abundant, well-known commercial fish stock that still remains underexploited. Total catches are in the lower tens of thousands tonnes per year, while the potential for their entire distribution is more than 100 000 tonnes. The total estimated biomass of Argentine anchovy varies widely. Most estimates have been well over 1 million tonnes, with maximum estimates close to 10 million tonnes in some years (Ciechomski and Sánchez, 1988; Hansen and Madirolas, 1999; Hansen, 2004). This is a stock that clearly could support a much higher fishing pressure. However, it is clear that, as the species is close to the base of the food web of the northern Patagonian and Plate River system, any significant increase in fishing pressure on this stock could have negative impacts on other fish species feeding on it.

Catches of tunas and other large pelagics have been more or less stable in recent years. Most stocks seem to be fully exploited, although some potential for limited expansion exists. Total catches of sharks, rays and chimaeras have remained more or less stable or increased slightly in the last decade, with 83 000 tonnes reported for this species group in 2009. Although some stocks are not subject to direct fishing, they might still be moderately or fully exploited as bycatch in other more intensive demersal fisheries in Area 41. Because of their low fecundity and other life history characteristics, there is some concern about the effect of this indirect fishing on shark, ray and chimaera populations. The excessive fishing mortality will probably be unsustainable. In extreme cases, it may lead to population depletion even when these species are not targeted by any particular direct fishery. More studies are needed in this respect, particularly in the context of the FAO International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks).

Among the crustaceans, the most abundant single species producing the highest yield is the Argentine red shrimp (*Pleoticus muelieri*) in the central Patagonian shelf (Boschi, 1989; Bezzi, Akselman and Boschi, 2000). At present, this stock is considered to be fully exploited.

Another main stock is the Argentine shortfin squid (*Illex argentinus*), which is distributed along the shelf and slope from 22° to 54°S. It is exploited by long range fleets from Area 41 as well as from distant areas. Several studies have been conducted on the shortfin squid stock in the Patagonian shelf and slope (Koronkiewicz, 1980, 1986; Brunetti, 1981; Otero *et al*., 1982; Hatanaka, 1986, 1988; Csirke, 1987; Haimovici and Perez, 1990; Haimovici *et al.*, 1998; Bakun and Csirke, 1998). Some work has been done to distinguish possible population groups or stocks in Area 41 by analysing differences in reproductive seasonality and distribution of early and older life stages. At least three main spawning stocks are described, the summer-spawning stock, the south Patagonia stock and a Bonaerensis-north Patagonia stock. There is a possible fourth stock in southern Brazil that could well be an extension of the Bonaerensis-north Patagonia stock.

In the first years of rapid development of this fishery, there was great uncertainty and concern regarding the state of this stock and the risk of overexploitation. This concern was addressed through the joint and coordinated research and management actions undertaken by Argentina and the United Kingdom of Great Britain and Northern Ireland within the South Atlantic Fisheries Commission. The results of these studies have contributed to improved assessment, monitoring and control of fishing operations of local and long-range fleets. Regardless of the high year-to-year variability in abundance and resulting catches, the Argentine shortfin squid as well as the Patagonian squid are considered fully exploited (Csirke, 2005; Maguire *et al*., 2006).

Most of these fisheries are under some kind of management scheme with specific management measures varying from one country to another and from one fishery to another. However, enforcement is not always as effective as desired. Only a few fisheries are under an open-access regime, and these are mostly coastal small-scale fisheries. In most cases, there is a limited-access scheme for which a fishing licence is required. These licensing requirements are usually combined with other fishing effort and total catch restrictions to keep fishing mortality under control. In addition, regulations on the size at first capture and seasonal and area closures are used to protect juveniles and spawners. In particular, Argentina and Uruguay, and their subregional organization, the Frente Marítimo, have been compelled to adopt more severe restrictive regulations, combining TAC limits, size-at-first-capture limits, and seasonal and area closures to address the critical situation of the Argentine hake stock.

REFERENCES

Arena, G.J. 1990. Evaluación de la captura máxima sostenible de la corvina blanca (*Micropogonias furnieri*) presente en el área operativa de la flota uruguaya, mediante modelos de producción excedente. *Frente Marítimo*, 7, Sec.A: 25–35.

Arena, G. & Rey, M., eds. 1999. Captura máxima sostenible de la corvina (*Micropogonias furnieri*) explotada en el Río de la Plata y la zona común de pesca (período 1986-1997). *In* M. Rey & G. Arena, eds. *Modelos de producción excedente aplicados a los recursos corvina y pescadilla*. Proyecto URU/92/003. Montevideo, INAPE-PNUD. 103 pp. (also available at www.dinara.gub.uy).

Arena, G. & Rey, M. 2003. Diagnóstico del recurso merluza en la zona común de pesca argentino–uruguaya. *In*: *DINARA, Informe Sectorial Pesquero 2000-2001*, pp. 9–12. Montevideo, MGAP. 63 pp. (also available at www.dinara.gub.uy).

Aubone, A. 2000. *El colapso de la merluza (*Merluccius hubbsi*) y su recuperación biológica*. Informe técnico interno, 17. INIDEP. 217 pp. (also available at www.sagpya.mecon.gov.ar).

Aubone, A., Perez, M., Renzi, M., Irusta, G., Dato, C., Villarino, F. & Bezzi, S. 1998. *Estado de explotación de la merluza (*Merluccius hubbsi*) al sur de los 41ºS (Atlántico sudoccidental) y recomendaciones de manejo para el año 1998*. Informe técnico, 149. INIDEP. 27 pp.

Bakun, A. 1993. The California Current, Benguela Current and Southwestern Atlantic Shelf Ecosystems: a comparative approach to identifying factors regulating biomass yields. *In* K. Sherman, *et al*., eds. *Large marine ecosystems: stress mitigation and sustainability*, pp. 199–221. Washington, DC, American Association for the Advancement of Science.

Bakun, A. & Csirke, J. 1998. Environmental processes and recruitment variability. *In* P.G. Rodhouse, E.G. Dawe & R.K. O'Dor, eds. *Squid recruitment dynamics*, pp. 105–124. FAO Fisheries Technical Paper No. 376. Rome, FAO. 273 pp.

Bakun, A. & Parrish, R.H. 1991. Comparative studies of coastal pelagic fish reproductive habitats: the anchovy (*Engraulis anchoita*) of the Southwestern Atlantic. *ICES Journal of Marine Science*, 48: 343–361.

Bezzi, S. 2000. *Síntesis de las evaluaciones y sugerencias de manejo efectuadas sobre el recurso merluza (*Merluccius hubbsi*) entre el año 1986 y mayo de 1997*. Informe Técnico, 30. INIDEP. 7 pp.

Bezzi, S. & Perrotta, R. 1983. *Determinación de la unidad del stock de la merluza común* Merluccius hubbsi *del Mar Argentino a través del análisis de los caracteres morfométricos y merísticos*. Contrib. Inst. Nac. Invest. Des. Pesq. 429. 30 pp. (in Spanish, English summary on p. 1)

Bezzi, S.I., Akselman, R. & Boschi, E.E., eds. 2000. *Síntesis del estado de las pesquerías marítimas argentinas y de la Cuenca del Plata. Años 1997-1998, con la actualización de 1999*. Publicaciones Especiales. Mar del Plata, Argentina, INIDEP. 388 pp.

Bezzi, S.I., Aubone, A. & Irusta, G. 1999. La zona común de pesca argentino-uruguaya y el problema de la cuota de captura de merluza (*Merluccius hubbsi*). *INIDEP, Rev. Invest. Desarr. Pesq*., 12: 95–98.

Bezzi, S.I., Verazay, G.A. & Dato, C.V. 1995. Biology and fisheries of Argentine hakes (*M. hubbsi* and *M. australis*). *In* J. Alheit & T.J. Pitcher, eds. *Hake: biology, fisheries and markets*, pp. 241–267. London, Chapman & Hall. 478 pp.

Boschi, E.E. 1989. *Fishery biology of the prawn from the Argentinian Patagonian littoral (*Pleoticus muelleri*). Biología pesquera del langostino del litoral patagónico de Argentina*. Contrib. Inst. Nac. Invest. Des. Pesq., 646. Mar del Plata, Argentina, INIDEP. 71 pp.

Brunetti, N.E. 1981. Distribución de tallas y biología reproductiva del calamar (*Illex argentinus*) en el mar argentino (campañas del B/I "Shinkai Maru", 1978-1979). *In* V. Angelescu, ed. *Campañas de Investigación Pesquera Realizadas en el Mar Argentino por los B/I "Shinkai Maru" y "Walter Herwig" y el B/P "Marburg", años 1978 y 1979. Resultados de la Parte Argentina*, pp. 119–127. Contrib. Inst. Nac. Invest. Des. Pesq. 383. 339 pp.

Castro, B.M. & Miranda, L.B. 1998. Physical oceanography of the western Atlantic continental shelf located between 4ºN and 34ºS. *In* A.R. Robinson & K.H. Brink, eds. *The Sea*, Vol. 11: 209–252. New York, USA, John Wiley & Sons.

Chiesa, E., Mello, C., González, S. & Silveira, S. 2011. Evaluación de la corvina (*Micropogonias furnieri*) en la Zona Común dePesca Argentino-Uruguaya mediante un modelo dinámico de producción excedente. *In* N. Gutiérrez & O. Defeo, eds. *Evaluación de recursos pesqueros de Uruguay mediante modelos dinámicos. Proyecto Gestión Pesquera en Uruguay*. MGAP-DINARA-FAO. 93 pp.

Ciechomski, J.D. & Sánchez, R.P. 1988. Análisis comparativo de las estimaciones de biomasa de la anchoita (*Engraulis anchoita*) en el Atlántico Sudoccidental en diferentes años y con distintas metodologías. *Publicaciones de la Comisión Técnica Mixta del Frente Marítimo*, 4: 117–131.

Consejo Federal Pesquero. 1998. Declárase al recurso merluza común (*Merluccius hubbsi*) en estado de emergencia. *Boletín Oficial de la República Argentina. Resolución 4/1998*: CFP, p. 7.

Consejo Federal Pesquero. 2002. Establécese la captura máxima permisible para el año 2002 respecto de determinadas especies. *Boletín Oficial de la República Argentina. Resolución 8/2002*: CFP, p. 6.

Cordo, H.D. & Wöhler, O.C. 2000. Estimación de índices de abundancia de la polaca (*Micromesistius australis*) en el Atlántico Sudoccidental. *Frente Marítimo*, 18, Sec. A: 125–134.

Csirke, J. 1987. *The Patagonian fishery resources and the off-shore fisheries in the South-West Atlantic*. FAO Fisheries Technical Paper No. 286. Rome, FAO. 75 pp.

Csirke, J. 2005. Southwest Atlantic – FAO Statistical Area 41: *In* FAO. *Review of the state of world marine fishery resources*, pp. 65–75. FAO Fisheries Technical Paper No. 457. Rome, FAO. 235 pp.

Dias Neto, J. & Mesquita, J.X. 1988. Potencialidade e explotação dos recursos pesqueiros do Brasil. *Ciência e Cultura*, São Paulo 40: 427–441.

Dias Neto, J. & Dornelles, L.D.C. 1996. *Diagnóstico da Pesca Marítima do Brasil*. Coleção Meio Ambiente, Série Estudos: Pesca, 20. Brasília, Instituto Brasileiro Do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA). 165 pp.

Dias Neto, J., Saccardo, S.A. & Bernardino, G. 2001. *Recursos Pesqueiros: pesca extrativisita e aqüicultura. Relatorio Perspectiva, do meio ambiente para o Brasil*. Brasilia, CGREP, IBAMA. 10 pp. (also available at www.ibama.gov.br).

Emílsson, I. 1959. Algunos aspectos físicos e químicos das águas marinhas brasileiras. *Ciência e Cultura*, S. Paulo 11: 44–54.

FAO. 1979. *Review of the state of world fishery resources*. FAO Fisheries Circular No. 710 Rev. 1. Rome. 41 pp. Issued also in French, Spanish, Arabic and Chinese.

FAO. 1981. *Review of the state of world fishery resources*. FAO Fisheries Circular No. 710 Rev. 2. Rome. 52 pp. Issued also in French, Spanish, Arabic and Chinese.

FAO. 1983. *Informe del Grupo Ad hoc de Trabajo sobre los recursos pesqueros de la plataforma continental patagónica. Roma, 7-11 Febrero 1983. Una reunión preparatoría para la Conferencia Mundial de la FAO sobre Ordenación y Desarrollo Pesquero. Report of the Ad hoc Working Group on fishery resources of the Patagonian Shelf. Rome, 7-11 February 1983. A preparatory meeting for the FAO World Conference on Fisheries Management and Development*. FAO Informe de Pesca/FAO Fisheries Report No. 297. Rome. 83 pp.

FAO. 1997. *Review of the state of world fishery resources: marine fisheries*. FAO Fisheries Circular No. 920. Rome. 173 pp.

FAO. 2002. *The State of World Fisheries and Aquaculture*. Rome. 150 pp. (also available at www.fao.org/fi).

Giussi, A.R. & Wohler, O.C. 2009. *Evaluación de la abundancia de merluza de cola (*Macruronus magellanicus*) en el atlántico sudoccidental. Período 1985-2008*. Informe Técnico Oficial No. 37. INIDEP. 24 pp.

Giussi, A.R. & Wohler, O.C. 2010. *Evaluación de la abundancia de merluza de cola (*Macruronus magellanicus*) en el atlántico sudoccidental. Período 1985-2008*. Informe Técnico Oficial No. 15. INIDEP. 12 pp.

Haimovici, M. 1988. Análisis de cohortes del stock de pargo blanco (*Umbrina canosai*) explotado en el sur de Brasil, Uruguay y Argentina. *Publicaciones de la Comisión Técnica Mixta del Frente Marítimo*, 4: 33–40.

Haimovici, M. & Perez, J.A.A. 1990. Distribution and sexual maturation of the Argentinian squid, *Illex argentinus* off southern Brazil. *Scientia Marina Barcelona*, 54: 179–185.

Haimovici, M., Brunetti, N.E., Rodhouse, P.G., Csirke, J. & Leta, R.H. 1998. *Illex argentinus*. *In* P.G. Rodhouse, E.G. Dawe & R.K. O'Dor, eds. *Squid recruitment dynamics*, pp. 27–58. FAO Fisheries Technical Paper No. 376. Rome, FAO. 273 pp.

Hansen, J.E. 2004. Anchoita (*Engraulis anchoita*). *In* E.E. Boschi, ed. *El mar Argentino y sus recursos pesqueros. Tomo 4. Los peces marinos de interés pesquero. Caracterización biológica y evaluación del estado de explotación*, pp. 101–115. Argentina, INIDEP. 359 pp.

Hansen, J.E. & Madirolas, A.O. 1999. *Algunos resultados de las campañas primaverales de evaluación annual de anchoíta bonaerense efectuadas entre 1993 y 1996*. Informe Técnico 28. INIDEP. 18 pp.

Hatanaka, H. 1986. Growth and life span of short-finned squid *Illex argentinus* in the waters off Argentina. *Bulletin of the Japanese Society of Scientific Fisheries*, 52: 11–17.

Hatanaka, H. 1988. Feeding migration of short-finned squid *Illex argentinus* in the waters off Argentina. *Nippon Suisan Gakkaishi*, 54: 1343–1349.

Hempel, G. 1971. Southwest Atlantic. *In* J.A. Gulland, ed. *Fish resources of the oceans*, pp. 146–152. London, Fishing News (Books) Ltd. 255 pp.

Irusta, C.G. & D'Atri, L.L. 2010. *Evaluación del estado del efectivo norte de 41° s de la Merluza (*Merluccius hubbsi*) y estimación de la captura biológicamente aceptable para el año 2010*. Informe Técnico Oficial No. 45. INIDEP. 39 pp.

Koronkiewicz, A. 1980. *Size, maturity, growth and food of squids,* Illex argentinus *(Castellanos, 1960)*. ICES Shellfish and Benthos Committee, C.M. 1980/k:18: 7 pp., 2 tables & 6 figures. (mimeo)

Koronkiewicz, A. 1986. *Growth and life cycle of the squid* Illex argentinus *from the Patagonian Shelf and Polish squid fishery in the region, 1978–85*. Gdynia, Poland, Sea Fisheries Institute. 9 pp., 12 tables & 14 figures. (mimeo)

Lima, I.D. & Castello, J.P. 1994. Distribución y abundancia de la anchoita (*Engraulis anchoita*) en la costa sur de Brasil. *Frente Marítimo*, 15, Sec. A: 87–99.

Lloris, D. & Matallanas, J., 2003. Description of a new species of hake: *Merluccius patagonicus* sp. nov. (Gadiformes: Merlucciidae) from the waters of Argentina. *Scientia Marina*, 67: 323–326.

Lorenzo, M.I. & Scavino, M. 2011. Evaluación de la pescadilla (*Cynoscion guatucupa*) en la Zona Común de Pesca Argentino-Uruguaya mediante modelos dinámicos. *In* N. Gutiérrez & O. Defeo, eds. *Evaluación de recursos pesqueros de Uruguay mediante modelos dinámicos*. Proyecto Gestión Pesquera en Uruguay. MGAP-DINARA-FAO. 93 pp.

Maguire, J.-J., Sissenwine, M., Csirke, J., Grainger, R. & Garcia, S. 2006. *The state of world highly migratory, straddling and other high seas fishery resources and associated species*. FAO Fisheries Technical Paper No. 495. Rome, FAO. 84 pp.

Matsuura, Y. 1998. Brazilian sardine (*Sardinella brasiliensis*) spawning in the southeast Brazilian Bight over the period 1976–1993. *Revista Brasileira de Oceanografia*, 46: 33–43.

Ministério do Meio Ambiente (MMA). 2006. *Programa REVIZEE: Avaliação do potencial sustentável de recursos vivos da Zona Econômica Exclusiva do Brasil – relatório executivo*. Brasília. 257 pp.

Otero, H. & Ibañez, P.M. 1986. Abundancia relativa de la corvina rubia (*Micropogonias furnieri*). Modelos de producción excedente. *Publicaciones de la Comisión Técnica Mixta del Frente Marítimo*, 1: 341–349.

Otero, H. & Kawai, T. 1981. The stock assessment on common hake (*Merluccius hubbsi*) in the south-west Atlantic. *Bulletin of Tokai Regional Fisheries Research Laboratory*, 104: 35–53

Otero, H., Giangiobbe, S. & Renzi, M. 1986. Aspectos de la estructura de población de la merluza común (*Merluccius hubbsi*). II. Distribución de tallas y edades. Estadíos sexuales. Variaciones estacionales. Montevideo, Uruguay. *Publicaciones de la Comisión Técnica Mixta del Frente Marítimo*, 1: 147–79 (in Spanish, English summary on p. 148).

Otero, H.O., Bezzi, S.I., Renzi, M.A. & Verazay, G. 1982. *Atlas de los recursos pesqueros demersales del Mar Argentino*. Contrib. Inst. Nac. Invest. Des. Pesq. 423. 248 pp.

Otero, H.O., Bezzi, S.I., Verazay, G.A., Pérez Comas, J.A., Perrotta, R.G., Simonazzi, M.A. & Renzi, M.A. 1983. Distribución, áreas de concentración, biomasa y rendimiento potencial de diferentes especies comerciales del Mar Argentino. *Contribución*, 433: 39–83 pp.

Perrotta, R. & Sanchez, F. 1992. Una vez más acerca de la identificación de las poblaciones de merluza (*Merluccius hubbsi*) en la plataforma argentino-uruguaya. Montevideo, Uruguay, *Publicaciones de la Comisión Técnica Mixta del Frente Marítimo*, 12: 39–46 (in Spanish, English summary on p. 46).

Rossi-Wongtschowski, C.L.D.B., Saccardo, S.A. & Cergole, M.C. 1995. *Situação do estoque de sardinha (*Sardinella brasiliensis*) na região sudeste do Brasil*. Coleção Meio Ambiente. Série Estudos–Pesca, 17. IBAMA/CEPSUL. 44 pp.

Rossi-Wongtschowski, C.L.D.B., Saccardo, S.A. & Cergole, M.C. 1996. Are fluctuations in Brazilian sardine catches related to global-scale climate changes? *Anais da Academia Brasileira de Ciências*, 68(Suppl. 1): 239–250.

Saccardo, S.A. 1983. *Biología y disponibilidada de sardina (*Sardinella brasiliensis, *Steindachner, 1879) en la costa sudeste del Brasil*. FAO Fisheries Report No. 291. Rome, FAO.

Saccardo, S.A. & Rossi-Wongtschowski, C.L.D.B. 1991. Biologia e avaliação do estoque da sardinha *Sardinella brasiliensis*: uma compilação. *Atlântica, Rio Grande*, 13: 29–43.

Tingley, G.A., Purchase, L.V., Bravington, M.V. & Holden, S.J. 1995. Biology and fisheries of hakes (*M. hubbsi* and *M. australis*) around the Falkland Islands. *In* J. Alheit & T.J. Pitcher, eds. *Hake: biology, fisheries and markets*, pp. 269–303. London, Chapman & Hall. 478 pp.

Tringali, L.S & Bezzi, S.I. 2001. *Captura máxima de merluza (Merluccius hubbsi): antecedentes científicos y relación con su marco regulatorio en la República Argentina entre 1970 y 2000*. Informe técnico interno, 55. INIDEP 19 pp. (also available at www.sagpya.mecon.gov.ar).

Vasconcellos, M.C. 2001. *The complementary roles of the single-species and ecosystem models in the fisheries management. An example from a Southwest Atlantic fishery*. FAO Fisheries Circular No. 970. Rome, FAO. 38 pp.

Vasconcellos, M.C. 2003. An analysis of harvest strategies and information needs in the purse seine fishery for the Brazilian sardine. *Fisheries Research*, 59: 363–378.

Vasconcellos, M. & Haimovici, M. 2006. Status of white croaker *Micropogonias furnieri* exploited in southern Brazil according to alternative hypotheses of stock discreetness. *Fisheries Research*, 80: 196–202.

Wöhler, O.C. 2000. Rendimiento potencial e incertidumbre en la estimación de puntos biológicos de referencia de la merluza de cola (*Macruronus magellanicus*) del Atlántico sudoccidental. *Frente Marítimo*, 18(Sec. A): 135–141.

B7. Southeast Atlantic

FAO STATISTICAL AREA 47

Pedro de Barros
Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: pedro.barros@fao.org

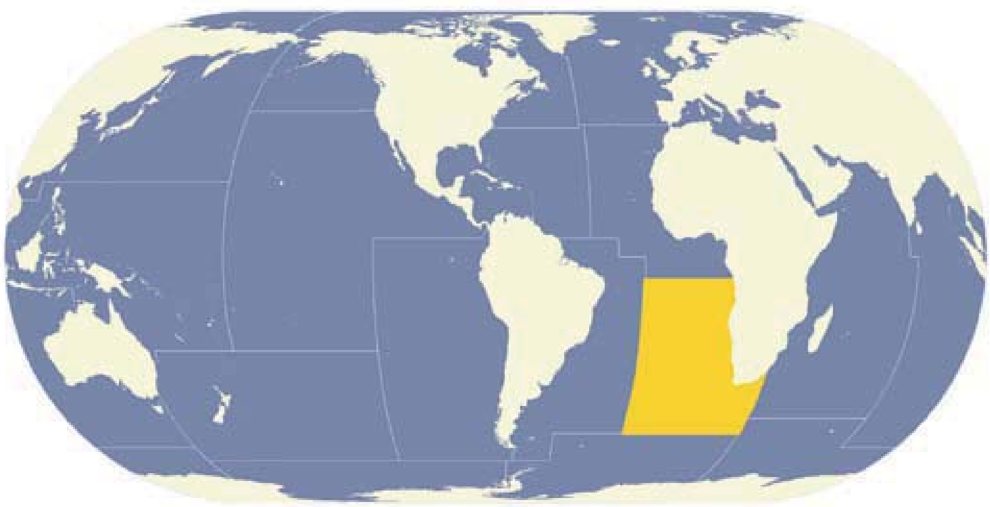
Kevern Cochrane
Director
Fisheries and Aquaculture Resources Use and Conservation Division
FAO Fisheries and Aquaculture Department
E-mail: kevern.cochrane@fao.org

INTRODUCTION

This section on the Southeast Atlantic deals with the waters adjacent to the coastlines of Angola, Namibia and South Africa and extends well into the high seas to the south and west (Figure B7.1). The islands of Saint Helena, Ascension and Tristan da Cunha also fall within Area 47. Nominal landings made by South Africa in the western Indian Ocean are included in Area 47. However, except for those from the Agulhas Bank, which is considered a part of the Benguela upwelling system, these landings form a very small part of the total for the region. The rest of the region is dominated by the Benguela upwelling system, which supports relatively high production along much of the coastline of these three countries.

The northern border of the Benguela upwelling system occurs at the thermal front with the warm Angola Current. This normally occurs between about 15°S and 17°S on the coastal shelf in southern Angola. North of the Angola-Benguela Front (ABF),

FIGURE B7.1
The Southeast Atlantic (Area 47)



most of the coastal shelf of Angola is dominated by the southward-flowing and less productive Angola Current. The Benguela ecosystem itself is subdivided into the northern Benguela system and the southern Benguela system. These are separated by the partial barrier of a very intense upwelling cell off the town of Lüderitz, some 300 km north of the border between Namibia and South Africa. Area 47 covers a total surface area of about 18.4 million km^2, with less than 0.5 million km^2 being shelf area.

This part of the Southeast Atlantic is a very variable and dynamic region from the point of view of oceanography. This variability significantly influences the marine living resources (Hutchings *et al.*, 2009). The last three decades have been characterized by several major oceanographic events that have influenced the dynamics of several important fish stocks.

One of these is the occasional occurrence of low-oxygen water spreading across the bottom of the Namibia shelf (Bartholomae and Plas, 2007). A major such event occurred in the period 1993–94. In this period, low-oxygen water occupied most of the central and northern Namibian shelf, leading to the almost total loss of a cohort of juvenile hake (Woodhead *et al*., 1997, Hamukuaya, O'Toole and Woodhead, 1998). Low oxygen levels near the seabed have also affected the distribution of hake over the Namibian shelf in a number of years (Mas-Riera *et al*., 1990, Woodhead *et al*., 1998).

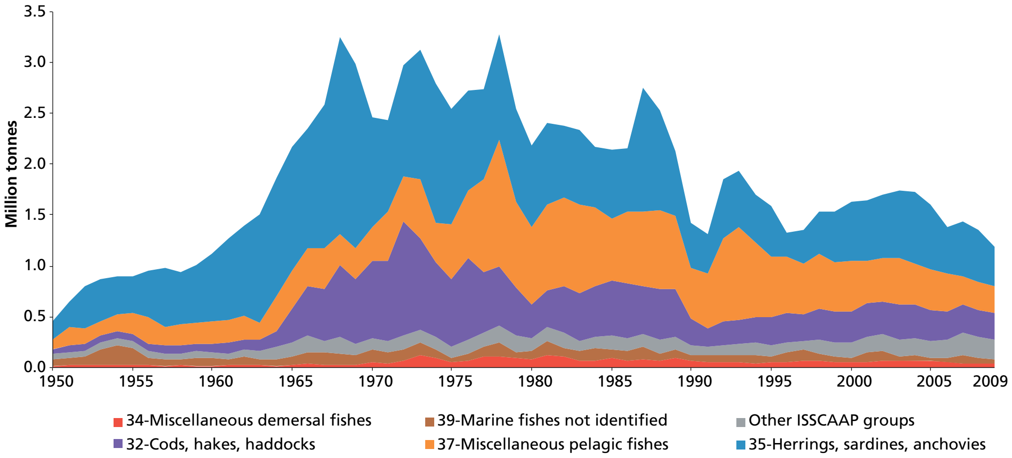
The other major oceanographic event affecting the region is the "Benguela Niño" that recurs about once a decade. Benguela Niños are extreme warm events that can be seen as abnormally high and persistent sea surface temperatures (SSTs) along the coast of Angola and Namibia (Shannon *et al.*, 1986). These anomalous warm events cause strong rainfall anomalies (Rouault *et al*., 2003) and drastically modify fish distribution and abundance (Boyer *et al*., 2001). Major Benguela Niños occurred in 1934, 1949, 1963, 1984 (Shannon *et al*., 1986) and in 1995 (Gammelsrød *et al*., 1998). The most recent Benguela Niño, in 1995, is credited with causing a 4–5° southward shift of the sardine population. It was also associated with high mortality and poor recruitment of several small pelagic fish species (Boyer and Hampton, 2001). The likely occurrence of a Benguela Niño in 2011 (IRI, 2011) will probably also create poor conditions for many fish stocks in the region (especially small pelagic fish). This will warrant more precautionary management measures to ensure the sustainability of the fisheries targeting them.

In a related sequence of events, the southern Benguela system experienced an unusual sequence of a short period of intense warming in December 1999, followed rapidly by a period of strong cooling early in 2000. This sequence was associated with record recruitment to the local anchovy stock, although any causal link is not well understood.

PROFILE OF CATCHES

Total nominal landings from the Southeast Atlantic (Area 47) increased from less than 0.5 million tonnes in 1950 to slightly more than 3 million tonnes in 1968 (Figure B7.2; Table D7). Landings varied at about 3 million tonnes until the end of the 1970s, before declining to fluctuate about 2.3 million tonnes in most of the following decade. They then decreased abruptly from 2.8 million tonnes in 1987 to 1.3 million tonnes in 1991. This was driven partly by a large decline in anchovy landings and policy changes in Namibia after it gained independence in 1990. Landings have remained under 2 million tonnes since then, with an average landing of about 1.6 million tonnes between 2000 and 2002 that declined to about 1.2 million tonnes in 2009. Landings from the region are dominated by ISSCAAP Group 35 (herring, sardine and anchovies), Group 37 (miscellaneous pelagic fishes [including horse mackerel]) and Group 32 (cods, hakes and haddocks) (Figure B7.2). The most important stocks within these groups were all subjected to heavy fishing pressure at different periods between the 1960s and the 1980s. In some cases, this fishing pressure led to quite severe declines in abundance

FIGURE B7.2
Annual nominal catches by ISSCAAP species groups for the Southeast Atlantic (FAO Area 47)



that was reflected in declining landings. The position was stabilized in several of these cases by imposition of more rigorous management regimes.

The small pelagic fisheries of the region, which together account for the highest proportion of the landings by mass, are dominated by six taxonomic groups: Cape horse mackerel (*Trachurus capensis*) and Cunene horse mackerel (*T. trecae*), Southern African pilchard (*Sardinops sagax*, also still referred to as *S. ocellatus*), Southern African anchovy (*Engraulis capensis*), sardinellas (round *Sardinella aurita* and Madeiran or flat *S. maderensis*) and Whitehead's round herring (*Etrumeus whiteheadi*). In 2009, Cape horse mackerel accounted for the largest landings of small pelagics, followed by South African pilchard and anchovy and then, substantially lower, the sardinellas and Whitehead's round herring (Figures B7.3 and B7.4).

FIGURE B7.3
Annual nominal catches of selected species in ISSCAAP Group 37, Southeast Atlantic (FAO Area 47)

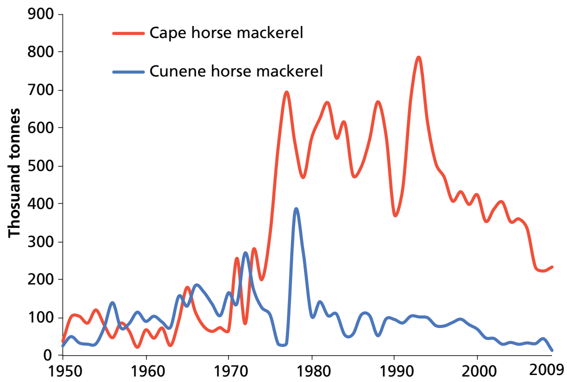
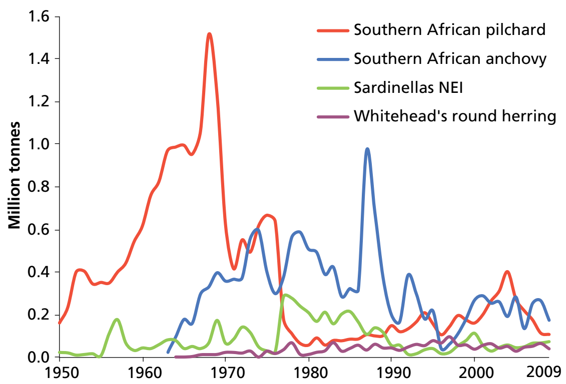


FIGURE B7.4
Annual nominal catches of selected species in ISSCAAP Group 35, Southeast Atlantic (FAO Area 47)



Cape horse mackerel is caught mainly in Namibia and in southern Angola, especially in the cold season. Cunene horse mackerel is the main exploited species off Angola, especially north of Namibe Province. Landings of the two horse mackerel species have declined since the late 1970s and mid-1980s. This was probably caused by the effects of heavy exploitation, particularly in Namibia and Angola, in this period. In both species, heavy exploitation in the late 1970s and 1980s was followed by a large reduction in fishing mortality when the then Soviet Union fleet was drastically reduced after 1989. The decrease in landings in this period also reflected this reduced effort. Effort has been increasing since the mid-

FIGURE B7.5
Annual nominal catches of selected species in ISSCAAP Group 32, Southeast Atlantic (FAO Area 47)

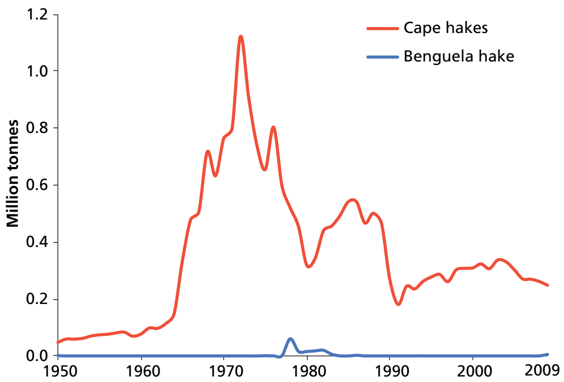
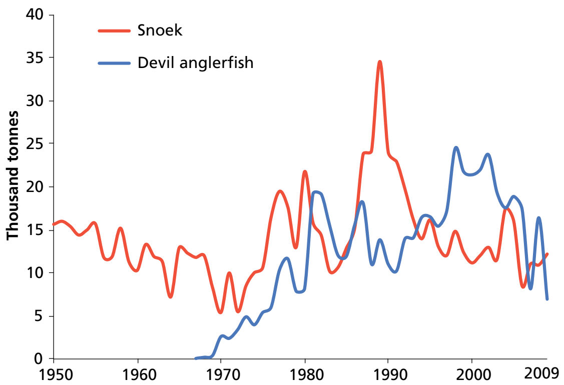


FIGURE B7.6
Annual nominal catches of selected species in ISSCAAP Group 34, Southeast Atlantic (FAO Area 47)



1990s in most cases. Declared landings of Cape horse mackerel were 223 000 tonnes in 2008, the lowest since the mid-1970s, and increased slightly to 233 000 tonnes in 2009. Declared landings of Cunene horse mackerel have been fluctuating around 30 000 tonnes since 2003, with a very marked decline to 13 000 tonnes in 2009, partially as a consequence of stricter regulation in place in Angola. These landing values are very low in relation to typical landings of the 1970s and 1980s.

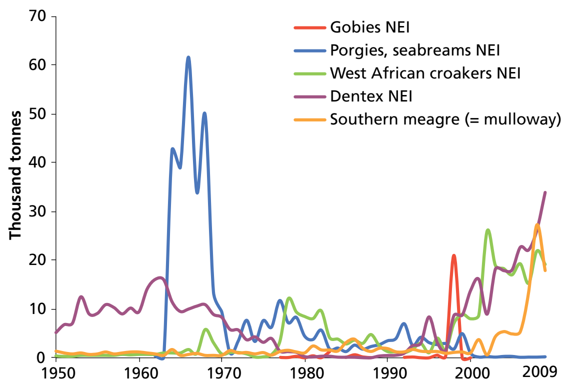
Declared landings of Southern African pilchard increased steadily from a low of about 105 000 tonnes in 1996 to a peak of about 400 000 tonnes in 2004, to decrease again to about 110 000 tonnes in 2009. Declared landings of Southern African anchovy have increased steadily since falling to a minimum of 42 000 tonnes in 1996, fluctuating between 135 000 tonnes in 2006 and 289 000 tonnes in 2001, with a value of 266 000 tonnes in 2009 (Figure B7.4). Landings of Whitehead's round herring fluctuated without a clear trend from the early 1980s, with a small peak in the mid-1990s and a maximum of 97 000 tonnes recorded in 1997. Since then, landings have been between 40 000 and 65 000 tonnes, apart from in 2000 and 2005 when they fell below 40 000 tonnes (Figure B7.4). The higher landings in 1995 (79 000 tonnes) and 1997 (97 000 tonnes) were probably, at least in part, a result of fishing effort being diverted to round herring from the struggling anchovy fishery, as the round herring is not regulated by a TAC in South Africa at present.

North of the Benguela front, primarily in Angolan waters, sardinellas are the dominant clupeoid in landings. The two species tend to alternate in dominance. Between 1994 and 2004, the flat sardinella tended to dominate in surveys, but the situation has reversed since 2004. In 2009, most of the estimated sardinella biomass off Angola was composed of round sardinella (INIP, 2011). Landings of the two species combined peaked at 286 000 tonnes in 1977. After 1989, following a substantial reduction in fishing effort in the region, landings declined and were well under 100 000 tonnes in the 1990s (Figure B7.4). They increased to 114 000 tonnes in 2000 but fell again to under 30 000 tonnes in 2002, to recover slightly to 74 000 tonnes in 2009.

The taxonomic groups most important in the demersal fisheries of the region include the shallow-water (*Merluccius capensis*) and deep-water (*M. paradoxus*) Cape hakes, devil anglerfish or Cape monkfish (*Lophius vomerinus*), snoek (*Thyrsites atun*), and also dentex, including Angolan (*Dentex angolensis*) and especially large-eyed dentex (*D. macrophthalmus*), which is important in Angola (Figures B7.5, B7.6 and B7.7).

Of these, Cape hakes accounted for the highest landings. Under TAC management, catches of Cape hakes have remained fairly constant at between 250 000 and 323 000 tonnes since 1995. Landings of snoek have declined from a maximum by the end of the 1980s to about 12 000 tonnes since 1997, with some evidence of a possible decline over this latter period. Landings of unidentified dentex remained fairly consistently above 10 000 tonnes from the early 1950s through to 1968, when they started to decline. They fell below 1 000 tonnes in 1980, and remained below this value until 1993. This marked the start of a recovery, leading to declared landings of more than 30 000 tonnes in 2009. Significant dentex landings are also recorded under the heading of large-eyed dentex, and these have ranged from 40 tonnes in 1994 to a maximum of 43 200 tonnes in 1976. Only 56 tonnes of large-eyed dentex landings were declared in 2009.

FIGURE B7.7
Annual nominal catches of selected species in ISSCAAP Group 33, Southeast Atlantic (FAO Area 47)



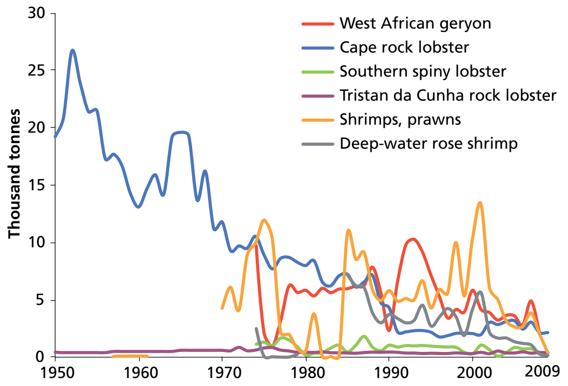
In addition to the fish species of particular commercial importance described above, a number of members of ISSCAAP Group 33 (miscellaneous coastal fishes) contribute to important fisheries in the region (Figure B7.7). The largest landings within this group, apart from dentex, are of West African croakers NEI (*Pseudotolithus* spp.), which are caught mainly by Angola. Declared landings of these fish fluctuated around 20 000 tonnes between 2002 and 2009. The period of increase in landings started in 1998, when they went from under 2 000 tonnes the previous year to more than 7 000 tonnes. Declared landings of mild (southern) meagre, known locally as kabeljou or kob (*Argysomus inodorus*, previously *A. hololepidotus*), are made mainly in Namibia and South Africa. Mild meagre landings have shown a sharp increase from an average about 1 200 tonnes before 2000 to an average of 22 000 tonnes in 2008–09. Declared landings of porgies and seabreams NEI (Sparidae) peaked at more than 61 000 tonnes in 1966 but soon dropped and have not been above 12 000 tonnes since 1970. Landings have been under 1 000 tonnes since 2000. The declared landings of southern meagre, dentex NEI and West African croakers NEI have increased very markedly in the last decade. The most recent landings are among the highest on record. The relatively high average landings of gobies are misleading. Apart from very high landings of 21 000 tonnes of gobies in 1998, landings of the group are generally well under 500 tonnes/year.

From 2000 to 2009, the following groups generated annual landings that averaged more than 1 000 tonnes: sea catfishes NEI (Ariidae); panga seabream (*Pterogymnus laniarius*); groupers, seabasses NEI (Serranidae); threadfins, tasselfishes NEI (Polynemidae); bigeye grunt (*Brachydeuterus auritus*); croakers, drums NEI (Sciaenidae); pargo seabreams NEI (*Pagrus* spp.); sand (locally "white") steenbras (*Lithognathus mormyrus*); grunts, sweetlips NEI (Haemulidae); and Canary drum (Baardman, *Umbrina canariensis*). Declared landings of picarels NEI (*Spicara* spp.), geelbek croaker (*Atractoscion aequidens*), carpenter seabream (*Argyrozona argyrozona*), black seabream (*Spondyliosoma cantharus*), porgies, seabreams NEI (*Sparidae*), mullets NEI (*Mugilidae*) and white stumpnose (*Rhabdosargus globiceps*) ranged between 100 and 500 tonnes/year in the same period.

Sharks, rays and chimaeras (ISSCAAP Group 38) did not use to account for substantial declared landings in Area 47. However, their landings have increased rapidly in recent years. Annual declared landings of the group have averaged 17 500 tonnes since 2000. These are made up primarily of: blue shark (*Prionace glauca*); unidentified sharks, rays, skates, etc.; unidentified raja rays; shortfin mako (*Isurus oxyrinchus*); and Cape elephantfish (*Callorhincus capensis*); their landings peaked in 2007 at a total of some 28 600 tonnes. Landings then declined to about 15 800 tonnes in 2009.

In recent years, there has been substantial interest in exploitation of the deep-sea species of the Southeast Atlantic (Area 47), including orange roughy (*Hoplostethus*

FIGURE B7.8
Annual nominal catches of selected species in ISSCAAP Groups 42, 43 and 45, Southeast Atlantic (FAO Area 47)



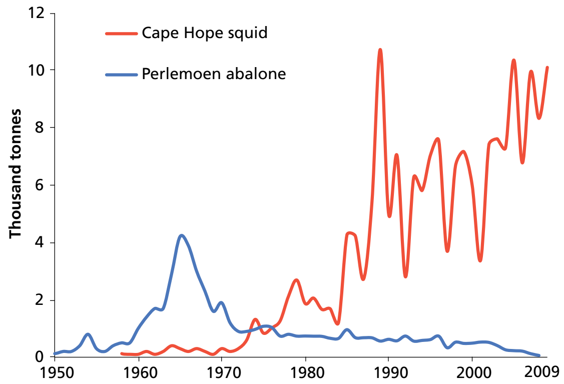
atlanticus), alfonsino (*Beryx splendens*) and Patagonian toothfish (*Dissostichus eleginoides*). Landings of Patagonian toothfish have been taken in the EEZ of South Africa at the Prince Edwards Islands (Commission for the Conservation of Antarctic Marine Living Resources [CCAMLR] Subareas 58.6 and 58.7). Therefore, they fall outside the geographic area of this review. Almost all of the deepwater fishing in the Southeast Atlantic has been undertaken in Namibian waters. Landings of alfonsino peaked at more than 4 000 tonnes in 1997 but declined thereafter. The average yearly landings in the 2000s reached only 360 tonnes, with just over 300 tonnes declared in 2009. Declared landings of orange roughy reached a peak of more than 18 000 tonnes in 1997, but declined steadily after that to 380 tonnes in 2005. The declared landings for 2008 and 2009 did not reach 10 tonnes.

Several crustacean species support valuable fisheries in Area 47 (Figure B7.8). *Geryon* crabs, dominated by the red crab (*Chaceon maritae*), are taken in both Namibian and Angolan waters. Recorded landings of *Geryon* crabs peaked at more than 10 000 tonnes in 1993 but fell in the following years, with average yearly landings in 2000–08 of about 3 800 tonnes. The highest declared landings of crustaceans were of shrimps, particularly the deep-water rose shrimp (*Parapenaeus longirostris*) and the striped red shrimp (*Aristeus varidens*). Declared landings of deep-water rose shrimp were more than 5 600 tonnes in 2001, the highest figure since the start of the 1990s. However, the landings declined to 1 400 tonnes in 2005 and to 160 tonnes in 2009, probably as a result of stringent management measures imposed on the fishery. The same pattern was observed with landings of the striped red shrimp, which reached 3 400 tonnes in 2001, the highest recorded since 1987. Landings declined to just over 360 tonnes in 2005 and 250 tonnes in 2009, after major fluctuations (reaching 1 200 tonnes in 2007).

The Cape rock lobster (*Jasus lalandii*) and southern spiny lobster (*Palinurus gilchristi*) occur towards the south of the region, with the Cape rock lobster occurring on the west coast of Namibia and South Africa, and the southern spiny lobster off the south coast of South Africa. Annual landings of Cape rock lobster have levelled off under TAC management at about 2 500 tonnes after a steady decline since the peak of more than 25 000 tonnes per year in the 1950s. Landings in 2009 were just over 2 100 tonnes. Landings of southern spiny lobster, also managed by a TAC, were reasonably constant between about 800 tonnes and 1 100 tonnes in the 1990s. They declined and became more variable after 1999, with an average of 540 tonnes in the 2000s and about 370 tonnes in 2009. The island of Saint Helena also occurs in Area 47, and it has recorded landings of Tristan da Cunha rock lobster (*Jasus tristani*) that have been quite stable, varying between 300 and 500 tonnes, since 1980. The highest landings of more than 800 tonnes were reported for 1972 and 1976.

The major fisheries for molluscs in the region are those for Cape Hope squid, also known as chokka squid (*Loligo vulgaris reynaudii*), and perlemoen abalone (*Haliotis midae*). The highest landings of squid were made in 1989 (10 730 tonnes) and, since then, landings have shown considerable variability, as would be expected from a short-lived species. Landings have varied from a peak of more than 7 500 tonnes in 1996 to a low of 2 800 tonnes in 1992 (Figure B7.9). Landings in 2009 were 10 100 tonnes. Landings of abalone have declined fairly steadily since a peak of more than 4 000 tonnes in the mid-1960s. They were maintained between about 550 and 750 tonnes from the mid-1980s to the very early 2000s, before dropping further to reach only 60 tonnes in 2008. The introduction of a total ban on the fishery in February 2008 meant that no more landings were declared in 2009. The fishery was re-opened in July 2010 with a TAC of 150 tonnes.

FIGURE B7.9
Annual nominal catches of selected species in ISSCAAP Groups 52 and 57, Southeast Atlantic (FAO Area 47)



RESOURCE STATUS AND FISHERY MANAGEMENT

Most of the commercially important stocks within the region are classified as being between fully exploited and overexploited (Table D7). The stocks that are currently overexploited are frequently, but not always, a result of historical overexploitation rather than current overfishing. In more recent years, more conservative management measures have generally been put in place. At present, the most important resources are managed either for sustainable yields or with a goal of encouraging recovery. The three countries in the region have well-developed management systems in place for the fisheries exploiting their most important stocks. Of the three countries, fisheries management is least developed in Angola. However, it is still improving and further developing its fisheries management system for the most important resources.

Nevertheless, in common with most fisheries in the world, substantial problems still exist in many fisheries. There are varying underlying causes that include environmental variability, scientific uncertainty and conflicting biological and socio-economic objectives. Difficulties in MCS occur throughout the region. These are particularly significant in some coastal fisheries where access and landings are difficult to control. A documented example of this is the severe problems with illegal fishing that are being experienced in the South African abalone (perlemoen) fishery. It has been difficult to estimate the size of the illegal take, but an indication of the magnitude of the problem is that, in 2006, more than 1 million abalone individuals were confiscated by the law enforcement agency. It is estimated that the illegal catch of abalone exceeded the legal commercial catch by more than tenfold in the past decade, with a total level that currently exceeds 1 000 tonnes/year (DAFF, 2011). In addition, more than two-thirds of the illegally caught abalone that were confiscated were below the minimum legal size. The status of the abalone stock was considered too low to allow commercial exploitation in 2008. A ban on commercial abalone fishing was imposed in February 2008, with a re-opening in July 2010. In addition, recreational fishing of abalone has been forbidden since the 2003–04 fishing season.

Small pelagic fish

The commercially important small pelagic stocks in all three countries are closely monitored, both by recording commercial landings and by making use of regular hydroacoustic surveys. In South Africa, the stocks of pilchard and anchovy are managed on the basis of formal management procedures, which have negotiated decision rules developed using rigorous simulation models of the fishery (Cochrane, Butterworth and Payne, 1997; De Oliveira *et al*., 1998). In Angola and Namibia, these stocks are managed under a licence and TAC system that adjusts allowable catch annually depending on the analyses of stock status. The status of the small pelagic resources of the region varies from stock to stock, with current conditions apparently being generally more favourable in the south and less so in the north.

The November 2002 survey found the highest peak in the estimated biomass of South African stock of Southern African pilchard (*Sardinops sagax*) since surveys started in 1985. The biomass estimated on that hydroacoustic survey exceeded 4 million tonnes. However, the estimated biomass has declined to less than 500 000 tonnes in the period since 2006. In the northern part of Area 47, north of the Lüderitz upwelling cell, the estimated biomasses have shown a clear increase in the most recent surveys. This is probably mainly the result of good recruitment from the 2008–09 spawning season and relatively higher survival of the adults. The improved biological conditions have been supported by a strict control on landings imposed by Namibia and Angola. However, the biomass is still at a very low level compared with the historical abundance.

The South African stock of anchovy is in a healthy condition. The biomass estimated in the November 2009 survey was 3.8 million tonnes, close to the maximum values observed since acoustic surveys for this species began. Fishing for Whitehead's round herring, which occurs mainly in South Africa, is not directly regulated at present. Recent assessments have suggested that it is being underexploited. However, with the recent increases in landings of the species, this approach is currently being re-examined.

The biomass estimates for Angolan waters of the two species of sardinella combined has shown a recovery from the 1990s. There was a period of substantial variability in the 2000s, with a minimum of about 250 000 tonnes in 2005 and a maximum of about 700 000 tonnes in 2007. Recently, landings have fluctuated about 500 000 tonnes, without any clear trend. In the late 1990s, flat sardinella dominated the landings and the estimated biomass. However, this situation was reversed in 2004, and the most recent acoustic surveys off Angola in March/April 2011 indicated that round sardinella represents about 60 percent of total biomass (INIP, 2011). The latest assessments indicate that the stocks of these two species are probably not fully exploited. However, there is a need for continuing monitoring of these stocks, particularly in view of the uncertainty about the magnitude of landings taken by the artisanal fisheries and the fast growth of this subsector since 2002 (INIP, 2011).

The stock structure of the Cape horse mackerel population of the Southeast Atlantic (Area 47) is not clear. For management purposes, horse mackerel are treated in the same way as sardine, with the stock from southern Angola and Namibia separated from that of South Africa by the upwelling cell off Lüderitz.

The South African stock is managed by a catch limit on adults on the Agulhas Bank and a bycatch limit on juveniles taken in the pelagic fishery on the west coast. The adult catch limit has rarely been fully subscribed in recent years, and the species is generally considered to be underutilized. However, the individuals captured by the existing fishery tend to be appreciably smaller than those landed in the period of high landings in the 1950s, warranting some care in its management.

The northern stock is an important contributor to the national fishery of Namibia, where it is fished by mid-water trawl and a purse-seine fleet. In Angola, since 2007, only purse seines are allowed to target horse mackerel. The abundance of this stock has been fluctuating appreciably. In Namibia, an all-time-low stock biomass of about 500 000 tonnes was estimated in 2007, but this recovered to more than 1.2 million tonnes in 2009 and 2010. The stock is currently considered to be fully exploited (MFMR, 2010).

The Cunene horse mackerel is the most important pelagic species north of the Angola–Benguela front. This is not only in total biomass, but also owing to its importance as food for the Angolan population. Biomass estimates from the winter surveys show a similar trend to that of the sardinellas, with an increase in the mid-1990s from the lower levels in the 1980s. However, recent survey estimates indicate a drastic decrease in biomass, particularly affecting the adult part of the population, to as low as 60 000 tonnes in 2008 (INIP, 2011) Commercial vessels could not catch their Cunene horse mackerel quota in 2009. The latest assessments indicate a state of severe growth overfishing, but good recruitment was still visible in the surveys (INIP, 2011).

A total ban on targeted fishing of Cunene horse mackerel came into force in 2010. This ban was partially lifted in 2011, but the state of the stock and the fishery is very closely monitored (INIP, 2011).

Large pelagic fish

Fisheries targeting tuna and tuna-like species (ISSCAAP Group 36) are also important in Area 47. These species attract several distant-water fishing nations in addition to participation by the coastal States. Large pelagic species caught include bigeye tuna (*Thunnus obesus*), albacore (*Thunnus alalunga*), swordfish (*Xiphias gladius*), southern bluefin tuna (*Thunnus maccoyii*) and a number of other species.

Both Namibia and South Africa have developed draft national plans of action (NPOAs) in accordance with the IPOA-Sharks, and Angola is preparing its National Plan. The ICCAT is responsible for the assessment of these species and stocks and for the management of fisheries exploiting them. These stocks are discussed in Chapter C2 of this report.

Demersal fish

Hakes

The Cape hakes are found in Namibia and South Africa, and Benguela hake (*M. polli*) occurs north of the Cunene River, the border between Namibia and Angola. Each State manages the fisheries occurring in its own EEZ. The shallow-water Cape hake (*M. capensis*) dominates the landings from Namibia, and is still dominant in landings from the south coast of South Africa. The deep-water Cape hake (*M. paradoxus*) is an increasingly important component of landings from Namibia and dominates landings from South Africa's west coast. However, the two species are not identified separately in commercial landings. Until recently, South Africa assessed the two as a single stock because of difficulties in separating the two Cape hake species in commercial landings (Payne and Punt, 1995). However, separate assessments are now being undertaken. Recent assessments indicate that the stock of *M. capensis* in South African waters can be considered as fully exploited, while that of *M. paradoxus* is strongly overexploited (DAFF, 2011).

The assessments in Namibia are currently undertaken on both species combined and make use of commercial CPUE information and the results of research surveys. Survey results in the past decade have shown little overall trend. However, following a peak in 1998, there was a decline in survey estimates of biomass until 2004. The introduction of drastic management measures in 2006 included important TAC cuts. These measures have probably helped the stock make the best use of the strong *M. capensis* 2002–04 and 2007 year classes. By 2008–09, the hake biomass (the two species combined) was estimated to be more than 1 million tonnes (MFMR, 2010).

Benguela hake is captured in Angola, mostly as bycatch of the important deep-sea shrimp fishery. Catch rates and survey abundance estimates have declined strongly since 2004. The stock is now considered to be overexploited, although not yet drastically so (INIP, 2011).

Other demersal fish

Demersal and coastal fisheries in the region exploit a wide range of species that vary markedly in a north–south gradient. Off Angola, the species composition of demersal assemblages shows important changes in a north–south direction. The fauna is predominantly subtropical–temperate off southern Angola, and tropical and more diverse in the central and northern parts, separated by the Angola–Benguela Front (Bianchi, 1992). Seabreams (Sparidae) and croakers (Sciaenidae) are prominent components of the fauna both in abundance and economic terms. In the southern shelf (south of Benguela), large-eyed dentex and African weakfish are the main species. Biomass estimates for both species have dropped substantially in recent years (INIP, 2011). A decrease in seabream biomass (including several species of *Dentex* and *Sparus*) was also observed in the central region. However, the biomass estimates seem to be more stable in the region north of Ponta das Palmeirinhas (INIP, 2011). Reacting to this decline in major demersal fish species, Angola has reinforced the restrictions on bottom trawl fishing and reduced the number of licences and the TACs for these species.

In South Africa, more than 200 species make up the landings from the line fishery (Verheye, 1998). Of these, 20 species can be considered economically important (Griffiths, 2000). However, South African landings of species such as seventy-four seabream (*Polysteganus undulosus*), red steenbras (*Petrus rupestris*), African weakfish (*Atractoscion aequidens*, known locally as geelbek) and others have fallen considerably since the 1960s when line-fish landings peaked. It is now considered that most of the major line-fish stocks are overexploited. The exceptions are probably snoek and yellowtail, which have been evaluated as being fully exploited (DAFF, 2011). The situation is similar in Namibia, where the authorities have decided to limit severely the capture of kob to give the stock a chance to recover (MFMR, 2010). South Africa has also introduced stringent regulations to recreational and coastal net fishing, aiming at recovering these important stocks (DAFF, 2011).

In Namibia, the 2009 swept-area survey indicated an appreciable increase in total biomass of monkfish (*Lophius vomerinus*). Large-sized fish were also present in the population. These had not been seen during the surveys made in the previous three years. This suggests that there has been a partial recovery of the stock (MFMR, 2010).

Crustaceans

Tagging results suggest that there is a single stock of deep-sea red crab (*Chaceon maritae*) shared between Namibia and Angola. Assessment of the stock indicates that it is currently overexploited, but probably recovering slowly (MFMR, 2010). The Angolan stocks of deep-water rose shrimp (*Parapenaeus longirostris*) and striped red shrimp (*Aristeus varidens*) are intensively exploited. This is despite a ban of foreign fishing that has been in place since 2004 after a period of marked decrease in abundances. Both stocks are considered to be fully exploited, although very intensively (INIP, 2011).

The Cape rock lobster (*Jasus lalandii*) has been the subject of intense monitoring and assessment for almost a decade, following a sudden decline in somatic growth rates, hence, in productivity in the late 1980s. Current estimates are that the South African stock has undergone a major decline since landings peaked in the 1950s. The resource is currently estimated to be strongly overexploited (DAFF, 2011). As a result, a formal management procedure was implemented in 1997 to rebuild the stock to healthier levels, defined as pre-1990. After a major decrease in 2006 and a cut in TACs in the subsequent fishing seasons, stock abundance and growth seem to have started recovering in 2009. There are still concerns about increasing illegal fishing and this may jeopardize the recovery. In Namibia, the CPUE from the commercial fishery showed a modest growth in 2009 compared with 2008, as did the average size of the lobsters exported. However, recruitment seems to have been appreciably lower. Care is thus justified in the management of this stock (MFMR 2010).

The other important crustacean stock in Area 47 is the southern spiny lobster (*Palinurus gilchristi*). This is estimated to have declined continuously between the 1988–89 season and 1998–99. Since then, the stock seems to have recovered, probably helped by a reinforcement of management measures introduced in 2000 and 2001. These measures included a reduction in the number of vessels active in the fishery by 30 percent. The species is now considered to be fully exploited (DAFF, 2011).

Molluscs

The major mollusc fisheries in Area 47 are those for Cape Hope squid, locally known as chokka squid (*Loligo vulgaris reynaudi*) and abalone (*Haliotis midae*) in South Africa, and for cuttlefish (*Sepia officinalis hierreda*) in Angola. The abundance of the squid and cuttlefish tends to vary strongly depending on environmental conditions owing to their short life span. In contrast, the long-lived abalone shows less interannual variability in abundance. Recent assessments of the chokka squid have indicated that the stock is fully exploited. Current management is based on a cap on effort and closed seasons. These measures aim at restricting effort to a level that secures the largest landings in the long term, while maintaining the stock at a level that does not risk recruitment reduction (DAFF, 2011). There are no formal assessments of the cuttlefish stock exploited in Angola. The artisanal fishery is based on spawners and it is not showing signs of concern, thus leading to the conclusion that the stock is not overexploited.

The prognosis for the stock of abalone in South Africa is pessimistic given the current scale of illegal harvests. In recent years, a new, ecological problem has also emerged. In the early 1990s, west coast rock lobster moved into a significant part of the range of abalone. The lobsters reduced the local population of sea urchins (*Parechinus angulosus*), which they feed upon. Sea urchins provide important shelter for juvenile abalone and their disappearance from the area has exposed the young abalone to predation by the lobsters and other predators. This has negatively affected the reproductive success of the stock (Mayfield and Branch, 2000; Tarr and McKenzie, 2002). The fishery was closed between February 2008 and July 2010, but poaching is estimated to have continued. Poaching still continues at a high level, despite a reduction between 2002 and 2009. The most recent assessments (DAFF, 2011) indicate that, if poaching continues at the current level, the stock will continue to decrease. The assessments also indicate that spawner biomass could recover quickly, at least for the southern coast (where the lobster is not a problem), if poaching could be stopped.

Deep-sea resources

Deep-sea resources in the region have only been exploited commercially on a significant scale in Namibia. The country has taken a cautious approach to the development of a fishery for its deep-sea resources, which started with a small experimental fishery in 1994. Recent assessments for orange roughy suggested that the high landings of the early period in the development of the fishery would not be sustainable. Thus, a precautionary management scheme has been implemented. This scheme has established four quota management areas, with a separate TAC for each area. Few data are available for alfonsino, but it is expected that, as with orange roughy, the yield will be considerably less than the initial TAC.

In response to the need to manage the deep-sea resources of the Southeast Atlantic in a rational and responsible manner, the coastal States of the region (Angola, Namibia, South Africa, and the United Kingdom of Great Britain and Northern Ireland [on behalf of Saint Helena and its dependencies Ascension and Tristan de Cunha]) took the initiative to begin negotiations for the establishment of an RFMO, the South East Atlantic Fisheries Organisation (SEAFO) in 1997. The organization was established within the framework of the 1995 UN Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks. The EU, Iceland, Japan, the Republic of Korea, Norway, Poland, the Russian Federation, Ukraine and the United States of America also participated in the negotiations as Interested States.

The region managed by SEAFO includes a substantial portion of the high seas of the Southeast Atlantic (Area 47). It covers alfonsino, orange roughy, armourhead grenadier, wreckfish, deepwater hake and red crab. The agreement was signed on 20 April 2001 and came into force in 2003. As of 10 March 2011, the contracting parties to the SEAFO Convention are Angola, EU, Japan, the Republic of Korea, Namibia, Norway and South Africa. This organization is still in the early stages of development and some time will be needed before measures taken within its framework can be evaluated.

ACKNOWLEDGEMENTS

The authors would like to thank Filomena Vaz-Velho and Kumbi Kilongo N'Singi, from the National Institute of Fisheries Research, (INIP) of Angola, Graça d'Almeida, from the National Marine Information and Research Centre (NatMIRC) of Namibia, and Johan Augustyn, Justice Matshili and Deon Durholtz, from the Department of Agriculture, Forestry and Fisheries (DAFF), South Africa for their valuable comments and inputs. Special thanks also to all the colleagues from INIP, NATMIRC and DAFF, who along the years have maintained high-quality fisheries research programmes providing the information this review is based on, because without their work there would still be no scientific knowledge on the status of exploited fish stocks in this region.

REFERENCES

Bartholomae, C.H. & Plas, A.K. 2007. Towards the development of environmental indices for the Namibian shelf, with particular reference to fisheries management. *African Journal of Marine Science*, 29: 25–35.

Bianchi, G. 1992. Demersal assemblages of the continental shelf and upper slope of Angola. *Marine Ecology Progress Series*, 81: 101–120.

Boyer, D.C., & Hampton, I. 2001: An overview of the living marine resources of Namibia. *South African Journal of Marine Science*, 23: 5–35.

Boyer, D.C., Boyer, H.J., Fossen, I. & Kreiner, A. 2001. Changes in abundance of the northern Benguela sardine stock during the decade 1990-2000, with comments on the relative importance of fishing and the environment. *South African Journal of Marine Science*, 23: 76–84.

Cochrane, K.L., Butterworth, D.S. & Payne, A.I.L. 1997. South Africa's offshore living marine resources: the scientific basis for management of the fisheries. *Proceedings of the Royal Society of South Africa*, 52: 149–176.

Department of Agriculture, Forestry and Fisheries (DAFF). 2011. *Status of the South African marine fishery resources 2010*. Cape Town, South Africa. 55 pp.

De Oliveira, J.A.A., Butterworth, D.S., Roel, B.A., Cochrane, K.L. & Brown, J.P. 1998. The application of a management procedure to regulate the directed and bycatch fishery of South African sardine *Sardinops sagax*. *South African Journal of Marine Science*, 19: 449–469.

Gammelsrød, T., Bartholomae, C., Boyer, D., Filipe, V. & O'Toole, M. 1998, Intrusion of warm surface water along the Angolan-Namibian Coast in February-March 1995: the 1995 Benguela Nino. *South African Journal of Marine Science*, 19: 41–56.

Griffiths, M.H. 2000. Long-term trends in catch and effort of commercial linefish off South Africa's Cape Province: snapshots of the 20 th century. *South African Journal of Marine Science*, 22: 81–110.

Hamukuaya, H., O'Toole, M.J. & Woodhead, P.M.J. 1998 Observations of severe hypoxia and offshore displacement of Cape hake over the Namibian shelf in 1994. *In* S.C. Pillar, C.L. Moloney, A.I.L. Payne & F.A. Shillington, eds. Benguela dynamics: impacts of variability on shelf-sea environments and their living resources. *South African Journal of Marine Science*, 19: 57–61.

Hutchings, L., van der Lingen, C.D., Shannon, L.J., Crawford, R.J.M., Verheye, H.M.S., Bartholomae, C.H., van der Plas, A.K., Louw, D., Kreiner, A., Ostrowski, M., Fidel, Q., Barlow, R.G., Lamont, T., Coetzee, J., Shillington, F., Veitch, J., Currie, J.C. & Monteiro, P.M.S. 2009. The Benguela Current: An ecosystem of four components. *Progress in Oceanography*, 83: 15–32.

Instituto Nacional de Investigação Pesqueira (INIP). 2011. *Relatório de Avaliação do Estado dos Principais Recursos Pesqueiros de Angola e Recomendações de Medidas de Gestão para 2011*. Luanda. 41 pp.

International Research Institute for Climate and Society (IRI). 2011. *Progress report to NOAA. July 1, 2010–March 31, 2011* [online]. [Cited 20 December 2011]. http://portal.iri.columbia.edu/portal/server.pt/gateway/PTARGS_0_2_7713_0_0_18/NOAAReport2011_FINAL_strip.pdf

Mas-Riera, J., Lombarte, A., Gordoa, A. & Macpherson, E. 1990. Influence of Benguela upwelling on the structure of demersal fish populations off Namibia. *Marine Biology*, 104: 175–182.

Mayfield, S. & Branch, G.M. 2000. Interrelations among rock lobsters, sea urchins, and juvenile abalone: implications for community management. *Canadian Journal of Fisheries and Aquatic Sciences*, 57: 2175–2185.

Ministry of Fisheries and Marine Resources of Namibia (MFMR). 2010. *An overview of Namibia's Commercial Fisheries in 2009*. Swakopmund, Namibia. 3 pp.

Payne, A.I.L. & Punt, A.E. 1995. Biology and fisheries of South African Cape hakes (*M. capensis* and *M. paradoxus*). *In* J. Alheit & T.J. Pitcher, eds. *Hake: biology, fisheries and markets*, pp. 15–47. London, Chapman & Hall.

Rouault, M., Florenchie, P., Fauchereau, N. & Reason, C.J.C. 2003. South East tropical Atlantic warm events and southern African rainfall. *Geophysical Research Letters*, 30: 8009 [online]. [Cited 20 December 2011]. doi:10.1029/2002GL014840.

Shannon, L.V., Boyd, A.J., Brundrit, G.B. & Taunton-Clark, J. 1986. On the existence of an El Niño-type phenomenon in the Benguela system. *Journal of Marine Research*, 44: 495–520.

Tarr, R.J.Q. & Mackenzie, A.J. 2002. Overview of the South African abalone fishery: biology, management, research, poaching. Unpublished Rep. BEN/DEC02/SAA/1a. Cape Town, MCM. 9 pp.

Verheye, H., ed. 1998. *Research highlights. 1997-1998*. Cape Town, South Africa, Sea Fisheries Research Institute. 68 pp.

Woodhead, P.M., Hamukuaya, H., O'Toole, M.J. & McEnroe, M. 1998. Effects of oxygen depletion in shelf waters on hake populations off central and northern Namibia. *In* V. Shannon & M.J. O'Toole, eds. *International Symposium, Environmental Variability in the South East Atlantic*. Namibia, National Marine Information and Research Centre,.

Woodhead, P.M., Hamukuaya, H., O'Toole, M.J., Strømme, T., Saetersdal, G. & Reiss, M. 1997 Catastrophic loss of two billion Cape hake recruits during widespread anoxia in the Benguela Current off Namibia. *In*: *ICES International Symposium, Recruitment Dynamics of Exploited Marine Populations: Physical-Biological Interactions, September 22–24 1997, Baltimore, Maryland*, pp. 105–106.

B8. Western Indian Ocean

FAO STATISTICAL AREA 51

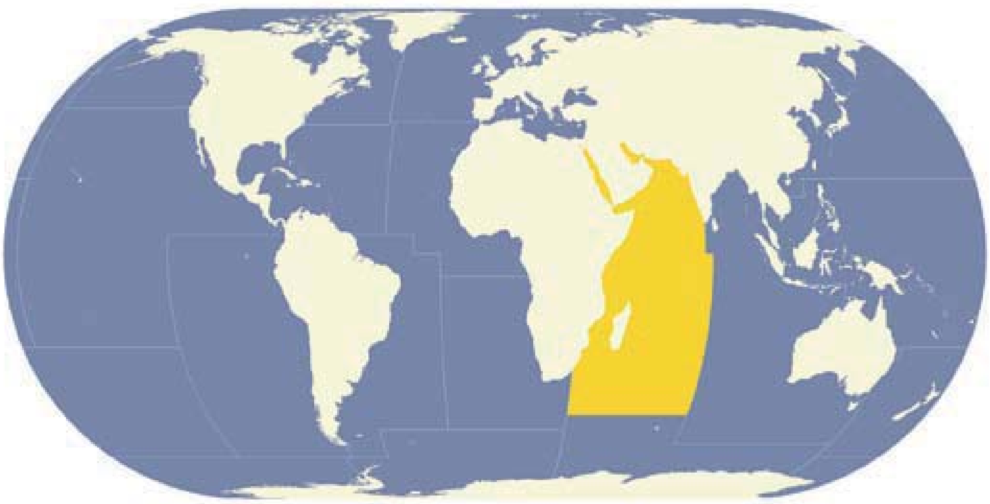
Yimin Ye
Senior Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: yimin.ye@fao.org

INTRODUCTION

The Western Indian Ocean (Figure B8.1) has a surface area of about 30 million km^2, of which about 6.3 percent is continental shelf. It encompasses regions with greatly differing oceanographic and fishery resource characteristics. Within the Western Indian Ocean, the Northwest Arabian Sea is influenced by both northeast and southwest monsoons, and it includes extremely productive areas because of nearly continuous upwelling off the Oman coast (Sharp, 1995). Areas with seasonal upwelling occur off the coast of Iran (Islamic Republic of), Pakistan in the Gulf of Oman, and the Indian coast along the Arabian Sea. These seasonal upwellings also result in periods of high productivity. Two extensions to the Western Indian Ocean, the Persian Gulf and the Red Sea, represent different marine environments compared with the rest of the Western Indian Ocean. However, these environments and their fisheries as still connected with the rest of the Western Indian Ocean.

The Persian Gulf is a shallow enclosed waterbody characterized by high-temperature highly saline waters. The target species of fisheries in this region are associated with reefs and shallow tropical seas. Water enters the Persian Gulf from the Gulf of Oman, forming a counter-clockwise gyre. These waters exist as a submerged denser, warmer and more saline water mass moving towards the centre of the Indian Ocean. The Persian Gulf is shallow; no part is deeper than 200 m and much of the north and west of the Persian Gulf is less than 50 m deep. It is fringed with extensive coral areas on the Arabian side.

FIGURE B8.1
The Western Indian Ocean (FAO Area 51)



Most of the river discharge into the Persian Gulf is concentrated in the north, primarily from Iraq and Iran (Islamic Republic of) (Hamza and Manawar, 2009). This discharge provides important nutrients to support the primary productivity in the region. The increased diversion of water flowing into the Shatt al Arab at the confluence of the Tigris and Euphrates Rivers is of continuing concern to the Persian Gulf countries. This reduction in freshwater inflow, and thus nutrients, has arisen from human-made changes. The main change has come from drainage of marshes near the opening of the Shatt al Arab with the Persian Gulf, although there has also been diversion of water in Turkey and other countries further upstream (Al-Yamani, 2007). Ecological theory predicts that this must affect the biological productivity of the Persian Gulf but no information exists to quantify the consequences.

In the Red Sea, narrow continental shelves on both sides and its enclosed nature also create unique fisheries situations. Extensive demersal resources are primarily found on the wider continental shelves off the Eritrean coast (around the Dahlak Archipelago) and along the southern Red Sea coast of Yemen. The Gulf of Aden and Somali coasts are also monsoon-influenced upwelling areas that have seasons of high productivity.

In the Western Indian Ocean, there are two regional fisheries bodies with their zones of competence entirely within Area 51. The first is the Regional Commission for Fisheries (RECOFI), covering the Persian Gulf and the Gulf of Oman. While the second, the Southwest Indian Ocean Fisheries Commission (SWIOFC), consists of the countries along the east coast of Africa from Somalia to South Africa. The eastern Arabian Sea (the western coast of India, Pakistan and partly Maldives) and the Red Sea and Gulf of Aden are not covered by these two regional commissions. Also present in the Western Indian Ocean is the Indian Ocean Tuna Commission (IOTC), which is responsible for the management of tunas and tuna-like species across the entire Indian Ocean. For the non-tuna species found outside of national jurisdictions, the South Indian Ocean Fisheries Agreement made in 2006 seeks to promote the long-term sustainable management of fisheries.

The coastal waters in the eastern Arabian Sea are the most productive in Area 51, producing more the 60 percent of the total catch of the Western Indian Ocean. The RECOFI countries contributed about 20 percent, the SWIOFC countries along the African continent 10 percent and the Red Sea and the Gulf of Aden the remaining 10 percent. Fisheries in these four regions have diverse and unique characteristics.

Myctophids, or lantern fishes, are abundant in the Oman Sea (FAO, 1998). Iranian scientists estimated the total biomass of lantern fishes at 2.3 million tonnes in their waters based on acoustic surveys (Valinassab *et al.*, 2006, Valinassab, Pierce and Johannesson, 2007). A similar biomass (1.9 million tonnes) was also estimated in Omani waters (FAO, 2011a). The possible development of a meal fishery for lantern fishes has attracted much attention recently. An Iranian company began trial fishing with paired vessels that purse-seined as close as 400 m from shore. However, the company found that it was commercially non-viable (Valinassab, Pierce and Johannesson, 2007).

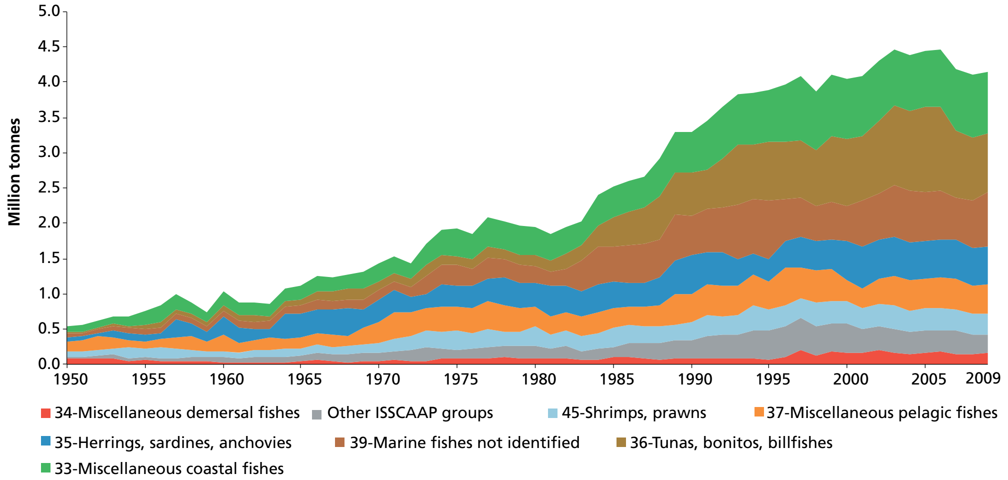
Piracy and IUU in Somali waters and beyond are a serious concern. According to the High Seas Task Force, there were more than 800 IUU fishing vessels in Somali waters in 2005 taking advantage of Somalia's inability to police and control its own waters and fishing ground. These IUU vessels were estimated to have taken more than US$450 million a year of fish (African Prospects, 2009).

In the Red Sea, ecotourism is an increasingly important activity in the two northern gulfs as well as in Eritrea. The beauty (and economic potential) of the coral reefs is being increasingly appreciated. Nearby, the fisheries situation in Somalia remains dismal with the country lacking even the most basic estimates of catches.

PROFILE OF CATCHES

Marine fisheries catches in the Western Indian Ocean were about 0.5 million tonnes per year in the 1950s. They reached a peak of 4.2 million tonnes in 2006 and have since

FIGURE B8.2
Annual nominal catches by ISSCAAP species groups for the Western Indian Ocean (FAO Area 51)



dropped back slightly in the last few years (Figure B8.2, Table D9). The fastest growth in catch was seen from the mid-1980s to the mid-1990s. Growth was most pronounced in ISSCAAP Group 33 (miscellaneous coastal fishes, dominated by croakers and drums, and Bombay-duck), Group 36 (tunas and billfishes) and Group 39 (marine fishes not identified).

Based on mean annual catches, miscellaneous coastal fishes (Group 33) make the largest contribution, accounting for 20 percent of the total catch of the West Indian Ocean (Figure B8.2). This group is dominated by croakers and drums NEI. These species groups had a jump in catch in the mid-1970s and a fast increase in catch from the mid-1980s to the mid-1990s. Catch peaked at 300 000 tonnes in 1999 and then declined linearly back to 200 000 tonnes by 2009 (Figure B8.3). The second largest specie of the Group 33 species is Bombay-duck. Landings of this species showed a step-wise increase in the mid-1950s and 1970s, and in the late 1990s and 2000s. The most recent catch was 160 000 tonnes in 2009.

Tuna and tuna-like species (Group 36) are the second-largest group in the West Indian Ocean and account for about 17 percent of the total catch (Figure B8.2). Skipjack tuna, yellowfin tuna, bigeye tuna and narrow-barred Spanish mackerel are the major species caught. Skipjack tuna had the largest catch, 500 000 tonnes in 2006, which dropped to 300 00 tonnes in 2009. Both yellowfin and bigeye tunas had a similar trend, with a peak in 2003 and 2004, respectively, and a decrease of 40–50 percent by 2009. The catch of narrow-barred Spanish mackerel increased substantially between 1981 and 1985, and has remained about 60 000 tonnes since 1995 (Figure B8.4). The IOTC carries out regular assessments based on the catches of tuna. It has found that the catches of tuna, particularly from small-scale and artisanal fisheries operating within areas of national sovereignty, are poorly estimated in several countries, and it has started a programme to assist these countries to improve their catch data.

FIGURE B8.3
Annual nominal catches of selected species in ISSCAAP Group 33, Western Indian Ocean (FAO Area 51)

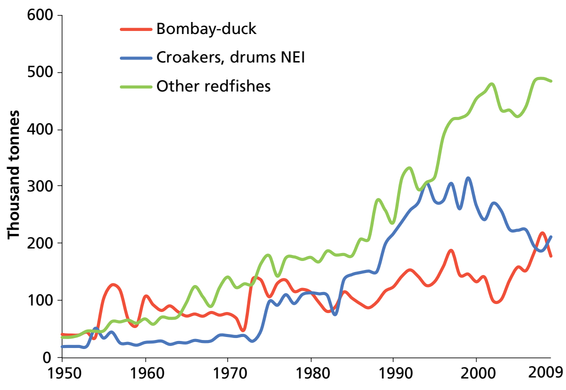


FIGURE B8.4
Annual nominal catches of selected species in ISSCAAP Group 36, Western Indian Ocean (FAO Area 51)

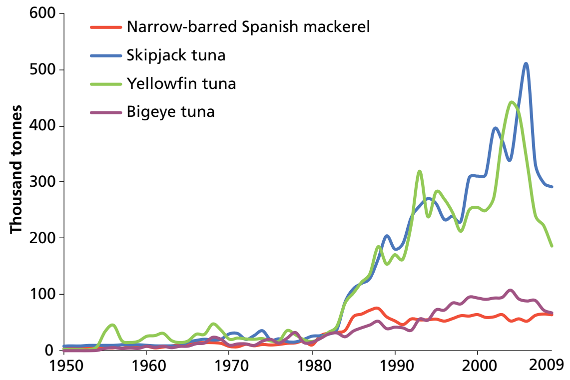


FIGURE B8.5
Annual nominal catches of selected species in ISSCAAP Group 39, Western Indian Ocean (FAO Area 51)

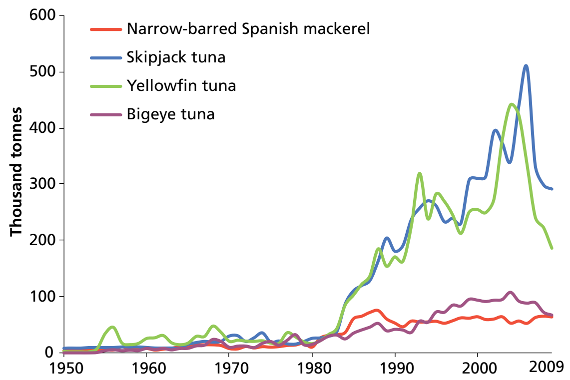
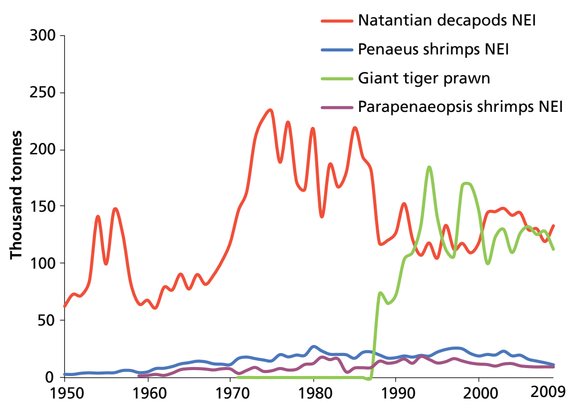


FIGURE B8.6
Annual nominal catches of selected species in ISSCAAP Group 45, Western Indian Ocean (FAO Area 51)



Marine fishes not identified (Group 39) accounts for 16 percent of the total catch in the Western Indian Ocean. Group 35 species (herrings, sardines, and anchovies) make a slightly smaller contribution of about 15 percent. Indian oil sardine is the major species of this latter group and annual catches of about 200 000 tonnes were made between 1965 and 1995. This has increased to about 300 000 tonnes in the last ten years (Figure B8.5). A pelagic species, its catch fluctuates widely between years. Clupeoids NEI were the second-largest species group, with a catch of less than 20 000 tonnes in the early 1950s. This increased to 60 000 tonnes in the early 1970s, and decreased in the late 1970s. The catch of clupeids NEI recovered rapidly in the 1980s to a peak of nearly 150 000 tonnes in 1992 but has since dropped back to 60 000 tonnes in 2009 (Figure B8.5). The catch of Indian mackerel does not show clear trends (Figure B8.5), but it has fluctuated widely over the years with the highest catch of 300 000 tonnes in the mid-1990s.

Shrimps and prawns (Group 45) accounted for 9 percent of total landings in the Western Indian Ocean. The four largest species groups in this category are natantian decapods NEI, giant tiger prawn, *Parapenaeopsis* shrimps NEI, and *Panaeus* shrimps NEI. The catch of the natantian decapods NEI group increased suddenly from about 5 000 tonnes in the late 1960s to 200 000 tonnes in the mid-1970s, but then showed an extended decline to 100 000 tonnes in 2009 (Figure B8.6). Giant tiger prawns were recorded in the catch only after 1990. The peak catch of about 200 000 tonnes was seen in 1995 and the most recently reported catch was 100 000 tonnes in 2009. *Parapenaeopsis* and *Panaeus* shrimps are also important species groups in this category, with peak landings of 20 000 tonnes and 10 000 tonnes, respectively (Figure B8.6). However, both species groups showed large declines in catch after 1990, and the 2009 catches were only half those of the peak period in the 1980s and 1990s.

Eastern Arabian Sea: India, Pakistan and Maldives

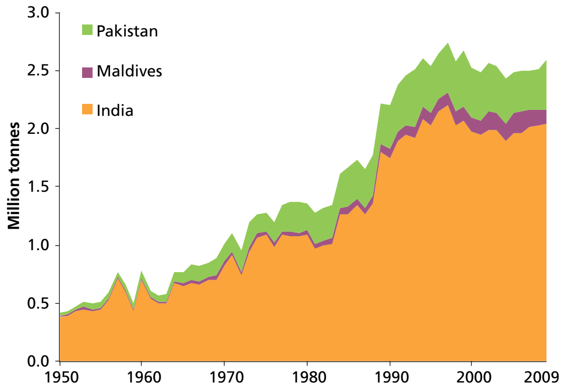
Reported catches for the eastern Arabian Sea reached a peak of 2.6 million tonnes in 1996 and have been roughly stable at this level since (Figure B8.7). This region accounts for more than 60 percent of the total catches of Area 51. India is the greatest contributor, producing about 2.5 million tonnes a year, and Pakistan and Maldives recently landed

400 000 and 100 000 tonnes, respectively. India's catches have stagnated since reaching a peak in 1996. In contrast, Pakistan has seen its catch decline by about 10 percent from the peak of 0.5 million tonnes in 1992, and Maldives dropped by about 40 percent from 200 000 tonnes in 2005 to 120 000 tonnes in 2009.

The top ten categories landed in Area 51 were: marine fishes NEI, Indian oil sardine, croakers and drums NEI, natantian decapods NEI, Bombay-duck, Indian mackerel, sea catfish NEI, skipjack tuna, giant tiger prawn, and anchovies, etc. NEI. Pelagic or mesopelagic species dominate the catches of the top ten species groups, reflecting the common nature of upwelling ecosystems. Most of the pelagic species caught in Area 51, such as Indian oil sardine, Indian mackerel, and anchovies, show large fluctuations without a clear trend in catch. Clear declines in landings have been seen in the last decade for croakers and drums, natantian decapods NEI, and Indian mackerel.

FIGURE B8.7

Annual nominal catches of selected countries in Western Indian Ocean (FAO Area 51)



The RECOFI area: Persian Gulf and Gulf of Oman

The RECOFI area showed a steady increase in overall catch from 350 000 tonnes in 1986 to about 700 000 tonnes in 2006. This has been followed by a small drop in total catch in the last three years (Figure B8.8). The Persian Gulf is part of the RECOFI area, and among the nine countries in RECOFI, only Iran (Islamic Republic of) and Oman undertake fishing both in and outside the Persian Gulf. In terms of catches, about half were captured inside the Persian Gulf and the other half from the Gulf of Oman and the Arabian Sea.

Iran (Islamic Republic of) is the largest fishery country in the RECOFI area and its catch reached 350 000 tonnes in 2009 followed by Oman (160 000 tonnes), Saudi Arabia (43 000 tonnes) and Bahrain (16 000 tonnes). Kuwait had the lowest catch among the RECOFI countries. Most countries, except Kuwait and the United Arab Emirates, have experienced a continuous increase in catch since the catch statistics for the RECOFI area began being recorded separately in 1985. Kuwait recorded the highest catch of 10 000 tonnes in 1987 and has since seen its catch decline gradually to 4 000 tonnes in 2009. The catch is now below half of its peak. Similarly, the United Arab Emirates reached a peak of about 120 000 tonnes in 1999 and then dropped drastically back to under 80 000 tonnes in 2009.

ISSCAAP Group 36 (tunas, bonitos, billfishes) is the largest category in the RECOFI area and contributes 25 percent of total catches. This is followed by ISSCAAP Group 33 (miscellaneous coastal fishes) with 20 percent, Group 39 (marine fishes not identified) 19 percent, Group 37 (miscellaneous pelagic fishes) 13 percent, and Group 35 (herrings, sardines, anchovies) 11 percent. The composition of the catch is dominated by mostly pelagic species, including Indian oil sardine, yellowfin tuna, longtail tuna,

FIGURE B8.8

Annual nominal catches of countries in RECOFI area

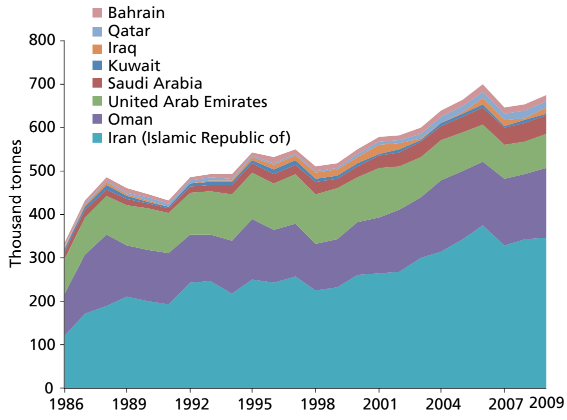
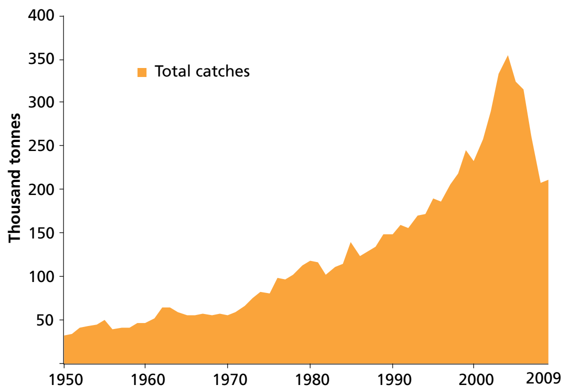


FIGURE B8.9
Total annual nominal catches in Red Sea and Gulf of Aden area



skipjack tuna, narrow-barred Spanish mackerel, and pelagic percomorphs NEI. Some demersal species are also caught and these groups included emperors NEI, groupers and sea basses NEI, and kawakawa.

The Red Sea and Gulf of Aden

Reported catches from this subarea were under 50 000 tonnes in 1950, but steadily increased sevenfold to 350 000 tonnes in 2004. However, a sharp fall was seen after that time, and only 200 000 tonnes were recorded in 2009 (Figure B8.9). The largest fishery country in this region is Yemen, which recorded its highest catch of 250 000 tonnes in 2004. Egypt ranked second with a record catch of 80 000 tonnes in 2000, followed by Saudi Arabia (40 000 tonnes in 1985) and Eritrea (12 000 tonnes in 2000). Jordan has the lowest landings in the Red Sea (about 200 tonnes in 2009).

In the Red Sea and the Gulf of Aden, 35 percent of landings come from ISSCAAP Group 37 (miscellaneous pelagic fishes), 19 percent from Group 33 (miscellaneous coastal fishes), 12 percent from Group 39 (marine fishes not identified), 11 percent from Group 36 (tunas, bonitos, billfishes), and 6 percent from Group 35 (herrings, sardines, anchovies).

In terms of species groups, pelagic percomorphs NEI remained as the main reported species group, indicative of the poor statistical reporting practices in FAO Statistical Subarea 51.1. This group reached a peak catch of 120 000 tonnes in 2004, but dropped back to 40 000 tonnes in 2009. The next-largest species group was equally unidentified, marine fishes NEI, which had its highest catch of about 50 000 tonnes in 1999 and declined back to 20 000 tonnes in 2009. These two categories constitute about 30 percent of the total landings for this subarea. The following eight categories in order of landings are demersal percomorphs NEI, yellowfin tuna, emperors NEI, cuttlefish and bobtail squids NEI, narrow-barred Spanish mackerel, Indian mackerel, groupers and sea basses NEI, and *Penaeus* shrimp NEI. Of the top ten species groups, all showed large declines except Indian mackerel. For example, *Penaeus* shrimps NEI landings were about 9 000 tonnes in 1998, but only about 400 tonnes in 2009.

The SWIOFC area (from Somali to South Africa)[1]

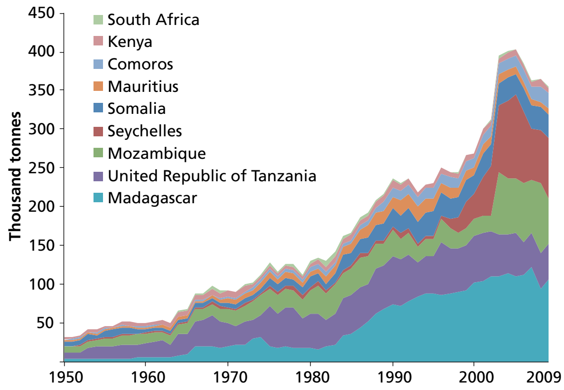
The SWIOFC countries had few marine fisheries in the 1950s, landing only 30 000 tonnes in total (Figure B8.10). Since then, the catches from most countries have increased steadily. The fastest growth occurred from the 1980s to the early 2000s, reaching about 400 000 tonnes in 2005. Total catch has declined by about 10 percent in the last four years.

Madagascar and Seychelles are the countries with the largest catches, landing 120 000 tonnes and 100 000 tonnes, respectively, in 2009. Their catches were substantially larger than others in the SWIOFC, with the United Republic of Tanzania (50 000 tonnes) and Somalia (27 000 tonnes) having the next largest fisheries. Fisheries development trends differ significantly between countries. They can be grouped into three categories. For some countries such as the Comoros, Madagascar, Mozambique and Somalia, catches seem to have stagnated, reflecting the absence of any catch assessment for more than a decade. Mozambique's catch also appears to have stagnated

[1] Although a member of the SWIOFC, Maldives is not included in this area. It is included in the eastern Arabian Sea because: (i) geographically it is closer; (ii) it has similar characteristics to upwelling ecosystems along the coast of India; and (iii) most of its EEZ is outside the SWIOFC area.

FIGURE B8.10

Annual nominal catches of selected countries in the SWIOFC area



and is in the process of review. The second group of countries have declining catches, including Mauritius, Seychelles, South Africa and the United Republic of Tanzania. The final category comprise countries where the catch has fluctuated, such as in Kenya. Kenya's catch has shown a 20-year cycle, increasing linearly over a period of 20 years and then suddenly dropping to a very low level with the lows in 1950, 1972 and 1993.

In the SWIOFC area, marine fishes not identified (ISSCAAP Group 39) account for 45 percent of total landings, Group 36 (tunas, bonitos, billfishes) 21 percent, Group 33 (miscellaneous coastal fishes) 10 percent and Group 45 (shrimps, prawns) 8 percent. The fact that 45 percent of total landings are unidentified marine fishes shows the poor quality of catch data in Area 51. There is a great need for better estimates of catch composition from the Comoros, Madagascar and Somalia.

The major ten species groups caught in Area 51 are marine fishes NEI, skipjack tuna, yellowfin tuna, emperors NEI, *Penaeus* shrimps NEI, natantian decapods NEI, sardinellas NEI, carangids NEI, demersal percomorphs NEI, and narrow-barred Spanish mackerel. Declines in landings have been apparent in emperors NEI, *Penaeus* shrimps NEI, and demersal percomorphs NEI at various times and more recently. Other species groups, such as Indian mackerel, have shown a continuing increase trend in catch, with large fluctuations for some species.

RESOURCE STATUS AND FISHERY MANAGEMENT

The capacity of data collection, stock assessment and fishery management in the Western Indian Ocean is generally poor in comparison with other regions. It also differs markedly between countries within the region. In the eastern Arabian Sea, India has estimated fish landings since the 1950s through stratified random sampling. The assessment of coastal stocks is undertaken by the Central Marine Fisheries Research Institute based on commercial fish catches. Assessments of oceanic stocks are made from exploratory surveys by Fishery Survey of India (Vivekanandan *et al*., 2010).

In the RECOFI, Kuwait has a rigorous research and monitoring programme for commercially valuable species such as shrimps. Catches of shrimps are estimated by systematic sampling of vessel landings at port. The start of the shrimp fishing closure is determined for each fishing season by monitoring the catch rates of commercial vessels (Ye, 1998). Iran (Islamic Republic of) and Oman have also progressed in the last decade in terms of fisheries data collection and stock assessment.

In the SWIOFC, Seychelles has a stratified sampling system to collect catch data. This system has been run since the mid-1980s through a series of catch assessment surveys undertaken by the Seychelles Fishing Authority (Skewes, Ye and Burridge, 2005). Almost all countries in Area 51 have a vessel licensing system in place, and most countries also use a minimum fish size limit as a management measure. In contrast, very few fisheries have a management plan. In the SWIOFC, only about 11 percent of fisheries have management plans (FAO, 2011b).

The assessment of fish stock status in the Western Indian Ocean (Area 51) is shown in Table D9. This assessment is complicated in that many countries continue to have difficulties in collecting accurate catch data. In some cases, countries have attempted to estimate catches by extrapolating from earlier years. When this process is continued for an extended period such as in the Comoros, Madagascar and Somalia in the SWIOFC, and the Sudan in the Red Sea, significant biases will occur. How large the bias could be in these countries is uncertain. The poor quality of catch data coupled with the poor capacity for stock assessment and fisheries management leads to the poor knowledge of stock status in this region. This in turn hinders the development of management plans for most fisheries. This is a vicious circle that must be addressed for the long-term sustainability of fisheries in the Western Indian Ocean.

Eastern Arabian Sea: India, Pakistan, Maldives

The three largest fisheries on the west coast of India are Indian oil sardine (*Sardinella longipes*), Bombay-duck and shrimp or prawn fisheries. The Indian oil sardine fishery occurs on both the west and east coasts of India although it is concentrated in large shoals along the southwest coast of Kerala and Mysore. The fishery, which in 2001 landed 288 000 tonnes from the west coast, is a mixed artisanal/industrial fishery and utilizes dugout canoes (Kerala coast), out-rigger vessels (Maharashtra and Karnataka coasts) and purse seiners (offshore areas) to take the fish. The fishery fluctuates significantly from year to year in response to oceanic conditions and particularly the abundance of phytoplankton blooms (*Fragillaria oceanica*, *Coscinodiscus* spp. and *Pleurosigma* spp.). These blooms and the extent of upwelling along the southwest coast of India that support them appear to be the major drivers of sardine productivity. As a consequence, there has been little concern about the status of the stocks despite rising levels of fishing effort. The stock is currently assessed as underexploited (Vivekanandan *et al*., 2010).

The fishery for Bombay-duck (*Harpodon nehereus*) contributes about 10 percent of the average national landings in India and, in 2001, 143 000 tonnes were landed along the west coast. The species has a wide and discontinuous distribution along both the east and west coasts of India. However, the northwest coastal states of Gujarat and Maharashtra contribute the largest catches. Fishing methods used to take Bombay duck vary between regions. The status of the stock of Bombay-duck is estimated to be fully exploited (Vivekanandan et al., 2010). Spawning and recruitment appear more or less continuous on the west coast, although peaking in the monsoon period between September and December.

The prawn or shrimp fisheries of the west coast of India target a large number of both penaeid and non-penaeid species. In Kerala in the southwest and along the west coast, *Penaeus indicus*, *P. monodon*, *Metapenaeus dobsoni*, *M. monoceros*, *M. affinis*, *Parapenaeopsis stylifera*, *P. sculptillis* and *P. hardwickii* are the major contributors to the catch. The species mix is dependent both on location and on the seasonal monsoons in coastal waters. Most shrimp fisheries on the west coast are subject to exploitation throughout their life cycle. There are large, traditional fisheries for juveniles occurring in the backwaters and estuaries of Kerala and other states and both traditional and large mechanized trawl fisheries for adults in offshore waters. The overall stock of shrimps is believed to be fully exploited (Vivekanandan *et al*., 2010).

The Coastal Fishing Policy in India has an open-access regime, which has resulted in a sector with many entrants exploiting coastal marine resources at and beyond their full potential. Pakistan's landings of marine fish have been about 0.5 million tonnes in the last few years and marine capture fisheries employ about 379 000 fishers (Jarwar, 2008). However, it is not known how many vessels are operating at the moment. Pakistan seems to be lacking in terms of fishery data collection and management. Very little is known about the state of fish stocks in Pakistan's territorial waters.

The RECOFI area

Fishing in the RECOFI is done using motorized dhows and sambuks, smaller wooden vessels and industrial-style trawlers. Nearly all of these still use ice to preserve their catch. Trawling has been banned in Qatar and the United Arab Emirates. Iran (Islamic Republic of) has also severely limited the use of trawlers inside the Persian Gulf, where such fishing is only permitted during the shrimp fishing season. The Iranian industrial trawl fishery that used to operate within the Persian Gulf is now restricted to fishing in the Gulf of Oman and the northwest Arabian Sea.

Accurate information on the state of individual stock and species continues to remain difficult to obtain, where it exists at all. This is because of the common practice of reporting catches in a highly aggregated form. The available catch data suggest that most fish groups are fully exploited. Three resources remain of major concern in Area 51: Spanish mackerel, shrimp (various Penaeid and Metapenaeid species) and a range of percid fishes, particularly groupers.

The average total annual landings of shrimps and prawns in the subarea were about 15 000 tonnes before 2005, while fluctuating between 10 000 and 20 000 tonnes. They then increased to 25 000 tonnes in 2009. Most species are considered fully exploited, but not overfished when information from the trend in catch, biology of shrimps and prawns and the seasonal closure in most countries is considered.

Kingfish (*Scomberomorus commerson*; Scombridae) is a popular target and it is commercially important in the RECOFI area. The total catch in the RECOFI countries reached a peak of 44 000 tonnes in 1988, but then dropped gradually to 15 000 tonnes in 2009. Because of the large volume and high value of the kingfish landings, scientific research on the fishery has boomed in the last few years. All the studies in Iran (Islamic Republic of) (Shojaei *et al*., 2007), the United Arab Emirates (Grandcourt *et al*., 2005), and Oman (Govender *et al*., 2006; Meriem, Al-Marzouqi and Al-Mamry, 2007) conclude that kingfish is overfished.

The countries of the Gulf Cooperation Council (GCC) met in Oman in February 2010 and agreed on a two-month (15 August–15 October) closure of fishing each year and a minimum landing size of 65 cm (fork length). This is the first initiative for a regional fishery regulation in the RECOFI area. However, Iran (Islamic Republic of) was not involved in this effort. It currently catches about 10 000 tonnes of kingfish, which is about two-thirds of the total of the GCC countries. Kingfish is a highly migratory species, and it is believed that the Persian Gulf, the Gulf of Oman and the Arabian Sea share a single stock (Hoolihan, Anandh and van Herwerden, 2006). Regulatory measures that are not implemented on the whole kingfish stock will not be effective or achieve the long-term sustainability of the fishery.

The most important group caught in the region are tuna and tuna-like species. These fishes form the largest catch component in the RECOFI area and their status can be found in Chapter C1. Another species group that may deserve special attention in terms of management are groupers. The catches of these species have declined dramatically since the early 2000s and are currently of great concern.

The Red Sea and Gulf of Aden

The overwhelming majority of fisheries in the Red Sea are small-scale and artisanal industries. These fisheries operate near the coast and catch a wide variety of demersal species. Fishing operations in the Red Sea range from foot fishers, who fish from land mainly for their own consumption, to very large trawlers with freezing facilities. The most commonly used types of fishing gear are handlines and gillnets operated from boats equipped with outboard (i.e. houris) and inboard (i.e. sambuks) engines. Red Sea fisheries are typical multigear and multispecies tropical fisheries with fishing vessels between 5 and 20 m in length.

The nature of multispecies and multigear tropical fisheries in this subarea, together with the poor quality of catch statistics, makes stock assessment difficult. The landings of all the top ten species groups have declined in the last few years, with the exception of Indian mackerel. Therefore, with the exception of some small pelagic resources with weak markets, the status of the various resources should to be assumed as fully exploited. However, it must be borne in mind that no explicit stock assessment information on the status of the fishery resources is available for Area 51. The landings data show clearly that the growth in catches declined sharply in the 1990s, being effectively constant in the last few years. Detailed analysis of the data is unwarranted because of the high "estimated" catches for these countries and changing patterns in disaggregation of the data. Increases in different categories may be best explained by increased disaggregation by species in the reported figures.

Fishery management appears weak in this region. The small areas available for trawling and the absence of any effective regulation in many parts of the Red Sea probably result in fisheries that are quickly fully exploited or overexploited. Markets for fish in the region are strong, particularly in Yemen and Egypt along with Saudi Arabia for higher-priced species. Low market demand for small pelagics has resulted in reduced fishing for these species. This reduction has been most noticeable with the withdrawal of East European operators that had fished there to supply their home markets.

The SWIOFC area (Somalia to South Africa)

The Scientific Committee of the SWIOFC started a process to estimate the status of focus fish groups in the region in 2006 (FAO, 2008), and continued this process in 2008 (FAO, 2009) and again in 2010 (FAO, 2011b). Most countries in the region have only catch statistics that are very roughly grouped. For example, Maldives groups its catch by four size classes regardless of species. Fishing effort information is also not available for the majority of fisheries in the SWIOFC area. Most countries have a vessel registration system in place, but these records give no information about what fisheries the vessel is involved in and whether the vessel is or is not currently in operation. Because of the very limited research capacity of member countries in the region, stock status is often determined on the basis of empirical indicators such as CPUE and survey catch rates, and by educated or expert judgements.

A total of 137 species (stocks) were selected for assessment by the Scientific Committee, but only 107 stocks or species were assessed in 2010. Of the assessed species, 35 percent were fully exploited, 36 percent were non-fully exploited and 34 percent were overexploited (FAO, 2010). This result is similar to the global state of marine fish resources. Although more stocks have become depleted, a large proportion of the fisheries are still underexploited.

Shrimps and prawns are among the most important species group in this region, and their catches increased to 30 000 tonnes in 2003–07. However, only half the peak catch, 15 000 tonnes, was landed in 2009. It is probable that some shrimp and prawn stocks may have been overfished. Because of their short life span and low trophic level that shrimps and prawn occupy, fluctuation in catch is common and stocks can often recover relatively quickly even if they are overfished.

The prawn fishery in the United Republic of Tanzania for the past decade has experienced drastic declines in catch. Commercial prawn production declined from 1 320 tonnes in 2003 to 202 tonnes in 2007, despite the reduction in fishing effort. In 2008, the Tanzania Fisheries Research Institute (TAFIRI) reported a serious decline in prawn stocks on the coast of the United Republic of Tanzania that was linked to higher levels of resource exploitation (FAO, 2011b). The report was discussed in a joint meeting involving TAFIRI and the prawn fishery stakeholders (small-, medium- and large-scale fishers) and a resolution to close the fishery for two years was agreed. From the latest assessment, the prawn stock has not recovered and may need more time to recover. In 2010, the industrial sector of the shrimp fishery remained closed, but the artisanal sector resumed fishing.

The stock of *Palinurus delagoae* off the central/southern coast of Mozambique was reported as depleted 13 years ago. When the fishing industry recognized that the fishery was no longer economically viable, most of the vessels stopped fishing and the fishery was formally closed by the national fisheries authority. In order to allow recovery of the stock, licences ceased to be issued in 2007 for vessels that target this lobster species. This management measure was complemented by scientific monitoring of the stock (FAO, 2011b).

While the coastal fisheries are harvested mostly by coastal States, the more lucrative oceanic fisheries are mostly harvested by distant-water fleets from Europe and East Asia. Despite this, and the low coastal catches, fishing and its associated economic activities are important to local economies. In some of the southwest Indian Ocean countries, fish are almost the only source of animal protein available to the local populations. Moreover, in a region faced with scarcities of foreign exchange, exports of fishery products represent vital sources of exchangeable earnings. The shrimp fishery on the Sofala Bank is important to Mozambique for foreign exchange earnings, and similarly for Madagascar. The industrial shrimp fishery in Mozambique is scientifically monitored and actively managed. Recent analyses suggest that the resource is fully exploited and that fishing effort should be reduced for reasons of economic efficiency. Effort controls should involve not only the number of vessels and seasonal closures but also the size of the gear used.

ACKNOWLEDGEMENTS

Aubrey Harris from the Subregional Office for Southern Africa and Piero Mannini from the Regional Office for the Near East and North Africa critically reviewed an earlier version of this paper and made critical comments and valuable feedbacks.

REFERENCES

African Prospects. 2009. Somali piracy: the other side of the coin [online]. www.exacteditions.com

Al-Yamani, F.Y. 2007. *Assessment of the effects of the Shatt Al-Arab's altered discharge regimes on the ecology of the Northern Arabian Gulf*. Kuwait, Aquaculture, Fisheries and Marine Environmental Department, Kuwait Institute for Scientific Research.

FAO. 1998. *Trial fishing for lantern fishes (Myctophids) in the Gulf of Oman (1989-1990)*. FAO Fisheries Circular No. 935 FIRM/C935.

FAO. 2008. *Report of the Second Session of the Scientific Committee of the South West Indian Ocean Fisheries Commission*. FAO Fisheries Report No. 875. Rome. 77 pp.

FAO. 2009. *Report of the Third Session of the Scientific Committee of the South West Indian Ocean Fisheries Commission*. FAO Fisheries Report No. 899. Rome. 96 pp.

FAO. 2010. *Report of the Fourth Session of the Scientific Committee*. FAO Fisheries and Aquaculture Report No. 966. 65pp.

FAO. 2011a. *Report of the FAO Workshop on the Status of Shared Fisheries Resources in The Northern Arabian Sea – Iran (Islamic Republic of), Oman and Pakistan, Muscat. Oman, 13–15 December 2010*. FAO Fisheries and Aquaculture Report No. 971. Karachi, Pakistan. 58 pp.

FAO. 2011b. *Report of the Fourth Session of the Scientific Committee of the South West Indian Ocean Fisheries Commission, Mahe, Seychelles, 29 November –2 December 2010*. FAO Fisheries Report No. 966. Rome. 65 pp.

Govender, A., Al-Oufi, H., McIlwain, J.L. & Claereboudt, M.C. 2006. A per-recruit assessment of the kingfish (*Scomberomorus commerson*) resource of Oman with an evaluation of the effectiveness of some management regulations. *Fisheries Research*, 77: 239–247.

Grandcourt, E.M., Abdessalaam, T.Z.A., Francis, F. & Shamsi, A.T. 2005. Preliminary assessment of the biology and fishery for the narrow-barred Spanish mackerel, *Scomberomorus commerson* (Lacépède, 1800), in the southern Arabian Gulf. *Fisheries Research*, 76: 277–290.

Hamza, W, Munawar, M. 2009. Protecting and managing the Arabian Gulf: Past, present and future. Aquatic Ecosystem Health & Management, 12/4: 429-439.

Hoolihan, J.P., Anandh, P. & van Herwerden, L. 2006. Mitochondrial DNA analyses of narrow-barred Spanish mackerel (*Scomberomorus commerson*) suggest a single genetic stock in the ROPME sea area (Arabian Gulf, Gulf of Oman, and Arabian Sea). *ICES Journal of Marine Science*, 63: 1066–1074.

Jarwar, A.M.A. 2008. A status overview of fisheries and aquaculture development in Pakistan with context to other Asian countries. *Asia Aquaculture Magazine*, April–June: 14–18.

Meriem, S.B., Al-Marzouqi, A. & Al-Mamry, J. 2007. Fisheries exploitation of narrow-barred Spanish mackerel, Scomberomorus commerson in Oman and potential management options. *Journal of Applied Ichthyology*, 22: 218–224.

Sharp, G.D. 1995. Arabian Sea Fisheries and their Production Contexts. *In* M.F. Thompson, N.M. Tirmizi & A.A. Balkema, eds. *The Arabian Sea: living marine resources and the environment*, pp. 239–264. Rotterdam, Netherlands.

Shojaei, M.G., Motlagh, S.A.T., Seyfabadi, J., Abtahi,B. & Dehghani, R. 2007. Age, growth and mortality rate of the narrow-barred Spanish mackerel (*Scomberomorus commerson* Lacepède, 1800) in coastal waters of Iran from length frequency data. *Turkish Journal of Fisheries and Aquatic Sciences*, 7: 115–121.

Skewes, T., Ye, Y. & Burridge, C. 2005. *Australian Government assistance to the Seychelles tsunami relief effort: assessing impacts to near-shore fisheries*. CSIRO report, ISBN 1 921061 29 4. Brisbane, Australia.

Valinassab, T., Pierce, G.J. & Johannesson, K. 2007. Lantern fish (*Benthosema pterotum*) resources as a target for commercial exploitation in the Oman Sea. *Journal of Applied Ichthyology*, 23: 573–577.

Valinassab, T., Daryanabard, R., Dehghani, R. & Pierce, G.P. 2006. Abundance of demersal fish resources in the Persian Gulf and Oman Sea. *Journal of the Marine Biological Association of the United Kingdom*, 86: 1455–1462.

Vivekanandan, E., Mohamed, K.S., Kuriakose, S., Sathianandan, T.V., Ganga, U., Pillai, S.L. & Nair, R.J. 2010. Status of marine fish stock assessment in India and development of a sustainability index. Presented at the 2nd Workshop on the Assessment of Fishery Stock Status in the South and Southeast Asia 5–9 October 2009, Bangkok, Thailand.

Ye, Y. 1998. Assessing effects of closed seasons in tropical and subtropical penaeid shrimp fisheries using a length-based yield-per-recruit model. *ICES Journal of Marine Science*, 55: 1112–1124.

B9. Eastern Indian Ocean

FAO STATISTICAL AREA 57

Gabriella Bianchi
Service Coordinator
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: gabriella.bianchi@fao.org

Rick Fletcher
FAO Consultant
Australia
E-mail: rick.fletcher@fish.wa.gov.au

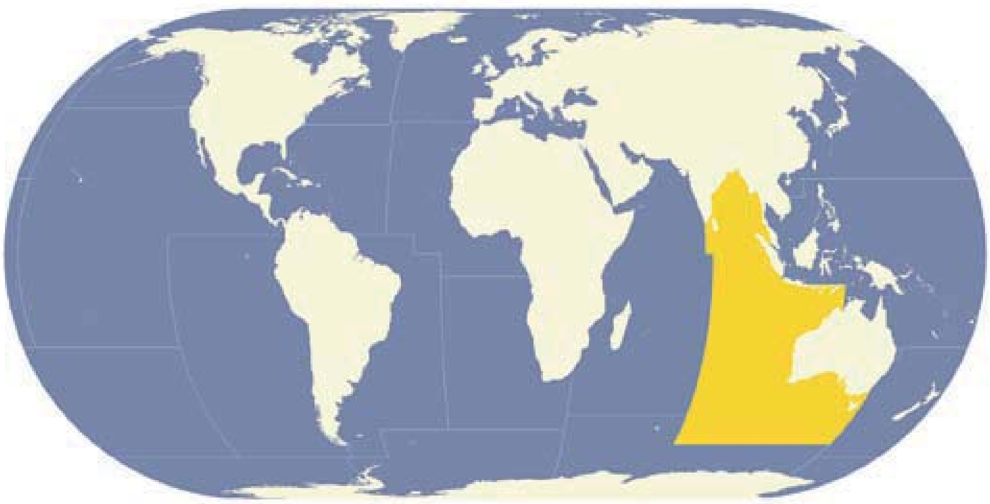
INTRODUCTION

The Eastern Indian Ocean covers an area extending west to 80°E, south to 55°S and mainly delimited by landmasses in the north and east (Figure B9.1). These landmasses include the countries of the Bay of Bengal in the north, and Malaysia, Indonesia and Australia in the east. The main shelf areas include those of the Bay of Bengal, the Gulf of Martaban and the narrower shelf areas on the west and south sides of Indonesia and Australia, for a total of 2.37 million km^2 of shelf area.

Because of its extensive latitudinal (north–south) span, this region includes tropical, subtropical and temperate regions. Tropical species and communities are found mainly in the north and central parts, while temperate species are found in the southern latitudes of west and south Australia.

The northern part of the area coincides with the Bay of Bengal and is located in the tropical monsoon belt, with sea surface circulation reversing in the monsoon period (clockwise from January to July, counter-clockwise from August to December) (Lamboeuf, 1987). In addition to the monsoon cycles, this region is affected by storm

FIGURE B9.1
The Eastern Indian Ocean (Area 57)



surges and cyclones. Moreover, the presence of large rivers (such as the Ganges–Brahmaputra and the Irrawaddy Rivers) strongly affects the water salinity in large parts of the bay. They provide considerable sediment loads to the shelves and lowered salinities.

On the shelf of the Bay of Bengal, the main type of demersal fish communities can be largely correlated with the type of bottom on which they occur. On muddy-soft bottoms, sciaenids (drums) dominate within a diverse and complex community including polynemids, sea catfishes, shads, hairtails, various flatfish species and crustaceans. On sandy shelf bottoms, such as off the Thai coast of the Andaman Sea, slipmouths, goatfishes, sciaenids and lizardfishes dominate.

The Indian Ocean shelves of Indonesia (Sumatra and Java) are relatively narrow and steep, mostly with coralline and sandy bottoms. The northern part of this area was affected by the tsunami in 2004. There is evidence of coral reefs having been affected by this event, through deposits of debris and siltation, as well as tectonic uplift. However, overall fish productivity in this region does not seem to have suffered. The south coast of Indonesia and the north coast of Australia are in the path of a low-salinity warm-water current flowing west from the Pacific into the Indian Ocean, the Indonesian Throughflow.

Overall, shelves have relatively low productivity, which is also reflected in the low abundance of fish. The southward flow of the warm and low-nutrient Leeuwin Current allows tropical fish fauna off west Australia to be found farther south than anywhere else in the world. However, this current is also responsible for the low productivity of these waters. Farther south, along the southwest and south coasts of Australia, the climate becomes more temperate with high rainfall in the west.

The oceanic regions are characterized by low overall productivity except for higher primary productivity resulting from equatorial upwelling. However, this is a more limited phenomenon in this area compared with the Atlantic and Pacific Oceans. The primary productivity of the Bay of Bengal is considered lower than that of the Arabian Sea, largely as a consequence of stronger stratification and lack of upwelling (Prasanna Kumar *et al.*, 2002).

The countries surrounding the northern and central parts of the region (Bay of Bengal and western Indonesia) include some of the largest populations on earth, with India, Indonesia and Bangladesh being among the world's top ten. The coastal population living around the Bay of Bengal is estimated to be about 450 million, with fisheries employing about 4.5 million people, of whom 2.2 million are fishers. Marine living resources are extremely important for the livelihoods of millions of people and their communities, in particular as a source of food.

Despite the increasing trends in the total catches reported from this region (Figure B9.2), there is a general perception that marine living resources are overexploited and critical habitats are becoming degraded, particularly in the northern area. Key factors that contribute to this situation are socio-economic, such as those resulting from population growth and increasing migration to the coast, and lack of alternatives for securing food, livelihoods and shelter in the poor rural coastal communities. Other factors are largely institutional, such as poor enforcement of policies, laws and regulations. Climate change resulting in ocean acidification, sea-level change (rises in most areas); and increased frequency or intensity of storms and cyclones is also considered as an emerging key concern.

The southern area is sparsely populated. Here, key environmental concerns include the impact of increased shipping activities, development of oil and gas deposits, mining, nutrient inputs from land-based activities and tourism. These concerns are addressed through a strong legislative framework combined with an advanced environmental monitoring system. Climate change has been recognized as one of the most important factors affecting fisheries in this region (Irvine *et al.*, undated).

PROFILE OF CATCHES

Catches in Area 57 have increased steadily since 1950 (Figure B9.2, Table D10). The rapid increase began in the 1970s and is still continuing, with the total catch exceeding 5 million tonnes in 2002. Since then, the total catch has increased to more than 6.5 million tonnes in 2009. The majority of this increase continues to be comprised of the "marine fish NEI" group and the five ISSCAAP fish groups that together accounted for almost 85 percent of the catches in 2009. The largest individual contribution (43 percent) remains marine fishes not identified (Group 39), followed by miscellaneous pelagic fishes (Group 37) at 12 percent and miscellaneous coastal fishes (Group 33) at 11 percent. The large contribution that these groups make to the total is a reflection of the multispecies nature of most fisheries in the region, particularly those in the tropical and subtropical areas. However, this is also the result of the way national reporting systems are organized. Countries have tended to pull statistics together into larger categories and disregard the advantages that a higher resolution in the statistics would bring. This is particularly in relation to the insights it would provide as a basis for policy-making. The other major groups include herrings, sardines and anchovies (Group 35) at 8.4 percent, and tunas, bonitos and billfish (Group 36) at 7.9 percent.

For the purpose of this review, Area 57 was divided into a northern area (Bay of Bengal and the Indian Ocean side of western Indonesia, including coastal and oceanic adjacent waters) and a southern area (mainly west and south Australia and adjacent oceanic waters). This was done to reflect the different climatic and oceanographic conditions as well as the types of fisheries and data availability.

Northern area

Much of the catch in the northern area comes from coastal fisheries. These fisheries are typically multispecies and multigear, and their catch is mostly used for local consumption. Fish represent one of the few affordable sources of protein for people in the region. The high proportion of the marine fishes not identified (ISSCAAP Group 39) in the catch is a reflection of both the types of fisheries that operate here and the relatively weak fishery statistical systems that exist in many of the countries of the region. Croakers (Sciaenidae), sea catfish and pony fish remain the largest components of the miscellaneous coastal fishes catch (Group 33). While catches of these species groups have largely stabilized in the past seven years (Figure B9.3), the catch of the entire group increased in this period from about 500 000 tonnes to 700 000 tonnes in 2009 (Table D10).

FIGURE B9.2
Annual nominal catches by ISSCAAP species groups in the Eastern Indian Ocean (Area 57)

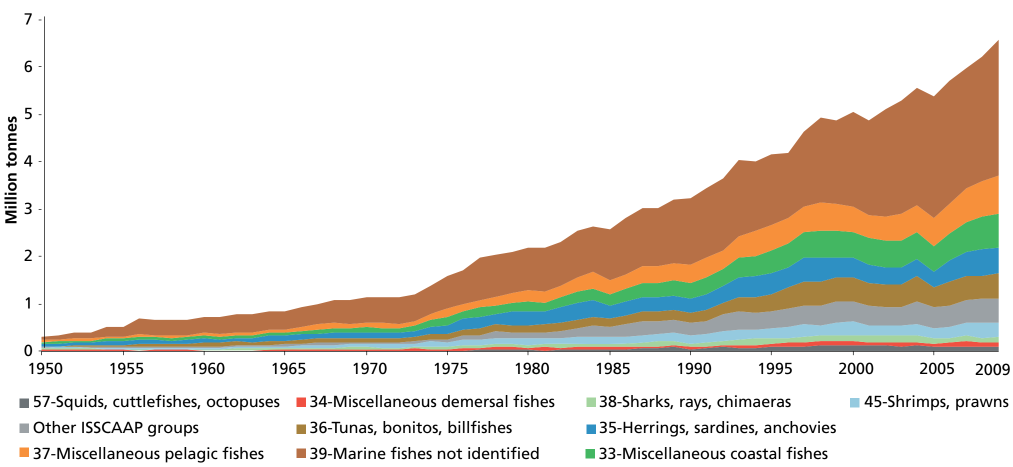


FIGURE B9.3
Annual nominal catches of selected species in ISSCAAP Group 33, Eastern Indian Ocean (Area 57)

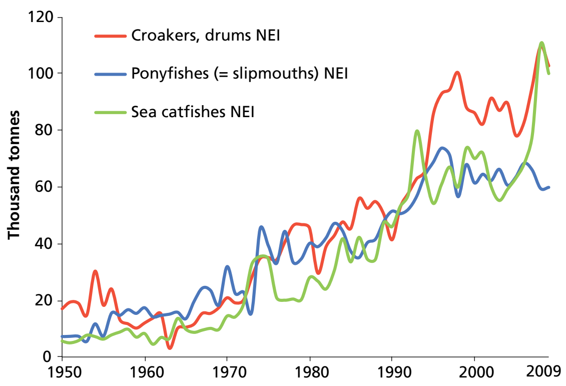


FIGURE B9.4
Annual nominal catches of selected species in ISSCAAP Group 35, Eastern Indian Ocean (Area 57)

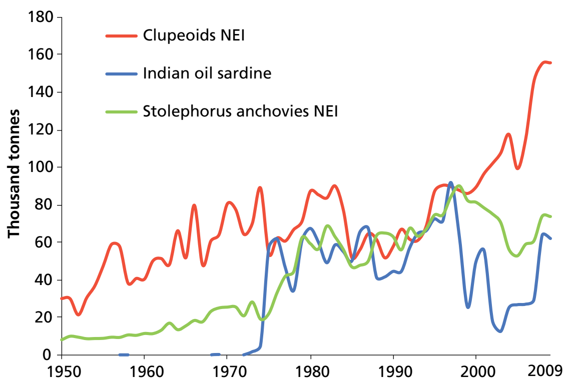
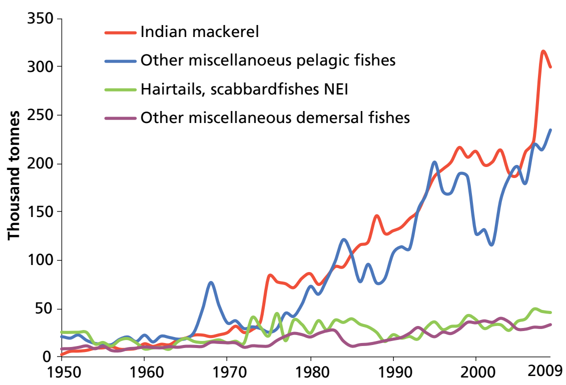


FIGURE B9.5
Annual nominal catches of selected species in ISSCAAP Groups 34 and 37, Eastern Indian Ocean (Area 57)



For the herring, sardines and anchovies (ISSCAAP Group 35), the catch of anchovy (*Stolephorus* spp.) and Indian oil sardine (*Sardinella longiceps*) increased until the end of the 1990s. Since this time, the anchovy catches have remained in the range of 53 000 to 82 000 tonnes. In contrast, the oil sardine declined from more than 80 000 tonnes to 13 000 tonnes in 2003, but has since recovered to some extent with catches of more than 60 000 tonnes in 2008 and 2009 (Figure B9.4). The total catch of Group 35 has continued to increase, rising from 384 000 tonnes in 2002 to more than 550 000 tonnes in 2009, with much of this increase due to the clupeoids NEI (Figure B9.4).

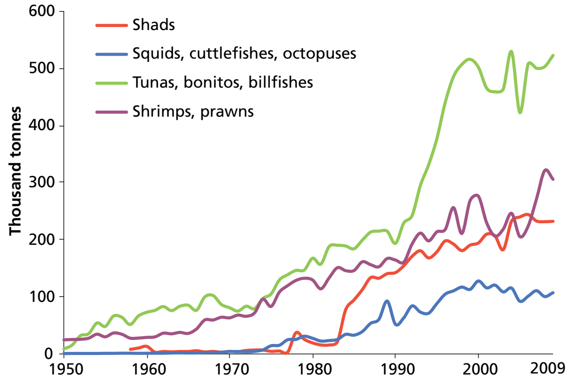
The catches of the miscellaneous pelagic species (ISSCAAP Group 37) increased from 524 000 tonnes in 2002 to 794 000 tonnes in 2009 (Figure B9.5). The major components for this increase include the catch of Indian mackerels (*Rastrelliger* spp.), which recovered from the downturn in the early 2000s to be 235 000 tonnes in total in 2009. There has also been a continual increase in the other miscellaneous pelagic catch, which has risen from 200 000 tonnes to 300 000 tonnes. The total catch of the miscellaneous demersal fishes (ISSCAAP Group 34) has been relatively stable for the past decade, which is reflected in the catches of the two largest components of this group (Figure B9.5).

The catches of shads (ISSCAAP Group 24) seem to have stabilized. This statistical group includes several species, with the hilsa shad (*Tenualosa ilisha)* making up most of the catches (almost 200 000 tonnes in 2007). Catches of the second-most important species in this group, the kelee shad (*Hilsa kelee*), have dropped substantially from almost 50 000 tonnes to less than 20 000 tonnes in more recent years. This drop is not visible in Figure B9.6 given the lower level of catches of this species as compared with the hilsa shad.

Cephalopods (ISSCAAP Group 57), tunas (ISSCAAP Group 36) and, to a lesser extent, shrimps (ISSCAAP Group 45) appear to have all reached a plateau in the past decade (Figure B9.6).

The catches of tuna, which are one of the major export-earning fisheries for the region, are now oscillating around 500 000 tonnes. Skipjack tuna make the largest species contribution to the catch with 100 000–135 000 tonnes. In comparison, the catch of yellowfin has now declined from its peak

FIGURE B9.6
Annual nominal catches of selected species in ISSCAAP Groups 24, 36, 45 and 57, Eastern Indian Ocean (Area 57)



in the late 1990s to be almost 70 000 tonnes/year. The catches of cephalopods, which is also a major commercial fishery, have not expanded as expected, with the total remaining close to 100 000 tonnes since 2002. This is despite an expansion in fishing activities from mainly around Thailand into Malaysia and Indonesia. The catch of shrimps, which appeared to peak at 270 000 tonnes in 2000, has rebounded to now be above 300 000 tonnes (Figure B9.6). The majority of this comes from the continued increase in catches of the giant tiger prawn (*Penaeus monodon*) and the recovery of the catch of natantian decapods (Table D10).

Southern area

The main fisheries in the southern area of the Eastern Indian Ocean are off the west and southwest of Australia. Total catches in the 1970s were about 60 000 tonnes, increasing to an initial peak of 127 800 tonnes in 1993 before fluctuating and then declining to 110 000 tonnes in 2001. In the last decade, the catch again increased to another peak of 160 000 tonnes in 2004 before again declining to 110 000 tonnes in 2009. This total catch is considerably less than in the northern areas and reflects the very low nutrient content of the waters occurring in this region.

The most important groups in this region in terms of economic value and export earnings are the spiny lobsters, abalone and tuna (ABARE, 2009). Lobster catches (other ISSCAAP groups) increased slowly from 6 000 tonnes in the 1950s and gradually reached a peak of almost 20 000 tonnes in 2000 before declining to 11 000 tonnes in 2009. These recent reductions reflect increased management restrictions introduced in response to a series of poor recruitments that have affected both lobster species (DOF, 2010). Abalone catches have been relatively stable at about 5 000 tonnes/year for the past ten years despite an outbreak of a disease in one of the regions. The tuna captured in this region are mostly southern bluefin tuna, which had a peak catch of 20 000 tonnes in 1982. After that time, TAC quotas were introduced when assessments indicated that the stock was overexploited. A series of quota reductions have been introduced in order to recover the stock towards an interim rebuilding target reference point (CCSBT, 2009). Much of the current quota of only 4 000 tonnes of southern bluefin tuna caught in this area is being value-added through sea ranching (ABARE, 2009).

The catches of herrings, sardines and anchovies (ISSCAAP Group 35) form the largest volume catch for this region. The catch peaked at 17 800 tonnes in 1988 and then subsequently declined to 4 377 tonnes in 1999 after two very large mass mortalities of pilchards occurred across the entire southern and lower east and west coasts of Australia in the mid- and late 1990s (Jones *et al.*, 2008). The stock has subsequently recovered in most locations (Ward, Ivey and McLeay, 2007; Gaughan *et al.*, 2008) with catches for the last six years having increased substantially to above 30 000 tonnes. Most of this catch is used as food for tuna ranching.

The other group contributing to the variations in overall catch for this area is scallops (ISSCAAP Group 55). There were two major peaks in scallop catches (more than 25 000 tonnes) in 1983 and 1993 and a minor peak of 12 000 in 2005. In between these peaks in catch have been periods where the annual catches sometimes declined to less than 2 000 tonnes. This boom–bust cycle has been experienced by these scallop fisheries over a long period. Recruitment events in scallops appear to be very episodic, but there is increasing evidence that overfishing can affect the frequency and intensity of these events (DOF, 2010).

RESOURCE STATUS AND FISHERY MANAGEMENT

Table D10 shows the assessments for Area 57. There is a difficulty in obtaining stock assessments for individual stocks and species within Area 57. Consequently, drawing more general conclusions about the status of individual stocks in the whole area are not possible. Thus, the results presented in Table D10 are based on regional catch data available in the FAO FishStat database and follow the methodology presented in this review. Stock assessments are available for the Australian fisheries, but because of their limited share in the totals for the region, they are not used for the regional assessment. Although very approximate, the assessments presented in Table D10 can still provide an indication of regional trends.

Of a total of 43 species and species groups assessed, 17 percent are non-fully exploited, 58 percent are fully exploited and 21 percent are overexploited. Among the overexploited groups of concern are the kelee shad, the largehead hairtail, sardinellas, silky shark, rays, penaeid shrimps, cephalopods and octopuses. Most of these fisheries take place in the northern area.

Northern area

The Bay of Bengal Large Marine Ecosystem Project[2] has recently completed a draft transboundary diagnostic analysis of this region to identify key sustainability issues as well as their causes.

Overfishing is a key issue in this region, with excess fishing capacity in many of the region's coastal fisheries reducing productivity and threatening long-term sustainability. Fisheries management within the region encompasses a range of situations and scales, from customary systems of marine tenure practised by coastal communities, to national fishery governance and participation in management of tuna stocks of the Indian Ocean. Despite the shared nature of many stocks within the Bay of Bengal region, there has been no effort in the past to assess and manage resources. The Bay of Bengal Large Marine Ecosystem Project is now attempting to address these issues. In some countries, customary rights are still in place, but these have often been replaced by open access. This has led traditional user rights to be eroded in favour of commercial fisheries development.

A number of destructive fishing practices, such as using dynamite and toxins to capture fish, small-mesh net fishing for prawn larvae, and live coral mining have been common and widespread in this area. Weak governance (inadequate monitoring and control systems, weak fisheries management decision-making processes, poor information on resources, and limited national and regional capacity) has also contributed to coastal fish stocks being under serious threat with the present level of exploitation and the types of fishing methods used. It should also be recognized that, in addition to fishing pressure, fishery resources are also threatened by other factors such as destruction of the mangrove ecosystems for timber or construction of shrimp ponds, pollution from land-based activities and coastal development.

The Bay of Bengal Large Marine Ecosystem Project is addressing the above fisheries governance and environmental issues and it is hoped that the above negative trends will be reversed. The project has adopted the ecosystem approach to fisheries as the framework to promote sustainable fisheries. As part of this effort, fisheries and environmental information is being compiled in order to formulate advice to the government agencies concerned.

Southern area

The most valuable fisheries in the southern area include rock lobster, abalone, prawns and tuna, which are all export fisheries. The fisheries management responsibility for

[2] Web site: www.boblme.org

these generally falls under the relevant state government agency (COA, 1980). The exception is for tuna, which is managed by the Government of Australia but as part of the Commission for the Conservation of Southern Bluefin Tuna (CCSBT). The CCSBT commission also includes Indonesia, Japan, the Republic of Korea, New Zealand, and the fishing entity Taiwan Province of China, plus a number of cooperating non-member countries (the Philippines, South Africa and the EU). The CCSBT is responsible for setting the TAC for southern bluefin tuna and its allocation among members.

All commercial fisheries in this region now have at least some form of limited entry management. Most have specific allocation of tradable fishing rights or access either in the form of catch and or effort (Rogers, 2000). In addition, in Australia, all export fisheries and all managed fisheries must now be assessed regularly against the "Guidelines for ecologically sustainable management of fishing" in order to meet the requirements of the Environment Protection and Biodiversity Conservation Act 1999, which is administered by the Federal Environment Agency (DEWR, 2007).

High seas

The main targets in the high seas of Area 57 are tuna and tuna-like species. Distant-water fleets from Asia (China, Japan, the Republic of Korea and Taiwan Province of China) and from Europe (primarily France and Spain) are playing a major role. As most of these high seas resources are shared throughout the Indian Ocean, the resource status adopted here is based on the results of the 13th session of the Scientific Committee of the IOTC (IOTC, 2011) covering whole stocks.

Yellowfin tuna (*Thunnus albacares*) is likely to be currently in, or approaching, an overfished state and overfishing has probably been occurring in recent years. The IOTC has recommended that catches not exceed 300 000 tonnes for the whole Indian Ocean. However, bigeye tuna (*Thunnus obesus*) and albacore (*Thunnus alalunga*) do not seem to show signs of overexploitation. Skipjack tuna is a species considered to be highly productive and robust to fisheries. Within Area 57 (and the Indian Ocean as a whole), it can still be considered as moderately exploited in the region. The IOTC advises government agencies of member countries to monitor this species closely as there are signs of local overexploitation.

Stock status of other tuna and tuna-like species (such as billfishes) is highly uncertain because of lack of data and formal assessments. Catch data seem to indicate a situation of the whole group of "other tunas, bonitos, billfishes, etc." being fully exploited. In tuna fisheries in the Indian Ocean, compliance seems to be the main problem. At its most recent meeting (March 2011), the IOTC Compliance Committee meeting, identified several shortcomings, especially regarding the tracking of catch data for science and management. In particular, there is a need to improve the information from the northeast Indian Ocean coastal States. While the IOTC is moving towards also considering bycatch and ecosystem issues relevant to these fisheries, there seems to be still some reluctance to comply with conservation and management proposals made at the commission level. For example, there is still no prohibition of retention on board of endangered species such as hammerhead or oceanic white tip sharks. Moreover, a proposal for mandatory collection of data on bycatch of endangered species by the gillnet fisheries, mainly in the northern part of Area 57, was downgraded to voluntary measure at the above meeting. Illegal fishing is also a major issue in the region and, to date, no serious effort has been made to combat it. This situation undermines the region's capacity to implement sustainable management efficiently.

ACKNOWLEDGEMENTS

The authors wish to thank Simon Funge-Smith (FAO Regional Office for Asia and the Pacific) and Rudolf Hermes (Bay of Bengal Large Marine Ecosystem Project, BOBLME) for their valuable comments and revisions of the initial draft of this chapter.

REFERENCES

Australian Bureau of Agricultural and Resource Economics (ABARE). 2009. *Australian fisheries statistics 2008*. Canberra. 96 pp.

Commission for the Conservation of Southern Bluefin Tuna (CCSBT). 2009. *Report of the Sixteenth Annual Meeting of the Commission*. Jeju Island, Republic of Korea. 111 pp.

Commonwealth of Australia (COA). 1980. *Offshore constitutional settlement: a milestone in cooperative federalism*. Canberra, Attorney General's Department. 10 pp.

Department of Environment and Water Resources (DEWR). 2007. Guidelines for the ecologically sustainable management of fisheries. Canberra. 18 pp.

Department of Fisheries (DOF). 2010. *State of the Fisheries and Aquatic Resources Report, 2009/10*. Western Australia. 321 pp.

Gaughan, D., Craine, M., Stephenson, P., Leary, T. & Lewis, P. 2008. *Regrowth of pilchard (*sardinops sagax*) stocks off southern WA following the mass mortality event of 1998/99*. Final report for FRDC Project 2000/135. Fisheries Research Report No. 176. Western Australia, Department of Fisheries. 82 pp.

Indian Ocean Tuna Commission (IOTC). 2011. *Report of the Thirteenth Session of the Scientific Committee. Victoria, Seychelles, 6–10 December, 2010*. IOTC-2010-SC-R[E]. 224 pp.

Irvine, T., Keesing, J., D'Adamo, N., Aquarone, M.C. & Adams, S. (undated). *VIII-17 West-Central Australian Shelf : LME #44* [online]. [Cited 20 December 2011]. www.lme.noaa.gov/index.php?option=com_content&view=article&id=90:lme44&catid=41:briefs&Itemid=72

Jones, J.B., Hyatt, A.D., Hine, P.M., Whittington, R.J., Griffin, D.A. & Bax, N.J. 2008. Special topic review: Australian pilchard mortalities. *World Journal of Microbiology and Biotechnology*, 13: 383–392.

Lamboeuf, K. 1987. *Bangladesh, Demersal resources of the continental shelf*. FAO/BGD Marine Fisheries Research, Management & Dev. Project, FI: DP/BGD/80/015. 26 pp.

Prasanna Kumar, S., Muraleedharan, P.M., Prasad, T.G., Gauns, M., Ramaiah, N., de Souza, S.N., Sardesai, S. & Madhupratap, M. 2002. Why is the Bay of Bengal less productive during summer monsoon compared to the Arabian Sea? *Geophysical Research Letters*, 29: 2235 [online]. [Cited 20 December 2011]. doi: 10.1029/2002GL016013

Rogers, P.P. 2000. Towards a better future fin fisheries management: rights-based fisheries management in Western Australia. *In* R. Shotton, ed. *Use of property rights in fisheries management, Volume 1*, pp. 172–181. FAO Technical Paper 404/1. Rome, FAO. 342 pp.

Ward, T.M., Ivey, A.R. & McLeay, L.J. 2007. *Spawning biomass of sardine,* Sardinops sagax, *in waters off South Australia in February-March 2007*. SARDI Research Report Series No. 245.

B10. Northwest Pacific

FAO STATISTICAL AREA 61

Akihiko Yatsu
National Research Institute of Fisheries Science, Japan
E-mail: yatsua@fra.affrc.go.jp

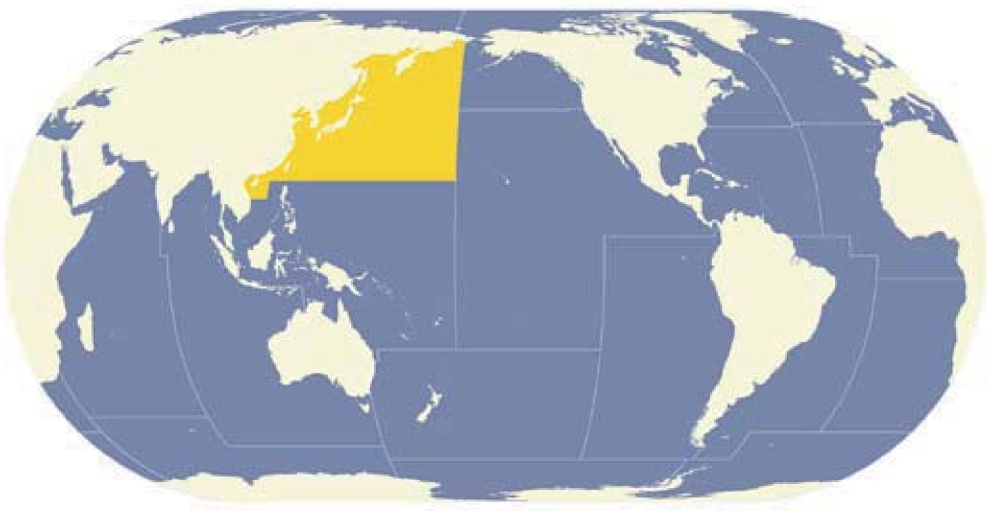
Yimin Ye
Senior Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: yimin.ye@fao.org

INTRODUCTION

The Northwest Pacific (Area 61, Figure B10.1) has a number of large, productive areas of continental shelf including the northern portion of the South China Sea, the East China Sea, the Yellow Sea, the Sea of Japan and the Sea of Okhotsk. Other subareas have less extensive areas of continental shelf with productive fisheries. These subareas include the western portion of the Bering Sea and the ocean east of the Japanese archipelago, the Kuril Islands, and the southeast part of the Kamchatka Peninsula. The enhanced productivity in these regions comes from the interaction and confluence of the Kuroshio and Oyashio western boundary currents. These interactions produce zones of enrichment and concentration of biological processes. The total surface area of the Northwest Pacific (Area 61) is close to 19 million km^2, including the third-largest shelf area at about 3.6 million km^2.

Nominal catches in the Northwest Pacific increased to 24 million tonnes in 1996 and 1997 after a general decline from 1988 to 1994. Catches have since stabilized at about 20 million tonnes, making the Northwest Pacific the most productive FAO Fishing

FIGURE B10.1
The Northwest Pacific (Area 61)



Area. Despite this high productivity, there continues to be concern over increasing fishing effort, IUU fishing, overfished stocks, and degradation of some ecosystems.

PROFILE OF CATCHES

Total catches in Area 61 grew steadily from about 4 million tonnes in 1950 to an intermediate peak of 23.6 million tonnes in 1988 (Figure B10.2). Catches declined to 20.4 million tonnes in 1994 because of abrupt declines in the two most important fish species in the catch, the Japanese pilchard (or sardine) (*Sardinops melanostictus*) in ISSCAAP Group 35 and the Alaska pollock (*Theragra chalcogramma*) in Group 32. The declines in the catches of these two extremely abundant species have been offset by increases in production of other major species. In 1996–1997, catches by industrial fisheries reached almost at the same level as the earlier 1988 peak. Since then, they have declined and stabilized at about 20 million tonnes (Figure B10.2, Table D12).

Japan used to be the largest fishery country in this area and landed about 10 million tonnes each year in the 1980s. However, its catch dropped rapidly in the 1990s and has remained at about 4 million tonnes a year in the last decade (Figure B10.3). In contrast, China had a relatively low catch of about 2 million tonnes in the 1960s and 1970s but this increased markedly between the mid-1980s and 1990s. After reaching a peak of more than 13.4 million tonnes in 1998, the total landings of China dropped slightly at the end of 1990s and remained at about 12.3 million tonnes in 2009. The Russian Federation/former Soviet Union is ranked third and its landings reached a peak at about 5 million tonnes in the mid-1980s. Its catches have since dropped to the current level of about 2 million tonnes. The Republic of Korea is also a major fishing country in the Northwest Pacific region, landing about 1.5 million tonnes between 1975 and 2000 and 1.3 million tonnes in 2009.

In the Northwest Pacific, about 18 percent (a percentage of total catch between 1950 and 2009, calculated from Table D12) of catches are not reported by species and are classified as marine

FIGURE B10.2
Annual nominal catches by ISSCAAP species groups in the Northwest Pacific (Area 61)

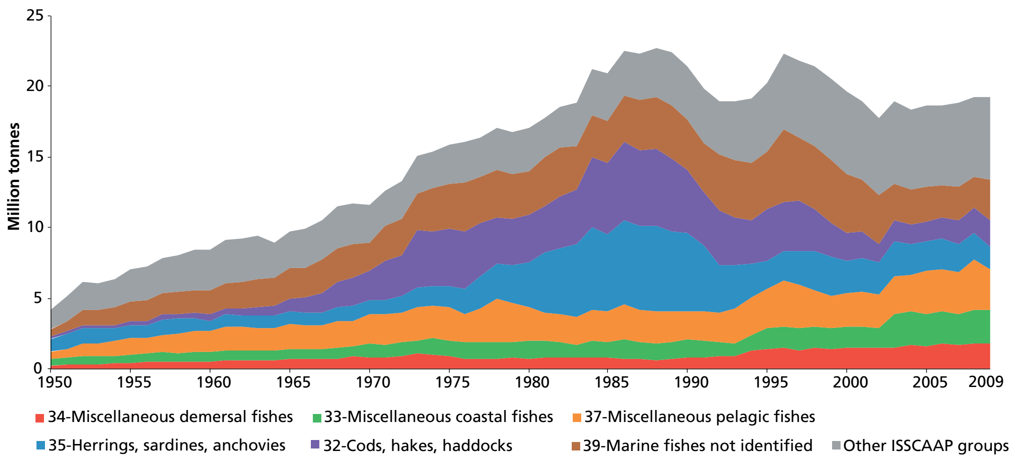
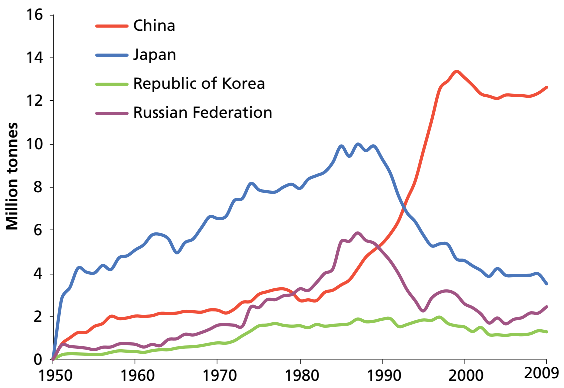


FIGURE B10.3
Annual nominal catches of selected countries in Northwest Pacific (Area 61)



fishes not identified (ISSCAAP Group 39). Cods, hakes, haddocks (Group 32) make the largest known contribution with 15 percent of the total. Alaska pollock had the largest catch of 5 million tonnes in the peak period around 1988. However, pollock catches dropped to a low of 1.1 million tonnes in 2002, with only a slight recovery by 2009 (Figure B10.4). The decline in the pollock may be related to excessive fishing pressure, although the evidence suggests at least some environmental factors were also important (McKinnell and Dagg, 2010). Pacific cod (*Gadus macrocephalus*) is second only to Alaska pollock, but had much lower landings that equal about 10 percent of the pollock catch. Pacific cod followed the declining trend in pollock and other North Pacific demersal catch from the 1980s to the early 2000s. Since that time, the catch has stabilized at about 111 000 tonnes (Figure B10.4). The highest catches of Pacific cod in Area 61 appear to be made in the Russian Navarin region of the Northern Bering Sea.

FIGURE B10.4
Annual nominal catches of selected species in ISSCAAP Groups 32 and 34, Northwest Pacific (Area 61)

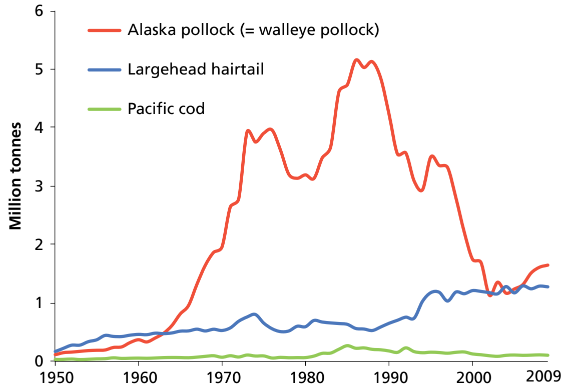
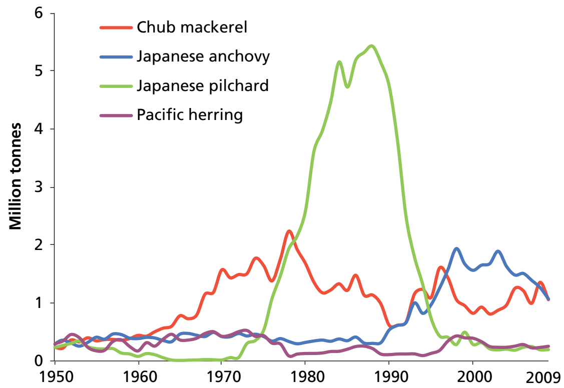


FIGURE B10.5
Annual nominal catches of selected species in ISSCAAP Groups 35 and 37, Northwest Pacific (Area 61)



Herrings, sardines and anchovies (ISSCAAP Group 35) form the second-largest group in Area 61, contributing about 15 percent of the total catch on average. Of this group, Japanese pilchard used to be the most important species, with a peak catch of 5 million tonnes in 1988 (Figure B10.5). However, the pilchard stock then collapsed and its catch fell to 282 000 tonnes and has remained at this level. It is believed that the collapse of Japanese pilchard in the late 1980s was the result of natural ecosystem variability associated with the 1988 regime shift (Yatsu *et al*., 2005; Ohshimo, Tanaka and Hiyama, 2009).

Japanese anchovy (*Engraulis japonicus*) is also an important species. Its catches increased from 0.3 million tonnes in 1988 to 1.9 million tonnes in 1998, before declining to about 1.4 million tonnes in 2008 (Figure B10.5). Pacific herring (*Clupea pallasii*) shows a multidecadal pattern in catch. The Sakhalin–Hokkaido stock dominated catches in the period from the 1920s to the 1940s. However, the Okhotsk and West Bering Sea stocks have made the largest contribution since the 1950s (Naumenko, 2001). Catches began showing a downward trend from the early 1970s until the late 1980s. The total catch in 1994 was only one-fourth of the average for the 1960s and 1970s. However, catches increased to a high of 431 000 tonnes in 1998 and decreased slightly to 226 000 tonnes in 2009 (Figure B10.5).

Miscellaneous pelagic fishes (ISSCAAP Group 37) make up another 13 percent of the total landings in Area 61. Among them, chub mackerel (*Scomber japonicus*) is the species with the largest catch. Its catch decreased from 1.6 million tonnes in 1996 to 0.81 million tonnes in 2002, and bounced back to 1.4 million tonnes in 2008 (Figure B10.5). Japanese jack mackerel (*Trachurus japonicus*) also increased from 0.06 million tonnes in 1980 to 0.37 million tonnes in 1994, thereafter fluctuating between 0.23 million and 0.41 million tonnes (Table D12). Pacific saury (*Cololabis saira*) declined from the 1950s to the 1980s.

FIGURE B10.6
Annual nominal catches of selected species in ISSCAAP Groups 55, 56 and 57, Northwest Pacific (Area 61)

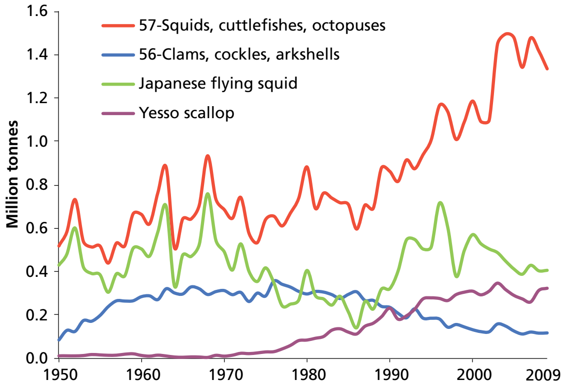


FIGURE B10.7
Annual nominal catches of selected species in ISSCAAP Group 23, Northwest Pacific (Area 61)

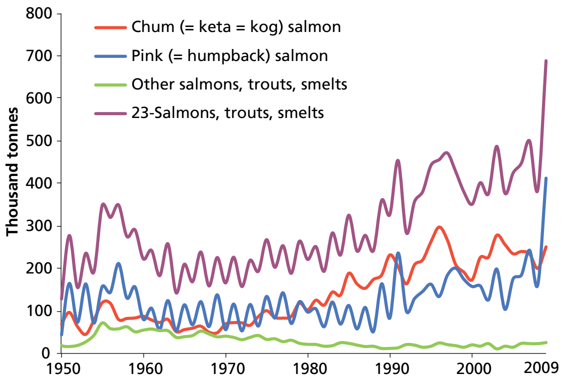
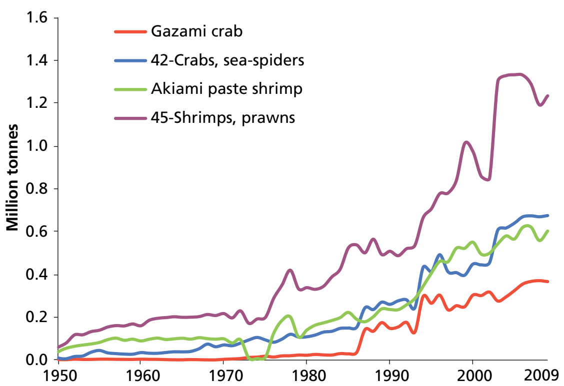


FIGURE B10.8
Annual nominal catches of selected species in ISSCAAP Groups 42 and 45, Northwest Pacific (Area 61)



The catch then increased from 0.18 million tonnes (1998) to 0.62 million tonnes (2008) and, thus, exceeded the historical peak in 1962 (Table D12).

Species reported as miscellaneous coastal fishes (ISSCAAP Group 33) constitute about 7 percent of the catch, and these have been stable since the early 2000s at between 2.1 million and 2.4 million tonnes (Table D10).

Species reported as miscellaneous demersal fishes (ISSCAAP Group 34) have a catch share of about 6 percent. Largehead hairtail (*Trichiurus lepturus*) is the major species in this group. Its catches increased from 0.53 million tonnes in 1988 to almost 1.2 million tonnes in 1998 and have been stable since (Figure B10.4).

ISSCAAP Group 57 (squid, cuttlefish, octopuses) produces about 5 percent of the total landings in Area 61. Catches for this group have increased steadily for the last two decades with clear year-to-year fluctuations (Figure B10.6). Japanese flying squid (*Todarodes pacificus*), the major species of the group, had large landings in the 1960s, but these declined until the mid-1980s. The catches bounced back to above 600 000 tonnes in 1997, but then dropped to 400 000 tonnes in 2009.

ISSCAAP Group 36 (tunas, bonitos, billfishes, etc.) constitute about 3 percent of the catch and the catch of this group has been stable since the early 2000s at between 0.63 million and 0.86 million tonnes (Table D12).

Catches of ISSCAAP Group 56 (clams, cockles, arkshells) have gradually declined since the 1970s and were about 100 000 tonnes in 2009 and are now only 1.5 percent of the total (Figure B10.6). Yesso scallops of ISSCAAP Group 55 exhibited a steady increase until the mid-2000s and then stabilized at about 0.3 million tonnes.

Salmons, trout, smelts, etc. (ISSCAAP Group 23) contribute only about 2 percent of the total landings. Their catches increased gradually after 1970, with a large jump to 700 000 tonnes in 2009 (Figure B10.7). Year-to-year fluctuations in salmonid catches have always been apparent. Over the whole time period, chum salmon (*Oncorhynchus keta*) and pink salmon (*Oncorhynchus gorbuscha*) have always been the major salmon species in the Northwest Pacific. After the 1980s, catches of chum salmon surpassed pink salmon and reached a peak of about 300 000 tonnes in 1996. Since then, chum salmon catches have fluctuated at about 200 000 tonnes (Figure B10.7). The pink salmon catch peaked in 1991, declined abruptly in 1992, and then fluctuated between 100 000 tonnes and 240 000 tonnes for many years before a sudden jump to about 400 000 tonnes in 2009.

It is worth noting that the catches of gazami crab (*Portunus trituberculatus*), shrimps and prawns have been increasing dramatically in the region in the past three decades (Figure B10.8). In contrast, the abundance and frequency of occurrence of gazami crab estimated by trawl surveys in Bohai Sea declined from 1959 to the 1990s (Jin, 2004). Recent catches of gazami crab in the western Japanese waters have also been low.

RESOURCE STATUS AND FISHERY MANAGEMENT

The status of each fishery stock in Area 61 is shown in Table D12. Fisheries in the Northwest Pacific are of great importance not only because they have the highest production among FAO Statistical Areas, but also because countries in the area such as Japan, China and the Republic of Korea have a tradition of eating fish. Fisheries management has been undertaken at both a country and regional level. However, that does not necessarily mean that fisheries resources are well managed. At a regional level, bilateral agreements on resource sharing and management are popular. For example, there are three bilateral agreements in the East China Sea and its adjacent seas. The 1965 agreement between Japan and the Republic of Korea concerning fisheries was revised and entered into force in 1999. This agreement was made in order to reflect the 1982 UNCLOS and resolve pending problems among coastal countries in the region (Kang, 2003). The 1975 agreement between China and Japan was also revised and entered into force in 2000. This agreement was intended to enhance cooperative fisheries management in the East China Sea. The agreement between China and the Republic of Korea for cooperative fisheries management in the Yellow Sea entered into force in 2001 (Kang, 2003; Yu and Mu, 2005). However, these agreements leave fundamental problems to be resolved, including: (i) neglect of the biological characteristics of fish stocks that migrate beyond the jurisdiction of one country; and (ii) enforcement and jurisdiction is conducted only by the flag State for broad areas known as “Provisional Waters”, “Middle Waters” and “Transitional Waters” (Kang, 2003).

The North Pacific Anadromous Fish Commission (NPAFC) was established in 1993 to promote conservation of anadromous fishes (six species of *Oncorhynchus*) in the international waters of the North Pacific Ocean and its adjacent seas. The NPAFC is responsible for fisheries north of 33°N that are beyond the 200-mile EEZs of the coastal States.[3] The Western and Central Pacific Fisheries Commission (WCPFC) was established in 2004 for a number of highly migratory species, such as tunas and billfishes, in the western and central Pacific Ocean.[4] A new arrangement on demersal fisheries operating on the high seas of the Northwest Pacific (Area 61) was established in 2007 and has been revised.[5] Multilateral meetings have also been under way to establish a new convention for management of fisheries stocks in the high seas of the Northwest Pacific that are not covered by the NPAFC and WCPFC.

The major approach to fishery management in the region is through input and technical controls. The exploitation level of fish stocks is regulated by input restrictions such as limits to the number of vessels and length of fishing season. The advantage of input controls is the ease and low cost of implementation. However, the disadvantage is that the effect of these regulations on total catch is not clear. In some circumstances, even if the number of fishing vessels or total fishing effort is reduced, the catch will not be reduced accordingly. Technical controls are also widely used in fisheries management by regulating the body size of the target species, mesh size of gear and release of artificially reared fry.

---

3 Web site: www.npafc.org/new/index.html
4 Web site: www.wcpfc.int
5 This is the North Pacific Fisheries Commission (http://nwpbfo.nomaki.jp/index.html).

There have been some major developments in domestic fishery management at the national level since the mid-1990s. In addition to the existing measures such as limited entry systems, Japan, the Republic of Korea and the Russian Federation implemented a TAC system for a number of species between 1997 and 2002 (Jamieson and Zhang, 2005). The Japanese Government developed a resource recovery plan in 2002 (Jamieson, Livingston and Zang, 2010). The Chinese Government introduced a negative growth policy, a fishing vessel buy-back programme, and summer fishing moratorium in its all coastal seas (Yu and Yu, 2008). The Republic of Korea started a buy-back programme in 1994 to reduce fishing capacity. It has recently developed a pragmatic ecosystem-based fisheries risk assessment method for fisheries of the Republic of Korea. The approach has been designed to measure the risks associated with fisheries relative to three different management objectives, such as sustainability, diversity, and habitat quality (Zhang *et al*., 2009).

China's summer season fishing moratorium has been implemented in all its coastal seas since 1995. At present, fishing is banned from 16 June to 1 September in the Bohai Sea, from 16 June to 1 September in the Yellow Sea, from 16 June to 16 September in the East China Sea, and from 1 June to 1 August in the South China Sea (FAO, 2009). The ban on major fishing gear in the summer has proved to be cost-effective to implement and monitor. It has resulted in clear benefits for the conservation of fish resources and biodiversity (Jiang *et al*., 2008).

Of the fish stocks that have been examined under this increased focus on fisheries management in the Northwest Pacific, only a few fish stocks have been assessed as overfished (Table D12). The most important is largehead hairtail, which mainly occurs in the East China Sea and is targeted by mainly Chinese fleets. In addition, Pacific saury and Japanese flying squid are considered to be non-fully exploited. Most fish stocks are believed to be fully exploited in the area (Table D12). However, it must be noted that the current assessments in Table D12 generally rely on catch criteria, because limited abundance or spawning biomass indices are available.

Despite the recent developments in management measures, excessive fishing capacity is still one of the major issues in the Northwest Pacific (Jamieson and Zhang, 2005). For example, the total fishing power of Chinese vessels in the East China Sea increased by 7.6-fold between the 1960s and 1990s. At the same time, their CPU declined by a factor of three (Maguire, 2005). Although the number of Chinese fishing vessels has stabilized since the late 1990s, the total power of vessel engines is still increasing (Yu and Yu, 2008). In coastal seas such as the East China, Yellow and Bohai Seas, there has been a shift in catches from large, high-valued fish to lower-valued smaller species (Tang and Jin, 1999; Zhang, Kim and Huh, 1988; Zhang and Kim, 1999; Jin, 2004, 2008). Reduction in fishing effort is still urgently needed in some areas (e.g. Chen and Shen, 1999; Zhang, Kim and Yun, 1992).

The largest variations in catches of marine resources in the Northwest Pacific have been caused by fluctuations in pilchard (or sardine) stocks. The pilchard fishery off Japan grew rapidly in the 1930s to become one of the largest single-species fisheries in the world. Then, in the early 1940s, the stocks abruptly collapsed. It remained depleted for nearly three decades and then suddenly exploded into a rapid rebuilding phase in the early 1970s (Kawasaki, 1983; Yatsu *et al*., 2005; Ohshimo, Tanaka and Hiyama, 2009). This led, in the 1980s, to catches of more than twice the peak before the earlier collapse. The pilchard stocks, after sustaining a major fishery for a similar period to that of the 1930s and 1940s, declined for a second time. The total catch of the fishery has remained at an extremely low level since the mid-1990s (Figure B10.5). The fluctuations in Japanese pilchard stocks are probably not related to fishing only, but more to climatic and ecosystem changes (Yatsu and Kaeriyama, 2005; Yatsu *et al*., 2005; Ohshimo, Tanaka and Hiyama, 2009). Given the influence of environmental conditions, it is difficult to classify the stock status of Japanese pilchard. However, the Pacific stock is considered overfished because the fishery is still taking catches above the level that the stock can sustain (Fisheries Agency and Fisheries Research Agency of Japan, 2010). As there have been no fisheries directly targeting the Tsushima Current stock since the 2000s, its stock status is uncertain.

During the rapid decline in pilchard catches in the late 1980s and early 1990s, a strong rebound of catches of Japanese anchovy, Japanese jack mackerel and Japanese flying squid occurred (Figures B10.3 and B10.5, Table D12). There seems to be a strong pattern of high alternating catches of sardine and anchovy stocks in many regions throughout the world (Lluch-Belda *et al*., 1989; Bakun, 1998; Schwartzlose *et al*., 1999; Barange *et al*., 2009). In addition, Japanese anchovy has also become the largest catch in both the Yellow Sea and the East China Sea. This seems to have occurred after removal of demersal and pelagic predatory fishes by heavy fishing (Tang and Jin, 1999). However, the anchovy fishery in the Bohai Sea nearly collapsed in 2001 (Jin, 2004). In recent years, the stocks of Japanese flying squid have maintained a moderate to high biomasses and are not considered to be fully exploited (Fisheries Agency and Fisheries Research Agency of Japan, 2010).

The recent rebound in the Alaska pollock catch is associated with an increase in catches of the Russian Federation from the western Bering Sea (Navarin region) since 2003 and the Sea of Okhotsk since 2007. Pollock biomass doubled in the Sea of Okhotsk in the 2000s compared with the 1990s (McKinnell and Dagg, 2010). Other major pollock stocks are believed to be currently at substantially lower biomasses than in the 1980s (McKinnell and Dagg, 2010). The pollock fishery in the international waters of the "Doughnut Hole" in the Bering Sea produced very high catches in the late 1980s and early 1990s. However, it was suspended in 1993 owing to overfishing and has still not recovered (McKelvey, Honkalehto and Williamson, 2006).

Yellow croaker has recovered since the early 1990s. Fishing pressure on this species increased substantially between the 1950s and the 1980s. As a consequence, the size of fish and proportion of older fish in the stock have continually declined (Jin, 2008). Therefore, the recovery is more likely to have been the result of favourable oceanographic conditions than changes in fishing practices. The increase in chum salmon catch in the past three decades is considered to be due to improved marine survival and/or hatchery rearing and releasing practices (Yatsu and Kaeriyama, 2005; McKinnell and Dagg, 2010). Although the catch of largehead hairtail has increased since the late 1980s, mean body size declined continuously from the 1960s to the 1990s. Overfishing is still a problem in the East China Sea despite the introduction of a "summer fishing moratorium" in 1995 (Xu, Liu and Zhou, 2003).

The northern South China Sea supports a tropical multispecies fishery. The majority of high-trophic level demersal stocks appear to be depleted and most low-trophic fishes are considered overfished (Qiu, Lin and Wang, 2010). The fishery remained open access until the late 1990s. This led to a continuous increase in fishing effort, which was especially rapid from the 1970s to 1990s. As a result of the increasing fishing effort and expansion of fishing into offshore waters, catch trends of the fishery became dome-shaped, with a long-term decline. This pattern in catch was seen first in the inshore fisheries and then in the offshore demersal catches. Total catch and catches of the low-trophic species rose until the 1990s, but eventually declined under high fishing pressure. Although fishing effort has levelled off since the late 1990s because of strict licensing controls, total stock density has remained at a low level. It is expected that further reductions in fishing effort will be needed in order to recover the stocks and subsequently raise the total catch.

Environmental problems affecting fisheries in the Northwest Pacific include land reclamation, heavy metals and chemical pollution, oil spills, eutrophication, hypoxia, invasion and escape of non-native species, and impacts of extensive mariculture (She, 1999; Jin, 2004; Maguire, 2005; McKinnell and Dagg, 2010). There appears to be an increasing frequency of red tides and outbreaks of harmful algae, macroalgae and giant jellyfish (*Nemopilema nomurai*) (She, 1999; Jamieson and Zhang, 2005; Liu *et al*., 2009; McKinnell and Dagg, 2010). In the Yellow Sea, bacterial epidemics are causing mortality of cultured shrimp (Maguire, 2005) and there is a risk that these could spread to adjacent open waters. The Sea of Okhotsk is the site of frequent earthquakes and the oil drilling that is poised to begin there is a cause for concern because of the high risk of oil spills (Maguire, 2005).

It is currently recognized that many fisheries are being affected by fishing and climatic and human-induced ecosystem changes such as global warming (Kim, 2010). To cope with the changes in productivity of regional ecosystems, control over fleet capacity and development of operational management procedures may be critical to the long-term sustainability of fisheries in the region (Barange *et al*., 2009). Establishment of a new convention on the management of international fisheries in northeast Asia has been recommended (Kim, 2010). This will add to the existing arrangements on high seas fisheries of the North Pacific Ocean (see above). Implementation of an ecosystem approach to fisheries or ecosystem-based management has recently started in this region, focusing on: (i) minimizing fishing and other human-induced impacts; (ii) rebuilding depleted fisheries stocks; and (iii) adapting to climate changes and natural disasters. In particular, widespread impacts in the marine environment of land runoff from both industrial and urban developments will be addressed (Jamieson and Zhang, 2005).

ACKNOWLEDGEMENTS

The authors would like to thank Chang Ik Zhang from the Institute of Fisheries Science, Pukyong National University, Korea and Yongsong Qiu from the South China Sea Fisheries Research Institute, China for their valuable comments and inputs.

REFERENCES

Bakun, A. 1998. Ocean triads and radical interdecadal stock variability: bane and boon for fishery management science. *In* T.J. Pitcher, P.J.B. Hart & D. Pauly, eds. *Reinventing fisheries management*, pp. 331–358. London, Chapman and Hall.

Barange, M., Bernal, M., Cercole, M.C., Cubillos, L., De Moor, C.L., Daskalov, G.M., de Oliveira, J.A.A., Dickey-Collas, M., Hill, K., Jacobson, L., Køster, F.W., Masse, J., Nishida, H., Ñiquen, M., Oozeki, Y., Palomera, I., Saccardo, S.A., Santojanni, A., Serra, R., Somarakis, S., Stratoudakis, Y., van der Lingen, C.D., Uriarte, A. & Yatsu, A. 2009. Current trends in the assessment and management of small pelagic fish stocks. *In* D. Checkley, C. Roy, Y. Oozeki & J. Alheit, eds. *Climate change and small pelagic fish stocks*, pp. 191–255. Cambridge University Press.

Chen, Y.Q. & Shen, X.Q. 1999. Changes in the biomass of the East China Sea ecosystem. *In* K. Sherman & Q. Tang, eds. *Large Marine ecosystems of the pacific rim: assessment, sustainability and management*, pp. 221–239. Malden, USA, Blackwell Science Inc.

FAO. 2009. China country profile. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. [Cited 20 December 2011]. www.fao.org/fishery/countrysector/FI-CP_CN/en

Fisheries Agency & Fisheries Research Agency of Japan. 2010. *Marine fisheries stock assessment and evaluation for Japanese waters (fiscal year 2009/2010)*. 1723 pp. (in Japanese). [Cited 20 December 2011] http://abchan.job.affrc.go.jp/index1.html

Jamieson, G. & Zhang, C.-I., eds. 2005. *Report of the study group on ecosystem-based management science and its application to the North Pacific*. PICES Sci. Rep. 29. pp. 1–77.

Jamieson, G., Livingston, P. & Zhang, C.-I., eds. 2010. *Report of Working Group 19 on ecosystem-based management science and its application to the North Pacific*. PICES Sci. Rep. 37. pp. 1–166.

Jiang, H., Chen H., Quesne, W.J.F., Xu, I, Wu, J., Ding, H. & Arreguin-Sanchez, F. 2008. Ecosystem model predictions of fishery and conservation trade-offs resulting from marine protected areas in the East China. *Environmental Conservation*, 35: 137–146.

Jin, X. 2004. Long-term changes in fish community structure in the Bohai Sea, China. *Estuarine Coastal and Shelf Science*, 59: 163–171.

Jin, X. 2008. People's Republic of China. *In* R.J. Beamish, ed. *Impacts of climate change on the key species in the fisheries in the North Pacific*, pp. 85–99. PICES Sci. Rep. 35.

Kang, J.-S. 2003. The United Nation convention on the law of the sea and fishery relations between Korea, Japan and China. *Marine Policy*, 27: 111–124.

Kawasaki, T. 1983. Why do some pelagic fishes have wide fluctuations in their numbers? -biological basis of fluctuation from the viewpoint of evolutionary ecology. *In* G.D. Sharp & J. Csirke, eds. *Proceedings of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources*, pp. 1065–1080. FAO Fisheries Report No. 291 Vol. 3. Rome, FAO.

Kim, S. 2010. Fisheries development in northeastern Asia in conjunction with changes in climate and social systems. *Marine Policy*, 34: 803–809.

Liu, D., Keesing, J.K., Xing, Q. & Shi, P. 2009. World's largest macroalgal bloom caused by expansion of seaweed aquaculture in China. *Marine Pollution Bulletin*, 58: 888–895.

Lluch-Belda, D., Crawford, R.J.M., Kawasaki, T., MacCall, A.D., Parrish, R.H., Schwartzlose, R.A. & Smith, P.E. 1989. World-wide fluctuations of sardine and anchovy stocks: the regime problem. *South African Journal of Marine Science*, 8: 195–205.

Maguire, J.J. 2005. FAO Statistical Area 61. *In* FAO Fisheries Department, ed. *Review of the state of world marine fishery resources*, pp. 99–103. FAO Fisheries Technical Paper No. 457. 235 pp.

McKelvey, D., Honkalehto, T. & Williamson, N. 2006. *Results of the March 2006 echo integration-trawl survey of walleye pollock (*Theragra chalcogramma*) conducted in the southeastern Aleutian Basin near Bogoslof Island, cruise MF2006-03*. AFSC Processed Report, 2006-14. AFSC, NMFS, NOAA. 36 pp.

McKinnell, S.M. & Dagg, M., eds. 2010. *Marine ecosystems of the North Pacific Ocean, 2003-2008*. PICES Special Publication 4. 393 pp.

Naumenko, N.I. 2001. *Historical trends of herring in Russian waters of the North Pacific*. PICES Sci. Rep. 17. pp. 93–95.

Ohshimo, S., Tanaka, H. & Hiyama, Y. 2009. Long-term stock assessment and growth changes of the Japanese sardine (*Sardinops melanostictus*) in the Sea of Japan and East China Sea from 1953 to 2006. *Fisheries Oceanography*, 18: 346–358.

Qiu, Y., Lin, Z. & Wang, Y. 2010. Responses of fish production to fishing and climate variability in the northern South China Sea. *Progress in Oceanography*, 85: 197–212.

Schwartzlose, R.A., Alheit, J., Bakun, A., Baumgartner, T., Cloete, R., Crawford, R.J.M., Fletcher, W.J., Green-ruiz, Y., Hagen, E., Kawasaki, T., Lluch-Belda, D., Lluch-Cota, S.E., MacCall, A.D., Matsuura, Y., Nevarez-Martinez, M.O., Parrish, R.H., Roy, C., Serra, R., Shust, K.V., Ward, N.M. & Zuzunaga, J.Z. 1999. World-wide large-scale fluctuations of sardine and anchovy populations. *South African Journal of Marine Science*, 21: 289–347.

She, J. 1999. Pollution in the Yellow Sea large marine ecosystem. *In* K. Sherman & Q. Tang, eds. *Large marine ecosystems of the Pacific rim: assessment, sustainability and management*, pp. 419–426. Malden, USA, Blackwell Science Inc.

Tang, Q. & Jin, X. 1999. Ecology and variability of economically important pelagic fishes in the Yellow Sea and Bohai Sea. *In* K. Sherman & Q. Tang, eds. *Large marine ecosystems of the Pacific rim: assessment, sustainability and management*, pp. 179–198. Malden, USA, Blackwell Science Inc.

Xu, H.-X., Liu, Z.-F. & Zhou, Y.-D. 2003. Study on the variation of hairtail (*Trichiurus haumela*) productivity and recruitment in the East China Sea. *Journal of Fisheries of China*, 27: 322–327. (in Chinese with English abstract).

Yatsu, A. & Kaeriyama, M. 2005. Linkages between coastal and open-ocean habitats and dynamics of Japanese stocks of chum salmon and Japanese sardine. *Deep-Sea Research*, II 52: 727–737.

Yatsu, A., Watanabe, T., Ishida, M., Sugisaki, H. & Jacobson, L.D. 2005. Environmental effects on recruitment and productivity of the Japanese sardine, *Sardinops melanostictus*, and chub mackerel, *Scomber japonicus*, with recommendations for management. *Fisheries Oceanography*, 14: 263–278.

Yu, Y. & Mu, Y. 2005. The new institutional arrangements for fisheries management in Beibu Gulf. *Marine Policy*, 30: 249–260.

Yu, H. & Yu, F. 2008. Fishing capacity management in China: theoretic and practical perspectives. *Marine Policy*, 32: 351–359.

Zhang, C.I. & Kim, S. 1999. Living marine resources of the Yellow Sea ecosystem in Korean waters: status and perspectives. *In* K. Sherman & Q. Tang, eds. *Large marine ecosystems of the Pacific rim: assessment, sustainability and management*, pp. 163–178. Malden, USA, Blackwell Science Inc.

Zhang, C.I., Kim, J.M. & Huh, H.T. 1988. Current status of fisheries resources and their rational management in the Yellow and East China Seas. *In* Y.B. Go, ed. *Proceedings of Symposium on Development of Marine Resources and International Cooperation in the Yellow Sea and East China Sea, Cheju, Korea, 19–22 October 1988*, pp. 71–96.

Zhang, C.I., Kim, S. & Yun, S.B. 1992. Stock assessment and management implications of small yellow croaker in Korean waters. *Bulletin of the Korean Fisheries Society*, 25: 280–290.

Zhang, C.I., Kim, S., Gunderson, D., Marasco, R., Lee, J.B., Park, H.W. & Lee, J.H. 2009. An ecosystem-based fisheries assessment approach for Korean fisheries. *Fisheries Research*, 100: 26–41.

B11. Northeast Pacific

FAO STATISTICAL AREA 67

Vidar G. Wespestad
FAO consultant
the United States of America
E-mail: vidarw@frontier.com

Jean-Jacques Maguire
FAO Consultant
Canada
E-mail: jjmaguire@sympatico.ca

INTRODUCTION

The Northeast Pacific (Figure B11.1) covers almost 8 million km^2, of which 1.3 million km^2 are shelf area. It encompasses several distinct "large marine ecosystems" including the California Current, the Gulf of Alaska, and Bering Sea. The dynamics of these systems are dominated by the Aleutian Low pressure cell – one of the most intense, quasi-permanent atmospheric systems on earth. In the Gulf of Alaska, the result is a strong coastal convergence that drives anticyclonic coastal flow around the periphery of the Gulf of Alaska. This interacts with coastal runoff to produce embedded frontal zones of concentrated biological processes. The eastern Bering Sea is a shallow shelf system, characterized by wind and tidal mixing with shelf-sea frontal currents. Each of the three domains, California Coast Current, Gulf of Alaska Gyre and eastern Bering Sea, contains abundant fishery resources that support catches of a wide variety of species.

In the past decade, the fisheries in the region have undergone a series of regulatory and market-driven reforms to reduce fishing effort to sustainable levels. "Boom and

FIGURE B11.1
The Northeast Pacific (Area 67)

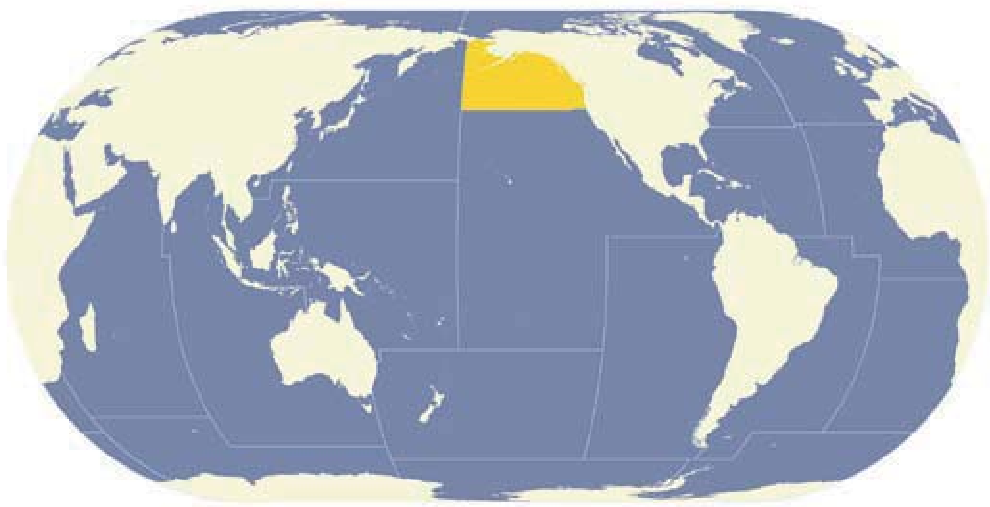


FIGURE B11.2
Annual nominal catches by ISSCAAP Group in the Northeast Pacific (Area 67)

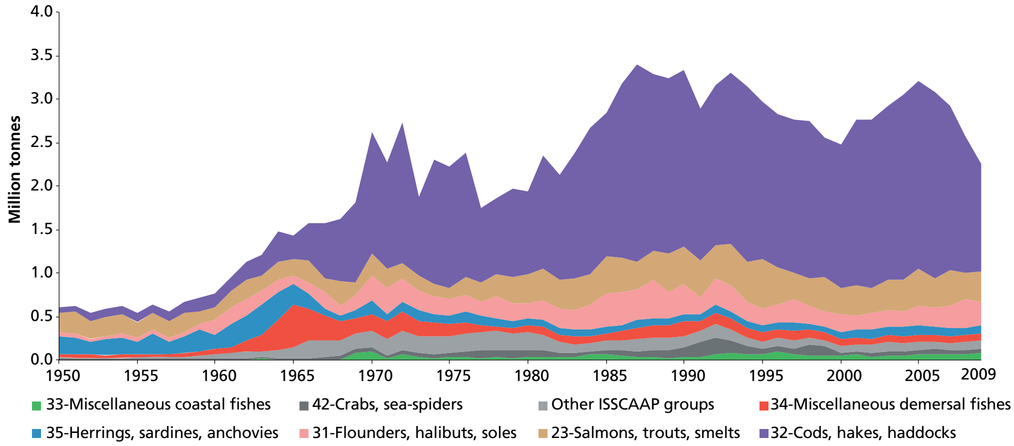


FIGURE B11.3
Annual nominal catches of selected species in ISSCAAP Group 32, Northeast Pacific (Area 67)

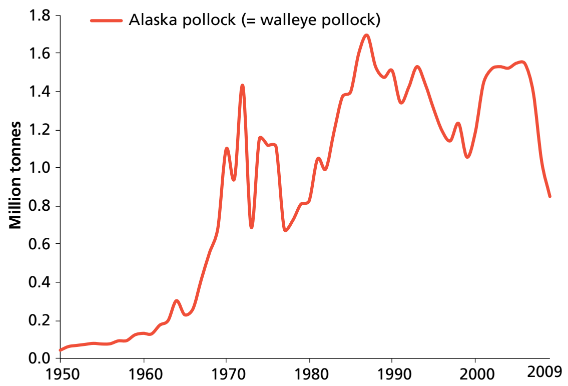
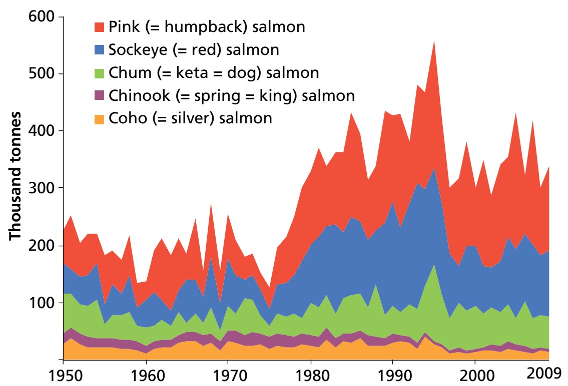


FIGURE B11.4
Annual nominal catches of selected species in ISSCAAP Group 23, Northeast Pacific (Area 67)



bust" fisheries have been stabilized to ensure catches are sustainable from available resources. Fishers have been able to improve fishing and marketing to achieve stable, profitable fisheries. Accompanying these actions have been management practices designed to improve monitoring and maintain catches within biological guidelines. The net result has been a generally stable catch in most fisheries. The greatest variability has been in the cods, primarily Alaska pollock. Variability and uncertainty in environmental conditions will continue to produce unexpected abundance changes over relatively short periods.

PROFILE OF CATCHES

Total nominal catches for the Northeast Pacific (Area 67) increased from about 600 000 tonnes in 1950 to slightly more than 3.3 million tonnes in 1992. Since that time, the aggregate catch has varied between 2.3 million and 3.3 million tonnes, with a reduction in the most recent years as a result of poor pollock recruitment. In 2009, total catch reached nearly 2.5 million tonnes (Figure B11.2 and Table D13). Alaska (walleye) pollock (*Theragra chalcogramma*) has contributed the largest part of the catches since the early 1970s. It has been between 40 and 50 percent of the total catch for most of that period (Figure B11.2). Catches of Alaska pollock declined from 2.2 million tonnes in 1996 to between 800 000 and 900 000 tonnes in 2009–2010 (Figure B11.3). The cause of the sharp decline in Alaska pollock is primarily linked to three very warm years in the eastern Bering Sea that led to extremely poor year classes (Ianelli *et al*., 2010). Recruitment in subsequent years has improved and catches are expected to rise in 2011 to almost 1.4 million tonnes.

Traditionally, ISSCAAP Group 23 (salmons, trouts, smelts) has accounted for the second-largest contribution. However, in the past two decades, the harvest of flatfish has grown to equal and exceed the catch of salmon in some years. The average annual catch of salmon from 1978 to 2010 was 396 000 tonnes, or 14 percent of the Northeast Pacific fisheries landings. In the same period, the flatfish catch grew to 516 000 tonnes, or 18 percent of the total catch. Salmon catches in Area 67 showed an increasing trend from the mid-1970s to the mid-1990s (Figure B11.4). This was mainly as a result of stock improving in the north of the region. Since that time, catches have decreased and have been fluctuating between 300 000 and 400 000 tonnes. The strong increase observed though the 1980s to early 1990s reflected a period of good environmental conditions and cessation of the high seas salmon fisheries. The catch comprises five species and, in recent years, it appears that some species are producing record catches (sockeye and pink salmon). At the same time, other species have been less productive: west coast coho (*Oncorhynchus kisutch*) and chinook (*Oncorhynchus tshawytscha*) salmon stocks in California and in Western Alaska.

FIGURE B11.5
Annual nominal catches of selected species in ISSCAAP Groups 32, 33 and 34, Northeast Pacific (Area 67)

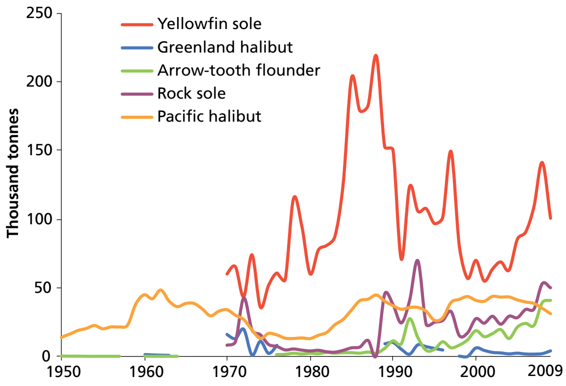
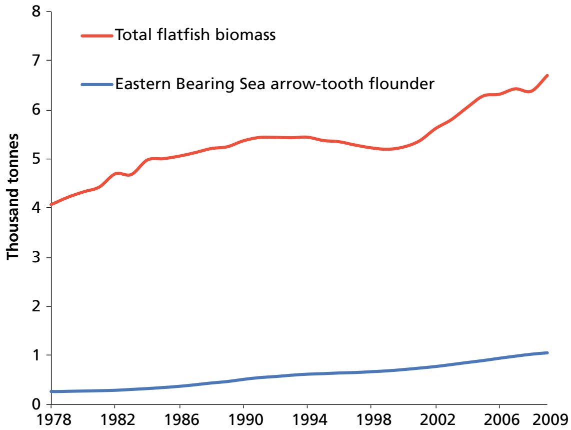


FIGURE B11.6
Biomass estimates for selected species in ISSCAAP Group 31, Northeast Pacific (Area 67)



For Area 67, the flatfish catch is dominated by landings from the eastern Bering Sea. Here, the yellowfin sole (*Limanda aspera*) fishery is the largest flatfish fishery in the world (Wilderbuer, Nichol and Ianelli, 2010) (Figure B11.5). This species is followed by northern rock sole (*Lepidopsetta polyxystra*), flathead sole (*Hippoglossoides elassodon*) and other eastern Bering Sea flatfish. The flatfish resource in the Bering Sea grew rapidly following the end of large removals by distant-water fleets. As the resource grew, the catch in Area 67 peaked at just over 700 000 tonnes in 1979. Since then, the catch has declined primarily as a result of to regulatory action to reduce the bycatch of halibut, crab and salmon species that are caught in other fisheries in Alaska, British Columbia (Canada), and along the United States west coast. Pacific halibut (*Hippoglossus stenolepis*) is a valuable species and the focus of many trawl fishery regulations. The catch nearly doubled from the late 1970s to a peak of about 40 000 tonnes in the mid-1980s. It then declined somewhat before increasing again in the late 1990s. The catch then declined again owing to apparent changes in growth. The International Halibut Commission (Hare, 2010) attributes some of the decline to increased biomass of a competitor, arrow-tooth flounder (*Atheresthes stomias*) (Figure B11.6). In the Gulf of Alaska, arrow-tooth flounder has become the most abundant demersal species (NMFS, 2010).

Catches of ISSCAAP Groups 32 (cods, hakes, haddocks), 33 (miscellaneous coastal fishes) and 34 (miscellaneous demersal fishes) species have been increasing, and catches have been regulated to comply with specific regulations. The most variable of these

FIGURE B11.7
Annual nominal catches of selected species in ISSCAAP Groups 32, 33 and 34, Northeast Pacific (Area 67)

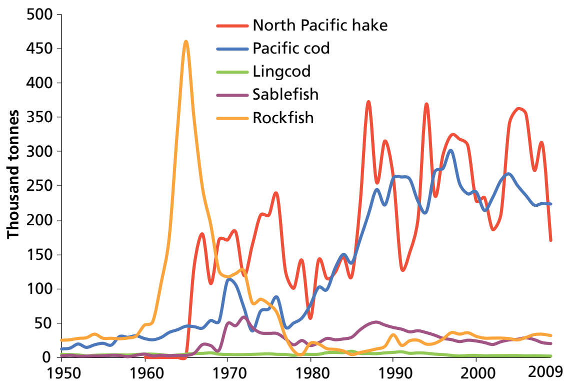
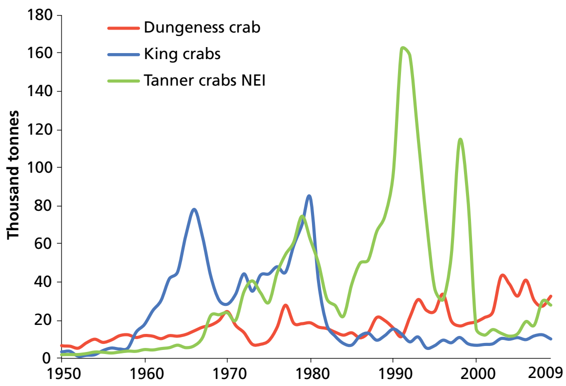


FIGURE B11.8
Annual nominal catches of selected species in ISSCAAP Groups 42 and 44, Northeast Pacific (Area 67)



stocks is Pacific hake (*Merluccius productus*), also commonly called Pacific whiting, which exhibits highly variable recruitment. It underwent a climate-driven decline in the 1990s followed by a recovery starting with a strong 1998 year class. Similarly, the largest stock in the group, Bering Sea pollock, declined strongly following extremely low recruitment in 2001–03 (Ianelli *et al.*, 2010). As these poor year classes became of fishable and reproductive age, catch limits were reduced dramatically in 2008–10. Currently, above-average recruitment has been estimated from the 2006 and 2008 year classes and the stock has recovered above B_{msy} levels. The biomass of eastern Bering Sea Pacific cod (*Gadus macrocephalus*) increased from the late 1970s to the mid-1980s. It declined to about half of the peak by the mid-1990s since when it has been estimated to be stable with moderate fluctuations. Generally, cod catch trends mirror pollock, and the catch has ranged between 200 000 and 300 000 tonnes since 1990 (Figure B11.7).

Catches of the valuable sablefish (*Anoplopoma fimbria*), commonly called blackcod, have slowly declined from a peak in the late 1970s (Figure B11.7). Lingcod (*Ophiodon elongatus*) has shown a similar decline and subsequent low stable catch in recent years. In the Pacific Fisheries Management Council management area (Washington–Oregon–California), lingcod was declared overfished for a number of years until it was recently declared recovered. Lingcod is a valuable recreational fish, and catch limits are in place to maintain availability to the recreational sector.

Rockfish (*Sebastes* spp.) as a group comprises many species. They are found from the Bering Sea south into Mexico. The most abundant rockfish, Pacific Ocean perch (*Sebastes alutus*), supported an important foreign fishery in the 1960s. However, since 1980, catches have been a small fraction of those reported earlier (Figure B11.7, Table D13). Rockfish are a long-lived, relatively slow-growing group of species and, hence, many stocks became overfished. While many stocks are recovering, some remain classified as overfished and require further rebuilding. Therefore, total S*ebastes* catch is anticipated to remain about 50 000 tonnes for the next few years.

King crab (*Paralithodes kamchaticus*) catches dominated ISSCAAP Group 44 (king crabs, squat-lobsters) species from the early 1960s to the late 1970s. It then declined owing to a combination of reduced recruitment and high levels of fishing effort. Since the early 1980s, king crab abundance has been low and stable, and the catch has averaged about 10 000–11 000 tonnes (Figure B11.8, Table D13). Snow crab (principally *Chionocetes opilio* but also *C. bairdi*) in ISSCAAP Group 42 (crabs, sea-spiders) catches were about equal in catch to king crab in the late 1980s. Catch increased rapidly through the 1980s, but then declined before increasing again as a result of strong recruitment in the 1990s that was not sustained. Consequently, catches declined and continue to be low. Wide fluctuations are common for other sea-spiders and crabs (mostly snow crab). The 2004 harvest was the lowest at just over 11 000 tonnes and catches since have climbed to 20 000–30 000 tonnes.

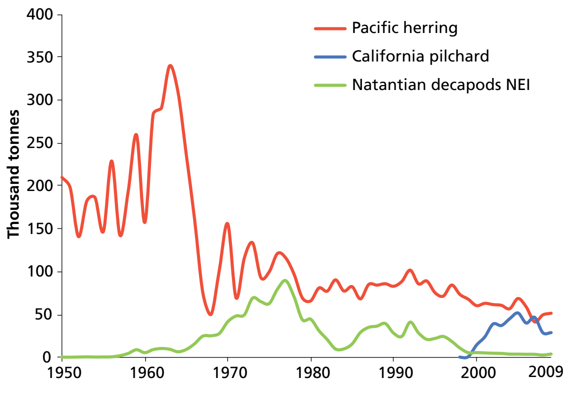
The other major commercial species in Group 42 is Dungeness crab (*Cancer magister*), which is primarily harvested from California to southeast Alaska. It has had an increasing catch trend since the late 1980s. The largest catches were between 2003 and 2006, when the catch exceeded 40 000 tonnes –almost double that at the beginning of the period. However, since then, the catch has declined and is currently small. Historically, Dungeness crab has a cyclic abundance and may be currently trending towards a period of reduced abundance and catch.

Squid, shrimp, and other invertebrates are also caught in the Northeast Pacific. Pink shrimp (*Pandalus jordani*) are caught primarily off the west coast of the United States of America, while *Pandalus borealis* is the most abundant species of shrimp in Alaska. Large pink shrimp catches were made in Alaska until the early 1980s. Catches then declined rapidly, believed to be a result of increased predation by rapidly increasing cod and pollock stocks (Anderson and Piatt, 1999). Catches increased in the 1990s and have remained relatively stable and below 30 000 tonnes since the 1990s (Table D13). Other shrimp species as well as sea urchins, sea cucumbers, clams and oysters are part of the invertebrate catch but the total catches of all of these species are in the range of thousands of tonnes. Squid, primarily *Loligo opalescens*, is a significant portion of the invertebrate catch. The largest catch occurs in central and southern California, and the total catch has been as high as 119 000 tonnes in 2000 and almost 95 000 tonnes in 2010. A sharp drop in catch occurred in 1998. This was attributed to a strong El Niño event (Zeidberg, Hamner and Nezlin, 2006). Since the early 1980s, another squid that has appeared in large numbers is the jumbo squid (*Dosidicus gigas*). It has been found to have a significant predatory impact on pelagic fishes (Field *et al*., 2007).

Compared with other FAO Statistical Areas, ISSCAAP Group 35 (herrings, sardines, anchovies) does not make a large contribution to catches in Area 67. Herring are found throughout the region, but the greatest concentrations are in British Columbia and Alaska. Catches of Pacific herring (*Clupea pallasi*) increased as stocks increased from a period of heavy fishing pressure in the 1950s and 1960s. Catches increased throughout the 1980s and then rose to a peak of 102 000 tonnes in 1992 (Figure D11.9, Table D13). Catches then trended downward until 2008 when they began to increase again. The 2010 catch of Pacific herring was almost 60 000 tonnes.

The sardine (*Sardinops caeruleus*) catch has been increasing in the Northeast Pacific. The California sardine fishery in Area 67 had essentially collapsed before FAO statistics began to be collected. Sardine catches increased from almost zero between 1950 and 1998, when the catch of sardine began to increase and then rose rapidly (Figure B11.9). Since 1999, the catch has continually increased up to a peak of 51 000 tonnes in 2005. Since then, the catch has declined slightly. Along with the increase in catch, the stock has expanded from southern California and has made a summer migration that reaches the north end of Vancouver Island. At present, it is unclear if the sardine abundance has peaked. The future pattern in California sardine distribution and abundance is unclear. In coming years, the stock may continue to expand its range and remain at high abundance, or contract its distribution and overall abundance.

FIGURE B11.9
Annual nominal catches of selected species in ISSCAAP Group 35, Northeast Pacific (Area 67)



RESOURCE STATUS AND FISHERY MANAGEMENT

Salmon resources

The salmon population increases in Alaska in most of the 1980s and 1990s were attributed to favourable ocean conditions allowing high survival of juveniles (Eggers *et al*., 2005). Several other factors contributed to the increases, including: (i) improved management; (ii) elimination of high seas driftnet fisheries; (iii) reduction in bycatch in fisheries for other species; and (iv) relatively pristine river habitats with minimal influence of extensive development.

Salmon stocks currently face increasing environmental problems. Many of the stocks, particularly those in the south of the region, are already severely affected. Being anadromous, salmon reproduction is strongly affected by riverine and estuarine habitat degradation caused by agriculture, logging, mining, oil and gas development, industrial development and urban expansion. The resulting conflicts with other economic sectors make mitigation difficult. There is also concern that the use of hatchery production to help compensate for habitat loss may lead to the destruction of wild stocks (Hilborn and Eggers, 2000). Damming of rivers for hydroelectric power development, water storage, and flood control have historically done great damage to salmon runs. However, under the United States Endangered Species Act and provisions of the United States Magnuson Stevens Fishery Conservation and Management Act, developments are required not to destroy essential fish habitat. As a consequence, there has been some movement towards mitigating prior habitat loss. Active projects are in place to remove dams that have blocked salmon passage on some rivers (Stadler *et al*., 2011).

The production of Pacific salmon (*Oncorhynchus* spp.) is variable and differs among species. Pink salmon (*Oncorhynchus gorbuscha*), the most abundant and smallest species, has biennial runs with one year weak and the other strong. However, when their abundance is averaged over the region, there has been an increasing trend since the 1970s. In the past decade, catch has exceeded the long-term average. The catch of sockeye salmon (*O. nerka*), the second-most abundant species, consists of the catch from several large river systems. The largest of these is the Bristol Bay River system in the southeast Bering Sea and the Fraser River system in British Columbia. The catch of sockeye increased in the 1980s following good in-river survival in the late 1970s and the end of the high seas interception fisheries. Overall catch then declined in the 1990s, but in recent years has increased and is near the long-term average of 127 000 tonnes. The dynamics of sockeye salmon are demonstrated by recent events in the Fraser Columbia River fisheries. This fishery experienced a record abundance in 2010 with catch in excess of 10 million fish, up from only 1 119 in 2008 (DFO, 2001–2011). Chum salmon (*O. keta*) is the third-most abundant species. Catches increased through the 1980s to a peak of 103 000 tonnes in 2000. Since then, chum catches have declined to near the long-term average of 70 000 tonnes. The bycatch of chum salmon in Bering Sea demersal trawl fisheries is currently a management issue. Chum salmon is an important species in many western Alaska rivers and the presence of sea-ranched Asian chum that feed in the eastern Bering Sea complicates management (NPFMC, 2011).

Long-term trends in the salmon catch in the Northeast Pacific appear to be favouring offshore species such as sockeye and pink salmon. These species have generally increased in the period of extended jurisdiction to 200 miles. However, the species that spend most of their ocean life near shore, such as chinook salmon (*O. tschawytscha*) and coho salmon (*O. kisutch*) have experienced a long-term downward trend in the same period. Some of this change may be the result of climate-induced changes in the forage base. In 1998–99, a shift from a warm to a cooler state in the region was observed to have induced a shift in the plankton community. This may account for some of observed trends in salmon survival (Peterson and Schwing, 2003).

Demersal resources

Many of the most important demersal fish stocks of the Northeast Pacific followed the same pattern of rapid increase that marked the large salmon stocks of the sub-Arctic Pacific region (Bakun, 1999). Accordingly, the largest demersal fish population of them all was the complex of Alaska pollock stocks. These stocks were distributed over the breadth of the sub-Arctic Pacific, both the Northeast Pacific (Area 67) and the Northwest Pacific (Area 61). In much of the 1980s, Alaska pollock held the distinction of being the largest exploited demersal fish population in the world. The resource declined sharply as a result of reduced recruitment in the early 1980s. This appeared to be a result of anomalous ocean conditions, but the resource has now recovered and catch is projected to be about 1.4 million tonnes.

The eastern Bering Sea pollock fishery is a limited-entry fishery with quota shares allotted to participating vessels. Almost all fisheries in the region are managed by a similar quota system. One advantage is that catch is accurately monitored to ensure catches are limited to share amounts. This ensures that total catch does not exceed harvest limits. Fisheries on Alaska pollock are managed to ensure catch does not exceed that derived from a risk-averse F_{MSY}. Pollock and other demersal species in Alaska are constrained to fall within total annual harvest limits, and aggregate catch cannot exceed the upper limit. In the eastern Bering Sea, this limit is set at 2 million tonnes (NPFMC, 2011).

The other large gadoid populations in Area 67 are Pacific cod and Pacific hake (or "Pacific whiting"). These species have followed a similar pattern of a rising catch from the mid-1970s to mid-1980s with moderate fluctuations at intermediate levels since 1995. Pacific cod are fully exploited in both the Bering Sea and the Gulf of Alaska. Pacific hake is considered to be fully exploited. While the largest stock of Pacific cod is in the Bering Sea, Pacific hake is concentrated in the region off the west coasts of Canada and the United States of America.

Of the important flatfish populations, the valuable Pacific halibut resource showed a rising trend through the 1980s. A slight decline occurred in the 1990s, followed by an upswing in catch with improved recruitment in the late 1990s to a peak of 41 000 tonnes in 2004. Since then, there has been a downward trend owing to reduced growth and recruitment, but stocks are expected to increase in future years. (Hare, 2010; Figure B11.5)

The stocks of other flatfish species are lightly exploited. The total Alaska flatfish population is estimated to be almost 7 million tonnes in 2010 (Table D13). Yellowfin sole is a significant species in the catch and the major species in the Bering Sea flatfish fishery. The exploitation rate is low on nearly all species of flatfish, with the exception of petrale sole off Washington–Oregon–California, which is currently assessed as overfished. However, that assessment is being re-evaluated as catches have remained stable for several decades. The primary reason for the low exploitation of flatfish is the bottom trawl restrictions in place to minimize the bycatch of halibut and crab species. Greenland halibut (*Reinhardtius hippoglossoides*) has long been classified as below target abundance as a result of a failure to observe significant recruitment in trawl surveys since the late 1970s. It has now been found to be increasing in newly developed surveys of the outer continental shelf slope.

The current large populations of flatfish have shown indications of density-dependent growth in some species. Bering Sea northern rock sole underwent a ninefold increase in stock size from 1975 to 2010 (200 000 tonnes to 1.8 million tonnes). Length-at-age has declined significantly as the population has increased and expanded west towards the shelf edge. This density-dependent downward trend in size-at-age primarily affected year classes between 1979 and 1987. It also has been observed in the strong 2001–03 year classes in recent surveys. The exploitation rate remained low from 1979 to 2009, averaging only 3.4 percent as the fish are primarily caught in a limited roe fishery and as bycatch in the large yellowfin sole fishery (Matta, Black and Wilderbuer, 2010). Some scientists are postulating that similar density-dependent growth reduction is occurring in Pacific halibut.

Demersal stocks in Alaska are all at or below full exploitation with no current overfishing occurring. In Canada, there are no overfished species either. Reference points are not fully developed for all monitored species, but fisheries are fully developed. All catch is allocated to stakeholders via an individual quota system that is designed to account for all catch. The current TACs are de-facto estimates of MSY that are adjusted periodically for changing stock condition (DFO, 2010).

In the Groundfish Fishery Management Plan of the Pacific Fishery Management Council, there are more than 80 demersal fish species (groundfish). These species include more than 60 species of rockfish in the family Scorpaenidae, 7 roundfish species, 12 flatfish species, dogfish shark, skate, and a few miscellaneous bottom-dwelling marine fish species. Based on the standards of the Groundfish Fishery Management Plan for defining overfished demersal fish species, eight species are currently assessed as overfished by the NMFS in the area of the Pacific Fishery Management Council. These species are: bocaccio rockfish (*Sebastes paucispinis*), canary rockfish (*S. pinniger*), cowcod (*S. levis*), darkblotched rockfish (*S. crameri*), Pacific Ocean perch (*S. alutus*), widow rockfish (*S. entomelas*) and yelloweye rockfish (*S. ruberrimus*). Since the previous review of resources in FAO Statistical Area 67, two species have been removed from the overfished category. These species are Pacific hake (*Merluccius productus*) and lingcod (*Ophiodon elongatus*), as well as an additional species, petrale sole (FAO, 2005). Some of the rockfish (*Sebastes* spp.) such as widow rockfish are close to being declared rebuilt. However, other species that are very long-lived and have low growth and reproduction may require many years to rebuild.

Sablefish (*Anoplopoma fimbria*) is distributed throughout Area 67 and is a fully exploited species that has been allocated to many stakeholders. Sablefish were exploited heavily by distant-water fisheries and had been reduced to a low biomass by the late 1970s. In the late 1970s, sablefish had a very strong year class, similar to many other fish species (Hollowed, Bailey and Wooster, 1987). This year class bolstered the fishery and supported the development and growth of a North American fishery. Since the late 1970s, there have been a few above-average recruitment events, but generally not large enough to sustain a stable population. Catch has been trending downward from high biomasses in the 1980s. In the 1990s, several demersal fish species experienced reduced year-class success (McFarlane, King and Beamish, 2000). Year-class success has improved since 1999 for many species and it is clear that ocean conditions are an important factor in determining abundance and trends. At present (2011), the North Pacific appears to have moved back into a cool state following a prolonged warm period (1977–1998). Moreover, the fisheries themselves have been totally restructured from those that existed at the start of the establishment of extended national jurisdiction in 1977. At that time, demersal fisheries were largely undertaken by distant-water fleets. The Canadian and United States fisheries for salmon, crab, herring and halibut were open access and largely unregulated. Today the distant-water fleets have been replaced with domestic fleets. These fleets have been reduced in size and primarily operate under individual catch allocations in one form or another. This has also occurred in some of the salmon, halibut, herring, crab and other fisheries. The current management regime prevents overfishing and allows fishers the control to optimize fishing effort and improve yield. One example is in the west coast whiting fishery, in which the establishment of an at-sea cooperative fishing strategy allowed participating vessels to divide the available quota. The industry then reduced the number of vessels in the fishery, reduced bycatch by more efficient targeting and increased yields by 16 percent to upwards of 30 percent. These increases in yield were also a result of less capture damage and the ability to develop products with higher flesh recovery that could not be produced when the vessels were competing to take the maximum catch per vessel (Bodal, 2003).

Small pelagics

Pacific herring *(Clupea pallasii*) supports an extremely valuable fishery, much of it for high-valued roe destined for the Japanese market. Since the mid-1970s, herring have been fluctuating at low to moderate abundances. The abundance trends vary among the numerous stocks in the region, but, overall, the very recent trend is for fairly healthy abundance (Woodby *et al*., 2005). Similarly, herring catches have been stable at moderate levels since the 1970s. The catch is much reduced from the very high catches of herring taken by fisheries in the first half of the twentieth century. Overall, Alaska and British Columbia fisheries on herring are well managed for their long-term sustained yield. In southeast Alaska, herring abundance has been trending upwards since 1980. The Pacific herring population in Prince William Sound collapsed in 1993, four years after the *Exxon Valdez* oil spill. The cause has yet to be determined and the population has shown little sign of recovery. Indications are that disease may have been a factor, but factors related to habitat modification from the oil spill cannot be excluded as a cause. In the southern end of the range, herring stocks are at very low levels in the region from California to Puget Sound. This may be related to long-term climate change.

Sardine stocks have shown a strong resurgence in the Northeast Pacific since the mid-1990s. The biomass for Pacific sardine increased rapidly through the 1980s and 1990s, peaking at 1.57 million tonnes in 2000. The biomass has subsequently trended downwards to 537 173 tonnes in 2010 (Hill *et al.*, 2010). Recruitment increased rapidly through the mid-1990s, peaking at 17.156 billion fish in 1997, 19.743 billion in 1998 and 18.578 billion in 2003. Recruitment was notably lower from 2006 to 2009. As the stock grew, it expanded its range from southern California towards Oregon and the northern tip of Vancouver Island in British Columbia. At this time, it is not clear whether large sardine populations will persist in these northern regions, or contract to a more southerly distribution. In a prior increase in the sardine population in the 1920s, the species also increased in British Columbia but then contracted until the recent expansion of the 1990s (McFarlane and Beamish, 1999).

Invertebrates

Crab and shrimp are the main invertebrates in the Northeast Pacific harvest. Dungeness crab (*Cancer magister*) populations may currently be declining from historic highs of the early 2000s. King crab (*Paralithodes*) catches have been stable for the past decade, but are far below the record harvests of the 1970s. The stock is expected to increase further in size through improved management as this fishery has recently entered into a catch share management programme. As in other rationalized fisheries, catch should improve and the fishery should have a reduced impact on crab populations. Effort has decreased and so has the handling mortality of sublegal-sized crabs that are released. Snow crab (*Chionoecetes opilio*) stocks have highly variable recruitment and fluctuating populations. Catches were high through the 1980s and 1990s, but then declined sharply in 2000. Starting in 2008, the catch began to increase again, but catches remain well below those of earlier years. Pandalid shrimp catches were high in Alaska until the 1980s. However, more recently, they have been very low, probably as a result of the sharp and rapid increase of gadoid predators. In southern regions of Area 67, catches have been relatively stable and increasing.

In the coastal zone, there are fisheries for clam, oysters, abalone sea urchin and sea cucumber. Clam populations have suffered local problems as a result of to disease or pollution. However, overall invertebrate catch is increasing primarily owing to increased demand from Asian markets. Coastal species that are taken include northern abalone (*Haliotis kamtshatkana*) and geoduck clam (*Panopea abrupta*). Catches of intertidal clams (*Venerupis philippinarum*, *Protothaca staminea* and *Saxidomus gigantea*), razor clam (*Siliqua patula*), and red sea cucumber (*Parastichopus californicus*) are currently stable or increasing in areas where commercial harvest occurs.

ACKNOWLEDGEMENTS

The authors thank the following individuals and agencies for their contributions to this chapter: Jim Ianelli from the NMFS Alaska Fisheries Science Center, DFO Pacific Region, Denby Lloyd from the Alaska Department of Fish and Game, John Devore from the Pacific Fisheries Management Council and David Colpo from the Pacific States Marine Fisheries Commission.

REFERENCES

Anderson, P.J. & Piatt, J.F. 1999. Community reorganization in the Gulf of Alaska following ocean climate regime shift. *Marine Ecology Progress Series*, 189: 117–123.

Bakun, A. 1999. A dynamical scenario for simultaneous "regime-scale" marine population shifts in widely separated large marine ecosystems of the Pacific. *In* K. Sherman & Q. Tang, eds. *Large Marine ecosystems of the pacific rim: assessment, sustainability and management*, pp. 2–26. Malden, USA, Blackwell Science Inc.

Bodal, B.O. 2003. Incorporating ecosystem considerations into fisheries management: large-scale industry perspective. *In* M. Sinclair & G. Valdimarsson, eds. *Responsible fisheries in the marine ecosystem*, pp. 41–46. Rome, Italy, and Wallingford, UK, FAO and CAB International.

Canada Department of Fisheries and Oceans (DFO). 2010. *Pacific Region Integrated Fisheries Management Plan, Groundfish* [online]. [Cited 30 April 2011]. www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/mplans.htm#Groundfish.

Canada Department of Fisheries and Oceans (DFO). 2001–2011. Salmon catch statistics and logbook reports. In: *Fisheries and Oceans Canada* [online]. [Cited 30 April 2011]. www.pac.dfo-mpo.gc.ca/fm-gp/species-especes/salmon-saumon/fisheries-peches/stats-donnees-eng.htm

Canada Department of Fisheries and Oceans (DFO). 2011. Herring spawn and catch records. In: *Fisheries and Oceans Canada* [online]. [Cited 30 April 2011]. www.pac.dfo-mpo.gc.ca/science/species-especes/pelagic-pelagique/herring-hareng/herspawn/pages/default5-eng.htm

Eggers, D.M., Irvine, J.R., Fukuwaka, M. & Karpenko, V.I. 2005. *Catch trends and status North Pacific salmon*. NPAFC Doc. No. 723, Rev. 3. 35 pp.

Field, J.C., Baltz, K., Phillips, A.J. & Walker, W.A. 2007. Range expansion and trophic interactions of the jumbo squid, *Dosidicus gigas*, in the California Current. *In California Cooperative Oceanic and Fisheries Investigations Report 48*, pp. 131–146.

Hare, S.R. 2010. *Assessment of the Pacific halibut stock at the end of 2010* [online]. IPHC report, 26 pp. [Cited 20 December 2011]. www.iphc.int/papers/sa10.pdf

Hilborn, R. & Eggers, D. 2000. A review of the hatchery programs for pink salmon in Prince William Sound and Kodiak Island, Alaska. *Transactions of the American Fisheries Society*, 129: 333–350.

Hill, K.T., Lo, N., Macewicz, B.J., Crone, P.R. & Felix-Uraga, R. 2010. *Assessment of the Pacific sardine resource in 2010 for U.S. management in 2011*.

Hollowed, A.B., Bailey, K.M. & Wooster, W.S. 1987. Patterns in recruitment of marine fishes in the northeast Pacific Ocean. *Biological Oceanography*, 5: 99–131.

Ianelli, J.N., Barbeaux, S., Honkalehto, T., Kotwicki, S., Aydin, K. & Williamson, N. 2010. *Assessment of the walleye pollock stock in the Eastern Bering Sea*.

FAO. 2005. B10. Northwest Pacific. *In* FAO Marine Resources Service, Fishery Resources Division. *Review of the state of world marine fishery resources*. FAO Fisheries Technical Paper No. 457. Rome. 235 pp.

Matta, M.B., Black, B.A. & Wilderbuer, T.K. 2010. Climate-driven synchrony in otolith growth-increment chronologies for three Bering Sea flatfish species. *Marine Ecology Progress Series*, 413: 137–145.

McFarlane, G.A. & Beamish, R.J. 1999. Sardines return to British Columbia waters. *In Proceedings of the 1998 Science Board Symposium on the Impacts of the 1997/98 El Nino event on the North Pacific Ocean and its marginal seas*, no. 10, pp. 77–82. PICES scientific report. Sidney, Canada.

McFarlane, G.A., King, J.R. & Beamish, R.J. 2000. Have there been recent changes in climate? Ask the fish. *Progress in Oceanography*, 47: 147–169.

National Marine Fisheries Service (NMFS). 2010. North Pacific groundfish stock assessment and fishery evaluation reports for 2010. Stock assessments for groundfish species in the Bering Sea and Gulf of Alaska. In: Alaska Fisheries Science Center [online]. [Cited 30 April 2011]. www.afsc.noaa.gov/refm/stocks/assessments.htm

North Pacific Fishery Management Council (NPFMC). 2011. Management plans for the eastern Bering Sea and Gulf of Alaska groundfish. In: NOAA Fisheries [online]. [Cited 30 April 2011]. www.fakr.noaa.gov/npfmc/PDFdocuments/fmp/GOA/GOA.pdf

Peterson, W.T. & Schwing, F.B. 2003. A new climate regime in northeast pacific ecosystems. *Geophysical Research Letters*, 30: 1896.

Stadler, J.H., Griffin, K.F., Chavez, E.J., Spence, B.C., Roni, P., Gavette, A., Charleen, A., Seekins, B.A. & Obaza, A.K. 2011. *Pacific Coast Salmon 5-Year Review of Essential Fish Habitat, Final Report to the Pacific Fishery Management Council, National Marine Fisheries Service, Pacific Fishery Management Council. March 23, 2011* [online]. [Cited 30 April 2011]. www.pcouncil.org/wp-content/uploads/G5b_ATT1_SAL5YEAR_APR2011BB.pdf

Wilderbuer, T.K., Nichol, D. & Ianelli, J. 2010. Yellowfin sole. *In*: *Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands Region as projected for 2011*, Chapter 4. Anchorage, USA, North Pacific Fishery Management Council.

Woodby, D., Carlile, D., Saddeek, S., Funk, F., Clark, J. & Hulbert, L. 2005. *Commercial fisheries in Alaska*. Special Publication 05-09, June 2005. USA, Alaska Department of Fish and Game.

Zeidberg, L.D., Hamner, W.M. & Nezlin, N.P. The fishery for *Loligo opalescens* from 1981 through 2003. *Fishery Bulletin US*, 104: 46–59.

B12. Western Central Pacific

FAO STATISTICAL AREA 71

Gabriella Bianchi
Service Coordinator
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: gabriella.bianchi@fao.org

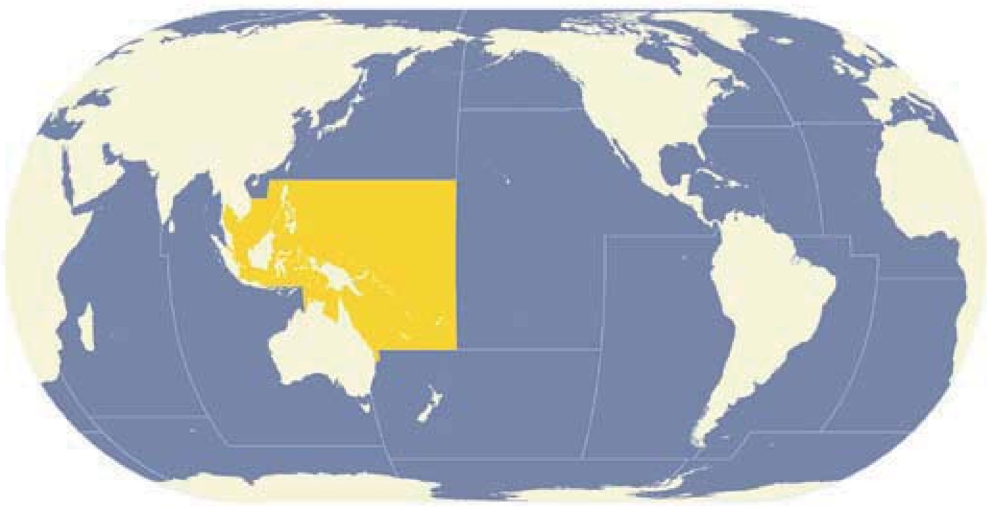
Rick Fletcher
FAO Consultant
Australia
E-mail: rick.fletcher@fish.wa.gov.au

IINTRODUCTION

FAO Statistical Area 71 covers 33.9 million km^2 and extends from the seas of Southeast Asian countries down to north and east Australia. It also covers the area further east to some of the smaller island countries of the South Pacific (Figure B12.1). Area 71 includes the South China Sea, Sulu-Celebes Sea, Arafura Timor Sea and the Gulf of Thailand as well as a significant amount of open ocean on the western side. More than half of this area covers a large continental shelf (6.6 million km^2) that is bordered in the north by Southeast Asian countries and in the southeast by Indonesia and Australia. The majority of this the shelf lies within the EEZs of Southeast Asian countries, and this is reflected in the major contribution these countries make to the total production of Area 71.

The region is characterized by a complex geomorphology, making this region one of the most highly diverse marine areas in the world, including continental, island and archipelagic countries. The Indonesian and Philippine archipelagos comprise more

FIGURE B12.1
The Western Central Pacific (Area 71)



than 7 000 islands. The coastlines of each of these two countries covers 54 716 km and 36 289 km, respectively. The Gulf of Thailand is a large shelf area with a maximum depth of about 80 m and a tropical climate governed by the monsoon regime. This is a highly productive area, mainly because of the high nutrient input coming from the rivers discharging into the Gulf of Thailand. However, its fishery resources are severely overexploited (Kongprom *et al*., 2003), and by 1995 biomass levels were already less than 10 percent of the biomass in the early 1960s. Reported production for the area still seems to be rising, although this is probably a reporting effect of catches from other fishing areas, as fishery assessments indicate clear overfishing effects.

Moving eastwards, the less productive South China Sea also has a tropical climate influenced by the monsoon seasons. Productivity is relatively stable in this region, with limited seasonal and interannual variability. The region is well known for its high marine shallow-water biodiversity. The South China Sea has stocks of marine pelagic species that are exploited for a variety of uses. Despite the increases in reported catches (see below), the fishery resources of this region are also considered to be overexploited. In some cases, these resources are also heavily depleted.

The Sulu- Celebes Sea, bordered by Malaysia, Indonesia and the Philippines is also highly diverse with many species found in the extensive coral ecosystems. In terms of capture fisheries, this region is not highly productive. The reefs provide fish for local consumption, and the region is exploited for live reef fish and marine ornamental trade. The high marine diversity here is threatened by a number of human-induced factors (overfishing, use of poison and dynamite fishing) and pollution. It is also threatened by extreme weather events, such as the two warm events of 1988 and 1998 that resulted in widespread coral bleaching and restructuring of coral communities. During the southwest monsoon months, the northern and central parts are affected by revolving tropical storms (typhoons) from the Pacific Ocean, bringing intense rains and destructive winds.

The Indonesian Sea is bordered by Indonesia and Timor-Leste. This sea is characterized by complex and strong currents, as the main water exchange between the Pacific and Indian Oceans takes place in this region. Productivity is high owing to the vertical currents (upwellings) that take place as a result of the monsoon winds. Fisheries include both artisanal as well as industrial operations. Despite increasing reported landings in this region in past decades, there is evidence of resources being overexploited, well beyond their biological limits (Dwippongo *et al*., 1987). Moreover, pollution from urban centres and from agriculture activities as well as siltation from deforestation and mining all result in major negative impacts on the marine environment and its resources.

The north and northeast Australian shelves make up the remainder of Area 71. Productivity is high along the northern coasts, mainly because of tidal mixing but also as a result of monsoon winds and tropical cyclones. This region is connected to the Indonesian Sea by the Indonesian Throughflow that brings warm Pacific water into the Indian Ocean. The marine fauna consists of species common to the Indo-Pacific. There are very few examples of resources being depleted, but most stocks are fully exploited.

The main fishery resources in the coastal areas of Area 71 include small pelagics (about 3 million tonnes) various demersals (with penaeid shrimps probably being the most economically valuable), and invertebrates (1.3 million tonnes) as well as a significant, large category of non-identified fish. The oceanic waters of the Western Central Pacific have large tuna resources, with catches of 2.9 million tonnes. Total catches of Area 71 increased steadily from 1950 to 2003, when the catch reached nearly 11 million tonnes. Since then, the catches have stabilized with 11.2 million tonnes caught in 2009. The majority of the catch is consumed locally by the large populations present in many of the bordering countries. The major export commodities in Area 71 are tunas and, to a far lesser extent, shrimp. An increasing amount of the low-value catch (including a significant amount of “trash fish” from the trawl fisheries) is now reduced to fishmeal and fish oil or used directly as unprocessed feed for the aquaculture industry. Increasingly, there are efforts to improve the quality and preservation of some of this catch (estimated at more than 300 000 tonnes) and divert it into processing for surimi.

Despite the rapid and continued development of fisheries in Area 71, knowledge of the status of the main fish resources is still very poor. The conditions in which fishery administrations operate are extremely challenging, with a very high population density in most coastal areas, a complex geomorphology and very high biological diversity. These conditions make collecting fishery statistics, developing reliable assessments and managing fisheries extremely challenging. While information on catches and status of stocks is poor and highly uncertain, there is some good evidence that major declines in fish productivity have taken place and that these add to the impacts of other land-based activities.

PROFILE OF CATCHES

The catches in Area 71 increased steadily from 540 000 tonnes in 1950 to 10.5 million tonnes in 2002 but have stabilized in the last few years with a total catch for 2009 of 11.2 million tonnes (Figure B12.2, Table D14). The five Southeast Asian countries (Indonesia, Malaysia, the Philippines, Thailand and Viet Nam) continued to contribute more than 85 percent of the total catch from 2002 through to 2009. These are largely tropical multispecies coastal fisheries with a large component of unidentified marine fish (ISSCAAP Group 39). The largest single component of the catch for Area 71 is now the tunas, bonitos and billfish (ISSCAAP Group 36), which increased from 22.3 percent of the catch in 2002 to 26.1 percent of the total in 2009.

The catches of tuna and billfish in this region now form the largest tuna fishery in the world and are an extremely important export commodity for many countries in the region (Figure B12.3). The catch of skipjack tuna has

FIGURE B12.2
Annual nominal catches by ISSCAAP species groups in the Western Central Pacific (Area 71)

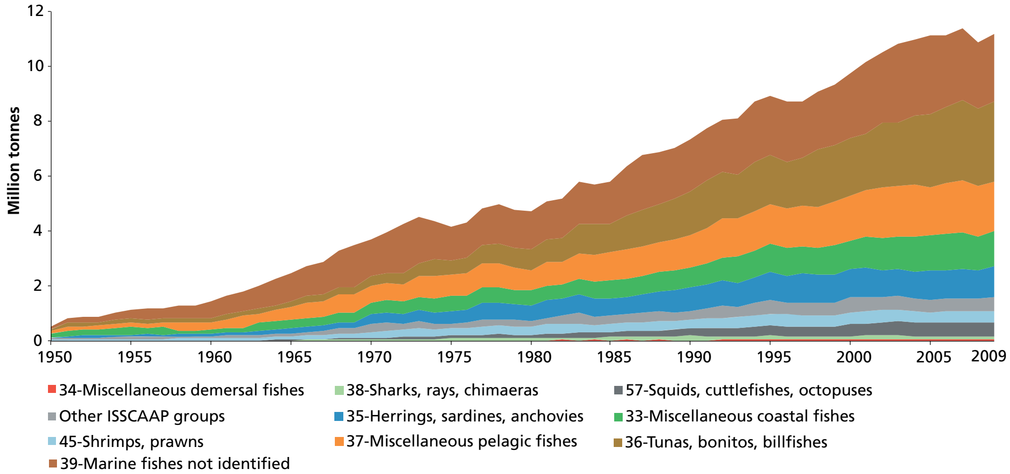


FIGURE B12.3
Annual nominal catches of selected species in ISSCAAP Group 36, Western Central Pacific (Area 71)

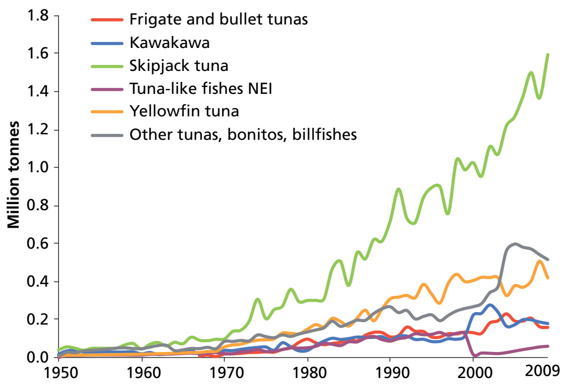


FIGURE B12.4
Annual nominal catches of selected species in ISSCAAP Group 35, Western Central Pacific (Area 71)

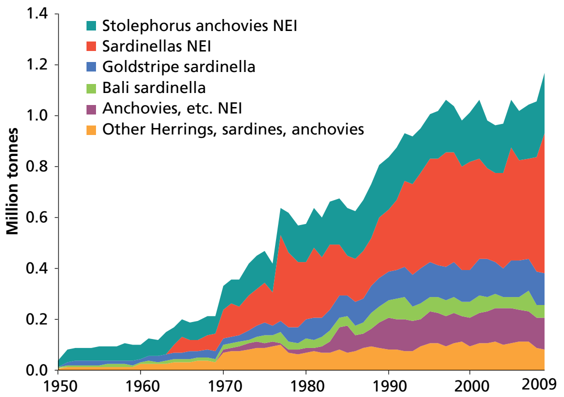


FIGURE B12.5
Annual nominal catches of selected species from ISSCAAP Groups 33 and 38, Western Central Pacific (Area 71)

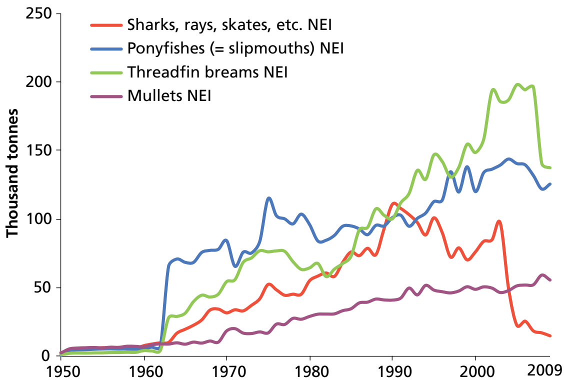
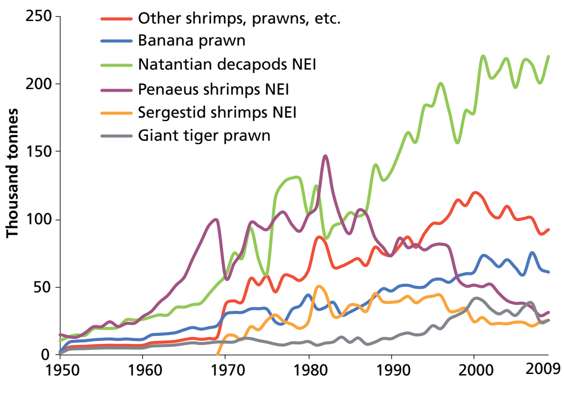


FIGURE B12.6
Annual nominal catches of selected species in ISSCAAP Group 45, Western Central Pacific (Area 71)



increased rapidly in the past 30 years following the introduction of large purse seine vessels. The catch rose from less than 100 tonnes in 1970 to more than 1 million tonnes in 2002 and further increased to 1.6 million tonnes in 2009. The catch of yellowfin tuna in this region has fluctuated around an average of 400 000 tonnes for the past ten years. While the catches of the other tuna, bonitos and billfishes have increased, the reported catch of tuna-like species has declined. This may represent improved catch reporting as a result of the increased observer coverage and training now occurring in many of these fisheries. The catch of the more coastal kawakawa has also declined in the last six years, from a peak of 277 000 tonnes in 2002 to 179 000 tonnes in 2009 (Figure B12.3).

The other main components of the catch include: miscellaneous pelagic fishes (ISSCAAP Group 37) at 16 percent; miscellaneous coastal fishes (ISSCAAP Group 33) with 11.1 percent; and herrings sardines, anchovies (ISSCAAP Group 35) with 10.4 percent. Shrimps, prawns (ISSCAAP Group 45) and cephalopods (ISSCAAP Group 57) only constitute 3.6 and 4.6 percent of the total, respectively. Despite their small contribution to the total catch, both these groups are economically important to the countries in this region.

There has been no overall increase in the catch of scads and other groups in the miscellaneous pelagic group (ISSCAAP Group 37), and even a slight decrease in recent years. Similarly, for herring, sardine and anchovy (ISSCAAP Group 35), the catches of the group, which include *Sardinella gibbosa* and *Stolephorus* anchovies, has been relatively stable for the past 15 years except for the slight increase observed in 2009 (Figure B12.4). While the overall catch of the miscellaneous coastal fishes (ISSCAAP Group 33) has continued to increase, the catches of some key components such as threadfin bream have shown sharp reductions in the last few years as have those of sharks, rays and skates (ISSCAAP Group 38, Figure B12.5).

Except for the catch of natantian decapods, which has remained at or near 200 000 tonnes for the past eight years, most of the shrimp and prawn catches have declined in the past decade. These declines have led to a lowering of the overall catch of this group (ISSCAAP Group 45) from 460 000 tonnes in 2002 to 405 000 tonnes in 2009 (Figure B12.6). The total catch of cephalopods (ISSCAAP Group 57) has only increased slightly from 496 000 tonnes caught in 2002 to

506 000 tonnes in 2009, which was generated by the rapid increase in catch of the other squids, octopus and cuttlefish component (Figure B12.7).

FIGURE B12.7
Annual nominal catches of selected species in ISSCAAP Group 57, Western Central Pacific

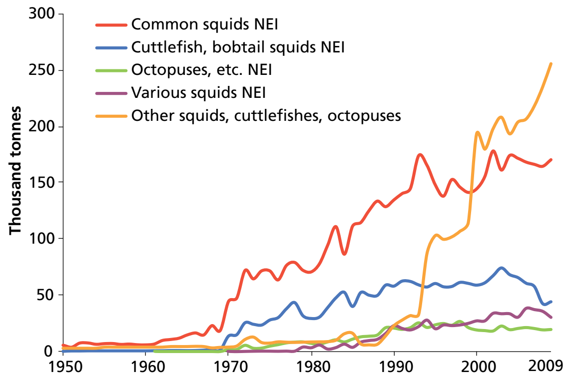
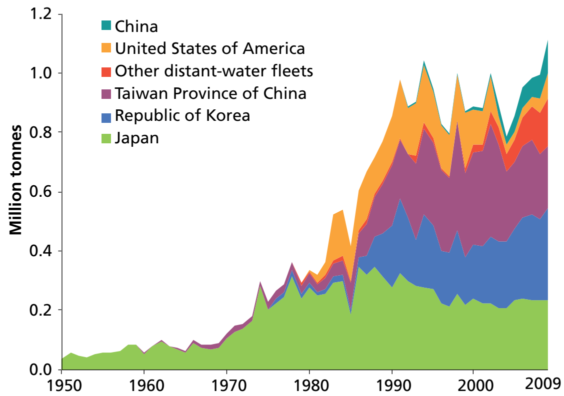


FIGURE B12.8
Annual nominal catches of distant-water countries' fleets, Western Central Pacific (Area 71)



High seas

The catches (mostly of tuna and tuna-like species) reported by distant-water nations fishing in Area 71 have been relatively stable at between 700 000 tonnes and 1 million tonnes for the past 20 years (Figure B12.8). However, these values may not include all the catches of tuna made by these countries. They are only reported as part of any access agreements to fish within the EEZs of countries in Area 71 (especially small island States) or where their vessels are actually licensed by one of these member countries. Methods to control the level of tuna fishing in the "high seas pockets" that are not contained within the EEZ of member countries are being actively pursued by the WCPFC, including the closure of some of these areas to tuna fishing by member countries.

RESOURCE STATUS AND FISHERY MANAGEMENT

A recent stock assessment workshop for South and Southeast Asia (FAO, 2010) indicated that many of the coastal fish resources in this region continue to be under increasing fishing pressure and that many of these resources are fully exploited or overexploited. The development of trawl fishing in the Gulf of Thailand in the 1960s resulted in the overexploitation of demersal resources. The most recent stock assessments suggest that this status has not changed (FAO, 2010, Table D14). Trawling has spread throughout the region to most areas with shallow shelf waters, alongside pushnetting-type gears. Consistent with the trends in overall catches of the different groups of coastal fish resources, the majority of stocks are now considered to be at least fully exploited in the east of Area 71 (e.g. Indonesia, Malaysia, the Philippines and Thailand). Some species (e.g. threadfin bream and pony fish) are targeted for surimi production and considered to be overfished at least in some places (e.g. Thailand). Substantial quantities of several other species groups such as lizardfishes and goatfishes are also used for surimi production. For example, in Thailand, production of surimi exceeded 300 000 tonnes in 2007, corresponding to about 1.2 million tonnes of unprocessed fish (Lymer, Funge-Smith and Miao, 2010). For the invertebrate groups, the crustacean (shrimp and crabs) and cephalopod (squid and cuttlefish) resources are considered to be at least fully fished, but overfished in one or more of the countries (e.g. Thailand and Cambodia; FAO, 2010).

Shrimp fisheries are important in this region, with Indonesia, Viet Nam, Thailand, Malaysia, the Philippines and Australia being the main producing countries. In 2009, Indonesia reported 150 000 tonnes of shrimp (ISSCAAP Group 45) and Viet Nam 127 000 tonnes. After China and India, Indonesia's shrimp catch is the largest in the world. However, shrimp fishing generates a multitude of conflicts, most of which involve small-scale fisheries. The effectiveness of the 1980s trawl ban in Indonesia waters has been eroded and, today, there are countless boats that catch shrimp using many types of fishing gear, a situation exacerbated by illegal activity and poor statistical information (Gillett, 2008).

In the south of the region, there are important shrimp fisheries to the south of Timor-Leste that are exploited by Indonesia and Australia. Shrimp fisheries in the Arafura Sea exploit various species of penaeid shrimp but the major species includes banana shrimp (*Penaeus merguiensis*) and various species of the genus *Metapenaeus*, particularly *M. endeavouri* and *M. ensis*, which are considered to be depleted. The shrimp fisheries off the Northern Territory and in the Gulf of Carpentaria in Australia also exploit banana shrimp, white shrimp (*P. indicus*), brown tiger shrimp (*P. esculentus*) and grooved tiger shrimp (*P. semisulcatus*) and a number of other species with a total catch in 2009 of 5 200 tonnes and a value of US$74 m. The main shrimp stocks and fishing levels are considered to be at acceptable levels (BRS, 2010).

Management of these shrimp fisheries is rather diverse. In Australia, restricted entry began in the late 1960s. The fishery is managed jointly by the Government and industry through the Prawn Fisheries Management Committee headed by an independent chair. The fishers themselves take an active role in research by participating in stock assessments using their vessels and crew (Gillett, 2008). However, in many other fisheries, the number of shrimp trawlers has increased under an essentially open-access regime with no formal management plans in place. Despite the lack of economic data on shrimp fishing, there are indications that, in many cases, both the profitability of individual shrimp fishing operations and the rent from the various shrimp fisheries are low. A rising proportion of trash fish and falling CPUEs are observed in many fisheries (Gillett, 2008).

Many of the countries within Area 71 have established fishery zones and/or management areas. These vary between zones established to separate coastal small-boat fisheries from larger-powered vessels, and larger zones delineated according to provincial or other political boundaries or fishing areas. Despite this zoning, considerable problems remain with the enforcement of measures, owing to weak MCS systems. In response to this, Indonesia and Malaysia have developed wheelhouse marking schemes to provide quicker visual indications of whether a vessel is operating in the right zone or not.

In the north of Area 71, apart from Malaysia, the use of limited-access management arrangements is not common, with gear and area restrictions being the most frequently used controls. In the south of Area 71, restrictions on effort, catch, gear, etc. using scientific advice within a rights-based framework have been integral to the fishery management process in Australia for some time.

An overall regional assessment carried out utilizing the landing statistics available in FAO FishStat, resulted in most of the species and species groups (77 percent) being assessed as fully exploited. Another 7 percent of the species or species groups were found to be non-fully exploited and 15 percent were overexploited. Sharks and rays were the most prominent overexploited groups (regional landings falling below 50 percent of the highest three-year average).

These results appear to be more optimistic compared with independent information available for some of the regions. Data available from the scientific surveys (e.g. Silvestre *et al*., 2003) show a situation of local depletions already by the 1990s. For example, in the Gulf of Thailand, by the mid-1990s, demersal biomass had declined to 8 percent of the level found in the early 1960s (Kongprom *et al*., 2003). Similarly, analyses carried out on surveys in Peninsular Malaysia and Sarawak from 1972 to 1998 indicate widespread overexploitation and depletion of resources (Ahmad *et al*., 2003). These reports are not consistent with the relatively positive impression that can be gained from the catch statistics and relative assessments. It is reasonable to think that widespread misreporting of catches may exist.

Information on trends in CPUEs from a number of countries in the region seems to be consistent with the information derived from the research surveys. As an example, annual CPUEs decreased in Viet Nam from 1.12 tonnes/hp in 1985 to 0.3512 tonnes/hp in 2003. In Indonesia, a substantial decrease has been observed for the period 1990 to 2007 in otter/pair trawling, purse seining and gillnetting. In Thailand, where resources were considered to be overexploited already by the mid-1990s, an additional drop in the CPUEs has been observed for the period from 1997 to 2002 as regards both otter/pair trawling (–8 percent) and purse seining (–35 percent) (Lymer, Funge-Smith and Miao, 2010).

The stock status of the tuna resources in the Western and Central Pacific Ocean (WCPO) are regularly assessed by the Scientific Committee of the WCPFC, and their status is reported at the annual meeting. The latest assessments (WCPFC, 2011) suggest that the WCPO skipjack stock is at a moderate level of depletion and there is no overfishing. Similarly, for south Pacific albacore tuna, the current level of depletion is considered moderate and current catches are sustainable. The overall level of depletion of the WCPO yellowfin stock is considered to be at a moderate level. However, this depletion is much greater in the western equatorial zone where most of the purse seine catches occur. Therefore, the WCPFC has recommended no increase in the catch of this species. For bigeye tuna, there is debate whether the very high level of depletion can be considered overfishing or not, but the WCPFC has recommended a minimum 29 percent cut in the fishing mortality for this stock.

Countries in the south and southeast Asian waters of Area 71 are becoming increasingly aware of the need for sustainable management of their marine resources. However, considerable effort is still required to implement appropriate management regimes. The most common management measures in this region includes zoning by fishing gear, closed season, closed area and mesh size limit. Malaysia has a formal fisheries development process as part of its National Agricultural Plan of 1992–2010 and is the most progressive and advanced country in this respect. This is one of the few countries to have policy statements in management strategies that recommend implementation of limited access, conservation measures or the establishment of sustainable harvesting limits (Flewwelling and Hosch, 2007).

There are a number of regional bodies that operate on fishery issues in this region: World Fish Center (WFC), Southeast Asian Fisheries Development Center (SEAFDEC), Association of Southeast Asian Nations (ASEAN) Fisheries Working Group, Asia-Pacific Economic Cooperation (APEC) Fisheries Working Group, and the FAO Asia-Pacific Fishery Commission (APFIC). All of these bodies play a major role in technical training; in addition, they assist members in the development of individual fishery management plans. Given the different priorities within countries, these management tools have been fully or partially implemented, yielding varying degrees of progress towards these management goals (Flewwelling and Hosch, 2007).

The offshore waters of the Western Central Pacific (Area 71) have come under increased management control through the establishment of the WCPFC in June 2004. The 15 small island States in this region depend strongly on these resources. Despite the rise in catches in the last decade, this small island group still accounts for only 4.1 percent of total catch of the region (discussed in detail in Chapter C3). A significant proportion of the catch of tuna within these countries' EEZs is taken by vessels of distant-water fishing nations. These access arrangements and other registration schemes are negotiated with the assistance of the Forum Fisheries Agency (FFA) and more recently the Parties to the Nauru Agreement. The distant-water fleets fishing in this region include those China, Japan, the Republic of Korea, Taiwan Province of China, and the United States of America. In total, catches by vessels flagged as distant-water fishing nations contributed to 8.7 percent of the total production of the Area 71.

The WCPFC has the mandate and authority to implement the Convention for the Conservation and Management of Highly Migratory Fish Stocks (Anon., 2000) in the WCPO. The convention entered into force on 19 June 2004 and covers almost 20 percent of the Earth's surface. Although the western boundary notionally extends to the East Asian seaboard, it is understood that the convention area does not include the South China Sea. The WCPFC has 25 member countries, a number of participating territories and 9 cooperating non-members under this convention. It seeks to ensure the long-term conservation and sustainable use of the tunas, billfish and marlin in the WCPO. It does this by developing conservation and management measures that cover target, non-target and bycatch species associated with the tuna fisheries operating in the region. The WCPFC works in cooperation with the FFA to establish effective licensing, compliance systems and observer coverage along with the Secretariat of the Pacific Community (SPC), which is the main science provider and data manager.

ACKNOWLEDGEMENTS

The authors wish to thank Simon Funge-Smith (FAO Regional Office for Asia and the Pacific) for his thorough review of the initial draft and for providing valuable additional information.

REFERENCES

Ahmad, A.T., Isa, M.M., Ismail, M.S. & Yusof, S. 2003. Status of demersal fishery resources of Malaysia. *In* G.T. Silvestre, L.R. Garces, I.C. Stobutzki, M. Ahmed, R.A. Valmonte-Santos, C. Luna, L. Lachica-Aliño, P. Munro, V. Christensen & D. Pauly, eds. *Assessment, management and future directions for coastal fisheries in Asian countries*, pp. 83–136 WorldFish Center Contributions, 1705. Penang, Malaysia, WorldFish Center. 1110 pp.

Anon. 2000 Convention on the conservation and management of highly migratory fish stocks in the western and central Pacific Ocean. Hawaii, September 2000. In: *Western and Central Pacific Fisheries Commission* [online]. [Cited 20 December 2011]. www.wcpfc.int/key-documents/convention-text

Bureau of Rural Sciences (BRS). 2010. *Fishery status reports 2009: Status of fish stocks and fisheries managed by the Australian Government*. Canberra, Australian Bureau of Agricultural and Resource Economics – BRS.

Dwiponggo, A., Hariati, T., Banon, S., Palomares, M.L. & Pauly, D. 1987. *Growth, mortality and recruitment of commercially important fishes and penaid shrimps in Indonesia waters*. ICLARM technical reports 17. 91 pp.

FAO. 2010. *Report on the Second Workshop on the Assessment of Fishery Stock Status in South and Southeast Asia, Bangkok, 5–9 October 2009*. FAO Fisheries and Aquaculture Report No. 940. Rome. 54 pp.

Flewwelling, P. & Hosch, G. 2007. West Central Pacific Ocean. *In* C. De Young, ed. *Review of the state of world marine capture fisheries management: Pacific Ocean*, pp. 141–170. FAO Fisheries Technical Paper. No. 488/1. Rome, FAO. 359 pp.

Gillett, R. 2008. *Global study of shrimp fisheries*. FAO Fisheries Technical Paper No. 475. Rome, FAO. 331 pp.

Kongprom, A, Khemakorn, P., Eiamsa-ard, M. & Supongpan, M 2003. Status of demersal fishery resources in the Gulf of Thailand. *In* G.T. Silvestre, L.R. Garces, I.C. Stobutzki, M. Ahmed, R.A. Valmonte-Santos, C. Luna, L. Lachica-Aliño, P. Munro, V. Christensen & D. Pauly, eds. *Assessment, management and future directions for coastal fisheries in Asian countries*. WorldFish Center Contributions, 1705. Penang, Malaysia, WorldFish Center. 1110 pp.

Lymer, D., Funge-Smith, S. & Miao, W. 2010. *Status and potential of fisheries and aquaculture in Asia and the Pacific 2010*. FAO Regional Office for Asia and the Pacific. RAP Publication 2010/17. 85 pp.

Silvestre, G.T., Garces, L.R., Stobutzki, I.C., Ahmed, M., Valmonte-Santos, R.A., Luna, C., Lachica-Aliño, L., Munro, P., Christensen, V. & Pauly, D., eds. 2003. *Assessment, management and future directions for coastal fisheries in Asian countries*. WorldFish Center Contributions, 1705. Penang, Malaysia, WorldFish Center. 1110 pp.

Western and Central Pacific Fisheries Commission (WCPFC). 2011 *Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, seventh regular session, Honolulu, Hawaii, United States of America, 6-10 December 2010*. Kolonia, Pohnpei. 212 pp.

B13. Eastern Central Pacific

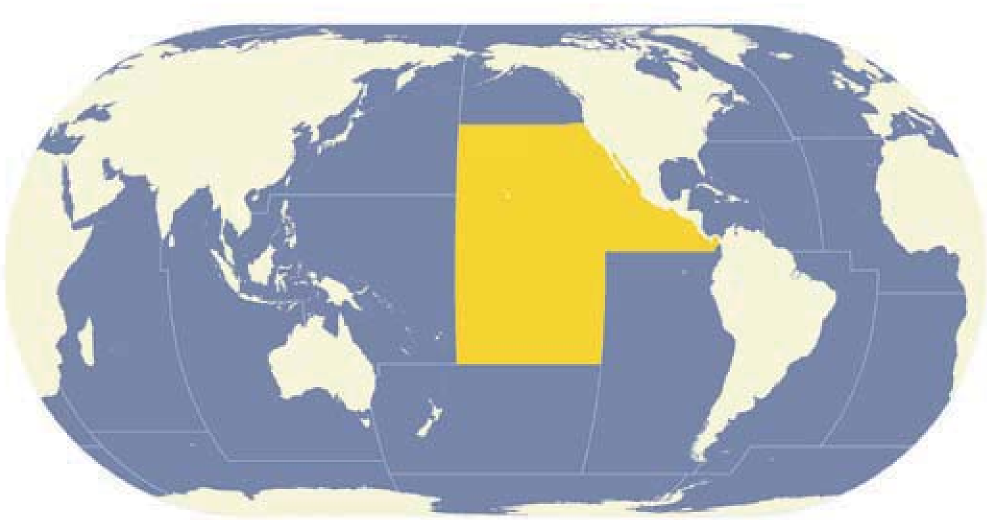
FAO STATISTICAL AREA 77

Jorge Csirke
FAO consultant
Peru
E-mail: jorge.csirke@gmail.com

INTRODODUCTION

The Eastern Central Pacific (FAO Statistical Area 77) covers a total surface area of 48.90 million km² including an estimated total shelf area of 0.81 million km². Area 77 is bounded by the west coast of the Americas to the east and the 175°00'W parallel to the west. In the north, it is bounded by latitudes 40°00'N and 40°30'N off northern California, the United States of America. Area 77 extends south to latitude 7°12'N, except close to the coast off southern Panama, where it stops at 5°00'N. Farther offshore, it extends down to 25°00'S off South America (Figure B13.1). The continental shelves in Area 77 rarely extend more than 20 km from the coast. Some regions off San Francisco Bay in El Salvador, Nicaragua and the Gulf of Panama are the exception. In these regions, it can widen to as much as 60 km. The benthic habitats on the sea floor of the continental shelf tend to be heterogeneous. There are several areas suitable for trawling, although there is little trawling except for shrimps. Trawling for coastal demersal fishes is limited and deep-water trawling has been done only occasionally, mostly for exploratory and research purposes. Two of the main features along the coast are the Gulf of California and the Gulf of Panama. There are also a few small coastal islands off southern California and Panama, and some other larger island groups in oceanic waters such as the Hawaii Islands. These island chains also have very narrow continental shelves.

FIGURE B13.1
The Eastern Central Pacific (Area 77)



Area 77 is influenced by two major surface current systems: the California Current, which spreads from northern California to Baja California (Parrish *et al.*, 1983); and, to the south, the great trans-Pacific equatorial surface current system. This system consists of the westward flowing North and South Equatorial Currents, with the eastward-flowing Equatorial Counter-current in between (Bakun *et al.*, 1999). These current systems, together with the prevailing equatorial winds that blow parallel to the coast, cause major upwelling to occur along the coast of California, Baja California and the Gulf of Panama and smaller upwelling along the Central American coast and offshore in the Costa Rica Dome.

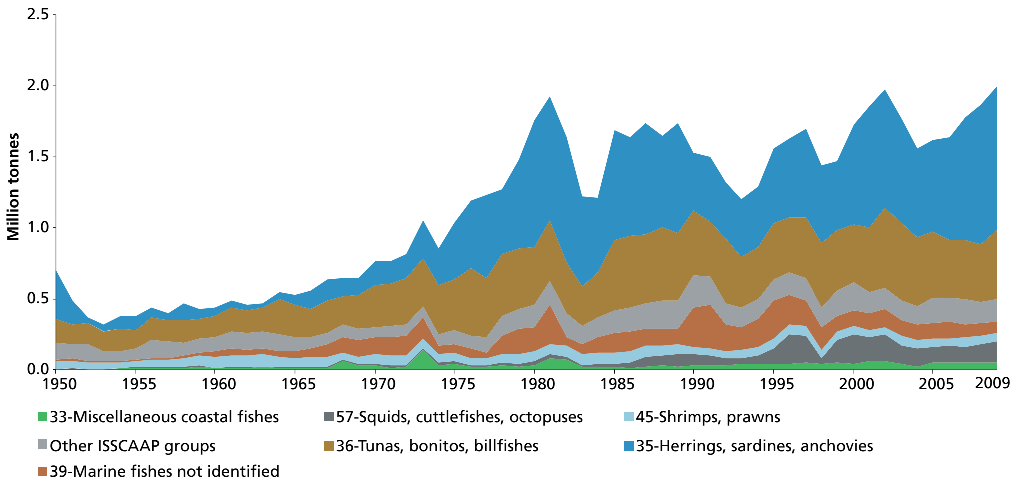
The coastal upwelling is the most important source of coastal water nutrient enrichment in the northern, more temperate subtropical part of the region off the Californias. The more tropical regions off Central America can be enriched by both coastal upwelling, driven by southeast trade winds, as well as by the coastal runoff. Farther offshore, the Costa Rica Dome appears to be an important source of upwelling and nutrient enrichment (Wyrtky, 1964; Bakun *et al.*, 1999).

The distribution and abundance of marine resources and fishing activities in Area 77 is strongly influenced by the different climates, the interaction of complex wind and water circulation patterns, and the nature of the enrichment processes. Fishing for small and large pelagic species is particularly important within and around the major upwelling regions. Inshore, fishing for shrimps and, to a lesser extent, for coastal demersal fishes sustains major local fisheries in the more tropical regions off Mexico, Central America and Panama. Fishing for squids is also important in the richest areas off California and Mexico. The El Niño-Southern Oscillation (ENSO) phenomenon is responsible for large interannual fluctuations in the conditions affecting marine populations in this region. It can cause natural perturbations that may take years to dissipate (Bakun, 1993). Some of the mid- to long-term fluctuations in annual catches of key species in Area 77 seem to be associated with these large interannual changes in environmental conditions (Lluch-Belda, Lluch-Cota and Lluch-Cota, 2005; Lluch-Cota *et al.*, 2010).

PROFILE OF CATCHES

Fisheries production from the Eastern Central Pacific comes mostly from small and large pelagic species, followed by squid, shrimp, coastal demersal fishes and a variety of other fish species (Figure B13.2, Table D15). Pelagic fisheries are particularly important off southern California, Baja California, the Costa Rica Dome and the Gulf of Panama.

FIGURE B13.2
Annual nominal catches by ISSCAAP species groups in the Eastern Central Pacific (Area 77)



Squid are important off southern California and Baja California. Shrimp catches are much lower in volume than those of pelagic fishes, but their high unit price makes shrimp the other major commercial fishery in Area 77. Shrimp are important off Mexico and particularly off Central American, where they can be the most important fishery for most of the coastal countries there.

The first major development of fisheries in Area 77 can be traced to the beginning of the twentieth century with the first recorded multidecadal bloom of the California pilchard (or sardine) (*Sardinops caeruleus*) fishery off the United States of America. This fishery built up more or less steadily from less than 2 000 tonnes in 1915 to more than 700 000 tonnes in 1936. It then declined dramatically in the late 1940s and in the 1950s and 1960s (Murphy, 1966; Gulland, 1970; Troadec, Clark and Gulland, 1980). The catch began to increase again in the late 1970s and in more recent years (Kawasaki, 1983; Csirke, 1995; Lluch-Belda *et al*., 1992; Csirke and Vasconcellos, 2005). Fishing for tunas also expanded steadily in the first half of the past century. By 1950, the total catch of tunas (mostly skipjack and yellowfin) was already 170 000 tonnes and remained more or less stable until 1960. Catch continued to increase further and has been about half a million tonnes in recent years.

After a record low of 320 000 tonnes in 1953, total catches for Area 77 had a period of sustained increase to peak at 1.8 million tonnes in 1981. Since then, catches by major species groups have fluctuated, with accumulated total catches varying between a minimum of 1.2 million tonnes in 1983, 1984 and 1993 and almost 1.9 million tonnes in 2002 and 2009. (Figure B13.2, Table D15).

Most of the year-to-year fluctuations in total production in Area 77 are dominated by changes in the abundance and overall production of small pelagic fishes. However, particularly strong El Niño events also tend to cause severe drops in the catches of larger pelagic species as well as in squid and several other species groups.

The collapse of the California pilchard (sardine) fishery off California in the late 1940s was partly compensated by an increase in the abundance of Californian anchovy (*Engraulis mordax*) in the same general fishing areas. However, no substantial fishery for Californian anchovy developed until much later (MacCall, 1983). It was only by the 1970s that Mexico developed a major industrial fishery for California pilchard and Californian anchovy. With the development of this fishery, the total production of small pelagics in ISSCAAP Group 35 increased from the record lows of 41 000 tonnes and 34 000 tonnes in 1952 and 1963, to a peak of almost 900 000 tonnes in 1980 (Figure B13.3; Table D15). Total catch of small pelagic species in this ISSCAAP group then remained in the range of 400 000 tonnes to 620 000 tonnes in 1990–1999, to increase to 853 000 tonnes in 2001 and reach a maximum of 1 million tonnes in 2009.

Most of these recent large total catches have been the result of an increase in the California pilchard catch, which peaked at 729 000 tonnes in 2009. This catch was the largest for this species in half a century. Increased catches of Pacific thread herring have also contributed to the recent large total catch from Area 77. The catch of Pacific threadfin herring reached a maximum of 233 000 tonnes in 2007, with 163 000 tonnes in 2009. The long-term fluctuations in the marine fish abundance and resulting catches of California pilchard seem to be associated with long-term changes in air pressure and sea water temperature in the Northern Hemisphere. Until the early 1990s, the California pilchard followed

FIGURE B13.3
Annual nominal catches of selected species in ISSCAAP Group 35, Eastern Central Pacific (Area 77)

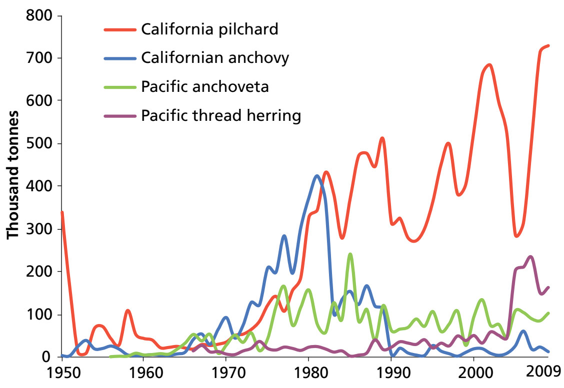


FIGURE B13.4
Annual nominal catches of selected species in ISSCAAP Group 37, Eastern Central Pacific (Area 77)

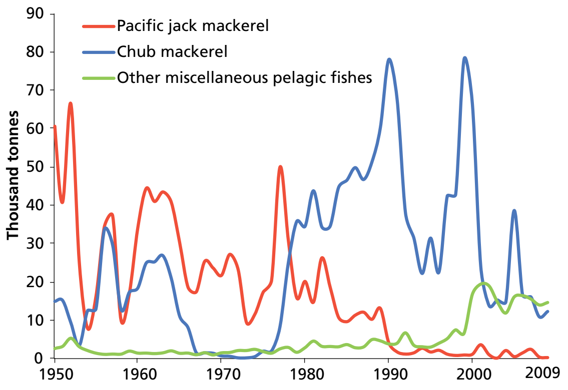


FIGURE B13.5
Annual nominal catches of selected species in ISSCAAP Group 36, Eastern Central Pacific (Area 77)

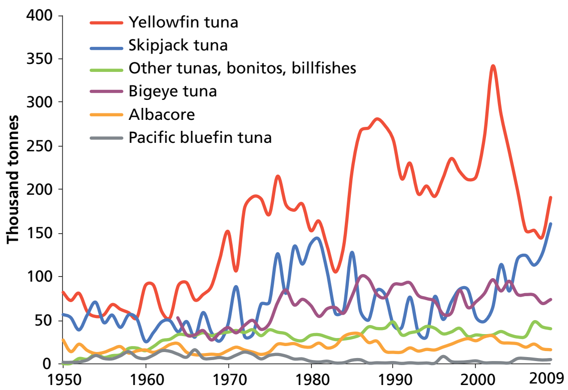
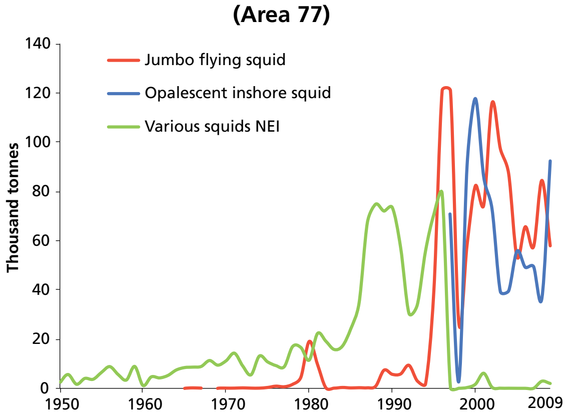


FIGURE B13.6
Annual nominal catches of selected species in ISSCAAP Groups 45 and 47, Eastern Central Pacific (Area 77)



the same trend as other congeners in the Pacific (Bakun, 1997; Csirke and Vasconcellos, 2005). At that time, the catches of the other two *Sardinops* species in the Pacific declined and have remained at very low levels after peaking in 1985 and 1988. In contrast, catches of California pilchard also peaked at 509 000 tonnes in 1989, declined to 273 000 tonnes in 1993 and then increased again to the high 683 000 tonnes in 2002 and to 729 000 tonnes in 2009. Californian anchovy yielded fairly large catches throughout the 1970s and 1980s, with a peak catch of 424 000 tonnes in 1981 (Figure B13.3). Since the 1990s, total annual catches of this species have been below 30 000 tonnes except for 2006 when catches peaked at 61 000 tonnes, only to decline to 13 000 tonnes in 2009.

Other important small pelagic species of ISSCAAP Group 35 in Area 77 are the Pacific anchoveta (*Cetengraulis mysticetus*) and the Pacific thread herring (*Opisthonema libertate*). These species are caught mostly off Panama and, since 2005, also off Mexico. Catches of these two species are also highly variable. The maximum recorded catch of Pacific anchoveta was 241 000 tonnes in 1985. Since then catches have been lower and highly variable, fluctuating between the record lows of 39 000 tonnes in 1988 and 27 000 tonnes in 1999. The largest catches of these species were 121 000 tonnes in 1989 and 108 000 tonnes in 1998. In 2008, the catch of Pacific anchoveta was 85 000 tonnes, and it was 103 000 tonnes in 2009. The catch of Pacific thread herring varied between 5 000 tonnes and 50 000 tonnes until 2004. However, when a fishery for this species started off Mexico in 2005, catches jumped to a maximum of 233 000 tonnes in 2005, with 163 000 tonnes in 2009 (Table D15).

The main mid-size pelagic species in Area 77 are the chub mackerel (*Scomber japonicus*) and the Pacific jack mackerel (*Trachurus symmetricus*) in ISSCAAP Group 37 (miscellaneous pelagic fishes). These two resources sustained important fisheries off Mexico and the United States of America in the first half of the twentieth century. Chub mackerel yielded peak catches of 67 000 tonnes in 1935. The Pacific jack mackerel fishery started later and peaked at 66 000 tonnes in 1952 (Leet *et al.*, 2001). Since then, catches of both species have been highly variable. Catches of Pacific jack mackerel have shown a clear downward trend with only 2 000 tonnes caught in 2001 and no recorded catch in 2009. Catches of chub mackerel have had prolonged periods of high and low catches, with only 12 000 tonnes in 2009 after peaking at 78 000 tonnes in 1999 (Figure B13.4). The severe decline and current low catches of Pacific jack mackerel seems to be due mostly to lack of commercial interest in this species.

Tunas and other large pelagic species in ISSCAAP Group 36 are important components of the marine fisheries in Area 77 (Figure B13.5). These species are widely distributed and highly productive. Catches of tunas also started to increase in the early 1900s, long before FAO started to gather global fish catch statistics. The total tuna catch from the South Central Pacific reached 170 000 tonnes by 1950. Total catches remained stable until the mid-1960s when they increased rapidly, peaking at 482 000 tonnes in 1976 and levelling off at about 420 000 tonnes until the early 1980s. Total tuna catch declined and increased again in 1983 and 1984, probably as a result of the strong 1982–83 El Niño. Tuna catches fluctuated between minimums of 363 000 tonnes and 371 000 tonnes in 1993 and 1994 and record highs of 570 000 tonnes and 547 000 tonnes in 2002 and 2003, respectively. The most recent recorded catch was 487 000 tonnes in 2009 (Figure B13.5). The main species of tuna caught in Area 77 are the yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*) followed by bigeye tuna (*Thunnus obesus*) and albacore (*Thunnus alalunga*). The main nations fishing for tunas in Area 77 are Mexico and the United States of America, followed by Venezuela (Bolivarian Republic of), Japan, the Republic of Korea, Spain and other Asian countries. Other large pelagic species in this ISSCAAP group being exploited in Area 77 include swordfish (*Xiphias gladius*), striped, black and blue swordfish (*Tetrapturus audax*, *Makaira indica* and *M. mazara*) and the Pacific sierra (*Scomberomorus sierra*). All together these species yield from 30 000 to 50 000 tonnes/year.

Shrimps and prawns sustain particularly valuable and important fisheries throughout Area 77. Total shrimp (ISSCAAP Group 45) catches were already at 50 000 tonnes/year when FAO catch records started in 1950. Shrimp catches reached a maximum of 86 000 tonnes in 1961, 1962 and 1963 before declining and have since fluctuated between 45 000 and 80 000 tonnes. Recent catches have declined from 73 000 tonnes in 1995–97 to between 49 000 tonnes in 2002 and 58 000 tonnes in 2009. It is worth noting that these catches represent the accumulation of a large number of stocks and more than 15 species (mostly from the genus Penaeus but also Xiphopenaeus, Trachypenaeus, Heterocarpus, Pandalus, Pandalopsis and others). Catches of each species tend to vary widely, even if most official catch statistics fail to identify them to species. The decline in catches off Central America has been particularly critical. The low catches have caused Nicaragua and El Salvador to close their shrimp fisheries completely or almost completely in recent years. At the same time, important catches of pelagic red crab (Pleuroncodes planiceps) in ISSCAAP Group 44 (king crabs, squat lobsters) have also been obtained by some countries in Central America. Total catches of up to 14 000 tonnes were made in 2005 and 4 000 tonnes and 3 000 tonnes in 2008 and 2009, respectively.

There have been large and highly variable catches of squids in ISSCAAP Group 57 in the Eastern Central Pacific. Squids represent most of ISSCAAP Group 57 landings in Area 77. These catches increased gradually from 3 000 tonnes in 1950 to 30 000 tonnes in 1980 and then rapidly increased with large year-to-year fluctuations. They peaked at 202 000 tonnes in 2000 before declining with some fluctuations to between a maximum of 190 000 tonnes in 2002 and a minimum of 107 000 tonnes in 2007, with 152 000 tonnes in 2009. The most abundant squid species in Area 77 is the jumbo flying squid (*Dosidicus gigas*). There was a rapid increase in fishing for this species with wide fluctuations in total catch, peaking at 19 000 tonnes in 1980, 121 000 tonnes in 1996 and 1997 and 82 000 tonnes and 166 000 tonnes in 2000 and 2002. The total catch of jumbo flying squid was 58 000 tonnes in 2009 (Figure B13.6). Also important in Area 77 is the market squid or opalescent inshore squid (*Loligo opalescens*). This species has been the basis of an important commercial fishery in California since the 1850s. It had a significant expansion in southern California waters in the 1980s and 1990s, to the point where it was ranked as the largest California commercial fishery by volume in six years of the 1990s (Leet *et al*., 2001). In 1981, the NMFS reported a total United States catch of market squid of 24 000 tonnes, and, since then, catches of this species have been increasing while remaining highly variable. Peak catches of 118 000 tonnes were reported in 2000, with 92 000 tonnes in 2009. Unlike squid, catches of octopus have been almost negligible in the Central Eastern Pacific. No octopus catches were reported prior to 1985, with about 1 000 tonnes most years since then and 2 000 tonnes in 2009.

There is not much of an ongoing deeper-water trawl fishery in Area 77, and the catch of flatfishes, hakes and other deep-water demersal fishes in ISSCAAP Groups 31, 32 and 34 is very low. Most of the reported catches of other more coastal demersal species (miscellaneous coastal fishes in ISSCAAP Group 33), such as croakers, groupers and snappers, are taken by small local fleets that target them or take them as bycatch in shrimp fisheries. Catches of this ISSCAAP group have been fairly stable, with 44 000 tonnes taken in 2009.

Sport fishing is becoming an important activity throughout Area 77, even if catch volumes are low. Well established off the United States of America, sport fishing has expanded along the coasts of Mexico and lately also in Central America. Target species for this fishery include tunas, billfishes and other large and mid-size pelagic fishes, and also coastal demersal species.

RESOURCE STATUS AND FISHERY MANAGEMENT

Tunas and other highly migratory species are exploited by both local fleets as well as distant-water fleets. Most of these tunas and other highly migratory species are assessed and managed through multinational efforts. The majority of these efforts have been made through the Inter-American Tropical Tuna Commission (IATTC, www.iatc.org). Fisheries for most other species groups are assessed and managed nationally. There have also been several regional and multinational initiatives to investigate, assess and manage some of the main shared, transboundary and high seas fisheries in the region.

The IATTC was established in 1950 and is responsible for the conservation and management of fisheries for tunas and other species taken by tuna-fishing vessels in the eastern Pacific Ocean. The IATTC is based in La Jolla, the United States of America. It has a long-standing tradition and experience in the resource assessment, monitoring and management of fisheries for the main tuna and other associated highly migratory species in Area 77. All main coastal States in Area 77 and most of the other States fishing for tunas in Area 77 are members of this regional organization.

Of particular relevance in the fisheries research context is the California Cooperative Ocean Fisheries Investigation Program (CalCOFI, www.calcofi.org) established in 1949. The programme is a partnership of the US Scripps Institution of Oceanography, the Coastal Fisheries Resources Division of the Southwest Fisheries Science Centre of NOAA/NMFS, and the California Department of Fish and Game. It aims at establishing and analysing long time-series of land-based and sea-going observations to monitor the physics, chemistry, biology and meteorology of the California Current ecosystem. It does so in cooperation with several Mexican institutions (including Centro de Investigación Científica y de Educación Superior de Ensenada, Universidad Autónoma de Baja California, Centro Interdisciplinario de Ciencias Marinas, Instituto Nacional de la Pesca, Centro de Investigaciones Biológicas del Noroeste, and Universidad Nacional Autónoma de México). These institutions are grouped under an interinstitutional project on Mexican Research of the California Current (Investigaciones Mexicanas de la Corriente de California, http://imecocal.cicese.mx). The project complements and extends the CalCOFI type of investigations to the southern part of the California current system.

There have also been a series of regional research activities covering fish stocks and fisheries further south, off Central America and Panama. Several of these activities were conducted with the technical or financial assistance of one or more international, regional or subregional organizations, such as the European Commission, FAO, Norwegian Agency for Development Cooperation, Swedish International Development Cooperation Agency, OLDEPESCA, Programa Regional de Apoyo al Desarrollo de la Pesca en el Istmo Centroamericano, and the United Nations Development Programme. Although more research needs to be done, particularly in terms of fisheries management, important progress has been made through these regional fisheries research and assessment programmes. Of particular relevance for the development of fisheries in Area 77 was the establishment of the Central American Organisation for the Fisheries and Aquaculture Sector (OSPESCA, www.sica.int/ospesca) in December 1995 by all the Central American States and Panama. This regional organization has the development and management of fisheries in Central America as one of its main objectives. It joined the General Secretariat of the Central American Integration System (Secretaría General del Sistema de la Integración Centroamericana [SICA], www.sica.int) in November 1999. It has been playing an instrumental role in promoting regional agreements for the adoption of harmonized approaches and coordinated fisheries research programmes and management measures by its members, particularly with respect to shared fish stocks. Its work is guided by a regional council of ministers composed of the ministers responsible for fisheries and aquaculture matters in the seven member countries of SICA-OSPESCA (SICA-OSPESCA, 2005). One of its main achievements has been the establishment of a common fisheries and aquaculture integration policy for the Central American isthmus, which has been implemented since 2005. Important progress is also being made towards the establishment of an integrated fishery and aquaculture central registry, the harmonization of fisheries management measures and other aspects of relevance for fisheries and aquaculture in the region.

The knowledge and available information on the status of the main fish stocks in Area 77 varies widely. This status is summarized in Table D15. The state of knowledge is related to some extent to the importance of the fisheries involved and the research facilities available. Most fisheries are subject to some kind of fisheries management regulation, which may include one or more of the traditional management measures, such as limited access, catch limits or TAC, area or seasonal closures, or minimum size limits of fish. The implementation of these regulations has contributed to the healthy maintenance and, in some cases, to the rebuilding of several key stocks in Area 77. In others, poor management and loose enforcement have contributed to the overexploitation and depletion of some important local shrimp stocks. Some of the most recent fisheries management regulations adopted to recover depressed shrimp fisheries in Central America have apparently been hampered by adverse environmental conditions. These conditions have caused a decline in rainfall and coastal runoff, which are important for enrichment of coastal waters (FIINPESCA, 2010).

More detailed and comprehensive information on the state of the main tuna and tuna-like highly migratory fish stocks and fisheries in Area 77 can be found in the IATTC assessment reports (IATTC, 2010, 2011) and in Chapter C1 of this review. Further information on the state of fish stocks and fisheries for these and other more coastal species can also be found in the California Department of Fish and Game, Living Marine Resources status reports (Leet *et al*., 2001; Ryan and Patyten, 2004; Barsky, 2008; Larinto, 2010), the Mexican stock assessment fisheries management reports (SEMARNAP-INP, 2000, 2003; SAGARPE-INP, 2006, 2010) and some working group reports presented in the context of regional meetings in the OSPESCA area. A brief status summary for the main stocks or species groups found in Area 77 based on these published reports and other information available is included in this section and in Table D15.

As already noted, fishing for deeper-water demersal fishes is limited and almost non-existent in parts of the Eastern Central Pacific. Resource surveys seem to indicate that deeper-water demersal fishes in ISSCAAP Groups 32 and 34 including hakes, rockfishes and scorpionfishes are not particularly abundant. While some stocks may remain moderately or non-fully exploited and even unexploited, most stocks are believed to be fully exploited. A few local stocks, particularly rockfishes in ISSCAAP Group 34, appear to have been severely reduced through overfishing and are assessed as overexploited.

Most coastal demersal species in ISSCAAP Group 33 (miscellaneous coastal fishes) are in most cases underexploited if one considers their directed fisheries. However, when the indirect effects of shrimp fisheries on these species are taken into account, they tend to be overexploited. This is because demersal fish (particularly juveniles) form a large portion of the bycatch.

It is well known that populations of small pelagic species in ISSCAAP Group 35 (herrings, sardines, anchovies) are subject to large environmentally driven fluctuations in their abundance. Since their low biomass levels in the 1950s and 1960s, the Californian pilchard (sardine) stocks have been recovering, and overall California pilchard abundance and catches have been increasing with some noticeable fluctuations. The Californian pilchard (sardine) is thought to comprise three subpopulations or stocks with the more northern subpopulation ranging from British Columbia, Canada, to northern Baja California, Mexico. The southern subpopulation ranges from the outer coastal region of Baja California to southern California and there is a subpopulation confined to the Gulf of California. Although the ranges of the northern and southern subpopulations overlap, all United States, Canada and Ensenada (Mexico) landings are believed to be taken from the northern stock. The remaining Mexican landings are taken from the southern and Gulf of California stocks.

Research seems to indicate that the northern Californian pilchard (sardine) stock population has recovered from a biomass well below 100 000 tonnes in the early 1960s to a total biomass (of age 1+) estimated at 1.0–1.7 million tonnes in the late 1990s and early 2000s. After that, the biomass of pilchards stabilized and started to decline to an estimated 0.54 million tonnes in 2010 (Conser *et al*., 2002; Hill *et al*., 2007, 2010). The southern stock seems to be more stable and has even maintained a slight increasing trend. The Gulf of California stock, which supports most of the Mexican landings of this species, also started to increase in the mid-1970s. However, unlike the northern stock, it seems to have maintained its upward trend. Under the current fishing conditions, the three stocks are considered to be moderately to fully exploited.

The total biomass and resulting catches of Californian anchovy had a noticeable increase in the early and mid-1970s but then declined in the early 1980s. This decline was partly the result of heavy fishing but also a consequence of adverse environmental conditions that are known to determine natural long-term fluctuations in stock abundance of this and similar species. In the recent past, the Californian anchovy has been fully to heavily exploited off Mexico and moderately to almost underexploited off the United States of America. There have been some signs of an increase in biomass of anchovy in the Gulf of California. Northern and central subpopulations are thought to be stable at lower biomass levels, mostly driven by environmental factors as fishing appears to be exerting only moderate pressure. Overall, the stocks of California anchovy are considered to be moderately to fully exploited.

The Pacific anchoveta stock has also been very variable, as reflected in the annual catches of the major industrial fishery in Panama. At the present level of exploitation (85 000 tonnes in 2008 and 103 000 tonnes in 2009), this stock is probably fully exploited.

Historically, Pacific thread herring catches were only reported in substantial quantities by Panama, with occasional catches by Costa Rica. Since 2005, there have been significant landings of Pacific thread herring by Mexico. This species is probably fully exploited off Panama and Mexico, while it is either not exploited or underexploited elsewhere in its distribution range.

The status of tuna, bonitos, billfishes, etc. (ISSCAAP Group 36) is reviewed in another section (Chapter C1) considering their wider distribution in the Pacific Ocean.

However, these stocks are considered overall to be moderately to fully exploited in Area 77.

Among the miscellaneous pelagic fishes (ISSCAAP Group 37), chub mackerel has recovered slightly although still remaining at a very low biomass after collapsing in the late 1960s. While the biomass has remained low, there were some indications of a slight increase in the abundance of the year class in 2000 and 2001 (Hill *et al*., 2002). Given the current catch rates, the stock is to be considered moderately exploited. There are no recent biomass estimates for Pacific jack mackerel for Area 77. However, there are some indications that its total biomass has declined substantially in the last three decades, probably owing to natural environmental causes. This species currently has a very low commercial value and minimum or no fishing effort is exerted on this stock. Given the small catches reported, with no catches reported in 2008 and 2009, it is most probable that the stock is moderately or even underexploited, although its biomass is small.

Among the invertebrates, there are some deepwater shrimps (mostly Galatheidae) within ISSCAAP Group 44 that are virtually unexploited. However, most of the main wild stocks of crabs and sea-spiders (ISSCAAP Group 42) and particularly shrimps and prawns (in ISSCAAP Group 45) are either fully exploited or overexploited. In some species, local stocks are showing signs of depletion. Other invertebrates such as squids (ISSCAAP Group 57) are also relatively abundant in Area 77. In particular, the jumbo flying squid (*Dosidicus gigas*) and the opalescens squid (*Loligo opalescens*) are abundant. Although the abundance and resulting catches of jumbo flying squid fluctuate widely, the stock is well monitored and management measures are applied to allow a 40 percent minimum spawning stock escapement, making the stock moderately to fully exploited. The abundance of the opalescens squid is also highly variable. Although there are no reliable biomass estimates, evidence from studies on paralarvae, egg beds, behaviour, genetics and catch data suggest that its biomass is large and may probably be moderately exploited.

ACKNOWLEDGEMENTS

I would like to thank Renato Guevara, Instituto del Mar del Peru (IMARPE), Callao, Peru, Sergio Martínez, Programa Manejo de Recursos Pesqueros y Alternativas Económicas (Programa MAREA), San Salvador, El Salvador, and Traci Larinto, Department of Fish and Game, Los Alamitos, California, U.S.A. for their critical review and constructive comments that improved upon an earlier version of the manuscript.

REFERENCES

Bakun, A. 1993. The California current, Benguela current, and Southwestern Atlantic Shelf ecosystems: a comparative approach to identifying factors regulating biomass yields. *In* K. Sherman, L.M. Alexander & B.D. Gold, eds. *Large marine ecosystems, stress, mitigation and sustainability*, pp. 199–222. Washington, DC, American Association for the Advancement of Science.

Bakun, A. 1997. Global synchrony in fish population variations. *In* FAO, Marine Resources Service, Fishery Resources Division. *Review of the state of world fishery resources: marine fisheries*, pp. 134–135. FAO Fisheries Circular No. 920. Rome, FAO. 173 pp.

Bakun, A., Csirke, J., Lluch-Belda, D. & Steer-Ruiz, R. 1999. The Pacific Central American Coastal LME. *In* K. Sherman & Q. Tang, eds. *Large marine ecosystems of the Pacific rim*, pp. 268–280. Cambridge, USA, Blackwell Science.

Barsky, K., ed. 2008. Status of the fisheries report – an update through 2006. In: *California Department of Fish and Game* [online]. 153 pp. [Cited 20 December 2011]. www.dfg.ca.gov/marine/status

California Department of Fish and Game. 2002. *Review of some California fisheries for 2001: market squid, sea urchin, Dungeness crab, lobster, prawn, abalone, groundfish, swordfish and shark, coastal pelagic finfish, ocean salmon, nearshore live-fish, Pacific herring, white seabass, and kelp*. Fisheries Review CalCOFI Rep. Vol. 43. 18 pp.

Conser, R.J., Hill, K.T., Crone, P.R., Lo, N.C.H. & Bergen, D. 2002. *Stock assessment of Pacific sardine with management recommendations for 2003. Executive summary. October 2002*. Submitted to the Pacific Fishery Management Council. USA, California Department of Fish and Game and NOAA/NMFS. 11 pp.

Csirke, J. 1995. Fluctuations in abundance of small and mid-sized pelagics. Scientia Marina 59(3-4): 481-490.

Csirke, J. & Vasconcellos, M. 2005. Fisheries and long-term climate variability. *In* FAO. *Review of the state of world marine fishery resources*, pp. 201–211. FAO Fisheries Technical Paper No. 457. Rome, FAO.

Fortalecimiento de la Investigación Interdisciplinaria para la Pesca Responsable en los Países Centroamericanos (FIINPESCA). 2010. *Informe Final de La Consultoría en Evaluación y Ordenación de Recursos Pesqueros*, por Renato Guevara, Consultor. Proyecto GCP/RLA/150/SWE FAO/OSPESCA/SUECIA para FIINPESCA. San Salvador. 229 pp.

Gulland, J.A., ed. 1970. *The fish resources of the ocean*. FAO Fisheries Technical Paper No. 97. Rome, FAO. 425 pp.

Hill, K.T., Bergen, D.R. & Crone, P.R. 2002. *Stock assessment of Pacific mackerel with recommendations for the 2002–2003 management season. Executive summary. 31 May 2002*. Submitted to the Pacific Fishery Management Council. USA, California Department of Fish and Game and NOAA/NMFS. 13 pp.

Hill, K.T., Dorval, E., Lo, N.C.H., Macewicz, B.J., Show, C. & Felix-Uraga, R. 2007. *Assessment of the Pacific sardine resource in 2007 for U.S. management in 2008*. NOAA Technical Memorandum NMFS, NOAA-TM-NMFS-SWFSC-413. 183 pp.

Hill, K.T., Lo, N.C.H., Macewicz, B.J., Crone, P.R. & Felix-Uraga, R. 2010. *Assessment of the Pacific sardine resource in 2010 for U.S. management in 2011*. NOAA Technical Memorandum NMFS, NOAA-TM-NMFS-SWFSC-469. 142 pp.

Inter-American Tropical Tuna Commission (IATTC). 2010. Status of the tuna and billfish stocks in 2009. Stock Assessment Report No. 10. In: *IATTC* [online]. [Cited 20 December 2011]. www.iattc.org/StockAssessmentReports/StockAssessmentReportsENG.htm

Inter-American Tropical Tuna Commission (IATTC). 2011. Status of the tuna and billfish stocks in 2009. Stock Assessment Report No. 11. In: *IATTC* [online]. [Cited 20 December 2011]. www.iattc.org/StockAssessmentReports/StockAssessmentReportsENG.htm.

Kawasaki, T. 1983. Why do some pelagic fishes have wide fluctuations in their numbers? Biological basis of fluctuation from the viewpoint of evolutionary ecology. *In* G.D. Sharp & J. Csirke, eds. *Proceedings of the Expert Consultation to examine changes in abundance and species composition of neritic fish resources. San José, Costa Rica, 18–29 April 1983*, pp. 1065–1080. FAO Fisheries Report No. 291, Vol. 3. Rome, FAO. pp. 557–1224.

Larinto, T., ed. 2010. Status of the fisheries report – an update through 2008. In: *California Department of Fish and Game* [online]. 232 pp. [Cited 20 December 2011]. www.dfg.ca.gov/marine/status

Leet, W.S., Dewees, C.M., Klingbeil, R. & Larson, E.J., eds. 2001. California's living marine resources: a status report. In: *California Department of Fish and Game* [online]. 594 pp. [Cited 20 December 2011]. www.dfg.ca.gov/marine/status

Lluch-Belda, D., Lluch-Cota, D.B. & Lluch-Cota, S.E. 2005. Changes in marina faunal distributions and ENSO events in the California Current. *Fisheries Oceanography*, 14: 458–467.

Lluch-Belda, D., Hernandez-Vazquez, S., Salinas-Zavala, C. & Shwartzlose, R. 1992. The recovery of the California sardine as related to global change. *California Cooperative Oceanic Fisheries Investigations Reports*, 33: 50–59.

Lluch-Cota, S.E., Parés-Sierra, A., Magaña-Rueda, V.O., Arreguín-Sánchez, F., Bazzino, G., Herrera-Cervantes, H. & Lluch-Belda, D. 2010. Changing climate in the Gulf of California. *Progress in Oceanography*, 87: 114–126.

MacCall, A.D. 1983. Variability of pelagic fish stocks off California. *In* G.D. Sharp & J. Csirke, eds. *Proceedings of the Expert Consultation to examine changes in abundance and species of neritic fish resources. San José, Costa, Rica, 18–29 April 1983*, pp. 101–112. FAO Fisheries Report No. 291(2). Rome, FAO. 553 pp.

Murphy, G. 1966. Population biology of the Pacific sardine (*Sardinops caerulea*). *Proceedings of the California Academy of Sciences*, 34: 1–84.

Parrish, R.H., Bakun, A., Husby, D.M. & Nelson, C.S. 1983. Comparative climatology of selected environmental processes in relation to eastern boundary current pelagic fish reproduction. *In* G.D. Sharp & J. Csirke, eds. *Proceedings of the Expert Consultation to examine changes in abundance and species of neritic fish resources. San José, Costa, Rica, 18–29 April 1983*, pp. 731–778. FAO Fisheries Report No. 291. Rome, FAO. pp. 557–1224.

Ryan, C. & Patyten, M., eds. 2004. Annual status of the fisheries report through 2003. In: *California Department of Fish and Game* [online]. 182 pp. [Cited 20 December 2011]. www.dfg.ca.gov/marine/status

Secretaría de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentacion – Instituto Nacional de la Pesca (SAGARPA-INP). 2006. *Sustentabilidad y pesca responsable en México. Evaluación y Manejo* [online]. 560 pp. [Cited 20 December 2011]. www.inapesca.gob.mx/portal/documentos/publicaciones/pelagicos/libro_Rojo.pdf

Secretaría de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentacion – Instituto Nacional de la Pesca (SAGARPA-INP). 2010. Carta Nacional Pesquera. In: *SAGARPA-INP* [online]. 318 pp. [Cited 20 December 2011]. www.inapesca.gob.mx

Secretaría de Medio Ambiente, Recursos Naturales y Pesca – Instituto Nacional de la Pesca (SEMARNAP–INP). 2000. *Sustentabilidad y pesca responsable en México. Evaluación y Manejo. 1997–1998*. 691 pp.

Secretaría de Medio Ambiente, Recursos Naturales y Pesca – Instituto Nacional de la Pesca (SEMARNAP–INP). 2003. Sustentabilidad y pesca responsable en México. Evaluación y Manejo. 1999–2000. In: *SEMARNAP–INP* [online]. 1112 pp. [Cited 20 December 2011]. http://inp.semarnat.gob.mx/Publicaciones/sustentabilidad/default.htm

Sistema de la Integración Centroamericana – Organización del Sector Pesquero y Acuícola de Centroamerica (SICA-OSPESCA). 2005. *Fisheries and Aquaculture Integration Policy for the Central American Isthmus*. 24 pp.

Troadec, J.-P., Clark, W.G. & Gulland, J.A. 1980. A review of some pelagic fish stocks in other areas. *Rapports et Proces-verbaux des Réunions. Conseil international pour l'éxploration de la mer*, 177: 252–277.

Wyrtky, K. 1964. Upwelling in the Costa Rica dome. *Fishery Bulletin US*, 63: 355–372.

B14. Southwest Pacific

FAO STATISTICAL AREA 81

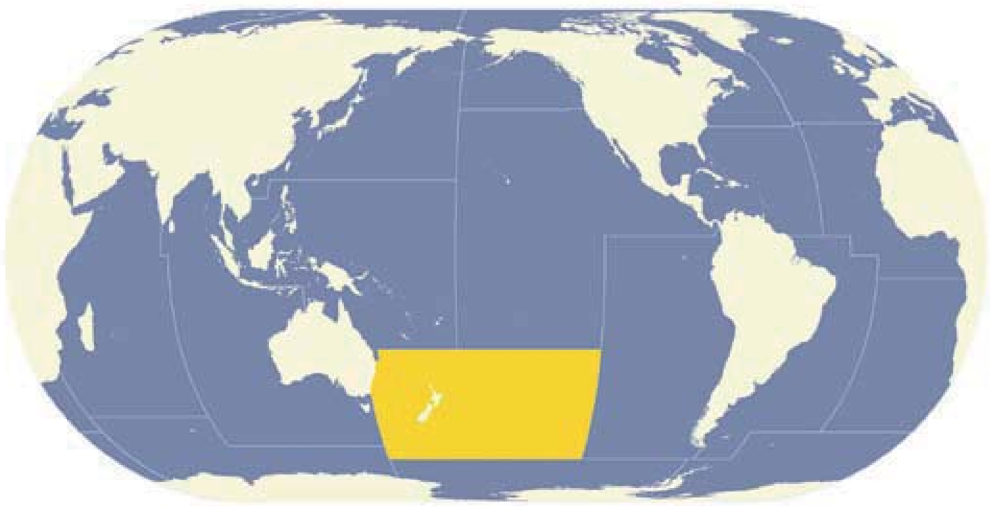
Yimin Ye
Senior Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: yimin.ye@fao.org

INTRODUCTION

FAO Statistical Area 81 includes the Tasman Sea and the Pacific Ocean from the 150°E to the 120°E meridians (Figure B14.1). The total surface area is 27.7 million km^2 with only 0.4 million km^2 of shelf area. In the Tasman Sea, the well-defined East Australian Current flows south along the east coast of Australia but becomes weaker and diffused south of Sydney. Part of this current system turns east after coming in contact with the more southerly West Wind Drift along the northern edges of the Southern Ocean and southern margin of the Tasman Sea. It then turns north along the two coasts of the South Island of New Zealand. On the east coast of New Zealand, this current encounters the south-flowing East Cape Current. Where the two currents meet, they mix and move offshore to form the Wairarapa Gyre. This gyre is strongest north of the Chatham Rise, a raised part of the sea bed extending to the Chatham Islands farther east.

The region is mostly deep oceanic water, with many seamounts where bathypelagic fish resources such as orange roughy and oreos are exploited. Within the region, there are two shallower plateaus of about 200–1000 m in depth. The largest is the Campbell Plateau, which occurs to the southeast of New Zealand below 46°S. The second, the Lord Howe Rise, is shallower and extends from the centre of New Zealand in a northwesterly direction. This rise continues to the eponymous mid-Tasman Sea islands. The types of habitats that are exploited in this region are very varied. It supports a

FIGURE B14.1
The Southwest Pacific (Area 81)



wide range of fisheries, from coastal continental to deep-water seamount fisheries. In fact, New Zealand and, to a lesser extent, Australia have been pioneers in developing profitable and sustainable deepwater (> 600 m) trawl fisheries. The fisheries within Australian jurisdiction consist of the coastal species of the Australian states of New South Wales, northern Victoria and offshore Tasmania. For New Zealand, there are two main fishing sectors. The first targets pelagic resources in the Southwest Pacific. The second important fishing sector focuses on the bathypelagic species associated with the sea bottom rises from the Tasman Sea east to the south, and east of the South Island of New Zealand. The most important species caught in these fisheries are orange roughy (*Hoplostethus atlanticus*) and hoki (*Macruronus novaezelandiae*).

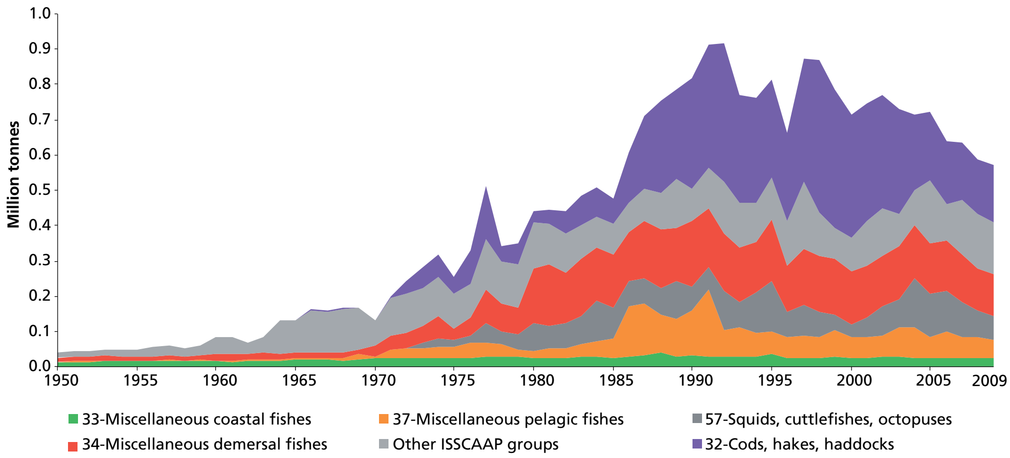
PROFILE OF CATCHES

Nominal catches from the Southwest Pacific increased from less than 50 000 tonnes in 1950 to 917 000 tonnes in 1992 and then gradually declined to 600 000 tonnes in 2009 (Figure B14.2, Table D16). Five taxonomic groups account for 81 percent of the catches: gadids (30 percent), miscellaneous demersal fishes (21 percent), miscellaneous pelagic fishes (11 percent), squids, cuttlefishes and octopuses (10 percent), and tunas, bonitos and billfishes (8 percent) (Figure B14.2).

There are only two countries in Area 81, Australia and New Zealand (Figure B14.1). However, 20 countries and areas/territories have been involved in fishing in the Southwest Pacific region in the past. These include Australia, Canada, China, the Cook Islands, Estonia, Georgia, Japan, the Republic of Korea, Latvia, Lithuania, New Zealand, Norway, Pitcairn Islands, Poland, the Russian Federation, Spain, Taiwan Province of China, Ukraine, the Union of Soviet Socialist Republics, and the United States of America. New Zealand has the largest landings, with a peak of 650 000 tonnes in 1998 and 420 000 tonnes in 2009. Japan caught the second-largest volume in Area 81 and landed 300 000 tonnes in 1988, but withdrew after 2006. Australia's landings from Area 81 increased gradually from 10 000 tonnes in 1950 to 30 000 tonnes in 1985, and then experienced a rapid growth to a peak of 80 000 tonnes in 1990. The total catch then fell sharply to about 20 000 tonnes in 2009. The Republic of Korea also has a strong presence in Area 81. Its catch increased rapidly from zero in 1964 to 60 000 tonnes in 1978. After a period of dramatic decline in the early 1980s, the catch recovered to about 50 000 tonnes in 2009 (Figure B14.3).

About 30 percent of the total landings in Area 81 are of ISSCAAP Group 32 (cods, hakes, haddocks) (Figure B14.4). Within this group, the largest catch is of blue

FIGURE B14.2
Annual nominal catches by ISSCAAP species groups in the Southwest Pacific (Area 81)



grenadier. Catches of this species were first recorded in 1973 and quickly increased to about 300 000 tonnes by 1998. However, the landings of gadids dropped rapidly after the peak to under 100 000 tonnes in 2009. Southern blue whiting is the second most fished species of Group 32. Its landings vary greatly from year to year. Although the catch of southern blue whiting peaked at 80 000 tonnes in 1992, the landings in 2009 were close to 50 000 tonnes and similar to those recorded in the early 1970s. Red codling and southern hake are ranked the third- and fourth-most important species with peak catches between 15 000 and 20 000 tonnes. The fisheries for these four main species all experienced clear declines in catch after 2000.

Orange roughy, snoek, oreo dories NEI, and demersal percomorphs NEI are the top four species groups of ISSCAAP Group 34 (miscellaneous demersal fishes) in Area 81. They contribute 21 percent of the total catches (Figure B14.2). Orange roughy was not recorded in the catch before 1979. After that time, its catch increased rapidly to reach a record high of more than 80 000 tonnes in 1990 (Figure B14.5). A dramatic decline in catch followed almost immediately, with only 10 000 tonnes landed in 2009. Snoek catch has increased quite steadily since 1970 to 25 000 tonnes in 2009, with the exception of a single large catch of about 60 000 tonnes in 1978. The catch of oreo NEI maintained an average of 20 000 tonnes from the late 1970s to 2000. This has decreased slightly to an average of 16 000 tonnes in the last ten years. Catches of demersal percomorphs NEI fluctuated in the 1970s and experienced a continuous decline after reaching a peak of about 35 000 tonnes in 1982.

Wellington flying squid and various squids NEI sustain the highest catches of ISSCAAP Group 57. They make the third-largest contribution to catches in Area 81. The landings of Wellington flying squid have varied greatly between 20 000 tonnes and 100 000 tonnes, and were about 50 000 tonnes in 2009 (Figure B14.6). In contrast, the catch of various squids NEI have fluctuated widely since recording began. However, they have declined overall from a peak of 70 000 tonnes in 1980 to 20 000 tonnes in 2009.

The catch of greenback horse mackerel is the largest among the species in ISSCAAP Group 37. Its total catch was quite high between 1985 and 1990, with an average catch of 100 000 tonnes.

FIGURE B14.3
Annual nominal catches by major fishing countries, Southwest Pacific (Area 81)

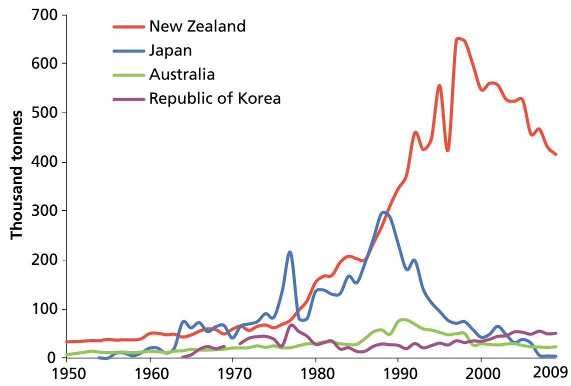


FIGURE B14.4
Annual nominal catches of selected species in ISSCAAP Group 32, Southwest Pacific (Area 81)

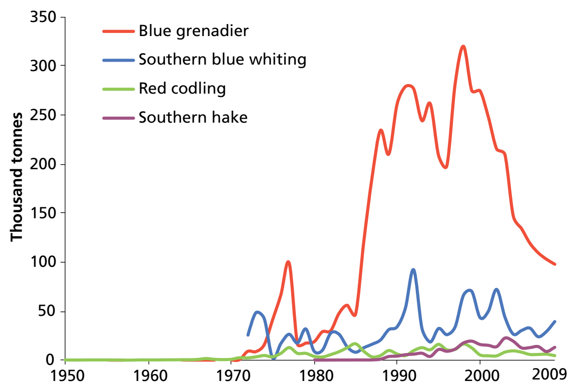
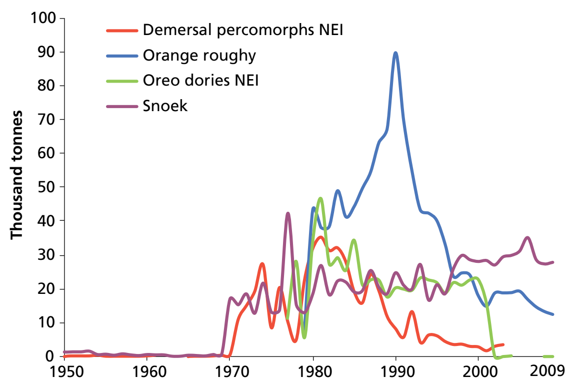


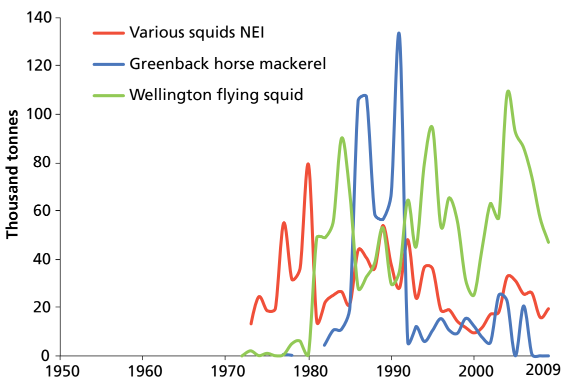
FIGURE B14.5
Annual nominal catches of selected species from ISSCAAP Group 34, Southwest Pacific (Area 81)



RESOURCE STATUS AND FISHERY MANAGEMENT

South West Pacific (Area 81) has only two coastal countries, Australia and New Zealand. Most of the catch is taken by New Zealand fisheries as this region covers only a small portion of Australia's EEZ. Other countries are mainly involved in high seas fishing in the region. Australia and New Zealand are often referred to as good examples in fisheries management. They have established clear fisheries policy and have fishery management plans for the long-term sustainability of fisheries in their

FIGURE B14.6
Annual nominal catches of selected species from ISSCAAP Group 57, Southwest Pacific (Area 81)



EEZs. Each country undertakes assessments of the state of major fish stocks and its fisheries each year. Annual reports are published and available to the public on government Web sites. Both countries have implemented strong rights-based fisheries management policies that are widely applied to a large number of stocks and species.

This section discusses the stock status of the major fish species that contribute large catches and have stock assessments completed (Table D16). The management issues of the fisheries for these species will be assessed separately for Australia and New Zealand. Further information on deep-sea fisheries is given in the Chapter C3.

Australia

Management of Australia's fisheries is complex as there is a mix of responsibility between the commonwealth and state governments. The states manage all fisheries out to 3 nautical miles from shore and the commonwealth manages those beyond that to the 200-mile limit. State fisheries account for about 70 percent of total catches in Australia, and the commonwealth fisheries make up the remaining 30 percent (Partners, 2010).

The Government of Australia's approach to fisheries management aims to "ensure that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development (ESD) and the exercise of the precautionary principle, in particular the need to have regard to the impact of fishing activities on non-target species and the long-term sustainability of the marine environment", as required under the Fisheries Management Act 1991 (FMA).

The commonwealth fisheries are managed by the Australian Fisheries Management Authority (AFMA). The Government of Australia's directions within the Commonwealth Fisheries Harvest Strategy: policy and guidelines (HSP; DAFF 2007) dictate that commonwealth fisheries need to be managed in both biological and economic terms. The HSP requires that harvest strategies be developed that pursue maximum economic yield for each commonwealth fishery (Wilson, Curtotti and Begg, 2010). Fish stock status and fishery economic state of commonwealth fisheries are reviewed and reported annually in the Fishery Status Reports.

The HSP provides a framework that allows a more strategic, science-based approach to setting fishery-by-fishery TAC levels in all commonwealth fisheries. A total of 101 stocks or species groups caught in commonwealth fisheries were assessed in 2009. These assessments had four tiers of assessment methods, including classic stock assessment and empirical indicator methods (Wilson, Curtotti and Begg, 2010).

Fisheries within three nautical miles of the coast are mostly managed by state and territory governments. In some fisheries, the states and commonwealth share the fisheries management responsibilities. This has resulted in state and territory governments managing fisheries that are partly within commonwealth waters under the terms of the Offshore Constitutional Settlement (Partners, 2010). Each state or territory has its own management plans for major fisheries and annual fishery status reports are published on its Web sites.

Blue grenadier

The long-term recommended biological catch (RBC) of blue grenadier estimated by the Slope Resource Assessment Group (SlopeRAG) was 4 700 tonnes (SlopeRAG, 2010).

The agreed TAC (global) set by the AFMA Commission for the 2009–10 fishing season was 4 700 tonnes. However, the actual TAC (global) was 4 851 tonnes once carryover of uncaught quota was taken into account. The 2009–10 total catch was 3 281 tonnes. There are two distinct blue grenadier fisheries: a fishery targeting spawning aggregations off western Tasmania between late May and early September, and a non-spawning fishery where the catch is caught during general commonwealth trawl sector (CTS) trawling. In 2008–09, the spawning fishery caught 70 percent of the CTS catch.

An age-structured, integrated assessment model for blue grenadier was last updated in 2008, with data up to 2007. The 2008 model estimated that the female spawning biomass was at $0.71B_0$ (71 percent of the unfished biomass) in 2007. This was projected to decline to $0.5B_0$ in 2009 if catches followed the RBC, as the abundance of strong cohorts from the mid-1990s declined. Most recent catch has taken from the relatively less abundant younger cohorts. The model suggested that the long-term RBC would be about 4 700 tonnes.

SlopeRAG examined standardized CPUE from the non-spawning fishery (Haddon, 2010a), the results of the 2008 acoustic biomass survey (SlopeRAG, 2010) and the size and age composition data (Hobsbawn, 2009). The size and age composition indicate that a new, relatively strong cohort is starting to enter the fishery. Taken together, these indicators and the projection from the 2008 assessment do not raise concerns. The stock remains assessed as not overfished in 2009, and current catch levels indicate that the stock is not subject to overfishing (Stobutzki *et al.*, 2010).

Orange roughy

Orange roughy is distributed in the Cascade Plateau, and the east, south and west zones, but its stock structure in Australia remains unclear despite considerable research. It is also worth noting that the south and west zones are not part of FAO Statistical Area 81. The assessments for orange roughy in the east, south and west zones were formally examined in 2008. There is no targeted fishing for orange roughy in these zones. Given the low recent catches (TACs only reflect incidental catch or catch taken under scientific permits) and the closures that have been introduced, all the zones except the Cascade Plateau remain assessed as overfished but not subject to overfishing in 2009.

The assessment for orange roughy on the Cascade Plateau was updated in 2009 based on new examination of the biomass estimate from the 2005 survey. When the biomass estimate was re-evaluated, it was found to include acoustic marks that were probably not orange roughy, which resulted in an overestimate of biomass. The new estimate of biomass in 2005 is now 18 000 tonnes (down from 31 000 tonnes), which results in an RBC of 315 tonnes. However, the assessment also indicated that the stock is at 64 percent of unfished levels, which is above the limit reference point required under the Orange Roughy Conservation Programme (ORCP) (AFMA, 2006). In addition, and in contrast to the past two years, the acoustic survey showed defined spawning marks of orange roughy on the Cascade Plateau. As it has been determined that the stock is above the limit reference point, and 2009 catches are below the RBC (465 tonnes), Cascade Plateau orange roughy remains assessed as not overfished and not subject to overfishing (Stobutzki *et al.*, 2010).

Pink cusk-eel (pink ling)

An age-structured, integrated stock assessment model for pink cusk-eel was updated in 2009 with data up to 2008 (Taylor, 2010). The model assumes separate stocks east and west of Bass Strait and incorporates the standardized CPUE series from the trawl sector (Haddon, 2010a) and non-trawl sector (2003–08 in the east, 2002–08 in the west) and the fisheries research vessel *FRV Kapala* surveys (Graham, Andrew and Hodgson, 2001).

The 2009 assessment incorporated some significant changes. In particular, depth was included as a factor in the CPUE standardization (Haddon, 2010a). The year up to which recruits were estimated by the model was changed from five years before the latest assessment to three years (east) and four years (west). The model also used a different approach to capture suspected changes in the targeting behaviour by trawlers that may have affected the trawl CPUE. The 2009 assessment is more optimistic than the 2008 assessment, estimating the spawning biomass at the start of 2008 to be $0.37B_0$ in the east and $0.49B_0$ in the west (Taylor, 2010). This compares favourably with the estimates of $0.28B_0$ in the east and $0.33B_0$ in the west in the 2008 assessment. The most recent assessments (2008 and 2009) do not suggest that the biomass in either region has declined below the limit reference point. Therefore, both stocks are assessed as not overfished, although the eastern stock requires some rebuilding to the target biomass (Stobutzki *et al*., 2010).

Silver gemfish

Silver gemfish (gemfish in Australia) are found from Cape Moreton (Queensland) to Western Australia, including Tasmania. They also occur in New Zealand, but this appears to be a genetically separate stock. In Australian waters, there are two genetically separate stocks. One stock is found on the east coast within Area 81 and the second occurs from the western Bass Strait to Western Australia. This second stock is found outside Area 81, with limited mixing off western Tasmania.

The RBC for western gemfish calculated by SlopeRAG was 102 tonnes for the 2009–2010 fishing season (SlopeRAG, 2010). The 2009–2010 agreed TAC was 125 tonnes; yet the actual TAC was 135 tonnes after the carryover of uncaught quota was taken into account (Stobutzki *et al*., 2010). The current assessment (Tier 4) suggests that the current CPUE is above the limit reference point and below the target (Haddon, 2010b). However, given the ongoing concern regarding the fact that the Great Australian Bight Trawl Survey data had not been taken into account in the assessment, western gemfish remain assessed as uncertain with regard to whether they are overfished and whether overfishing is occurring (Stobutzki *et al*., 2010).

In 2009, the assessment of eastern gemfish was moved to the SS3 modelling framework and updated with 2008 survey data (there was no survey in 2009; Little, 2010). The 2008 SSB was estimated to be $0.15B_0$ (15 percent of unexploited levels), which was similar to the level estimated by the previous assessment. Therefore, eastern gemfish remain assessed as overfished because the current biomass is below the $0.20B_0$ limit reference point (Stobutzki *et al*., 2010).

South Pacific breams NEI (blue warehou)

Catches of South Pacific breams (*Seriolella* spp.) consist of blue warehou (*Seriolella brama*) and silver warehou (*Seriolella punctata*). Blue warehou are typically found in southeast Australia (New South Wales, Victoria, Tasmania and South Australia) and New Zealand. There are two stocks targeted in the Southern and Eastern Scalefish and Shark Fishery, east and west of Bass Strait. Significant catches of blue warehou have been made by Tasmanian fishers.

The Tier 4 assessment for blue warehou was updated in 2009 (Haddon, 2010b). Separate Tier 4 assessments are undertaken for the east and west stocks. The target reference point was the average CPUE from the reference period 1986–1995, and the limit reference point was 40 percent of this target. The recent standardized CPUE series for both east and west stocks was below the limit reference point, indicating that both stocks remain assessed as overfished.

Silver warehou are found along the south coast of Australia from South Australia to Victoria, including Tasmania. A recent study did not indicate the existence of separate stocks east and west of the Bass Strait. Thus, a single stock is assumed for management purposes (Stobutzki *et al*., 2010).

In 2009, a fully updated Tier 1 assessment was undertaken, which included updated catch and discard data. The 2009 assessment indicated that the SSB was 44 percent of unfished levels. The biomass is estimated to have increased to 48 percent in 2010. As the model indicates that the biomass is close to the target stock biomass of 48 percent of the unfished biomass and the levels of catch have been low, silver warehou remains assessed as not overfished and not subject to overfishing (Stobutzki *et al*., 2010).

Blue mackerel

Blue mackerel are found throughout continental shelf waters in southern Australia. Separate stocks have been identified east and west of 146°30'E in Australian waters. Only the east stock is covered by Area 81. No formal stock assessment was made for blue mackerel in 2009. The RBCs in 2008–09 were set using Harvest Strategy rules and relate to the time since the last DEPM survey. The DEPM survey was undertaken in 2005, three years before the RBC was set. The RBC was set at 6 000 tonnes in the east and 8 400 tonnes in the west. These catch estimates are 15 percent of the biomass estimates. After consideration of state catches, the commonwealth TAC was set at 5 400 tonnes in the east and left at 8 400 tonnes in the west. The spawning biomass estimates calculated from the DEPM survey are considered to be between $0.7B_0$ and $0.9B_0$. Therefore, both the east and west stocks are assessed as not overfished. Total catches in 2009 were well below the RBCs for both stocks. Therefore, the stocks are assessed as not subject to overfishing (Hobsbawn, Larcombe and Mazur, 2010).

New Zealand

Fisheries in New Zealand are managed under the Fisheries Act 1996, the purpose of which is "to provide for the utilization of fisheries resources while ensuring sustainability". The Fisheries Act 1996 provides the legal framework for New Zealand's world-leading quota management system (QMS) under which their fisheries are managed. Under the QMS, fishers can purchase and own quota for a particular fish stock. Each year, a TAC is set for each stock and the fishers are allocated an annual catch entitlement (ACE), which is a specific amount (in kilograms) of a species that the fishers is allowed to catch based on the proportion of the quota for that stock they own.

There are currently 100 species or species groups covered by the QMS. Each species or species group is split into quota management areas (QMAs) based on a combination of biological and administrative factors. The TACs and ACE are based on the QMAs for a particular species. The Fisheries Act 1996 requires that TACs "maintain the stock at or above a level that can produce the MSY, having regard to the interdependence of stocks". The TACs are set using the best available scientific information. Each year, there is considerable investment in research and fisheries assessments. All research and assessments are carefully reviewed by expert scientists with active participation by fisheries managers and representatives of environmental and commercial fishing interests. The current status of fish stocks and biological information on species is reported in the report from the Fisheries Assessment Plenary each year.

New Zealand approved a Harvest Strategy Standard in 2008 that describes best practice for the setting of fishery and stock targets and limits. The Harvest Strategy Standard provides guidance on how to develop species-specific targets and limits, and provides default values for targets and limits to establish a consistent and transparent framework for fisheries management decision-making.

In 2009, the Government of New Zealand developed a strategic direction document and goal for managing fisheries resources. Fisheries 2030 provides a long-term goal for the New Zealand fisheries sector that is: "New Zealanders maximizing benefits from the use of fisheries within environmental limits". This goal is supported by two objectives:

- Use – Fisheries resources are used in a manner that provides greatest overall economic, social and cultural benefit.

- Environment – The capacity and integrity of the aquatic environment, habitats and species are sustained at levels that provide for current and future use.

These outcomes are given effect through the development of five national fisheries plans. the national fisheries plans are five-year plans that establish the medium-term management approach through setting management objectives (and in some cases operational objectives). Once these management objectives have been achieved, they will contribute to the Fisheries 2030 goal and outcomes. National fisheries plans (MinFish, 2011a) are in place for highly migratory species and deep-water and middle-depth species. Three plans covering inshore shellfish, finfish, and freshwater species are currently being finalized. Plans can be viewed on the Ministry of Fisheries Web site: www.fish.govt.nz.

In 2010, 14 stocks were considered to be overfished (below the soft limit of 20 percent B_0): southern bluefin tuna (a highly migratory species over which New Zealand has limited management influence), three stocks of black cardinalfish, six stocks or substocks of orange roughy, and one stock or substock each of paua, rock lobster, scallop and snapper. Rebuilding programmes or TAC/total allowable commercial catch (TACC) reductions are in place in all these fisheries to allow them to rebuild to target levels (MinFish, 2011b).

Blue grenadier (hoki)

Blue grenadier is called hoki in New Zealand. Annual stock assessment reviews of hoki are undertaken by New Zealand scientists, often in collaboration with international scientists. The process is public, transparent and peer reviewed. The Ministry of Fisheries publishes the outcomes of stock assessments every year and catch limits are reviewed annually based on this information. The New Zealand hoki fishery has been certified by the Marine Stewardship Council.

Hoki are widely distributed throughout New Zealand waters from 34°S to 54°S, from depths of 10 m to over 900 m, with greatest abundance between 200 and 600 m. Large adult fish are generally found deeper than 400 m, while juveniles are more abundant in shallower water. The two main spawning grounds on the west coast of the South Island and in the Cook Strait are considered to comprise fish from separate stocks. This is based on the geographical separation of their spawning grounds and several other factors.

The hoki fishery was developed by Japanese and then-Soviet vessels in the early 1970s. Before the declaration of the EEZ and the implementation of the QMS, catches peaked at 100 000 tonnes in 1977. Hoki was introduced into the QMS in 1986 with a catch limit of 250 000 tonnes. The hoki catch then increased to a peak of 269 000 tonnes in 1997–98. Poor recruitment saw the TACC reduced through the early 2000s to 90 000 tonnes in 2007 and then increase to the current level of 120 000 tonnes as the stock has rebuilt.

Hoki is managed as one administrative stock; however, the western and eastern stocks are assessed separately. Non-regulatory catch limits are in place to ensure that the catch is spread appropriately across the two stocks. The 2011 stock assessment estimated the eastern stock to be at 53 percent B_0 and virtually certain (> 99 percent probability) to be above the lower limit of the management target range (35–50 percent B_0). The western stock was estimated to be at 41 percent B_0 and very likely (> 90 percent probability) to be above the lower end of the management target range. The western stock has been rebuilding in recent years. The biomass is expected to increase at current catch levels and was declared as being fully rebuilt by the stock assessment working group.

Southern blue whiting

Southern blue whiting (*Micromesistius australis*) is a schooling species generally confined to sub-Antarctic waters. Although dispersed for much of the year, commercial vessels target southern blue whiting in late winter to early spring when the fish aggregate to spawn at depths of 250–600 m. Four spawning areas have been identified: Bounty Platform, Pukaki Rise, Auckland Islands Shelf and the Campbell Island Rise (MinFish, 2008). These four areas are managed separately as unit stocks. About 20 000–30 000 tonnes of southern blue whiting is caught each year, and it is an important catch for the middle-depths trawl fleet.

The latest assessment shows that the Campbell Island Rise stock has a 40–60 percent probability of being at or above the management target of 40 percent B_0 (MinFish, 2011c). For the Campbell Island stock, B_{2009} was estimated to be 136 000 tonnes, corresponding to 41 percent B_0. It is projected that the stock will increase in the next 1–2 years as the recent recruits enter the fishery.

The Bounty Platform stock was assessed in 2009, but data from a 2010 survey led experts to believe the biomass estimates were too high. The current stock status for the Bounty Platform is therefore unknown but is unlikely (< 40 percent probability) to be below 20 percentB_0.

The biomass of the Pukaki Rise stock is thought to be stable, while the sustainability of current catch limits in the Auckland Islands stock is unknown (MinFish, 2011d).

The National Fisheries Plan for Southern Blue Whiting is currently being finalized; it sets out the management objectives for the next five years. One objective focuses on the continual support for the fishery achieving and maintaining environmental certification. The southern blue whiting trawl fishery is currently seeking environmental certification by the Marine Stewardship Council.

Barracouta

Barracouta are caught in coastal waters around mainland New Zealand, The Snares and Chatham Islands, down to about 400 m. The species has been managed under the QMS since 1986. Catches increased significantly in the late 1960s and peaked at about 47 000 tonnes in 1977. Between 1983–84 and 2004–05, catches fluctuated between 18 000 and 28 000 tonnes per annum (annual average about 24 000 tonnes). Landings have increased from the lower level of the early 2000s to 27 000–30 000 tonnes in the last four years.

No robust stock assessments have been developed for any barracouta stock, but a fishery characterization and standardized CPUE analyses were carried out for all barracouta stocks in New Zealand with data up to 2007–08. Barracouta management is based on five QMAs, although only three of them support significant levels of catch. The recent characterization and CPUE analyses did not indicate any alarming trends. However, it was concluded that stock assessment models would be necessary to draw conclusions on stock status appropriately. At least one stock is being reviewed in 2011–12 because of anecdotal reports that barracouta are currently very abundant in the southern parts of the New Zealand EEZ.

Orange roughy

Orange roughy inhabit depths from 700 m to at least 1500 m within the New Zealand EEZ. They are slow-growing, long-lived fish, and on the basis of otolith annuli counts and radiometric isotope studies may live up to 120–130 years. Orange roughy are managed under the QMS with the management objective of maintaining stocks at or above a level that will support the MSY (B_{MSY}). The EEZ is divided into eight orange roughy QMAs. Where more than one discrete orange roughy fishery occurs within a QMA, management subareas have been implemented and separate stock assessments are undertaken for each biological stock. These assessments may result in separate catch limits for each stock.

Stock management is based on the best available independent science. Stock assessment reviews are undertaken every two to three years by New Zealand scientists, often in collaboration with international scientists from the United States of America, Canada and Australia. The stock assessment process is public, transparent and subject to peer review. The Ministry of Fisheries publishes the outcomes of stock assessments annually, and summaries are available on its Web site (see above).

Commercial orange roughy fishing began in New Zealand on the Chatham Rise in the late 1970s – early 1980s, whereas the fisheries in other parts of the New Zealand EEZ typically started in the mid-1980s. Catches peaked in the late 1980s and have decreased since, largely in response to reductions in catch limits as the biomass of the various stocks has been fished down to target levels. More than 9 000 tonnes of orange roughy were landed from the New Zealand EEZ in the 2009–2010 fishing year. The most important fishery is on the east and south Chatham Rise (MinFish, 2010).

In earlier years, the productivity (growth and regeneration rates) of orange roughy was overestimated, leading to some New Zealand orange roughy fisheries being fished to levels below B_{MSY}. As a result, two fisheries were closed to fishing (in 2000 and 2003) to allow rebuilding at the maximum rate. One of these fisheries has since reopened to fishing after the stock was considered to have rebuilt to a sufficient level to allow limited fishing to recommence. The remaining orange roughy fisheries are deemed to be below B_{MSY}, or their status is not known. Conservative catch rates have been implemented to promote the rebuilding of these stocks in the medium term while maintaining commercial fisheries.

Oreos

There are three species of oreo fished within the New Zealand EEZ: smooth oreo, black oreo and spiky oreo. All three species are managed under the QMS with quota allocated as a combined oreo assemblage. Target fisheries exist for black and smooth oreo in quota management areas. Spiky oreo is taken as a bycatch in these fisheries and all three species are taken as bycatch in the target orange roughy fishery (MinFish, 2010).

Oreo are found predominantly in southern latitudes of the EEZ from the south Chatham Rise to the sub-Antarctic. They are found at depths from 600 to 1 500 m with younger fish typically found towards the shallower end of this depth range. Oreo are long-lived and slow-growing species. Black oreo may reach a maximum size of 45 cm and live for up to 150 years, and smooth oreo may reach a maximum size of 51 cm at an age of 86 years. Spawning for both species occurs from late October to at least December, with an average length at maturity of 34 and 41 cm for black and smooth oreo, respectively.

The annual catch limit for oreos was set at 18 850 tonnes in 2009–2010. Recorded catch was 16 791 tonnes in 2009–2010, down from a peak of 24 799 tonnes in 1996–1997. Smooth and black oreo are divided up into four different management areas. Seven of the eight oreo fisheries have been assessed. Five of the assessments are on smooth oreo and two on black oreo. Two of the eight stocks were estimated to be probably overfished, five at or near the management target of 40 percent B_0, and one stock was not assessed (MinFish, 2011c), based on FAO criteria.

ACKNOWLEDGEMENTS

Michelle Beritzhoff and James Brown from the Ministry of Fisheries, New Zealand and Ross Shotton, former FAO Fishery Resources Officer reviewed an earlier version of this chapter. Their valuable comments and suggestions greatly improved this paper.

REFERENCES

AFMA. 2006. Workshop Report - Orange Roughy Conservation Programme (available at www.afma.gov.au/wp-content/uploads/2010/07/n20070412_workshop.pdf)

Australian Government Department of Agriculture, Fisheries and Forestry (DAFF). 2007. *Commonwealth Fisheries Harvest Strategy: policy and guidelines*. Canberra.

Graham, K.J., Andrew, N.L. & Hodgson, K.E. 2001. Changes in relative abundance of sharks and rays on Australian South East Fishery trawl grounds after twenty years of fishing. *Marine and Freshwater Research*, 52: 549–561.

Haddon, M. 2010a. Catch rate standardizations for data 1986–2008. *In* G.N. Tuck, ed. *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009, part 2*, pp. 21–191. Hobart, Australia, AFMA & CSIRO Marine and Atmospheric Research.

Haddon, M. 2010b. Tier 4 analyses 1986–2008. *In* G.N. Tuck, ed. *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009, part 2*, pp. 318–368. Hobart, Australia, AFMA & CSIRO Marine and Atmospheric Research.

Hobsbawn, H. 2009. *Data summaries for SESSF quota species 1994–2008*. Canberra, Bureau of Rural Sciences.

Hobsbawn, H., Larcombe, J., Mazur, K. 2010. Small Pelagic Fishery. *In* D.T. Wilson, R. Curtotti & G. Begg, eds. *Fishery status report 2009 – status of fish stocks and fisheries managed by the Australian Government*. Canberra, Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences.

Little, L.R. 2010. Moving the eastern gemfish (*Rexea solandri*) stock assessment to SS3. *In* G.N. Tuck, ed. *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009, part 1*, pp. 76–98. Hobart, Australia, AFMA & CSIRO Marine and Atmospheric Research.

Ministry of Fisheries, New Zealand (MinFish). 2008. Species focus – southern blue whiting (*Micromesistius australis*). In: *Ministry of Fisheries* [online]. [Cited 20 December 2011]. www.fish.govt.nz/en-nz/Publications/The+State+of+our+Fisheries+2008/Species+Focus/Southern+Blue+Whiting.htm

Ministry of Fisheries, New Zealand (MinFish). 2010. New Zealand Fisheries InfoSite. In: *Ministry of Fisheries* [online]. [Cited 20 December 2011]. http://fs.fish.govt.nz/Page.aspx?pk=7&tk=37&sc=SKI

Ministry of Fisheries, New Zealand (MinFish). 2011a. *National Fisheries Plan for Deepwater and Middle-depth Fisheries (Approved by the Ministry of Fisheries under s. 11A of the Fisheries Act 1996 2010/11-2015/2016).*

Ministry of Fisheries, New Zealand (MinFish). 2011b. New Zealand's quota management system. In: *Ministry of Fisheries* [online]. [Cited 20 December 2011]. http://fs.fish.govt.nz/Page.aspx?pk=81

Ministry of Fisheries, New Zealand (MinFish). 2011c. 2010 Stock status table. In: *Ministry of Fisheries* [online]. [Cited 20 December 2011]. http://fs.fish.govt.nz/Page.aspx?pk=16&tk=478

Ministry of Fisheries, New Zealand (MinFish). 2011d. The May 2011 Plenary. In: *Ministry of Fisheries* [online]. [Cited 20 December 2011]. http://fs.fish.govt.nz/Page.aspx?pk=113&dk=22080

Partners, R. 2010 *Overview of the Australian fishing and aquaculture industry: present and future* [online]. Australia Government: Fisheries Research and Development Corporation. [Cited 20 December 2011]. www.frdc.com.au/documentlibrary/finalreports/2009-214-DLD.pdf

Slope Resource Assessment Group (SlopeRAG). *2010, SlopeRAG assessment report – 2009 stock assessment report for SESSF species assessed by SlopeRAG*. Report to the AFMA, Canberra.

Stobutzki, I., Patterson, H., Ward, P., Sampaklis, A., Sahlqvist, P., Moore, A. & Vieira, A. 2010. Commonwealth trawl and scalefish hook sectors. *In* D.T. Wilson, R. Curtotti & G. Begg, eds. *Fishery status report 2009 – status of fish stocks and fisheries managed by the Australian Government*. Canberra, Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences.

Taylor, B. 2010. Stock assessment of pink ling (*Genypterus blacodes*) in the south east fishery, December 2009. *In* G.N. Tuck, ed. *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2009, part 1*, pp. 14–49. Hobart, Australia, AFMA & CSIRO

Marine and Atmospheric Research.

Wilson, D.T., Curtotti, R. & Begg, G.A., eds. 2010. *Fishery status report 2009 – status of fish stocks and fisheries managed by the Australian Government*. Canberra, Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences.

B15. Southeast Pacific

FAO STATISTICAL AREA 87

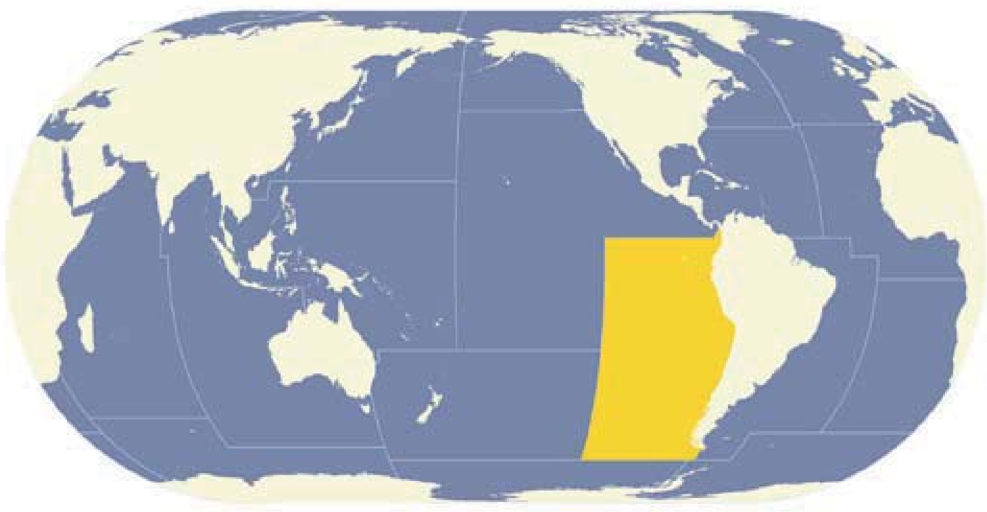
Jorge Csirke
FAO consultant
Peru
E-mail: jorge.csirke@gmail.com

INTRODUCTION

The Southeast Pacific (FAO Statistical Area 87) has a total surface of 30.02 million km^2 including a total continental shelf of 0.5 million km^2. It is located between longitude 120°00'W and the western coastline of South America, and between latitude 7°12'N on the coastline and along 5°00'N farther offshore off northern Colombia and latitude 60°00'S off southern Chile (Figure B15.1). Throughout most of Area 87, the continental shelf is narrow and with a steep slope. Some limited areas off southern Ecuador, northern Peru and central and southern Chile have a broader shelf, reaching a maximum width of 130 km for several hundred kilometres off southern Chile south of 41°00'S. The main oceanic islands in Area 87 are the Galapagos Islands off Ecuador and Juan Fernandez off Chile. The main regions suitable for bottom trawling are found off northern Colombia, Ecuador, northern Peru and central and southern Chile. The most productive regions are found in northern Peru and southern Chile. The coastline has two notable features: the Gulf of Guayaquil at 3°S in Ecuador and the zone of fjords south of 41°S in Chile.

The north of Area 87, off Colombia and Ecuador, has a tropical climate typical of lower latitudes. It has relatively low productivity, a mean SST of about 28 °C and salinity of 33 or lower in the rainy season and near the coast. The region is under the influence of surface equatorial currents that flow parallel to the equator. Further south, off Peru and northern and central Chile, the coastal areas are dominated by the

FIGURE B15.1
The Southeast Pacific (Area 87)



Humboldt–Peru eastern boundary current system. Seasonally, this current generates the cold nutrient-rich coastal upwelling that makes this region highly productive. Even near the equator, water masses close to these coastal upwelling areas have low SSTs, usually ranging from 14 to 20 °C, with surface salinity about 35. These features are influenced by the Andes Mountain Ridge that runs parallel and close to the coastlines along Peru and Chile. The Andes strongly influence the air and water circulation in Area 87 and contribute to a notably dry climate, particularly at lower latitudes. Farther south off southern Chile, the water masses are much colder and more turbulent, yet still highly productive. In this region, SSTs remain well below 14 °C and salinity about 34, with the coastal area influenced by the freshwater inflow from the fjords (Schweigger, 1964; Jordán, 1979; Guillén, 1983; Bernal, Robles and Rojas, 1983; Strub *et al.*, 1998). Another important feature in this region is the presence of an extremely shallow oxygen minimum zone (OMZ) off Peru. This is a consequence of the decay and sinking of the primary production in the surface and poor ventilation (Chavez *et al.*, 2008). The long-term dynamics of this OMZ can help to explain part of the long-term variability of the living marine resources in this part of Area 87.

The distribution and abundance of fishery resources and the development of fisheries are strongly influenced by the local topography and prevailing environmental conditions. Shrimps, small coastal pelagic fish and large tropical migratory pelagic fish are the most abundant groups. They sustain the main fisheries off Colombia and Ecuador, while small pelagics are by far the most abundant and dominant species off Peru and northern and central Chile. Demersal fish and benthic invertebrates become more abundant and support the most important fisheries further south.

Large environmental variations within Area 87 are known to cause large year-to-year fluctuations as well as longer-term changes in fish abundance and total production of the main exploited species (Jordán, 1983; Zuta, Tsukayama and Villanueva, 1983; Serra, 1983, 1991a; Csirke, 1995). The adverse effects of El Niño events on the distribution, recruitment success and abundance of the world's largest single-species fishery on anchoveta (*Engraulis ringens*) are well known. Similar negative impacts are also recorded on other fish populations as well as seabirds and mammals. However, El Niño events are not always negative for other marine fisheries that include other small pelagics, hakes, shrimps, cephalopods and shellfish (Arntz, Landa and Tarazona, 1985; Arntz and Fahrbach, 1996; Bakun and Broad, 2003; Csirke, 1980, 1989; Pauly and Tsukayama, 1987; Pauly *et al*., 1989; Valdivia, 1978).

Area 87 is under the influence of two phases of the ENSO cycle (known as El Niño and La Niña). These are the main source of interannual environmental variability, having noticeable regional and extraregional impacts on climate and on the productivity of fishery resources. This is particularly noticeable during the warm phase or El Niño that occurs with variable intensity every 3–7 years (Rasmusson and Carpenter, 1982; Arntz and Fahrbach, 1996). More subtle, longer-term environmental changes have also been proposed as explanations for the interdecadal shifts observed in the availability and abundance of some of the main living resources in Area 87 (Alheit and Bernal, 1999; Chavez *et al*., 2003; Lluch-Belda *et al*., 1989, 1992; Yañez, Barbieri and Silva, 2003; Klyashtorin, 2001; Csirke and Vasconcellos, 2005; Alheit, Roy and Kifani, 2009).

The most striking fishery resource changes in Area 87 have been the collapse of anchoveta in the early 1970s, the bloom and severe depletion of South American sardine (or pilchard) (*Sardinops sagax sagax*) between the mid-1970s and late 1990s, the recovery of anchoveta in the 1990s, and the bloom of Chilean jack mackerel (*Trachurus murphy*) from the mid-1970s throughout the mid-1990s, with a significant decline in the 2000s. Catches of jumbo flying squid (*Dosidicus gigas*) also declined in 1995–98 before they increased sharply and levelled off at a much higher levels in the 2000s.

PROFILE OF CATCHES

There have been wide fluctuations in the total catches from the Southeast Pacific in the past six decades. Major changes in catch volumes and species composition and abundance have been caused by changes in fishing effort and the effects of natural environmental fluctuation.

These fluctuations result from short-term (ENSO) and longer-term (interdecadal) changes in climate. In the 1960s, the total catch increased rapidly, peaking at 13.8 million tonnes in 1970. Catches were mainly based on anchoveta, until the sudden decline of this fishery in the early 1970s. In the mid-1970s, total catches started to increase again and became more multispecies. Small pelagics continued to dominate the catch, but with a wider variety of species including anchovies, sardines, herrings, jack mackerel and chub mackerels (Figure B15.2, Table D17). By the mid-1980s, the anchoveta had become the dominant species again and catches of other pelagic species stabilized or declined. Noticeable changes have also occurred in other species groups, particularly hakes, other demersals and, more recently, squids (especially jumbo flying squid). All this contributed to an increase in the total catch from Area 87 to a record high of 20.4 million tonnes in 1994. These catches probably corresponding to the upper limit of the yield range for the area. Following this peak in catches, the total catch declined to 7.4 million tonnes in 1998 (mainly owing to the strong 1997–98 El Niño). It has since fluctuated between 15.3 million tonnes in 2000 and 11.1 million tonnes in 2009.

The general trends and high variability of total catches from Area 87 are strongly influenced by the anchoveta, a major component of ISSCAAP Group 35 (herrings, sardines, anchovies). After reaching 13.1 million tonnes in 1970, the total catch of anchoveta fell to 1.7 million tonnes in 1973 and to a record low of only 94 000 tonnes in 1984. Since then, catches of this species have generally recovered, albeit with major declines during the 1997–98 El Niño and a subsequent very rapid recovery. In recent years, catches have been between 6 and 11 million tonnes per year with 6.9 million tonnes in 2009 (Figure B15.3).

Catches of other small pelagics, such as South American sardine, Chilean jack mackerel, and chub mackerel (*Scomber japonicus*), started to increase following the anchoveta fishery collapse in 1972–73. The catches of these species had been negligible (a few 10 000 tonnes per year) until the early 1970s. Now, these species have become major contributors to the total fish production in Area 87 with combined catches of several million tonnes per year. The South American sardine has now almost disappeared while the Chilean jack mackerel and the chub mackerel continue to maintain relatively

FIGURE B15.2
Annual nominal catches by ISSCAAP species groups in the Southeast Pacific (Area 87)

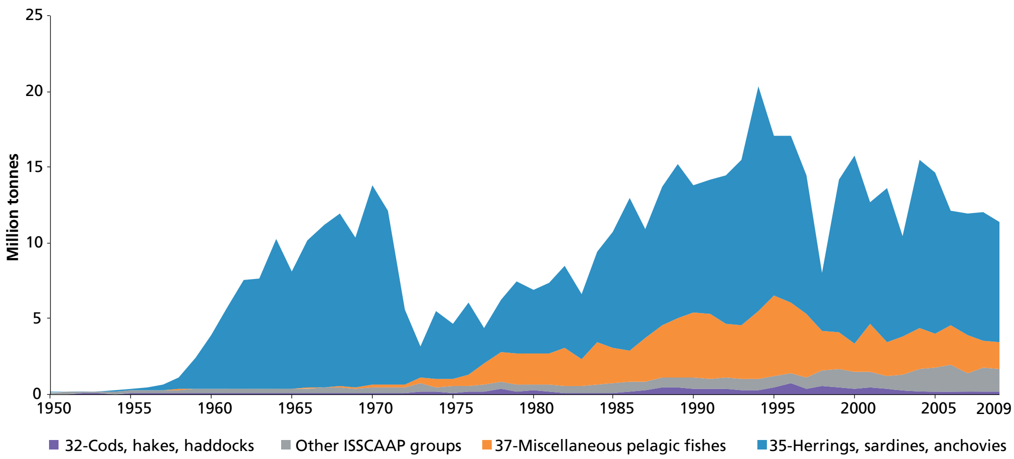


FIGURE B15.3
Annual nominal catches of selected species in ISSCAAP Group 35, Southeast Pacific (Area 87)

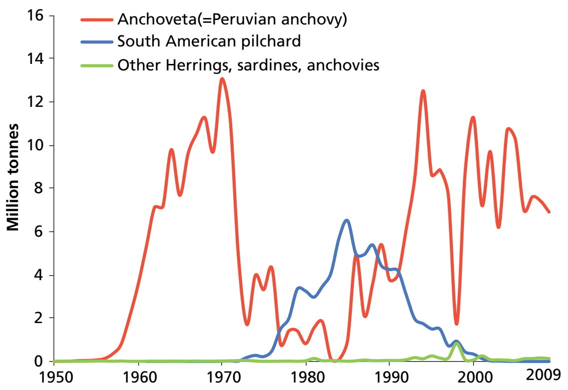
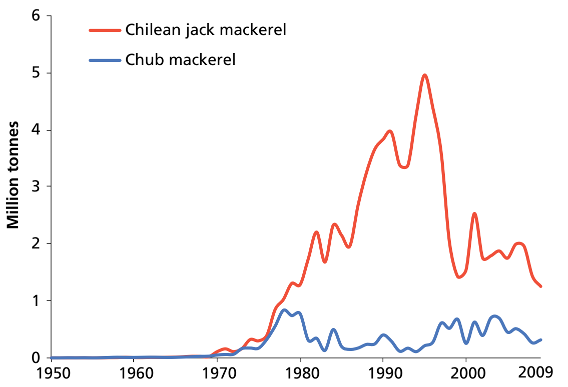


FIGURE B15.4
Annual nominal catches of selected species in ISSCAAP Group 37, Southeast Pacific (Area 87)



high catches in Area 87, although with some noticeable fluctuations.

The South American sardine (pilchard) become a major contributor to the total production of ISSCAAP Group 35 and the total catch after anchoveta declined in the mid-1970s (Figure B15.3). Catches of South American sardine increased from under 10 000 tonnes/year prior to 1970 to a maximum of 6.5 million tonnes in 1985. Then, catches declined continuously, to only 27 000 tonnes in 2002 and to about 300 tonnes in 2008 and 2009. This sharp decline was apparently caused by the heavy fishing in the 1980s coinciding with the onset of the declining phase of an environmentally driven long-term "regime change" in abundance (Kawasaki, 1983; Lluch-Belda *et al.*, 1989, 1992; Patterson, Zuzunaga and Cardenas, 1992; Schwartzlosse *et al.*, 1999; Serra, 1991a).

Other main species in ISSCAAP Group 35 are the Araucanian herring (*Strangomera benticki*) and the Pacific thread herring (*Ophisthonema libertate*). Catches of these species have also been highly variable. The Araucanian herring or Araucarian (common) sardine is fished mainly between 34°S and 40°S off Chile. It has had two distinguishable periods of high production. One lasted from the mid-1960s to the mid-1970s, with peak catches of 159 000 tonnes and 183 000 tonnes in 1971 and 1974. The second period started with a rapid increase in catch after 1989. This period of high catch apparently still continues but with large fluctuations within lows of 127 000 and 281 000 tonnes in 1995 and 2007, and record highs of 584 000, 782 000 and 855 000 tonnes in 1991, 1999 and 2009, respectively.

The Pacific thread herring is mostly fished to the north of 6°S. The highest recorded catch was 90 000 tonnes in 1989, followed by a decline with wide fluctuations to 6 900 tonnes in 2003 and then an increase to 25 000 tonnes and 22 000 tonnes in 2008 and 2009.

In the same group, the Pacific anchoveta (*Cetengraulis mysticetus*) is a small pelagic species associated with estuarial waters. It is mainly fished off Colombia and Ecuador and has yielded highly variable catches. These have fluctuated between peaks of 123 000 tonnes, 118 00 tonnes and 99 000 tonnes reported in 1981, 1997 and 2001, and lows of 4 000 tonnes, 15 000 tonnes and 13 000 tonnes in 1985, 2005 and 2009, respectively.

The other main species dominating total catches in recent years from Area 87 is the Chilean jack mackerel (ISSCAAP Group 37). There is no evidence that this species was in particularly high abundance prior to 1970 when annual catches were barely 30 000 tonnes per year. However, in the early 1970s, this species started to appear consistently as bycatch in local artisanal and industrial fisheries. Then, more specialized Chilean, Peruvian and then-Soviet-Union fishing fleets began targeting it in the mid-1970s and 1980s. Total catches increased rapidly to peak at almost 5 million tonnes in 1995. The catch then began to decline and reached a low of 1.2 million tonnes in 2009 (Figure B15.4).

Another important small pelagic in ISSCAAP Group 37 is chub mackerel (Figure B15.4). Catches of this species show two main periods of higher catches. The first period ran from the mid-1970s to the mid-1980s with a maximum catch of 836 000 tonnes in 1978 (65 percent off Ecuador), mostly caught closer inshore. The other period was from the mid-1990s onwards, with an increased portion of the catches being taken farther south and offshore with maximum catches of 676 000 tonnes in 1999 and 701 000 tonnes in 2003, with 317 000 tonnes in 2009.

The eastern Pacific bonito (*Sarda chiliensis*) (ISSCAAP Group 36) (Figure B15.5, Table D17) used to support an important coastal small pelagic fishery in the region, mainly off Peru. Catches were in the order of 60 000 tonnes per year in the 1950s and 1960s, with a record high of 109 000 tonnes in 1961. Following the collapse of the anchoveta (its main food source), catches of eastern Pacific bonito dropped to 4 300 tonnes in 1976. They recovered thereafter to almost 40 000 tonnes in 1990, but dropped drastically to 5 700 tonnes in 1998 and to only 500 tonnes in 2000 and 875 tonnes in 2002. More recently, catches have recovered to 43 000 tonnes in 2008 and 31 000 tonnes in 2009.

FIGURE B15.5
Annual nominal catches of selected species in ISSCAAP Group 36, Southeast Pacific (Area 87)

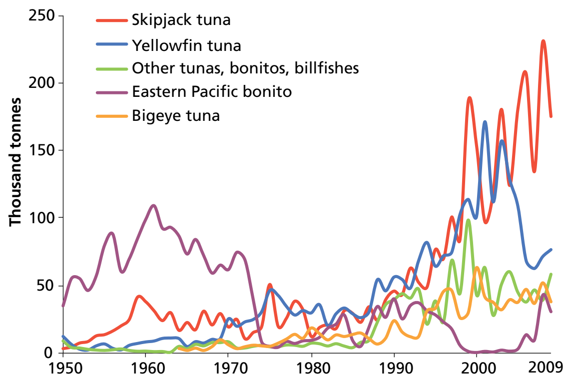
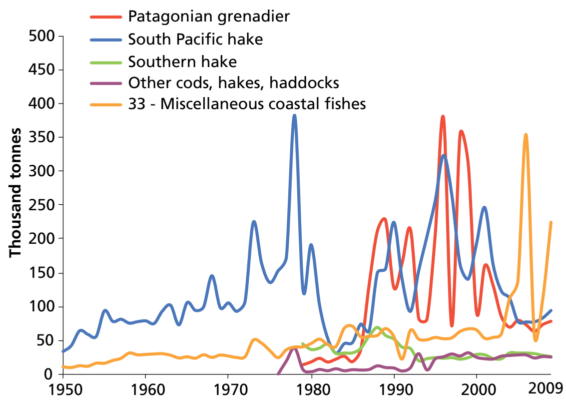


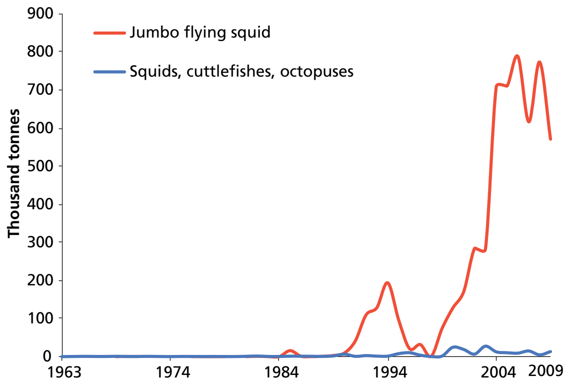
FIGURE B15.6
Annual nominal catches of selected species in ISSCAAP Groups 32 and 33, Southeast Pacific (Area 87)



Within the same ISSCAAP Group 36 (Figure B15.5), catches of tunas have continued to show a general increasing trend with some fluctuations since the late 1980s. Skipjack tuna (*Katsuwonus pelamis*) catch peaked at 231 000 tonnes in 2008, with 175 000 tonnes in 2009. Bigeye tuna (*Thunnus obesus*) catch peaked at 63 000 tonnes in 2000, with 52 000 tonnes and 38 000 tonnes in 2008 and 2009, respectively. Catches of yellowfin tuna (*Thunnus albacares*) also peaked at 171 000 tonnes in 2001 but then declined to 72 000 tonnes and 77 000 tonnes in 2008 and 2009. Other tunas, bonitos and billfishes caught include the frigate and bullet tunas (*Auxis* spp.) and swordfish (*Xiphias gladius*) with catches of 35 000 tonnes and 15 000 tonnes, respectively, in 2009.

Total catches of demersal fish in ISSCAAP Group 32 generally increased with high variability until a maximum total catch of 752 000 tonnes was reached in 1996. Then, total catches began a decreasing trend to a low 196 000 tonnes in 2007 and 211 000 tonnes and 225 000 tonnes in 2008 and 2009. The main species in this ISSCAAP group (Figure B15.6) are South Pacific hake (*Merluccius gayi*), with two subpopulations (one off Peru and the other off Chile), southern (Patagonian) hake (*Merluccius australis* = *polylepis*) and Patagonian grenadier (*Macruronus magellanicus*). Total catches of South Pacific hake have been highly variable with sharp declines in the 1980s and the mid-2000s. There are two stocks of this species. Catches from the Peruvian stock of South Pacific hake have been very variable, with more than 300 000 tonnes in 1978 and 235 000 tonnes in 1996. Catches from this stock declined drastically to only 42 000 tonnes in 2002 as it became less abundant. The sudden decline in biomass and catch in 2002 led to an almost complete ban on fishing for South Pacific hake off Peru. This ban reduced total

FIGURE B15.7
Annual nominal catches of selected species in ISSCAAP Group 57, Southeast Pacific (Area 87)



catches to only 8 000 tonnes in 2003, which was followed by a controlled recovery in catch off Peru to 47 000 tonnes in 2009. Catches of the Chilean stock of South Pacific hake have been less variable, with maximum recorded catches of 128 000 tonnes in 1968 and 121 000 tonnes in 2001. After 2001, catches declined to about 47 000 tonnes/year by 2005 and have remained at these levels since. These changes in catches of the two stocks of South Pacific hake are reflected in the overall high variability and the sharp declines of the total catch of in ISSCAAP Group 32 fishes in the 1980s and the mid-2000s.

Catches of Patagonian grenadier were also high from 1987 to 2002, with a record high of 379 000 tonnes in 1996. Since 2003, catches of this species have been under 85 000 tonnes per year, with 78 000 tonnes in 2009. Catches of southern hake increased to a record high of 69 000 tonnes in 1988 before then declining and levelling off at between 20 000 and 30 000 tonnes per year in the last decade, with 26 000 tonnes in 2009.

Until recently, the accumulated catch of all miscellaneous coastal species in ISSCAAP Group 33 (Figure B15.6) used to have a low variability with a slight increasing trend. Catches reached 60 000 tonnes by 2003 even with major fluctuations in the catches of several of the more than 30 individual species represented in this group. However, since 2004, catch totals of this ISSCAAP group have increased and become highly variable because of the noticeable increase in the catches of mote sculpin (*Normanichthys crockeri*) by Chile. Mote sculpin catch was 70 000 tonnes in 2004, a record high of 319 000 tonnes in 2006, and 67 000 tonnes and 170 000 tonnes in 2008 and 2009. It has become the dominant species in this species group, followed by mullets (*Mugilidae* spp.) and corvina drum (*Cilus gilberti*) with 19 000 tonnes and 10 000 tonnes in 2009, with other species reaching less than 6 000 tonnes per year.

The first major increase in the total catches of squids and particularly of jumbo flying squid (*Dosidicus gigas*) in ISSCAAP Group 57 was reported in the early 1990s. However, this first period of high catches lasted only five to six years, reaching a maximum of 200 000 tonnes in 1994. It was followed by another period of high catches that seems to be lasting longer and yielding higher catches. These peaked at 787 000 tonnes in 2006 and 773 000 tonnes in 2008, with a decline to 571 000 tonnes in 2009 (Figure B15.7).

RESOURCE STATUS AND FISHERY MANAGEMENT

The status of each fishery stock in Area 87 is shown in Table D17. Fishery resources in Area 87 are well known for experiencing large changes in their abundance and species composition (Csirke and Sharp, 1984; Sharp and Csirke, 1983). This feature of the fisheries tends to have major social and economic impacts on the communities in the region that rely on marine fisheries production. Moreover, as Area 87 is the second-largest contributor to world capture fish production and the third-largest contributor to total world fish production (in 2009, the Southeast Pacific accounted for 14.5 percent of total world marine captured fish and 8.5 percent of total world fish production), the effects of changes in this region also tend to have noticeable effects on global fisheries trends and projections.

The small pelagics complex formed primarily by anchoveta, South American sardine and Chilean jack mackerel provides a striking example of how these changes in abundance and species composition can affect local fisheries and national economies.

The most important, highly variable and best-studied species in Area 87 is the anchoveta (IMARPE, 1970, 1972, 1973, 1974, 2000; Tsukayama, 1983; Zuta, Tsukayama and Villanueva, 1983; Pauly and Tsukayama, 1987; Pauly *et al.*, 1989; Csirke, 1980, 1988, 1989; Bertrand *et al.*, 2008), this single species produces the largest catches worldwide, all from Area 87.

There are two main stocks of anchoveta in Area 87: the northern-central Peruvian stock that is found between 3° and 15°S, and the southern Peru–northern Chile stock that is found between 16° and 24°S (Tsukayama, 1966; Jordán, 1971; IMARPE, 1973; GTE IMARPE-IFOP, 2003). A smaller, third substock has been proposed for fish found in the southernmost part of the species range at 37°S (Serra, 1983). More recent reports have also documented increased spawning and catch of anchoveta as far south as 47°S (Bustos, Landaeta and Balbontin, 2008; SUBPESCA, 2008c).

The northern-central Peruvian stock is by far the most abundant and important, with an average biomass usually in the range of 3 million–16 million tonnes (Tsukayama, 1983; Pauly and Palomares, 1989; Csirke *et al.*, 1996). The southern Peru–northern Chile stock has been estimated to reach a biomass in the order of 3 million–6 million tonnes (GTE IMARPE-IFOP, 2003). Most of the catches of anchoveta correspond to the northern-central Peruvian stock that is generally found within Peruvian waters and is usually exploited solely by Peruvian fleets. However, in some particularly cold years and under the influence of a stronger flow of the Humboldt–Peru current, part of the stock may migrate north into Ecuadorian waters where anchoveta may also be reported in commercial catches. In 2009, 5.4 million tonnes or 78 percent of the total anchoveta catch (within the historical 70–80 percent estimated for previous years) were produced by the northern-central Peruvian stock. The remainder is mostly produced by the southern Peru–northern Chile stock that is exploited by fleets from these two countries. The most southern stock that is exploited only by Chilean fleets forms a minor component of the overall catch.

The anchoveta fishery started in the late 1950s and developed rapidly in the 1960s. At this time, management was ineffective and had an overoptimistic perception of the sustainable catches. This contributed to overexploitation of the stocks, followed by a dramatic collapse in the early 1970s. In fact, in the 1960s, the fishery grew rapidly, obtaining record high catches in several consecutive years. Fishing capacity expanded substantially and, for several years, managed to remove a total catch well in excess of the recommended ceilings. For the main northern-central Peruvian stock alone, the catch was in the order of 8 million–9 million tonnes per year (Schaefer, 1967; Boerema *et al.*, 1967; Gulland, 1968; Csirke *et al.*, 1996; Csirke and Gumy, 1996; IMARPE, 1970, 1972, 1973, 1974). Total catches of this species peaked at 13.1 million and 11.2 million tonnes in 1970 and 1971, just prior to the 1972–73 collapse.

While overfishing did play a major role in the collapse of the anchoveta fishery in the early 1970s (IMARPE, 1974; Zuta, Tsukayama and Villanueva, 1983; Jordán, 1983), it is also recognized that the 1972–73 El Niño was a primary cause of recruitment failure and stock decline (Csirke, 1980). The lack of adequate management action to reduce fishing pressure drastically when this was most needed did not help. Moreover, it contributed to aggravating and prolonging the decline well into the 1980s. The anchoveta stock was already depleted and catches were already low when the much stronger 1982–83 El Niño hit the area. That is why the 1982–83 El Niño apparently did not have as severe an impact on the total regional fish production. However, it did have a severe impact on the marine ecosystem in the area and it did reduce the anchoveta stock to its historical minimum. The fortunate coincidence of favourable environmental conditions, a bankrupt industry with much reduced fishing capacity and reduced fishing effort allowed the stock to recover and catches to increase in later years (Csirke *et al.*, 1992, 1996).

By the early 1990s, the stock and the anchoveta fishery had recovered to its pre-1972 collapse state. However, poor management allowed fishing capacity to expand again well beyond advisable levels. Thus, by 1995, both the fishing vessels and fishmeal-processing factories were estimated to be at least 30 percent more than were needed or advisable (Csirke and Gumy, 1996). They continued to increase further, although at a slower rate, until there was another serious stock depletion in 1998. This depletion resulted from several years of heavy fishing and the adverse environmental conditions associated with the strong 1997–98 El Niño. By mid-1998, hydroacoustic surveys estimated the total biomass of anchoveta off Peru at one of its lowest levels (1.2 million–2.7 million tonnes; Castillo, Gutiérrez and Gonzales, 1998; IMARPE, 1998; Gutiérrez, 2000). However, the stock made a rapid recovery shortly afterwards. Particularly favourable environmental conditions and good recruitment, coupled with a tighter and more careful management and surveillance scheme, apparently contributed to the rapid recovery in the post 1997–98 El Niño years (Bouchon *et al*., 2000; Ñiquen *et al*., 2000). While the two stocks of anchoveta soon recovered from the El Niño 1997–98 depletion, there were still serious concerns over potential risks of overfishing because of the gross overcapacity of the fishing fleet (estimated to be 40 percent higher than required). The fishing pressure, SSBs and other stock values have been maintained within sustainable safe limits by keeping the fleet and processing factories idle for extended periods of time. More recently, the adoption of an individual quota system has apparently contributed to reducing the excess fishing capacity for anchoveta in Area 87. This approach has improved net economic returns from this fishery and reduced the potential excess pressure on the stock.

In fact, in addition to the individual quota system, other measures such as minimum size at first capture, seasonal closures, area closures, and seasonal and annual TAC-type of regulations have been in force for the anchoveta fishery for decades in both Peru and Chile. The Government of Peru has applied an individual quota system per boat owner since 2009 for the northern-central Peruvian stock. It extended the same scheme to the southern anchoveta fishery in 2010 (PRODUCE, 2008a, 2008b, 2009). Meanwhile, the Government of Chile has already been applying an individual quota per boat owner (maximum catch limit per boat owner) for the anchoveta fishery off northern-central Chile since 2001. It expanded this in 2007 by applying a similar catch quota in the southern part of Chile (SUBPESCA, 2008a, 2008b, 2008c).

All this, coupled with closer monitoring and more careful management, has recently contributed to maintaining these stocks of anchoveta at near fully exploited. This level of exploitation has still been within safe sustainable limits despite the natural fluctuations characteristic of this species and its ecosystem. The exploitation rate and the mean total biomass and SSB of the northern-central Peruvian stock has been maintained within safe target limits in recent years (Guevara-Carrasco, Wosnitza-Mendo and Ñiquen, 2010; Oliveros-Ramos *et al*., 2010; Diaz *et al*., 2010). However, for the more southern stocks, there are indications of declining total biomass and SSB (GTE IMARPE-IFOP, 2010). These declines have led to adjustment of the TACs accordingly (SUBPESCA, 2010a, 2010b).

As noted above, the South American sardine had a period of particularly high abundance from the late 1970s through to the early 1990s before virtually disappearing from catches. At least three substocks are described for this species in the area (Parrish, Serra and Grant, 1989). The northern stock is found from 1°S to 15°S off Ecuador and Peru, with a probable separate substock around the Galapagos Islands. The central stock is found from 15°S to 25°S off southern Peru and northern Chile, and the southern stocks off Coquimbo (30°S) and off Talcahuano (37°S) in Chile. Serra and Tsukayama (1988) describe the one off Talcahuano as a separate stock. All the stocks of South American sardine are severely depressed. In periods (or regimes) of high abundance, the most abundant stocks have been the northern (Ecuador–Peru) stock, with a biomass peaking at 10 million tonnes in 1987, and the central (southern Peru–northern Chile) stock, peaking at 9 million tonnes in 1980.

The first recorded sudden increase in biomass and particularly high catches of the two main stocks of South American sardine started more or less simultaneously in the early 1970s (IMARPE, 1974; Serra and Zuleta, 1982; Salazar *et al.*, 1984; Zuzunaga, 1985). The increase followed the 1972 collapse of the anchoveta. This increase in biomass lasted for almost two decades, but now the abundance of both stocks has declined to very low levels. They have supported only negligible catches in the last decade, with no catches reported at all since 2008. Total catches on the southern Peru–northern Chile stock started to decline in 1985, and the northern stock (Peru–Ecuador) started to decline in 1990. There are clear indications that in both cases these declines were preceded by three to four years of declining trends in recruitment and total biomass. Moreover, in both cases, managers allowed fishing pressure to build up rapidly and remain high, even while biomass and recruitments were declining (Csirke *et al.*, 1996; GTE IMARPE-IFOP, 1994, 1999, 2003; Serra, 1991a). The high fishing pressure accelerated the decline in abundance caused by an environmentally driven long-term "regime change" (Kawasaki, 1983; Lluch-Belda *et al.*, 1989, 1992; Schwartzlosse *et al.*, 1999). This unfavourable phase of a longer-term regime will probably ensure that the catches remain negligible for some years. Therefore, even if fishing pressure and total catches are drastically reduced and remain very low, the stocks need to be considered as moderately to fully exploited. Given this situation, these sardine stocks need to be properly monitored to ensure that they do not become further overexploited.

Among other small pelagics in the same ISSCAAP group, worth noting are Araucanian herring, Pacific herring and Pacific anchoveta, which also have large fluctuations in biomass in Area 87. Araucanian herring was considered to be fully exploited to overexploited in the late 1990s and early 2000s as biomass and recruitment levels declined (Cubillos, Bovary and Canales, 2002; Attica *et al*., 2007). However, recent stock assessments of Araucanian herring have shown that there have been substantial increases in recruitment, total biomass and spawning biomass of this species (SUBPESCA, 2010b). This has led to increases in the TACs and actual catches, despite the stock remaining fully exploited. Pacific thread herring and Pacific anchoveta are most likely moderately to fully exploited in most of their distribution range. They are mainly used to produce fishmeal and fish oil. In Colombia, the Pacific anchoveta is managed under a system of annual quotas and spawning bans (Beltrán and Villaneda, 2000; CPPS, 2003; FAO, 2003).

The first signs of a significant increased abundance of Chilean jack mackerel in Area 87 dates back to the early 1970s. This was just a few years prior to having large specialized industrial fleets from Chile, Peru and the then Soviet Union targeting this species in the mid-1970s and 1980s. A large, although variable proportion (65–95 percent) of the annual catch of Chilean jack mackerel was taken off Chile, which soon become the main fishing country of this species. Signs of overexploitation, including a noticeable reduction in the mean sizes in the catch, led the Government of Chile to establish tighter management measures in the late 1990s. These measures were followed by a drastic decline in the total catch and the introduction of a non-transferable individual quota system. Although the catch had stabilized by the early 2000s, there were still concerns about possible overexploitation of the stock and the sustainability of the fishery (Barría *et al*., 2003; Perez and Buschmann, 2003; Serra, 2001). By then, catches in Peru were much lower and more variable than in Chile. In 2002, the Government of Peru ruled that Peruvian catches of Chilean jack mackerel as well as those of chub mackerel and South American sardine could only be used for direct human consumption (PRODUCE, 2002). This was partly done with the aim of reducing fishing pressure on these species as well as increasing the supply for human consumption.

However, the distribution of Chilean jack mackerel extended to the high seas beyond the EEZs of Chile and Peru. In this region, the species was heavily exploited by fleets from several other nations. It became clear that proper management of this and other important fish resources exploited in the high seas of the South Pacific could only be achieved through international cooperation within the context of an RFMO. A first international meeting to discuss the establishment of such an RFMO took place in Wellington, New Zealand, in February 2006. After eight consecutive meetings, participating countries adopted the Convention on the Conservation and Management of High Seas Resources of the South Pacific Ocean in November 2009 (SPRFMO, 2009). Upon coming into force, this convention will close the gap in the international conservation and management of non-highly migratory fisheries. It will help protect marine biodiversity from the easternmost part of the South Indian Ocean through the Pacific towards the EEZs of South American countries. Most of the key mechanisms have already been implemented through a series of interim measures and the activities of the Interim Secretariat of the South Pacific Regional Fisheries Management Organisation SPRFMO based in Wellington, New Zealand (www.southpacificrfmo.org).

The Chilean jack mackerel is widely distributed in Area 87 and, because of its extensive migrations, it has been particularly difficult to establish distinguishable stock units. The possible existence of two or more subpopulations of this species was proposed in the early 1990s (Serra, 1991b; Arcos and Grenchina, 1994). All hypotheses suggesting up to four independent populations were discussed in 2008 (SPRFMO, 2008). More recent follow-up studies and genetic analyses show that there is a single population in the whole Pacific Ocean. These results suggest that the stock structure of Chilean jack mackerel is better described by a meta-population, with a source population creating several subpopulations that can remain separate for long periods depending on environmental conditions (Gerlotto *et al*., 2010).

Recent stock assessment studies suggest that fishing mortality (F) on Chilean jack mackerel has exceeded sustainable levels since at least 2002. They have confirmed that the current biomass levels are substantially lower than during the peak of the fishery in the 1990s. The total biomass has been estimated to have declined by almost 80 percent since 2001, to 2.1 million tonnes in 2010 (SPRFMO, 2010). Taking into account the scientific advice of its own advisory groups, member countries participating in the second session of the Preparatory Conference for the South Pacific Fisheries Management Organization (SPRFMO, 2011) recognized the overexploitation and seriously depleted state of the stock. They accepted a series of interim measures that include lowering the 2011 quotas for Chilean jack mackerel in Area 87 by at least 40 percent compared with those of 2010. These reductions are in addition to catch restrictions imposed in 2009 and previous years. The stock was considered fully exploited and now is overexploited. The proper implementation of the SPRFMO recommendations is expected to reduce catches and fishing pressure by all national fleets fishing in Area 87. This should also reduce the risk of further depletion and favour the recovery of the stock. The role and impacts of natural environmental changes in the Southern Pacific are however adding another important source of uncertainty regarding the recovery of this stock.

Chub mackerel is mostly caught as bycatch in the jack mackerel fishery. While there is less information regarding its abundance and general state than for many other species, it is clear that it is also highly variable but far less abundant than jack mackerel. Currently, the stock is probably moderately to fully exploited.

The eastern Pacific bonito gave some signs of recovery in the early 1990s, most likely owing to the recovery of the anchoveta, its main food source. However, the severe 1997–98 El Niño, associated with some large catches as bycatch in the anchoveta and other fisheries, apparently caused the depletion of this stock again. As a result, this species was only occasionally reported as target or as bycatch in the Peruvian small-scale fisheries for several years in the late 1990s and early 2000s (Estrella *et al.*, 2001). However, in recent years, catches have improved and the populations of Pacific bonito are showing some signs of recovery.

Within the demersal fishes, the South Pacific hake has also shown large recruitment and stock size variability associated with changes in environmental conditions such as

El Niño events (Samamé, Castillo and Mendieta, 1985; Espino, Castillo and Fernández, 1995). There are two distinct stock units corresponding to different subspecies of South Pacific hake: *Merluccius gayi peruanus*, found from 0°S to 14°S off Peru; and *Merluccius gayi gayi*, found from 19°S to 44°S off Chile (FAO, 1990). The total biomass of the Peruvian stock of South Pacific hake was estimated to be as high as 700 000 tonnes in 1978, with a second high peak estimated at 640 000 tonnes in 1994. However, it is now known that relaxed regulations coupled with overoptimistic assessments in the late 1990s contributed to overexploitation and severe depletion of the stock (Espino, Samamé and Castillo, 2001; Lleonart and Guevara, 1995; IMARPE, 2003, 2004a). The biomass declined to a low of 102 000 tonnes in 2002 and led the Government of Peru to decide on a total ban of this fishery. It took this closure almost two years to begin to have some effect two years. After that time, the stock began to show some signs of recovery (IMARPE, 2003, 2004a, 2004b). However, although severe management regulations are being adopted, these do not appear sufficient to ensure a high probability of recovery of the Peruvian South Pacific hake stock. The biomass of the Peruvian stock remains low, with reduced spawning potential and a total biomass estimated in 2008 of only 180 000 tonnes (IMARPE, 2008a, 2008b).

The Chilean (southern) stock of South Pacific hake has had two periods of high abundance. One period lasted until the early 1970s, while the other started with an increasing trend from 1988 throughout the very early 2000s to an estimated peak biomass of 1.4 million tonnes in 1996 and about 1 million tonnes in 2000 (Payá, 2003). Until the late 1990s and early 2000s, the Chilean stock of South Pacific hake was considered fully exploited (Cerda *et al.*, 2003; Pérez and Buschmann, 2003). However, it started to show signs of overexploitation and was severely depleted by 2004–05. The decline in abundance has been at least partially attributed to an increase in abundance of jumbo flying squid. Since tight management measures were adopted in 2005, the stock has shown no signs of recovery. Recruitment and SSB remain low and below the 250 000 tonnes set as a minimum safe biomass reference limit (SUBPESCA, 2010c).

The Patagonian grenadier has been showing signs of heavy exploitation for several years (Payá *et al.*, 2002) and is now considered to be overexploited (SUBPESCA, 2010d). Even in the late 1990s, the southern hake was considered fully exploited or overexploited owing to the high catch of juveniles and its low turnover rate (Payá *et al.*, 2000). More recent analyses on southern hake suggest declines in the total biomass, recruitment and other population parameters associated with overfishing (SUBPESCA, 2010e). The Patagonian toothfish is also considered fully exploited to overexploited (SUBPESCA, 2010f). Most of the other commercially important species of toothfish are believed to be fully exploited, with some showing signs of overexploitation (Pérez and Buschmann, 2003). There are also some indications that the common eel (*Ophichthus remiger*) might be showing some signs of overexploitation off Peru.

Squids are ecological opportunists whose dynamics are similar to those of desert locusts, and their abundance often fluctuates widely from one generation to the next (Rodhouse, 2001). This region is able to sustain large population of squids, and the jumbo flying squid is particularly abundant in some years. As a consequence, catches and fishing pressure have been building rapidly on this species. The jumbo flying squid has a wide distribution in the eastern Pacific, from California, the United States of America, to southern Chile (Nigmatullin, Nesis and Arkhipkin, 2001). Some catches have been reported as far north as off Oregon, the United States of America, in 1997 and off Alaska, the United States of America, in 2004. There are no clear indications of possible population subgroupings, mainly because of its active and extensive migrations. There has been a striking increase in abundance of jumbo flying squid since 1999, and the stock has extended its distribution and availability southwards from Peru to Chile (IMARPE, 2004c). The active and voracious predatory behaviour of this species has been a source of concern for Peruvian and Chilean authorities and fishers. This is mainly because of the probable impact of this species on the abundance of other high-value species in the region. Although catches have increased rapidly, the stock is probably only moderately exploited.

Other invertebrates, such as tropical and more temperate water shrimps, tend to be fully exploited to overexploited. Some local populations of sea urchins, clams, scallops and other shellfishes have been overexploited and even depleted in some areas. Other invertebrate species are only moderately or very lightly exploited (Rabí, Yamashiru and Quiroz, 1996; Beltrán and Villaneda, 2000; Pérez and Buschmann, 2003).

It is worth noting the apparent increase in abundance of some species such as the mote sculpin (*Normanichthys crockeri*) and jellyfish. Catches of mote sculpin, known as "bacaladillo" in Chile, have been higher than usual in recent years. The same species, known as "camotillo" in Peru, has also been reported in apparently higher than usual volumes in some recent pelagic acoustic surveys. The species has even been caught in lower latitudes where it had not previously been reported. The apparent higher incidence of jellyfish has also been reported as a problem affecting some fisheries in both Chile and Peru in recent years.

Some mention should also be made of the negative impacts of the February 2010 earthquake and tsunami on the Chilean fisheries sector. The worst-affected sector appears to be the artisanal sector along the central-south coast of Chile (CONAPACH, 2010).

All the main fish stocks in this region are exploited either by national fleets operating within their own EEZs or by land-based foreign fleets operating under a licence or fisheries agreement with a coastal State. These fisheries are also assessed and managed nationally, except for occasional shared stocks. This situation simplifies the assessment and management of these fisheries to some extent. It also helps in the allocation of responsibilities for the conservation and use of these living marine resources in Area 87. The exceptions to this pattern are the regional assessments of fisheries for tunas and other highly migratory species, Chilean jack mackerel fishery and jumbo flying squid. As a consequence, there is a well-established tradition of regional cooperation regarding general fisheries research issues. In the last five years, there have been major steps forward in the cooperation between coastal States and neighbouring or distant-water fishing countries. This is particularly in regard to the assessment and management of fish stocks that extend beyond the national EEZs in Area 87.

Of particular relevance are the negotiations for the establishment of the SPRFMO and the adoption in 2009 of the Convention on the Conservation and Management of the High Seas Fishery Resources of the South Pacific Ocean (above). This organization is already undertaking valuable and intense work on the assessment and management of important fish stocks such as Chilean jack mackerel. Although the interim measures are pending ratification from member countries, they are paving the way for similar work to be undertaken on other important non-highly migratory fish stocks that are, or can be, exploited in the high seas in Area 87.

The fisheries for tunas and other highly migratory species in Area 87 are assessed and managed through the IATTC. This commission is also responsible for assessments of tuna fisheries that extend well beyond the northwest of Area 87. Other regional organizations such as the Permanent Commission for the Southeast Pacific (www.cpps-int.org) and the Latin American Organization for Fishery Development (OLDEPESCA, www.oldepesca.com) are also active in supporting regional cooperation in fisheries and the marine environment in the region.

ACKNOWLEDGEMENTS

I would like to acknowledge Renato Guevara, Instituto del Mar del Peru (IMARPE), Callao, Peru, and Rodolfo Serra, Instituto de Fomento Pesquero (IFOP), Valparaiso, Chile for their review and providing constructive feedback that improved upon an earlier version of the manuscript.

REFERENCES

Alheit, J. & Bernal, P. 1999. Effects of physical and biological changes on the biomass yield of the Humboldt Current Ecosystem. *In* K. Sherman & Q. Tang, eds. *Large marine ecosystems of the Pacific rim. assessment, sustainability and management*, pp. 251–267. USA, Blackwell Science Inc.

Alheit, J., Roy, C. & Kifani, S. 2009. Decadal-scale variability in populations. *In* D.M. Checkley, J. Alheit, Y. Oozeki & C. Roy, eds. *Climate change and small pelagic fish*, pp. 64–87. Cambridge University Press.

Arcos, D. & Grenchina, A.S. 1994. *Biología y Pesca Comercial del Jurel en el Pacífico Sur*. Talcahuano, Chile, Instituto de Investigación Pesquera. 203 pp.

Arntz, W.E. & Fahrbach, E.J. 1996. *El Niño: experimento climático de la naturaleza*. Ciudad de México, Fondo de Cultura Económica. 312 pp.

Arntz, W., Landa, A. & Tarazona, J., eds. 1985. El Niño, su impacto en la fauna marina. *Boletin Instituto del Mar del Peru, Callao*, Volumen Extraordinario: 222 pp.

Bakun, A. & Broad, K. 2003. Environmental 'loopholes' and fish population dynamics: comparative pattern recognition with focus on El Niño effects in the Pacific. *Fisheries Oceanography*, 12: 458–473.

Barría, P., Aranís, A., Mora, S., Böhm, G., Serra, R., Martínez, C., Catasi, B., Reyes, H., Muñoz, G. & Gómez, A. 2003. Diagnóstico de la pesquería chilena del jurel (*Trachurus symmetricus murphyi*). *In* E. Yánez, ed. *Actividad pesquera y de acuicultura en Chile*, pp. 123–141. Chile, Pontificia Universidad Católica de Valparaíso.

Beltrán, C.S. & Villaneda, A.A. 2000. *Perfil de la pesca y la acuicultura en Colombia* [online]. Instituto Nacional de Pesca y Acuicultura – INPA, Subdirección de Investigaciones. Santa Fé de Bogota, D.C. [Cited 20 December 2011] www.rlc.fao.org/prior/recnat/pdf/pescol.pdf

Bernal, P.A., Robles, F.L. & Rojas, O. 1983. Variabilidad física y biológica en la región meridional del sistema de corrientes Chile-Perú. *In* G.D. Sharp & J. Csirke, eds. *Proceedings of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources, San Jose, Costa Rica, 18–19 April 1983*, pp. 683–711. FAO Fisheries Report No. 291. Rome, FAO.

Bertrand, A., Guevara, R., Soler, P., Csirke, J. & Chavez, F., eds. 2008. The northern Humbolt Current system: ocean dynamics, ecosystem processes, and fisheries. *Progress in Oceanography*, 79: 95–412.

Boerema, L.K., Saetersdal, G., Tsukayama, I., Valdivia, J.E. & Alegre, B. 1967. Informe sobre los efectos de la pesca en el recurso peruano de anchoveta. *Boletin Instituto del Mar del Peru, Callao*, 4(Vol.1): 133–186.

Bouchón, M., Cahuín, S., Díaz, E. & Ñiquen, M. 2000. Captura y Esfuerzo pesquero de la pesquería de anchoveta peruana (*Engraulis ringens*). *Boletin Instituto del Mar del Peru*, 19: 109–116.

Bustos, C.A., Landaeta, M.F. & Balbontin, F. 2008. Spawning and early nursery areas of anchoveta *Engraulis ringens* (Jenyns, 1842) in fjords of southern Chile. *Revista de Biología Marina y Oceanografía*, 43: 381–389

Castillo, R., Gutiérrez, M. & Gonzales, A. 1998. *Biomasa de la principales especies pelágicas en el mar peruano a fines de otoño 1998. Crucero BIC José Olaya Balandra 9805-06 de Tacna a Máncora*. Informe No. 137. IMARPE.

Cerda, R., Pavez, P., Urbina, M., Arancibia, L., Melo, T. & Yáñez, E. 2003. Aspectos del manejo de la merluza común (*Merluccius gayi,* Guichenot 1848) en la unidad de pesquería centro-sur. *In* E. Yánez, ed. *Actividad pesquera y de acuicultura en Chile*, pp. 221–232. Chile, Pontificia Universidad Católica de Valparaíso.

Chavez, F., Ryan, J., Lluch-Cota, S.E. & Ñiquen, M. 2003. From anchovies to sardines and back: multidecadal change in the Pacific Ocean. *Science*, 299: 217–221.

Chavez, F., Bertrand, A., Guevara-Carrasco, R., Soler, P. & Csirke, J. 2008. Editorial. The northern Humboldt Current System: brief history, present status and a view towards the future. *Progress in Oceanography*, 79: 95–105.

Confederación Nacional de Pescadores de Chile (CONAPACH). 2010. *Diagnostico de los impactos del terremoto y tsunami en la pesca artesanal*. Valparaiso, Chile, CONAPACH. 31 pp.

CPPS. 2003. *Octava Reunión del Grupo de Trabajo CPPS/FAO sobre evaluación de recursos y pesquerías artesanales en el Pacífico Sudeste. Valparaíso, Chile, 15-17 de octubre de 2003*. (also available at www.cpps.com).

Csirke, J. 1980. Recruitment in the Peruvian anchovy and its dependence on the adult population. *In* A. Saville, ed. The assessment and management of pelagic fish stocks. *Rapports et Proces-verbaux des Réunions. Conseil International pour l'Éxploration de la Mer*, 177: 307–313.

Csirke, J. 1988. Small shoaling pelagic fish stocks. *In* J.A. Gulland, ed. *Fish population dynamics*, pp. 271–302. 2nd edition. New York, USA, John Wiley & Sons. 422 pp.

Csirke, J. 1989. Changes in the catchability coefficient in the Peruvian anchoveta (*Engraulis ringens*) fishery. *In* D. Pauly, P. Muck & I. Tsukayama, eds. *The Peruvian upwelling ecosystem: dynamics and interactions*, pp. 207–219. ICLARM Conference Proceedings 18. 438 pp.

Csirke, J. 1995. Fluctuations in abundance of small and mid-size pelagics. *In* C. Bas, J.J. Castro & J.M. Lorenzo, eds. International Symposium on Middle-Sized Pelagics, pp. 481–490. *Scientia Marina*, 59(3–4): 660 + Erratum *Scientia Marina*, 60(2–3).

Csirke, J. & Gumy, A.A. 1996. Análisis bioeconómico de la pesquería pelágica peruana. *Boletin Instituto del Mar del Peru, Callao*, 15: 25–68.

Csirke, J. & Sharp, G. 1984. *Proceedings of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources, San Jose, Costa Rica, 18–19 April 1983*. FAO Fisheries Report No. 291 (Vol. 1). Rome, FAO. 102 pp.

Csirke, J. & Vasconcellos, M. 2005. Fisheries and long-term climate variability. *In* FAO. *Review of the state of world marine fishery resources*, 201–211. FAO Fisheries Technical Paper No. 457. Rome, FAO. 235 pp.

Csirke, J., Guevara-Carrasco, R., Cárdenas, G., Ñiquen, M. & Chipollini, A. 1996. Situación de los recursos anchoveta (*Engraulis ringens*) y sardina (*Sardinops sagax*) a principios de 1994 y perspectivas para la pesca en el Perú, con particular referencia a las regiones norte y centro de la costa peruana. *Boletin Instituto del Mar del Peru*, 15: 1–23.

Csirke, J., Bombín, L.M., González de la Rocha, J., Gumy, A.A., Jensen, N., Medina-Pizzali, A.F., Ruckes, E. & Shawyer, M. 1992. *La ordenación y planificación pesquera y la reactivación del sector pesquero en el Perú*. Informe del Programa de Cooperación FAO/Gobierno de Noruega. FI:GCP/INT/466/NOR, Informe de Campo 92/15. 92 pp.

Cubillos, L.A., Bucarey, D.A. & Canales, M. 2002. Monthly abundance estimation for common sardine (*Strangomera benticki)* and anchovy *(Engraulis ringens)* in the central-south area off Chile (34ºS-40ºS). *Fisheries Research*, 57: 117–130.

Díaz E., García, C., Espinoza, D., Guevara-Carrasco, R., Csirke, J., Ñiquen, M., Vargas N. & Argüelles, J. 2010. Evaluación del stock norte–centro de la anchoveta peruana (*Engraulis ringens,* Jenyns) por un modelo estadístico estructurado por edades. *In* V Panel Internacional de Expertos en evaluación de la anchoveta peruana (Engraulis ringens Jenyns) – Hacia un enfoque ecosistémico en la pesquería de la anchoveta peruana. IMARPE, Callao, Peru, 10-14 Agosto 2009. *Boletin Instituto del Mar del Peru*, 25 (1–2): 57–62.

Espino, M., Castillo, R. & Fernández, F. 1995. Biology and fisheries of Peruvian hake (*Merluccius gayi peruanus*). *In* J. Alheit & T.J. Pitcher, eds. *Hake, fisheries, ecology and markets*, pp. 339–363. London, Chapman & Hall.

Espino, E., Samamé, M. & Castillo, R. 2001. *La merluza peruana (*Merluccius gayi peruanus*): biología y pesquería*. Callao, Peru, Instituto del Mar del Perú. 120 pp.

Estrella, C., Palacios, J., Avila, W., & Medina, A. 2001. *Informe Estadístico de los recursos hidrobiológicos de la pesca artesanal marina por especies, artes, meses y lugares de desembarque durante el segundo semestre del 2000*. Informe Inst. Mar Perú Nº 164. 163 pp.

FAO. 1990. *FAO species catalogue. Gadiform fishes of the world*. FAO Fisheries Synopsis No. 125, Volume 10. Rome.

FAO. 2003. *Resumen informativo sobre la pesca por países: la República del Ecuador*. In: *FID/CP/ECU* [online]. [Cited 20 December 2011]. www.fao.org/fi/fcp/es/ECU/profile.htm

Gatica, C., Arteaga, M., Giacaman, J. & Ruiz, P. 2007. Tendencias en la biomasa de sardina común (*Strangomera benticki*) y anchoveta (*Engraulis ringens*) en la zona centro-sur de Chile, entre 1991 y 2005. *Invest. Mar., Valparaiso*, 35: 13–24.

Gerlotto, F., Bertrand, A., Gutierrez, M. & Sepulveda, A. 2010. *Population structure of the Chilean Jack mackerel (*Trachurus murphyi*) in the South Pacific Ocean*. SWG Jack Mackerel Document No. SWG-09-JM-04. Viña del Mar, Chile, SPRFMO. 38 pp.

Guevara-Carrasco, R., Wosnitza-Mendo, C. & Ñiquen, M. 2010. V Panel Internacional de Expertos en Evaluación de la Anchoveta Peruana (*Engraulis ringens,* Jenyns). *In* V Panel Internacional de Expertos en evaluación de la anchoveta peruana (*Engraulis ringens* Jenyns) – Hacia un enfoque ecosistémico en la pesquería de la anchoveta peruana. IMARPE, Callao, Peru, 10–14 Agosto 2009. *Boletin Instituto del Mar del Peru*, 25: 7–12.

Gulland, J.A. 1968. Informe sobre la dinámica de la población de anchoveta peruana. *Boletin Instituto del Mar del Peru, Callao*, 6(1): 305–346.

Guillén, O. 1983. Condiciones oceanográficas y sus fluctuaciones en el Pacífico sur oriental. *In* G.D. Sharp & J. Csirke, eds. *Proceedings of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources, San Jose, Costa Rica, 18–19 April 1983*, pp. 607–658. FAO Fisheries Report No. 291(3). Rome, FAO.

Gutiérrez, M. 2000. Estimados e biomasa hidroacústica de los cuatro principales recursos pelágicos en el mar peruano durante 1983-2000. *Boletin Instituto del Mar del Perú*, 19: 139–156.

GTE IMARPE-IFOP, 1994. *Evaluación conjunta de los stocks de sardina y anchoveta del sur de Perú y norte de Chile*. Informe Técnico, Grupo de Trabajo IMARPE-IFOP sobre pesquerías de pequeños pelágicos. Tercer Taller, Callao, 9 al 20 de Mayo 1994. 37 pp. + tablas y gráficos. (mimeo)

GTE IMARPE-IFOP. 1999. *6º Taller. Evaluación conjunta de los stocks de sardina y anchoveta del sur del Perú y norte de Chile*. Grupo de Trabajo IMARPE-IFOP sobre pesquerías de pelágicos pequeños. Callao, 8 al 19 de noviembre de 1999. Informe Final. 47 pp. + anexos.

GTE IMARPE-IFOP. 2003. *9º Taller. Evaluación conjunta de los stocks de anchoveta y sardina del sur del Perú y norte de Chile*. Grupo de Trabajo IMARPE-IFOP sobre pesquerías de pelágicos pequeños. Callao, 17 al 21 de noviembre de 2003. Informe Final. 39 pp.

GTE IMARPE-IFOP. 2010. *13º Taller. Evaluación conjunta del stock de anchoveta del sur del Perú y norte de Chile*. Grupo de Trabajo IMARPE-IFOP sobre pesquerías de pelágicos pequeños. Callao, 12 al 16 de abril de 2010. Informe Final. 39p + Anexos.

Instituto del Mar del Perú (IMARPE). 1970. Informe del cuadro de expertos sobre dinámica de la población de la anchoveta peruana. *Boletin Instituto del Mar del Perú, Callao*, 2: 324–372.

Instituto del Mar del Perú (IMARPE). 1972. Informe sobre la segunda reunión del panel de expertos en dinámica de la población de la anchoveta peruana. *Boletin Instituto del Mar del Perú, Callao*, 2: 373–458.

Instituto del Mar del Perú (IMARPE). 1973. Tercera sesión del panel de expertos sobre la dinámica de la población de la anchoveta peruana. *Boletin Instituto del Mar del Perú, Callao*, 2: 525–599.

Instituto del Mar del Perú (IMARPE). 1974. Informe de la cuarta sesión del panel de expertos de la evaluación del stock de anchoveta peruana. *Boletin Instituto del Mar del Perú, Callao*, 2: 605–671.

Instituto del Mar del Perú (IMARPE). 1998. *Crucero 9811-12 de Evaluación Hidroacústica de Recursos Pelágicos: Isla Lobos de Tierra a Sama – B/C Olaya – L/P Imarpe IV*. Informe Ejectuvio del Crucero 9811–12: 21 pp. (also available at ftp://ftp.imarpe.gob.pe/pub/informes/cru981112.pdf).

Instituto del Mar del Perú (IMARPE). 2000. Trabajos expuestos en el Taller Internacional sobre la anchoveta peruana (TIAP) 09-12 mayo 2000. *Boletin Instituto del Mar del Perú, Callao*, 19: 1–204.

Instituto del Mar del Perú (IMARPE). 2003. *Informe del panel internacional de expertos "Evaluación de la merluza peruana"*, por J. Castro, H. Lassen & J. Lleonart. IMARPE, Callao, Peru, 18-21 marzo 2003. Informe Interno. 46 pp.

Instituto del Mar del Perú (IMARPE). 2004a. *Informe del panel internacional de expertos "Evaluación de la merluza peruana"*, por E. Ferrandis, F. González, H. Lassen y J. Lleonart. IMARPE, Callao, Peru, 15–22 de marzo 2004. Informe Interno. 46 pp.

Instituto del Mar del Perú (IMARPE). 2004b. *II Panel Internacional de expertos para la evaluación de la merluza peruana (15–22 de marzo, 2004)*. (also available at www.imarpe.gob.pe).

Instituto del Mar del Perú (IMARPE). 2004c. *Anuario Científico y Tecnológico IMARPE, Enero-Diciembre, 2001*. 88 pp.

Instituto del Mar del Perú (IMARPE). 2008a. *Crucero de investigación multidisciplinario asociado a los recursos demersales en el verano del 2008, Cr0801-02 BIC Humboldt, 22 Enero - 20 Febrero 2008, Puerto Pizarro – Chicama*. Informe Ejecutivo. Callao, Peru. 65 pp.

Instituto del Mar del Perú (IMARPE). 2008b. *Crucero de evaluación de merluza y otros demersales en el otoño del 2008, Cr0805-06 BIC José Olaya Balandra, 26 Mayo - 25 Junio 2008, Puerto Pizarro – Chimbote*. Informe Ejecutivo. Callao, Peru. 56 pp.

Jordán, R. 1971. Distribution of anchoveta (*Engraulis ringens* J.) in relation to the environment. *Invest. Pesq.*, 35: 113–126.

Jordán, R. 1979. Recursos pesqueros y medio ambiente marino en el Océano Pacífico Oriental. *Rev. Com. Perm. Pacífico Sur*, 10: 189–208.

Jordán, R. 1983. Variabilidad de los recursos pelágicos en el Pacífico sudeste. *In* G.D. Sharp & J. Csirke, eds. *Proceedings of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources, San Jose, Costa Rica, 18–19 April 1983*, pp. 113–130. FAO Fisheries Report No. 291. Rome, FAO.

Kawasaki, T. 1983. Why do some pelagic fishes have wide fluctuations in their numbers? – Biological basis of fluctuation from the viewpoint of evolutionary ecology. *In* G.D. Sharp & J. Csirke, eds. *Proceedings of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources, San Jose, Costa Rica, 18–19 April 1983*, pp. 1065–1080. FAO Fisheries Report No. 291(3). Rome, FAO.

Klyashtorin, L.B. 2001. *Climate change and long-term fluctuations of commercial catches: the possibility of forecasting*. FAO Fisheries Technical Paper No. 410. Rome, FAO. 86 pp.

Lleonart, J. & Guevara, R. 1995. *Ordenación de la pesquería: Peru. Estado de la merluza, otras especies demersales y especies costeras*. FAO Programa de Cooperación Técnica, FI:TCP/PER/4451, Documento de campo No.2. 90 pp.

Lluch-Belda, D., Crawford, R.J.M., Kawasaki, T., MacCall, A., Parrish, R.H., Schwartzlose, R.A. & Smith, P.E. 1989. World wide fluctuations of sardine and anchovy stocks: the regime problem. *South African Journal of Marine Sciences*, 8: 195–205.

Lluch-Belda, D., Schwartzlose, R.A., Serra, R., Parrish, R., Kawasaki, T., Hedgecock, D. & Crawford, R.J.M. 1992. Sardine and anchovy regime fluctuations of abundance in four regions of the world oceans: a workshop report. *Fisheries Oceanography*, 1(4): 339–347.

Nigmatullin, C.M., Nesis, K.N. & Arkhipkin, A.I. 2001. A review of the biology of the jumbo squid *Dosidicus gigas* (Cephalopoda: Ommastrephidae). *Fisheries Research*, 54: 9–19.

Ñiquen, M., Bouchón, M., Cahuín, S. & Díaz, E. 2000. Pesquería de anchoveta en el mar peruano. 1950-1999. *Boletin Instituto del Mar del Perú*, 19: 117–123.

Oliveros-Ramos, R., Guevara-Carrasco, R., Simmonds, J., Csirke, J., Gerlotto, F., Castillo, R. & Tam, J. 2010. Modelo de evaluación integrada del stock norte-centro de la anchoveta peruana *Engraulis ringens* Jenyns - Integrated assessment model for the north-central stock of Peruvian anchoveta *Engraulis ringens* Jenyns. *In* V Panel Internacional de Expertos en evaluación de la anchoveta peruana (*Engraulis ringens* Jenyns) – Hacia un enfoque ecosistémico en la pesquería de la anchoveta peruana. IMARPE, Callao, Peru, 10–14 Agosto 2009. *Boletin Instituto del Mar del Perú*, 25(1–2): 49–56.

Parrish, R.H., Serra, R. & Grant, W.S. 1989. The monotypic sardines, sardina and sardinops: their taxonomy, distribution, stock structure and zoogeography. *Canadian Journal of Fisheries and Aquatic Sciences*, 46: 2019–2036.

Patterson, K.R., Zuzunaga, J. & Cárdenas, G. 1992. Size of the South American Sardine (*Sardinops sagax*) Population in the Northern Part of the Peru Upwelling Ecosystem after Collapse of Anchoveta (*Engraulis ringens*) Stocks. *Canadian Journal of Fisheries and Aquatic Sciences*, 49: 1762–1769.

Pauly, D. & Palomares, M.L. 1989. New estimates of monthly biomass, recruitment and related statistics of anchoveta (*Engraulis ringens*) off Peru (4-14ºS), 1953-1985, *In* D. Pauly, P. Muck, J. Mendo & I. Tsukayama, eds. *The Peruvian upwelling ecosystem: dynamics and interactions*, pp. 189–206. ICLARM Conference Proceedings 18. Callao, Perú, IMARPE; Eschborn, Germany, GTZ; and Manila, ICLARM. 438.

Pauly, D. & Tsukayama, I. 1987. *The Peruvian anchoveta and its upwelling ecosystem: three decades of change*. ICLARM Studies and Reviews. 15. Callao, Perú, IMARPE; Eschborn, Germany, GTZ; and Manila, ICLARM. 351.

Pauly, D., Muck, P., Mendo, J. & Tsukayama, I. 1989. *The Peruvian upwelling ecosystem: dynamics and interactions*. ICLARM Conference Proceedings, 18. ICLARM Conference Proceedings 18. Callao, Perú, IMARPE; Eschborn, Germany, GTZ; and Manila, ICLARM. 438.

Payá, I., 2003. Asesoría biológica para el manejo de la pesquería de merluza común (*Merluccius gayi gayi*): Evaluación del stock y análisis de riesgo. *In* E. Yánez, ed. *Actividad pesquera y de acuicultura en Chile*, pp. 189–207. Chile, Pontificia Universidad Católica de Valparaíso.

Payá, I., Pool, H., Aguayo, M., Ojeda, V. & Céspedes, R. 2000. Estrategias de explotación en merluza del sur y congrio dorado en la zona sur austral bajo incertidumbre del tamaño y rendimiento sustentable del stock. (citado en: Pérez, A y Buschmann A. 2003. *Sustentabilidad e incertidumbre de las principales pesquerías Chilenas*. Publicaciones Oceanía, Santiago de Chile). Informe Final Proyecto FIP-IT 97–14.

Payá, I., Rubilar, P., Pool, H., Céspedes, R., Reyes, H., Ehrhardt, N., Adarme, L. & Hidalgo, H. 2002. Evaluación de la merluza de cola y merluza tres aletas. (citado en: Pérez, A y Buschmann A. 2003. *Sustentabilidad e incertidumbre de las principales pesquerías Chilenas*. Publicaciones Oceanía, Santiago de Chile). Informe Final Proyecto FIP 2000-15, 163 pp.

Pérez, A. & Buschmann, A. 2003. *Sustentabilidad e incertidumbre de las principales pesquerías Chilenas*. Santiago de Chile, Publicaciones Oceana. 163 pp.

PRODUCE. 2002. *Anuario Estadístico 2002*. Lima, Oficina General de Tecnología de la Información y Estadística, Ministerio de la Producción. 227 pp. (also available at www.produce.gob.pe).

PRODUCE, 2008a. *Ley sobre los límites máximos permisibles de capturas por embarcación*. Decreto Legislativo N° 1084. Lima. (also available at www.produce.gob.pe).

PRODUCE 2008b. *Aprueban Reglamento del Decreto Legislativo N° 1084 – Ley sobre Límites Máximos de Captura por Embarcación. Decreto Supremo 021-2008-PRODUCE, Lima, Perú, 12 Diciembre 2008*. (also available at www.produce.gob.pe).

PRODUCE, 2009. *Establecen disposiciones reglamentarias para la aplicación del Decreto Legislativo N° 1084 - Ley sobre Límites Máximos de Captura por Embarcación en la Zona Sur del país. Decreto Supremo N° 009-2009-PRODUCE. Lima, Perú, 31 Marzo 2009*. (also available at www.produce.gob.pe/pesqueria/publicaciones/2009/abril/ds009-2009-produce.pdf).

Rabí, M., Yamashiro, C. & Quiroz, M. 1996. Revisión de la biología y pesquería del recurso chanque *Concholepas concholepas* (Bruguiere, 1789) (Mollusca: gastropoda: Muricidae). *Inf. Prog. Inst. Mar. Perú*, 31: 3–23.

Rasmusson, E.M. & Carpenter, T.H. 1982. Variations in tropical sea surface temperature and surface wind fields associated with the Southern Oscillation/El Niño. *Monthly Weather Review*, 110: 354–384.

Rodhouse, P.G. 2001. Managing and forecasting squid fisheries in variable environments. *Fisheries Research*, 54: 3–8.

Salazar, C., Martínez, C., Mendieta, J. & Böhm, G. 1984. Evaluación del recurso sardina española (*Sardinops sagax musica*) de la zona norte de Chile, por análisis de Población Virtual. *Invest. Pesq*. (Chile), 31: 3–16.

Samamé, M., Castillo, J. & Mendieta, A. 1985. Situación de las pesquerías demersales y los cambios durante "El Niño". *In* W. Arntz, A. Landa & J. Tarazona, eds. "El Niño". Su impacto en la fauna marina, pp. 153–158. *Bol. Inst. Mar Perú,* Vol. Extraord. 222 pp.

Schaefer, M.B. 1967. Dynamics of the fishery for the anchoveta *Engraulis ringens*, off Peru. *Boletin Instituto del Mar del Perú, Callao*, 5(Vol.1): 265–304.

Schwartzlose, R.A., Alheit, J., Bakun, A., Baumgartner, T., Colte, R., Crawford, R.J.M., Fletcher, W.J., Green-Ruiz, Y., Hagen, E., Kawasaki, T., Lluch-Belda, D., Lluch-Cota, S.E., MacCall, A., Matsuura, Y., Nevarez-Martínez, M.O., Parrish, R.H., Roy, C., Serra, R., Shust, K.V., Ward, M.N. & Zuzunaga, J. 1999. Worldwide large-scale fluctuations of sardine and anchovy populations. *South African Journal of Marine Sciences*, 21: 289–347.

Schweigger, E. 1964. *El litoral peruano*. Segunda edición. Lima, Universidad Nacional Federico Villarreal. 435 pp.

Serra, R. 1983. Changes in the abundance of pelagic resources along Chilean coast. *In* G.D. Sharp & J. Csirke, eds. *Proceedings of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources, San Jose, Costa Rica, 18–19 April 1983*, pp. 255–284. FAO Fisheries Report No. 291. Rome, FAO.

Serra, R. 1991a. Long-term variability of the Chilean sardine. *In* T. Kawasaki, S. Tanaka, Y. Toba & A. Taniguchi, eds. *Proceedings of the International Symposium on the Long-Term Variability of Pelagic Fish Populations and their Environment*, pp. 165–172. New York, USA, Pergamon Press.

Serra, R. 1991b. Important life history aspects of the Chilean jack mackerel, *Trachurus symmetricus murphyi*. *Invest. Pesq. Chile*, 36: 67–83.

Serra, R. 2001. An overview of the Chilean jack mackerel: its life history and present status. *In Proceedings of an International Workshop on the Research and Management of the Horse Mackerel in Namibian Waters*. Ministry of Fisheries and Marine Resources, Swakopmund, Namibia.

Serra, R. & Tsukayama, I. 1988. *Sinopsis de datos biológicos y pesqueros de la sardina* Sardinops sagax *(Jenyns, 1842) en el Pacífico suroriental*. FAO Sinopsis sobre la pesca 13.

Serra, R. & Zuleta, A. 1982. *Antecedentes biológico pesqueros de los recursos pelágicos de la pesquería de la zona norte, con énfasis en la sardina española*. Informe interno. Santiago, Subsecretaría de Pesca.

Sharp, G.D. & Csirke, J., eds. 1983. *Proceedings of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources, San Jose, Costa Rica, 18–19 April 1983*. FAO Fisheries Report No. 291(Vols. 2&3). Rome, FAO. pp. 1–1224.

South Pacific Regional Fisheries Management Organisation (SPRFMO). 2008. *Chilean Jack Mackerel Workshop. Report of the South Pacific Fisheries Management Organisation Chilean Jack Mackerel Workshop. Santiago, Chile, 30 June/4 July 2008*. 71 pp. (also available at www.southpacificrfmo.org).

South Pacific Regional Fisheries Management Organisation (SPRFMO). 2009. *Final Act of the International Consultations on the Establishment of the Proposed South Pacific Fisheries Management Organisation, Auckland, New Zealand, 14 November 2009*. 15 pp. (also available at www.southpacificrfmo.org).

South Pacific Regional Fisheries Management Organisation (SPRFMO). 2010. *Report of the 9th Science Working Group. South Pacific Fisheries Management Organisation, 9th Science Working Group, Viña del Mar, Chile, 21–29 October 2010*. 66 pp. (also available at www.southpacificrfmo.org).

South Pacific Regional Fisheries Management Organisation (SPRFMO). 2011. *Report of the Second Session of the Preparatory Conference for the Commission of the South Pacific Regional Fisheries Management Organisation, Cali, Colombia, 24–28 January 2011*. 4 pp. + 8 annexes (also available at www.southpacificrfmo.org).

Strub, P.T., Mesías, J., Montecino, V., Rutlant, J. & Salinas, S. 1998. Coastal ocean circulation off western South America, coastal segment (6,E). *In* A. Robinson & K. Brink, eds. *The Sea*, Chapter 10. John Wiley & Sons, Inc.

Subsecretaría de Pesca (SUBPESCA). 2008a. *Ficha Pesquera Noviembre 2008 - Anchoveta V-X Regiones (*Engraulis ringens*, Jenyns 1842)*. Chile. (also available at www.fip.cl).

Subsecretaría de Pesca (SUBPESCA). 2008b. *Ficha Pesquera Noviembre 2008 - Anchoveta XV, I y II Regiones (*Engraulis ringens*, Jenyns 1842)*. Chile. (also available at www.fip.cl).

Subsecretaría de Pesca (SUBPESCA). 2008c. *Ficha Pesquera Noviembre 2008 - Anchoveta III-IV Regiones (*Engraulis ringens*, Jenyns 1842)*. Chile. (also available at www.fip.cl).

Subsecretaría de Pesca (SUBPESCA). 2010a. *Cuota global anual de captura para las unidades de pesquería de anchoveta y sardina española, Regiones XV, I y II, Año 2011*. Informe Técnico (R. Pesq.) No. 107–10. Valparaiso, Chile. 49 pp.

Subsecretaría de Pesca (SUBPESCA). 2010b. *Cuota global anual de captura para las unidades de pesquería de anchoveta (*Engraulis ringens*) y sardina común (*Strangomera bentincki*), V a X Regiones, Año 2011.* Informe Técnico (R. Pesq.) No. 120–10. Valparaiso, Chile. 32 pp.

Subsecretaría de Pesca (SUBPESCA). 2010c. *Cuota global anual de captura de merluza común (*Merluccius gayi gayi*), año 2011*. Inf. Tec. (R. Pesq) No. 124–2010. Valparaiso, Chile. 56 pp.

Subsecretaría de Pesca (SUBPESCA). 2010d. *Cuota global anual de captura para las unidades de pesquería de merluza de cola (*Macruronus magellanicus*), año 2011*. Inf. Tec. (R. Pesq) No. 122–2010. Valparaiso, Chile. 28 pp.

Subsecretaría de Pesca (SUBPESCA). 2010e. *Cuota global anual de captura merluza del sur (*Merluccius australis*), año 2011*. Inf. Tec. (R. Pesq) No. 123–2010. Valparaiso, Chile. 56 pp.

Subsecretaría de Pesca (SUBPESCA). 2010f. *Cuota global anual de captura de bacalao de profundidad (*Dissostichus eleginoides*), año 2011*. Inf. Tec. (R. Pesq) No. 98–2010. Valparaiso, Chile. 26 pp.

Tsukayama, I. 1966. El número de branquispinas como carácter diferencial de subpoblaciones de anchoveta (*Engraulis ringens* Jenyns) en la costa del Perú. *In: Memorias 1er. Seminario Latino-Americano sobre el Océano Pacífico Oriental*, pp. 139–145. Lima, Universidad Nacional Mayor de San Marcos.

Tsukayama, I. 1983. Recursos pelágicos y sus pesquerías en el Perú. *Rev. Com. Perm. Pacífico Sur*, 13: 25–63.

Valdivia, J. 1978. The anchoveta and El Niño. *Rapports et Proces-verbaux des Réunions. Conseil International pour l'Éxploration de la Mer*, 173: 196–202.

Yañez, E., Barbieri, M.A. & Silva, C. 2003. Fluctuaciones ambientales de baja frecuencia y principales pesquerías pelágicas chilenas. *In* E. Yánez, ed. *Actividad pesquera y de acuicultura en Chile*, pp. 109–121. Chile, Pontificia Universidad Católica de Valparaíso.

Zuta, S., Tsukayama, I. & Villanueva, R. 1983. El ambiente marino y las fluctuaciones de las principales poblaciones pelágicas de la costa peruana. *In* G.D. Sharp & J. Csirke, eds. *Proceedings of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources, San Jose, Costa Rica, 18–19 April 1983*, pp. 179–254. FAO Fisheries Report No. 291(3). Rome, FAO.

Zuzunaga, J. **1985.** Cambios del equilibrio poblacional entre la anchoveta (*Engraulis ringens*) y la sardina (*Sardinops sagax*) en el sistema de afloramiento frente al Perú. *In* W. Arntz, A. Landa & J. Tarazona, eds. "El Niño". Su impacto en la fauna marina, pp. 107–117. *Boletin Instituto del Mar del Perú*, Vol. Extraord. 222 pp.

B16. Southern Ocean

FAO STATISTICAL AREAS 48, 58 AND 88

Ross Shotton
FAO Consultant
Greece
E-mail: r_shotton@hotmail.com

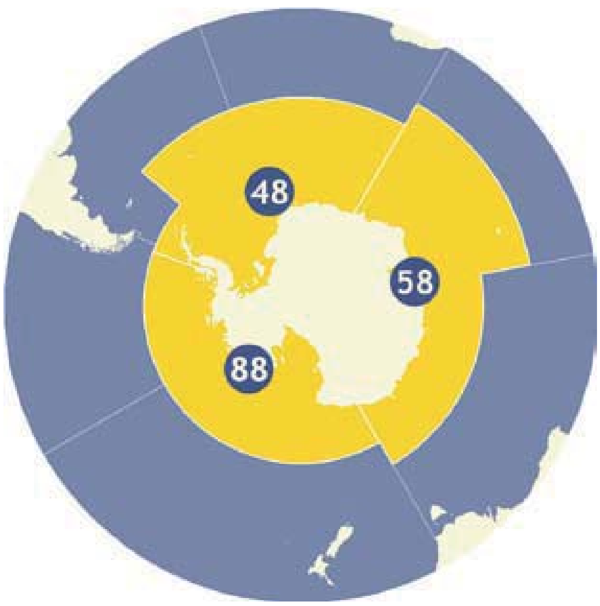
Merete Tandstad
Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: merete.tandstad@fao.org

INTRODUCTION

The Southern Ocean surrounds Antarctica and represents about 15 percent of the world's ocean area. It extends from the coast of the continent north to the Antarctic Convergence. This is a physically and biologically distinct frontal zone where the cold water of the Southern Ocean encounters, and flows under, the warmer and more saline sub-Antarctic water of the Atlantic, Indian and Pacific Oceans. The Southern Ocean is characterized by an eastward-flowing Antarctic Circumpolar Current and a series of clockwise-rotating gyres that contribute to a westward-flowing East Wind Drift along the Antarctic coast. The Southern Ocean has three distinct ecological zones: an ice-free zone to the north; an extensive seasonal pack-ice zone between about 55–60°S and 70–75°S; and a permanent pack-ice zone adjacent to the continent.

The Antarctic Convergence front encircles Antarctica and is formed by cold, northward-flowing Antarctic waters sinking beneath the relatively warmer waters of the sub-Antarctic. Associated zones of mixing and upwelling create high biological productivity, especially of Antarctic krill. The convergence separates two hydrological regions with distinctive marine life and climate. The position of the Antarctic Convergence varies seasonally and geographically, but is generally located near 50°S in the Atlantic and Indian sectors of the Southern Ocean and near 60°S in the Pacific sector. The Southern Ocean (Figure B16.1) is divided for statistical purposes into: Area 48 (Antarctic Atlantic), between 70°W and 30°E; Area 58 (Antarctic Indian Ocean), between 30°E and 150°E; and Area 88 (Antarctic Pacific) between 150°E and 70°W.

FIGURE B16.1
The Southern Ocean (Areas 48, 58 and 88)



Antarctic krill (*Euphausia superba*) is a keystone circumpolar species of the Southern Ocean. It is abundant in the seasonal pack-ice zone, where it provides the staple food for many species of whales, seals, penguins and other seabirds, and fish that inhabit the region. This is particularly so in the Antarctic Atlantic region, and this area is where krill fishing is focused. *E. superba* is also dominant in Area 58, while another species *Euphausia crystallorophias* is abundant in Area 88, but these populations are not currently fished.

The marine living resources of the Southern Ocean have been harvested since 1790, when sealers first hunted fur seals for their pelts. By 1825, some populations of fur seal had been hunted close to extinction. Sealers then began hunting elephant seals and some species of penguins for their oil. Whaling in Areas 48, 58 and 88 began in 1904, and all seven species of whales found in the Southern Ocean were extensively exploited. Large-scale fishing did not begin until the late 1960s. Important species fished included lanternfish (myctophids), mackerel icefish (*Champsocephalus gunnari*), marbled rockcod (*Notothenia rossii*) and Patagonian rockcod (*Patagonotothen guntheri*). By the late 1970s, certain species of finfish had been severely overfished in some regions.

The management of marine living resources in the Southern Ocean is the mandate of several international organizations. The International Whaling Commission (IWC), established in 1946, is responsible for management and conservation of whales. The Convention for the Conservation of Antarctic Seals, ratified in 1978, reports to the Scientific Committee on Antarctic Research, which undertakes the tasks requested of it in the convention. The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), established in 1982, is responsible for the conservation of marine species including seabirds and the management of fisheries in the Southern Ocean. It purposely has a wide mandate that encompasses all ecological aspects of the area for which it has competence. Under this mandate, the CCAMLR pioneered the implementation of the precautionary principle and the ecosystem-based approach to fisheries management. The CCAMLR meets annually and the extensive reports of its Scientific Committee and those of the Commission are available on its Web site (www.ccamlr.org).

PROFILE OF CATCHES[6]

Overall trends in fishery catches have varied widely, reflecting intense fishing in the 1960s and 1970s. Such fishing led to the overexploitation of stocks of marbled rockcod and large fluctuations in catches of mackerel icefish in the mid-1970s and 1980s. These fluctuations were possibly related to large variations in recruitment (Kock and Everson, 1997). There were also large but variable catches of krill from about 1978 until the early 1990s when the Soviet fleet was disbanded following the breakup of the former Soviet Union.

In the 1980s and 1990s, fishing focused on krill, Patagonian toothfish (*Dissostichus eleginoides*), mackerel, icefish and, to a limited extent, squid and crab. The development of new harvesting technology and markets in recent years has seen growing interest in exploratory fisheries targeting Antarctic toothfish (*Dissostichus mawsoni*) adjacent to the continent, and renewed interest in krill fishing. At its peak in 1982, the krill fishery contributed about 13 percent of the global annual catches of crustaceans.

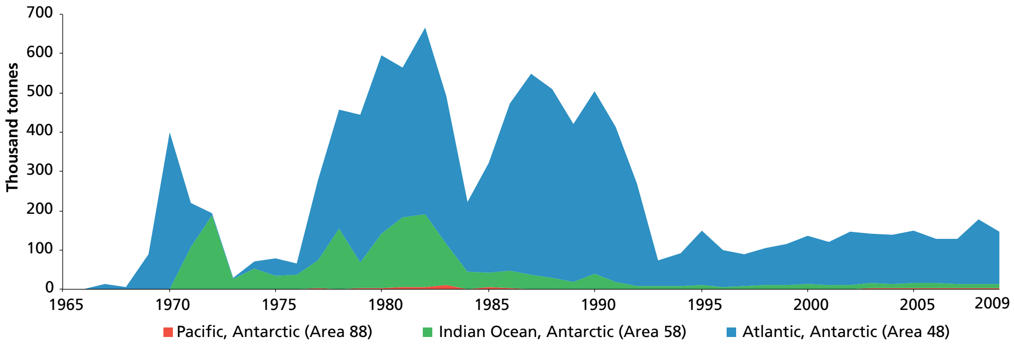
Catches from the Southern Ocean are dominated by those from the Antarctic Atlantic. As a consequence, the total catch from Area 48 has traditionally dominated reported landings from the Southern Ocean with relatively minor landings from the other two regions. In 2009, catches recorded from this region were 90 percent of the total recorded catches from the Southern Ocean. However, recent catches remain about one-third of the general period of the 1980s and 1990s (Figure 16.2).

When considered by major statistical area,[7] the overall catch of the Antarctic Atlantic (Area 48) has shown a steadily increasing trend from a low in 1993 of 64 000 tonnes to

[6] Management of Southern Ocean fishery resources by CCAMLR is based on an austral CCAMLR season rather than the calendar year, and reporting of catches reflects this season and not the calendar year as followed by the FAO for the other Statistical Areas. The CCAMLR season extends from 1 December to 30 November of the following year (e.g. the 2009/2010 season is from 1 December 2009 to 30 November 2010).

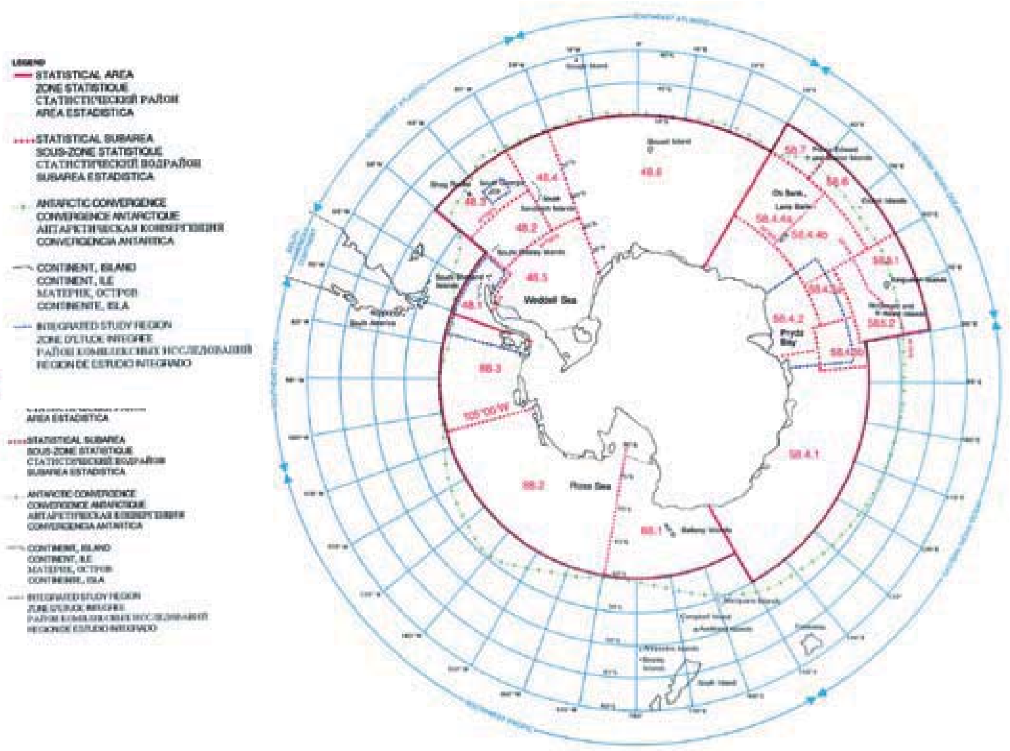
[7] The statistical areas have been developed jointly by the CCAMLR and FAO.

FIGURE B16.2
Annual nominal catches in Areas 48, 58 and 88



131 700 tonnes in 2009. In the Antarctic Indian Ocean (Area 58), there were highly variable catches from 1970 to 1990. After that time, landings stabilized at a small fraction of this period's maximum, although with a slightly increasing trend. In the Pacific sector of the Southern Ocean, catches were also highly variable from 1977 to 1992. No landings were reported after that until 1998. Then, reported landings showed a generally increasing trend with a peak of 3 730 tonnes in 2005 (Tables D8, D11 and D18). In the 1990s and early 2000s, IUU fishing took large unreported quantities of toothfish. These unreported catches may have exceeded the reported catch by five to six times (e.g. SC-CCAMLR, 2010, Annex 8, Table 5).

FIGURE B16.3
CCAMLR boundaries of statistical reporting areas in the Southern Ocean

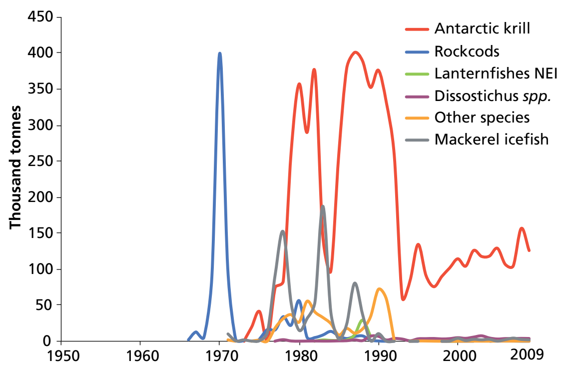


Antarctic Atlantic (Area 48)[8]

The krill fishery is the dominant fishery in the Antarctic Atlantic. Historically, peak catches were taken in early and late 1980s with catches of 374 000 tonnes in 1982 and

[8] In the following section, the reference to the subareas relates to the CCAMLR subareas (Figure B16.3).

FIGURE B16.4
Annual nominal catches of selected species in Area 48



400 000 in 1987. These large catches were made prior to the breakup of the then Soviet Union and the disbanding of the Soviet fishing fleet. Krill catches have been between 100 000 tonnes and 150 000 tonnes in the last decade (Figure B16.4). These lower catches reflect a decrease in fishing effort rather than overfishing. The fishery has operated predominantly in Area 48, around the South Shetland Islands (Subarea 48.1) and South Orkney Islands (Subarea 48.2). It generally occurs in summer when pack-ice is at its minimum extent and adjacent to South Georgia (Subarea 48.3) in winter. In 2008–09, 126 000 tonnes of krill was reported from Subareas 48.1, 48.2 and 48.3. In 2009–2010, 211 984 tonnes of krill was harvested from the same subareas. As a result, the krill fishery in Subarea 48.1 was closed following the highest recorded catch. This was the first time that a subarea had been closed because catches had reached the threshold amount (155 000 tonnes). Intentions to catch 410 000 tonnes in 2010–11 had been indicated by the main fleets in this fishery from Norway and the Republic of Korea. A change in the fishing pattern for krill had been reported, with the catches coming mostly from Subarea 48.2 in 2008–09 and from around Bransfield Strait in Subarea 48.1 in 2009–10. The fishery concentrated in Subarea 48.1 in 2009–2010. Moreover, the krill fishery was able to operate in Subarea 48.1 in winter because of the low level of pack-ice.

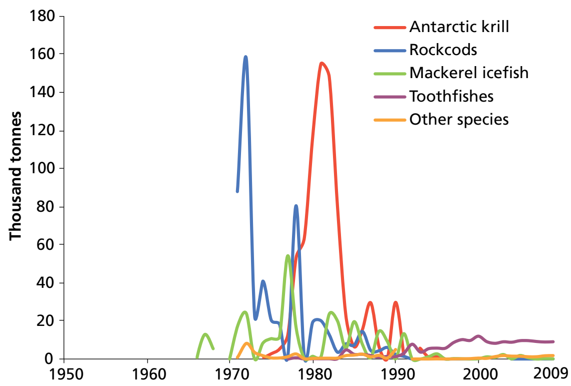
The former Soviet fleet fished intensively on rockcods (Nototheniidae) in the decade starting in 1966, and catches peaked at almost 400 000 tonnes in 1970. The CCAMLR implemented long-term prohibitions on the directed fishing on rockcods and other finfish species in Subarea 48.1 and 48.2, and on marbled rockcod in Subarea 48.3 between 1984 and 1986. The results of repeated scientific surveys to investigate recovery from this intense period of fishing have been inconclusive (Kock, Belchier and Jones, 2004). The collapse of the marbled rockcod fishery was followed by the expansion of a fishery for mackerel icefish (*Champsocephalus gunnari*), which peaked at about 190 000 tonnes in 1983. This fishery also was soon depleted by a combination of regional overfishing and highly variable annual recruitment. The icefish fishery is now managed by the CCAMLR, and fishing is permitted in Subarea 48.3 at a relatively minor level – just under 2 000 tonnes in 2009.

In 2009, krill dominated landings (95.7 percent), followed by Patagonian toothfish (*Dissostichus eleginoides*) (2.6 percent). The toothfish catch represented 59.5 percent of non-krill landings, followed by mackerel icefish (*Champsocephalus gunnari*) (31.4 percent of non-krill landings) (Figure B16.4). Of these, Patagonian toothfish is the most valuable species. It is the dominant species of toothfish in Subarea 48.3. Antarctic toothfish (*Dissostichus mawsoni*) dominates the catch in the Subareas 48.4 and 48.6. The increased landings of krill have attracted considerable international attention because of the important role of krill as a prey species in regional ecosystems.

Antarctic Indian Ocean (58)

In the Antarctic Indian Ocean, catches from vessels targeting toothfish now dominate the fishery – 9 000 tonnes in 2009 (Figure B16.5). Catches are down from their peak of about 12 000 tonnes in 2000 and have been essentially stable since 2002. Patagonian toothfish dominates the catches in Divisions 58.5.1 and 58.5.2 and Subareas 58.6 and 58.7, while Antarctic toothfish (*Dissostichus mawsoni)* dominates the catches in Divisions 58.4.1, 58.4.2, 58.4.3a and 58.4.3b. Ridgescaled rattail (*Macrourus carinatus*) is taken as bycatch in the fisheries for toothfish, and form a by-product in the fisheries operating in the French EEZs. The once-important fisheries for mackerel icefish (54 187 tonnes in 1977) and grey rockcod (*Notothenia squamifrons*) (52 912 tonnes in 1972) continue to show no sign of recovery, and fishing on these species is prohibited.

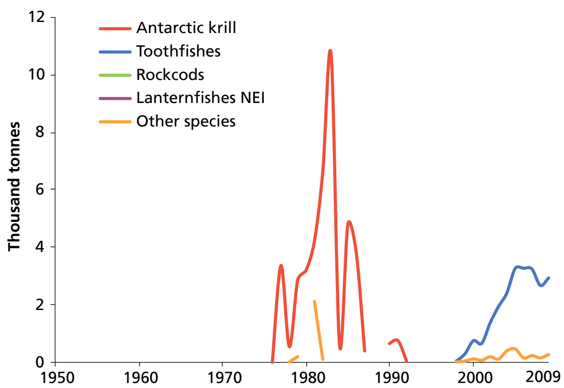
FIGURE B16.5
Annual nominal catches of selected species in Area 58



Antarctic Pacific (Area 88)

The fishery in the Antarctic Pacific is relatively small, and it is dominated by catches of Antarctic toothfish (*Dissostichus mawsoni*) with a total of 2 917 tonnes taken in 2009 (91 percent of reported landings from Area 88) (Figure B16.6). This species is taken in exploratory fisheries in Subarea 88.1 and 88.2 that were initiated in 1987. Catches have been stable since around 2004. The bycatch in Area 88 is largely *Macrourus* spp.

FIGURE B16.6
Annual nominal catches of selected species in Area 88



RESOURCE STATUS AND FISHERY MANAGEMENT

Whaling in the Southern Ocean began with the introduction of industrial harvesting methods in the early twentieth century. It has a complex, although well-documented, history. Of the major whale groups, only the minke whale escaped severe depletion. Commercial exploitation on this species (the smallest of the large whales) only began in the early 1970s. Several hundred thousand Antarctic minke whales exist and the species is not considered to be endangered. However, there was an appreciable decline in the estimated abundance of minke whale between 1982/83–1988/89 and 1991/92–2003/04. Present estimates of total Antarctic minke whale abundance range from about 460 000 to 690 000 individuals. Several hundred minke whales are taken annually in Areas 48, 58 and 88 by Japan for research that is endorsed by the IWC. Recovery of the southern whale stocks proceeds slowly depending on species.

A moratorium on commercial whaling was introduced in 1987. The Southern Ocean Whale Sanctuary surrounds the Antarctic continent and is bounded by the 40°S parallel in the Antarctic Atlantic, the 55°S parallel in the Antarctic Indian Ocean and the 60°S parallel in the Antarctic Pacific Ocean. Whale sanctuaries were established in the Indian Ocean in 1979 and Southern Ocean in 1994. Management of whales in the Antarctic (and elsewhere) is the responsibility of the IWC. It evaluates the recovery of whale stocks and the effectiveness of the moratorium and sanctuaries. There are indications that some species of whale are recovering, but the low abundance of some of the largest species has made total numbers difficult to estimate from sightings data.

Early hunting had almost decimated populations of seals in many locations in the Southern Ocean by 1830. This led to a decline in the sealing industry, although it continued on a small scale into the twentieth century. However, there has been no commercial sealing in Antarctica since the 1950s. The Convention for the Conservation of Antarctic Seals was established to avoid future overexploitation of seal populations. It established permissible catch limits for species such as crab-eater, leopard and

Weddell seals. Annual catch limits were set at 175 000 individuals for crab-eater seals, 12 000 individuals for leopard seals and 5 000 individuals for Weddell seals. A zoning system was established with closed hunting seasons. Total protection was given for the rare Ross seal and southern elephant seal and certain species of fur seal.

In 1982, parties to the Antarctic Treaty established the CCAMLR under an international convention. Its purpose was to apply an ecosystem approach to the conservation of marine living resources in the Southern Ocean. Conservation was defined to also include rational use. The conservation principles set down in the convention require that exploited populations must not be allowed to fall below an abundance close to that which ensures their greatest net annual increase. Depleted populations must be restored to such abundance, and the risks of changes to the marine ecosystem that are not potentially reversible in two or three decades must be minimized. Importantly, ecological relationships between harvested, dependent and related species must be maintained.

These stringent principles embody an ecosystem approach to the management of living resources. It sets the CCAMLR convention apart from other regional marine resource management regimes. Management of fishing must not only aim to conserve the targeted species (status shown in Tables D8, D11 and D18), but take into account the impact of fishing on those animals that prey on, and compete with, the targeted species. In its broadest interpretation, the convention requires that management action should take into account the impact of activities on all living organisms in the Antarctic ecosystem or subsystems.

The status and management of the marine ecosystem of the Southern Ocean is reviewed annually by all member countries of the CCAMLR. These assessments are based on information gathered from the commercial fisheries and fishery surveys, the Scheme of International Scientific Observation aboard fishing vessels, and CCAMLR's Ecosystem Monitoring Program. Fishery resources are reassessed and decisions are agreed by consensus. The management regime applied is defined by conservation measures that regulate all fisheries, and fishing for research purposes within the CCAMLR convention area (Areas 48, 58 and 88). The CCAMLR's unified framework for fisheries includes new and exploratory fisheries and assessed fisheries, as well as lapsed and closed fisheries.

Complementary management measures are also in force in territorial waters adjacent to Prince Edward and Marion Islands (South Africa), Crozet Islands and Kerguelen Islands (France) and Heard and McDonald Islands (Australia) in Area 58. Of particular interest has been the recent creation of the world's largest fully protected marine reserve in the Australian sub-Antarctic. The Heard and McDonald Islands Marine Reserve (65 000 km^2; see www.environment.gov.au/coasts/mpa/heard/) should ensure that this pristine ecosystem remains intact. It surrounds the uninhabited Heard and McDonald Islands and includes two large zones of the Southern Ocean. The Heard Island reserve is intended to protect the habitat and food sources of seals, penguins, albatrosses and other marine life.

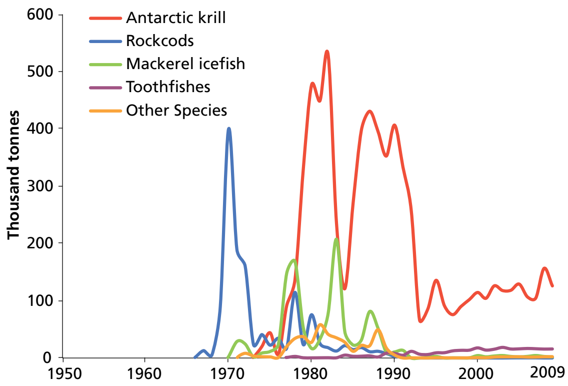
The CCAMLR has also declared the first high seas marine protected area (MPA) to the south of the South Orkney Islands in Area 48 (94 000 km^2).[9] This MPA is the first component of a Southern Ocean MPA network. Fishing activities are prohibited along with the discharge and disposal of refuse from fishing vessels. This area also provides an opportunity to improve monitoring of the effects of human activities and climate change on the Southern Ocean.

Krill

Krill is central to the food chain in the Southern Ocean, and its circumpolar standing stock is generally estimated at about 500 million tonnes. There remains much uncertainty

[9] See www.ccamlr.org/pu/e/e_pubs/cm/10-11/91-03.pdf

FIGURE B16.7
Annual nominal catches of selected species in Areas 48, 58 and 88



over the accuracy of these production estimates for krill. The decline in krill catches in 1992 (Figure B16.7) was attributed to a combination of factors. These included economic factors, a shift in fishing effort from krill fisheries to finfish fisheries, and the breakup of the Soviet Union, which until then had dominated the fishery. There was no evidence that the decline of the fishery was not due to overfishing.

The CCAMLR Scientific Committee has noted that "Interest in krill fishing continues to grow and catches exceeded 200 000 tonnes in 2009/10." Following an extensive four-vessel acoustic survey in Area 48, the CCAMLR set a new precautionary catch limit of 5.61 million tonnes for krill in Subareas 48.1–48.4. Precautionary limits are implemented in each subarea. A further small-scale subdivision of these catch limits will be required before the fishery is allowed to expand above a trigger level of 620 000 tonnes. This trigger level is not linked to an assessment of virgin biomass (B_0). The CCAMLR Scientific Committee also expressed concern over krill escape mortality and the impact of krill fishing on fish larvae and krill predators.[10] For these reasons, krill fisheries are closely monitored because vessels target krill aggregations on the shelf or at the shelf break. In many cases, these aggregations are close to the breeding sites of land-based krill predators such as penguins. The interaction between krill fisheries and land-based krill predators is being researched under the CCAMLR's Ecosystem Monitoring Program.[11] The potential impact of climate change upon the extent of ice-sheet coverage in the Antarctic has also been of concern. This is because of its possible affect upon krill life history and recruitment variability. The CCAMLR is cognizant of the need to consider the influence of recruitment variability on the calculation of sustainable yields.

Toothfish

Toothfish is harvested under exploratory and assessed fisheries in Areas 48, 58 and 88. Two species are taken: Patagonian toothfish (*Dissostichus eleginoides*), representing 70.3 percent by weight in 2009; and Antarctic toothfish (*Dissostichus mawsoni*), representing 29.7 percent (figure B16.7). Patagonian toothfish occur mostly near the sub-Antarctic islands and to the north of the CCAMLR convention area. Antarctic toothfish occur predominantly along the continental coastline of Antarctica. Annual landings within the CCAMLR convention area have been stable at just below 16 000 tonnes since 2002.

Catches of toothfish from both inside and outside the CCAMLR convention area are reported using the CCAMLR's Catch Documentation Scheme (CDS). In addition to total landings of 15 784 tonnes of toothfish in 2009 from Areas 48, 58 and 88, 9 952 tonnes of *Dissostichus* spp. were taken outside the CCAMLR convention area in 2009–2010 (to October 2010). This compares with 12 806 tonnes in 2008–09, which was mostly taken in Areas 41 and 87.

Since May 2000, the CCAMLR has operated its CDS for *Dissostichus* spp. This scheme was established under Conservation Measure 10–05 to assist in the management and conservation of toothfish. The CDS is designed to track the landings and trade of toothfish caught inside the CCAMLR convention area. It has also been extended

[10] See www.ccamlr.org/pu/e/e_pubs/sr/10/toc.htm
[11] See www.ccamlr.org/pu/e/sc/cemp/intro.htm

to toothfish fisheries in adjacent waters. The scheme provides the CCAMLR with the information necessary to identify the origins of toothfish entering the markets of contracting parties. It allows the CCAMLR to determine if it was harvested in the CCAMLR convention area in a manner consistent with its conservation measures. This process is facilitated by the use of an electronic system for recording toothfish landings and product movements. The landing or transfer of toothfish from a vessel is certified by the port State where it is landed. Any export, import or re-export is tracked by the CDS, and documentation must accompany each consignment of fish.

Mackerel icefish

Fishing for icefish is now concentrated in the vicinity of South Georgia (Subarea 48.3) and about Heard Island (Division 58.5.2). In the 2009–2010, season the catch limit set for *C. gunnari* in Subarea 48.3 was 1 548 tonnes, and only 12 tonnes had been caught by October 2010. The catch limit for *C. gunnari* was recommended to be 2 305 tonnes in 2010–11 and 1 535 tonnes in 2011–12. For Heard Island (Division 58.5.2), the catch limit for the 2009–2010 season was 1 658 tonnes and the catch reported for this division was, at October 2010, only 365 tonnes. The CCAMLR manages both fisheries using a short-term assessment method based on the results of pre-recruit surveys (SC–CCAMLR, 2010, Annex 8). It is recognized that additional work remains outstanding on the assessment method for icefish. The method always predicts a precautionary yield and the question remains as to whether a rebuilding strategy needs to be undertaken for such stocks when they have small biomasses. The catch limit for *C. gunnari* in 2010–11 was to be set at 78 tonnes. As an additional precaution, directed fishing on finfish along the Antarctic Peninsula (Subarea 48.1) and around the South Orkney Islands (Subarea 48.2) is prohibited.

Crab resources

An exploratory fishery for crabs in Subarea 48.2 was undertaken for the first time in 2009–2010. Fishing effort consisted of 79 140 pot hours and 17 sets. However, only three *Paralomis formosa* males were captured. No member of the CCAMLR indicated that they intended to fish for crabs in Subarea 48.2 in the 2010–11 season. There was also no new information available on the stock status of crabs or the conduct of the fishery in Subarea 48.3.

Elasmobranchs

Rajid rays are the dominant elasmobranch group caught as bycatch in the Southern Ocean fisheries. Some species of sharks are also taken (e.g. *Somniosus antarcticus*), but they represented less than 0.2 percent of the elasmobranchs catch in 2009. Of the ray species identified, *Bathyraja eatonii* is the most common (53.4 percent). The CCAMLR had undertaken initiatives in the "Year of the Skate" to collect biological data on skates and implement a tag-recapture programme. On all vessels, all skates must be brought on board or alongside the hauler to be scanned for tags and for their condition to be assessed.

REFERENCES

Kock, K.H., Belchier, M. & Jones, C. 2004. Is the attempt to estimate the biomass of Antarctic fish from a multi-species survey appropriate for all targeted species? *Notothenia rossii* in the Atlantic Ocean sector – revisited. *CCAMLR Science*, 11: 141–153.

Kock, K.H. & Everson, I. 1997. Biology and ecology of mackerel icefish, *Champsocephalus gunnari*: an Antarctic fish lacking haemoglobin. *Comparative Physiology and Biochemistry*, 118A: 1067–1077

Scientific Committee of the Commission for the Conservation of Antarctic Marine Living Resources (SC-CCAMLR). 2010. *Report of the Twenty-ninth Meeting of the Scientific Committee (SC-CCAMLR-XXIX).* Hobart, Australia, CCAMLR. 420 pp.

PART C

Special topics

C1. Tuna and Tuna-like Species

Jacek Majkowski
Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: jacek.majkowski@fao.org

Haritz Arrizabalaga
FAO Consultant
Spain.
E-mail: harri@azti.es

Fabio Carocci
Fishery Information Assistant
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: fabio.carocci@fao.org

Hilario Murua
FAO Consultant
Spain
E-mail: hmurua@azti.es

INTRODUCTION

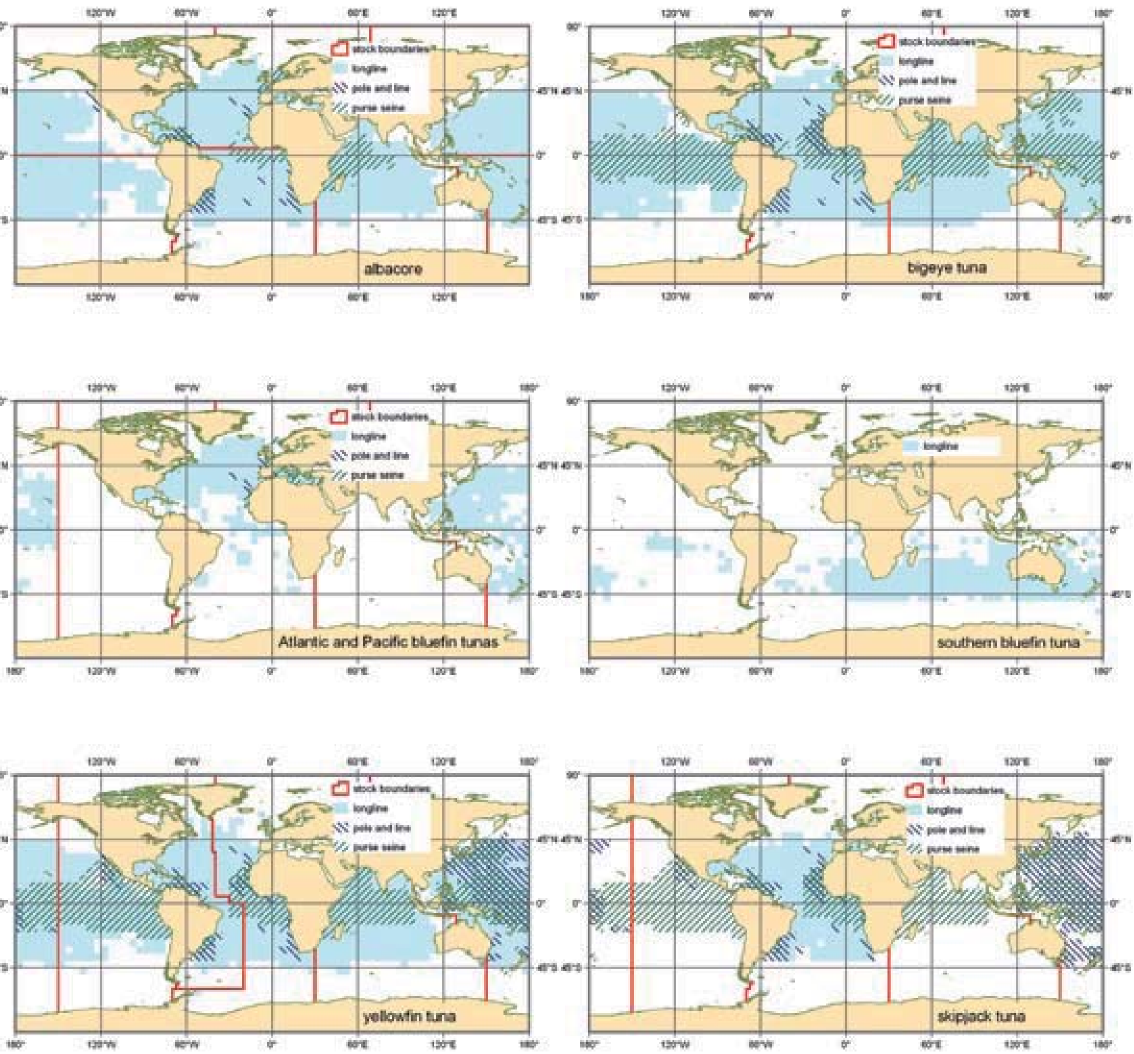
The suborder Scombroidei is usually referred to as tuna and tuna-like species (Klawe, 1977; Collette and Nauen, 1983; Nakamura, 1985). It is composed of tunas (sometimes referred to as true tunas), billfishes and other tuna-like species. They include some of the largest and fastest fishes in the sea. The tunas are classified into 5 genera (*Thunnus*, *Euthynnus*, *Katsuwonus*, *Auxis* and *Allothunnus*) with 15 species all together.

The most economically important tuna species on the global scale are referred to as principal market tunas. From the genus *Thunnus*, they include albacore (*T. alalunga*), Atlantic bluefin tuna (*T. thynnus*), bigeye tuna (*T. obesus*), Pacific bluefin tuna (*T. orientalis*), southern bluefin tuna (*T. maccoyii*) and yellowfin tuna (*T. albacares*). Skipjack tuna (*Katsuwonus pelamis*) is the seventh principal market tuna species. They are subject to intensive international trade for canning and sashimi (raw fish regarded as a delicacy in Japan and, increasingly, in many other countries).

The efficient physiology of principal market tunas allows them to retain or dissipate heat as required for peak biological performance and efficiency. They are all oceanic (Figure C1.1), capable of long migrations or movements, but not necessarily all species re-distribute or mix well within the areas of their stocks' distribution. Most species constitute one or two stocks in each ocean, although the albacore in the Atlantic consists of three stocks (including that in the Mediterranean Sea). The exceptions are Atlantic and Pacific bluefins, which occur only in their eponymous oceans. Southern bluefin constitute a single stock extending in the Atlantic, Indian and Pacific Oceans.

Because of the economic situation in Japan in recent years, prices of bluefin tuna (the species most valued for sashimi), although still high compared with other species, have decreased. For a whole fish, a fisher may receive US$30–40 per kilogram with some receiving closer to US$100. Fish of exceptional quality can reach US$500 per kilogram and, more recently, even more. However, such prices are paid for very few fish and do

FIGURE C1.1
Distribution of principal market tunas and fishing areas



Source: Based on data available from the Atlas of Tuna and Billfishes Catches (www.fao.org/fishery/statistics/tuna-atlas/en).

not reflect the overall situation in the market. At present, the voluntary public restraint in spending in Japan has had a dramatic impact on sashimi demand and consumption. By recent standards, prices are very low (about US$25 per kilogram). Bigeye are also well priced on the sashimi markets. Although yellowfin are also very popular on these markets, their prices are much lower.

For canning, albacore fetch the best prices owing to their white meat (about US$3 per kilogram), followed by yellowfin and skipjack, for which fishers are paid much less (about US$2.30 and US$1.60 per kilogram, respectively). The relatively low prices of canning-quality fish are compensated by their very large catches, especially in the case of skipjack and yellowfin. Longtail tuna (*T. tonggol*) is becoming increasingly important for canning and the object of substantial international trade. The consumption of tuna and tuna-like species in forms other than canned products and sashimi (e.g. fresh and frozen steaks, and salted and dried skipjack) is increasing.

The tunas other than the principal market species are more neritic (living in water masses over the continental shelf). They include longtail tuna, blackfin tuna (*T. atlanticus*), black skipjack (*E. lineatus*), kawakawa (*E. affinis*), little tunny (*E. alleteratus*), bullet tuna (*A. rochei*) and frigate tuna (*A. thazard*).

The billfishes (Istiophoridae) are composed of marlins (*Makaira* spp.), sailfish (*Istiophorus* spp.), spearfish (*Tetrapturus* spp.) and swordfish (*Xiphias gladius*, only species in the genus). With the exception of two species (Mediterranean and roundscale spearfish), all billfishes have very wide geographical distributions, but not all species occur in all oceans. Billfishes are mostly caught by longlines as bycatch. The exceptions are swordfish, which are targeted in certain regions with longlines and harpoons. Billfishes are also taken in sport fisheries, where they are greatly valued. They are all considered excellent eating.

Other important tuna-like species include slender tuna (*Allothunnus fallai*), butterfly kingfish (*Gasterochisma melampus*), wahoo (*Acanthocybium solandri*), bonitos (*Cybiosarda*, *Orcynopsis* and *Sarda*), Spanish and king mackerels, seerfish and sierra (*Scomberomorus* spp.). They and other tuna-like species are all the object of fishing. They have a significant fishery potential, especially for developing countries where mostly artisanal and recreational fisheries are now catching them. Slender tuna and butterfly kingfish (with a circumpolar distribution in the Southern Ocean) are now caught mostly as bycatch of the Japanese longline fishery targeting southern bluefin tuna.

The 1982 UNCLOS classifies the principal market tunas, billfishes, blackfin tuna, bullet and frigate tuna, little tunny and kawakawa as highly migratory. This is despite little tunny and kawakawa being mostly confined to the continental shelf and upper slope. Black skipjack is not classified as highly migratory, but it is probably more oceanic than little tunny and kawakawa.

Further information on the biological characteristics of tuna can be found in Goujon and Majkowski (2010). Global aspects of tuna resources, fishing, fisheries management, processing and trade can be found in Allen (2010), Joseph (1998, 2000, 2003), Miyake, Miyabe and Nakano (2004) and Miyake *et. al.* (2010). Information references at regional scale are given in the respective sections on resource status.

FISHERIES

Since the nineteenth century (and even from more ancient times), traditional tuna fishing has been carried out in various parts in the world. Those fisheries were local and generally near the coasts. In the Atlantic, they included purse seining for bluefin tuna off Norway, baitboat and trolling for albacore in the Bay of Biscay, trap fishing near the Strait of Gibraltar and North African coast, swordfish fishing in the northwest Atlantic and in the Mediterranean, bigeye and skipjack fishing near islands, and artisanal fishing along the African coasts. In the Pacific, various artisanal fisheries operated near islands in the tropical waters. Off South America, coastal fisheries operated using baitboats and small seines. In the Indian Ocean, skipjack fishing off India, Maldives Sri and Lanka was carried out. Off Australia, longline fishing was carried out for southern bluefin tuna. Many other artisanal fisheries for tuna-like fishes existed in tropical or subtropical areas all over the world.

As a result of increasing demand for canned tuna, industrialized fisheries started in the 1940s and 1950s. They included Japanese longline and baitboat fishing in the Pacific, and United States baitboat fishing off California along the Mexican coasts. The traditional fisheries described above continued at the same time. After the Second World War, the fishing areas for the Japanese tuna fishery were limited to its coast until the late 1940s or early 1950s. However, thereafter, the fisheries, particularly the longline fisheries, expanded their fishing area very rapidly. In late 1950s, Japanese fishing vessels reached the Atlantic Ocean. Also in the late 1950s, some European pole-and-line fishing started off the African coasts from local harbours.

In the 1960s, Spanish and French boats with pole and line and purse seines started tuna fishing off West Africa. In addition, Japanese longliners expanded their fishing area all over the world, mostly fishing albacore and yellowfin for canning. In the mid-1960s, the Republic of Korea and Taiwan Province of China started large-scale longline fishing to export tuna for canning, learning the techniques from Japan.

United States pole-and-line fishing off Central and South America was almost completely replaced by purse seiners in the 1960s. Moreover, purse seining of tuna with dolphin was developed in the eastern Pacific.

In the 1970s, purse seine fisheries of European countries developed quickly in the eastern tropical Atlantic. They attained the first peak of their catches of yellowfin and skipjack. In addition, the purse seine fishery developed further in the east tropical Pacific. A strict regulation for the reduction of mortality of dolphins caught in association with tuna was also implemented in this area. Consequently, the United States-flagged vessels started changing their flags to those of Central and South American countries. Some fishing effort also shifted to the central and western Pacific, where no dolphin fishing occurred.

With the development of extremely cold storage, some longliners gradually changed their target from yellowfin (for canning) to bigeye (for sashimi). This shift was first seen among Japanese longliners, but it gradually expanded to the fleets from the Republic of Korea and Taiwan Province of China. To catch bigeye, whose habitat is much deeper than that of tropical tunas, longlines were set deeper and deeper. This change in fishing strategy implied changes in fishing areas, leading to modifications in target and bycatch species.

In the 1980s, a new purse seine fishery started in the western Indian Ocean. Many French seiners from the eastern Atlantic moved into this fishery. In the Pacific Ocean, the purse seine fishery expanded its fishing area, particularly in the south, central and western Pacific. Purse-seine fishing efficiency increased with modern equipment such as bird radar and the use of helicopters. In the 1980s, many new countries began large-scale industrial fishing, mostly with purse seines (e.g. Mexico, Venezuela [Bolivarian Republic of] and Brazil). Small-scale longline fishing operations by coastal countries in various areas (e.g. Mediterranean countries, the Philippines and Indonesia) also started in the 1980s. The Japanese longline fleet started to reduce its size in that decade. At the same time, longliners from Taiwan Province of China and others flying flags of convenience increased rapidly.

Particularly in the 1980s, management regulatory measures for tuna fisheries were introduced by tuna regional fisheries management organizations (t-RFMOs). These regulations also affected fishing patterns and country shares of catches. In the 1990s, more management measures were introduced. With insufficient MCS, this resulted in an increase in IUU fishing. This became a major problem for proper management of fish resources. In general, tuna-fishing capacity extensively increased in the 1990s. Increases in the catches sometimes caused oversupply to the market, particularly for skipjack because of large purse-seine catches.

Starting in the 1980s and increasingly in the 1990s, many coastal States started new tuna fishing ventures using arrangements with the existing tuna-fishing nations. These ventures included the chartering of vessels and other arrangements of association. This practice occurred in all oceans. Some of these chartered vessels changed flags to those of coastal States and, possibly, this tendency may intensify in the near future. This is one of the reasons for declines in fishing effort by traditional longline fishing countries.

Purse seiners started fishing around fish aggregating devices (FADs) in the Atlantic in the late 1980s or early 1990s, and this method expanded to the Indian and Pacific Oceans. The FAD fishing is less selective for fish species and sizes. The fishing efficiency, sizes of fish taken, species composition and incidental catches changed drastically with the adoption of this new practice.

Tuna fattening started in the 1990s. This new industry resulted in: (i) an increasing demand for bluefin of specific sizes (relatively small) suitable for growing on; and (ii) better prices being paid for such fish to the fishers. Through the fattening process, the particularly small bluefin (or ones with little fat) taken by purse seiners that used to be sold only for canning can now be used for the sashimi market after their fattening. To date, the three species of bluefin tuna are the main species used in farming, but farming is extending to bigeye and yellowfin tuna. Bluefin farming is expanding, it now includes Australia, Japan, Mexico and several Mediterranean countries (particularly Croatia, Malta, Spain and Turkey).

Currently, on the industrial scale, tuna and tuna-like species are mainly caught with purse-seine, longline and, to a less extent, pole-and-line over wide areas in oceans (Figure C1.1; Carocci and Majkowski, 1996, 1998, 2011a, 2011b). Other gear types used include troll lines, handlines, driftnets, traps and harpoons.

The industrial tuna fisheries are very dynamic, and fleets, especially distant-water fishing fleets, can react very quickly to changes in stock sizes or market conditions. For example, in the early 1980s, many French and Spanish purse seiners from the Atlantic moved to the Indian Ocean, contributing to the doubling of catches there in the 1980s. Some of these vessels have now moved back to the Atlantic as a result of the piracy problem in the Indian Ocean. Similarly, many United States purse seiners have moved from the eastern to the western Pacific.

The purse seine and pole-and-line are used to catch fish found close to the surface (e.g. skipjack and relatively small yellowfin, albacore and bluefin tunas). Longlines are used for tuna found at greater depths (e.g. large individuals of bluefin, bigeye, yellowfin, albacore and billfishes). Most purse seine and pole-and-line catches are canned. With the exception of those for albacore, longline catches are mainly sold on the sashimi market to be consumed raw. The market has traditionally been in Japan, but it now extends also to many other countries. To some extent, catches are also sold on the fresh and frozen market to be consumed in the form of steaks. The use of pole-and-line and large-scale longlining has been generally declining, while purse seining is increasingly used. This has resulted in increased catches of skipjack, small-to-medium yellowfin and small bigeye, while catches of large yellowfin and the other principal market tunas have remained relatively stable. Information on industrial tuna fisheries entirely or partially on the high seas is summarized in Table C1.1.

Small-scale longlining for high-quality fish for the sashimi market is increasingly being used by China, Taiwan Province of China and various developing countries. This contributes to a general trend of rapidly increasing importance of developing coastal countries (including island countries of the Indian and Pacific Oceans) in tuna fishing. This increasing importance of developing countries results from the purchase of purse seiners and from the intensification of artisanal fisheries. Catches from these fisheries may still be underestimated despite the fact that the rate of non-reporting of catches in developing countries is being reduced.

Further information on tuna fisheries, fish processing and trade can be found in Miyake *et al*. (2004, 2010).

PROFILE OF CATCHES

Similar to most other sections of this review, the catch profiles in this section are based on FAO general catch statistics. These include tuna and tuna-like species, but they are not exclusively for them. The t-RFMOs and tuna-fishing countries may have more detailed and possibly more accurate or up-to-date statistics specifically for tuna (see their Web sites given in the section on resource status of this review). On the global scale, these tuna-specific statistics of t-RFMOs have also been collated and made available by FAO (Carocci and Majkowski, 2011b).

The global annual catch of tuna and tuna-like species reached about 6.5 million tonnes in 2009. It has shown an increasing trend since 1950, when it was less than 1 million tonnes, The global production of the principal market tunas increased relatively steadily from less than 0.5 million tonnes in the early 1950s to the maximum of about 4.4 million

TABLE C1.1
Industrial tuna fisheries operating entirely or partially on the high seas, with an indication of some fishing countries

Area	Gear	Major vessel flags	Target species
Northeast Pacific	Longline	Japan and Taiwan Province of China	Albacore, bigeye and swordfish
	Troll	Canada and United States of America	Albacore
Southeast Pacific	Longline	Chile and Spain	Swordfish
Eastern Pacific	Purse seine	Costa Rica, Columbia, Ecuador, Mexico, Panama, Peru, Spain, Vanuatu, Venezuela (Bolivarian Republic of) and United States of America	Skipjack, bigeye and yellowfin
	Longline	Japan, Republic of Korea, United States of America and Taiwan Province of China	Albacore, bigeye and yellowfin
Western, Central and South Pacific	Longline	China, Japan, Papua New Guinea, Philippines, Republic of Korea, Taiwan Province of China and Vanuatu	Albacore, bigeye, yellowfin, southern bluefin tuna, Pacific bluefin tuna, and swordfish
	Pole and line	Japan	Skipjack, albacore and yellowfin,
	Purse seine	Indonesia, Japan, New Zealand, Papua New Guinea, Philippines, Republic of Korea, Taiwan Province of China and United States of America	Skipjack, bigeye and yellowfin
Eastern Indian Ocean	Longline	Belize, China, Honduras, Indonesia, Japan, Panama, Republic of Korea and Taiwan Province of China	Albacore, bigeye, southern bluefin, swordfish and yellowfin
	Purse seine	Indonesia, Japan and Liberia	Skipjack and yellowfin
Western and Central Indian Ocean	Gillnet	India, Indonesia, Iran (Islamic Republic of), Maldives and Sri Lanka,	Skipjack and yellowfin
	Longline	China, Belize, Honduras, India, Indonesia, Japan, Panama, Republic of Korea, Réunion, Seychelles, Taiwan Province of China and Thailand	Bigeye and yellowfin
	Pole and line	Maldives and Sri Lanka	Skipjack and yellowfin
	Purse seine	Belize, France, Japan, Netherlands Antilles (dissolved), Seychelles and Spain	Skipjack and yellowfin
Eastern Atlantic	Longline	Belize, China, Honduras, Iceland, Ireland, Japan, Panama, Philippines, Portugal, Republic of Korea, Taiwan Province of China and Spain	Albacore, bigeye, Atlantic bluefin, swordfish and yellowfin
	Pole and line	France, Ghana, Namibia, Panama, Portugal, Republic of Korea, Senegal, South Africa and Spain	Albacore, bigeye, skipjack and yellowfin
	Purse seine	Côte d'Ivoire, France, Ghana, Morocco, Portugal, Spain, Senegal and Vanuatu	Bigeye, skipjack and yellowfin
	Troll	France, Ireland and Spain	Albacore
Western Atlantic	Longline	Brazil, Japan, Spain, Taiwan Province of China, United States of America, Uruguay and Venezuela (Bolivarian Republic of)	Albacore, bigeye, Atlantic bluefin, swordfish and yellowfin
	Pole and line	Brazil, Japan, Taiwan Province of China and Venezuela (Bolivarian Republic of)	Skipjack
	Purse seine	Brazil and Venezuela (Bolivarian Republic of)	Skipjack and yellowfin
Western and Central Atlantic	Longline	China, Japan, Portugal, Spain, Taiwan Province of China and United States of America	Bigeye and Atlantic bluefin
Western Mediterranean (Tyrrhenian and Liguria Seas & Strait of Sicily)	Gillnet	Morocco	Atlantic bluefin and swordfish
	Longline	Cyprus, Greece, Italy, Japan, Libya, Spain and Taiwan Province of China	Atlantic bluefin and swordfish
	Purse seine	Algeria, France, Italy, Spain and Tunisia	Atlantic bluefin
	Handline	Morocco and Spain	Atlantic bluefin
Central Mediterranean (Adriatic & Ionian Seas)	Purse seine	Croatia and Italy	Atlantic bluefin and swordfish
	Longline	Cyprus and Italy	Atlantic bluefin, albacore and swordfish
Eastern Mediterranean (Aegean & Marmara Seas)	Longline	Greece	Atlantic bluefin and swordfish
	Purse seine	Turkey	Bonito and Atlantic bluefin

tonnes in 2005, decreasing and then, reaching nearly that level in 2009 (Figure C1.2, Table D19). Between 1970 and 1978, the catches of principal market tunas increased significantly as a result of the expansion of fisheries in the eastern Atlantic and the development of new offshore fishing grounds in the eastern Pacific. Between 1978 and 1984, many vessels moved to the western Pacific and the western Indian Ocean, developing new fisheries there.

Annual catches of tuna and tuna-like species cannot grow indefinitely (Figure C1.2, Table D19). In fact, they might already have started to stabilize in recent years. In particular, the principal market species may have peaked, given the recent declines in catches of bigeye, some bluefins and yellowfin. Skipjack catches still continue to increase and the other species are stabilizing. The total annual catch of principal market tunas may even eventually decline if the management of their fisheries is not successful.

FIGURE C1.2
Annual global catches of tuna and tuna-like species

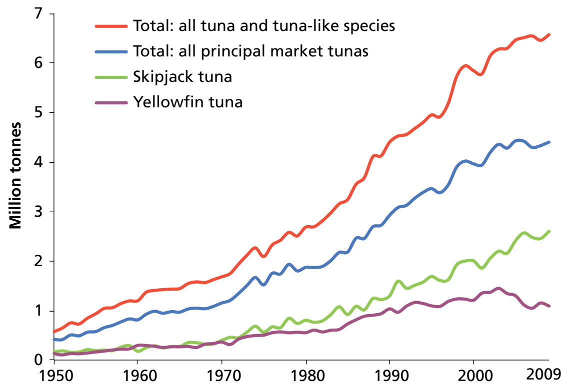
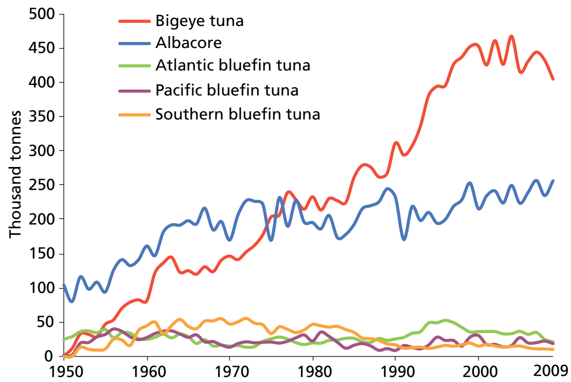


FIGURE C1.3
Annual global catches of selected tunas



Main species

Skipjack, which is used mostly for canning, accounts for the greatest proportion of the world catches of tuna (Figure C1.2). Its catches have tended to increase over the entire period of its exploitation. In 2009, the skipjack catch was more than 2.5 million tonnes (the highest on record), being more than half of the total catch of all principal market tuna landed. In the early 1980s, catches of skipjack increased steadily as a result of expansion of fishing effort into the tropical western and central Pacific and into the western Indian Ocean.

Yellowfin is commercially the second most important species of tuna by volume. Its catches increased until 2003, reaching a maximum of 1.44 million tonnes. Since then, catches have decreased to about 1 million tonnes in 2008 and 2009 (Figure C1.2). Most yellowfin is used for canning, but more and more of the catch is being sold in fresh-fish markets (also some as frozen fish). Catches in the Atlantic (Table D19) reached a peak of 161 000 tonnes in 2001 but have since declined to about 120 000 tonnes. Catches from the Indian Ocean increased to a maximum of more than 0.5 million tonnes in 2004, decreasing to about 259 000 tonnes in 2009. Catches of yellowfin from the Pacific increased consistently until 1976, when they stabilized. They did not begin to rise again until the early 1980s, when large fleets of purse-seine vessels began to fish in the tropical western and central Pacific. Catches reached a maximum of almost 900 000 tonnes in 2002 and have recently fluctuated between 610 000 and 752 000 tonnes.

Bigeye, the third-most important species in terms of landed volume (Figure C1.3) is similar in appearance to yellowfin. However, unlike yellowfin, large bigeye tuna live primarily in deeper waters and spend most of their lives in cold waters below the upper mixed layer of the ocean where they are mainly taken by longlines. Their high fat content (for insulation from the cold water) make them desired for the Japanese sashimi market. The rapid and substantial increase in catches in the mid-1970s resulted from modifications to longline gear. This enabled longlines to be used in much deeper water than previously. However, the use of FADs has shown smaller bigeye aggregate in schools mixed with skipjack closer to the surface. Recently, the longline catches of large bigeye have been declining. At the same time, purse-seine catches of smaller bigeye have been rapidly increasing. These trends resulted in continuous large increases in total catches for the species to the maximum of about 467 000 tonnes in 2004, decreasing to slightly more than 400 000 tonnes in 2009.

World production of albacore, used mostly for canning, increased from 1950 to the early 1970s. It has fluctuated without a clear trend since then (recently at a slightly higher level) with the maximum catches of 256 000 tonnes in 2009 (Figure C1.3). In the 1980s and early 1990s, driftnet fisheries made large catches of small albacore on the high seas in the southwest and northeast Pacific. With the termination of these fisheries, the total albacore catch declined in the Pacific.

Atlantic, Pacific and southern bluefin contribute relatively little in terms of volume to the total catches of principal market tunas (Figure C1.3). However, their individual value is high because of their use for sashimi. Catches of Atlantic bluefin followed a generally declining trend from the early 1950s to the early 1970s. In the next decade and half, catches fluctuated without trend. In the early 1990s, catches increased rapidly to 53 000 tonnes in 1996 as a consequence of improved reporting in the Mediterranean Sea. Reported catches declined after 1996 to 21 000 tonnes in 2009. The catch of Pacific bluefin peaked at 40 000 tonnes in 1956. The smallest catch was 8 000 tonnes in 1990. Catches have fluctuated between 10 000 and 30 000 tonnes since that time. Catches of southern bluefin increased steeply from 14 000 tonnes in 1952 to 50 000 tonnes in 1961. They fluctuated without trend between 40 000 tonnes and 55 000 tonnes until 1972. Catches decreased steeply and steadily from 47 000 tonnes in 1980 to 12 000 tonnes in 1991. In the last decade, they have been between 10 000 and 17 500 tonnes.

The catches of tunas and tuna-like species other than the principal market tunas also increased significantly from about 0.5 million tonnes in the early 1970s to slightly more than 2 million tonnes in 2009 (Table D19). Less than 10 percent of them are composed of billfishes, taken mainly in the Pacific and Atlantic. In terms of volume, the most important species of tunas and tuna-like species other than the principal market tunas (i.e. small tunas and tuna-like species) are: kawakawa, frigate and bullet tunas, longtail tuna, narrow-barred Spanish mackerel, swordfish, frigate tuna, Japanese Spanish mackerel, Indo-Pacific king mackerel, eastern Pacific bonito, Atlantic bonito, Indo-Pacific sailfish, blue marlin and king mackerels.

Main areas

Since 1950, the largest proportion (Table D19) of principal market tunas has been always taken from the Pacific (Figure C1.1), reaching more than 3 million tonnes in 2009 (Gillett 2010, 2011a, 2011b). This represents about 71 percent of global annual catch of principal market tunas. Skipjack and yellowfin contribute about 87 percent of the total catch of principal market tunas in the Pacific.

Until the mid-1980s, catches of principal market species in the Atlantic Ocean and the Mediterranean Sea were greater than those in the Indian Ocean. About that time, they became smaller than those in the Indian Ocean. Catches of principal market tunas in the Atlantic declined from the maximum of slightly more than 0.6 million tonnes annually in 1994 to slightly below 0.4 million tonnes in 2009. This represents only about 9.5 percent of global landings of principal market tunas. Bigeye, skipjack and yellowfin contribute about 85 percent of the total catches of principal market species there.

Prior to the 1980s, the catch from the Indian Ocean accounted for less than 8 percent of world production of principal market tunas. As a result of the expansion of tuna fishing operations in the region, catches of skipjack and yellowfin increased rapidly in the mid-1980s. Consequently, catches of principal market tunas in the Indian Ocean surpassed those in the Atlantic Ocean, accounting for about 20 percent of global landings of principal market tunas in 2009 (about 836 000 tonnes). Currently, skipjack and yellowfin contribute about 94 percent of the total catches of principal market tunas from the Indian Ocean.

The principal market tuna catches of Japan, Indonesia and the Philippines are currently the largest of all countries (more than 0.4 million tonnes caught in 2009). Traditional tuna fishing players include Taiwan Province of China (328 217 tonnes in 2009), the Republic of Korea (319 726 tonnes in 2009), Spain (252 391 tonnes in 2009), the United States of America (201 208 tonnes in 2009) and France (89 856 tonnes in 2009). In addition, recent catches of Papua New Guinea (213 018 tonnes in 2009), Ecuador (185 323 tonnes in 2009), Mexico (129 926 tonnes in 2009) and China (124 809 tonnes in 2009) exceeded those of some traditional tuna fishing countries. This reflects a general trend of increasing importance of non-traditional tuna fishing countries (mostly developing countries). Tuna fisheries are growing in both the Indian and Pacific Oceans, particularly off Southeast Asia. These fisheries include the artisanal sector and catch mostly small tunas, skipjack and yellowfin. This sector's growth has also been significant in the entire Indian Ocean. Other important countries catching principal market tunas include: Sri Lanka (121 176 tonnes in 2009), Panama (86 918 tonnes in 2009), Maldives (86 804 tonnes in 2009), Seychelles (73 819 tonnes in 2009), Iran (Islamic Republic of) (67 415 tonnes in 2009) and Ghana (64 973 tonnes in 2009).

RESOURCE STATUS

A summary on the status of various stocks of tuna and tuna-like species is given in Table D19. It was obtained by interpreting results of stock assessments according to the classification procedure adopted by FAO in this review. Those assessments available at the time of preparation of this review (end of March 2011) were taken mostly from Web pages of:

- Commission for the Conservation of Southern Bluefin Tuna (CCSBT, www.ccsbt.org);
- Inter-American Tropical Tuna Commission (IATTC, www.iattc.org) for the eastern Pacific;
- International Commission for the Conservation of Atlantic Tunas (ICCAT, www.iccat.int);
- Indian Ocean Tuna Commission (IOTC, www.iotc.org);
- Western Central Pacific Fishery Commission (WCPFC, ww.wcpfc.int).

The knowledge and data on the principal market tunas are generally much better than those for other species of tuna and tuna-like species. They have been studied for many years and more research effort is devoted to them. However, even for these species, significant uncertainties exist in the basic biological knowledge and data. For example, relatively recent research indicates that the life span of southern bluefin tuna, one of the best studied tuna, may be considerably longer than previously believed. Moreover, for this species, as compared with trade statistics, the catches were substantially under reported for a number of years. For Atlantic bluefin tuna, another well-studied species, officially reported catches might be significantly smaller in the past than those actually taken. This conclusion is based on information from a trade-based statistical programme introduced by ICCAT (Miyake, 1998) as well as from capacity estimates (ICCAT, 2009). When considering the information on the stock status, uncertainties in stock assessment need to be taken into account.

Most tuna stocks are fully exploited, some are overexploited. Generally, some temperate tuna species (i.e. Atlantic and southern bluefins [most desired for sashimi]) are much more overexploited (depleted) than any of the tropical tuna species. For the Pacific bluefin (also used for sushimi), the yield-per-recruit could be increased if the number of small bluefin caught by trolling and purse seining can be reduced.

The stocks of albacore (temperate species) used mostly for canning are not fully exploited in the South Pacific but they are fully exploited in the Indian Ocean and the South Atlantic and overexploited in the North Atlantic and the North Pacific. The status of albacore in the Mediterranean Sea is unknown.

Generally, most tropical principal market tunas have reacted well to exploitation owing to their very high reproductive potential, wide geographical distribution, opportunistic behaviour and other population dynamics characteristics that make them highly productive. With proper management, they are capable of sustaining high yields.

There may still be potential for increasing catches of skipjack in the western and central Pacific with lower potential in the other oceans. However, skipjack are caught together with tuna species that are fully exploited or overexploited. Therefore, until more selective fishing methods are developed, it is not desirable to increase the catches of skipjack.

Most other stocks of tropical tunas have become fully exploited and a few are overexploited. Generally, a possibility of further deterioration in the status of tropical tunas should not be underestimated. Concerns are increasing over the exploitation of bigeye in all oceans. This is another species that is highly desired for sashimi and has a shorter life span than bluefin. In addition to possibly causing overfishing in the future, the increasing purse seine catches of small bigeye may negatively affect the yield per recruit.

The status of many tuna and tuna-like species other than the principal tunas is highly uncertain or simply unknown. Therefore, the intensification of their exploitation raises concerns. Significant uncertainties in the status of many billfishes represent a serious conservation problem. Some stocks are overexploited in the Atlantic and the Pacific, while their status is mainly unknown in the Indian Ocean. Because of commercial exploitation, there is more known about swordfish than other billfishes. In the Mediterranean Sea, the swordfish stock seems to be overexploited, but the overall situation in the remainder of the Atlantic and Pacific is more optimistic. However, in the Indian Ocean, there are concerns about the intensification of swordfish fishing owing to the risk of potential local overexploitation.

FISHERIES MANAGEMENT AND CONSERVATION

States fishing tuna and tuna-like species cooperate regarding conservation and fisheries management within several international frameworks (FAO, 1994; Marashi, 1996; Beckett, 1998), particularly those of the CCSBT, IATTC, ICCAT, IOTC and WCPFC.

The IATTC is the oldest tuna fishery body and was established in 1950, whereas the WCPFC is the youngest body and has been operational since 2004. In addition to their responsibilities in conservation and fisheries management, the CCSBT, IATTC, ICCAT, IOTC and WCPFC facilitate the data collection, collation, processing and dissemination. They are also responsible for stock assessment and other fisheries research in support of fisheries management and for regional coordination in their areas of competence. The IATTC carries out intensive research, having significant research capacity, while the role of the CCSBT, ICCAT and IOTC in research is mostly limited to the coordination of activities of their member countries.

In the past, many countries fishing tuna in the Mediterranean Sea (which is included in the area of competence of ICCAT) were not members of ICCAT. Instead, they were and are members of the General Fisheries Commission for the Mediterranean (GFCM). Therefore, ICCAT closely collaborated with the GFCM regarding tuna and tuna-like species. This collaboration still continues regardless of this no longer being the case. The IOTC and GFCM are fishery bodies of FAO. Before the creation of the IOTC, the FAO/UNDP Indo-Pacific Tuna Programme coordinated and carried out tuna research in the Indian Ocean and the Pacific off Southeast Asia. Before its termination, it transferred the responsibility for data collation, processing and dissemination for tuna and tuna-like species in the Pacific off Southeast Asia to the Southeast Asian Fishery Development Center (SEAFDEC). Now, the WCPFC is mostly responsible for these activities.

The Secretariat to the South Pacific Community (SPC) has a significant research capacity that fulfils technical functions similar to the tuna fishery bodies. However, its responsibilities do not extend to fisheries management in the region. The recently created WCPFC fulfils that responsibility. The Forum Fisheries Agency (FFA, www.ffa.int/) is substantially involved in negotiating and regulating access of distant-water tuna vessels to the EEZs of its members in the South Pacific. The Parties to the Nauru Agreement, another subregional grouping of coastal countries, have established a management regime with limits on fishing effort for purse-seine vessels.

Cooperation must also extend beyond the scale of single oceans. Industrial tuna fleets are highly mobile and the principal market tunas are intensively traded on a global scale. In addition, many tuna research, conservation and management problems are similar in all oceans. Therefore, there is a need for global exchange of information and collaboration regarding fisheries for tunas and other species with a wide global distribution. An important example of such collaboration is the formulation in 1995 of the Agreement for the Implementation of the Provisions of the UN Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (frequently referred to as the UN Fish Stocks Agreement or UNFSA). The UN facilitated the conclusion of this agreement, and FAO actively assisted, from the technical point of view, in the agreement being reached (Doulman, 1995).

The UNFSA entered into force on 11 December, 2001. It became a new legal basis for its signatories in relation to conservation and fisheries management of tuna and tuna-like species (supplementing the UNCLOS). In 1995, the Code of Conduct for Responsible Fisheries (the Code) was completed within the framework of FAO (FAO, 1995). Although not legally binding, the Code provides a norm for all fisheries and related activities. The UNFSA and the Code introduce new requirements for conservation, fisheries management, technology and research regarding tuna and tuna-like species. They are likely to affect various sectors of the tuna industry (Mahon, 1996). As a result, the high seas are no longer an area where unrestricted fishing is allowed.

The precautionary approach incorporated into the UNFSA and the Code may affect the exploitation of tuna and tuna-like species. It calls on States to be more cautious where information is uncertain, unreliable or inadequate (FAO, 1996; Majkowski, 1998). Adequate information is available for most stocks of principal market tunas to determine whether they are fully exploited or overexploited. However, for many other tuna and tuna-like species, this is not the case. Within the context of the precautionary approach, the absence of adequate scientific information should not be used as a reason for postponing or failing to undertake conservation or fisheries management measures. In Thailand in March 2000, FAO coorganized, jointly with the CCSBT, IATTC, ICCAT, IOTC and SPC, a global Expert Consultation on Implications of the Precautionary Approach for Tuna Biological and Technological Research (FAO, 2001).

FAO has been involved in the consideration of many other global issues involving tuna and tuna-like species. For example, it executed a technical, multidisciplinary trust fund project (GCP/INT/851/JPN) on the management of tuna fishing capacity, conservation and socio-economics. The technical advisory committee for the project was composed of experts affiliated with the CCSBT, FFA, IATTC, ICCAT, INFOFISH (www.infofish.org/), IOTC, SPC and international associations of tuna longliners and purse seiners. The project's activities involved global studies and an Expert Consultation on the Management of Tuna Fishing Capacity, Conservation and Socio-economics. For many tuna fishing fleets, there is insufficient control of their capacity, actual fishing effort and catches. Recently, concerns on overcapacity of tuna fleets have emerged (Joseph, 2003). As a result, FAO has formulated and implemented a project on the management of tuna fishing capacity. This project has been undertaken in collaboration with the organizations mentioned above with the objectives of: (i) providing the necessary technical information; and (ii) identifying, considering and resolving technical problems associated with the global management of tuna fishing capacity, taking into account conservation and socio-economic issues.

FAO has actively participated in joint tuna RFMOs (t-RFMOs) meetings and in meetings with their member countries. This global consultation has been frequently referred to as the Kobe Process because it started from a meeting held in Kobe, Japan, in 2007. The objectives of this meeting were to improve the operation and effectiveness of t-RFMOs and to achieve their objectives by harmonizing their activities on a global scale. FAO's project on the management of tuna fishing capacity has provided a significant input to the process in a form of recommendations on that management including those on the application of a rights-based approach to tuna fisheries management.

Currently, FAO is formulating a Programme on Areas Beyond National Jurisdiction to be supported by the GEF. Within this programme, FAO, in consultation with t-RFMOs and other intergovernmental and non-governmental organizations, is formulating a project on tuna fisheries to improve their sustainability. This project will probably implement some of the recommendations made during the Kobe Process, but the activities of the project may go beyond that process.

In addition, FAO collates data on nominal catches of all fish species including tunas as a part of a general database on all fish species. It also collates data for other databases, specifically for only tuna and billfishes. The first data set for all species is based mostly on official national statistics and does not distinguish among different types of fishing gear. The second data set specifically for tunas identifies gear types as it is based mainly on statistics from the t-RFMOs (Carocci and Majkowski, 2011b). Both sets can be accessed from the FAO Web page. FAO also collates data on the geographical distribution of catches of tunas and billfishes on the global scale. On the basis of these data, paper, CD and Internet versions of an atlas of tuna and billfish catches have been prepared (Carocci and Majkowski 1996, 1998, 2011a). These data as well as information on tuna resources, fisheries and their management are being incorporated into FAO's Fisheries Global Information System (FIGIS).

The depletion of some bluefin stocks has been the prime problem for the t-RFMOs, particularly for those specifically dealing with these stocks (ICCAT and CCSBT). However, the problem creates a very bad image for all tuna fishing and also for the other t-RFMOs. This concern has been also discussed within the context of CITES. In 2010, Atlantic bluefin was not listed in Appendixes of CITES because of CITES' conclusion that ICCAT rather than CITES is the more appropriate organization to manage Atlantic bluefin tuna fisheries.

However, with the exception of bluefins, serious overfishing has been largely avoided for several reasons. These include the high productivity of tuna species and decreases in fish prices when markets become saturated. In the past, the global overproduction of canned tuna led to drastic reductions in prices of some species for canning. With the fully exploited status of most stocks of tuna and tuna-like species and the overexploitation of some stocks, more concerns related to their conservation and fisheries management are likely to arise. In addition to the concern for bluefin, some stocks of albacore (North Atlantic and North Pacific), bigeye (western and central Pacific), swordfish and some other billfishes merit close attention because of overfishing. Without adequate fisheries management, future catches of some species may decline in the long term as a result of overfishing.

The measures used by the t-RFMOs are a mix of catch limits for stocks, closed fishing seasons either for the entire fishery or for smaller areas, and limiting entry to fisheries. However, the management techniques used tend to encourage competition among fishers to obtain the greatest share of catches available under the management rule. Some of the t-RFMOs (IATTC, IOTC and WCPFC) have adopted forms of limited entry to vessels or are limiting fishing effort. The ICCAT relies more on catch quotas that are allocated to its members.

The monitoring, control and surveillance (MCS) of tuna fisheries are mostly carried out by the members of t-RFMOs. It is essential to ensure management measures are observed, but some observer programmes and one vessel monitoring system are managed multilaterally. The t-RFMOs have included trade measures as incentives for compliance with management measures. Many of the major market States have a requirement for tracing imports to their source. The International Seafood Sustainability Foundation (ISSF) and World Wide Fund for Nature (WWF) are working actively as stakeholders to improve the application of Marine Stewardship Council certification in tuna fisheries. The t-RFMOs are in the process of introducing improved MCS systems, which are the subject of discussions of the Kobe Process.

The effectiveness of tuna fisheries management has been improving. However, further substantial progress is still required. Allen (2010) reported that, for the 14 stocks of principal stocks in need of fisheries management at the time of his study, the t-RFMOs took action consistent with the scientific advice for only five of them. Moreover, when the right management decisions are undertaken, these decisions are not necessarily properly executed. In other words, there is a need for significant improvement in fisheries management in terms of implementing the correct decisions and much better MCS. The facilitation of these changes has been one of the reasons for initiating the Kobe Process and seeking the GEF's support for improving the effectiveness of tuna fisheries management.

With the present status of stocks, the catches of principal market tunas should not increase on the global scale in the near future. This is unless future technological developments can allow an increase in skipjack catches without increasing those of bigeye and yellowfin. As mentioned above, there is potential for a significant increase in catches of skipjack in the western and central Pacific. However, in this area, skipjack is taken together with small bigeye and yellowfin, and increases of bigeye and yellowfin catches are not desirable. In general, the multispecies nature of many tuna fisheries makes it difficult to control the fishing mortality selectively because several species are frequently caught together.

The overall yield from tuna and tuna-like species depends on the combination of fishing techniques and fishing effort. The various fishing methods have different effectiveness and selectivity characteristics when targeting various age groups. Improvements in the yield might be achieved in some cases (e.g. albacore and yellowfin in the Atlantic and other oceans, bigeye in the Atlantic and Pacific, and southern bluefin tuna) by reducing the catch of small or immature tuna. This would allow them to grow and become available to fisheries such as longlining that target larger fish. Problems occur with compliance to the present size regulations (e.g. within the framework of ICCAT, especially for Atlantic bluefin in the Mediterranean Sea and in the eastern Atlantic). The intensification of fishing around FADs also raises concerns because such fishing tends to result in large catches of small fish. For example, the problem became so acute in the eastern Atlantic that the industry (French and Spanish purse seiners) placed self-imposed controls on the use of FADs. In general, the protection of small sized fish may not necessarily result in increases in a local yield from an area when species make extensive migrations. In addition, protecting smaller individuals of species with high natural mortality, such as skipjack, may not always achieve the expected results from the conservation point of view.

Bioeconomic interactions among fisheries need to be scientifically addressed for the resolution of fisheries management problems. Coordinated effort in this direction was initiated by FAO's trust fund project Cooperative Research on Interactions of Pacific Tuna Fisheries (Shomura, Majkowski and Langi, 1993a, 1993b; Shomura, Majkowski and Harmon, 1995, 1996). At present, with the completion of this project, this effort is being continued by regional and national institutions.

The magnitude of incidentally caught species (bycatch), their discards as well as catch of small individuals of target species and the status of stocks of the bycatch species have been another area of concern (Alverson *et al.*, 1994; Bailey *et al.*, 1994; Joseph, 1994; Gillett, 2011b; Hall, 1996, 1998; IATTC, 1998). Generally, bycatch from tuna fisheries are relatively low. However, they include species of dolphins, turtles, seabirds and sharks, which receive particularly wide attention from the international community.

In recent years, there has been more attention given by the t-RFMOs to conservation of associated biodiversity. The IATTC has an active programme of conserving dolphins that started in 1980. It developed into a standalone voluntary agreement among the countries involved in purse-seine fishing in 1992. This agreement was succeeded by the legally binding Agreement on the International Dolphin Conservation Program in 1998. This programme successfully maintains the mortality of dolphins associated with the purse seine fishery at very low levels.

Of associated fish species, sharks are the most vulnerable to fishing (Chapter C2; Musick and Musick, 2011). In recent years, t-RFMOs have been initiating assessments of some shark stocks, and have taken measures to reduce bycatch and to control shark finning. This generally requires that bodies of sharks as well as fins are unloaded. The IATTC requires parties to encourage the live release of sharks taken as bycatch. The ICCAT prohibits directed fisheries for thresher sharks, and any landings of bigeye thresher sharks. It requires that parties take measures to reduce mortality from directed fisheries for porbeagle and shortfin mako sharks. Bycatch of other fish species taken during tuna fishing, which seem to be less vulnerable than sharks, are also receiving attention. The IATTC and WCPFC have measures to encourage the live release of these species to the extent possible.

All of the t-RFMOs have measures to reduce mortality of turtles and seabirds. The IATTC and members of ICCAT and IOTC have been carrying out research to minimize turtle mortality during longlining and purse-seining. The IATTC has an extension programme training and assisting artisanal longline fishers in reducing turtle mortality. All of the t-RFMOs have measures requiring longline vessels to use devices to keep seabirds away from fishing gear. Governments, the ISSF and WWF have carried out investigative work with the aim of making fishing more selective.

In the future, a greater utilization of bycatch species may be expected. Fishing may become more selective through gear modifications and changes in fishing areas and seasons. Moreover, more research will probably be undertaken to determine the status of stocks of incidentally caught species. There is already some improvement in the collection of data on bycatch.

There are various management measures imposed for tuna fisheries at regional scales, particularly in areas where the t-RFMOS have been operational for a long time. This is the case in the Atlantic Ocean and the Mediterranean Sea (ICCAT) and the eastern tropical Pacific (IATTC). In the case of ICCAT, the measures include: size limits for bluefin; fishing effort restrains for yellowfin and bluefin; catch limits for albacore, bigeye and bluefin; and restrictions on the use of FADs in some areas or periods. Some other measures include seasonal and geographical closures in the Mediterranean Sea.

ACKNOWLEDGEMENTS

The authors are grateful to Dr Peter Miyake and his colleagues for their help with the provision of information for the preparation of the section ob Fisheries and Table C1.1. They also appreciate the assistance of the Secretariats and tuna scientists of FFA, t-RFMOs and SPC with obtaining information for this review and their cooperation and collaboration with FAO. Drs Robin Allen and Victor Restrepo have kindly provided helpful suggestions for improving an earlier version of this review.

REFERENCES

Allen, R.L. 2010. *International management of tuna fisheries: arrangements, challenges and a way forward*. FAO Fisheries and Aquaculture Technical Paper No. 536. Rome, FAO. 45 pp.

Alverson, D.L., Freeberg, M.H., Pope, J.G. & Murawski, S.A. 1994. *A global assessment of fisheries by-catch and discards*. FAO Fisheries Technical Paper No. 339. Rome, FAO. 233 pp.

Bailey, K., Williams, P.G. & Itano, D. 1994. By-catch and discards in Western Pacific tuna fisheries: a review of SPC data holdings and literature. *Oceanic Fisheries Programme, Internal Report* No. 28. Nouméa, New Caledonia, South Pacific Commission. 87p.

Beckett, J.S., ed. 1998. *Proceedings of the ICCAT Tuna Symposium/Actes du Symposium sur le thon organisé par la CICTA/Actas del Simposio CICAA sobre Túnidos. Part 1*. Collect. Vol. Sci. Pap. ICCAT/Recl. Doc. Sci. CICTA/Colecc. Doc. Cient. CICAA, Vol. L(1). 447 pp.

Carocci, F. & Majkowski, J. 1996. *Pacific tunas and billfishes: atlas of commercial catches*. Rome, FAO. 9 pp., 28 maps.

Carocci, F. & Majkowski, J. 1998. *Pacific tunas and billfishes: atlas of commercial catches*. Rome, FAO. CD–ROM.

Carocci, F. & Majkowski, J. 2011a. Atlas of tuna and billfish catches. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. [Cited 30 March 2011]. www.fao.org/fishery/statistics/tuna-atlas/en

Carocci, F. and Majkowski, J. 2011b. Global tuna catches by stock. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. [Cited 30 March 2011]. www.fao.org/fishery/statistics/tuna-catches/en

Collette, B.B. & Nauen, C.E. 1983. *FAO species catalogue. Vol. 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date*. FAO Fisheries Synopsis (125)Vol. 2. 137 pp.

Doulman, D. 1995. *Structure and process of the 1993–1995 United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks*. FAO Fisheries Circular No. 898. Rome, FAO. 81 pp.

FAO. 1994. *Report of the* Ad hoc *Consultation on the Role of Regional Fishery Agencies in Relation to High Seas Fishery Statistics. La Jolla, California, USA, 13–16 December 1993*. FAO Fisheries Report No. 500. Rome. 167 pp.

FAO. 1995. *Code of Conduct for Responsible Fisheries*. Rome. 41 pp.

FAO. 1996. *Precautionary approach to capture fisheries and species introductions. Elaborated by the Technical Consultation on the Precautionary Approach to Capture Fisheries (Including species introductions). Lysekil, Sweden, 6–13 June 1995*. FAO Technical Guidelines for Responsible Fisheries No. 2. Rome. 54 pp.

FAO. 2001. *Research implications of adopting the precautionary approach to management of tuna fisheries*. FAO Fisheries Circular No. 963. Rome. 74 pp.

Gillett, R. 2010. *Marine fishery resources of the Pacific islands*. FAO Fisheries and Aquaculture Technical Paper No. 537. Rome, FAO. 58 pp.

Gillett, R. 2011a. *Marine fishery resources in the Pacific islands* [online]. FAO Fisheries and Aquaculture Reviews and Studies. Rome, FAO. 13 pp. [Cited 30 March 2011] www.fao.org/fi/oldsite/eims_search/1_dett.asp?calling=simple_s_result&lang=en&pub_id=287042

Gillett, R. 2011b. *Bycatch in small-scale tuna fisheries: global study*. FAO Fisheries and Aquaculture Technical Paper No. 560. Rome, FAO. 116 pp.

Goujon, M. & Majkowski, J. 2010. Biological characteristics of tuna. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. [Cited 30 March 2011]. www.fao.org/fishery/topic/16082/en

Hall, M.A. 1996. On bycatches. *Reviews in Fish Biology and Fisheries*, 6: 319–352.

Hall, M.A. 1998. An ecological view of the tuna-dolphin problem: impacts and trade-offs. *Reviews in Fish Biology and Fisheries*, 8: 1–34 pp.

Inter-American Tropical Tuna Commission (IATTC). 1998. *Purse seine bycatch working group 1st meeting, 8-9 July 1998, La Jolla, California, USA*. La Jolla, USA.

International Commission for the Conservation of Atlantic Tuna (ICCAT). 2009. *Report of the 2008 Atlantic Bluefin tuna stock assessment session (Madrid, Spain – June 23 to July 4, 2008).* Collect. Vol. Sci. Pap. ICCAT, 64(1). pp. 1–352.

Joseph, J. 1994. The tuna-dolphin controversy in the eastern Pacific Ocean: biological, economic, and political impacts. *Ocean Development and International Law*, 25: 1–30.

Joseph, J. 1998. *A review of the Status of World Tuna Resources.* Tuna 97 Bangkok. Papers of the 5th World Tuna Trade Conference, 25–27 October 1997. Bangkok, Thailand. Published by INFOFISH, Kuala Lumpur, Malaysia. 8–21p.

Joseph, J. 2000. World tuna production: past, present and future. *In* S. Subasinghe & Sudari Pawiro, eds. *Papers of the 6th World Tuna Trade Conference, 25–27 May 2000, Bangkok, Thailand.* p. 3–20, Bangkok. INFOFISH, 233p.

Joseph, J. 2003. *Managing fishing capacity of the world tuna fleet*. FAO Fisheries Circular No. 982. Rome, FAO. 67 pp.

Klawe, W.L. 1977. What is tuna? *Marine Fisheries Review*, 39(11): 1–5.

Mahon, R. 1996. *Fisheries and research for tunas and tuna-like species in the Western Central Atlantic: implications of the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks*. FAO Fisheries Technical Paper No. 357. Rome, FAO. 62 p.

Majkowski, J. 1998. Precautionary approach and tuna research: perspective from the 1995 UN Agreement. *In* P. Cayré & J.-Y. Le Gall. *Le thon: enjeux et stratégies pour l'océan Indien/Tuna prospects and strategies for the Indian Ocean. Proceedings of the International Tuna Conference 1996, 27–29 November 1996, Maurice*. Collection Colloques et Séminaires, 433. Paris, COI/Orstom. 60 pp.

Marashi, S.H. 1996. *Summary information on the role of international fishery and other bodies with regard to the conservation and management of living resources of the high seas*. FAO Fisheries Circular No. 908. Rome, FAO. 104 pp.

Miyake, P.M. 1998. *Stock management measures taken by the International Commission for the Conservation of Atlantic Tunas (ICCAT) in relation to trade measures*. WTO Committee on Trade and Environment, Geneva, 23–24 July 1998. 5 pp.

Miyake, P.M., Miyabe, N. & Nakano, H. 2004. *Historical trends of tuna catches in the world*. FAO Fisheries Technical Paper No. 467. Rome, FAO. 74 pp.

Miyake, P.M., Guillotreau, P., Chin-Hwa Sun & Ishimura, G. 2010. *Recent developments in the tuna industry: stocks, fisheries, management, processing, trade and markets*. FAO Fisheries and Aquaculture Technical Paper No. 543. Rome, FAO. 125 pp.

Musick, J.A. & Musick, S. 2011. *Sharks*. FAO Fisheries and Aquaculture Reviews and Studies. Rome, FAO. 13 pp.

Nakamura, I. 1985. *FAO species catalogue. Vol. 5. Billfishes of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date*. FAO Fisheries Circular, No. 125(5). Rome, FAO. 65 pp.

Shomura, R.S., Majkowski, J. & Harman, R.F., eds. 1995. *Summary Report of the Second FAO Expert Consultation on Interactions of Pacific Tuna Fisheries. Shimizu, Japan, 23–31 January 1995*. FAO Fisheries Report No. 520. Rome, FAO. 58 pp.

Shomura, R.S., Majkowski, J. & Harman, R.F., eds. 1996. *Status of interactions of Pacific tuna fisheries in 1995. Proceedings of the second FAO Expert Consultation on Interactions of Pacific Tuna Fisheries. Shimizu, Japan, 23–31 January 1995*. FAO Fisheries Technical Paper No. 365. Rome, FAO. 612 pp.

Shomura, R.S., Majkowski, J. & Langi, S., eds. 1993a. *Interactions of Pacific tuna fisheries. Proceedings of the First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries. 3–11 December 1991. Nouméa, New Caledonia. Vol. 1: Summary report and papers on interaction*. FAO Fisheries Technical Paper No. 336, Vol. 1. Rome, FAO. 326 pp.

Shomura, R.S., Majkowski, J. & Langi, S., eds. 1993b. *Interactions of Pacific tuna fisheries. Proceedings of the First FAO Expert Consultation on Interactions of Pacific Tuna Fisheries. 3–11 December 1991. Nouméa, New Caledonia. Vol. 2: Summary report and papers on biology and fisheries*. FAO Fisheries Technical Paper No. 336, Vol. 2. Rome, FAO. 439 pp.

C2. Sharks

John A. Musick
FAO consultant
the United States of America
E-mail: j musick@vims.edu

Susanna Musick
FAO consultant
the United States of America
E-mail: susanna@vims.edu

INTRODUCTION

Sharks and their relatives – the batoids and chimaeras – comprise the chondrichthyan fishes, a group of more than 1 100 species, of which more than 400 are sharks (Compagno, 2005). The chimaeras are a small, mostly deep-sea group that contributes little to fisheries landings. Discussions in the following article that refer to sharks generally will include both sharks and batoids (elasmobranchs) as the fishery statistics for many countries report the two groups together as one category (Lack and Sant, 2009). Examples will mostly be taken from sharks.

Most elasmobranches have slow growth rates, late age-at-maturity and low fecundity compared with bony fishes (Cortes, 2004; Musick, 2005a). These life history parameters result in low intrinsic rates of population growth and a limited ability to withstand fishing pressure (Smith, Au and Show, 1998). The history of most directed shark fisheries around the world has been one of overharvest, rapid stock decline, collapse and limited recovery (Bonfil, 1994). Examples of such fisheries include: the porbeagle (*Lamna nasus*) in the North Atlantic (Campana *et al*., 2008); the soupfin or school shark (*Galeorhinus galeus*) off California and Australia (Ripley, 1946; Olsen, 1959; Stevens, 1999); various basking shark (*Cetorhinus maximus*) fisheries (Parker and Scott, 1965; CITES, 2002); and several spiny dogfish (*Squalus acanthias*) fisheries (Bargmann, 2009; Pawson, Ellis and Dobby, 2009; Rago and Sosebee, 2009; Wallace *et al*., 2009).

Sustainable fisheries for sharks are possible, particularly for the smaller, faster-growing species such as the Australian gummy shark (*Mustelus antarcticus*), which has been managed through size-selective gillnet regulations for several decades (Walker, 1998a, 1998b; Stevens, 1999). Even slower-growing species can be harvested sustainably. However, they must be very closely managed with small yields relative to standing stocks, particularly the reproductive portion of the stock (Simpfendorfer, 1999). Two previously decimated spiny dogfish stocks (Northeast Pacific and Northwest Atlantic) have since recovered and are currently being fished sustainably albeit at much lower levels (Rago and Sosebee, 2009; Wallace *et al*., 2009). This has been revelatory because spiny dogfish have among the lowest rebound potentials known for any shark (Smith, Au and Show, 2008).

Products

Sharks are harvested primarily for their meat, fins, skin, cartilage and liver (Musick, 2005b). Historical use of shark meat was mostly local because the meat spoils rapidly without refrigeration (Vannuccini, 1999). Sharks retain urea in their blood and tissues as their primary mode of osmoregulation. Urea breaks down into ammonia, which imparts an offensive taste and smell to the meat and is toxic in higher concentrations (Musick, 2005b). This problem may be ameliorated by bleeding freshly captured animals. Urea

FIGURE C2.1
Global trends in nominal shark and ray catches, 1990–2008

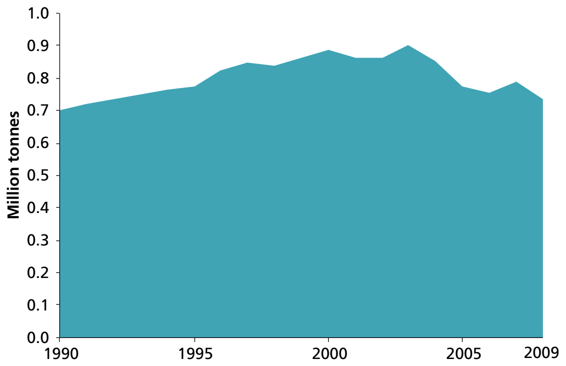
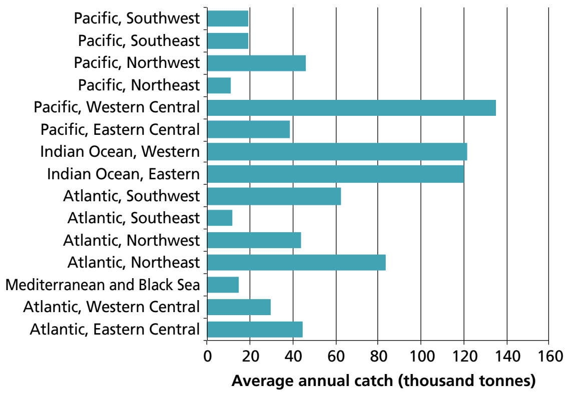


FIGURE C2.2
The most important FAO Statistical Area for shark and ray captures, 1990–2008



concentrations vary by species, with spiny dogfish having among the lowest concentrations and hammerhead sharks (Sphyrnidae) having the highest (Gordievskaya, 1973). In addition to fresh consumption, shark meat may be salted, dried, smoked or processed into surimi (Musick, 2005b). Shark-like batoids, such as guitarfishes (Rhinobatidae) and sawfishes (Pristidae) are processed in a similar way to sharks. More typical batoids such as skates (Rajidae) and stingrays (Myliobatiformes) have their wing-like pectoral fins removed before the meat is filleted off the upper and lower surfaces (Musick, 2005b).

Shark fins are the most valuable of shark products and are used to make traditional shark fin soup, a delicacy in Chinese culture (Clarke *et al.*, 2006). The first dorsal, pectorals and lower lobe of the caudal are the largest and most valuable fins on most sharks and shark-like batoids and are usually sold as a set. The smaller second dorsal, anal and pelvic fins may be sold in lots mixed from several sharks. Only the fine cartilaginous ceratotrichia (needles) from the upper part of the fin are used to make the soup (Musick, 2005b). Shark fins are removed from the body neatly to avoid including the fleshy lower part of the fin. They are then dried and packed for marketing. Most fins are processed in China, Hong Kong SAR or in mainland China, and the resulting "nests" of cartilage are sold to national and international traders.

In several countries in Asia and Oceania, shark skin is eaten after it has been boiled and the denticles removed (Musick, 2005b). However, the greatest use for shark skin has been for leather. Shark leather is both attractive and very durable and used in the same kinds of products that utilize leather from other animals. Skins from larger sharks are preferred for tanning. Most shark leather is currently tanned in Mexico.

Shark cartilage is used for food in China and Japan and may include any part of the cartilaginous skeleton (except the highly valuable ceratotrichia used in shark fin soup). By far, the largest market for shark cartilage is the pharmaceutical industry, which uses the dried and milled cartilage powder to make pills and capsules. Shark cartilage pills were promoted as a cure for cancer (Lane and Comac, 1992), a claim subsequently proved to have no validity (Musick, 2005b). However, shark cartilage is high in chondroitin and glucosomine sulphate, compounds used effectively in treating arthritis. Although dried cartilage is ineffective in treating cancer, certain biologically active compounds extracted from cartilage have shown promise in retarding tumour growth and may provide another potential pharmaceutical market.

Shark liver, both fresh and salted, is consumed in China and elsewhere. However, the largest markets have been for liver extracts, mostly oils and other hydrocarbons, which have been used in a wide array of industries throughout history. Currently, the most valuable use of liver extracts is in pharmaceutical products such as squalene. This is used in lubricants and skin creams (Kuang, 1999), and squalamine, a steroid with antibiotic properties (Rao *et al.*, 2000).

PROFILES OF CATCHES

Nominal catches

Nominal catches of sharks and rays by species in the FAO FishStat database (FAO, 2010a) are difficult to interpret because of the uneven categorization of catches among landing countries. Some countries provide species-specific catch data, whereas some of the most important countries with the highest catches, such as India, simply report "sharks, rays, skates, etc.". In 2007, only 20 percent of the reported catch was identified to species. The remaining 80 percent was comprised of several general groupings (Lack and Sant, 2009). Global trends from 1990 to 2008 in nominal shark and ray catches (Figure C2.1) show landings of about 700 000 tonnes in 1990, increasing to just under 900 000 tonnes in 2003, then declining back to about 700 000 tonnes in 2008.

In the period 1990–2008, the most important FAO Statistical Area for shark and ray captures were the Western Central Pacific, the Eastern and Western Indian Ocean, and the Northeast Atlantic (Figure C2.2).

In this same time period, the top five countries/territories contributing to these landings were Indonesia, India, Taiwan Province of China, Spain and Mexico (Figure C2.3). Pakistan, Argentina, the United States of America, Japan and Malaysia rounded off the top ten countries (Lack and Sant, 2009). The landings from Indonesia, India and Mexico were primarily from coastal artisanal and industrial fisheries, whereas a substantial proportion of the catches from Spain and Taiwan Province of China were from their high seas longline fleets. From the FAO Fisheries Commodities database (FAO, 2010b), the global values of shark landings rose from about US$400 million in 1990 to more than US$1 billion in 2000, declining to about US$800 million in 2006 (Figure C2.4). The value of shark landings in Asia far surpassed that of all other areas together because six of the top ten countries landing sharks are in Asia. Moreover, China, Hong Kong SAR has been the centre of the shark fin trade, and shark fins are the most valuable shark product by far.

FIGURE C2.3
The top five countries/territories contributing to shark and ray captures, 1990–2008

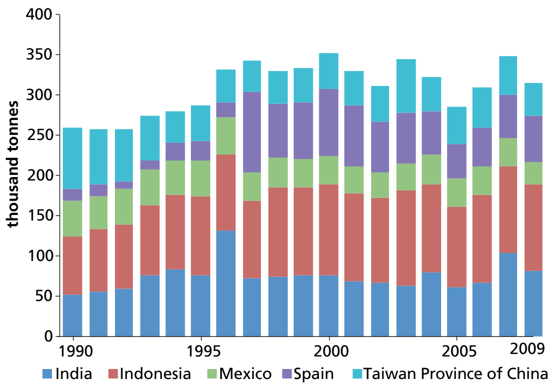
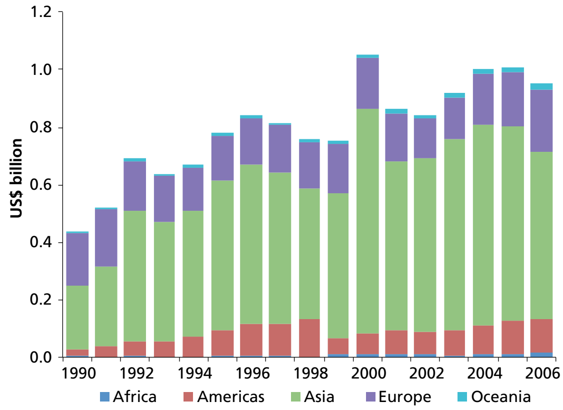


FIGURE C2.4
The global value of shark landings, 1990–2006



In order to try to obtain some approximation of the relative landings of sharks versus rays in the FishStat database, the data were parsed out and summarized separately for all those countries that had provided separate statistics for the two groups. It was not possible to resolve the trends in nominal catches of sharks because of uncertainties in the content of the aggregated entries for several countries. Trends in nominal catches of batoids (Figure C2.5) show that Indonesia had the highest landings from 1990 to 2008, and they included a wide variety of tropical batoids (White and Sommerville, 2010). The United States landings were increasing at the end of the period and were attributable mostly to a skate (Rajidae) fishery off New England (the United States of America) that developed after the lucrative ground fishery was restricted (NEFMC, 2010).

FIGURE C2.5
Proportion of batoid captures, top five countries, 1990–2008

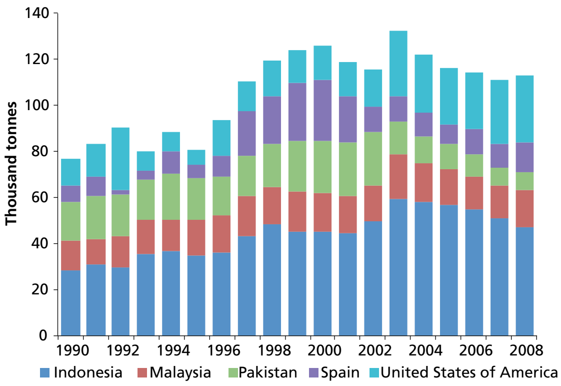


FIGURE C2.6
Global trends in blue shark catches, 1997–2008

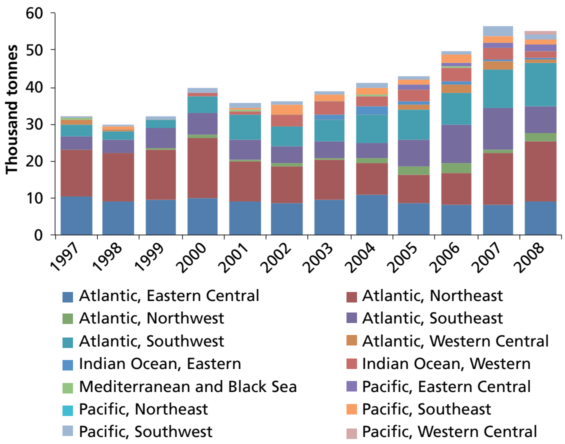
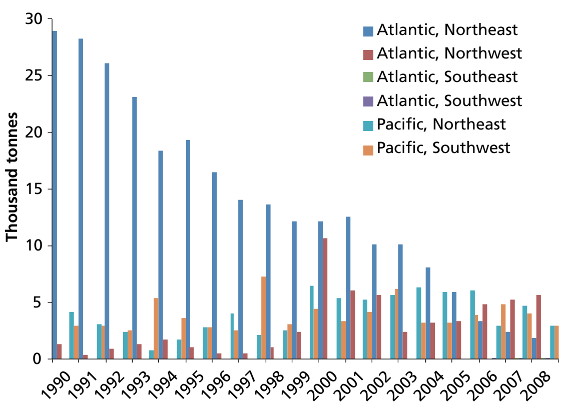


FIGURE C2.7
Trends in dogfish catches, 1990–2008



Major fisheries

Shark and ray fisheries in the world may be classified into four main categories: high seas pelagic, coastal cold-temperate, coastal tropical and deep sea. High seas pelagic fisheries are driven by international longline fleets that target tunas and billfishes, but which have a huge bycatch of sharks (Camhi, Pickitch and Babcock, 2008; Stevens, 2010). Blue sharks (*Prionace glauca)* are by far the most common of the dozen or so commercially important shark species captured. They have the largest global landings of all sharks in the FAO database.

Global trends in the blue shark catch (Figure C2.6) from 1997 to 2008 show a peak of more than 16 000 tonnes in the Northeast Atlantic in 2000, followed by a decline, and then a rise again to 2008. The highest catches came from the Northeast Atlantic, followed by the Eastern Central Atlantic (largely attributable to Spain) with an increase in the Southwest Atlantic (largely attributable to Brazil) at the end of the time series. These nominal catches underestimate the true blue shark fishery removals, as most sharks taken in this fishery are finned and the carcasses are discarded at sea (Camhi, Pickitch and Babcock, 2008). Blue shark fins are five times more common than any other pelagic species in the fin trade in China, Hong Kong SAR. Clarke *et al.* (2006) calculated that the shark biomass required to support the documented global fin trade (all species) annually exceeded the total catch reported to FAO by four times.

Coastal cold-temperate shark and ray fisheries in both hemispheres are dominated by the piked dogfish, smooth hounds (Triakidae) and several species of rajid skates (Ebert and Winton, 2010). Piked dogfish catches are second only to blue shark in the FAO database. Trends in dogfish catches between 1990 and 2008 (Figure C2.7) show a high of just under 30 000 tonnes in the Northeast Atlantic in 1990, followed by a steep decline to negligible levels in 2008 (Pawson, Ellis and Dobby, 2009). The ICES conducted a stock assessment in 2006 and concluded that the Northeast Atlantic dogfish stock was 94 percent depleted. The IUCN has declared it to be critically endangered (Gibson *et al.*, 2008). The primary market for these Northeast Atlantic dogfish has been for fish and chips in the United Kingdom of Great Britain and Northern Ireland and for smoked belly flaps in Germany. In response to the declining supply, but continuing demand in these European markets, landings of piked dogfish in the Northeast Pacific and Western Atlantic increased in the 1990s and 2000s (Figure C2.7). Since then, the fishery in the Northeast Pacific has been pursued at a relatively low yield level compared with total standing stock and has been stable (Wallace *et al*., 2009). The fishery in the Northwest Atlantic initially targeted large females, causing recruitment failure for several years. This fishery has come under stricter management controls and is currently being fished near the management targets (Rago and Sosebee, 2009).

Coastal tropical regions of the world's oceans hold the highest shark and ray species diversity (White and Sommerville, 2010), which is reflected in the fishery captures. Among the batoids, the myliobatiform rays, guitarfishes (Rhinobatidae) and wedgefishes (Rhynchobatidae) are important fishery components. Among the sharks, the requiem sharks and their relatives (Carcharhiniformes) are particularly important. The three main shark-producing FAO areas are tropical (Figure C2.2), and six out of the ten most productive shark-fishing nations are in the tropics. Indonesia has been the top global shark and ray capture producer in recent years (Figure C2.3). At least 105 species were observed in Indonesian landings in a recent study (White and Sommerville, 2010). The fisheries have included a wide variety of both fixed and mobile fishing gear types and a high percentage of artisanal fishers who depend on elasmobranches landings. A decline in the CPUE of these fisheries in recent years is causing concern among fisheries managers.

Directed deep-sea fisheries for sharks have been ongoing locally over continental and insular slopes (200–2 000 m) for several decades. These demersal fisheries typically target deep-water dogfishes (Squaliformes) of several genera (Kyne and Simpfendorfer, 2010). Two well-documented examples include the kitefin shark (*Dalatia licha*) in the Azores and the deep-water line fishery in Suruga Bay, Japan (Kyne and Simpfendorfer, 2010; Yano and Tanaka, 1988). Deep-water dogfishes have been targeted for their meat, but especially for their livers, which are high in squalene (Gordon, 1999). Catches of deep-sea sharks increased substantially in the last decades of the twentieth century, as large industrial fisheries moved from the continental shelves (where fish stocks were depleted) to the continental slopes (Merrett and Haedrich, 1997). The targets of these fisheries were bony fishes, but sharks made up a substantial part of the non-target catch, some of which was landed, some discarded. Because of the incomplete nature of the catch statistics, Kyne and Simpfendorfer (2010) chose to present four case studies of deep-sea sharks for which there were adequate fisheries-dependent or fisheries-independent data to examine abundance trends. The case studies for the two largest fisheries are summarized here. In the Australian scalefish and shark fishery, deep-sea shark abundance over around a 30-year period dropped by 75–99 percent depending on species. Gulper sharks (*Centrophorus* sp.) were the most heavily affected. In the Northeast Atlantic deep-water fisheries, gulper sharks, Portuguese dogfish and birdbeak dogfish (*Deania* sp.) declined by 62–99 percent between the late 1970s and the early 2000s. Deep-sea squaliform sharks have inherently slow growth rates and live in deep, cold water where food resources are limited (Kyne and Simpfendorfer, 2010). Such species have very limited capacity to respond to fishing pressure and can be harvested only at very low ratios of yield to standing stock. When taken in mixed species fisheries supported by more productive teleosts, deep-sea shark populations have declined rapidly and local extirpations have occurred.

STATUS OF SHARK AND RAY RESOURCES

The global status of shark and ray populations is not good despite the rather modest recent decline seen in the catch statistics (Figure C2.1). Species-specific catch statistics are lacking from most shark fishing countries, although data may be available for aggregations of species in some higher groups (orders or families) (Lack and Sant, 2009). Species catch data aggregated into higher groups can easily mask declines of individual species within the groups. Examples abound of larger, slower-growing sharks being replaced by smaller, faster-growing species with no apparent changes in landings data for the group (Dulvy and Forrest, 2010). While directed fisheries have been the cause of stock collapse in many species of elasmobranchs, capture in mixed fisheries and non-target catch in fisheries directed towards more productive teleosts are the main global threats to elasmobranch stocks (Musick, 1999).

The low economic value of sharks and rays has meant that few resources have been put into the collection of elasmobranch fisheries landings data (FAO, 2009). This has been compounded by IUU fishing, particularly in regard to shark fins. The CPUE trends from either fisheries or fisheries-independent data are available for only a handful of stocks. Most recent CPUE analyses of elasmobranch stocks have shown declines (Dulvy and Forrest, 2010). Formal stock assessment models have been produced for even fewer stocks. Notable exceptions include those for blue and mako sharks in the North Atlantic (Babcock and Nakano, 2008), the piked dogfish assessment in the Northwest Atlantic (Rago and Sosebee, 2009), and others such as the Australian gummy shark assessment (Walker, 1998a). Regardless, most shark and ray populations are being fished without established fishery yield targets or limits, or without any sort of management (Dulvy and Forrest, 2010). For many elasmobranch species, the question is no longer about fishery sustainability, but rather extinction risk. The IUCN Shark Specialist Group recently completed assessments of the conservation status of all recognized chondrichthyans (1 044 species) (IUCN, 2010). Of these, almost half did not have sufficient data to make an assessment. Of the remainder, 37 percent were assessed in threatened categories: 23 percent as vulnerable; 9 percent as endangered; and 5 percent as critically endangered. Fisheries mortality was identified as the major cause of decline in virtually all of the threatened species.

SHARK FISHERY MANAGEMENT AND CONSERVATION

FAO International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks)

In 1999, FAO adopted the IPOA-Sharks in response to growing international concerns about the inherent vulnerability of elasmobranch stocks to overfishing, the demonstrated historical collapse of some shark fisheries and the rapidly increasing shark landings (FAO, 2000). The IPOA-Sharks requested that all UN Member Countries that captured sharks and their relatives voluntarily prepare national "Shark plans" (NPOAs). These NPOAs should include monitoring, assessments and management protocols to ensure that shark stocks are fished sustainably and that threatened species are conserved. Although the target date for these plans was set at 2001, as of June 2010 only 12 of some 37 shark-fishing countries (which have landed 5 000 tonnes or more in any year in the last ten years) had submitted NPOAs, and these vary widely in content from substantial to ephemeral (FAO, 2010c). The two countries with the highest shark landings, India and Indonesia, have not submitted NPOAs.

Regional fisheries management organizations

Recently, several RFMOs, including the IATTC, ICCAT, IOTC, NAFO, GFCM, NEAFC and WCPFC, have adopted regulations that require that any vessel under their jurisdictions that retains shark fins needs also to retain shark carcasses such that the fin/carcass ratio does not exceed 5 percent (Lack and Sant, 2009). Although not perfect, this regulation discourages the wasteful practice of finning and, in some instances, it may encourage fishers to release sharks of low value to reserve hold space for more valuable species such as tuna. In addition to finning restrictions, several RFMOs are collecting more complete shark catch data. Some have begun to undertake stock assessments on shark species and to implement some retention restrictions.

Several regional and international conventions to encourage conservation of threatened species have included species of sharks and their relatives on their lists.

The most important convention in terms of conservation impact is CITES, which can restrict or prohibit international trade in threatened species. Currently, three sharks and one sawfish are listed under Appendix II (restricted trade) and six sawfishes are listed under Appendix I (prohibited trade). Additional sharks have been nominated for listing but declined recently. Many of these species will probably be re-nominated along with others at the next conference of the parties.

ACKNOWLEDGEMENTS

Thanks are due to Dr Kenneth Goldman of the Alaska Department of Fish and Game and President of the American Elasmobranch Society for constructive review of this manuscript.

REFERENCES

Babcock, E.A. & Nakano, H. 2008. Data collection, research and assessment efforts for pelagic sharks by the International Commission for the Conservation of Atlantic Tunas. *In* M.D. Camhi, E.K. Pickitch & E.A. Babcock, eds. *Sharks of the open ocean*, pp. 472–477. Oxford, UK, Blackwell. 536 pp.

Bargmann, G.C. 2009. A history of the fisheries for spiny dogfish along the Pacific Coast from California to Washington. *In* V.F. Gallucci, G.A. McFarlane & G.C. Bargmann, eds. *Biology and management of dogfish sharks*, pp. 287–297. Bethesda, USA. American Fisheries Society.

Bonfil, R. 1994. *Overview of world elasmobranch fisheries*. FAO Fisheries Technical Paper. No. 341. Rome, FAO. 119 pp.

Camhi, M.D., Pickitch, E.K. & Babcock, E.A. 2008. *Sharks of the open ocean.* Oxford, UK, Blackwell. 502 pp.

Campana, S.E., Joyce, W., Marks, L., Hurley, P., Natanson, L.J., Kohler, N.E., Jensen, C.F., Mello, J.J., Pratt, H.L., Myklevoll, S. & Hurley, S. 2008. The rise and fall (again) of the porbeagle shark population in the Northwest Atlantic. *In* M.D. Camhi, E.K. Pickitch & E.A. Babcock, eds. *Sharks of the open ocean*. pp. 445–461. Oxford, UK, Blackwell.

Clarke, S., Magnusson, J.E., Abercrombie, D.L., McAllister M. & Shivji, M.S. 2006. Identification of shark species composition, and proportion in the Hong Kong shark fin market based on molecular genetics and trade records. *Conservation Biology*, 20: 201–211.

Compagno, L.J.V. 2005. Checklist of living Chondrichthyes. *In* W.C. Hamlett, ed. *Reproductive biology and phylogeny of chondrichthyes.* pp. 503–548. Plymouth, UK, Science Publishers.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). 2002. Twelfth meeting of Conference of Parties, Santiago Chile, 3–15 November 2002. In: *CITES* [online]. [Cited 30 March 2011]. www.cites.org/eng/news/meetings/cop12.shtml

Cortes, E. 2004. Life history patterns, demography and population dynamics. *In* J.C. Carrier, J.A. Musick & M.R. Heithaus, eds. *Biology of sharks and their relatives*, pp. 449–470. Boca Raton, USA, CRC Press.

Dulvy, N.K. & Forrest, R.E. 2010. Life histories, population dynamics and extinction risk in chondrichthyans. Chapter 17. *In* J.C. Carrier, J.A. Musick & M.R. Heithaus, eds. *Sharks and their relatives II*, pp. 639–679. Boca Raton, USA, CRC Press.

Ebert, D.A. & Winton, M.V. 2010. Chondrichthyans of high latitude seas. *In* J.C. Carrier, J.A. Musick & M.R. Heithaus, eds. *Sharks and their relatives II*. Boca Raton, USA, CRC Press.

FAO. 2000. *Fisheries Management: 1. Conservation and management of sharks*. Technical Guidelines for Responsible Fisheries No. 4, Suppl. 1. Rome. 37 pp.

FAO. 2009. *Report of the Technical Workshop on the Status, Limitations and Opportunities for Improving the Monitoring of Shark Fisheries and Trade, Rome, 3–6 November 2008*. FAO Fisheries and Aquaculture Report No. 897. Rome. 152 pp.

FAO. 2010a. Global capture production 1950–2009. In: *FAO Fisheries and Aquaculture Department FIGIS* [online]. Rome. [Cited 30 March 2011]. www.fao.org/fishery/statistics/global-capture-production/query/en

FAO. 2010b. Commodities 1976–2008. In: *FAO Fisheries and Aquaculture Department FIGIS* [online]. Rome. [Cited 30 March 2011]. www.fao.org/fishery/statistics/global-commodities-production/query/en

FAO. 2010c. International Plan of Action for the Conservations and Management of Sharks. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. [Cited 30 March 2011]. www.fao.org/fishery/ipoa-sharks/npoa/en

Gibson, C., Valenti, S.V., Fowler, S.L. & Fordham, S.V. 2008. *The conservation status of Northeast Atlantic chondrichthyans.* Newbury, UK, IUCN Shark Specialist Group.

Gordievskaya, V.S. 1973. *Shark flesh in the fish industry*. Israel Program for Sci. Trans. IPST No. 60080.

Gordon, J.D.M. 1999. Management considerations of deep-water shark fisheries. *In* R. Shotton, ed. *Case studies of the management of elasmobranch fisheries*, pp. 775–818. FAO Technical Paper No. 378. Rome, FAO.

International Union for Conservation of Nature (IUCN). 2010. Red list of threatened flora and fauna. In: *IUCN* [online]. [Cited 30 March 2011]. www.iucnredlist.org/apps/redlist/search

Kuang, H.K. 1999. Non-food use of sharks. *In* S. Vannuccini. *Shark utilization, marketing and trade. Appendix III*, pp. 285–294. FAO Fisheries Technical Paper No. 389. Rome, FAO. 470 pp.

Kyne, P.M. & Simpfendorfer, C.A. 2010. Deepwater chondrichthyans. *In* J.C. Carrier, J.A. Musick & M.R. Heithaus, eds. *Sharks and their relatives II*, pp. 37–114. Boca Raton, USA, CRC Press.

Lack, M. & Sant, G. 2009. *Trends in recent shark catch and recent developments in management.* Cambridge, UK, TRAFFIC International. 29 pp.

Lane, W.I. & Comac, L. 1992. *Sharks don't get cancer*. Garden City Park, USA. Avery. 186 pp.

McFarlane, G., King, J. & Christiansen, L.B. 2008. *Assessment of information used to develop a recovery potential assessment for basking shark* Cetorhinus maximus *(Pacific population) in Canada*. Canadian Science Advisory Secretariat, Res Doc 2008/071. 98 pp.

Merret, N.R. & Haedrich, R.L. 1997. *Deep-sea demersal fish and fisheries.* New York, USA, Chapman & Hall. 282 pp.

Musick, J.A. 1999. Ecology and conservation of long-lived marine animals. *In* J.A. Musick, ed. *Life in the slow lane: ecology and conservation of long-lived marine animals*, pp. 1–10. American Fisheries Society Symposium 23. Bethesda, USA.

Musick, J.A. 2005a. Management of sharks and their relatives (Elasmobranchii). *In* J. Musick & R. Bonfil, eds. *Elasmobranch fisheries management techniques*, pp. 1–8. FAO Fisheries Technical Paper No. 474. Rome, FAO.

Musick, J.A. 2005b. Shark utilization. *In* J. Musick & R. Bonfil, eds. *Elasmobranch fisheries management techniques*, pp. 223–236. FAO Fisheries Technical Paper No. 474. Rome, FAO.

New England Fishery Management Council (NEFMC). 2010. *Northeast Skate Complex Fishery Management Plan* [online]. [Cited 30 March 2011]. www.nefmc.org/skates/Plan%20summary%20_2_.pdf

Olson, A.M. 1959. The status of the school shark fishery in South-eastern Australia waters. *Australian Journal of Marine and Freshwater Research*, 10: 150–176.

Parker, H.W. & Scott, F.C. 1965. Age, size, and vertebral calcification in the basking shark, *Cetorhinus maximus* (Gunnerus). *Zoologische Mededelingen (Leiden)*, 40: 305–319.

Pawson, M.J., Ellis, J. & Dobby, H. 2009. The evolution and management of spiny dogfish (spurdog) fisheries in the Northeast Atlantic. *In* V.F. Gallucci, G.A. McFarlane & G.C. Bargmann, eds. *Biology and management of spiny dogfish sharks*, pp. 373–400. Bethesda, USA, American Fisheries Society.

Rago P. & Sosebee, K. 2009. The agony of recovery: challenges of spiny dogfish recovery programs. Chapter 30. *In* V.F. Gallucci, G.A. McFarlane & G.C. Bargmann, eds. *Biology and management of spiny dogfish sharks*, pp. 343–372. Bethesda, USA, American Fisheries Society.

Rao, M.N., Shinnar, A.E., Noecker, L.A., Chao, T.L., Feibush, B., Snyder, B., Sharkansky, I., Sarkahian, A., Zhang, X., Jones, S.R., Kinney, W.A. & Zasloff, M. 2000. Aminosterols from the dogfish shark, *Squalus acanthias*. *Journal of Natural Products*, 63: 631–635.

Ripley, W.E. 1946. The soup-fin shark and the fishery. *Fishery Bulletin*, 64: 7–37.

Simpfendorfer, C. 1999. Demographic analysis of the dusky shark fishery in southwest Australia. *In* J.A. Musick, ed. *Life in the slow lane: ecology and conservation of long-lived marine animals*, pp. 149–160. Bethesda, USA, American Fisheries Society.

Smith, S.E., Au, D.W. & Show, C. 1998. Intrinsic rebound potentials of 26 species of Pacific sharks. *Marine and Freshwater Research*, 49: 663–678.

Smith, S.E., Au, D.W. & Show, C. 2008. Intrinsic rates of increase in pelagic elasmobranches. *In* M.D. Camhi, E.K. Pickitch & E.A. Babcock, eds. *Sharks of the open ocean*, pp. 288–297. Oxford, UK, Blackwell.

Stevens, J.D. 1999. Variable resilience to fishing pressure in two sharks: the significance of different ecological and life history parameters. *In* J.A. Musick, ed. *Life in the slow lane: ecology and conservation of long-lived marine animals*, pp. 11–15. American Fisheries Society Symposium 23.

Stevens, J.D. 2010. Epipelagic oceanic elasmobranches. *In* J.C. Carrier, J.A. Musick & M.R. Heithaus, eds. *Sharks and their relatives II*, pp. 3–36. Boca Raton, USA, CRC Press.

Vannuccini, S. 1999. *Shark utilization, marketing and trade*. FAO Fisheries Technical Paper No. 389. Rome, FAO. 470 pp.

Walker, T.I. 1998a. Can shark resources be harvested sustainably? A question revisited with a review of shark fisheries. *Marine and Freshwater Research*, 49: 553–572.

Walker. T.I. 1998b. Southern Australian shark fishery management. pp. 480–514. *In* R. Shotton, ed. *Case studies of the management of elasmobranch fisheries*. FAO Technical Paper No. 378. Rome, FAO.

Wallace, S., McFarlane, G., Campana, S. & King, J.R. 2009. Status of spiny dogfish in Atlantic and Pacific Canada. *In* V.F. Gallucci, G.A. McFarlane & G.C. Bargmann, eds. *Biology and management of spiny dogfish sharks*, pp. 313–334. Bethesda, USA, American Fisheries Society.

White, W.T. & Sommerville, E. 2010. Elasmobranchs of tropical marine ecosystems. *In* J.C. Carrier, J.A. Musick & M.R. Heithaus, eds. *Sharks and their relatives II*, pp. 159–240. Boca Raton, USA, CRC Press.

Yano, K. & Tanaka, S. 1988. Size at maturity, reproductive cycle, fecundity, and depth segregation of the deep-sea squaloid sharks *Centroscymnus owstoni* and *c. coelolepis* in Suruga Bay Japan. *Bulletin of the Japanese Society for the Science of Fish*, 5(2): 167–174.

C3. Pacific Islands Region

FAO STATISTICAL AREAS 71 AND 77

Robert Gillett
FAO consultant
The Republic of Fiji
E-mail: gillett@connect.com.fj

INTRODUCTION

In the Pacific Islands Region, fishery resources are critically important as a source of food and employment, a generator of government revenue and a foundation for economic development. The two main categories of marine fishery resources, coastal and offshore, have major differences with respect to species diversity, resource condition and interventions used in their management.

The Pacific Islands Region

The Pacific Islands Region consists of 14 countries and 8 territories located in the WCPO. There is also a substantial area of international waters (high seas) in the region. Figure C3.1 shows the countries and territories, their 200-mile EEZs and the international waters.

FIGURE C3.1
The Pacific Islands Region

Source: Secretariat of the Pacific Community.

The Pacific Islands Region contains about 200 high islands and some 2 500 low islands and atolls. In general, the islands increase in size from east to west, with Papua New Guinea at the westernmost edge having most of the region's land area.

FISHERY STATISTICS IN THE REGION

With respect to the quality and coverage of statistics, there are major differences between the region's coastal fisheries and the offshore fisheries. The offshore statistical systems are in relatively good condition, both at the national and regional level. The Secretariat of the Pacific Community (SPC) has a Statistics and Monitoring Section, whose functions include: (i) the compilation of estimates of annual catches of target tuna and billfish species; (ii) the estimation of annual catches of non-target species; (iii) the compilation of operational (logsheet) catch and effort data; (iv) data processing on behalf of member countries and territories; and (v) the provision of technical support for port sampling programmes and observer programmes in member countries and territories.

The situation of coastal fisheries statistics is considerably different. For coastal fisheries, the quality of fisheries statistics furnished to FAO by national governments is generally not very good. In fact, the estimation of the production from coastal fisheries by government fishery officers in about half of the Pacific Island countries is largely guesswork. Typically, government fisheries agencies give low priority to estimating the amount of coastal catches. In general, the smaller the scale of the fishing is, the less is known about the production levels, with quantitative information being especially scarce for the subsistence fisheries in most countries.

MAIN CATEGORIES OF FISHERIES IN THE REGION

Fishing activity in the Pacific Islands can be classified both by area in which the fishing is undertaken and by scale. Coastal fishing is of fundamental importance in the Pacific Islands. Much of the region's nutrition, welfare, culture, employment and recreation is based on the living resources in the zone between the shoreline and the outer reefs. The continuation of current lifestyles, the opportunities for future development and food security are all highly dependent on coastal fisheries resources. Although dwarfed in both volume and value by the offshore tuna fisheries, the Pacific Island fisheries that are based on coastal resources provide most of the non-imported fish supplies to the region. Coastal fisheries harvest a very diverse range of finfish, invertebrates and algae. Unlike the tuna fishery, virtually all the coastal catch is taken by Pacific Islanders themselves, with very little access by foreign fishing vessels. Coastal fishing in the region can be placed mostly in three categories:

- Small-scale commercial fishing (also referred to as "artisanal"), which can be further broadly subdivided into that supplying domestic markets and that producing export commodities.
- Subsistence fisheries, which support rural economies and are extremely important to the region's nutrition and food security.
- The industrial-scale shrimp fisheries, which in the region only occur in Papua New Guinea.

Offshore fishing is undertaken mainly by large industrial-scale fishing vessels. About 1 500 of these vessels operate in the EEZs of Pacific Island countries, mainly using purse seine, longline and pole-and-line gear to catch tuna. A fourth type of tuna fishing, trolling, is not undertaken on an industrial scale in the Pacific Islands, but some industrial tuna trollers are based in the region and troll in temperate waters in the south. The amount of tuna captured by offshore vessels in the region is many times greater than the catch from coastal fisheries. Offshore fishing in the region can be further subdivided into two categories:

- Locally-based offshore fishing. A survey carried out in 2008 (Gillett, 2008) showed that 269 longline vessels, 56 purse seine vessels and 2 pole-and-line vessels were

TABLE C3.1
Marine fishery production in Pacific Island countries, 2007

	Coastal commercial	Coastal subsistence	Offshore, locally-based	Offshore foreign-based	Total
			(tonnes)		
Papua New Guinea	5 700	30 000	256 397	327 471	619 568
Kiribati	7 000	13 700	0	163 215	183 915
Micronesia (Federated States of)	2 800	9 800	16 222	143 315	172 137
Solomon Islands	3 250	15 000	23 619	98 023	139 892
Marshall Islands	950	2 800	63 569	12 727	80 046
Nauru	200	450	0	69 236	69 886
Fiji	9 500	17 400	13 744	492	41 136
Tuvalu	226	989	0	35 541	36 756
Vanuatu	538	2 830	0	12 858	16 226
Samoa	4 129	4 495	3 755	25	12 404
Tonga	3 700	2 800	1 119	0	7 619
Palau	865	1 250	3 030	1 464	6 609
Cook Islands	133	267	3 939	0	4 339
Niue	10	140	640	0	790

Source: ADB, 2009.

based in the region. About 1 169 people from the Pacific Islands are employed on these tuna vessels.

- Foreign-based offshore fishing. About 1 200 foreign-based vessels operate in the waters of Pacific Island countries. Although about 65 percent of the vessels are longliners, about three-quarters of the tuna catch is taken by purse seiners. Most foreign fishing vessels are based in Asia, while some United States-flagged purse seine vessels are based in American Samoa. The licence fees paid to Pacific Island countries by these foreign-based vessels is substantial and, in some cases, the major source of government revenue for some countries.

In 2009, the Asian Development Bank estimated the fishery production in each Pacific Island country. All readily available sources of production information for each country were scrutinized to arrive at a best estimate of national catches in the four fishery categories (Table C3.1).

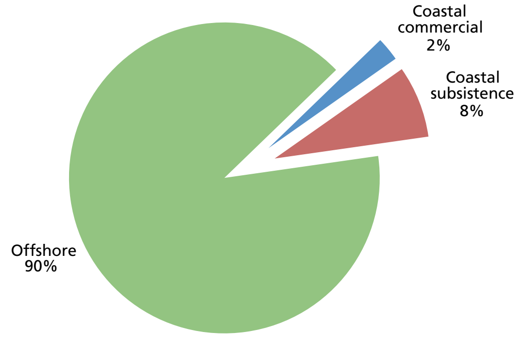
The six countries that have the most production have large tuna fisheries. With the exception of Papua New Guinea, most of the tuna catch in those countries is taken by foreign-based vessels. Other notable features of the information in Table C3.1 are:

- a general pattern of decreasing total national catches going from west to east across the region, and from equatorial to higher latitudes;
- the relatively large contribution of offshore locally based production in the Marshall Islands and, to a lesser extent, Fiji;
- the relatively large contribution of non-tuna production in Fiji.

Figure C3.2 shows that the production from the offshore fisheries is about nine times greater than that of the coastal fisheries (commercial and subsistence). It is easy to conclude that offshore fishing and the tuna resources upon which they are based are very important to the region.

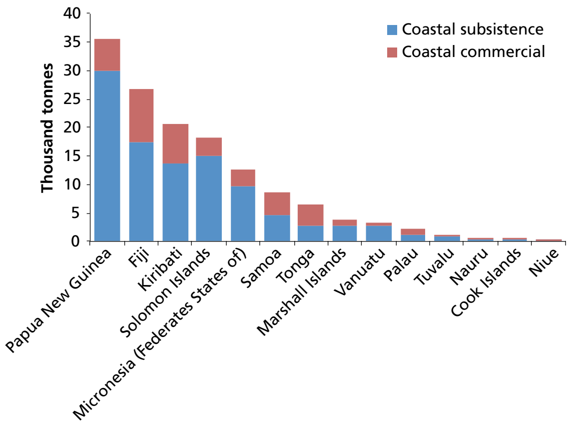
The region's marine fishery resources can be broadly split into two main categories: coastal (or inshore) and offshore (or oceanic). Coastal

FIGURE C3.2
Marine fishery production by volume and by fishery category, Pacific Islands Region, 2007



Source: Modified from ADB, 2009.

FIGURE C3.3
Coastal fishing production in the Pacific Islands Region, 2007



resources include a wide range of finfish and invertebrates, while offshore resources are mainly tunas, billfish and allied species.

PROFILE OF CATCHES

Coastal fishery resources

There are considerable differences between coastal subsistence fisheries and the coastal commercial fisheries of the region. Table C3.1 above gives estimates of fisheries production for each Pacific Island country for 2007. Figure C3.3 takes the coastal fishing data from the table and shows the annual production by country graphically.

About 70 percent of the overall fisheries production from coastal areas of the Pacific Islands is produced by subsistence fishing. In several countries, well over 80 percent of the coastal catch is from the subsistence sector: Niue, Papua New Guinea, Solomon Islands, Tuvalu and Vanuatu.

Subsistence fisheries generally involve a large variety of species, including fish, molluscs, crustaceans, algae and other groups. For example, Zann (1992) reported that in Samoa the subsistence fisheries made use of 500 species. In a study of coastal resources management in the Pacific Islands (World Bank, 2000), residents in coastal villages in five countries identified what they considered were their major coastal resources (Table C3.2).

Dalzell and Schug (2002) reviewed finfish that are important in small-scale Pacific Island coastal fisheries. They state that a typical fishery may harvest between 200 and 300 finfish species, although it is likely that only a few species will dominate landings. About one-third of the coastal catch total is comprised of emperors (Lethrinidae), surgeonfish (Acanthuridae) and snappers (Lutjanidae).

Compared with the subsistence fisheries of the region, the coastal commercial fisheries are smaller and take a more restricted range of species, although it may still be substantial. For example, more than 100 species of finfish and 50 species of invertebrates are included in Fiji's fish market statistics. Total commercial fishery products from the region include reef and deep-slope fish (about 43 percent of total weight), coastal pelagic fish (18 percent), shell products (trochus, green snail and pearl shell, 9 percent), crustaceans (8 percent), beche-de-mer (7 percent) and estuarine fish (6 percent).

It may not be appropriate to place the various types of coastal commercial fishing into discrete "fisheries", especially for the smaller-scale fishing. A single fishing trip often involves the use of several types of gear to make a range of catches. For example, Gillett and Moy (2006) state that during a multiday fishing trip, spearfishers in Fiji characteristically collect beche-de-mer, trochus and lobster, and do some handlining in

TABLE C3.2
Resources that support subsistence fishing in Pacific Island countries

Country	Groups of fishery resources (descending order of importance)
Fiji	Finfish, beche-de-mer, octopus, seaweed, lobster, mud crab and various bivalve molluscs
Tonga	Finfish, octopus, lobster, beche-de-mer, turbo, giant clams, seaweed and *Anadara*
Samoa	Finfish (especially surgeonfish, grouper, mullet, carangids, rabbitfish), octopus, giant clams, beche-de-mer, turbo, and crab
Solomon Islands	Finfish, beche-de-mer, trochus, giant clam, lobster, turbo and mangroves
Palau	Finfish, giant clams, mangrove crab, lobster, turtle and beche-de-mer

Source: World Bank, 2000.

addition to the main effort of spearing finfish. Therefore, it is more suitable to discuss the various types of coastal commercial fishing in the region by primary target.

Shallow-water reef fish. In most of the Pacific Islands, finfish found in relatively shallow water (< 50 m) are the basis of much commercial fishing. About 300 species, representing 30–50 fish families comprise the majority of the catch. The main gear types are handlines, spears and gillnets.

Beche-de-mer. About 20 species are currently exploited in the region, primarily for export to Asia. Recent annual production from Pacific Island countries is about 1 500 tonnes (dried, equivalent to 15 000 tonnes live weight). Villagers can process beche-de-mer into a non-perishable product that can be stored for extended periods awaiting opportunistic transport to markets. “Pulse fishing” is often used to describe the fishery – long cycles in which a period of intense exploitation is followed by a sharp fall in the abundance of the resource with associated difficulty in maintaining commercial exploitation and then a dormant period in which the resource is able to recover.

Aquarium fish and invertebrates. Aquarium fish collectors target a large number of species, with the major families being butterflyfish (Chaetodontidae), damselfish (Pomacentridae), surgeonfish (Acanthuridae) and angelfish (Pomacanthidae). Most aquarium species have the characteristics of relatively small size, bright coloration and good survival in captivity. Many operations also harvest and export invertebrates and “live rock”. An appealing aspect is that aquarium fish are rarely taken for food in the Pacific Islands and, therefore, this fishery does not interfere with subsistence fishing activities.

Trochus. The topshell, *Trochus niloticus*, is commercially one of the most important shellfish in the Pacific Islands. Although the natural range of trochus is limited to the western part of the region, the gastropod has been transplanted to almost all Pacific Island countries. It is valued for the inner nacreous layer of the shell, which, along with that of the pearl oysters and some other shells, is used for the manufacture of “mother of pearl” buttons. The annual harvest of trochus in the Pacific Islands in recent years has been about 2 300 tonnes, with five Pacific Island countries providing most of the harvest.

Live reef food fish. The live reef food fish fisheries typically harvest certain groups of fish in the tropical Indo-Pacific region and ship them by air or sea to Chinese communities in east Asia. Sadovy *et al*. (2003) indicate that, in the main destination markets, the bulk of the trade consists of the groupers (Serranidae). Also taken are snappers (Lutjanidae), wrasses (Labridae), small numbers of emperors (Lethrinidae), sweetlips (Haemulidae), seabream (Sparidae) and members of a few other families. A variety of techniques and gear types are used in live reef food fish fishing.

Lobsters. The commercial lobster fishery in the region is based on three species in the genus *Panulirus.* The largest fishery occurs in the Torres Strait of Papua New Guinea and targets the ornate spiny lobster (*Panulirus ornatus*). Smaller lobster fisheries, based mainly on the double-spined lobster (*P. penicillatus*), take place in many Pacific Island countries. The most common fishing method is walking on reef flats and catching by hand at night.

Nearshore pelagics. Trolling for tuna and other large pelagics just outside the reef is practised in most Pacific Island countries. Fiji, Kiribati and Papua New Guinea probably have the largest production from coastal trolling. The use of FADs increases catches and reduces operating costs.

Deep-water bottom fish. The target of deep-water bottom fishing in the Pacific Islands is a number of fish species (mainly in the families Lutjanidae and Serranidae) that inhabit reef slopes and shallow seamounts between 100 and 400 m. The most active, export-oriented, deep-water bottom fish fisheries in the Pacific Islands are currently in Fiji and Tonga.

RESOURCE STATUS AND FISHERY MANAGEMENT

Coastal fishery resources

In general, the coastal fishery resources are heavily fished and often show signs of overexploitation. This is especially the case in areas close to population centres and for fishery products in demand by the rapidly growing Asian economies. The coastal fisheries are also negatively affected by habitat degradation, which occurs from destructive fishing practices, urbanization, siltation from mining and logging, and competing uses of the coastal zone.

On a more detailed level, the degree of exploitation of coastal finfish is generally related to the distance from urban markets. The perishable nature of finfish has a limiting effect on fishing pressure in rural areas. By contrast, the products of commercial invertebrate fishing are mostly non-perishable. The SPC (2008) stated that most sites surveyed in the Pacific Islands were "seriously depleted of commercial invertebrate resources". Another aspect of the status of invertebrate fisheries in the region is variability. Dalzell and Schug (2002) found that commercial harvests of invertebrates are characterized by boom and bust cycles, and in some cases the bust part of the cycle has persisted with no indication of recovery.

The management of coastal fishery resources in many Pacific Island countries is a mixture of several systems:

- Traditional management. This is most prevalent in rural areas and characteristically involves village leaders restricting the fishing by those outside the community and by various controls on fishing by community members.
- Central government management. All Pacific Island countries have a fisheries law giving wide powers to the government fisheries agency in controlling fishing activity. For various reasons, the system is mostly ineffective. There is some degree of success, however, in central governments applying point of export restrictions on those coastal resources that are exported.
- The use of MPAs and similar arrangements. With varying degrees of outside assistance, communities establish an area that is closed to fishing or is subjected to reduced fishing pressure.

Current coastal fishery management measures (both centrally administered and community-driven) tend to be non-quantitative and are intended to protect stocks in a generalized way (Preston, 2008). These include MPAs, size limits (both minimum and maximum), gear restrictions (minimum mesh sizes for nets, bans on torch fishing at night), prohibitions on the use of destructive fishing methods (blast fishing, poisons), prohibitions on the taking of berried females, and seasonal or area closures.

Quantitative stock assessments have been undertaken for only a few of the coastal fish stocks in the region, with deep-water bottom fish in Tonga being an example. Some fisheries are managed on the basis of trends in catch per unit effort or, more precisely, perceptions of such trends.

Many current management measures are in support of biological objectives. This is most often stock sustainability and prevention of resource collapses (rather than catch optimization). There is also management for purely economic objectives, such as encouraging in-country trochus processing. Cultural objectives, such as the closure of a reef to fishing after the death of a traditional leader to show respect, are also common.

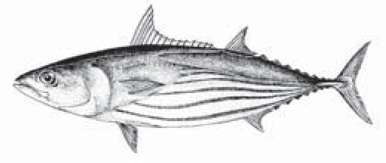
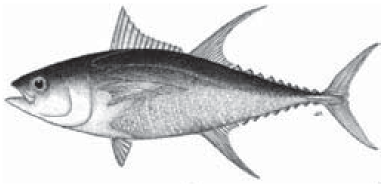
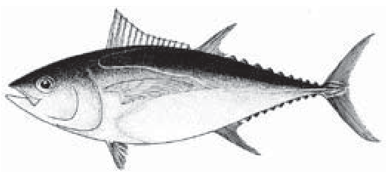
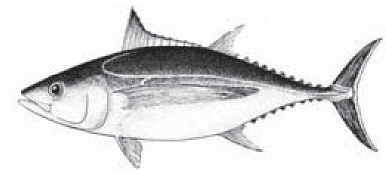
Offshore fishery resources

Although several species of scombrids are found in the Pacific Islands (Areas 71 and 77), four species of tuna are of major commercial importance: skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*T. obesus*) and albacore tuna (*T. alalunga*). Table C3.3 gives information on these fish in the WCPO.

Another important target of offshore fishing is swordfish (*Xiphias gladius*). This is caught by relatively shallow longline gear mainly in the subtropical parts of the WCPO. A few billfish species and some sharks are targeted by specific fisheries, but the usual situation is that they are bycatch in tuna longlining and, to a lesser extent, tuna purse seining. The common billfish are black marlin (*Makaira indica*), blue marlin (*M. mazara*), sailfish (*Istiophorus platypterus*), shortbill spearfish (*Tetrapturus angustirostris*) and striped marlin (*T. audax*). The most common shark caught is the blue shark (*Prionace glauca*).

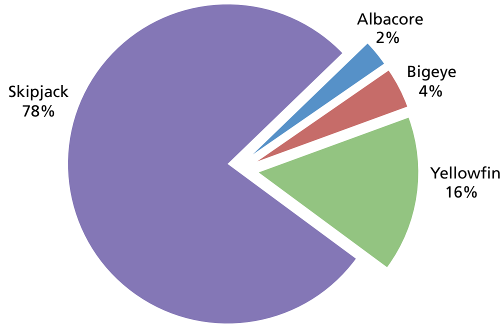
In 2007, about 1.1 million tonnes of tuna was captured in the Pacific Islands Region. Figure C3.4 gives the catch composition by species. About 72 percent of the tuna catch in the region is taken by purse-seining gear, with the remainder by longline, pole-and-line and troll gear. Almost 70 percent of the tuna

TABLE C3.3
The tuna species of major commercial importance in the Pacific Islands Region

Tuna species		Typical size captured	Important aspects
Skipjack		40–70 cm	Skipjack are caught mainly on the surface by purse seine and pole-and-line gear and used for producing canned tuna. Most fish caught are from one to three years old. In the WCPO, the skipjack biomass is greater than that of the other three main tuna species combined.
Yellowfin		40–70 cm and 90–160 cm	Small yellowfin are caught on the surface by purse seine and pole-and-line gear, while larger/older fish are caught in deeper water using longline gear. Small fish are used mainly for canning while high-quality larger fish are often shipped fresh to overseas markets. Most fish caught are from one to six years old.
Bigeye		40–70 cm and 90–160 cm	Small bigeye are caught on the surface by purse seine and pole-and-line gear, while larger/older fish are caught in deeper water using longline gear. Small fish are used mainly for canning while high-quality larger fish are especially valuable as fresh fish in the Japanese market. Most fish caught are from one to ten years old. Bigeye tuna account for a relatively small proportion of the total tuna catch in the region, but these tuna are extremely valuable.
Albacore		60–110 cm	Small albacore are caught by trolling at the surface in cool water outside the tropics, while larger fish are caught in deeper water and mainly at lower latitudes using longline gear. Most of the catch is used for producing "white meat" canned tuna. Fish caught are typically from one and a half to ten years old.

Source: Drawings courtesy of the SPC.

FIGURE C3.4
Composition of the tuna catches in the EEZs of Pacific Island countries



catch in the EEZs of Pacific Island countries was made by vessels based outside the region. All Pacific Island countries received fees for foreign tuna fishing activity in their waters – the total access fee payments for the countries of the region for 2007 were about US$77 million (ADB, 2009).

Tuna management

The management of the tuna resources in the Pacific Islands (Areas 71 and 77) is complex and involves political, resource and historical considerations. Current management occurs on the national, regional and international levels.

A general feature of national level tuna management in the region is the use of tuna management plans (TMPs). In 1998, the Canada–South Pacific Ocean Development Programme cooperated with the Forum Fisheries Agency (FFA) to produce a detailed TMP for Solomon Islands. The FFA and Canada have subsequently prepared plans, on country request, for Fiji, Kiribati, Palau and Vanuatu. The Asian Development Bank and Australia have also assisted in the formulation of TMPs for the Federated States of Micronesia and Samoa, respectively. The FFA has continued with this process using its own staff and has prepared TMPs for Niue, the Marshall Islands, Tokelau and Tonga. Recently, New Zealand has provided fisheries assistance that includes support for TMPs in the Cook Islands and Solomon Islands.

Currently, all Pacific Island countries have prepared national TMPs, and most have been formally adopted. Characteristically, the TMPs give a description of the current national tuna fisheries, the status of the tuna resources, overall government goals in the fisheries sector, specific objectives for the management of the fishery, and the interventions used to obtain the objectives. Tuna resource sustainability is often given as the priority objective in the TMPs. Other objectives are related to increasing employment, increasing access fees, and creating and/or enhancing domestic tuna fisheries.

At the regional level, there are a number of tuna fishery management arrangements in the Pacific Islands. All are promoted and coordinated by the FFA. The first measures, introduced in the 1980s and early 1990s, were:

- In licensing foreign fishing vessels, countries agreed to insist on the Harmonised Minimum Terms and Conditions for Foreign Fishing Vessel Access (e.g. use of a common regional licence form, requirement to carry observers if requested). These have been progressively added to over the years and now encompass several types of measures, such as the use of vessel monitoring systems.
- Reciprocal fisheries law enforcement as per the Niue Treaty on Cooperation in Fisheries Surveillance and Law Enforcement in the South Pacific Region.
- Incentives to locally based industrial tuna vessels as per the Federated States of Micronesia Arrangement for Regional Fisheries Access.

The region's first conservation-oriented management move in the tuna fisheries was the Palau Arrangement for the Management of the Western Pacific Purse Seine Fishery, which entered into force in November 1995. The arrangement places a ceiling on the number of purse-seine licences that can be issued by the seven Pacific Island countries party to the agreement. The limit was originally set at 164 vessels and has been progressively increased. For several years there, has been discussion about modifying the Palau Arrangement so that purse-seine-vessel fishing days (rather than vessel numbers) are used as the basis for management. In May 2004, a subset of FFA member countries decided to adopt such a scheme and it has subsequently been progressively implemented.

In a general sense, the original thrust of regional tuna fishery management in the 1980s and 1990s was to increase foreign fishing access fees. This has been broadened in recent years to include domestic tuna industry development and resource sustainability. The latter objective overlaps with international fishery management efforts in the WCPO.

At the international level, a management convention came into force in June 2004 establishing the Western and Central Pacific Fisheries Commission (WCPFC). The WCPFC adopts "resolutions" that are non-binding statements and "conservation and management measures" (CMMs) that are binding. As of mid-2009, a total of 26 CMMs had come into force.

In the December 2008 WCPFC meeting, a crucial CMM was adopted – which may increase the effectiveness of the WCPFC in its tuna management efforts. The objectives of that measure (CMM 2008–06) are:

- the implementation of a package of measures that, in a three-year period commencing in 2009, results in a minimum of 30 percent reduction in bigeye tuna fishing mortality from the annual average in the period 2001–04 or 2004;
- ensuring that there is no increase in fishing mortality for yellowfin tuna beyond the annual average in the period 2001–04 average or 2004;
- the adoption of a package of measures that shall be reviewed annually and adjusted as necessary by the WCPFC, taking account of the scientific advice available at the time as well as the implementation of the measures.

ACKNOWLEDGEMENTS

Jacek Majkowski of the Fisheries and Aquaculture Department of the Food and Agriculture Organization of the United Nations is acknowledged as initiating this study and providing valuable guidance in its preparation. Garry Preston and Mike McCoy, two Pacific Island fishery specialists, reviewed an earlier version of the manuscript and provided corrections and helpful suggestions. The Secretariat of the Pacific Community is to be thanked for materials, information and responses to enquiries.

REFERENCES

Asian Development Bank (ADB). 2009. *The contribution of fisheries to the economies of Pacific Island countries and territories.* Pacific Studies Series. ADB, World Bank, FFA, SPC and Australian Agency for International Development. 362 pp.

Dalzell, P. & Schug, D. 2002. *Synopsis of information relating to sustainable coastal fisheries.* Technical Report 2002/04. Apia, International Waters Programme, South Pacific Regional Environment Programme.

Gillett, R. 2008. *A Study of tuna industry development aspirations of FFA member countries.* Honiara, FFA. 70 pp.

Gillett, R. & Moy, W. 2006. *Spearfishing in the Pacific Islands: current status and management issues.* FAO FishCode Review No. 19. Rome, FAO. 72 pp.

Preston, P. 2008. *The ecosystem approach to coastal fisheries and aquaculture in Pacific Island Countries.* Report to the Secretariat of the Pacific Community and The Nature Conservancy.

Sadovy, Y., Donaldson T., Graham, T., McGilvray, F., Muldoon, J., Phillips, M., Rimmer, M., Smith, A. & Yeeting, B. 2003. *While stocks last: the live reef food fish trade.* Manila, Asian Development Bank.

Secretariat of the Pacific Community (SPC). 2008. *Status report: nearshore and reef fisheries and aquaculture.* Noumea.

Secretariat of the Pacific Community (SPC). 2009. *SPC/SPREP/CRISP Subregional Workshop for the Marine Ornamental Trade*. Noumea.

World Bank. 2000. *Voices from the village – a comparative study of coastal resource management in the Pacific Islands.* Pacific Island Discussion Paper Series No. 9. World Bank, Papua New Guinea and Pacific Islands Country Unit.

Zann, L. 1992. *The inshore resources of Upolu, Western Samoa.* Field Report No. 2. FAO/UNDP Project SAM/89/002. Apia.

C4. Deep-sea Fisheries

Merete Tandstad
Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: merete.tandstad@fao.org

Ross Shotton
FAO consultant
Greece
E-mail: r_shotton@hotmail.com

Jessica Sanders
Fishery Planning Analyst
Policy, Economics and Institutions Service
FAO Fisheries and Aquaculture Department
E-mail: jessica.sanders@fao.org

Fabio Carocci
Fishery Information Assistant
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: fabio.carocci@fao.org

INTRODUCTION

Deep-sea fisheries comprise those fisheries that occur beyond and below the continental shelf break (on the continental slopes and below to about 2 000 m), or are undertaken in association with deep oceanic topographic structures such as seamounts, ridges and banks. The types of fishing gear and vessels that are involved vary considerably depending on the species targeted and their behaviour. The gear can include longlines and other hook and line gears, bottom trawls, midwater trawls, gillnets and traps/pots, but also in some cases pelagic gear such as purse seines.

The deep-sea habitat poses particular challenges to marine life as it is relatively cold, dark and of low productivity. The main thermocline rarely extends below 1 200 m and, below this, the temperature falls to about 2 °C and even lower in certain areas. No light penetrates beyond 1 000 m, and even at depths of 150 m light intensity is reduced to 1 percent of that at the surface and is insufficient for photosynthesis (van Dover, 2000; Koslow, 2007). Deep-sea species have developed different strategies for biological and life history adaptations to cope with the conditions found in the deep sea. They are a therefore a diverse group of species with different life histories, productivity rates and distribution patterns.

Deep-sea fisheries have attracted increased attention worldwide in recent years, and the sustainability of these fisheries and their potential impacts on biodiversity have been the focus of discussions in many international fora. Many deep-sea fisheries take place in the high seas, thus posing additional governance challenges. Those that have given rise to most concerns are fisheries that affect the most vulnerable species (e.g. those with lower productivity) and that are undertaken with gear types that may have an impact on the bottom habitat.

Deep-sea fishes

Although there is no commonly agreed definition for deep-sea fishes as such, in general, from a fisheries perspective, these species can be defined as those inhabiting waters of the continental slopes and beyond and exploited by fisheries operating n these areas. The behavioural characteristics of many "deep-sea" species further complicate a search for an easy and useful definition. Some deep-sea species migrate towards the surface at night, returning to deeper waters during the day. They thereby form a trophic link between surface waters and the benthopelagic fishes when these latter prey upon fish returning from the surface. Other fishes make this diel migration themselves, feeding in the surface layers and then descending, presumably to avoid being eaten themselves. Some species only inhabit deep-sea depths as adults.

Deep-sea fish species also display a variety of reproductive strategies ranging from strongly K-selected species, which may be semelparous (e.g. abyssal grenadier - *Coryphaenoides armatus*, a widely occurring macrourid), through ovoviparous and oviparous species to those that are strongly r-selected. A number of tactics have been adopted to reduce dispersion of eggs. For example, the buoyant eggs of the widespread deep-sea macrourids bear sculptured patterns that slow their ascent. This is an adaptation not present in species of this family living in shallower waters. Eggs of orange roughy (*Hoplostethus atlanticus*) are initially buoyant but later sink and probably finish their development on the seafloor, in this way facilitating their retention in their adult habitat.

Growth rate, an important factor for determining stock productivity, is also affected by depth and temperature. Although some deep-sea species, such as the blue whiting (*Micromesistius poutassou*), are highly productive, many deep-sea species are slow-growing, with a relatively high age of first maturity (e.g., orange roughy and the roundnose grenadier - *Coryphaenoides rupestris*). They may not spawn every year and thus have intermittent recruitment. These characteristics make them highly vulnerable to exploitation pressure.

Some species form dense aggregations which are accessible to fisheries which have developed the capability to fish in deep water over the last few decades. Important deep-sea species that form aggregations include orange roughy, the oreos (*Allocyttus* spp., *Neocyttus* spp. and *Pseudocyttus* spp.), alfonsinos (*Beryx* spp.) in lower-latitude fisheries, Patagonian toothfish (*Dissostichus eleginoides*) in Southern Ocean fisheries, armourhead (*Pseudopentaceros* spp.) and others.

Away from seamounts, Gadiform fishes such as the *Macrouridae predominate*. These species also tend to be slow-growing but are not as "extreme" in their characteristics as species associated with seamount fisheries. Other species that may be included in this group are sablefish (*Anoplopoma fimbria*), Greenland halibut (*Reinhardtius hippoglossoides*), morids (Moridae), cusk-eels (Brotulidae), and hakes (Merlucciidae). Species such as the blue whiting may also be considered a deep-sea fish.

Another important feature of deep-sea fishes is that much remains unknown and new discoveries continue to be made. Indeed, deep-sea elasmobranchs are one of the groups of particular conservation concern even when not exploited as they are late-maturing and exhibit low fecundity and intermittent reproduction.

DEEP-SEA FISHERIES

Traditional deep-sea fisheries such as the Portuguese (Madeira) line fishery for black scabbardfish (*Aphanopus carbo*) is a rare example of a deep-sea fishery that, because it has traditionally used hook-and line-gear, has proved sustainable over a period of about 150 years (Martins and Fereira, 1995). Adults of this species are benthopelagic living in the depth range 400–1 600 m. It is a fast growing species with a life span of about 12–14 years (Morales-Nin *et al*., 2002; Figueiredo *et al*., 2003). Landings in Madeira reached a maximum value of around 4 400 tonnes in 1998 and since then has steadily decreased to just below 3 000 tonnes in 2007 (Bordalo-Machado *et al.*, 2009). The number of vessels active in this fishery has progressively decreased over time. However gear efficiency has increased mainly though an increase in the number of hooks per line set.

The most commercially important deep-sea fisheries are those that are harvested by trawling. Many of these occur in association with seamount and seafloor ridges. Trawl fisheries using factory freezer trawlers started in the mid-1950s, primarily based on exploratory fishing conducted by large fishing fleet of the then Soviet Union. However, it was only later on, starting in the mid-1970s and further developing into the 1990s, that widespread exploitation of deep-sea regions began. This development was triggered by several factors including, among others, the introduction of EEZs. The establishment of EEZs excluded fleets that in the past had fished these waters and led some of them to look for new fishing grounds. Technological advances made fishing in the deep sea possible and commercially viable. Changes in the consumer perception of seafood, including the more widespread marketing of frozen products, also contributed to improved prices for deep-sea fishes.

The *Worldwide Review of Bottom Fisheries in the High Seas* (Bensch *et al*., 2009) provided a regional overview of historical and current fisheries in the deep sea high seas. The review found that in 2006 about 285 vessels were involved in high seas demersal fisheries, with an estimated total catch of about 250 000 tonnes in 2006, based on a catch of about 60 species. The species targeted differs between regions. In the Northeast Atlantic, vessels typically target a range of species including blue ling (*Molva dyptergygia*), roundnose grenadier (*Coryphaenoides rupestris*), tusk (*brosme brosme*), black scabbardfish (*Aphanopus carbo*) and some species of sharks. In the Northwest Atlantic, important species include Greenland halibut (*Reinhardtius hippoglossoides*), northern shrimp (*Pandalus borealis*), Atlantic redfishes (*Sebast*es spp.) and skates. In other areas, more limited numbers of species are generally targeted. In the Southwest Atlantic, for example, Argentine hake is the main species (*Merluccius hubbsi*), and in the Southeast Atlantic the main species of commercial value are orange roughy, alfonsino (*Beryx* spp.), deep-sea red crab (*Chaecon* spp.) and Patagonian toothfish (*Dissostichus eleginoides*). In the North and South Pacific as well as the Indian Ocean, most of the deep-sea fishing occurs over seamounts and ridge areas. The targeted species in these fisheries include orange roughy, alfonsino, and slender armourhead (*Pseudopentaceros wheeleri*). In the North Pacific, there is a pot fishery for deep-sea crabs. In the Southern Ocean, fisheries target mainly toothfish with longlines (*D. eleginoides* and *D. mawsoni*).

The fishery for orange roughy is well known among recently developed deep-sea fisheries. In New Zealand and southeast Australia, commercial fisheries began in the 1970s and 1980s; however, orange roughy was first described from the Azores. Fisheries later developed in the North Atlantic, on the Walvis Ridge in the Southeast Atlantic (Namibia) in the mid-1990s, off Chile also in the 1990s and in the Southwest Indian Ocean in 1999. A small fishery also exists in the Bay of Biscay. Specialized aimed-trawling techniques have developed. At first, massive catches from spawning aggregations could be taken in minutes, resulting in split codends and lost catches. Maximum sustainable levels of exploitation of orange roughy may be as low as or lower than 5 percent of unfished biomass, i.e. $M \sim 0.04$. Accumulating evidence indicates that few of these fisheries have been exploited sustainably, and it remains uncertain what ongoing yields will be. Smaller stocks usually do not escape depletion once they become targeted. However, there is conflicting evidence as to whether other stocks have proved more resilient to overexploitation, possibly because fishing disperses the fish before the stock is depleted, and because of episodic spawning. In this case, where fishing depends on spawning aggregations, not all of the stock may be vulnerable to capture in any one year as not all spawn each year (Butterworth and Brandão, 2005).

The Macrouridae are another group whose members are widespread and abundant in particular locations. They are typical pelagic "cruisers" and inhabit the mid-to-upper continental slope. In the North Atlantic, fisheries that use bottom trawls exist for roughhead grenadier (*Macrourus berglax*) and roundnose grenadier. These fisheries initially fished in depths of 600–800 m, and more recently to 1 500 m. However, experience in these fisheries off Newfoundland shows the all-too-familiar pattern of TACs tracking declining trends in reported landings. The roundnose grenadier has a potential longevity of 70 years, although in the Northeast Atlantic, fish ages are usually of 20–30 years (Valerie and Pascal, 2000). Thus, as for other deep-sea species, Macrourids exhibit the characteristics of many deep-sea fisheries that render them particularly susceptible to overfishing.

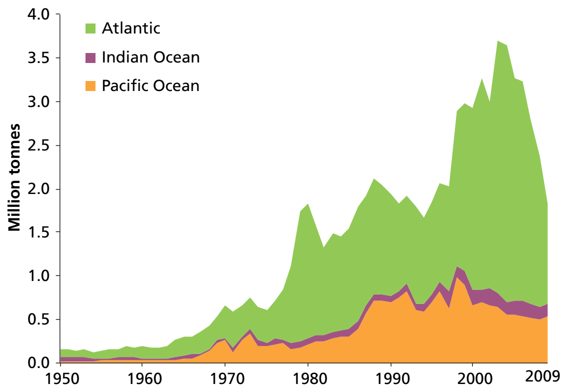
The Pleuronectidae are a highly evolved group that is not usually associated with deep-sea fisheries. However, they constitute important fisheries as members of this group occur in both the North Atlantic and North Pacific Oceans. In the Atlantic, the best known has been that for Greenland halibut on the continental slopes and high seas. This fish had an average size in commercial catches of about 1 kg up until the mid-1980s, but then declined to about 200 g in the early 1990s (Koslow *et al*., 2000).

The blue whiting (*Micromesistius poutassou*) is also often classified as a deep-sea species, although this species has generally higher growth rates and is highly productive and supports large fisheries. The blue whiting is a bathypelagic species found from 150–3 000 m depth, and is caught mainly by pelagic gear types. This species is caught by purse seiners in the Northeast Atlantic. The species can attain a length of 40 cm with an average length of about 31 cm (Campos, Fonseca and Henriques, 2003). Blue whiting is a straddling stock occupying the EEZs of Faeroe Islands, Norway, the countries of the EU, and Iceland as well as the high seas. Exploitation started in the 1970s, but has become increasingly important. However, since the record catch of this species of 2.4 million tonnes in 2004, the catches have decreased drastically and catches in 2009 were only about 640 000 tonnes. The decrease has been attributed to a fall in recruitment in 2006, declining spawning stock and reduction of quotas. For 2012, the ICES recommends an allowable catch of 391 000 tonnes. Recruitment remains low and is forecast to decline (ICES, 2011).

PROFILE OF CATCHES

As for most of the other sections in this volume the catch descriptions are based on FAO catch statistics – these are species reported to FAO by Member Countries. As mentioned above, there is no exact "definition" of what are regarded as "deep-sea fishes" and the type of fishes referred to may vary between different sources. Figure C4.1 shows the trend in catch of the deep-sea species listed in Table C4.1. Unlike in the previous edition of this report (FAO, 2005), reported catches of largehead hairtail (*Trichiurus lepturus*) and Bombay-duck (*Harpadon nehereus*) have not been included as these two species have a wide distribution range. Much of the catch is taken in relatively shallow waters (Sissenwine and Mace, 2007), and it is difficult to determine which portion comes from deep-sea fishing. Moreover, in the catch reports to FAO, there is often no indication of the proportion caught in the high seas.

FIGURE C4.1
Annual nominal catches of deep-sea species



The catches increased from the 1950s, and this occurred most rapidly between the mid-1970s and the end of the 1990s. This pattern was particularly obvious in the Pacific and Indian Oceans. However, no information is available to attribute the changes between

TABLE C4.1
Main groups of deep-sea species

Order	Family	Scientific name	Common name
Crustaceans	ARISTAEIDAE	*Plesiopenaeus edwardsianus*	Scarlet shrimp
	GERYONIDAE*	*Chaceon* spp.*	Chaceon geryons NEI
		*Chaceon affinis**	Deep-sea red crab
		*Geryon longipes**	Mediterranean geryon
		*Chaceon quinquedens**	Red crab
		*Chaceon notialis**	Southwest Atlantic red crab
		*Chaceon maritae**	West African geryon
	LITHODIDAE	*Paralomis spinosissima*	Antarctic stone crab
		Lithodes aequispina	Golden king crab
	PANDALIDAE	*Pandalus* spp.	Pandalus shrimps NEI
	SOLENOCERIDAE	*Pleoticus robustus*	Royal red shrimp
Chondricthyans	CALLORHINCHIDAE	*Callorhinchus capensis*	Cape elephantfish
		Callorhinchidae	Elephantfishes, etc. NEI
		Callorhinchus milii	Ghost shark
	Chimaeras, etc. NEI	*Chimaeriformes*	Chimaeras, etc. NEI
	HEXANCHIDAE	*Hexanchus griseus*	Bluntnose sixgill shark
	RAJIDAE	*Bathyraja* spp.	Bathyraja rays NEI
		Bathyraja meridionalis	Dark-belly skate
	SQUALIDAE	*Somniosus microcephalus*	Greenland shark
		Centroscymnus crepidater	Longnose velvet dogfish
		Somniosus pacificus	Pacific sleeper shark
		Centroscymnus coelolepis	Portuguese dogfish
Teleosteans	ANOPLOMATIDAE	*Anoplopoma fimbria*	Sablefish
	ARGENTINIDAE	*Glossanodon semifasciatus*	Deep-sea smelt
	BERYCIDAE	*Beryx decadactylus*	Alfonsino
		Beryx spp.	Alfonsinos NEI
		Centroberyx affinis	Redfish
		Beryx splendens	Splendid alfonsino
	BRANCHIOSTEGIDAE	*Branchiostegidae*	Tilefishes NEI
	CAPROIDAE	*Capros aper*	Boarfish
		Caproidae	Boarfishes NEI
	CENTROLOPHIDAE	*Hyperoglyphe antarctica*	Bluenose warehou
		Seriolella caerulea	White warehou
	CHIMAERIDAE	*Hydrolagus novaezealandiae*	Dark ghost shark
		Chimaera monstrosa	Rabbit fish
		*Hydrolagus*spp.	Ratfishes NEI
	CHLOROPHTHALMIDAE	*Chlorophthalmidae*	Greeneyes
	EMMELICHTHYIDAE	*Emmelichthyidae*	Bonnetmouths, rubyfishes NEI
		Emmelichthys nitidus	Cape bonnetmouth
	EPIGONIDAE	*Epigonus* spp.	Cardinal fishes NEI
	GADIDAE	*Molva dypterygia*	Blue ling
		Micromesistius poutassou	Blue whiting (= poutassou)
		Molva molva	Ling
		Micromesistius australis	Southern blue whiting
		Brosme brosme	Tusk (= cusk)
	GEMPYLIDAE	*Lepidocybium flavobrunneum*	Escolar
		Ruvettus pretiosus	Oilfish
		Rexea solandri	Silver gemfish
		Thyrsitops lepidopoides	White snake mackerel
	MACRORAMPHOSIDAE	*Macroramphosus scolopax*	Longspine snipefish
	MACROURIDAE*	*Macrourus holotrachys**	Bigeye grenadier
		*Caelorinchus chilensis**	Chilean grenadier
		*Nezumia aequalis**	Common Atlantic grenadier
		*Cynomacrurus piriei**	Dogtooth grenadier
		Macrourus spp.	Grenadiers NEI
		Macrouridae	Grenadiers, rattails NEI
		Coryphaenoides spp.	Grenadiers, whiptails NEI
		*Macrourus carinatus**	Ridge scaled rattail
		Macrourus berglax	Roughhead grenadier
		*Trachyrincus scabrous**	Roughsnout grenadier
		Coryphaenoides rupestris	Roundnose grenadier
		Lepidorhynchus denticulatus	Thorntooth grenadier
		*Macrourus whitsoni**	Whitson's grenadier
	MERLUCCIIDAE	*Macruronus novaezelandiae*	Blue grenadier
		Macruronus magellanicus	Patagonian grenadier
	MORIDAE	*Antimora rostrata*	Blue antimora
		Mora moro	Common mora
	MYCTOPHIDAE	*Lampanyctodes hectoris*	Hector's lanternfish
		Myctophidae	Lanternfishes NEI
	NOTOTHENIIDAE	*Dissostichus mawsoni*	Antarctic toothfish
		Dissostichus eleginoides	Patagonian toothfish

TABLE C4.1 (CONTINUED)

Order	Family	Scientific name	Common name
	OPHIDIIDAE	*Genypterus maculatus*	Black cusk-eel
		Genypterus spp.	Cusk-eels NEI
		Ophidiidae	Cusk-eels, brotulas NEI
		Genypterus capensis	Kingklip
		Genypterus blacodes	Pink cusk-eel
		Genypterus chilensis	Red cusk-eel
	OREOSOMATIDAE*	*Allocyttus niger**	Black oreo
		Oreosomatidae	Oreo dories NEI
		*Pseudocyttus maculates**	Smooth oreo dory
		*Neocyttus rhomboidalis**	Spiky oreo
	PENTACEROTIDAE	*Pseudopentaceros richardsoni*	Pelagic armourhead
		Pseudopentaceros spp.	Pelagic armourheads NEI
	PLEURONECTIDAE	*Reinhardtius hippoglossoides*	Greenland halibut
	POLYPRIONIDAE	*Polyprion oxygeneios*	Hapuku wreckfish
		Polyprion americanus	Wreckfish
	SCORPAENIDAE	*Scorpaena scrofa*	Red scorpionfish
	STERNOPTYCHIDAE	*Maurolicus muelleri*	Silvery lightfish
	TRACHICHTHYIDAE	*Hoplostethus atlanticus*	Orange roughy
		Trachichthyidae	Slimeheads NEI
	TRICHIURIDAE	*Aphanopus carbo*	Black scabbardfish
		Trichiuridae	Hairtails, scabbardfishes NEI
		Lepidopus caudatus	Silver scabbardfish
	TRIGLIDAE	*Pterygotrigla picta*	Spotted gurnard

Notes: The table has been updated since the last Review of the state of the world marine fishery resources (FAO, 2005) to address changes in reporting due to taxonomic developments (e.g. for the family Geyonidae) or groups now reported at a lower taxonomic level (e.g., species). Species groups for which changes have been made/added species are marked with a star. Two species, Bombay duck (*Harpadon nehereus*) and largehead hairtail (*Trichiurus lepturus*), have been excluded from the list.

1979 and 1998 to an increase in actual catches or better reporting. Peak catches were observed in 2003 and 2004, when catches of about 3.7 million tonnes were reported. Since then, reported catches have declined, and in 2009 total catches were about 1.8 million tonnes. This decreasing trend can in large part be attributed to the decrease in reported catches of blue whiting in the Atlantic Ocean that decreased from 2.4 million tonnes in 2004 to about 640 000 tonnes in 2009. Other species in the Atlantic Ocean with high average catch in the last five years (2005–09) include Patagonian grenadier (*Macruronus magellanicus*), Greenland halibut, southern blue whiting (*Micromesistius australis*) and ling (*Molva molva*). In the Indian Ocean, reported catches have generally been higher since 1997 compared with earlier years. They have been fluctuating between 125 000 and 195 000 tonnes, with the highest catch being observed in 1997. The hairtails and scabbardfishes (not identified) are the species group with the highest average reported catches in the Indian Ocean in the last five years. Other important species include Patagonian toothfish (*Dissostichus eleginoides*), blue grenadier (*Macruronus novaezelandiae*) and orange roughy (*Hoplostethus atlanticus).* With the exception of the Patagonian toothfish, reported catches have decreased for these species in recent years in this region. In the Pacific Ocean, catches increased until 1992, after which they began to fluctuate until 1998–99 (peak just below 1 million tonnes in 1998). Since then, catches in the Pacific have begun to decrease. Since 2004, reported catches in the Pacific have been in the range between 500 000 tonnes and 550 000 tonnes. Species with the highest average catches in this ocean in the last five years include the grenadiers (blue grenadier, Patagonian grenadier and grenadiers and rattails [not identified]), southern blue whiting and the groups tilefishes (Branchiostegidae) and hairtails and scabbardfishes.

Catch trends and biological characteristics of selected deep-sea species

Orange roughy

The orange roughy (*Hoplostethus atlanticus*) of the family Trachichthyidae is a species with a wide distribution range that is found in the North and South Atlantic, the

Southern Indian Ocean, the Tasman Sea, and the South Pacific. It inhabits continental slopes, seamounts and other bottom features and is commonly found at depths of 500–1 500 m. It is a slow-growing species, with a high age of first maturity and relatively low fecundity (Bell *et al.*, 1992). This species exists as national, transboundary, straddling and high seas stocks. It is caught at depths over 800 m by fisheries that often target spawning aggregations associated with seamounts.

FIGURE C4.2
Annual nominal catches of orange roughy

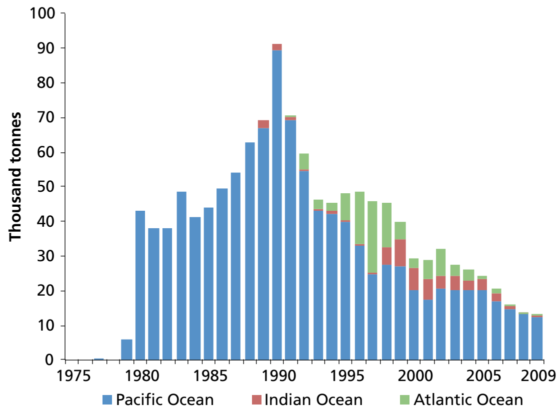


Figure C4.2 shows the catches of orange roughy reported to the FAO. Catches from the Pacific Ocean dominate, with only limited catches from the Atlantic and Indian Oceans in recent years. Catches for this species are decreasing, and catches in 2009 were about 13 000 tonnes compared with more than 91 000 tonnes in 1990.

The biological characteristics of this species (slow growth and exceptional longevity) and its aggregating behaviour make it vulnerable to overfishing. As such, many smaller fisheries for this species have been closed down as the stocks have been overexploited and the fishery has become commercially unviable. Stock assessments for this species are often uncertain, and lack of knowledge of recruitment is a main issue of concern for the management of this fishery (Dunn, 2007).

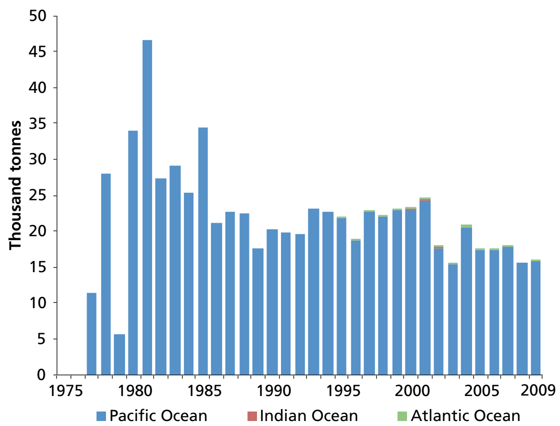
Oreo dories

The oreo dories (*Allocystus* spp., *Neocystus* spp. and *Pseudocustus* spp.) (Figure C4.3) are Oreostomadids that aggregate close to the sea bed in the deep-sea and form large shoals over seamounts and canyons. Similar to orange roughy, these species are also long-lived and slow-growing. The juveniles are pelagic and inhabit oceanic waters. They tend to be dispersed over smooth grounds. Their eggs float near the sea surface, and the larvae also inhabit surface waters. The species are caught both within national jurisdictions and on the high seas.

In Australian waters, spiky oreo (*Neocyttus rhomboidalis*) are more abundant at intermediate depths (600–800 m) and warty oreo (*Alocyttes verrucosus*) in deeper waters (900–1 200 m). Both species are benthopelagic feeders feeding on salps, crustaceans, fish and squid.

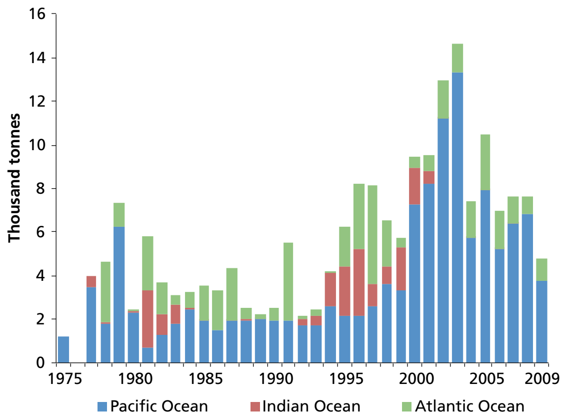
Figure C4.3 shows the reported catches of oreo dories NEI (not identified to species level), the black oreo (*Alocyttes niger*), smooth oreo dory (*Pseudocyttus maculates*) and spiky oreo indicating catches between 15 000 and 20 000 tonnes in the Pacific in the last five years. Up to 2001, species were recorded at an aggregated level, and since then catches have been reported for the species listed above.

FIGURE C4.3
Annual nominal catches of Oreo dories



As for many other species, management of these fisheries on the high seas is challenging because of a lack of data. Ageing data from Australia and New Zealand indicate that the maximum age for smooth is around 86 years, and 153 years for black oreo (Stewart *et al.*, 1995; McMillan, 2008). Natural mortality for smooth

FIGURE C4.4
Annual nominal catches of alfonsino



oreo has been estimated at 0.063 per year, and 0.044 per year for black oreo. Estimates from New Zealand indicates the MSY to be of the order of 1.6 percent of B_0 if the population is not to be reduced to a biomass of less than 0.2 B_0 (probability < 0.2) (Doonan and McMillan, 2006). For operational reasons, where they are managed at all, smooth, black and spiky oreos have been managed as a single stock with the associate dangers this implies (Annala, Sullivan and O'Brien, 1999).

Alfonsinos

The alfonsinos (*Beryx* sp., Bericidae) have a circumglobal distribution although they are generally not present in the northeast Pacific. They inhabit the outer shelf (180 m) and slope to at least 1 300 m depth, probably rising from the bottom at night. Reported catches of this genus are mainly *B. splendens and B. decadactylus*. *Beryx splendens* are caught in midwater trawls over shallower seamounts, underwater ridges and on the slope edge between 300 and 500 m. The juveniles are pelagic. There is no common agreement on the stock structure for alfonsino and contradictory information is available supporting different hypothesis (ICES WGDEEP, 2010). Alfonsino are caught both within national jurisdictions and on the high-seas.

Figure C4.4 shows that catches of alfonsinos have fluctuated widely, with high catches at the end of the 1990s and the first decade of 2000. The highest catch was in 2003 (just over 14 000 tonnes). Since then, catches have generally decreased and, in 2009, catches of about 5 000 tonnes were reported. Highest catches are reported from the Pacific, where this species constitutes one of the main target species in the trawl and gillnet fisheries in the high seas areas of the Northwest Pacific (Bensch et al., 2009). Catches are also reported from the Atlantic and Indian Oceans, although almost no catches have been reported from the Indian Ocean in recent years. This low level of catch may also be linked to national reporting restrictions which apply to fisheries operating with a limited number of vessels.

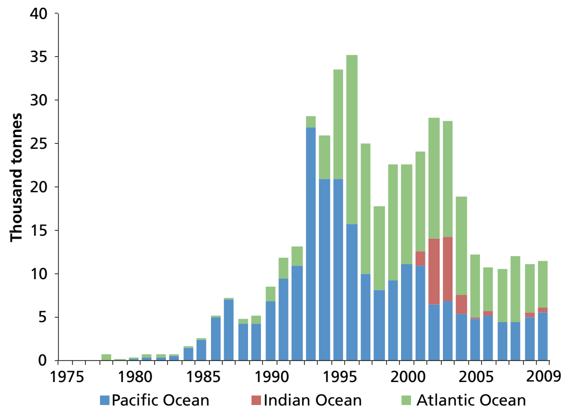
The maximum recorded age for this species range from 9 years (Krug *et al.*, 2011) to 23 years (Adachi *et al.*, 2000; Froese and Pauly, 2011) and become sexually mature at about 4 years of age. Natural mortality is estimated to be about 0.23. Thus, they offer a greater prospect of sustaining the deep-sea fisheries that target them. Little is known about the local area stock structure of these species, and it is for example believed that the New Zealand fishery may be exploiting a wider South Pacific stock (Annala, Sullivan and O'Brien, 1999).

Toothfish

Toothfish (*Dissostichus* spp.) of the family Notothenidae, have a circumpolar distribution within Southern Ocean waters. Patagonian toothfish (*D. eleginoides*) are found around southern South America, and Antarctic toothfish (*D. mawsoni*) occur in high latitudes south of the Pacific region. The two species overlap between 60°S and 65°S, and both occur to depths of 3 000 m. The northern limit for most populations of Patagonian toothfish is 45°S, except along the coasts of Chile and Argentina where they may extend north in deeper colder water. Significant populations of Patagonian toothfish exist in the waters of, and adjacent to, the various sub-Antarctic islands and in the waters of Chile, Argentina, Uruguay and Peru. Figure C4.5 indicates that most catches of toothfish have been reported in the Atlantic and Pacific Oceans in recent years, with total reported catches of about 10 000–12 000 tonnes since 2004.

The problem of IUU has been considerably reduced in recent years. However, it still remains a major concern in many regions. Toothfish mainly fall under the management responsibility of the CCAMLR (see Chapter B16 for further information on toothfish).

FIGURE C4.5
Annual nominal catches of toothfish

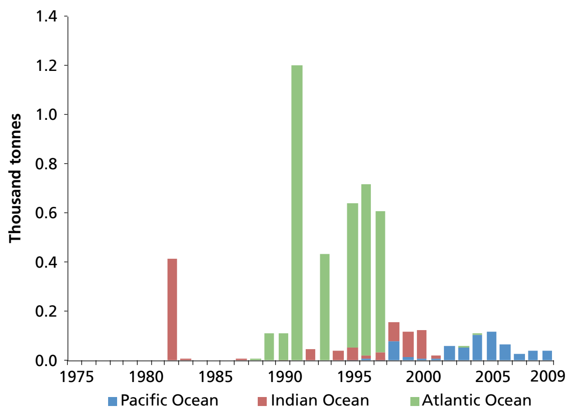


Pelagic armourhead

The armourheads belong to the family Pentacerotidae and inhabit seamounts, especially in the North Pacific but also in other oceans. There are three species of armourhead, the pelagic armourhead (*Pseudopentaceros richardsoni*), the slender armourhead (*P. wheeleri*) and longfin (*P. pectoralis*), but only the pelagic armourhead is currently reported in FAO catch data.

Figure C4.6 shows that reported catches of pelagic armourhead have stayed quite low, with a peak of reported catches in the Atlantic in 1991 of about 1 200 tonnes. However, historically, substantial catches of pelagic armourheads NEI (*Pseudopentaceros* spp.) were reported in the late 1960s and early 1970s, reaching almost 1.8 million tonnes in 1973. The slender armourhead – often also referred to as pelagic armourhead was the target of a large fishery in the high seas of the North Pacific starting in the late 1960s. At this time, vessels from Japan and the then Soviet Union began trawling on the Emperor Seamount chain and the Northern Hawaiian Ridge. The total catch for the Soviet vessels was unknown but was estimated to be more than 133 400 tonnes in the period 1967–1977. Between 1969 and 1977, the Japanese sent from two to five trawlers a year to this area and catches ranged from 22 800 to 35 100 tonnes a year. Ninety percent of the catch was of pelagic armourhead. Catches then fell to 5 800–9 900 tonnes between 1977 and 1982.

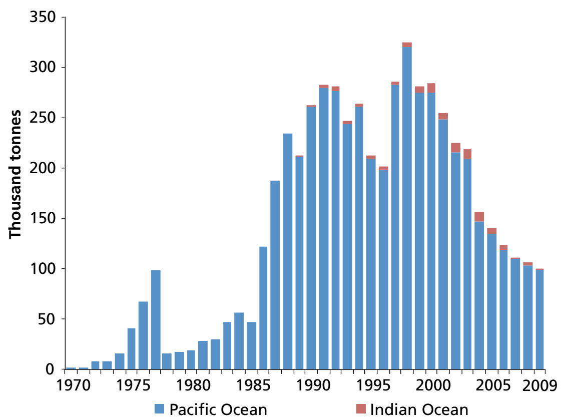
FIGURE C4.6
Annual nominal catches of pelagic armourhead



Blue grenadier (hoki)

Blue grenadier or hoki (*Macruronus novaezelandiae*) is a benthopelagic macruronid that usually lives near the bottom but forms midwater aggregations for spawning. Large adult fish generally occur deeper than 400 m, while juveniles may be found in shallower water. Midwater trawl fisheries target aggregations near canyons that are often close to coasts in areas of narrow continental shelves. Figure C4.7 shows the reported catches of these species, which are mainly caught in the Pacific. Reported catches decreased from more than 300 000 tonnes in 1998 to about 100 000 tonnes in 2009.

FIGURE C4.7
Annual nominal catches of blue grenadier



Knowledge of the stock structure for this species is often uncertain. Management experience in at least some jurisdictions indicates that this resource can be sustainably managed. In the major global fishery for this species, in New Zealand, the TAC has changed from time to time as the size of the hoki stocks varied. The TAC in New Zealand has fluctuated between 200 000 and 250 000 tonnes in earlier years, being reduced gradually from the year 2000, down to 90 000 tonnes in 2007 and 2008 as the spawning stock declined. This decline is also believed to have been influenced by ENSO-related oceanographic events. Subsequent to this, the TAC has again increased to 130 000 tonnes for the coming season as a result of the rebuilding of stocks in recent times.

RESOURCE MANAGEMENT ISSUES

Deep-sea fisheries face many of the same management issues as coastal fisheries. However, the great depths and distances from the coast at which marine living resources are caught by these fisheries pose some additional scientific, technical and governance-related difficulties in their management. Some deep-sea species are widespread and can be found in all major oceans. In other cases, the species may be specific to a region. In both situations, management methods must address the vulnerability of the stocks to depletion.

In some fisheries that targeted deep-sea species, initial high catch rates decreased rapidly as the low productivity of the species did not allow for sustainable harvest at the initial levels of fishing effort, leading to closure of these fisheries (Clarke, 2001). Similar to many shelf fisheries, deep-sea fisheries (depending on species targeted and gear used) can catch considerable amounts of bycatch, including sharks. Little information is currently available on bycatch from deep-sea fisheries because of the lack of tools and procedures to obtain information in a consistent way. The potential effects of deep-sea fishing operations on deep-sea communities have also raised great concern and debate globally. Some of these communities, such as coldwater corals and hydroids, some sponge-dominated communities and seep or vent communities are comprised of unique invertebrate or microbial species. Concern has also been raised for species and ecosystems associated with the target species. The potential recovery time of affected ecosystems can be great, although the consequences of impacts differ depending on the fishing gear used, and these impacts can be reduced by use of appropriate fishing practices.

Deep-sea fisheries, particularly those taking place in the high seas, and the potential impact on fish stocks, biodiversity and critical habitats have recently been the focus of much international debate. Although deep-sea fisheries in the high seas affect species with diverse life histories and productivity rates, those that have raised the most concern are fisheries that affect target or bycatch species with long lives and low productivity and/or damage fragile habitats.

These issues have been discussed in various international forums, including COFI and the United Nations General Assembly (UNGA) meetings in recent years. In 2006, a UNGA Resolution (61/105) called on "States to take action immediately, individually and through regional fisheries management organizations and arrangements (RFMO/As), and consistent with the precautionary approach and ecosystem approaches, to sustainably manage fish stocks and protect vulnerable marine ecosystem". In 2009, the UNGA reaffirmed the commitment to sustainable deep-sea bottom fishing practices through the passage of Resolution 64/72.

Acting on the requests of UNGA Resolution 61/105, the Twenty-seventh Session of COFI agreed in March 2007 that FAO should develop technical guidelines, including standards for the management of deep-sea fisheries in the high seas, and these were finalized in 2008 (FAO, 2009).

The FAO International Guidelines for the management of deep–sea fisheries in the high seas are a voluntary international instrument. They provide management guidance to facilitate and encourage the efforts of States and RFMO/As towards sustainable use of marine living resources exploited by deep-sea fisheries as well as advice on the prevention of significant adverse impacts on deep-sea vulnerable marine ecosystems (VMEs) and the protection of marine biodiversity that these ecosystems contain. The FAO International Guidelines also establish a set of criteria to be used to determine if an area is a VME and suggest management approaches for reducing adverse impacts. This high level guidance have been taken up by RFMOs and States that are analysing the guidance with the aim to make then operational in the context of deep-sea fisheries in different regions.

As of January 2010, five RFMO/As and multilateral organizations had the legal competence to manage discrete demersal fisheries in the high seas. These include the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), General Fisheries Commission for the Mediterranean (GFCM), Northwest Atlantic Fisheries Organization (NAFO), North East Atlantic Fisheries Commission (NEAFC) and Southeast Atlantic Fisheries Organization (SEAFO). Other RFMO/As are being developed and await ratification (Southern Indian Ocean Fisheries Agreement [SIOFA]) or are being negotiated, such as the South Pacific Regional Fisheries Management Organisation (SPRFMO) and the North Pacific Regional Fisheries Management Organization (NPRFMO).

In areas where RFMO/As do not yet exist, some measures have been put in place by flag States, the EU or the fishing industry (e.g. the Southern Indian Ocean Deepwater Fishers Association). These measures cover their vessels or member States operating in areas beyond national jurisdictions to address management and conservation on an interim basis.

Despite the progress on improved management of these fisheries, there are many aspects that are yet to be addressed before full implementation of the FAO International Guidelines or the relevant UNGA resolutions can be achieved. An FAO workshop in 2010 (FAO, 2011) identified different impediments to implementation of the guidelines. These barriers include: (i) support for the signature and ratification of RFMO/As where they are in progress; (ii) specific assistance for developing countries in the implementation of the FAO deep-sea guidelines; (iii) compilation of best practices and development of relevant guidance on impacts and risk assessment, encounter protocols and related mitigation measures; (iv) facilitation of opportunities for discussions among fishing nations operating in the same area (particularly where no RFMO/A is in place); (v) development of guidance on the use of the VME criteria; and (vi) facilitation of work on deep-sea high seas stock assessments to ensure sustainable fisheries.

ACKNOWLEDGEMENTS

David Milton, Mario Rui R. Pinho and Yimin Ye are gratefully acknowledged for their contributions and review of the earlier version of the chapter.

REFERENCES

Adachi, K., Tagaki, K., Tanaka, E., Yamada, S. & Kitakad, T. 2000. Age and growth of alfonsino *Beryx splendens* in the waters around the Izu islands. *Fisheries Science.* 66: 232-240.

Annala, J.H., Sullivan, K.J. & O'Brien, C.J. 1999. *Report from the Fishery Assessment Plenary, April 1000: stock assessments and yield estimates*. Ministry of Fisheries. 430 pp.

Bell, J.D., Lyle, J.M., Bulman, C.M., Graham, K.J., Newton, G.M. & Smith, D.C. 1992. Spatial variation in reproduction, and occurrence of non-reproductive adults, in orange roughy, *Hoplostethus atlanticus* Collett (Trachichthyidae), from south-eastern Australia. *Journal of Fish Biology*, 40: 107–122.

Bensch, A, Gianni, M., Gréboval, D., Sanders, J.S. & Hjort, A. 2009. *Worldwide review of bottom fisheries in the high seas*. FAO Fisheries and Aquaculture Technical Paper No. 522, Rev. 1. Rome, FAO. 145 pp.

Bordalo-Machado, P., Fernades, A.C., Figueiredo, I., Moura, O., Reis, S., Pestana, G. & Searano Gordo, L. 2009. The black scabbardfish (*Aphanopus carbo*, Lowe, 1939) fisheries from the Portuguese mainland and Madeira island. *Scientia Marina*, 73S2: 63-76.

Butterworth, D.S. & Brandão, A. 2005. Experiences in Southern Africa in the Management of Deep-sea Fisheries. *In* R. Shotton, ed. *Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries. Part 1: Conference reports. Queenstown, New Zealand, 1–5 December 2003*. FAO Fisheries Proceedings No. 3/1. Rome, FAO. 718 pp.

Campos, A., Fonseca, P. & Henriques, V. 2003. Size selectivity for four fish species of the deep groundfish assemblage off the Portuguese southwest coast: evidence of mesh size, mesh configuration and cod end catch effects. *Fisheries Research*, 63: 313–333.

Clarke, M. 2001. Are deepwater fisheries sustainable? — the example of orange roughy (*Hoplostethus atlanticus*) in New Zealand. *Fisheries Research*, 51: 123–135.

Doonan, I.J. & McMillan, P.J. 2006. *Smooth oreo OEO 3A abundance estimates from standardised catch per unit of effort data, 1979–80 to 2002–03*. New Zealand Fisheries Assessment Report. Wellington, NIWA.

Dunn, M. 2007. Orange roughy. What might the future hold? *New Zealand Science Review*, 63: 70–75.

FAO. 2005. *Review of the state of world marine fishery resources*. FAO Fisheries Technical Paper No. 457. Rome, FAO. 235 pp.

FAO. 2009. *International guidelines for the management of deep-sea fisheries in the high-seas. Directives internationales sur la gestion de la pêche profonde en haute mer. Directrices Internacionales para la Ordénacíon de las Pesquerías de Aguas Profundas en Alta Mar*. Rome, FAO. 73 pp.

FAO. 2011. *Report of the FAO Workshop on the Implementation of the International Guidelines for the management of Deep-sea Fisheries in the High Seas – Challenges and Ways Forward. Busan, Republic of Korea, 10–12 May 2010*. FAO Fisheries and Aquaculture Report No. 948. Rome, FAO. 74 pp.

Figueiredo, I, Bordalo-Machado, P., Reis, S., Sena-Carvalho, D, Blasdale, T., Newton, A. & Gordo, L.S. 2003. Observations on the reproductive cycle of the black scabbardfish (*Arphanopus carbo* Lowe, 1839) in the Northeast Atlantic. *ICES Journal of Marine Science*, 60: 774–779.

Froese, R. & D. Pauly (eds). 2011. FishBase.World Wide Web electronic publication. www.fishbase.org, version (12/2011).

International Council for the Exploration of the Sea (ICES). 2011. *Advice September 2010. Blue whiting in subareas 1-IX, XII and XIV (combined stock)*.

Koslow, A.J. 2007. *The silent deep: the discovery, ecology and conservation of the deep sea*. Chicago, USA, University of Chicago Press. 270 pp.

Koslow, A.J., Boehlert, G.W., Gordon, J.D.M., Haedrich, R.L., Lorance, P. & Parin, N. 2000. Continental slope and deep-sea fisheries: implications for a fragile ecosystem. *ICES Journal of Marine Science*, 57: 548–557.

Krug, H., Carvalho, D., & González, J.A. 2011. Age and growth of the alfonsino *Beryx decadactylus* (Cuvier, 1829) from the Azores, Madeira and Canary Islands, based on historical data. *Arquipelago. Life and Marine Sciences,* 28: 25-31.

Lehodey, P., Grandperrin, R. & Marchal, P. 1997. Reproductive biology and ecology of a deep-demersal fish, alfonsino *Beryx splendens*, over the seamounts off New Caledonia. *Marine Biology*, 128:17–27.

Lehodey, P., Grandperrin, R. & Marchal, P. 1997. Reproductive biology and ecology of a deep-demersal fish, alfonsino *Beryx splendens*, over the seamounts off New Caledonia. *Marine Biology*, 128:17–27.

McMillan, P.J. 2008. *Ageing of smooth oreo otoliths for stock assessment*. New Zealand Fisheries Assessment Report. Wellington, NIWA.

Martins, R. & Fereira, C. 1995. Line fishing for black scabbardfish (*Alpanopus carbo* Lowe, 1839) and other deep water species in the eastern mid-Atlantic to the north of Madeira. *In* A.G. Hooper, ed. *Deep-water fisheries of the north Atlantic oceanic slope*, pp. 323–335. Dordrecht, Netherlands, Kluwer Academic Publishers.

Morales-Nin, B., Canha, A., Casas, M., Figuereido, I. & Gordo, L.S. 2002. Intercalibration of age readings of deepwater black scabbardgish, *Aphanpous carbo* (Lowe, 1839). *ICES Journal of Marine Science*, 59: 352–364.

Sissenwine, M.P. & Mace, P.M. 2007. Can deep-water fisheries be managed sustainably? *In* FAO. *Report and Documentation of the Expert Consultation on Deep-sea Fisheries in the High Seas. Bangkok, Thailand, 21–23 November 2006*, pp. 61–111. FAO Fisheries Report No. 838. Rome, FAO. 201 pp.

Smith, P.J. 2000. *Managing biodiversity: Invertebrate by-catch in seamount fisheries in the New Zealand Exclusive Economic Zone*. Wellington, NIWA. 30 pp.

Stewart, B.D., Fenton, G.E., Smith, D.C. & Short, S.A. 1995. Validation of otolith-increment age estimates for a deepwater fish species, the warty oreo *Allocyttus verrucosus*, by radiometric analysis. *Marine Biology*, 123: 29–38.

Valerie, A. & Pascal, L. 2000. Age estimation and growth of some deep-sea fish from the northeast Atlantic ocean. *Cybium*, 24: 7–16.

Van Dover, C.L. 2000. *The ecology of deep-sea thermal vents*. New York, USA, Princeton University Press. 424 pp.

C5. Climate change impacts on the world fisheries resources

Tarûb Bahri
Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: tarub.bahri@fao.org

Kevern Cochrane
Director
Fisheries and Aquaculture Resources Use and Conservation Division
FAO Fisheries and Aquaculture Department
E-mail: kevern.cochrane@fao.org

INTRODUCTION

Many of the world fisheries resources are in serious trouble from over-fishing and poor management. As widely described in the literature, stock levels are known to be influenced by exploitation patterns and environmental factors, including climate variability, with consequences on spatial distribution, growth, reproduction recruitment and mortality. The changes in climate (Box C5.1), that are being observed around the world are having and will continue to have impacts on fisheries, and they are likely to increase with the extent and level of climate change. Impacts occur as a result of both gradual warming and associated physical changes as well as increase in frequency and intensity, as well as change in location of extreme events, and take place in the context of other global socio-economic pressures on natural resources. It is essential to gain knowledge on type, magnitude and potential consequences of these impacts, as fish (including shellfish) provides essential nutrition for almost 3 billion people and at least 50 per cent of animal protein and minerals to 500 million people in the poorest countries. (FAO, 2011). With global populations set to rise to 9-10 billion by 2050, the demand for food and the importance of fisheries resources will become even greater.

BOX C5.1
Definitions of climate change

Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes (IPCC, 2007).

Source: IPCC, 2007.

The effects of climate change cannot be easily distinguished from direct anthropogenic effects already impacting the fisheries resources, such as overexploitation, but there is compelling evidence that global warming is modifying the distribution of marine species, with warm-water species being displaced towards the poles and experiencing changes in the size and productivity of their habitats (Barange and Perry, 2009). With global warming, ecosystem productivity is likely to be reduced in most tropical and subtropical oceans, seas and lakes, and to be increased in high latitudes. Fish physiological and behavioral processes will also be affected, resulting in both positive and negative effects on fisheries resources depending on the region and latitude.

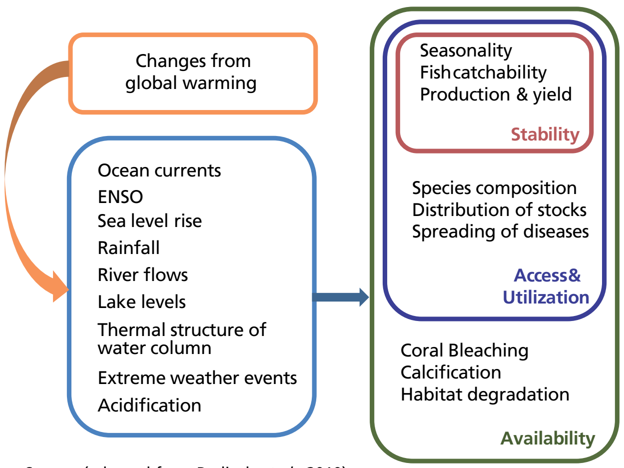
GENERIC INTERACTIONS

Results of a modeling exercise on the latitudinal shift in catch under different greenhouse gas concentrations scenarios indicate that there could be drastic changes, with tropical countries suffering up to a 40 percent drop in catch potential and high-latitude regions enjoying as much as a 30 to 70 percent increase in catch potential (Cheung *et al*., 2009). Climate change is already affecting the seasonality of particular biological processes, altering marine food webs, with unpredictable consequences for fish production. Increased risks of species invasions and spreading of vector-borne diseases provide additional concerns (Harvell *et al*., 2002; Bruno *et al*., 2007). In addition, differential warming between land and oceans and between polar and tropical regions will affect the intensity, frequency and seasonality of climate patterns (e.g. El Niño) and extreme weather events (e.g. floods, droughts and storms), impacting the stability of marine resources adapted to or affected by these.

In addition to the above, sea level rise, glacier melting, ocean acidification and changes in precipitation, groundwater and river flows will affect key habitats for fisheries resources, requiring adaptive measures to exploit opportunities while minimising impacts, as these will have implications on all four dimensions of food security. Thus, availability of aquatic foods will vary through changes in habitats, stocks and species distribution; stability of supply will be impacted by changes in seasonality, increased variance in ecosystem productivity and increased supply variability and risks; access to aquatic foods will be affected by changes in livelihoods and changes in fishing operations; and utilization of aquatic foods will also be impacted (FAO, 2008) (Figure C5.1; Table C5.1).

FIGURE C5.1

Examples of consequences of global warming on the four components of food security: stability, access, utilization and availability of aquatic foods



Source: (adapted from Badjeck *et al*., 2010).

For example, the influence of extreme weather events will have an impact on fisheries resources availability, as described in the Caribbean where different impacts of storms and hurricanes were identified (Mahon, 2002). Lobster availability tends to increase after a hurricane, resulting in higher catches and therefore higher risk of stock depletion, whereas conchs are not easily found after a hurricane, as they bury themselves in the sand to protect themselves from rough sea conditions. Moreover, fishing operations and the resulting fishing effort are also impacted by such events; the destruction of fishing gears is likely to alleviate short-term fishing effort on the resources, but with negative effects on fishers and their dependants. In some situations, the dislocation of workers from other sectors

TABLE C5.1
Examples of impact of climate change on marine fisheries resources

Drivers	Biophysical effects	Implications for fisheries
Higher sea surface temperature	Less dissolved oxygen	Impacts on physiological performance of organisms and consequences on altered distributions or extinction of fish
	Increased incidence of disease and parasites	Changing susceptibility of some stocks to disease
	Altered local ecosystems with changes in competitors, predators and invasive species and changes in plankton composition and/or distribution	Impacts on the abundance and species composition of capture fisheries stocks Food webs impacted
	Change in the location and area of suitable range for particular species	Increase in productivity of some fisheries/species: longer growing seasons and lower natural mortality in winter; enhanced metabolic and growth rates Potential species loss & altered species composition
	Enhanced primary productivity	Potential benefits for fisheries but perhaps offset by changed species composition ; increased risk of harmful algal blooms
	Changes in timing and success of migrations, spawning and peak abundance, as well as in sex ratios	Potential loss of species or shift in composition and seasonal patterns in capture fisheries
	Damage to coral reefs that serve as breeding habitats and may help protect the shore from wave action	Reduced recruitment and availability of fishery species
Rising sea level	Changes to estuary systems	Physical loss/displacement of spawning/nursery grounds for coastal fisheries
	Changing coastal ecosystems, mudflats and mangrove forests. In some areas mangroves/wetlands may increase through flooding of inland areas	Reduced recruitment and stocks for capture fisheries Worsened exposure of fishing households and infrastructure to waves and storm surges
Ocean acidification	Reduced capacity of the ocean to buffer climate change and other processes	Potential changes in species growth, reproduction and behaviour Potential negative effects on formation and dissolution of calcium carbonate shells and skeletons Potential impacts on marine ecosystems and the benefits they provide
Changes in precipitation and water availability	Changes in coastal salinity, nutrient loadings, productivity, fish migration, recruitment patterns, and recruitment success	Altered abundance and composition of wild stock Food webs impacted
Extreme weather events	Impacts on fish habitats Impacts on fishing infrastructure and operations	Effects on habitat-linked resource capacity, on catchability of fisheries resources and on safety at sea

Source: modified from Sriskanthan and Funge-Smith, 2011.

into the fishing industry (because of loss of jobs following extreme weather events) would result in a heavier pressure on coastal resources.

However, in analyzing possible scenarios, as well as the scientific information currently available on fisheries resources, the conclusion is that both negative and positive impacts could be expected in the future. A recent PICES/ICES/FAO symposium held in May 2010, Sendai, Japan provided an assessment of the current knowledge of the effects of climate change on fish and fisheries (Hollowed *et al*., 2011). A wide array of scientific results were provided, from individual biological responses to those at multispecies and ecosystem level, as well as potential impacts of climate change at regional scale and implications for fisheries management.

Overall the findings showed that it was still difficult to forecast whether the productivity of the oceans will increase or decrease, as a result of the interacting and sometimes counteractive combination of warming, ocean acidification, nutrient flux and other oceanographic phenomena (Murawski, 2011). The areas where more information is available remain the North Atlantic, North Pacific, the southern African area and a few other locations. Yet, there is an urgent need for information in the tropical and subtropical zones where climate change is expected to have strong impacts and where vulnerability is higher (Allison *et al*., 2009, Cheung *et al*., 2009).

REGIONAL IMPACTS

To provide some initial perspectives, Barange and Perry (2009) carried out an analysis of potential scenarios for different regions of the world in terms of climate change impacts on fish production and ecosystems at "rapid" (few years), intermediate (few years to a decade) and long (multidecadal) time scales. In the Arctic, air temperature, precipitation and cloud cover are expected to increase and sea level could rise by up to 15 cm. Ecological consequences of these changes could be a two to five fold increase of primary production and a shift in distribution of fish species. According to the authors' scenario, species with narrow temperature tolerances and late reproduction are expected to disappear from southerly habitats, whereas Atlantic and Pacific species may expand northwards.

In the North Atlantic, with increased sea temperatures (1° to 3° C over the next 50 years) in particular in the northernmost areas, vertical stratification and reduced ice cover are expected. Decreased temperatures may however also be observed as a result of glacial melting in Greenland, provoking thermal shocks to species such as cod. The consequences are a probable increase of primary production in the Barents Sea, whereas the zooplankton production would decline. Northward shifts in the distribution of all species are expected, with a change in species proportion in the North Sea, where herrings and mackerel would dominate in the North whereas anchovy and sardine would be predominant in the South. Salinity changes in the Baltic Sea would result in stronger vertical stratification with warmer and fresher water and consequent exclusion of marine-tolerant species and expected salinity stress for non-native species (Barange and Perry, 2009).

Similar projections are available for the North Pacific, except that this area is potentially more sensitive to increasing ocean acidification, with a negative impact consequent on various species. Northward shifts of fish populations are predicted on the West coast of North America and Pacific sockeye salmon might be restricted to the Bering Sea where a loss of cold-water species can be expected (Barange and Perry, 2009). Even though projections are associated with large uncertainties, model results also show that recruitment, biomass and harvests of walleye Pollock (*Theragra chalcogramma*) in the Eastern Bering Sea could decline by 32–58 percent in 2040–2050 (Mueter *et al*., 2011). In the Western North Pacific, there seems to be controversy about the effects of global warming on fishing yields, as there is evidence that increasing temperatures may result in better feeding, higher recruitment success and growth rate of the main species targeted by fishing (Kim, 2010). Contradictory information is certainly due to physiological differences between species and the fact that climate change impacts are the result of combined effects of several parameters. For example, the growth rate of black rockfish (*Sebastes cheni*) in the Western North Pacific was higher at a certain temperature range, but growth efficiency was found to be highest at 16°C (Shoji *et al*., 2011). Shifts in spawning season and area would have different effects on fish early life stages related to changes in day length resulting from a poleward shift in the spawning area. Opposite effects would be observed on summer- and winter-growing early life stages. Juvenile growth is significantly affected by a combination of temperature and photoperiod and these effects are expected to be more prominent at higher latitudes.

In Asia, coastal zones were found to be already under a strong anthropogenic pressure, which poses a significant threat to environmental systems, with coastal areas undergoing a series of stresses that are likely to be exacerbated by climate change (IPCC, 2001). Loss of coastal mangroves that act as major environmental determinants of many coastal fisheries has become a serious problem (75 per cent of forest mangrove lost in the Philippines in less than 70 years, over 44 000 km^2 of mangroves lost in Indonesia since 1975). Sea level rise will aggravate the situation because it will change the distribution of salinity and hence mangrove productivity, with overall consequences on sedimentation, organic accumulation, the nature of the coast profile and species interaction. Coral reef ecosystems were already affected by the 1997/1998 El Niño, with an estimated loss of 34 per cent of the reefs, and are likely to undergo further degradation because of climate change (Sriskanthan and Funge-Smith, 2011). However, a moderate rise in sea level would stimulate the growth of coral reef flats and extend corals shoreward in Thailand, unless they are restricted by human infrastructure and development along the coast (IPCC, 2001). In the Western Pacific the rise in sea surface temperatures is expected to shift the southern limit of species such as salmon northwards. A decrease of oxygen supply in the bottom waters of the Sea of Japan is also projected to have consequences on biological productivity at a time scale of 100 years. Increased surface runoff and higher nutrient load would benefit plankton development in Northern Asia, whereas increased frequency of El Niño events would lead to a decline in plankton and fish larvae abundance in South and Southeast Asia. The eventual impact on fisheries will depend on the trophic relationships of the food chain and on the changes in currents and in the mixing layer.

In the South Pacific Region, a recent review stated that all fisheries activities are likely to be affected by climate change (Bell *et al*., 2011). This is particularly true for the distribution and abundance of tuna, which is largely influenced by water temperature and the availability of nutrients. Shifts in ocean temperatures and currents and the food chains that support tuna, are projected to affect both their location and abundance. In particular, concentrations of skipjack and bigeye tuna are likely to be located further east than in the past. This has implications for the long-term management of the region's tuna resources, and for the development and profitability of national industrial fishing fleets and canneries in the western Pacific. Moreover, habitats sustaining coastal fisheries are threatened by changes in water temperature, acidification of the ocean and sea-level rise, and possibly more severe and frequent cyclones and storms. Rising sea surface temperatures and more acidic oceans are projected to have direct impacts on coral reefs and the habitats and food webs they provide for reef fish and invertebrates. Degraded coral reefs are likely to support different types of fish and lower yields of some species.

In the Eastern Pacific, specifically in the Humboldt Current system, the most relevant physical impacts that are expected regard the oxygen concentration in the water column and the sediments, a change in the upwelling intensity, in sea temperature, currents, sea level and freshwater discharge. Catches are currently dominated by horse mackerel (*Trachurus murphyi*), anchoveta (*Engraulis ringens*), Araucanian herring (*Strangomera benticki*) and South Pacific hake (*Merluccius gayi*). These species are expected to shift their distribution poleward by 2-4 km per year (Quiñones *et al*., *in prep*.).

A wide variety of habitats that sustain fisheries resources are threatened by anthropogenic activities in Latin America. Climate change is expected to add to the current vulnerability of ecosystems and consequently the fisheries they sustain. Regional IPCC models indicate an increase of air temperature, important variations in precipitation (+5 per cent to -10 per cent depending on the time of the year). More drastic changes are expected in Central America, with a decrease in rainfall and an increase in temperatures. These changes are estimated to affect more severely the Pacific side of the isthmus, with effects on tuna (skipjack and yellow fin), lobster, and shrimp resources (Bravo-Moreno, *in prep*.).

In the Caribbean, the 1990s appear to be the warmest decade since 1900 and models suggest that both air and sea temperatures will continue to increase. Diurnal and seasonal temperature ranges are expected to decrease, hence consistently exposing marine organisms to higher minimum and maximum temperatures. Warming is likely to result in more frequent bleaching and increased mortality of corals, which host nurseries for a number of fish species and provide a natural protection against storm surges. Moreover, the increased incidence, duration and intensity of El Niño events will likely affect habitats and also cause coral bleaching, as already experienced in 2005 when nearly 30 per cent of the corals bleached, unless there is an adaptive increase in coral tolerance to higher temperatures. The frequency of hurricanes in the region is also expected to increase, with consequences for amplification of storm surge effects, coastal erosion and habitat destruction because of a higher probability of habitat and ecosystem damage and the resulting stress on corals, mangroves, and seagrasses (Mahon, 2002; Nurse, 2011). Species shifts because of changes in temperature regimes are also to be expected, as for example bluefin tuna (*Thunnus thynnus*) in the Gulf of Mexico (Muhling *et al*., 2011). Temperature triggers spawning and determines the presence of bluefin tuna (and hence their migration behavior). An increase in temperature, associated to primary and secondary production regimes, would affect spawning times and locations, migration behavior, larval growth, feeding and survival.

In Africa, current understanding of "natural" climatic variability indicates that at least for some regions, the ENSO (El Niño/La Niña-Southern Oscillation) is one of the more important controlling factors of interannual rainfall variability, (Hulme *et al*., 2001). On top of such normal variability, climate change models have also generated some predictions for the region. Based on these, warming in Africa is very likely to be larger than the global annual mean warming throughout the continent and in all seasons, with drier subtropical regions warming more than the wetter tropics. Annual rainfall is likely to decrease in much of Mediterranean Africa, northern Sahara and southern Africa. There is likely to be an increase in annual mean rainfall in East Africa. It is unclear however how rainfall in the Sahel, the Guinea coast, the southern Sahara and the rest of Africa will evolve (Barange and Perry 2009). Other impacts of ENSO include changes in the vertical structure of the sea water column and consequently on available habitats, on plankton and food webs, both in upwelling and non-upwelling coastal areas.

Jury *et al*. (2010) examined marine climate variability in the context of the fish catch statistics of two countries in East Africa. Fish catch was higher when sea surface temperatures and atmospheric humidity were below normal in the tropical west Indian Ocean. Their modeling suggested a continuing increase of sea surface temperature to a predicted 30oC in 2100, a gradual increase of SW monsoon winds, and a gradual doubling of dissolved CO_2 in that region, with impacts on coral bleaching and on fish productivity.

In North Africa and the Near East, water stress is likely to increase, in particular in the Mediterranean Basin where rainfall is expected to decrease while an increase of temperature is foreseen (Curtis *et al*., 2011). The sole exception is Egypt where the Nile runoff is projected to increase because of higher rainfall levels in the Central African Nile source waters. Consequences for fisheries resources are still poorly understood, though fishing yields are expected to drop as a result of the combined effect of temperature, rainfall and the physiology and behavior of marine organisms. In the Near East, coral bleaching was recorded and associated with water temperature fluctuations, and harmful algal bloom episodes were experienced in particular during the calm winter of 2008. In the Red Sea and the Gulf of Aden area where the temperature and salinity are among the highest in the world, shifts in climate causing these to increase could have noticeable negative effects on commercial fish stocks.

The response of coastal upwelling areas to climate change is likely to be more complex than a simple increase or decrease. Predictions of the responses of coastal wind-driven upwelling systems to climate change are at this stage contradictory in some respects, partially because higher model resolution is still required. However, studies show that upwelling off North West Africa intensified during the twentieth century, and may continue to intensify with global warming (McGregor *et al*., 2007). This would allow the productivity of the system to be maintained, but with possible changes in the predominant pelagic species composition (e.g. Zeeberg *et al*., 2008).

Predictions of the climate change impacts on the Benguela upwelling system are different, as it is characterized by the presence of phytoplankton settling on the sea floor, the decomposition of which consumes oxygen and produces hydrogen sulphide. An intensified upwelling could therefore bring oxygen-depleted waters to the surface and potentially result in significant species displacements and mortalities (Bakun and Weeks, 2004)

CONCLUSIONS

Some of the impacts of climate change are predictable and are already being observed, while there is still doubt about other impacts, because of the uncertainty in climate projections, the complexity of the responses at individual, community and ecosystem levels, and poor understanding of these responses (Munday *et al*., 2008). However, increasing the resilience of the resource system through improved fisheries management is recognisably essential to cope with climate change impacts, including for example, the preservation or restoration of stocks and habitats that sustain fisheries, setting fishing effort that is appropriate to stock levels, and adaptation of existing fishing gears and practices, either to fish in new areas or to catch new species.

Adaptation to climate change should be envisaged as a long-term process that does not necessarily imply the implementation of costly measures or strategies or drastic change in existing management practices. However, management structures should be strengthened and adaptation measures should be mainstreamed into existing arrangements. Options to increase resilience and adaptability through improved fisheries management include the adoption as standard practice of adaptive and precautionary management, as well as temporally and spatially adaptive management tools in line with the principles of the ecosystem approach to fisheries (FAO, 2003). Flexible fishery management approach that would allow responding more rapidly to changing conditions would include, for example, adjustment of fishing capacity to new situations, catch limitations and development of alternative livelihoods (Perry, 2010).

In the future, planning for uncertainty will need to take into account the greater possibility of unforeseen events, such as the increasing frequency of extreme weather events. However, examples of past management practices under variability and extreme events can still provide useful lessons to design robust and responsive adaptation systems. In addition, improved knowledge in a number of areas will be valuable e.g. projections of future fish production level, detailed impact predictions on specific fisheries systems, improved tools for decision-making under uncertainty, and improved knowledge of who is or will be vulnerable with respect to climate change and food security impacts and how they can be addressed.

Furthermore, integrated solutions to climate change have the potential for multiple benefits if cross-sectoral considerations are taken into account. For instance, the use of replanted mangrove for coastal protection both improves physical protection from coastal storms as well as providing improved fisheries resources for local communities (World Bank, 2010), and potentially increasing carbon sequestration within mangrove sediments. Another example of integrated solutions has been proposed in response to adverse effects of climate change on coral reef ecosystems in the Pacific and in Eastern Africa. That consists in selectively banning or restricting fishing gears as a tool to reduce detrimental ecosystem effects of climate change, while maintaining incomes and support for reef protection, as an alternative to full fisheries closures that are not always practical or appropriate (Cinner *et al*., 2009).

In order to reduce uncertainties and strengthen options for responding to climate change impacts it will be necessary to fill a range of knowledge gaps. In particular it will be important to carry out region-specific research to describe better the local impacts of climate change on fisheries resources, to define more clearly the social and economic consequences, and to set out practical options for addressing these.

In terms of bioecological impacts, genetic plasticity and physiological adaptation of fisheries resources to newly developing environmental conditions should be taken into account in experimental research or in response modelling exercises (Box C5.2 on ocean acidification) and knowledge should be increased on the effects of temperature, wind and circulation regimes on the migration patterns of commercially important species.

BOX C5.2

The uncertain impacts of ocean acidification

The ocean absorbs approximately 25% of the carbon dioxide (CO_2) added to the atmosphere from human activities each year, greatly reducing its impact on the climate. When CO_2 dissolves in seawater, carbonic acid is formed, causing gradual acidification. This increases the dissolution rate and impairs the formation of shells and skeletons of many marine organisms as well as affecting reproduction and physiology. Damage to marine ecosystems and services from ocean acidification is likely to affect developing nations and coastal regions which rely on marine-related activities (Cooley *et al.*, 2009). A recent IPCC workshop took stock of the current scientific understanding of ocean acidification for microbial processes and biochemistry, phytoplankton calcification and photosynthesis, fishes, calcification and dissolution of coral reefs, coral reef organisms, and non-coral reef invertebrates (IPCC, 2011). Few studies have investigated ocean acidification effects on the early life history of marine fishes, the majority of data deriving from aquaculture species which are typically resistant and hardy, potentially of little relevance for wild species. Elevated CO_2 and reduced pH does not seem to have a negative effect on spawning, early development, and growth of larvae and juveniles of several species studied (reef species, spotted wolf-fish, Atlantic salmon, rainbow trout, white sturgeon). However, evidence was found of high metabolic costs for fish under elevated CO_2. High CO_2 also seems to have an impact on larval behavior and their sensory systems, which could have significant effects on population replenishment and connectivity. There is still a poor understanding of the impact on migration, social interaction, spawning, predator avoidance and prey capture. As regards corals, there seem to be contradictions between laboratory and field observations in the sensitivity of calcification to changes in aragonite concentration. This highlights the complexity of organisms' and ecosystem responses to ocean acidification and the importance of other environmental and biological factors in modulating or exacerbating the CO_2 effect. Moreover, most studies have focused on adult organism responses or on a single life stage, hence probably underestimating the potential lifecycle and multiple-generation impact. In contrast, short experiments do not allow for expression of genetic plasticity or selection of resilient phenotypes, thus potentially leading to overestimation of impact. When scaling up to the ecosystem level, uncertainty also rises if data from experimental observations of individual species are used to assess impacts at the level of community structures and food web dynamics, as species interacting within an ecosystem respond differently to environmental stressors. These constraints regardless, there is broad agreement that ocean acidification operates on increasing spatial and temporal scales, likely to affect ecosystem services and to result in significant implications for in terms of economic output and food security.

Both research institutions and governmental fisheries institutions and bodies have therefore a role to play. Rapid improvements in scientific knowledge to provide more accurate and region-specific projections and greater involvement of stakeholders in the sound management of fisheries resources and their habitats is urgently required in order to alleviate the pressure on exploited stocks, or take advantage of new resources becoming available without being detrimental to livelihoods.

In relation to this, fishing opportunities in new locations should also be projected more accurately, both regarding distribution shifts of current species in an area, but also forecasting the arrival of "new species" and their possible exploitation. Targeting these species will usually require new gears, marketing strategy and production of outreach material. Moreover, more sophisticated ecosystem modeling would be required to address the complexity of trophic relationships and hence ecosystem-scale effects of climate change, taking into account possible new species entering an ecosystem, as well as predator/prey responses under different scenarios. At the same time, the effect of climate change on invasive and on toxic species should also be addressed.

ACKNOWLEDGEMENTS

Many thanks to J. Muir, P. Barros, C. de Young and D. Soto for their suggestions and helpful comments.

REFERENCES

Allison, E.H., Perry, A.L., Badjeck, M.-C., Adger, W.N., Brown, K., Conway, D., Halls, A.S., Pilling, G.M., Reynolds, J.D., Andrew, N.L. & Dulvy, N.K. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries* 10 (2): 173–96.

Badjeck, M.-C., Allison, E. H., Halls, A.S. & Dulvy, N.K. 2010. Impacts of climate variability and change on fishery-based livelihoods. *Marine Policy* 34: 375–383.

Bakun, A. & Weeks, S.J. 2004. Greenhouse gas buildup, sardines, submarine eruptions and the possibility of abrupt degradation of intense marine upwelling ecosystems. *Ecological Letters*, 7: 1015–1023.

Barange, M. & Perry, R.I. 2009. Physical and ecological impacts of climate change relevant to marine and inland capture fisheries and aquaculture. *In* K. Cochrane, C. De Young, D. Soto and T. Bahri (eds). Climate change implications for fisheries and aquaculture: overview of current scientific knowledge. *FAO Fisheries and Aquaculture Technical Paper.* No. 530. Rome, FAO. pp. 7–106.

Bell, J.D., Adams. T.J.H., Johnson. J.E., Hobday, A.J. & Gupta, A.S. 2011. Pacific communities, fisheries, aquaculture and climate change: An introduction. *In* J.D. Bell, J.E. Johnson and A.J. Hobday, eds. *Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change*. Secretariat of the Pacific Community, Noumea, New Caledonia: 1-48.

Mohanty B., Mohanty S., Sahoo J. & Sharma A. 2010. Climate Change: Impacts on Fisheries and Aquaculture, Climate Change and Variability. S. Simard, ed. (Available from: www.intechopen.com/articles/show/title/climate-change-impacts-on-fisheries-and-aquaculture)

Bravo-Moreno, J.R. *In preparation*. Evaluación de Potenciales impactos y reducción de la vulnerabilidad de la pesca y la acuicultura al cambio climático en el Golfo de Fonseca. *In* R. Quiñonez and D. Soto, eds. *Cambio climático, vulnerabilidad y potencial de adaptación en la pesca y la acuicultura en América Latina.* FAO Fisheries and Aquaculture Technical Paper Proceedings. Rome, FAO. In preparation.

Bruno, J.F., Selig, E.R., Casey, K.S., Page, C.A., Willis, B.L., Harvell, C.D., Sweatman, H. & Melendy, A.M. 2007. Thermal stress and coral cover as drivers of coral disease outbreaks. *PLoS Biology.* 5(6): e124.

Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J.L., Kearney, K., Watson, R. & Pauly, D. 2009. Projecting global marine biodiversity impacts under climate change scenarios. *Fish and Fisheries* 10(3): 235–251.

Cinner, J.E., McClanahan, T.R., Graham, N.A.J., Pratchett, M.S., Wilson, S.K. & Raina, J.B. 2009. Gear-based fisheries management as a potential adaptive response to climate change and coral mortality. *Journal of Applied Ecology*, 46: 724–732

Cooley, S.R., Kite-Powell, H. L. & Doney, S.C. 2009. Ocean acidification's potential to alter global marine ecosystem services. *Oceanography* Vol.22, No.4: 172-181.

Curtis, L., Beveridge, M.C.M., el-Gamal, A.R. & Mannini, P., eds. 2011. Adapting to climate change: the Ecosystem Approach to Fisheries and Aquaculture in the Near East and North Africa Region – Workshop Proceedings. *FAO Fisheries and Aquaculture Circular*. No. 1066. Rome, FAO. 2011. 130p.

FAO. 2003. The ecosystem approach to fisheries. *FAO Technical Guidelines for Responsible Fisheries*. No.4, Suppl. 2. Rome. FAO. 2003. 112 p.

FAO. 2008. Report of the FAO expert workshop on climate change implications for fisheries and aquaculture. Rome, Italy, 7-9 April 2008. *FAO Fisheries Report*. No. 870. Rome, FAO. 2008. 32p.

FAO. 2011. FAO Yearbook: Fishery and aquaculture statistics 2011. Rome, FAO. 2011.

Harvell, C.D., Mitchell, C.E., Ward, J.R., Altizer, S., Dobson, A.P., Ostfeld, R.S. & Samuel, M.D. 2002. Climate warming and disease risks for terrestrial and marine biota. *Science* **296** (5576): 2158-2162.

Hollowed, A.B., Barange, M., Ito, S., Kim, S., Loeng, H. & Peck, M.A. 2011. Effects of climate change on fish and fisheries: forecasting impacts, assessing ecosystem responses, and evaluating management strategies. *ICES Journal of Marine Science*, 68(6): 985-986.

Hulme, M., Doherty, R., Ngara, T., New, M. & Lister, D. 2001. African climate change: 1900-2100. *Climate Research* 17: 145-168

IPCC. 2001. Climate change 2001: Impacts, adaptation, and vulnerability. *In* J.J. McCarthy, O. F. Canziani, N.A. Leary, D.J. Dokken and K.S. White, eds. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1032 pp.

IPCC. 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. *In* S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, eds. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

IPCC. 2011: Workshop Report of the Intergovernmental Panel on Climate Change Workshop on Impacts of Ocean Acidification on Marine Biology and Ecosystems. C.B. Field, V. Barros, T.F. Stocker, D. Qin, K.J. Mach, G.-K. Plattner, M.D. Mastrandrea, M. Tignor and K.L. Ebi, eds. IPCC Working Group II Technical Support Unit, Carnegie Institution, Stanford, California, United States of America, pp. 164.

Jury, M., McClanahan T. & Maina, J. 2010. West Indian Ocean variability and East African fish catch. *Marine Environmental Research.* 70(2):162-70

Kim, S. 2010. Fisheries development in northeastern Asia in conjunction with changes in climate and social systems. *Marine Policy* 34 : 803–809

Lan, K.-W., Lee, M.-A., Lu, H.-J., Shieh, W.-J., Lin, W.-K. & Kao, S.-C. 2011. Ocean variations associated with fishing conditions for yellowfin tuna (*Thunnus albacares*) in the equatorial Atlantic Ocean. *ICES Journal of Marine Science*, 68(6): 1063-1071

Mahon, R. 2002. Adaptation of fisheries and fishing communities to the impacts of climate change in the CARICOM Region. CARICOM Fisheries Unit, Belize City, Belize Caribbean Centre for Climate Change (CCCC)

McGregor, H.V., Dima, M., Fischer, H.W. & Mulitza, S. 2007. Rapid twentieth century increase in coastal upwelling off North West Africa*. Science,* 315: 637–639

Mueter, F.J., Bond, N.A., Ianelli J.N. & Hollowed, A.B. 2011. Expected declines in recruitment of walleye Pollock (*Theragra chalcogramma*) in the eastern Bering Sea under future climate change. *ICES Journal of Marine Science*, 68(6): 1284-1296.

Muhling, B.A., Lee, S.-K., Lamkin, J.T. & Liu, Y. 2011. Predicting the effects of climate change on bluefin tuna (*Thunnus thynnus*) spawning habitat in the Gulf of Mexico. *ICES Journal of Marine Science*, 68(6): 1051-1062.

Munday, P.L., Jones, G.P., Pratchett, M.S. & Williams, A.J. 2008. Climate change and the future for coral reef fishes. *Fish and fisheries*, 2008, 9: 261–285.

Nurse, L.A. 2011. The implications of global climate change for fisheries management in the Caribbean. *Climate and Development*, 3:3, 228-241.

Perry, I. 2010. Potential impacts of climate change on marine wild capture fisheries: an update. *Journal of Agricultural Science* (2011), **149**: 63–75

Quiñones, R.A., Salgado, H., Montecinos, A., Dresdner, J. & Venegas, M. *In prep*. Evaluación de potenciales impactos y reducción de la vulnerabilidad de la pesca al cambio climático: el caso de las pesquerías principales de la zona centro-sur de Chile. *In* R. Quiñonez and D. Soto, eds. *Cambio climático, vulnerabilidad y potencial de adaptación en la pesca y la acuicultura en América Latina.* FAO Fisheries and Aquaculture Technical Paper Proceedings. Rome, FAO. In preparation.

Shoji, J., Toshito, S.-i., Mizuno, K.-i, Kamimura, Y., Hori, M. & Hirakawa, K. 2011. Possible effects of global warming on fish recruitment: shifts in spawning season and latitudinal distribution can alter growth of fish early life stages through changes in daylength. *ICES Journal of Marine Science*, 68(6): 1165-1169.

Sriskanthan, G. & Funge-Smith, S.J. 2011. The potential impact of climate change on fisheries and aquaculture in the Asian region. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. *RAP Publication* 2011/16, 41 pp.

World Bank. 2010. Development and climate change. World Development Report 2010. Washington D.C. The World Bank. 417 pp.

Zeeberg, J.J., Corten, A, Tjoe-Awie, P., Coca, J. & Hamady, B. 2008. Climate modulates the effects of *Sardinella aurita* fisheries off Northwest Africa. *Fisheries Research*, 89: 65–75.

Part D

Marine resources tables

Table D1: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Northwest Atlantic (FAO Statistical Area 21), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes 1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	State of exploitation*	Uncertainty**
Amer. plaice (= long rough dab)	*Hippoglossoides platessoides*	United States of America, Spain, Portugal, Canada	31	77	97	79	19	10	11	9	8	6	5	3	4	4	4	O	L
Flatfishes NEI	*Pleuronectiformes*	Faroe Islands, Canada	2	6	4	7	5	< 1	< 1	3	3	2	2	1	1	< 1	< 1		
Flounders, halibuts, soles	*Paralichthys oblongus*	United States of America	-	-	-	-	-	-	-	-	-	-	-	-	< 1	< 1	< 1		
Greenland halibut	*Reinhardtius hippoglossoides*	Spain, Russian Federation, Greenland, Canada	< 1	17	47	38	67	65	61	64	72	58	59	62	57	53	54	F	L
Summer flounder	*Paralichthys dentatus*	United States of America	14	10	14	22	11	11	11	14	13	17	17	14	10	10	11	F	L
Winter flounder	*Pseudopleuronectes americanus*	United States of America, Canada	9	15	15	16	9	8	9	8	8	7	5	4	4	4	4		
Witch flounder	*Glyptocephalus cynoglossus*	United States of America, Spain, Portugal, Canada	5	28	38	19	9	6	7	7	7	6	5	4	3	3	3	O	L
Yellowtail flounder	*Limanda ferruginea*	United States of America, Saint Pierre and Miquelon, Spain, Canada	9	42	50	30	12	21	24	19	21	21	18	3	7	14	8	F/U	L
Other flounders, halibuts, soles			5	4	3	6	3	2	3	2	2	2	2	2	2	2	3	F	L
31 – Flounders, halibuts, soles			**76**	**199**	**268**	**217**	**133**	**124**	**127**	**126**	**135**	**119**	**113**	**94**	**89**	**90**	**87**		
Atlantic cod	*Gadus morhua*	United States of America, Portugal, Greenland, Canada	857	1 453	754	644	165	63	60	55	41	40	42	44	50	62	43	F	L
Haddock	*Melanogrammus aeglefinus*	United States of America, Norway, Greenland, Canada	144	148	39	54	16	17	22	23	23	25	28	20	23	27	29	U/F	L
Saithe (= pollock)	*Pollachius virens*	United States of America, Canada	49	37	38	61	27	11	11	11	14	14	15	11	15	16	6	F	L
Silver hake	*Merluccius bilinearis*	United States of America, Canada	48	180	203	83	46	26	33	24	20	22	19	18	18	19	18	F	L
Tusk (= cusk)	*Brosme brosme*	United States of America, Norway, Greenland, Canada	2	5	6	6	3	1	2	1	1	1	1	< 1	1	< 1	< 1	O	L
White hake	*Urophycis tenuis*	United States of America, Spain, Portugal, Canada	15	10	18	24	13	8	8	13	14	9	8	6	5	4	4	O	L
Other cods, hakes, haddocks			3	42	66	12	10	13	12	13	10	7	6	3	2	3	2	F	L
32 – Cods, hakes, haddocks			**1 118**	**1 876**	**1 126**	**884**	**280**	**139**	**148**	**141**	**124**	**118**	**118**	**104**	**115**	**131**	**102**		
33 – Miscellaneous coastal fishes			**34**	**28**	**23**	**21**	**18**	**23**	**21**	**23**	**23**	**22**	**20**	**17**	**18**	**15**	**16**		
American angler	*Lophius americanus*	United States of America, Portugal, Canada	< 1	2	10	6	22	22	25	27	31	24	21	17	13	11	9	F	L
Atlantic redfishes NEI	*Sebastes* spp.	Spain, Portugal, Estonia, Canada	175	215	212	143	87	47	50	57	67	32	38	34	23	22	29	O	L
Other miscellaneous demersal fishes			7	34	35	12	6	5	6	9	10	24	28	21	16	12	11		
34 – Miscellaneous demersal fishes			**181**	**250**	**257**	**161**	**115**	**74**	**81**	**92**	**108**	**79**	**88**	**72**	**52**	**45**	**49**		
Atlantic herring	*Clupea harengus*	United States of America, Canada	170	451	466	233	278	277	308	259	298	265	261	254	240	218	256	F	L
Atlantic menhaden	*Brevoortia tyrannus*	United States of America	428	268	270	305	301	183	236	181	182	191	189	184	215	188	182	F	L
Other herrings, sardines, anchovies			-	-	-	-	< 1	-	-	-	-	-	< 1	-	-	-	-		
35 – Herrings, sardines, anchovies			**598**	**719**	**736**	**538**	**580**	**461**	**544**	**439**	**479**	**456**	**449**	**437**	**455**	**406**	**438**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D1: Area 21 (Continued)

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Atlantic mackerel	*Scomber scombrus*	United States of America, Canada	15	33	244	49	39	23	37	70	79	108	97	110	78	51	65	F	L
Capelin	*Mallotus villosus*	Greenland, Canada	15	6	174	65	46	21	20	14	22	34	37	42	37	39	35	F	L
Other miscellaneous pelagic fishes			5	7	14	11	7	5	9	4	4	4	4	4	5	4	4		
37 – Miscellaneous pelagic fishes			**35**	**46**	**431**	**125**	**93**	**50**	**66**	**88**	**106**	**146**	**138**	**157**	**120**	**95**	**104**		
American lobster	*Homarus americanus*	United States of America, Canada	34	33	32	52	74	83	84	82	81	82	84	95	78	96	101	F	L
43 – Lobsters, spiny-rock lobsters			34	**33**	**32**	**52**	**74**	**83**	**84**	**82**	**81**	**82**	**84**	**95**	**78**	**96**	**101**		
Pandalus shrimps NEI	*Pandalus* spp.	Canada	-	1	4	12	23	35	31	33	1	2	2	3	3	2	1	F	L
Other shrimps, prawns			< 1	7	33	64	142	234	232	255	286	357	343	347	355	339	287	F	L
45 – Shrimps, prawns			**< 1**	**8**	**38**	**76**	**165**	**270**	**264**	**288**	**287**	**360**	**346**	**350**	**358**	**340**	**289**		
American sea scallop	*Placopecten magellanicus*	United States of America, Canada	83	120	122	155	147	197	254	280	293	325	268	284	285	270	281	F	L
Atlantic bay scallop	*Argopecten irradians*	United States of America	5	5	6	3	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Iceland scallop	*Chlamys islandica*	Greenland, Canada	-	-	-	< 1	9	4	3	3	3	3	5	4	2	< 1	< 1	F	L
55 – Scallops, pectens			**88**	**125**	**127**	**159**	**156**	**201**	**257**	**284**	**296**	**329**	**273**	**288**	**288**	**271**	**282**		
Atlantic surf clam	*Spisula solidissima*	United States of America, Canada	44	124	129	149	159	166	166	176	169	150	144	146	152	139	123	F	L
Northern quahog (= hard clam)	*Mercenaria mercenaria*	Canada	52	48	45	32	16	9	7	15	4	3	1	< 1	4	< 1	< 1	F	L
Ocean quahog	*Arctica islandica*	United States of America	1	< 1	34	159	175	123	143	150	157	152	114	119	130	129	131	F	L
Sand gaper	*Mya arenaria*	United States of America, Canada	17	20	24	20	10	8	10	9	9	10	9	9	9	8	9	F	M
Other clams, cockles, arkshells			< 1	< 1	< 1	5	23	23	21	23	31	26	22	23	20	20	26		
56 – Clams, cockles, arkshells			**114**	**193**	**232**	**365**	**383**	**329**	**347**	**372**	**369**	**341**	**290**	**298**	**315**	**297**	**289**		
Total selected species groups			**2 278**	**3 477**	**3 270**	**2 599**	**1 997**	**1 754**	**1 939**	**1 936**	**2 008**	**2 051**	**1 919**	**1 913**	**1 887**	**1 786**	**1 757**		
Total other species groups			**357**	**300**	**427**	**308**	**320**	**315**	**290**	**298**	**286**	**302**	**282**	**278**	**251**	**275**	**284**		
Total marine capture			**2 635**	**3 777**	**3 697**	**2 907**	**2 317**	**2 069**	**2 229**	**2 234**	**2 293**	**2 353**	**2 201**	**2 191**	**2 138**	**2 061**	**2 040**		
Total aquaculture			**1**	**1**	**2**	**8**	**50**	**108**	**108**	**105**	**112**	**147**	**114**	**117**	**99**	**109**	**113**		
Total production			**2 636**	**3 778**	**3 699**	**2 915**	**2 368**	**2 176**	**2 338**	**2 338**	**2 405**	**2 500**	**2 315**	**2 308**	**2 237**	**2 170**	**2 154**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D2: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Northeast Atlantic (FAO Statistical Area 27), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Atlantic salmon	*Salmo salar*	Sweden, Russian Federation, Finland, Denmark	7	9	8	8	5	3	3	2	2	2	2	2	1	1	< 1	O	L
Other salmons, trouts, smelts			10	14	11	9	10	12	7	7	6	6	6	6	6	6	7	O	L
23 – Salmons, trouts, smelts			**17**	**23**	**19**	**17**	**15**	**15**	**9**	**9**	**8**	**8**	**8**	**7**	**7**	**7**	**8**		
European plaice	*Pleuronectes platessa*	United Kingdom, Netherlands, Iceland, Denmark	107	161	176	169	146	113	111	99	93	88	77	83	76	74	78	F	L
Other flounders, halibuts, soles			96	145	170	183	195	186	192	177	183	182	171	155	153	143	151	O	L
31 – Flounders, halibuts, soles			203	307	346	352	341	300	303	276	276	270	247	238	229	217	230		
Atlantic cod	*Gadus morhua*	Russian Federation, Norway, Iceland, Faroe Islands	1 675	1 611	1 772	1 426	1 106	877	885	848	808	865	808	790	732	707	823	F	L
Blue whiting (= poutassou)	*Micromesistius poutassou*	Russian Federation, Norway, Iceland, Faroe Islands	13	18	223	713	675	1 446	1 794	1 558	2 373	2 419	2 060	2 024	1 673	1 277	635	F	L
Haddock	*Melanogrammus aeglefinus*	United Kingdom, Russian Federation, Norway, Iceland	289	464	493	316	256	196	208	247	259	301	284	299	316	305	336	F	L
Norway pout	*Trisopterus esmarkii*	Norway, Iceland, Germany, Denmark	19	155	532	409	275	205	91	108	38	23	< 1	54	5	39	57	F	L
Polar cod	*Boreogadus saida*	Russian Federation	1	16	105	15	16	41	39	37	39	2	22	16	27	8	17	U	M
Saithe (= pollock)	*Pollachius virens*	United Kingdom, Norway, Iceland, Faroe Islands	210	323	592	420	349	302	319	376	377	389	444	485	429	440	395	F	L
Whiting	*Merlangius merlangus*	United Kingdom, Ireland, Iceland, France	118	191	214	147	80	56	49	44	37	32	33	37	36	29	32	O	L
Other cods, hakes, haddocks			200	245	237	249	217	208	226	185	209	154	173	156	153	167	184	F	L
32 – Cods, hakes, haddocks			**2 524**	**3 024**	**4 169**	**3 695**	**2 973**	**3 331**	**3 612**	**3 403**	**4 140**	**4 184**	**3 824**	**3 862**	**3 371**	**2 974**	**2 479**		
Sandeels (= sandlances) NEI	*Ammodytes* spp.	Sweden, Norway, Germany, Denmark	75	152	498	810	966	741	906	917	341	390	184	300	233	363	368	O	L
Other miscellaneous coastal fishes			32	35	48	24	23	28	27	25	27	31	31	36	39	31	37	F	M
33 – Miscellaneous coastal fishes			**108**	**186**	**546**	**834**	**989**	**769**	**933**	**942**	**368**	**421**	**215**	**337**	**273**	**394**	**404**		
Atlantic redfishes NEI	*Sebastes* spp.	Spain, Lithuania, Iceland, Faroe Islands	222	173	230	260	218	73	62	58	64	43	35	48	38	18	32	O	L
Other miscellaneous demersal fishes			63	90	116	164	188	349	368	357	322	318	278	313	309	307	381	F	L
34 – Miscellaneous demersal fishes			**285**	**263**	**346**	**424**	**406**	**421**	**430**	**415**	**386**	**361**	**313**	**361**	**347**	**326**	**412**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D2: Area 27 (Continued)

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Atlantic herring	*Clupea harengus*	Russian Federation, Norway, Iceland, Faroe Islands	2 478	2 738	1 078	1 081	1 733	2 104	1 645	1 615	1 661	1 755	2 055	1 971	2 128	2 261	2 254	F	L
European pilchard (= sardine)	*Sardina pilchardus*	Spain, Portugal, Netherlands, France	179	223	165	203	169	124	131	144	137	140	139	141	150	135	131	F	L
European sprat	*Sprattus sprattus*	Sweden, Poland, Latvia, Denmark	67	151	581	321	484	616	585	550	569	634	733	550	535	489	575	F	L
Other herrings, sardines, anchovies			55	91	41	17	39	46	64	34	17	29	6	7	7	4	5	O	L
35 – Herrings, sardines, anchovies			**2 779**	**3 203**	**1 865**	**1 622**	**2 425**	**2 890**	**2 424**	**2 342**	**2 384**	**2 559**	**2 933**	**2 668**	**2 821**	**2 889**	**2 964**		
Atlantic horse mackerel	*Trachurus trachurus*	United Kingdom, Norway, Netherlands, Ireland	44	66	168	190	418	222	237	204	196	195	204	198	195	174	234	F	L
Atlantic mackerel	*Scomber scombrus*	United Kingdom, Norway, Ireland, Iceland	100	415	603	581	654	655	660	685	600	587	448	421	475	548	632	F	L
Capelin	*Mallotus villosus*	Russian Federation, Norway, Iceland	44	314	2 294	1 838	1 231	1 463	1 646	1 963	1 120	628	713	225	382	214	327	O	L
Other miscellaneous pelagic fishes			82	96	108	53	68	65	74	68	66	69	93	129	131	135	77	F	H
37 – Miscellaneous pelagic fishes			**269**	**890**	**3 174**	**2 661**	**2 371**	**2 405**	**2 618**	**2 920**	**1 982**	**1 479**	**1 458**	**973**	**1 182**	**1 070**	**1 270**		
Northern prawn	*Pandalus borealis*	Norway, Iceland, Faroe Islands, Estonia	8	18	29	117	132	131	106	110	87	84	68	49	50	46	47	U	L
Other shrimps, prawns			63	60	44	29	34	42	37	39	41	40	46	42	41	42	49	F	L
45 – Shrimps, prawns			**71**	**78**	**73**	**146**	**166**	**173**	**142**	**149**	**128**	**124**	**114**	**91**	**90**	**88**	**96**		
Blue mussel	*Mytilus edulis*	United Kingdom, Spain, France, Denmark	22	20	42	87	128	127	145	132	99	112	90	72	66	48	42	?	
Other mussels			-	-	-	< 1	< 1	2	1	< 1	< 1	2	< 1	< 1	< 1	< 1	1	?	
54 – Mussels			**22**	**20**	**42**	**87**	**129**	**129**	**146**	**132**	**99**	**113**	**91**	**72**	**66**	**48**	**43**		
Total selected species groups			**6 280**	**7 993**	**10 580**	**9 839**	**9 814**	**10 430**	**10 618**	**10 588**	**9 772**	**9 519**	**9 202**	**8 609**	**8 386**	**8 012**	**7 907**		
Total other species groups			**484**	**619**	**647**	**608**	**580**	**583**	**516**	**495**	**499**	**476**	**441**	**493**	**518**	**510**	**526**		
Total marine capture			**6 763**	**8 612**	**11 227**	**10 447**	**10 394**	**11 014**	**11 134**	**11 083**	**10 271**	**9 996**	**9 643**	**9 102**	**8 905**	**8 522**	**8 433**		
Total aquaculture			**169**	**258**	**413**	**607**	**926**	**1 299**	**1 297**	**1 292**	**1 373**	**1 467**	**1 363**	**1 429**	**1 572**	**1 550**	**1 701**		
Total production			**6 932**	**8 870**	**11 641**	**11 053**	**11 320**	**12 313**	**12 431**	**12 376**	**11 644**	**11 462**	**11 006**	**10 531**	**10 477**	**10 072**	**10 134**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D3: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Western Central Atlantic (FAO Statistical Area 31), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Flathead grey mullet	*Mugil cephalus*	Venezuela (Bolivarian Republic of), Mexico	3	4	5	9	15	11	10	8	7	10	8	7	5	7	6	F/O	M
Groupers	*Epinephelus morio*	Venezuela (Bolivarian Republic of), United States of America, Mexico, Dominican Republic	9	18	23	26	24	23	20	21	18	19	22	20	21	21	20	O	M
Grunts	*Haemulidae* (= *Pomadasyidae*)	Venezuela (Bolivarian Republic of), Mexico, Dominican Republic, Cuba	4	13	26	8	15	10	15	8	12	16	10	7	5	8	8	F/O	M
Mullets NEI	*Mugilidae*	United States of America, Mexico, Cuba, Colombia	18	22	19	18	16	15	13	13	12	12	5	8	5	6	6	?	
Sciaenides	*Sciaenops ocellatus*	Venezuela (Bolivarian Republic of), United States of America, Mexico, French Guiana	21	20	38	30	29	29	29	24	31	40	32	20	13	19	20	F/O	M
Snappers	*Lutjanus campechanus*	Venezuela (Bolivarian Republic of), United States of America, Mexico, Cuba	10	17	20	23	30	28	24	22	25	27	28	26	24	26	27	O	M
Other miscellaneous coastal fishes			7	25	27	34	42	39	38	43	46	57	45	37	32	29	28		
33 – Miscellaneous coastal fishes			**73**	**119**	**158**	**149**	**170**	**154**	**149**	**140**	**150**	**182**	**150**	**124**	**106**	**116**	**114**		
34 – Miscellaneous demersal fishes			**8**	**9**	**10**	**8**	**13**	**15**	**22**	**20**	**20**	**27**	**17**	**11**	**10**	**15**	**17**		
Atlantic menhaden	*Brevoortia tyrannus*	United States of America	25	41	65	59	30	24	25	31	22	24	6	< 1	< 1	< 1	< 1	F/O	L
Atlantic thread herring	*Opisthonema oglinum*	Venezuela (Bolivarian Republic of), United States of America, Dominican Republic, Cuba	2	6	9	5	9	15	7	5	12	18	10	7	5	9	9	?	
Gulf menhaden	*Brevoortia patronus*	United States of America	290	470	603	786	558	591	529	582	522	464	370	409	457	421	455	F	L
Round sardinella	*Sardinella aurita*	Venezuela (Bolivarian Republic of), United States of America	19	38	42	61	119	77	74	159	143	121	100	81	61	37	37	O	L
Other herrings, sardines, anchovies			< 1	4	7	4	3	7	7	6	7	7	8	8	7	7	7		
35 – Herrings, sardines, anchovies			**336**	**560**	**727**	**914**	**719**	**714**	**641**	**783**	**706**	**634**	**494**	**505**	**529**	**474**	**508**		
Atlantic bonito	*Sarda sarda*	Venezuela (Bolivarian Republic of), Trinidad and Tobago, Saint Vincent/ Grenadines, Mexico	< 1	< 1	2	2	4	2	2	2	2	2	1	1	1	1	2	?	
Atlantic Spanish mackerel	*Scomberomorus maculatus*	United States of America, Mexico	5	8	10	9	10	7	7	7	7	9	9	8	7	9	7	?	
Cero	*Scomberomorus regalis*	Puerto Rico, Dominican Republic	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	?	
King mackerel	*Scomberomorus cavalla*	Venezuela (Bolivarian Republic of), United States of America, Trinidad and Tobago, Mexico	5	6	7	7	9	9	10	12	11	15	11	10	9	12	11	O,O	H
Serra Spanish mackerel	*Scomberomorus brasiliensis*	Venezuela (Bolivarian Republic of), Trinidad and Tobago, Guyana, Grenada	< 1	< 1	3	4	6	6	6	5	6	8	6	4	3	4	4	?	
Other tunas, bonitos, billfishes			4	14	10	17	23	35	26	35	18	20	14	10	13	12	14		
36 – Tunas, bonitos, billfishes			**14**	**30**	**32**	**40**	**52**	**59**	**50**	**63**	**44**	**54**	**41**	**34**	**34**	**37**	**37**		
38 – Sharks, rays, chimaeras			**3**	**7**	**10**	**25**	**32**	**25**	**23**	**26**	**31**	**40**	**31**	**26**	**22**	**23**	**24**	?	
42 – Crabs, sea-spiders			**22**	**35**	**38**	**52**	**61**	**61**	**49**	**60**	**67**	**71**	**60**	**61**	**53**	**58**	**60**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D3: Area 31 (Continued)

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Caribbean spiny lobster	*Panulirus argus*	Nicaragua, Honduras, Cuba, Bahamas	6	14	21	27	31	33	26	34	31	33	30	27	26	28	24	F/O	L
Other lobsters, spiny-rock lobsters			< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1		
43 – Lobsters, spiny-rock lobsters			**6**	**14**	**21**	**27**	**31**	**34**	**27**	**34**	**31**	**34**	**31**	**28**	**26**	**28**	**24**		
Atlantic seabob	*Xiphopenaeus kroyeri*	United States of America, Suriname, Mexico, Guyana	< 1	< 1	2	6	13	29	38	32	35	27	27	29	27	22	26	F	L
Northern brown shrimp	*Penaeus aztecus*	United States of America, Mexico	58	54	59	67	57	63	68	57	65	56	45	62	47	40	57	F	L
Northern pink shrimp	*Penaeus duorarum*	United States of America, Mexico, Cuba	11	11	19	16	8	7	9	9	8	9	8	8	4	5	4	O	M
Northern white shrimp	*Penaeus setiferus*	United States of America, Mexico	32	31	33	38	37	52	41	43	47	57	52	65	37	50	56	?	
Penaeus shrimps NEI	*Penaeus* spp.	Venezuela (Bolivarian Republic of), Nicaragua, Mexico, French Guiana	5	30	54	46	47	45	48	42	53	52	39	35	27	26	25	?	
Redspotted shrimp	*Penaeus brasiliensis*		< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	O	H
Rock shrimp	*Sicyonia brevirostris*	United States of America	< 1	< 1	1	2	3	3	3	< 1	3	4	< 1	2	< 1	1	2		
Royal red shrimp	*Pleoticus robustus*		< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	?	
Other shrimps, prawns			< 1	< 1	< 1	2	4	5	5	3	6	6	6	4	3	3	4		
45 – Shrimps, prawns			**106**	**126**	**169**	**177**	**170**	**204**	**212**	**188**	**218**	**212**	**178**	**205**	**148**	**148**	**174**		
Stromboid conchs NEI	*Strombus* spp.	Turks and Caicos Islands, Jamaica, Dominican Republic, Belize	< 1	3	6	14	34	29	37	27	32	26	25	28	18	19	23	F/O	L
Other abalones, winkles, conchs			< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	6	3	2		
52 – Abalones, winkles, conchs			**< 1**	**3**	**6**	**14**	**35**	**30**	**38**	**27**	**32**	**26**	**25**	**28**	**24**	**22**	**25**		
American cupped oyster	*Crassostrea virginica*	United States of America, Mexico	39	61	68	107	90	195	156	146	154	100	111	79	95	78	84	U, F	H
Other oysters			< 1	3	2	2	4	2	4	< 1	2	4	2	1	< 1	2	2		
53 – Oysters			**39**	**63**	**71**	**109**	**94**	**197**	**160**	**147**	**156**	**103**	**113**	**81**	**96**	**80**	**86**		
Calico scallop	*Argopecten gibbus*		< 1	2	12	130	32	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	?	
Other scallops, pectens			1	2	1	3	1	< 1	< 1	< 1	5	< 1	< 1	< 1	< 1	< 1	< 1		
55 – Scallops, pectens			**1**	**4**	**13**	**132**	**33**	**< 1**	**< 1**	**< 1**	**5**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**		
Total selected species groups			**609**	**971**	**1 254**	**1 648**	**1 410**	**1 492**	**1 373**	**1 488**	**1 459**	**1 382**	**1 142**	**1 103**	**1 047**	**1 001**	**1 068**		
Total other species groups			**67**	**162**	**226**	**363**	**386**	**332**	**333**	**308**	**321**	**362**	**258**	**287**	**270**	**269**	**281**		
Total marine capture			**676**	**1 133**	**1 480**	**2 011**	**1 796**	**1 824**	**1 706**	**1 797**	**1 781**	**1 744**	**1 400**	**1 390**	**1 317**	**1 269**	**1 349**		
Total aquaculture			**42**	**72**	**96**	**87**	**70**	**55**	**57**	**71**	**89**	**132**	**83**	**120**	**117**	**115**	**115**		
Total production			**718**	**1 205**	**1 576**	**2 097**	**1 866**	**1 879**	**1 763**	**1 867**	**1 870**	**1 876**	**1 483**	**1 510**	**1 433**	**1 384**	**1 464**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D4: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Eastern Central Atlantic (FAO Statistical Area 34), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Common sole	*Solea solea*	Portugal, Morocco, Italy, Greece	-	< 1	2	5	6	6	5	4	3	3	3	4	4	3	4	O	H
Flatfishes NEI	*Pleuronectiformes*	Spain, Morocco, Mauritania, Guinea	< 1	2	8	10	16	25	23	25	18	11	21	15	12	11	7	O	H
Tonguefishes	*Cynoglossidae*	Sierra Leone, Nigeria, Republic of Korea, Ghana	2	7	14	11	6	13	13	12	12	11	14	12	13	11	12	O	H
Other flounders, halibuts, soles			-	< 1	2	2	9	6	9	4	8	5	5	6	6	8	7	O	H
31 – Flounders, halibuts, soles			**3**	**9**	**26**	**29**	**37**	**49**	**50**	**45**	**41**	**29**	**43**	**37**	**35**	**33**	**30**		
European hake	*Merluccius merluccius*	Spain, Portugal, Morocco, Italy	2	3	9	11	9	2	6	13	18	18	15	11	11	8	9	O	L
Senegalese hake	*Merluccius senegalensis*	Spain, Senegal, Poland, Latvia	-	11	52	19	16	25	24	7	6	6	2	4	5	5	13	F	L
Other cods, hakes, haddocks			-	5	8	3	3	4	4	6	8	6	6	6	6	4	4	?	
32 – Cods, hakes, haddocks			**2**	**19**	**69**	**33**	**29**	**31**	**33**	**26**	**32**	**30**	**23**	**20**	**22**	**17**	**26**		
Bigeye grunt	*Brachydeuterus auritus*	Togo, Sierra Leone, Ghana, Côte d'Ivoire	3	11	21	26	25	22	20	17	16	36	26	27	30	30	31	F	L
Bobo croaker	*Pseudotolithus elongatus*	Sierra Leone, Guinea, Gambia, Gabon	< 1	1	3	4	10	14	11	14	19	20	20	23	16	22	22	O	L
Common dentex	*Dentex dentex*	Latvia, Greece	-	3	1	2	2	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	F	M
Croakers, drums NEI	*Sciaenidae*	Senegal, Nigeria, Morocco, Republic of Korea	3	9	24	20	22	31	31	34	33	31	38	27	31	23	25		
Mullets NEI	*Mugilidae*	Senegal, Nigeria, Mauritania, Guinea	< 1	3	11	13	16	22	20	23	26	24	23	26	26	21	21		
Threadfins, tasselfishes NEI	*Polynemidae*	Sao Tome and Principe, the Democratic Republic of the Congo	2	5	13	13	3	< 1	< 1	2	< 1	< 1	2	2	2	2	< 1		
Other miscellaneous coastal fishes			39	140	245	242	181	192	207	204	221	213	239	253	225	248	253		
33 – Miscellaneous coastal fishes			**49**	**171**	**317**	**320**	**258**	**281**	**291**	**296**	**316**	**325**	**348**	**359**	**331**	**346**	**353**		
Largehead hairtail	*Trichiurus lepturus*	Sierra Leone, Senegal, Nigeria, Morocco	< 1	5	26	58	52	17	19	23	17	14	15	13	18	12	13		
Other miscellaneous demersal fishes			< 1	12	24	26	23	22	20	18	20	24	18	23	23	30	26		
34 – Miscellaneous demersal fishes			**1**	**17**	**50**	**84**	**75**	**38**	**39**	**41**	**37**	**38**	**33**	**36**	**41**	**42**	**39**		
Bonga shad	*Ethmalosa fimbriata*	Sierra Leone, Nigeria, Guinea, Cameroon	24	44	80	126	149	162	179	184	189	184	172	195	190	222	222	F	L
European anchovy	*Engraulis encrasicolus*	Morocco, Mauritania, Latvia, Ghana	4	4	47	113	151	209	199	165	175	141	122	116	79	111	105	F	L
European pilchard (= sardine)	*Sardina pilchardus*	Russian Federation, Netherlands, Morocco, Lithuania	97	188	572	622	739	-	-	-	-	-	-	-	-	-	-	U-F	L
Madeiran sardinella	*Sardinella maderensis*	Senegal, Nigeria, Ghana, Congo	< 1	1	29	24	103	141	129	134	181	167	151	139	140	124	123	F	L
Round sardinella	*Sardinella aurita*	Senegal, Netherlands, Lithuania, Ghana	25	54	100	263	340	285	442	310	361	354	322	281	258	322	269	O	L
Other herrings, sardines, anchovies			34	57	287	88	240	387	234	217	194	173	173	201	192	174	194	F	M
35 – Herrings, sardines, anchovies			**185**	**347**	**1 114**	**1 237**	**1 721**	**1 791**	**1 992**	**1 775**	**1 834**	**1 759**	**1 667**	**1 595**	**1 477**	**1 705**	**1 801**		
Atlantic bonito	*Sarda sarda*	Togo, Senegal, Morocco, Latvia	3	3	5	5	5	6	7	9	5	6	5	7	5	6	11		
Frigate and bullet tunas	*Auxis thazard, A. rochei*	Togo, Sao Tome and Principe, Russian Federation, Cape Verde	-	2	6	13	3	2	3	2	1	2	1	1	1	2	2		
Little tunny (= Atl. black skipj.)	*Euthynnus alletteratus*	Senegal, Other NEI, Ghana, Côte d'Ivoire	-	< 1	5	14	10	8	7	11	12	13	10	6	11	9	7		
Swordfish	*Xiphias gladius*	Taiwan Province of China, Portugal, Morocco, Japan	< 1	1	2	3	4	3	4	2	5	2	3	3	4	4	3		
Tuna-like fishes NEI	*Scombroidei*	Sierra Leone, Nigeria, Mauritania, Benin	< 1	3	3	7	7	4	9	2	2	4	7	5	5	8	4		
Other tunas, bonitos, billfishes			5	14	18	14	19	26	28	23	15	13	16	16	15	14	11		
36 – Tunas, bonitos, billfishes			**8**	**23**	**40**	**55**	**47**	**50**	**58**	**50**	**40**	**39**	**43**	**38**	**40**	**43**	**39**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D4: Area 34 (Continued)

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Atlantic horse mackerel	*Trachurus trachurus*	Portugal	4	5	14	13	< 1	< 1	2						< 1	< 1	< 1	O	L
Barracudas NEI	*Sphyraena* spp.	Togo, Sierra Leone, Senegal, Nigeria	3	8	22	11	11	17	21	22	20	21	22	24	19	21	23	F	M
Chub mackerel	*Scomber japonicus*	Russian Federation, Morocco, Lithuania, Latvia	3	67	171	197	158	214	168	177	167	216	183	169	210	200	178	F	L
False scad	*Caranx rhonchus*	Ghana, Gambia			6	11	7	4	< 1	2	3	3	2	4	1	1	1	F-O	M
Jack and horse mackerels NEI	*Trachurus* spp.	Russian Federation, Poland, Lithuania, Latvia	1	78	394	304	198	238	305	250	151	245	321	231	173	239	258	O	L
Other miscellaneous pelagic fishes			6	19	78	72	68	111	101	95	77	63	66	66	75	85	63		
37 – Miscellaneous pelagic fishes			**18**	**176**	**684**	**608**	**442**	**584**	**596**	**545**	**419**	**547**	**594**	**493**	**479**	**546**	**523**		
38 – Sharks, rays, chimaeras			**4**	**13**	**33**	**28**	**36**	**53**	**52**	**53**	**54**	**53**	**60**	**53**	**55**	**59**	**68**		
39 – Marine fishes not identified			**85**	**212**	**298**	**315**	**301**	**264**	**294**	**219**	**210**	**272**	**373**	**288**	**309**	**260**	**286**		
European lobster	*Homarus gammarus*	Morocco, Greece	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Norway lobster	*Nephrops norvegicus*	Morocco	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Palinurid spiny lobsters NEI	*Palinurus* spp.	Senegal, Morocco, Gambia	< 1	2	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	O	H
Tropical spiny lobsters NEI	*Panulirus* spp.	Sierra Leone, Nigeria, Ghana, Congo	-	< 1	< 1	1	3	2	2	< 1	2	2	3	3	2	3	4	F	H
Other lobsters, spiny-rock lobsters			-	-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
43 – Lobsters, spiny-rock lobsters			**1**	**2**	**2**	**2**	**3**	**3**	**3**	**1**	**3**	**3**	**3**	**4**	**3**	**3**	**4**		
Deep-water rose shrimp	*Parapenaeus longirostris*	Spain, Senegal, Portugal, Liberia	-	-	10	8	6	6	9	5	5	2	2	2	2	1	1	F	L
Natantian decapods NEI	*Natantia*	Nigeria, Morocco, Italy, Ghana	1	2	6	9	22	19	24	37	37	27	33	33	31	18	24		
Penaeus shrimps NEI	*Penaeus* spp.	Sierra Leone, Côte d'Ivoire, Congo, Cameroon	-	-	2	2	5	9	7	5	8	5	4	5	5	4	3	O	L
Southern pink shrimp	*Penaeus notialis*	Senegal, Portugal, Nigeria, Gambia	1	2	7	9	18	25	24	17	17	14	15	14	14	14	13	O	L
Other shrimps, prawns			-	-	2	2	1		10	10	11	11	13	11	12	12	12		
45 – Shrimps, prawns			**2**	**5**	**27**	**30**	**51**	**60**	**74**	**74**	**76**	**58**	**66**	**64**	**65**	**49**	**52**		
Common octopus	*Octopus vulgaris*	Spain, Italy, Guinea-Bissau, Congo	-	12	60	44	32	13	16	9	14	10	11	12	6	7	8	O	L
Common squids NEI	*Loligo* spp.	Portugal, Italy	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-		
Cuttlefish, bobtail squids NEI	*Sepiidae, Sepiolidae*	Senegal, Morocco, Mauritania, Ghana	1	17	33	45	43	58	45	29	26	24	32	29	29	26	34	O	L
Octopuses, etc. NEI	*Octopodidae*	Senegal, Morocco, Mauritania, Greece	20	35	44	67	96	127	102	83	54	36	61	57	48	66	74	O	L
Various squids NEI	*Loliginidae, Ommastrephidae*	Spain, Senegal, Morocco, Mauritania		9	33	15	21	19	15	8	3	3	9	6	3	6	8		
Other squids, cuttlefishes, octopuses			2	4	2	1	3	1	1	2	2	1	1	1	-	2	-		
57 – Squids, cuttlefishes, octopuses			**22**	**77**	**172**	**174**	**197**	**218**	**178**	**131**	**99**	**74**	**115**	**105**	**87**	**108**	**124**		
Total selected species groups			**379**	**1 073**	**2 832**	**2 916**	**3 199**	**3 422**	**3 659**	**3 256**	**3 160**	**3 227**	**3 369**	**3 093**	**2 943**	**3 212**	**3 345**		
Total other species groups			**18**	**85**	**239**	**282**	**358**	**308**	**336**	**276**	**304**	**298**	**294**	**266**	**266**	**306**	**321**		
Total marine capture			**396**	**1 158**	**3 071**	**3 198**	**3 557**	**3 730**	**3 994**	**3 532**	**3 464**	**3 524**	**3 663**	**3 359**	**3 209**	**3 518**	**3 666**		
Total aquaculture							**1**									**7**	**9**		
Total production			**396**	**1 158**	**3 071**	**3 199**	**3 558**	**3 731**	**3 994**	**3 532**	**3 465**	**3 525**	**3 663**	**3 359**	**3 209**	**3 525**	**3 675**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D5: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Mediterranean and Black Sea (FAO Statistical Area 37), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Black and Caspian Sea sprat	*Clupeonella cultriventris*	Ukraine, Russian Federation	51	41	75	85	6	12	28	27	18	15	19	16	17	18	17	O	L
Pontic shad	*Alosa pontica*	Ukraine, Russian Federation, Romania, Bulgaria	2	2	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	O	L
Other shads			-	< 1	< 1	1	3	2	3	4	3	4	4	4	5	5	5		
24 – Shads			**54**	**44**	**77**	**87**	**10**	**14**	**31**	**31**	**21**	**18**	**23**	**21**	**22**	**24**	**22**		
Common sole	*Solea solea*	Turkey, Italy, Greece, Egypt	1	5	5	8	8	5	5	6	6	5	5	6	6	6	7	O	L
Other flounders, halibuts, soles			3	5	6	7	6	6	6	3	3	3	5	4	4	3	3		
31 – Flounders, halibuts, soles			**4**	**10**	**11**	**15**	**14**	**11**	**11**	**9**	**9**	**9**	**10**	**11**	**10**	**9**	**10**		
European hake	*Merluccius merluccius*	Spain, Italy, Greece, France	12	15	22	37	40	23	23	22	21	22	27	32	28	28	30	O	L
Whiting	*Merlangius merlangus*	Turkey, Italy, Greece, Algeria	< 1	2	10	20	19	19	11	10	9	9	10	11	15	14	13	F	M
Other cods, hakes, haddocks			8	9	11	15	23	29	31	17	14	12	15	19	16	9	10		
32 – Cods, hakes, haddocks			**20**	**27**	**43**	**72**	**82**	**70**	**65**	**49**	**44**	**42**	**53**	**63**	**59**	**51**	**53**		
Bogue	*Boops boops*	Morocco, Greece, Egypt, Algeria	12	19	23	25	28	26	24	26	27	24	30	31	29	33	30	F	L
Common dentex	*Dentex dentex*	Turkey, Libya, Italy, Greece	< 1	1	1	3	3	1	< 1	< 1	< 1	< 1	< 1	1	2	2	2		
Common pandora	*Pagellus erythrinus*	Tunisia, Spain, Libya, Algeria	< 1	1	5	8	4	6	5	5	6	5	5	5	5	7	12	O	L
Dusky grouper	*Epinephelus marginatus*	Turkey, Libya, Italy, Greece	< 1	< 1	< 1	3	5	3	3	3	2	2	2	2	1	2	1	O	L
European seabass	*Dicentrarchus labrax*	Spain, Greece, Egypt, Albania	< 1	1	2	3	3	4	4	6	6	5	3	4	4	3	3	O	M
Flathead grey mullet	*Mugil cephalus*	Tunisia, Montenegro, Libya, Greece	2	2	2	4	5	4	2	3	2	3	4	3	3	3	3	F	M
Gilthead seabream	*Sparus aurata*	Turkey, Tunisia, Spain, Egypt	< 1	2	3	3	5	5	6	7	7	7	5	5	5	6	5	O	L
Mullets NEI	*Mugilidae*	Turkey, Tunisia, Russian Federation, Egypt	10	13	14	16	28	38	35	29	25	27	25	22	22	15	15		
Picarels NEI	*Spicara* spp.	Turkey, Tunisia, Italy, Greece	10	16	17	14	14	8	9	7	7	7	10	8	7	7	7		
Porgies, seabreams NEI	*Sparidae*	Turkey, Tunisia, Lebanon, Israel	< 1	< 1	3	7	12	9	9	8	7	7	6	6	3	3	3	O	L
Red mullet	*Mullus barbatus*	Turkey, Tunisia, Italy, Greece	1	1	2	7	8	6	7	7	7	7	17	17	18	15	16	O	L
Surmullets (= red mullets) NEI	*Mullus* spp.	Spain, Libya, Egypt, Algeria	12	15	18	20	19	21	18	16	15	16	8	9	10	9	12		
Other miscellaneous coastal fishes			50	63	25	31	42	43	37	42	40	51	63	66	64	61	63		
33 – Miscellaneous coastal fishes			**101**	**137**	**116**	**144**	**178**	**173**	**160**	**159**	**153**	**162**	**177**	**179**	**173**	**165**	**174**		
34 – Miscellaneous demersal fishes			**1**	**6**	**14**	**16**	**20**	**16**	**19**	**20**	**15**	**16**	**21**	**24**	**24**	**23**	**25**		
European anchovy	*Engraulis encrasicolus*	Turkey, Italy, Georgia, Croatia	118	198	364	562	329	392	438	481	401	464	261	411	524	390	366	F	L
European pilchard (= sardine)	*Sardina pilchardus*	Turkey, Tunisia, Croatia, Algeria	102	113	170	245	235	216	200	189	179	182	204	232	213	156	198	F	L
European sprat	*Sprattus sprattus*	Ukraine, Turkey, Russian Federation, Bulgaria	2	3	17	70	28	42	64	72	69	55	59	43	40	73	92	O	M
Sardinellas NEI	*Sardinella* spp.	Tunisia, Spain, Egypt, Algeria	10	10	6	12	40	62	82	60	57	55	55	59	61	64	52	U	L
Other herrings, sardines, anchovies			4	6	9	9	11	12	11	13	14	12	13	14	18	23	12		
35 – Herrings, sardines, anchovies			**237**	**330**	**565**	**899**	**642**	**724**	**796**	**816**	**720**	**768**	**591**	**758**	**855**	**706**	**719**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D5: Area 37 (Continued)

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Plain bonito	*Orcynopsis unicolor*	Tunisia, Morocco, Algeria		< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Swordfish	*Xiphias gladius*	Spain, Morocco, Italy, Greece	2	3	5	13	14	16	15	13	17	14	15	15	15	12	12		
Other tunas, bonitos, billfishes			3	5	6	9	9	8	9	7	7	11	7	9	11	14	16		
36 – Tunas, bonitos, billfishes			**5**	**8**	**11**	**22**	**22**	**24**	**24**	**20**	**23**	**25**	**22**	**23**	**26**	**27**	**29**		
Chub mackerel	*Scomber japonicus*	Turkey, Tunisia, Morocco, Greece	1	2	4	24	27	19	14	12	19	28	25	19	14	15	12	F	M
Jack and horse mackerels NEI	*Trachurus* spp.	Tunisia, Spain, Morocco, Algeria	30	30	30	33	24	32	32	27	26	28	44	65	74	74	51	F	M
Silversides (= sand smelts) NEI	*Atherinidae*	Turkey, Tunisia, Spain, Italy	< 1	3	4	5	8	3	5	5	5	6	8	2	2	2	3	U	M
Other miscellaneous pelagic fishes			37	48	58	146	72	55	69	81	82	77	82	73	74	69	67		
37 – Miscellaneous pelagic fishes			**69**	**83**	**97**	**208**	**131**	**109**	**121**	**124**	**133**	**139**	**158**	**159**	**164**	**160**	**133**		
Common prawn	*Palaemon serratus*	Spain	-	< 1	< 1	< 1	< 1	-		< 1	< 1		< 1	< 1	< 1	< 1	< 1		
Deep-water rose shrimp	*Parapenaeus longirostris*	Turkey, Tunisia, Italy, Algeria	8	7	9	15	14	12	11	10	9	8	16	16	13	14	16	O	L
Other shrimps, prawns			4	8	5	13	16	23	19	21	22	23	26	23	21	25	27		
45 – Shrimps, prawns			**12**	**15**	**13**	**27**	**30**	**35**	**30**	**31**	**32**	**31**	**42**	**40**	**35**	**39**	**42**		
Mediterranean mussel	*Mytilus galloprovincialis*	Ukraine, Turkey, Tunisia, Greece	14	21	19	25	39	46	46	51	51	41	13	10	3	1	8		
54 – Mussels			**14**	**21**	**19**	**25**	**39**	**46**	**46**	**51**	**51**	**41**	**13**	**10**	**3**	**1**	**8**		
Striped venus	*Chamelea gallina*	Turkey, Spain, Italy, Greece	4	9	23	33	45	45	43	36	62	55	26	68	76	62	42		
Other clams, cockles, arkshells			1	1	2	1	4	3	2	3	2	2	6	6	6	5	4		
56 – Clams, cockles, arkshells			**5**	**10**	**26**	**34**	**48**	**47**	**45**	**39**	**64**	**57**	**33**	**74**	**82**	**67**	**46**		
Common cuttlefish	*Sepia officinalis*	Turkey, Tunisia, Libya, Greece	2	5	2	6	10	9	10	12	12	10	10	10	11	9	9	U	L
Common octopus	*Octopus vulgaris*	Tunisia, Italy, Greece, France	5	8	11	17	18	15	15	16	14	16	13	12	11	8	9	F	M
Common squids NEI	*Loligo* spp.	Spain, Libya, Italy, Greece	4	8	7	8	7	4	5	4	4	5	6	6	6	6	6	U	M
Other squids, cuttlefishes, octopuses			10	20	26	31	28	26	24	22	17	21	38	40	46	39	38		
57 – Squids, cuttlefishes, octopuses			**21**	**42**	**46**	**62**	**63**	**54**	**54**	**54**	**46**	**51**	**67**	**68**	**73**	**62**	**62**		
Total selected species groups			**543**	**733**	**1 039**	**1 611**	**1 280**	**1 325**	**1 401**	**1 403**	**1 310**	**1 359**	**1 211**	**1 429**	**1 525**	**1 335**	**1 323**		
Total other species groups			**217**	**192**	**178**	**231**	**219**	**192**	**182**	**169**	**169**	**151**	**232**	**190**	**162**	**155**	**157**		
Total marine capture			**760**	**924**	**1 217**	**1 842**	**1 499**	**1 517**	**1 583**	**1 572**	**1 479**	**1 510**	**1 442**	**1 619**	**1 687**	**1 490**	**1 479**		
Total aquaculture			**2**	**9**	**40**	**87**	**220**	**339**	**350**	**312**	**348**	**292**	**388**	**394**	**408**	**380**	**400**		
Total production			**763**	**934**	**1 257**	**1 929**	**1 720**	**1 857**	**1 934**	**1 884**	**1 827**	**1 802**	**1 830**	**2 014**	**2 095**	**1 869**	**1 880**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D6: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Southwest Atlantic (FAO Statistical Area 41), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
31 – Flounders, halibuts, soles			**< 1**	**1**	**4**	**8**	**12**	**9**	**9**	**8**	**9**	**9**	**10**	**11**	**10**	**11**	**10**		
Argentine hake	*Merluccius hubbsi*	Uruguay, Spain, Falkland Islands (Malvinas), Argentina	26	142	231	366	535	247	307	412	380	481	423	407	347	316	331	O	L
Patagonian grenadier	*Macruronus magellanicus*	Spain, Japan, Falkland Islands (Malvinas), Argentina	-	-	4	37	54	143	136	127	123	146	136	146	117	128	135	U	L
Southern blue whiting	*Micromesistius australis*	Spain, Japan, Falkland Islands (Malvinas), Argentina	-	-	19	117	131	84	79	62	61	79	54	52	41	33	32	O	L
Southern hake	*Merluccius australis*	Spain, Argentina	-	-	< 1	1	4	7	5	5	7	6	4	3	3	3	3	F-O	M
Other cods, hakes, haddocks			-	< 1	5	30	16	30	22	20	23	18	16	17	22	33	29		
32 – Cods, hakes, haddocks			**26**	**142**	**259**	**551**	**739**	**511**	**548**	**626**	**594**	**729**	**632**	**625**	**530**	**513**	**531**		
Argentine croaker	*Umbrina canosai*	Uruguay, Brazil, Argentina	2	4	4	10	12	9	17	18	15	17	9	20	17	16	18	F-O	M
Striped weakfish	*Cynoscion striatus*	Uruguay, Argentina	1	4	9	21	24	23	23	20	14	27	19	25	25	26	20	F-O	L
Weakfishes NEI	*Cynoscion* spp.	Brazil	8	19	39	48	31	44	44	9	8	9	7	12	19	6	7		
Whitemouth croaker	*Micropogonias furnieri*	Uruguay, Brazil, Argentina	28	40	69	73	65	58	74	75	82	77	80	101	98	91	96	F-O	L
Other miscellaneous coastal fishes			34	64	98	100	81	113	117	114	108	114	124	129	126	141	168		
33 – Miscellaneous coastal fishes			**73**	**132**	**219**	**252**	**213**	**247**	**275**	**236**	**228**	**243**	**240**	**287**	**285**	**280**	**308**		
Patagonian toothfish	*Dissostichus eleginoides*	Uruguay, Republic of Korea, Falkland Islands (Malvinas), Argentina	-	-	< 1	< 1	9	11	14	12	9	7	5	6	8	5	5	O	L
Pink cusk-eel	*Genypterus blacodes*	Spain, Republic of Korea, Falkland Islands (Malvinas), Argentina	3	2	3	12	26	18	23	20	16	19	21	24	25	20	21	O	L
Other miscellaneous demersal fishes			< 1	40	17	16	26	27	28	27	19	22	34	49	54	88	58		
34 – Miscellaneous demersal fishes			**4**	**43**	**20**	**29**	**61**	**55**	**64**	**59**	**44**	**48**	**60**	**78**	**86**	**113**	**84**		
Argentine anchovy	*Engraulis anchoita*	Argentina	9	15	24	18	19	12	13	21	29	39	44	44	28	23	28	U	L
Brazilian sardinella	*Sardinella brasiliensis*	Brazil	28	66	155	112	68	17	40	22	25	53	43	54	56	75	83	O	L
Other herrings, sardines, anchovies			5	7	14	13	14	30	37	35	32	32	26	32	38	31	34		
35 – Herrings, sardines, anchovies			**43**	**87**	**193**	**143**	**101**	**59**	**90**	**79**	**86**	**125**	**112**	**130**	**121**	**129**	**145**		
Swordfish	Xiphias gladius	Uruguay, Spain, Japan, Brazil	< 1	1	1	2	8	11	9	9	7	8	8	10	8	6	8		
Other tunas, bonitos, billfishes			< 1	7	8	11	8	6	5	11	12	4	4	5	3	18	20		
36 – Tunas, bonitos, billfishes			**< 1**	**8**	**9**	**13**	**17**	**17**	**14**	**20**	**19**	**12**	**12**	**15**	**12**	**24**	**27**		
37 – Miscellaneous pelagic fishes			**20**	**36**	**39**	**58**	**38**	**43**	**36**	**48**	**40**	**41**	**50**	**48**	**57**	**58**	**63**		
38 – Sharks, rays, chimaeras			**6**	**18**	**31**	**43**	**53**	**62**	**68**	**62**	**71**	**73**	**77**	**77**	**82**	**85**	**83**		
39 – Marine fishes not identified			**18**	**15**	**64**	**179**	**95**	**83**	**81**	**82**	**72**	**79**	**79**	**78**	**71**	**48**	**56**		
42 – Crabs, sea-spiders			**2**	**11**	**14**	**19**	**16**	**18**	**17**	**17**	**17**	**15**	**18**	**13**	**11**	**12**	**13**		
43 – Lobsters, spiny-rock lobsters			**< 1**	**3**	**8**	**8**	**9**	**6**	**7**	**7**	**6**	**9**	**7**	**7**	**6**	**7**	**7**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D6: Area 41 (Continued)

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Argentine red shrimp	*Pleoticus muelleri*	Argentina	2	< 1	< 1	10	14	37	79	51	53	27	8	44	48	47	54	F	L
Other shrimps, prawns			18	33	51	54	39	40	31	42	40	33	39	39	44	38	41	F-O	M
45 – Shrimps, prawns			**20**	**34**	**51**	**64**	**54**	**77**	**110**	**94**	**93**	**60**	**46**	**83**	**92**	**85**	**94**		
Argentine shortfin squid	*Illex argentinus*	Taiwan Province of China, Republic of Korea, China, Argentina	< 1	1	20	242	675	985	750	540	504	179	288	704	955	838	261	F-O	M
Patagonian squid	*Loligo gahi*	United Kingdom, Spain, Falkland Islands (Malvinas), Argentina	-	< 1	< 1	28	55	68	58	30	49	30	61	43	45	54	35	F	M
Various squids NEI	*Loliginidae, Ommastrephidae*	Spain	-	6	7	79	26	-	-	-	-	-	-	-	-	-	< 1	F	M
Other squids, cuttlefishes, octopuses			< 1	< 1	< 1	22	16	3	3	6	2	4	4	4	4	4	4		
57 – Squids, cuttlefishes, octopuses			**< 1**	**8**	**28**	**370**	**773**	**1 056**	**811**	**576**	**555**	**212**	**352**	**751**	**1 004**	**896**	**301**		
Total selected species groups			**215**	**539**	**939**	**1 737**	**2 181**	**2 243**	**2 130**	**1 915**	**1 833**	**1 655**	**1 695**	**2 203**	**2 368**	**2 260**	**1 722**		
Total other species groups			**10**	**21**	**3**	**46**	**69**	**98**	**106**	**145**	**155**	**140**	**140**	**169**	**139**	**144**	**172**		
Total marine capture			**224**	**560**	**942**	**1 783**	**2 250**	**2 342**	**2 236**	**2 060**	**1 987**	**1 795**	**1 836**	**2 372**	**2 506**	**2 404**	**1 895**		
Total aquaculture							**3**	**13**	**13**	**11**	**11**	**13**	**15**	**16**	**14**	**13**	**13**		
Total production			**224**	**560**	**942**	**1 783**	**2 253**	**2 355**	**2 249**	**2 071**	**1 998**	**1 809**	**1 851**	**2 388**	**2 520**	**2 417**	**1 908**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D7: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Southeast Atlantic (FAO Statistical Area 47), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Cape hakes	*Merluccius capensis, M. paradox.*	Spain, South Africa, Portugal, Namibia	68	320	736	457	263	309	323	306	337	331	303	271	270	262	248	F,O	M
Other cods, hakes, haddocks			< 1	< 1	13	6	< 1	< 1	2	3	1	2	2	2	6	3	7		
32 – Cods, hakes, haddocks			**68**	**320**	**750**	**463**	**263**	**310**	**325**	**310**	**338**	**333**	**304**	**272**	**275**	**264**	**256**		
Geelbek croaker	*Atractoscion aequidens*	South Africa	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	O	L
Panga seabream	*Pterogymnus laniarius*	South Africa, Namibia	3	3	8	2	1	10	7	4	4	4	3	3	2	2	2		
Red steenbras	*Petrus rupestris*	South Africa			< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	O	L
Other miscellaneous coastal fishes			23	51	46	37	23	38	54	70	75	72	69	81	77	109	106	O,O,F	
33 – Miscellaneous coastal fishes			**25**	**54**	**54**	**39**	**25**	**48**	**62**	**74**	**80**	**77**	**73**	**84**	**79**	**111**	**109**		
Devil anglerfish	*Lophius vomerinus*	Spain, South Africa		< 1	6	14	16	21	22	24	19	18	19	17	8	16	7	O	H
Kingklip	*Genypterus capensis*	South Africa, Namibia	1	2	11	11	5	8	11	13	11	12	10	8	8	6	7	O	
Snoek	*Thyrsites atun*	Spain, South Africa, Namibia	14	11	12	18	17	11	12	13	12	17	16	8	11	11	12	F	M
Other miscellaneous demersal fishes			3	9	50	41	21	12	10	20	25	17	18	18	17	8	8		
34 – Miscellaneous demersal fishes			**19**	**23**	**79**	**85**	**58**	**52**	**56**	**70**	**68**	**65**	**63**	**52**	**44**	**42**	**34**		
Sardinellas NEI	*Sardinella* spp.	Angola	49	69	132	170	40	114	58	30	47	59	46	50	67	68	74	U/F	L
Southern African anchovy	*Engraulis capensis*	South Africa, Namibia	-	212	448	476	185	268	289	255	261	192	283	135	253	266	174	F	L
Southern African pilchard	*Sardinops ocellatus*	South Africa, Namibia	364	991	437	85	156	161	200	265	312	402	274	220	177	114	108	F/O	M
Whitehead's round herring	*Etrumeus whiteheadi*	South Africa		8	27	41	60	39	57	64	44	52	29	48	53	66	41	U	L
Other herrings, sardines, anchovies			< 1	< 1	22	5	< 1	-	-	-	-	-	-	-	-	-	-		
35 – Herrings, sardines, anchovies			**412**	**1 280**	**1 066**	**778**	**442**	**582**	**605**	**614**	**664**	**705**	**633**	**453**	**549**	**514**	**397**		
Other tunas, bonitos, billfishes			11	12	11	11	12	11	12	10	11	10	14	13	17	10	15		
36 – Tunas, bonitos, billfishes			**11**	**12**	**11**	**11**	**12**	**11**	**12**	**10**	**11**	**10**	**14**	**13**	**17**	**10**	**15**		
Cape horse mackerel	*Trachurus capensis*	Spain, South Africa, Namibia	75	82	349	584	511	424	354	386	405	353	360	335	233	223	233	F	M
Cunene horse mackerel	*Trachurus trecae*	Angola	66	124	170	94	91	70	47	45	30	35	30	34	32	44	14	O	L
Other miscellaneous pelagic fishes			41	89	126	90	15	8	13	9	21	12	15	14	10	11	14		
37 – Miscellaneous pelagic fishes			**182**	**295**	**644**	**768**	**617**	**502**	**414**	**441**	**456**	**400**	**405**	**383**	**276**	**279**	**261**		
39 – Marine fishes not identified			**104**	**89**	**97**	**98**	**69**	**47**	**91**	**91**	**39**	**54**	**33**	**48**	**75**	**55**	**46**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D7: Area 47 (Continued)

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
West African geryon	*Chaceon maritae*		-	-	5	6	6	6	4	4	3	4	4	3	5	2	-	O	M
Other crabs, sea-spiders			-	-	< 1	< 1	< 1	1	1	2	1	2	< 1	< 1	< 1	< 1	< 1		
42 – Crabs, sea-spiders			**< 1**	**< 1**	**5**	**6**	**7**	**7**	**5**	**5**	**4**	**5**	**5**	**3**	**5**	**2**	**< 1**		
Cape rock lobster	*Jasus lalandii*	South Africa, Namibia	20	16	9	7	2	2	2	3	3	3	3	2	3	2	2	O	L
Southern spiny lobster	*Palinurus gilchristi*		-	-	1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	F	L
Other lobsters, spiny-rock lobsters			< 1	< 1	< 1	< 1	< 1	< 1	1	1	1	1	< 1	< 1	< 1	< 1	1		
43 – Lobsters, spiny-rock lobsters			**20**	**16**	**11**	**8**	**4**	**3**	**5**	**5**	**4**	**5**	**5**	**4**	**5**	**3**	**4**		
45 – Shrimps, prawns			**< 1**	**< 1**	**6**	**4**	**6**	**10**	**13**	**6**	**5**	**3**	**3**	**3**	**4**	**2**	**< 1**	F/O	M
Perlemoen abalone	*Haliotis midae*		< 1	2	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-	O	L
52 – Abalones, winkles, conchs			**< 1**	**2**	**1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**		
53 – Oysters			**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**		
Cape Hope squid	*Loligo reynaudi*		< 1	< 1	1	4	6	6	3	7	8	7	10	7	10	8	10	F	L
Other squids, cuttlefishes, octopuses				< 1	< 1	< 1	< 1	< 1	< 1	2	1	1	1	1	2	< 1	1	F	M
57 – Squids, cuttlefishes, octopuses			**< 1**	**< 1**	**2**	**4**	**7**	**6**	**4**	**9**	**9**	**8**	**12**	**8**	**12**	**9**	**12**		
Total selected species groups			**843**	**2 092**	**2 719**	**2 260**	**1 504**	**1 568**	**1 578**	**1 629**	**1 674**	**1 662**	**1 546**	**1 320**	**1 337**	**1 289**	**1 133**		
Total other species groups			**3**	**- 43**	**41**	**58**	**53**	**68**	**73**	**67**	**63**	**71**	**53**	**60**	**103**	**70**	**61**		
Total marine capture			**846**	**2 049**	**2 760**	**2 318**	**1 557**	**1 637**	**1 651**	**1 696**	**1 736**	**1 733**	**1 598**	**1 381**	**1 440**	**1 359**	**1 194**		
Total aquaculture							**3**	**1**	**1**	**2**	**4**	**4**	**4**	**4**	**4**	**3**	**3**		
Total production			**846**	**2 049**	**2 760**	**2 319**	**1 560**	**1 637**	**1 652**	**1 698**	**1 740**	**1 736**	**1 602**	**1 385**	**1 444**	**1 362**	**1 198**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D8: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Southern Atlantic Ocean (FAO Statistical Area 48), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Antarctic rockcods, noties NEI	*Nototheniidae*		-	-	< 1	< 1	< 1	-	-	< 1	-	-	-	-	-	-	-		
Humped rockcod	*Nothothenia gibberifrons*	United Kingdom	-	-	4	5	< 1	< 1	< 1	< 1	-	-	-	< 1	< 1	< 1	< 1		
Marbled rockcod	*Notothenia rossii*	United Kingdom	-	18	54	5	< 1	-	-	< 1		< 1	< 1	< 1	< 1	< 1	< 1		
Other miscellaneous coastal fishes			-	-	< 1	< 1	< 1	< 1	< 1	-	-	< 1		< 1	< 1	-	-		
33 – Miscellaneous coastal fishes			**-**	**18**	**60**	**12**	< 1	< 1	< 1	< 1	0	< 1	< 1	< 1	< 1	< 1	< 1		
Blackfin icefish	*Chaenocephalus aceratus*		-	0	< 1	< 1	< 1	-	< 1	< 1	< 1	< 1	< 1	< 1	-	< 1	-		
Lanternfishes NEI	*Myctophidae*		-	0	0	5	< 1	< 1	-	-	-	-	< 1	-	-	-	-	U/F	M
Mackerel icefish	*Champsocephalus gunnari*		-	-	32	47	1	4	< 1	3	2	3	< 1	2	4	2	2	O	M
Patagonian toothfish	*Dissostichus eleginoides*	United Kingdom, Spain, New Zealand, Chile	-	-	< 1	1	3	5	4	6	8	5	3	4	4	4	3	F	M
South Georgia icefish	*Pseudochaenichthys georgianus*	United Kingdom, Norway	-	0	2	< 1	< 1	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Other miscellaneous demersal fishes			-	0	3	19	13	-	< 1	-	-	-	< 1	< 1	< 1	< 1	< 1		
34 – Miscellaneous demersal fishes			**-**	**0**	**38**	**74**	**18**	**9**	**5**	**8**	**10**	**7**	**3**	**6**	**8**	**6**	**6**		
Antarctic krill	*Euphausia superba*	Russian Federation, Norway, Republic of Korea, Japan	-	-	48	304	160	114	104	126	118	118	129	107	105	157	126	U-F	M
46 – Krill, planktonic crustaceans			**-**	**0**	**48**	**304**	**160**	**114**	**104**	**126**	**118**	**118**	**129**	**107**	**105**	**157**	**126**		
Total selected species groups			**-**	**18**	**146**	**390**	**178**	**124**	**109**	**134**	**127**	**126**	**133**	**113**	**113**	**163**	**131**		
Total other species groups			**-**	**-**	**4**	**7**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**		
Total marine capture			**-**	**18**	**150**	**397**	**178**	**124**	**109**	**135**	**127**	**126**	**133**	**113**	**113**	**163**	**132**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D9: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Western Indian Ocean (FAO Statistical Area 51), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Bombay-duck	*Harpadon nehereus*	Pakistan, India	67	83	108	100	146	133	141	100	102	135	159	153	185	219	178	F	M
Croakers, drums NEI	*Sciaenidae*	Pakistan, Oman, Iran (Islamic Republic of), India	29	29	70	134	272	266	242	270	257	225	223	224	195	188	212	F	H
Emperors (= scavengers) NEI	*Lethrinidae*	United Arab Emirates, Saudi Arabia, Qatar, Oman	3	11	17	27	44	57	62	61	60	60	57	53	56	57	62	F	L
Lizardfishes NEI	*Synodontidae*	Saudi Arabia, India, Eritrea, Egypt	< 1	3	5	8	20	18	12	12	11	14	10	13	11	7	16		
Mullets NEI	*Mugilidae*	Pakistan, Iraq, India, Egypt	< 1	1	6	10	23	21	22	21	21	22	20	21	24	23	25		
Sea catfishes NEI	*Ariidae*	United Arab Emirates, Pakistan, Iran (Islamic Republic of), India	26	29	56	49	76	77	88	88	76	77	77	79	91	109	95		
Other miscellaneous coastal fishes			20	44	67	107	179	276	276	291	262	257	255	271	299	290	284		
33 – Miscellaneous coastal fishes			**146**	**200**	**330**	**434**	**760**	**849**	**843**	**845**	**790**	**789**	**801**	**813**	**861**	**893**	**871**		
Demersal percomorphs NEI	*Perciformes*	Yemen, Seychelles, Oman, Kenya	9	15	27	26	16	13	16	23	18	19	19	20	21	15	17	F	M
Hairtails, scabbardfishes NEI	*Trichiuridae*	Oman, Republic of Korea, India	23	15	29	42	61	110	91	128	102	97	102	117	88	68	84		
Largehead hairtail	*Trichiurus lepturus*	Pakistan, Iran (Islamic Republic of)	-	< 1	< 1	4	12	32	30	32	28	27	27	27	25	28	27		
Other miscellaneous demersal fishes			26	5	14	11	17	16	20	16	11	9	13	11	18	29	26		
34 – Miscellaneous demersal fishes			**58**	**35**	**70**	**82**	**106**	**172**	**157**	**199**	**158**	**152**	**160**	**175**	**152**	**139**	**155**		
Anchovies, etc. NEI	*Engraulidae*	Zanzibar, Pakistan, India, Comoros	14	15	36	51	80	77	80	82	98	83	77	78	80	76	74	F	L
Clupeoids NEI	*Clupeoidei*	Zanzibar, Pakistan, Iran (Islamic Republic of), India	28	37	32	47	96	64	63	69	65	57	65	63	62	60	57		
Dorab wolf-herring	*Chirocentrus dorab*	Pakistan	-	-	3	4	1	3	3	3	2	2	1	1	1	1	1		
Indian oil sardine	*Sardinella longiceps*	Pakistan, Oman, Iran (Islamic Republic of), India	64	215	202	241	192	369	402	343	361	357	334	351	356	365	360	U	L
Sardinellas NEI	*Sardinella* spp.	Zanzibar, United Republic of Tanzania, Egypt, Comoros	3	7	16	17	21	28	26	25	25	26	26	13	21	22	21		
Wolf-herrings NEI	*Chirocentrus* spp.	India	2	5	6	11	10	7	8	13	7	7	9	11	13	9	11		
Other herrings, sardines, anchovies			-	-	< 1	< 1	6	6	4	4	5	5	6	4	8	11	11		
35 – Herrings, sardines, anchovies			**110**	**279**	**294**	**372**	**407**	**554**	**586**	**539**	**564**	**536**	**519**	**521**	**541**	**543**	**536**		
Kawakawa	*Euthynnus affinis*	Yemen, Maldives, Iran (Islamic Republic of), India	< 1	< 1	2	21	34	45	41	47	47	37	44	38	49	54	52		
Narrow-barred Spanish mackerel	*Scomberomorus commerson*	Pakistan, Madagascar, Iran (Islamic Republic of), India	6	11	11	47	56	64	59	60	64	53	57	53	63	65	64	F-O	H
Tuna-like fishes NEI	*Scombroidei*	Zanzibar, United Republic of Tanzania, Pakistan, Comoros	1	5	14	14	15	10	8	8	7	8	8	10	9	10	9		
Other tunas, bonitos, billfishes			10	35	47	69	120	163	155	151	154	145	139	143	172	167	175		
36 – Tunas, bonitos, billfishes			**17**	**52**	**74**	**151**	**225**	**282**	**264**	**266**	**271**	**243**	**247**	**244**	**292**	**297**	**300**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D9: Area 51 (continued)

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes 1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	State of exploitation*	Uncertainty**
Barracudas NEI	*Sphyraena* spp.	Yemen, Pakistan, Oman, Iran (Islamic Republic of)	1	2	4	9	16	16	14	21	24	23	24	26	25	28	29	F	L
Butterfishes, pomfrets NEI	*Stromateidae*	Pakistan, Kuwait, India	13	18	25	31	27	14	13	23	16	14	28	22	26	27	32	O	L
Carangids NEI	*Carangidae*	United Arab Emirates, Pakistan, Oman, India	2	7	18	37	58	38	35	57	62	54	48	57	68	64	78		
Chub mackerel	*Scomber japonicus*	South Africa, Egypt	-	-	< 1	< 1	1	4	3	2	3	1	< 1	< 1	1	< 1	< 1		
Indian mackerel	*Rastrelliger kanagurta*	Yemen, Pakistan, Oman, India	72	52	93	63	160	78	48	59	52	97	95	94	129	102	116	F	M
Indian mackerels NEI	*Rastrelliger* spp.	Seychelles, Comoros		2	1	11	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	F	L
Jacks, crevalles NEI	*Caranx* spp.	Yemen, Pakistan, Oman, India	10	11	14	18	66	37	44	41	69	45	45	51	49	55	55		
Mackerels NEI			-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		-	-	-		
Pelagic percomorphs NEI	*Perciformes*	Yemen, Oman, Kenya	50	68	167	100	59	53	64	89	119	120	106	107	68	39	37		
Pompanos NEI	*Trachinotus* spp.	India	-	< 1	< 1	5	18	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Other miscellaneous pelagic fishes			< 1	10	24	24	34	53	51	60	65	68	72	81	79	80	71		
37 – Miscellaneous pelagic fishes			**149**	**171**	**347**	**297**	**440**	**293**	**273**	**352**	**410**	**423**	**419**	**440**	**445**	**397**	**418**		
39 – Marine fishes not identified			**70**	**109**	**229**	**443**	**636**	**502**	**651**	**661**	**729**	**733**	**698**	**708**	**599**	**662**	**764**		
Indian white prawn			-	-	-	1	1	-	-	-	-	-	< 1	-	< 1	-	-	O	M
Knife shrimp	*Haliporoides triarthrus*	Mozambique	-	< 1	< 1	3	2	2	2	2	1	1	2	2	1	1	< 1	O	M
Natantian decapods NEI	*Natantia*	Madagascar, Kuwait, Iran (Islamic Republic of), India	95	82	185	173	120	118	144	146	148	142	144	130	130	119	133	F	H
Penaeus shrimps NEI	*Penaeus* spp.	Yemen, United Republic of Tanzania, Pakistan, Mozambique	4	11	17	21	21	19	20	20	23	19	20	16	15	13	11	F	H
Other shrimps, prawns			< 1	10	14	36	154	172	124	149	156	139	152	160	154	159	146		
45 – Shrimps, prawns			**101**	**103**	**217**	**235**	**301**	**312**	**290**	**316**	**329**	**302**	**318**	**307**	**301**	**293**	**290**		
Total selected species groups			**651**	**950**	**1 561**	**2 014**	**2 875**	**2 963**	**3 065**	**3 177**	**3 252**	**3 178**	**3 162**	**3 208**	**3 190**	**3 224**	**3 335**		
Total other species groups			**74**	**138**	**219**	**372**	**834**	**1 012**	**965**	**1 112**	**1 195**	**1 202**	**1 280**	**1 249**	**984**	**878**	**816**		
Total marine capture			**725**	**1 088**	**1 781**	**2 385**	**3 709**	**3 975**	**4 030**	**4 289**	**4 447**	**4 380**	**4 442**	**4 457**	**4 174**	**4 102**	**4 151**		
Total aquaculture							**32**	**54**	**86**	**117**	**104**	**82**	**86**	**99**	**104**	**139**	**134**		
Total production			**725**	**1 088**	**1 781**	**2 386**	**3 741**	**4 029**	**4 116**	**4 406**	**4 551**	**4 462**	**4 528**	**4 557**	**4 279**	**4 241**	**4 285**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D10: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Eastern Indian Ocean (FAO Statistical Area 57), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes 1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	State of exploitation*	Uncertainty**
Chacunda gizzard shad	*Anodontostoma chacunda*	Malaysia, Indonesia	-	< 1	< 1	2	2	3	3	2	2	3	4	5	6	4	3	U	H
Diadromous clupeoids NEI	*Clupeoidei*	Malaysia	-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Hilsa shad	*Tenualosa ilisha*	Bangladesh	-	-	-	88	126	140	155	152	136	185	198	199	197	200	203	U	H
Indian pellona	*Pellona ditchela*	Malaysia	-	-	< 1	3	7	7	7	7	6	6	10	13	13	10	10		
Kelee shad	*Hilsa kelee*	India	9	5	9	18	40	44	45	44	37	38	27	27	17	17	14	O	M
Toli shad	*Tenualosa toli*	Indonesia	-	-	< 1	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1	1	< 1	2	2		
24 – Shads			**9**	**5**	**10**	**112**	**176**	**194**	**210**	**207**	**183**	**232**	**240**	**244**	**233**	**231**	**232**		
Croakers, drums NEI	*Sciaenidae*	Thailand, Malaysia, Indonesia, India	18	12	33	46	74	86	82	91	87	90	78	83	96	110	103	F	H
Mullets NEI	*Mugilidae*	Thailand, Malaysia, Indonesia, India	3	4	6	17	27	32	31	28	28	29	30	32	49	33	40		
Percoids NEI	*Percoidei*	India	4	5	9	24	29	36	38	29	32	37	31	34	40	52	60		
Ponyfishes (= slipmouths) NEI	*Leiognathidae*	Indonesia, India	11	18	32	41	61	61	65	62	66	61	63	68	66	60	60	F	H
Sea catfishes NEI	*Ariidae*	Malaysia, Indonesia, India, Bangladesh	7	9	23	34	62	70	72	60	55	59	63	68	78	110	100	F	H
Threadfin breams NEI	*Nemipterus* spp.	Thailand, Malaysia, Indonesia	< 1	1	6	12	38	50	42	47	42	46	43	48	53	37	38	F	H
Other miscellaneous coastal fishes	*Arripis trutta*		14	19	45	68	164	225	212	233	257	250	224	236	246	271	319		
33 – Miscellaneous coastal fishes			**57**	**69**	**154**	**243**	**456**	**561**	**541**	**550**	**568**	**572**	**533**	**569**	**627**	**672**	**719**		
Hairtails, scabbardfishes NEI	*Trichiuridae*	Indonesia, India	19	13	27	31	28	39	29	33	33	27	37	39	50	47	46	F	H
Largehead hairtail	*Trichiurus lepturus*	Thailand, Malaysia	< 1	< 1	2	3	12	11	10	11	10	11	11	12	12	8	8	F	H
Snoek	*Thyrsites atun*	Australia	2	2	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Other miscellaneous demersal fishes			9	11	16	18	25	35	37	36	40	36	29	29	31	31	33		
34 – Miscellaneous demersal fishes			**30**	**28**	**46**	**53**	**66**	**85**	**77**	**80**	**84**	**75**	**77**	**80**	**92**	**86**	**87**		
Anchovies, etc. NEI	*Engraulidae*	Thailand, India	13	18	19	29	49	40	39	36	35	43	36	46	55	66	62	F	H
Clupeoids NEI	*Clupeoidei*	Sri Lanka, Malaysia, India, Australia	39	56	70	71	76	89	97	102	108	117	99	115	146	155	156	U-F	H
Indian oil sardine	*Sardinella longiceps*	India	< 1	< 1	33	56	60	50	55	18	13	25	27	27	29	64	62	O	M
Sardinellas NEI	*Sardinella* spp.	Thailand			4	24	41	42	34	21	16	17	17	19	16	18	17	O	M
Stolephorus anchovies NEI	*Stolephorus* spp.	Malaysia, Indonesia	9	17	32	58	72	81	78	75	71	56	53	59	61	74	74	F	H
Other herrings, sardines, anchovies			4	7	28	67	115	110	108	133	136	115	114	175	189	179	180		
35 – Herrings, sardines, anchovies			**66**	**98**	**187**	**305**	**414**	**413**	**411**	**384**	**377**	**373**	**346**	**441**	**496**	**555**	**551**		
Kawakawa	*Euthynnus affinis*	Thailand, Malaysia, Indonesia, India	1	2	8	26	49	65	55	61	62	67	54	80	71	77	72	U	H
Narrow-barred Spanish mackerel	*Scomberomorus commerson*	Sri Lanka, Indonesia, India, Australia	4	8	10	15	26	36	36	35	35	42	36	53	43	37	37	U	H
Seerfishes NEI	*Scomberomorus* spp.	Thailand, Malaysia, Bangladesh	3	6	13	9	8	8	9	11	12	12	12	16	12	12	12	F	H
Tuna-like fishes NEI	*Scombroidei*	Timor-Leste, Sri Lanka, Portugal, Australia	2	5	7	7	10	15	15	15	14	13	5	10	13	14	15		
Other tunas, bonitos, billfishes			21	43	42	83	133	176	155	165	161	187	147	170	162	159	174	F	H
36 – Tunas, bonitos, billfishes			**32**	**64**	**80**	**140**	**227**	**301**	**270**	**288**	**284**	**321**	**254**	**330**	**301**	**298**	**310**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D10: Area 57 (continued)

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes 1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	State of exploitation*	Uncertainty**
Butterfishes, pomfrets NEI	*Stromateidae*	Malaysia, India	3	4	7	18	20	15	16	17	16	22	16	17	26	24	22	F	H
Carangids NEI	*Carangidae*	Thailand, Sri Lanka, Malaysia, India	2	8	13	26	29	34	32	34	37	43	38	44	63	37	46	F	H
Indian mackerel	*Rastrelliger kanagurta*	Thailand, Indonesia, India	6	4	12	19	47	30	31	30	31	42	50	47	45	47	50	F	H
Indian mackerels NEI	*Rastrelliger* spp.	Thailand, Malaysia	12	28	24	68	110	98	101	86	132	143	147	133	174	167	184	F	H
Indian scad	*Decapterus russelli*	Thailand, Malaysia	4	5	7	20	34	30	31	48	52	55	60	62	58	60	50	F	H
Jacks, crevalles NEI	*Caranx* spp.	Indonesia, India	8	9	9	17	23	29	27	31	29	25	28	32	36	35	45	F	H
Scads NEI	*Decapterus* spp.	Indonesia	< 1	1	5	22	36	45	43	49	37	33	36	45	48	50	50	F	H
Torpedo scad	*Megalaspis cordyla*	Thailand, Malaysia, Indonesia	2	3	7	14	26	24	25	27	22	22	37	37	36	35	45		
Other miscellaneous pelagic fishes			7	18	54	105	173	213	199	202	214	190	188	212	224	314	300		
37 – Miscellaneous pelagic fishes			**45**	**80**	**138**	**309**	**498**	**517**	**505**	**524**	**571**	**577**	**600**	**629**	**710**	**770**	**794**		
Rays, stingrays, mantas NEI	*Rajiformes*	Thailand, Malaysia, Australia	1	3	6	11	20	22	22	23	22	23	12	10	9	9	8	O	M
Silky shark	*Carcharhinus falciformis*	Sri Lanka	-	8	10	13	17	10	8	7	4	3	2	2	< 1	< 1	< 1	O	M
Other sharks, rays, chimaeras	*Squatinidae*	0	16	24	37	51	77	107	105	101	111	126	84	87	113	92	97		
38 – Sharks, rays, chimaeras			**18**	**36**	**53**	**75**	**114**	**139**	**135**	**131**	**137**	**152**	**98**	**99**	**124**	**102**	**105**		
39 – Marine fishes not identified			**215**	**409**	**683**	**1 074**	**1 549**	**2 007**	**1 990**	**2 270**	**2 386**	**2 470**	**2 545**	**2 588**	**2 548**	**2 612**	**2 883**	U-F	H
Banana prawn	*Penaeus merguiensis*	Thailand, Indonesia, Australia	2	4	6	9	15	24	17	23	25	19	19	19	21	26	31	F	H
Giant tiger prawn	*Penaeus monodon*	Thailand, Indonesia, India, Australia	1	2	1	6	40	66	68	55	59	78	70	71	85	102	79	F	H
Natantian decapods NEI	*Natantia*	Myanmar, Malaysia, Indonesia, India	22	30	69	99	114	148	102	93	98	114	83	98	123	137	140		
Penaeus shrimps NEI	*Penaeus* spp.	Thailand, Australia	< 1	3	9	12	17	16	20	14	14	14	13	12	10	9	9	F	H
Sergestid shrimps NEI	*Sergestidae*	Thailand, Malaysia		< 1	1	13	13	10	8	7	7	6	5	5	12	26	26	O	H
45 – Shrimps, prawns			**26**	**39**	**87**	**139**	**198**	**264**	**215**	**192**	**203**	**230**	**188**	**206**	**250**	**301**	**285**		
Cephalopods NEI	*Cephalopoda*	Timor-Leste, India	< 1	< 1	< 1	11	10	10	9	11	14	13	12	12	11	12	13	O	H
Common squids NEI	*Loligo* spp.	Thailand, Indonesia	< 1	< 1	4	9	24	31	28	29	24	25	22	24	28	30	30	F	H
Cuttlefish, bobtail squids NEI	*Sepiidae, Sepiolidae*	Thailand, Sri Lanka, Malaysia, Indonesia	< 1	1	7	9	27	38	36	38	35	39	29	32	34	25	26	F	H
Octopuses, etc. NEI	*Octopodidae*	Thailand, Malaysia, Indonesia, Australia			< 1	< 1	9	14	16	15	11	13	7	6	6	7	6	O	M
Various squids NEI	*Loliginidae, Ommastrephidae*	Malaysia, Australia	< 1	< 1	2	11	17	30	24	23	22	24	20	25	28	23	28	F	H
57 – Squids, cuttlefishes, octopuses			**1**	**2**	**14**	**41**	**87**	**124**	**112**	**115**	**106**	**113**	**90**	**99**	**108**	**97**	**102**		
Total selected species groups			**499**	**829**	**1 452**	**2 491**	**3 784**	**4 604**	**4 466**	**4 743**	**4 899**	**5 114**	**4 971**	**5 285**	**5 488**	**5 725**	**6 069**		
Total other species groups			**21**	**57**	**92**	**191**	**352**	**489**	**441**	**437**	**488**	**460**	**439**	**559**	**498**	**646**	**525**		
Total marine capture			**519**	**887**	**1 545**	**2 681**	**4 136**	**5 093**	**4 907**	**5 181**	**5 387**	**5 575**	**5 410**	**5 843**	**5 985**	**6 370**	**6 594**		
Total aquaculture			**4**	**19**	**43**	**60**	**86**	**82**	**116**	**122**	**117**	**126**	**102**	**153**	**129**	**290**	**275**		
Total production			**524**	**905**	**1 588**	**2 741**	**4 222**	**5 176**	**5 023**	**5 303**	**5 504**	**5 701**	**5 512**	**5 997**	**6 114**	**6 661**	**6 868**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D11: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Southern Indian Ocean (FAO Statistical Area 48), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Antarctic silverfish			-	-	< 1	< 1	0	-	-	-	-	-	-	-	-	-	-		
Marbled rockcod			-	-	27	3	< 1	-	-	-	-	-	-	-	-	-	-		
Other miscellaneous coastal fishes			-	-	16	7	< 1	-	-	< 1		< 1	< 1	< 1	< 1	< 1	< 1		
33 – Miscellaneous coastal fishes			**-**	**-**	**43**	**10**	**< 1**	**0**	**0**	**< 1**	**0**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**		
Mackerel icefish	*Champsocephalus gunnari*	Australia	-	-	14	10	2	< 1	1	< 1	2	< 1	2	< 1	< 1	< 1	< 1	O	M
Patagonian toothfish	*Dissostichus eleginoides*	South Africa, Japan, France, Australia	-	-	< 1	1	6	12	9	8	9	9	9	9	8	8	9	F	M
Other miscellaneous demersal fishes			-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
34 – Miscellaneous demersal fishes			**-**	**-**	**14**	**12**	**8**	**12**	**10**	**9**	**11**	**9**	**11**	**10**	**9**	**9**	**9**		
Antarctic krill			-	-	14	58	4	-	-	-	-	-	-	-	-	-	-	U/F	M
46 – Krill, planktonic crustaceans			**-**	**-**	**14**	**58**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
Total selected species groups			**-**	**-**	**71**	**81**	**13**	**12**	**10**	**9**	**11**	**9**	**11**	**10**	**9**	**9**	**9**		
Total other species groups			**-**	**-**	**2**	**-**	**-**	**< 1**	**< 1**	**1**	**2**	**1**	**1**	**1**	**1**	**2**	**2**		
Total marine capture			**-**	**-**	**73**	**81**	**13**	**13**	**11**	**10**	**13**	**10**	**13**	**11**	**10**	**11**	**11**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D12: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Northwest Pacific (FAO Statistical Area 61), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Chum (= keta = dog) salmon	*Oncorhynchus keta*	Russian Federation, Japan	83	65	84	149	226	173	226	227	278	256	234	240	234	200	251	F	L
Pink (= humpback) salmon	*Oncorhynchus gorbuscha*	Russian Federation, Japan	132	93	96	95	155	158	159	126	199	104	176	184	243	162	412	F	L
Other salmons, trouts, smelts			42	48	34	19	18	20	17	23	11	17	15	24	23	23	26	F	H
23 – Salmons, trouts, smelts			**257**	**205**	**214**	**263**	**398**	**351**	**402**	**376**	**487**	**377**	**425**	**448**	**500**	**385**	**689**		
Alaska pollock (= walleye poll.)	*Theragra chalcogramma*	Russian Federation, Republic of Korea, Democratic. People's Republic of Korea, Japan	199	882	3 289	4 298	3 256	1 746	1 695	1 134	1 358	1 169	1 242	1 315	1 514	1 613	1 649	F,F,O	M
Pacific cod	*Gadus macrocephalus*	Russian Federation, Republic of Korea, Japan	45	71	82	180	167	130	116	99	89	106	112	106	109	114	108	F	H
Other cods, hakes, haddocks			13	20	46	66	44	76	68	73	95	88	76	84	94	60	86	F	H
32 – Cods, hakes, haddocks			**258**	**973**	**3 416**	**4 544**	**3 467**	**1 951**	**1 880**	**1 306**	**1 542**	**1 363**	**1 429**	**1 505**	**1 718**	**1 787**	**1 843**		
Yellow croaker	*Larimichthys polyactis*	Taiwan Province of China, Republic of Korea, China	93	115	69	50	153	262	218	233	245	285	294	317	373	388	407	F	H
Other miscellaneous coastal fishes			459	603	1 005	1 115	1 164	1 296	1 262	1 197	2 091	2 060	1 960	1 984	1 767	2 008	2 032		
33 – Miscellaneous coastal fishes			**552**	**718**	**1 074**	**1 165**	**1 316**	**1 558**	**1 480**	**1 430**	**2 336**	**2 345**	**2 253**	**2 300**	**2 140**	**2 396**	**2 439**		
Largehead hairtail	*Trichiurus lepturus*	Taiwan Province of China, Republic of Korea, Japan, China	342	505	622	617	964	1 214	1 200	1 179	1 159	1 283	1 175	1 294	1 244	1 290	1 278	O	M
Other miscellaneous demersal fishes			88	162	228	132	220	268	289	314	395	427	410	514	481	471	479		
34 – Miscellaneous demersal fishes			**430**	**667**	**850**	**748**	**1 184**	**1 482**	**1 488**	**1 492**	**1 555**	**1 710**	**1 585**	**1 807**	**1 725**	**1 761**	**1 757**		
Japanese anchovy	*Engraulis japonicus*	Taiwan Province of China, Republic of Korea, Japan, China	364	417	398	343	1 105	1 563	1 651	1 679	1 893	1 629	1 481	1 509	1 391	1 266	1 071	F	M
Japanese pilchard	*Sardinops melanostictus*	Republic of Korea, Japan, China	228	47	795	4 560	1 646	284	316	209	191	203	185	235	248	192	196	?, O	L
Pacific herring	*Clupea pallasii*	Russian Federation, Republic of Korea, Japan, China	304	367	357	176	205	392	334	248	236	236	255	283	226	233	254	F	H
Other herrings, sardines, anchovies			92	98	127	147	134	109	97	97	106	87	106	91	131	124	130		
35 – Herrings, sardines, anchovies			**988**	**929**	**1 678**	**5 227**	**3 089**	**2 348**	**2 398**	**2 233**	**2 426**	**2 156**	**2 028**	**2 118**	**1 996**	**1 815**	**1 651**		
36 – Tunas, bonitos, billfishes			**< 1**	**1**	**32**	**89**	**273**	**430**	**410**	**434**	**338**	**328**	**361**	**338**	**459**	**437**	**432**		
Chub mackerel	*Scomber japonicus*	Taiwan Province of China, Republic of Korea, Japan, China	338	717	1 672	1 272	1 044	822	929	810	876	966	1 252	1 212	994	1 356	1 056	F	L
Japanese jack mackerel	*Trachurus japonicus*	Taiwan Province of China, Republic of Korea, Japan, China	229	455	154	148	304	272	236	230	317	308	403	329	380	260	217	F	L
Pacific saury	*Cololabis saira*	Taiwan Province of China, Russian Federation, Republic of Korea, Japan	372	341	309	261	334	305	376	335	446	356	478	395	525	622	477	U	M
Other miscellaneous pelagic fishes			107	142	211	521	834	902	940	1 004	1 053	1 018	1 024	1 028	1 061	1 404	1 067		
37 – Miscellaneous pelagic fishes			**1 044**	**1 656**	**2 346**	**2 201**	**2 516**	**2 300**	**2 480**	**2 378**	**2 692**	**2 649**	**3 158**	**2 964**	**2 960**	**3 643**	**2 817**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D12: Area 61 (continued)

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
38 – Sharks, rays, chimaeras			**118**	**88**	**92**	**68**	**42**	**56**	**39**	**41**	**42**	**55**	**64**	**56**	**55**	**45**	**39**		
39 – Marine fishes not identified			**1 239**	**2 045**	**2 921**	**3 328**	**4 182**	**4 119**	**3 645**	**3 488**	**2 532**	**2 516**	**2 494**	**2 326**	**2 356**	**2 219**	**2 871**		
Gazami crab	*Portunus trituberculatus*	Republic of Korea, Japan, China	3	2	14	64	221	303	301	317	276	296	324	355	367	371	366	F	H
Other crabs, sea-spiders			22	42	78	105	140	145	143	137	331	321	315	314	306	298	308		
42 – Crabs, sea-spiders			**25**	**44**	**92**	**169**	**362**	**448**	**444**	**455**	**607**	**617**	**639**	**669**	**673**	**669**	**675**		
Akiami paste shrimp	*Acetes japonicus*	Republic of Korea, China	78	99	92	189	373	550	494	499	543	580	565	620	621	558	602		
Other shrimps, prawns			52	98	167	255	310	423	363	350	759	748	767	710	668	633	631		
45 – Shrimps, prawns			**129**	**197**	**260**	**445**	**683**	**974**	**858**	**849**	**1 301**	**1 328**	**1 332**	**1 330**	**1 289**	**1 191**	**1 234**		
Yesso scallop	*Patinopecten yessoensis*	Russian Federation, Republic of Korea, Japan	16	10	35	128	253	310	293	310	347	317	290	274	260	314	323		
55 – Scallops, pectens			**16**	**10**	**35**	**128**	**253**	**310**	**293**	**310**	**347**	**317**	**290**	**274**	**260**	**314**	**323**		
Japanese carpet shell	*Ruditapes philippinarum*	Republic of Korea, Japan	70	127	144	141	67	57	51	49	51	49	49	43	44	60	54		
Other clams, cockles, arkshells			121	175	165	145	119	76	73	74	108	100	78	70	77	57	64		
56 – Clams, cockles, arkshells			**191**	**302**	**310**	**286**	**186**	**133**	**124**	**123**	**159**	**149**	**126**	**113**	**122**	**117**	**118**		
Japanese flying squid	*Todarodes pacificus*	Russian Federation, Republic of Korea, Japan	429	537	371	267	503	570	529	504	488	448	412	388	429	404	406	U	L
Various squids NEI	*Loliginidae, Ommastrephidae*	Democratic People's Republic of Korea, Japan, China, Hong Kong SAR, China	51	62	141	273	198	260	190	227	501	617	651	524	540	531	454	F	H
Other squids, cuttlefishes, octopuses			76	111	138	198	280	355	372	366	458	430	413	428	507	481	474		
57 – Squids, cuttlefishes, octopuses			**556**	**710**	**650**	**737**	**981**	**1 186**	**1 091**	**1 097**	**1 447**	**1 494**	**1 476**	**1 341**	**1 476**	**1 416**	**1 334**		
Total selected species groups			**5 804**	**8 544**	**13 968**	**19 398**	**18 933**	**17 645**	**17 031**	**16 013**	**17 813**	**17 404**	**17 661**	**17 590**	**17 729**	**18 195**	**18 220**		
Total other species groups			**872**	**1 367**	**1 287**	**1 557**	**2 864**	**3 514**	**3 420**	**3 243**	**2 076**	**1 903**	**2 046**	**2 035**	**2 159**	**1 986**	**2 016**		
Total marine capture			**6 677**	**9 912**	**15 255**	**20 955**	**21 797**	**21 159**	**20 451**	**19 256**	**19 889**	**19 307**	**19 706**	**19 625**	**19 887**	**20 181**	**20 236**		
Total aquaculture			**275**	**1 008**	**2 489**	**4 828**	**11 893**	**17 358**	**18 124**	**19 413**	**20 386**	**21 657**	**22 331**	**22 998**	**23 705**	**24 071**	**25 138**		
Total production			**6 952**	**10 920**	**17 744**	**25 783**	**33 690**	**38 517**	**38 576**	**38 669**	**40 276**	**40 963**	**42 038**	**42 622**	**43 592**	**44 252**	**45 375**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D13: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Northeast Pacific (FAO Statistical Area 67), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Chinook (= spring = king) salmon	*Oncorhynchus tshawytscha*	United States of America, Canada	17	15	20	17	9	5	7	10	11	12	10	9	7	5	5	F-O	L
Chum (= keta = dog) salmon	*Oncorhynchus keta*	United States of America, Russian Federation, Canada	48	29	38	57	71	76	58	63	57	65	47	78	54	58	54	F	L
Coho (= silver) salmon	*Oncorhynchus kisutch*	United States of America, Canada	24	25	26	28	24	15	17	18	15	21	17	16	12	17	16	F-O	L
Pink (= humpback) salmon	*Oncorhynchus gorbuscha*	United States of America, Russian Federation, Canada	65	75	66	140	162	102	184	125	167	139	237	102	219	119	147	F	L
Sockeye (= red) salmon	*Oncorhynchus nerka*	United States of America, Canada	48	52	58	126	151	103	83	72	90	119	121	118	128	104	117	F	L
Other salmons, trouts, smelts			1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
23 – Salmons, trouts, smelts			**204**	**197**	**209**	**369**	**417**	**301**	**349**	**288**	**341**	**356**	**432**	**323**	**420**	**303**	**339**		
Pacific halibut	*Hippoglossus stenolepis*	United States of America, Canada	22	39	20	30	35	41	40	44	43	43	41	40	39	35	31	F	L
Yellowfin sole	*Limanda aspera*	United States of America	-	-	66	137	104	70	55	64	69	63	85	91	109	141	101	U	L
Other flounders, halibuts, soles			24	119	142	130	101	93	79	83	75	78	88	100	102	150	150	F-U	L
31 – Flounders, halibuts, soles			**46**	**157**	**227**	**297**	**240**	**204**	**174**	**190**	**187**	**184**	**214**	**230**	**250**	**326**	**282**		
Alaska pollock (= walleye poll.)	*Theragra chalcogramma*	United States of America, Russian Federation, Canada	79	309	976	1 313	1 318	1 183	1 444	1 519	1 530	1 523	1 549	1 546	1 395	1 036	850	F	L
North Pacific hake	*Merluccius productus*	United States of America, Canada	-	60	166	187	260	229	233	186	209	340	362	355	273	311	171	F	L
Pacific cod	*Gadus macrocephalus*	United States of America, Russian Federation, Canada	21	40	71	154	256	241	214	233	258	267	250	236	222	225	224	F	L
Other cods, hakes, haddocks			-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
32 – Cods, hakes, haddocks			**101**	**408**	**1 212**	**1 655**	**1 834**	**1 654**	**1 892**	**1 939**	**1 998**	**2 130**	**2 162**	**2 137**	**1 890**	**1 572**	**1 244**		
33 – Miscellaneous coastal fishes			**4**	**15**	**39**	**41**	**61**	**48**	**60**	**41**	**49**	**53**	**63**	**63**	**62**	**62**	**76**		M
Pacific herring	*Clupea pallasii*	United States of America, Canada	189	201	107	80	82	60	63	62	61	57	69	59	41	50	52		L
Other herrings, sardines, anchovies			-	< 1	< 1	< 1	< 1	14	24	39	37	45	52	40	47	29	30		L
35 – Herrings, sardines, anchovies			**189**	**201**	**107**	**80**	**82**	**75**	**87**	**101**	**98**	**102**	**121**	**99**	**88**	**79**	**81**		
Chub mackerel	*Scomber japonicus*	United States of America	-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	F	L
Other miscellaneous pelagic fishes			-	-	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
37 – Miscellaneous pelagic fishes			**< 1**	**< 1**	**1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D13: Area 67 (continued)

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Dungeness crab	*Cancer magister*	United States of America, Canada	9	14	16	16	22	19	21	24	43	39	33	41	30	27	33	F	M
Pacific rock crab	*Cancer productus*	United States of America	-	-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	F	L
Other crabs, sea-spiders			3	10	42	48	93	16	12	15	13	12	13	19	17	30	28	F	L
42 – Crabs, sea-spiders			**12**	**23**	**58**	**64**	**115**	**35**	**34**	**39**	**56**	**51**	**46**	**60**	**48**	**57**	**60**		
Natantian decapods NEI	*Natantia*	United States of America, Canada	2	14	62	27	23	6	5	5	5	4	4	4	4	3	4	F	M
Ocean shrimp	*Pandalus jordani*	United States of America	-	-	-	-	6	15	18	25	14	9	11	8	11	16	14	F	M
45 – Shrimps, prawns			**2**	**14**	**62**	**27**	**29**	**20**	**23**	**30**	**18**	**13**	**15**	**12**	**15**	**18**	**18**		
Total selected species groups			**558**	**1 016**	**1 916**	**2 533**	**2 780**	**2 337**	**2 619**	**2 629**	**2 748**	**2 889**	**3 052**	**2 925**	**2 774**	**2 417**	**2 101**		
Total other species groups			**52**	**339**	**283**	**210**	**189**	**141**	**140**	**137**	**168**	**158**	**158**	**149**	**151**	**157**	**157**		
Total marine capture			**610**	**1 355**	**2 199**	**2 743**	**2 969**	**2 478**	**2 759**	**2 766**	**2 915**	**3 048**	**3 210**	**3 073**	**2 926**	**2 574**	**2 259**		
Total aquaculture			**41**	**33**	**28**	**37**	**71**	**97**	**135**	**142**	**146**	**119**	**120**	**126**	**121**	**117**	**119**		
Total production			**651**	**1 388**	**2 226**	**2 780**	**3 040**	**2 575**	**2 894**	**2 907**	**3 061**	**3 167**	**3 330**	**3 199**	**3 046**	**2 691**	**2 378**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D14: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Western Central Pacific (FAO Statistical Area 71), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Chacunda gizzard shad	*Anodontostoma chacunda*	Philippines, Malaysia, Indonesia	-	< 1	< 1	1	2	3	3	2	3	3	3	4	6	7	7		
Diadromous clupeoids NEI	*Clupeoidei*	Malaysia	< 1	2	1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	1	< 1	< 1	1		
Indian pellona	*Pellona ditchela*	Philippines, Malaysia			1	1	4	6	7	6	6	7	8	8	9	7	4		
Toli shad	*Tenualosa toli*	Indonesia	< 1	< 1	1	2	3	2	5	3	5	5	4	4	3	3	3	U	H
24 – Shads			**< 1**	**2**	**5**	**5**	**10**	**12**	**15**	**12**	**15**	**16**	**16**	**18**	**19**	**19**	**15**		
Bigeyes NEI	*Priacanthus* spp.	Thailand, Malaysia, Indonesia	< 1	< 1	14	16	53	70	64	72	70	108	97	90	89	44	50		
Lizardfishes NEI	*Synodontidae*	Thailand, Singapore, Philippines, Malaysia	-	29	28	23	53	66	79	88	80	63	63	61	60	33	36	F	H
Mullets NEI	*Mugilidae*	Thailand, Philippines, Malaysia, Indonesia	6	9	21	35	47	49	51	50	46	48	51	52	52	59	56	F	H
Percoids NEI	*Percoidei*	Philippines, Kiribati	142	28	35	36	38	9	11	12	12	11	9	10	10	11	17		
Ponyfishes (= slipmouths)	*Leiognathus* spp.	Singapore, Malaysia, Fiji	3	5	3	4	2	2	2	2	1	2	2	2	2	2	3		
Ponyfishes (= slipmouths) NEI	*Leiognathidae*	Philippines, Indonesia	5	52	90	91	112	120	134	136	139	144	141	140	132	122	126	F	H
Sea catfishes NEI	*Ariidae*	Thailand, Philippines, Malaysia, Indonesia	5	10	26	41	67	80	85	87	89	93	81	86	87	95	98	F	H
Threadfin breams NEI	*Nemipterus* spp.	Thailand, Philippines, Malaysia, Indonesia	2	27	69	79	131	149	158	193	186	187	198	194	196	141	137	F	H
Other miscellaneous coastal fishes			39	105	214	300	432	482	534	531	567	613	635	675	737	728	729		
33 – Miscellaneous coastal fishes			**202**	**267**	**499**	**626**	**935**	**1 027**	**1 117**	**1 171**	**1 191**	**1 269**	**1 278**	**1 310**	**1 365**	**1 236**	**1 252**		
Hairtails, scabbardfishes NEI	*Trichiuridae*	Philippines, Indonesia	1	9	13	20	29	30	33	36	32	33	36	37	42	72	69	U	H
Largehead hairtail	*Trichiurus lepturus*	Thailand, Singapore, Malaysia	< 1	< 1	7	6	9	17	16	14	14	15	14	13	13	8	8	F	H
Other miscellaneous demersal fishes			2	3	9	13	7	7	7	8	8	8	8	9	8	8	7		
34 – Miscellaneous demersal fishes			**4**	**13**	**28**	**39**	**45**	**54**	**56**	**58**	**54**	**56**	**58**	**58**	**64**	**88**	**85**		
Anchovies, etc. NEI	*Engraulidae*	Thailand	-	< 1	18	58	118	117	121	124	133	139	135	126	119	120	120	F	H
Bali sardinella	*Sardinella lemuru*	Indonesia	7	12	24	42	66	58	66	61	60	45	49	49	82	50	50	F	H
Goldstripe sardinella	*Sardinella gibbosa*	Indonesia	13	23	42	91	125	130	146	147	122	116	138	141	124	128	130	F	H
Sardinellas NEI	*Sardinella* spp.	Thailand, Philippines	-	52	180	212	372	420	394	353	352	374	447	394	395	448	547	F	H
Stolephorus anchovies NEI	*Stolephorus* spp.	Philippines, Malaysia, Indonesia	52	72	120	181	188	195	230	192	182	194	185	196	215	219	236	F	H
Other herrings, sardines, anchovies			13	30	79	78	93	91	104	104	109	102	106	113	110	89	84		
35 – Herrings, sardines, anchovies			**86**	**189**	**462**	**661**	**961**	**1 010**	**1 060**	**982**	**959**	**970**	**1 060**	**1 019**	**1 044**	**1 054**	**1 167**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D14: Area 71 (continued)

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Frigate and bullet tunas	*Auxis thazard, A. rochei*	Thailand, Philippines	-	8	35	96	126	131	127	181	194	230	193	192	207	162	158	F	M
Kawakawa	*Euthynnus affinis*	Thailand, Philippines, Malaysia, Indonesia	30	24	48	91	99	222	233	277	238	165	172	199	198	187	179	F	H
Tuna-like fishes NEI	*Scombroidei*	Viet Nam, New Caledonia, Malaysia, Australia	11	20	35	79	116	16	23	22	21	26	34	42	49	56	59	O	H
Other tunas, bonitos, billfishes			36	50	103	185	231	268	283	341	374	560	597	581	571	541	515	F	M
36 – Tunas, bonitos, billfishes			**78**	**103**	**222**	**452**	**572**	**637**	**667**	**822**	**827**	**981**	**996**	**1 014**	**1 025**	**946**	**912**		
Bigeye scad	*Selar crumenophthalmus*	Thailand, Philippines, Malaysia, Indonesia	20	27	46	35	57	100	112	133	141	163	130	128	128	159	161	F	H
Carangids NEI	*Carangidae*	Thailand, Singapore, Philippines, Malaysia	6	21	55	88	101	99	115	125	113	114	102	104	136	108	106		
Flyingfishes NEI	*Exocoetidae*	Philippines, Kiribati, Indonesia	5	9	25	32	38	53	47	44	46	44	38	42	43	42	37	F	H
Indian mackerel	*Rastrelliger kanagurta*	Thailand, Philippines, Indonesia, Fiji	< 1	< 1	52	70	86	78	78	90	96	106	113	119	115	122	120	F	H
Indian mackerels NEI	*Rastrelliger* spp.	Thailand, Singapore, Malaysia	50	78	69	112	118	153	140	148	149	159	151	143	120	116	113	F	H
Indian scad	*Decapterus russelli*	Thailand, Malaysia	5	6	52	47	92	147	139	146	125	112	107	112	101	63	68	F	H
Short mackerel	*Rastrelliger brachysoma*	Philippines, Indonesia	24	62	79	101	145	157	165	182	167	188	204	237	231	220	220	U	H
Other miscellaneous pelagic fishes			78	267	381	490	778	856	913	957	1 011	1 008	930	951	1 005	999	970	O	H
37 – Miscellaneous pelagic fishes			**186**	**470**	**759**	**974**	**1 415**	**1 643**	**1 710**	**1 825**	**1 848**	**1 893**	**1 775**	**1 836**	**1 879**	**1 830**	**1 796**		
Rays, stingrays, mantas NEI	*Rajiformes*	Thailand, Philippines, Malaysia, Republic of Korea	4	9	18	30	48	57	56	64	79	74	22	19	16	16	16	O	M
Sharks, rays, skates, etc. NEI	*Elasmobranchii*	Thailand, Philippines, Malaysia, Australia	5	19	41	70	92	76	84	85	97	49	23	26	18	17	15	O	M
Other sharks, rays, chimaeras			-	-	-	-	-	-	-	-	< 1	< 1	69	77	70	65	63		
38 – Sharks, rays, chimaeras			**9**	**28**	**59**	**100**	**140**	**133**	**140**	**149**	**177**	**123**	**113**	**121**	**105**	**98**	**94**		
Marine fishes NEI	*Osteichthyes*	Viet Nam, Thailand, Malaysia, Indonesia	293	1 004	1 431	1 621	2 068	2 371	2 602	2 557	2 854	2 735	2 864	2 644	2 625	2 401	2 470	F	H
39 – Marine fishes not identified			**293**	**1 004**	**1 431**	**1 621**	**2 068**	**2 371**	**2 602**	**2 557**	**2 854**	**2 735**	**2 864**	**2 644**	**2 625**	**2 401**	**2 470**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D14: Area 71 (continued)

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Banana prawn	*Penaeus merguiensis*	Thailand, Papua New Guinea, Indonesia, Australia	10	17	31	38	53	61	73	71	65	70	64	59	75	64	61	F	H
Giant tiger prawn	*Penaeus monodon*	Thailand, Philippines, Indonesia, Australia	5	8	10	10	20	41	40	34	30	33	29	35	38	24	26	F	H
Natantian decapods NEI	*Natantia*	Viet Nam, Malaysia, Indonesia, Cambodia	18	36	93	109	169	179	220	205	210	218	197	217	214	201	220		
Penaeus shrimps NEI	*Penaeus* spp.	Thailand, Philippines, Australia	19	60	88	104	75	52	50	52	46	40	38	38	35	29	31	O	H
Sergestid shrimps NEI	*Sergestidae*	Thailand, Philippines, Malaysia	-	< 1	20	37	39	25	28	23	23	23	24	24	21	24	26	F	H
Other shrimps, prawns			2	3	20	25	34	54	48	47	48	54	47	41	41	41	41		
45 – Shrimps, prawns			**54**	**124**	**263**	**324**	**390**	**411**	**460**	**432**	**422**	**439**	**401**	**415**	**426**	**383**	**405**		
Common squids NEI	*Loligo* spp.	Thailand, Singapore, Philippines, Indonesia	7	13	66	105	149	144	155	178	161	174	172	168	166	165	170	F	H
Cuttlefish, bobtail squids NEI	*Sepiidae, Sepiolidae*	Thailand, Philippines, Malaysia, Indonesia	< 1	1	27	45	60	59	61	67	74	68	66	61	58	43	44	F	H
Octopuses, etc. NEI	*Octopodidae*	Thailand, Philippines, Malaysia, Indonesia	-	< 1	5	12	23	19	19	18	23	20	21	21	21	19	20	F	H
Various squids NEI	*Loliginidae, Ommastrephidae*	Malaysia, Republic of Korea, Australia	-	-	< 1	7	23	27	27	34	34	34	31	38	37	36	30		
Other squids, cuttlefishes, octopuses			4	4	8	10	73	193	180	198	208	193	204	207	218	235	256		
57 – Squids, cuttlefishes, octopuses			**11**	**19**	**108**	**179**	**327**	**443**	**442**	**496**	**500**	**489**	**492**	**495**	**500**	**497**	**520**		
Total selected species groups			**924**	**2 219**	**3 836**	**4 980**	**6 863**	**7 742**	**8 269**	**8 504**	**8 845**	**8 971**	**9 051**	**8 931**	**9 051**	**8 553**	**8 716**		
Total other species groups			**110**	**193**	**552**	**955**	**1 610**	**1 997**	**1 868**	**1 997**	**1 977**	**1 987**	**2 076**	**2 206**	**2 360**	**2 324**	**2 481**		
Total marine capture			**1 034**	**2 412**	**4 388**	**5 935**	**8 474**	**9 738**	**10 136**	**10 501**	**10 822**	**10 958**	**11 127**	**11 136**	**11 411**	**10 876**	**11 198**		
Total aquaculture			**23**	**40**	**110**	**325**	**776**	**1 225**	**1 405**	**1 690**	**1 826**	**2 313**	**2 975**	**3 371**	**3 989**	**4 639**	**5 565**		
Total production			**1 057**	**2 452**	**4 498**	**6 261**	**9 250**	**10 964**	**11 542**	**12 190**	**12 648**	**13 271**	**14 102**	**14 507**	**15 400**	**15 516**	**16 762**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D15: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Eastern Central Pacific (FAO Statistical Area 77), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
32 – Cods, hakes, haddocks			**< 1**	**< 1**	**6**	**< 1**	**< 1**	**< 1**	**1**	**1**	**1**	**1**	**2**	**2**	**1**	**2**	**1**		
33 – Miscellaneous coastal fishes			**9**	**22**	**39**	**33**	**41**	**46**	**59**	**63**	**37**	**26**	**48**	**47**	**51**	**47**	**44**	F	H
34 – Miscellaneous demersal fishes			**7**	**7**	**13**	**15**	**10**	**5**	**4**	**4**	**4**	**4**	**5**	**5**	**5**	**5**	**5**		
California pilchard	*Sardinops caeruleus*	United States of America, Mexico	90	28	100	404	359	532	662	683	596	520	287	315	513	713	729	F	L
Californian anchovy	*Engraulis mordax*	United States of America, Mexico	16	23	165	207	11	19	20	9	4	9	26	61	18	24	13	F	L
Pacific anchoveta	*Cetengraulis mysticetus*	Panama, Mexico	4	23	70	111	74	95	134	74	77	47	108	104	90	85	103	F	M
Pacific thread herring	*Opisthonema libertate*	Panama, Mexico	-	16	18	17	33	50	33	59	51	46	202	211	233	151	163	F	H
Other herrings, sardines, anchovies			2	< 1	3	10	6	5	5	8	5	4	28	31	8	6	6		
35 – Herrings, sardines, anchovies			**111**	**91**	**357**	**748**	**483**	**702**	**853**	**833**	**733**	**626**	**651**	**722**	**861**	**978**	**1 013**		
Other tunas, bonitos, billfishes			9	29	35	34	38	33	32	33	37	33	31	32	48	42	40		
36 – Tunas, bonitos, billfishes			**9**	**29**	**35**	**34**	**38**	**33**	**32**	**33**	**37**	**33**	**31**	**32**	**48**	**42**	**40**		
Chub mackerel	*Scomber japonicus*	United States of America, Mexico	16	14	8	45	45	66	24	14	15	15	39	17	16	11	12	U	L
Pacific jack mackerel	*Trachurus symmetricus*	United States of America, Mexico	32	32	23	15	2	1	4	1	< 1	2	< 1	1	2	< 1	< 1	U	L
Other miscellaneous pelagic fishes			2	1	2	4	5	17	19	19	15	12	16	16	16	14	15		
37 – Miscellaneous pelagic fishes			**50**	**47**	**32**	**63**	**52**	**84**	**47**	**34**	**30**	**29**	**55**	**35**	**34**	**25**	**27**		
39 – Marine fishes not identified			**14**	**63**	**108**	**131**	**205**	**116**	**125**	**126**	**110**	**108**	**108**	**112**	**89**	**91**	**79**		
Dungeness crab	*Cancer magister*	United States of America	6	4	< 1	< 1	1	< 1	< 1	2	2	3	3	3	2	2	1		
Other crabs, sea-spiders			< 1	< 1	< 1	2	7	13	12	9	8	9	11	12	17	19	16		
42 – Crabs, sea-spiders			**7**	**4**	**2**	**3**	**8**	**13**	**13**	**11**	**10**	**12**	**14**	**15**	**19**	**21**	**18**		
45 – Shrimps, prawns			**51**	**69**	**63**	**75**	**64**	**57**	**52**	**49**	**65**	**53**	**54**	**56**	**68**	**64**	**58**	F/O	H
53 – Oysters			**2**	**5**	**3**	**5**	**4**	**4**	**3**	**3**	**3**	**3**	**3**	**10**	**7**	**3**	**3**		
Jumbo flying squid	*Dosidicus gigas*	United States of America, Mexico	-	< 1	< 1	4	39	82	74	116	97	87	53	66	58	84	58	U	M
Octopuses, etc. NEI	*Octopodidae*	Nicaragua, Mexico, Costa Rica, Cook Islands	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	1	< 1	< 1	1	1	2		
Opalescent inshore squid	*Loligo opalescens*	United States of America, Mexico	-	-	-	-	55	118	86	73	39	40	56	49	49	37	92	U	M
Various squids NEI	*Loliginidae, Ommastrephidae*	United States of America, Nicaragua, Republic of Korea, El Salvador	5	7	12	36	40	2	6	< 1	< 1	< 1	< 1	< 1	< 1	3	2		
57 – Squids, cuttlefishes, octopuses			**5**	**7**	**13**	**40**	**135**	**203**	**167**	**190**	**137**	**128**	**110**	**116**	**108**	**125**	**154**		
Total selected species groups			**265**	**345**	**671**	**1 148**	**1 041**	**1 265**	**1 358**	**1 349**	**1 168**	**1 024**	**1 081**	**1 151**	**1 292**	**1 405**	**1 447**		
Total other species groups			**172**	**200**	**379**	**474**	**423**	**461**	**500**	**627**	**601**	**533**	**541**	**488**	**484**	**462**	**549**		
Total marine capture			**438**	**545**	**1 050**	**1 622**	**1 464**	**1 726**	**1 858**	**1 976**	**1 769**	**1 557**	**1 622**	**1 640**	**1 776**	**1 866**	**1 996**		
Total aquaculture						**1**	**18**	**34**	**50**	**46**	**47**	**65**	**96**	**118**	**116**	**135**	**131**		
Total production			**438**	**545**	**1 050**	**1 623**	**1 481**	**1 760**	**1 908**	**2 021**	**1 815**	**1 622**	**1 718**	**1 758**	**1 892**	**2 001**	**2 127**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D16: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Southwest Pacific (FAO Statistical Area 81), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Blue grenadier	*Macruronus novaezelandiae*	New Zealand, Republic of Korea, Australia	< 1	< 1	27	98	261	275	248	215	209	147	134	119	110	103	98	F	M
Gadiformes NEI	*Gadiformes*	New Zealand, Republic of Korea	-	-	5	< 1	6	3	5	3	3	< 1	1	< 1	< 1	< 1	1	F	L
Red codling	*Pseudophycis bachus*	New Zealand	< 1	< 1	5	8	11	5	5	4	8	10	8	6	6	6	5		
Southern blue whiting	*Micromesistius australis*	New Zealand	-	-	26	18	46	43	50	72	44	27	30	33	24	29	39	F	H
Southern hake	*Merluccius australis*	Spain, New Zealand, Republic of Korea	-	-	-	< 1	10	16	15	14	23	19	13	13	14	9	13	F	M
Other cods, hakes, haddocks			-	-	-	< 1	3	8	9	11	11	11	8	8	7	7	6		
32 – Cods, hakes, haddocks			< 1	< 1	64	124	336	350	332	320	298	214	194	179	161	155	162		
Mullets NEI	*Mugilidae*	New Zealand, Australia	2	3	3	5	5	4	5	5	5	4	5	5	4	5	3	F	L
Silver seabream	*Pagrus auratus*	New Zealand, Australia	7	10	16	10	7	8	7	7	7	7	7	7	6	7	6	F	L
Other miscellaneous coastal fishes			6	5	7	14	16	15	15	15	17	15	13	12	14	15	14	F	H
33 – Miscellaneous coastal fishes			15	18	26	28	28	27	27	28	29	25	26	23	25	26	23		
Demersal percomorphs NEI	*Perciformes*		< 1	< 1	14	25	6	3	2	3	4	-	-	-	-	-	-		
Hairtails, scabbardfishes NEI	*Trichiuridae*	Republic of Korea	-	-	-	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Orange roughy	*Hoplostethus atlanticus*	New Zealand, Australia	-	-	3	49	45	18	15	19	19	19	19	17	15	13	12	O	M
Oreo dories NEI	*Oreosomatidae*	New Zealand	-	-	15	28	21	23	16	< 1	< 1	< 1		< 1		< 1	< 1	F,O	H
Pink cusk-eel	*Genypterus blacodes*	Spain, New Zealand, Republic of Korea, Australia	< 1	< 1	< 1	3	17	25	20	22	22	21	17	17	20	16	13	F	M
Silver gemfish	*Rexea solandri*	New Zealand, Australia	< 1	< 1	2	5	4	1	< 1	< 1	< 1	1	1	< 1	< 1	< 1	< 1	F,O	H
Silver scabbardfish	*Lepidopus caudatus*	New Zealand	< 1		< 1	< 1	2	2	3	2	3	3	3	3	2	2	2		
Snoek	*Thyrsites atun*	New Zealand, Australia	< 1	< 1	18	21	23	28	28	27	29	30	31	35	29	27	28	U	H
Warehou NEI	*Seriolella* spp.		-	-	3	< 1	< 1	2	< 1	< 1	-	-	-	-	-	-	-	F	M
Other miscellaneous demersal fishes			11	16	16	22	40	53	59	70	76	75	69	72	68	60	61	N	H
34 – Miscellaneous demersal fishes			**12**	**17**	**72**	**154**	**160**	**154**	**145**	**145**	**154**	**150**	**141**	**145**	**134**	**119**	**117**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D16: Area 81 (continued)

Stock or species groups	Scientific name	Main fishing countries/ territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Barracudas NEI	*Sphyraena* spp.		-	-	< 1	-	< 1	< 1	< 1	< 1	-	< 1	< 1	-	-	-	-	F	L
Blue mackerel	*Scomber australasicus*	New Zealand	-	-	< 1	3	9	12	12	15	13	13	7	17	8	7	10	U	M
Butterfishes, pomfrets NEI	*Stromateidae*		-	-	8	6	3	2	2	1	2	-	-	-	-	-	-		
Greenback horse mackerel	*Trachurus declivis*	Australia	-	-	< 1	42	29	12	8	6	25	23	< 1	21	< 1	< 1	< 1	F	M
Jack and horse mackerels NEI	*Trachurus* spp.	New Zealand, Republic of Korea	-	< 1	13	19	39	23	29	32	38	43	46	36	47	48	41	F	H
Mackerels NEI	*Scombridae*	Australia	-	-	< 1	-	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	U	M
White trevally	*Pseudocaranx dentex*	New Zealand, Australia	< 1	3	5	4	4	4	4	4	4	4	4	4	3	4	3	F	M
Other miscellaneous pelagic fishes			< 1	2	3	3	3	1	2	1	1	< 1	< 1	< 1	< 1	< 1	< 1		
37 – Miscellaneous pelagic fishes			**2**	**6**	**31**	**76**	**87**	**56**	**57**	**61**	**84**	**85**	**58**	**79**	**59**	**59**	**54**		
Cuttlefish, bobtail squids NEI	*Sepiidae, Sepiolidae*	Australia	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Octopuses, etc. NEI	*Octopodidae*	New Zealand, Australia	-	-	-	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	U	H
Various squids NEI	*Loliginidae, Ommastrephidae*	New Zealand, Republic of Korea, Australia	-	< 1	28	36	27	10	12	17	18	33	31	26	26	16	20	F	H
Wellington flying squid	*Nototodarus sloanii*	New Zealand, Japan	-	-	2	46	55	25	45	63	57	108	93	86	74	57	47	F	H
57 – Squids, cuttlefishes, octopuses			**< 1**	**< 1**	**30**	**83**	**84**	**35**	**58**	**81**	**77**	**142**	**124**	**112**	**100**	**73**	**67**		
Total selected species groups			**29**	**40**	**223**	**466**	**696**	**622**	**618**	**634**	**642**	**616**	**544**	**538**	**478**	**432**	**423**		
Total other species groups			**21**	**83**	**73**	**100**	**119**	**92**	**128**	**135**	**89**	**97**	**178**	**100**	**156**	**157**	**150**		
Total marine capture			**50**	**123**	**296**	**566**	**815**	**714**	**746**	**769**	**731**	**714**	**722**	**638**	**635**	**589**	**573**		
Total aquaculture			**6**	**8**	**11**	**21**	**75**	**101**	**93**	**106**	**105**	**114**	**127**	**132**	**141**	**144**	**140**		
Total production			**56**	**131**	**308**	**587**	**889**	**815**	**839**	**875**	**836**	**828**	**848**	**770**	**776**	**732**	**714**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D17: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Southeast Pacific (FAO Statistical Area 87), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Patagonian grenadier	*Macruronus magellanicus*	Chile	-	-	14	74	199	91	161	131	85	70	80	73	63	73	78	O	H
South Pacific hake	*Merluccius gayi*	Peru, Chile	66	97	166	92	196	194	246	162	123	112	78	77	78	83	94	O	L
Southern hake	*Merluccius australis*	Chile	-	-	44	44	29	29	29	23	23	32	31	31	31	28	26	F	H
Other cods, hakes, haddocks			-	-	17	7	20	25	23	23	27	28	29	29	24	26	26		
32 – Cods, hakes, haddocks			**66**	**97**	**241**	**216**	**445**	**339**	**459**	**340**	**258**	**241**	**218**	**211**	**196**	**211**	**225**		
33 – Miscellaneous coastal fishes			**18**	**27**	**35**	**56**	**54**	**66**	**53**	**55**	**60**	**112**	**138**	**354**	**56**	**111**	**225**		
Patagonian toothfish	*Dissostichus eleginoides*	Chile	-	-	< 1	3	14	11	7	7	5	5	5	4	4	5	5	F	H
Other miscellaneous demersal fishes			18	22	29	46	28	70	40	33	32	25	20	19	22	17	19		
34 – Miscellaneous demersal fishes			**18**	**22**	**29**	**50**	**42**	**81**	**47**	**40**	**37**	**30**	**25**	**23**	**26**	**22**	**24**		
Anchoveta (= Peruvian anchovy)	*Engraulis ringens*	Peru, Ecuador, Chile	345	8 166	4 605	2 147	7 059	11 276	7 213	9 703	6 204	10 679	10 244	7 007	7 612	7 419	6 910	F	L
Araucanian herring	*Strangomera bentincki*	Chile	14	58	81	47	403	723	325	347	304	356	290	440	281	795	855	F	M
Pacific thread herring	*Opisthonema libertate*	Ecuador	-	-	-	43	37	21	20	11	7	9	8	17	14	25	23	F	H
South American pilchard	*Sardinops sagax*	Peru, Chile	-	4	807	4 575	2 031	338	136	27	20	7	5	1	1	< 1	< 1	F	L
Other herrings, sardines, anchovies			12	11	21	45	196	75	257	82	74	60	41	124	135	162	129		
35 – Herrings, sardines, anchovies			**371**	**8 239**	**5 514**	**6 858**	**9 728**	**12 432**	**7 950**	**10 170**	**6 609**	**11 111**	**10 587**	**7 589**	**8 043**	**8 402**	**7 918**		
Eastern Pacific bonito	*Sarda chiliensis*	Peru, Chile	63	84	29	18	25	< 1	1	< 1	2	1	3	14	10	43	31		
Other tunas, bonitos, billfishes			3	4	5	11	47	43	63	28	51	60	45	38	47	39	58		
36 – Tunas, bonitos, billfishes			**66**	**88**	**34**	**30**	**71**	**44**	**65**	**29**	**53**	**62**	**48**	**51**	**57**	**82**	**89**		
Chilean jack mackerel	*Trachurus murphyi*	Vanuatu, Peru, China, Chile	3	16	474	2 292	3 518	1 543	2 529	1 750	1 790	1 874	1 748	1 993	1 954	1 430	1 253	O	M
Chub mackerel	*Scomber japonicus*	Vanuatu, Peru, Ecuador, Chile	5	16	315	306	339	255	627	393	701	695	451	512	422	264	317	F	H
Miscellaneous pelagic fishes			-	-	-	-	5	8	15	4	3	4	13	3	4	7	15		
37 – Miscellaneous pelagic fishes			**8**	**32**	**789**	**2 598**	**3 862**	**1 805**	**3 172**	**2 148**	**2 494**	**2 573**	**2 212**	**2 508**	**2 379**	**1 701**	**1 585**		
Jumbo flying squid	*Dosidicus gigas*	Peru, Japan, China, Chile	-	< 1	< 1	2	71	128	171	284	282	708	710	787	616	773	571	U	H
Various squids NEI	*Loliginidae, Ommastrephidae*	Ecuador, Colombia, Chile	-	1	< 1	< 1	3	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	< 1		
Other squids, cuttlefishes, octopuses			-	-	< 1	2	5	3	3	3	3	4	4	5	3	6	4		
57 – Squids, cuttlefishes, octopuses			**< 1**	**1**	**< 1**	**5**	**79**	**131**	**174**	**288**	**286**	**713**	**716**	**792**	**619**	**779**	**575**		
Total selected species groups			**549**	**8 506**	**6 643**	**9 813**	**14 280**	**14 898**	**11 919**	**13 069**	**9 797**	**14 842**	**13 944**	**11 528**	**11 377**	**11 308**	**10 639**		
Total other species groups			**79**	**167**	**265**	**419**	**617**	**914**	**778**	**634**	**727**	**673**	**708**	**651**	**614**	**730**	**745**		
Total marine capture			**628**	**8 674**	**6 909**	**10 231**	**14 897**	**15 812**	**12 697**	**13 702**	**10 524**	**15 515**	**14 652**	**12 179**	**11 991**	**12 038**	**11 384**		
Total aquaculture					**2**	**54**	**325**	**482**	**683**	**685**	**687**	**791**	**858**	**978**	**968**	**1 026**	**1 048**		
Total production			**628**	**8 674**	**6 911**	**10 285**	**15 222**	**16 294**	**13 380**	**14 388**	**11 211**	**16 307**	**15 510**	**13 156**	**12 959**	**13 064**	**12 432**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D18: State of exploitation and annual nominal catches of selected species and ISSCAAP groups fished in the Southern Pacific Ocean (FAO Statistical Area 48), 1950–2009

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Lanternfishes NEI	*Myctophidae*		-	-	-	< 1	-	-	-	-	-	-	-	-	-	-	-	F	M
Other miscellaneous demersal fishes	*Dissostichus mawsoni*		-	-	-	< 1	< 1	< 1	< 1	1	2	2	3	3	3	3	3	F	M
34 – Miscellaneous demersal fishes			**-**	**-**	**0**	**< 1**	**< 1**	**< 1**	**< 1**	**1**	**2**	**2**	**3**	**3**	**3**	**3**	**3**		
Antarctic krill	*Euphausia superba*		-	-	< 1	3	< 1	-	-	-	-	-	-	-	-	-	-	U-F	M
46 – Krill, planktonic crustaceans			**-**	**-**	**< 1**	**3**	**< 1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
Total selected species groups			**-**	**-**	**1**	**4**	**< 1**	**1**	**1**	**1**	**2**	**2**	**3**	**3**	**3**	**3**	**3**		
Total other species groups			**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**		
Total marine capture			**-**	**-**	**1**	**4**		**1**	**1**	**2**	**2**	**3**	**4**	**3**	**3**	**3**	**3**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

Table D19: State of exploitation and annual nominal catches of tuna and tuna-like species in all Oceans, 1950–2009

Stock or species groups	Scientific name	Main fishing countries/territories in 2009	Thousand tonnes															State of exploitation*	Uncertainty**
			1950–59	1960–69	1970–79	1980–89	1990–99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Atlantic Ocean (FAO Statistical Areas 21, 27, 31, 34, 37, 41, 47 and 48)																			
Albacore	*Thunnus alalunga*	Taiwan Province of China, Spain, South Africa, Namibia	40	78	75	70	68	66	69	61	61	52	57	68	49	43	42	North: O, South: F, Med: ?	L
Atlantic bluefin tuna	*Thunnus thynnus*	Spain, Morocco, Italy, France	32	25	20	23	40	36	36	36	33	33	37	32	35	25	21	West: O, East: O	L
Bigeye tuna	*Thunnus obesus*	Taiwan Province of China, Spain, Japan, Ghana	4	25	53	68	110	108	99	80	90	84	71	66	79	70	82	F	L
Skipjack tuna	*Katsuwonus pelamis*	Spain, Netherlands Antilles, Ghana, Brazil	2	19	80	130	170	149	157	117	146	157	161	142	140	154	152	West: N, East: N	L
Southern bluefin tuna	*Thunnus maccoyii*	Taiwan Province of China, South Africa, Republic of Korea, Japan	-	-	7	5	2	2	3	1	2	1	2	1		1	1	O	L
Yellowfin tuna	*Thunnus albacares*	Spain, Netherlands Antilles, Ghana, France	18	68	106	146	156	132	161	137	122	117	104	104	98	110	120	F	L
Billfishes			**6**	**20**	**19**	**37**	**49**	**49**	**46**	**40**	**45**	**42**	**44**	**43**	**46**	**40**	**40**		
Other tunas and tuna-like species			**60**	**79**	**84**	**126**	**122**	**124**	**120**	**128**	**98**	**104**	**157**	**111**	**90**	**111**	**115**		
36 – Tunas, bonitos, billfishes			**162**	**315**	**444**	**605**	**717**	**667**	**691**	**601**	**597**	**591**	**635**	**568**	**538**	**553**	**574**		
Indian Ocean (FAO Statistical Areas 51, 57 and 68)																			
Albacore	*Thunnus alalunga*	Taiwan Province of China, Japan, Indonesia, India	3	15	11	19	26	25	22	21	24	36	31	29	43	46	39	F	L
Bigeye tuna	*Thunnus obesus*	Taiwan Province of China, Spain, Seychelles, Japan	6	18	25	48	99	141	131	138	124	142	118	113	120	102	100	F	L
Skipjack tuna	*Katsuwonus pelamis*	Sri Lanka, Spain, Maldives, Indonesia	12	21	39	126	320	435	440	497	489	470	534	616	461	433	431	N	M
Southern bluefin tuna	*Thunnus maccoyii*	Taiwan Province of China, Japan, Indonesia, Australia	14	27	24	25	10	11	13	12	9	12	12	11	10	9	8	O	L
Yellowfin tuna	*Thunnus albacares*	Sri Lanka, Spain, Iran (Islamic Rep. of), France	25	40	36	109	293	331	318	340	442	519	496	404	311	292	259	F	L
Billfishes			**5**	**9**	**5**	**10**	**33**	**52**	**48**	**48**	**53**	**55**	**44**	**46**	**39**	**32**	**34**		
Other tunas and tuna-like species			**26**	**58**	**105**	**222**	**347**	**446**	**411**	**428**	**440**	**426**	**388**	**463**	**470**	**478**	**496**		
36 – Tunas, bonitos, billfishes			**90**	**188**	**244**	**560**	**1 128**	**1 442**	**1 383**	**1 485**	**1 581**	**1 661**	**1 623**	**1 682**	**1 455**	**1 393**	**1 367**		
Pacific Ocean (FAO Statistical Areas 61, 67, 71, 77, 81, 87 and 88)																			
Albacore	*Thunnus alalunga*	Taiwan Province of China, Japan, Indonesia, China	71	94	121	115	119	124	144	159	139	161	135	143	165	146	175	North: O, South: N	L
Bigeye tuna	*Thunnus obesus*	Republic of Korea, Japan, Indonesia, Ecuador	38	81	110	131	165	204	196	243	212	241	227	251	245	261	223	East F; West F	L
Pacific bluefin tuna	*Thunnus orientalis*	United States of America, Taiwan Province of China, Mexico, Japan	23	29	22	19	18	31	17	18	14	16	28	20	20	22	19	O	L
Skipjack tuna	*Katsuwonus pelamis*	Philippines, Republic of Korea, Japan, Indonesia	188	246	483	727	1 138	1 422	1 262	1 440	1 566	1 528	1 714	1 811	1 877	1 866	2 017	East: F, West: N	East: M, West: L
Southern bluefin tuna	*Thunnus maccoyii*	Taiwan Province of China, New Zealand, Japan, Australia	5	20	13	5	3	2	2	2	2	2	1	1	1	1	1	O	L
Yellowfin tuna	*Thunnus albacares*	Philippines, Mexico, Japan, Indonesia	119	176	339	467	674	745	872	893	884	709	700	609	639	752	714	East: F; West: N	L
Billfishes			**46**	**65**	**49**	**52**	**58**	**60**	**58**	**67**	**71**	**70**	**74**	**76**	**76**	**72**	**70**		
Other tunas and tuna-like species			**158**	**245**	**343**	**623**	**950**	**1 151**	**1 158**	**1 238**	**1 214**	**1 318**	**1 327**	**1 354**	**1 531**	**1 394**	**1 414**		
36 – Tunas, bonitos, billfishes			**625**	**928**	**1 458**	**2 120**	**3 106**	**3 708**	**3 692**	**4 043**	**4 090**	**4 030**	**4 178**	**4 245**	**4 535**	**4 492**	**4 615**		

* U: Non-fully exploited; F: Fully exploited O: Overexploited

** L: low; M: Intermediate; H: High

APPENDIX

Assessment methodology[1]

Yimin Ye
Senior Fishery Resources Officer
Marine and Inland Fisheries Service
FAO Fisheries and Aquaculture Department
E-mail: yimin.ye@fao.org

ASSESSMENT APPROACH FOR THIS REVIEW OF STOCK STATUS

The objective of the FAO assessment is to provide a global overview of the state of world marine fishery resources to help with policy formulation and decision-making for the long-term sustainability of marine fisheries. Fish stock status is normally assessed based on the relationship between stock abundance and productivity. For example, the United Nations Convention on the Law of the Sea (UN, 1982), the United Nations Fish Stocks Agreement (UN, 1995), and the FAO Code of Conduct for Responsible Fisheries (FAO, 1995) require maintaining fish stocks at the biomass that can produce MSY. Such a relationship is often established through a formal stock assessment process. However, because of the high data demands of classical stock assessment methods, only a limited number of fish stocks have been assessed. These species account for 17–25 percent of the global catch (Trevor *et al*., 2011), and most are caught by fisheries in developed countries. To balance the global representativeness of the assessment results and the goal of using the best available information, the FAO uses a wide spectrum of data and methods to extend its assessment to the fish stocks that account for the majority (80 percent) of the global catch (FAO, 2005).

There are three recognized types of overfishing: biological (Hilborn and Walters, 1992), economic (Clark, 1976) and ecosystem overfishing (Murawski, 2000). This review focuses on biological overexploitation as it is the key reference point of most fishery-related international treaties (UN, 1982, 1995; FAO, 1995). In this review, fish stocks/species are classified into three categories: non-fully exploited, fully exploited and overexploited. The criteria corresponding to each category are listed in Table DA1. As discussed below, the approach in this report differs from the previous FAO assessments that used five separate status categories. In this report, the classification uses four major indicators, whose use varies according to their availability. These are: stock abundance, spawning potential, catch, and size/age composition. Stock abundance is the fundamental attribute on which the three categories of stock status have been defined in this review.

Stock abundance

Fully exploited refers to the situation where the current stock is at 40–60 percent of the unfished level (Table 1). This definition originated from the concept of surplus production of fish stocks and assumes that MSY is the goal of fishery management (UN, 1982, 1995; FAO, 1995). The most commonly used Schaefer model assumes that

[1] The assessment methods described here were used as guidelines for the assessment of marine fish stock status in the preparation of this review report. A series of meetings and consultations were held within the Marine and Inland Fisheries Service of the FAO Fisheries and Aquaculture Department, and external reviews were carried out by world renowned experts to further improve the methods. Therefore, they are the results of collective contributions and decisions of the whole Service, rather than the author's personal opinion.

MSY occurs at 50 percent of the virgin stock. However, the stock biomass associated with MSY (B_{MSY}) varies with assessment models. For example, the Pella-Tomlinson model allows for MSY to range from 25 to 63 percent of pristine biomass (B_0) when parameter *n* varies from 0.25 to 4 (with *n*=2, the Pella-Tomlinson model becomes a Schaefer's model; Quinn and Deriso, 1999). The range in these models reflects the uncertainty about the value of B_{MSY} in reality. For example, Thompson (1992) shows that MSY occurs at B < 50 percent B_0 when a stock has a Beverton-Holt spawner–recruit relationship. Hilborn (2010) concluded that 80 percent of the MSY can be obtained over a range of 20–50 percent B_0. However, Dick and MacCall (2011) argue that there is no objective reason that actual populations are restricted to B_{MSY} < 50 percent B_0, with practical evidence of $B_{MSY} > 0.5B_0$ (Taylor and DeMaster, 1993; MacCall, 2002). It seems clear that the real B_{MSY} may lie within a range of stock biomass, depending on the characteristics of the fish species concerned. Moreover, the use of a single reference point to define B_{MSY} may cause unnecessary difficulties in practical management of stocks that show strong interannual fluctuations in abundance. Selection and application of models needs to take these differences and variability into account. The estimates of stock biomass derived from different data sets and different models can also vary because of the uncertainties involved in data and models.

Therefore, there is no clear consensus or precise estimates of suitable thresholds for defining status of stocks. However, the FAO definition is centred on stock biomass (abundance) and is loosely based on the standard Schaefer model. As a result, "fully exploited" is defined as a biomass within a band of 40–60 percent of the virgin stock, taking into account various uncertainties. As a result, stocks above 60 percent of the unfished biomass are classified as non-fully exploited, and those under 40 percent as overexploited (Table 1).

This classification of stock status is primarily based on stock abundance, but any other information or indicator that can linearly reflect changes in stock abundance can also be used as surrogates in the diagnosis of stock status. There would be clear advantages to also including an index of the current relative fishing mortality (e.g. overfished, or fished at F_{MSY}) as is currently done in several national and regional assessments. However, this more-demanding information is not available for many of the stocks covered by the FAO assessment.

Spawning potential

A fundamental goal of fishery management is to protect the reproductive potential of fish stocks for maximum yield and sustainability. The relative value of spawning stock biomass per recruit in comparison with the unfished situation is often used to measure the impact of fishing on the potential productivity (Goodyear, 1993). Many fisheries are managed based on reference points of fishing mortality that can maintain the spawning stock biomass per recruit at a certain level, instead using reference points that are associated with stock biomass (e.g. in the EU [ICES, 2010]; the United States of America (NMFS, 2010), and Australia (Wilson *et al*., 2009]). In this review, the spawning stock biomass per recruit is, therefore, used as another indictor. A stock is considered to be overfished when its spawning stock biomass per recruit falls below 20 percent, and non-fully exploited if this value is above 40 percent of the unfished biomass. Stocks with values between 20 and 40 percent are referred to as fully exploited.

Catch

Catch represents the extent of biomass removal from a fish stock, and the development process of a fishery is usually accompanied by temporal changes in landings. Landings often initially increase and then decrease as species abundance decreases when no regulations over fishing effort are implemented (Grainger and Garcia, 1996). A drop in landings is often a symptom of overfishing. Grainger and Garcia (1996) diagnosed

TABLE 1
Criteria for the classification of fish stock status

Category	Characteristics
Overexploited	**1. Stock abundance** • Estimates of current stock biomass are < 40 percent of the estimated unfished stock size. • Catch rates (CPUE) are < 40 percent of the initial levels. • Survey abundance indices are < 40 percent of the initial values. **2. Spawning potential** • Spawning stock biomass is < 20 percent of the unfished biomass. **3. Catch trend** • Catches have dropped significantly from a peak without a clear cut in fishing effort. • Current catch is < 50 percent of the maximum after a 5-year smoothing. **4. Size/age composition** • Size/age composition unstable (excessively affected by recruitment, too few size classes in the exploited population given a species' life history). • Trends in size/age compositions are evident that indicate increasing (and/or excessive) fishing mortality.
Fully exploited	**1. Stock abundance** • Estimates of current stock biomass are between 40 and 60 percent of the estimated unfished stock size. • Catch rates (CPUE) are between 40 and 60 percent of the catch rates of the initial fishery stage. • Survey abundance indices are between 40 and 60 percent of the initial values. **2. Spawning potential** • Spawning stock biomass is between 20 and 40 percent of the unfished biomass. **3. Catch trend** • Catches have stabilized at or close to the peak values in the last 5–10 years although there may be interannual fluctuations. **4. Size/age composition** • Size/age composition is stable (not excessively affected by recruitment, enough age or size classes in the exploited population given a species' life history).
Non-fully exploited	**1. Stock abundance** • Estimates of current stock biomass are > 60 percent of the estimated unfished stock size. • Catch rates (CPUE) are > 60 percent of the initial catch rates. • Survey abundance indices are > 60 percent of the initial values. **2. Spawning potential** • Spawning stock biomass is > 40 percent of the unfished biomass. **3. Catch trend** • Catches increased over time when fishing effort has increased. **4. Size/age composition** • Size/age composition of the catch has been stable and has not shown large changes in comparison with that of the initial stage of the fishery.

the development status of a fishery by analysing the trend in landings over time. Pauly (2007) assessed stock status by comparing the current landings with the maximum historical catch. However, Trevor *et al.* (2011) show that this method has the potential to overestimate the status of stocks that are overfished when such a simple catch-only method is used. Moreover, low catches or declines in catch can be caused by management regulations. Connecting catch trends to stocks status is difficult when only catch data are available. However, fisheries that have only catch data usually have insufficient data to undertake any formal stock assessment and, consequently, rarely have management in place. For such fisheries, catch trend analyses may provide useful information on stock status if they are used together with other informal information and data.

Size/age composition

Finally, fishing is often a selective removal process. With the increase in fishing intensity, the size composition of the catch will shrink. Different size-based indicators can be used to detect the impact of fishing (Jennings and Dulvy, 2005). FAO's assessment uses no numeric length-based reference points, but includes some general judgements as supplementary information when required and when suitable size information is available. It should be borne in mind that changes in size composition can only be detected in the medium term rather than annually.

Synthesizing the information

Spawning potential, catch trend and size composition data are not directly linked with stock biomass. They should be used together with other supplementary information when abundance (biomass) data are absent or believed to be unreliable. Classification of stock status should be undertaken by integrating all the sources of information available. There is no simple rule to follow for such integration in data-poor fisheries. Informal and innovative approaches may need to be adopted, which may vary in accordance with assessors' personal experience and the specific circumstances of the stock concerned. To ensure the quality and objectiveness of the assessment, FAO relies on two measures. One is close consultation with local and regional experts on the fishery, and the other is seeking supplementary information when the assessment is based on limited information, qualitative methods or unpublished information.

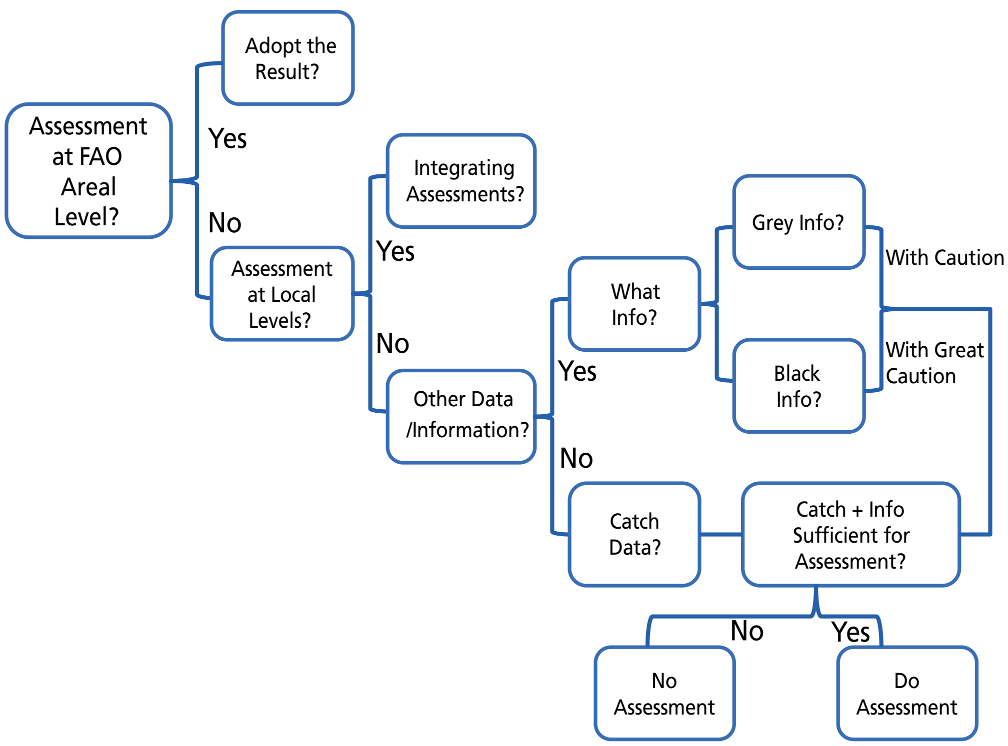
ASSESSMENT PROCEDURES

Assessment of status

The fish stocks that FAO has monitored since 1974 represent a wide spectrum of data availability, ranging from data-rich and formally assessed stocks to those that have very little information apart from catch statistics and those with no stock assessment at all. For the purposes of using the best available data and information and maintaining consistency among stocks and assessors, the following procedures have been used (Figure 1).

1. For stocks that have formal assessment at the FAO Statistical Area level (e.g. stocks assessed by the ICES, the FAO fishery commissions or RFMOs), these assessment results should be simply adopted. However, the following adjustments may be necessary in practice:
   a. The classification of stock status should follow the criteria listed in Table 1 if an estimate of current biomass of a stock relative to B_{MSY} is available.

FIGURE 1
Diagram of the decision tree for the classification of fish stock status



   b. If existing assessments are not fully updated (with a gap of 1–3 years), other formal or informal information and the catch data extracted from the FAO database may be used to extend the previous assessment to the year of the current assessment.
2. For stocks that have no formal assessment at the FAO Statistical Area level, stock status assessments at regional, national or even finer scales should be used where available. FAO's assessment of stock status is about the overall condition of fish stocks/species. If a stock/species consists of several stocks or substocks, the following rules should be followed:
   a. The overall stock status should be the average of the status of the substocks weighted by their biomasses. Where no biomass data are available, the averages of the five consecutive years of the largest catches for each substock should be used as weighting factors.
   b. In cases where the above approach a) is not applicable, the state of exploitation in the summary table should list all the substocks if there are three or fewer substocks as "F, O, N", indicating one substock "fully exploited", one "overfished" and the other "non-fully exploited", or the three substocks that have the largest catches if there are more than three substocks.
   c. Any information that may have influenced the determination of stock status should be reflected in the text.
3. For stocks that do not have assessment at all, effort should be made to collect data/information that may exist in the "grey literature" or "black literature",[2] which may not always be about stock status. However, it may contain other relevant information such as length frequency data, survey abundance indices or fishing mortality estimates in selected years. Classification of these stocks should follow the rules below:
   a. Where data/information, such as intermittent CPUE data from the fishery or a sector of the fishery, survey abundance indices or ad hoc indicators are available in working papers or reports of local governments, RFMOs and projects (grey information), stock status may be classified following the criteria related to stock abundance in Table 1. This should be done in combination with other information or methods such as catch trend analysis; in the meantime:
      - some extrapolation may be necessary to bring the assessment up to date based on surrogate data/information from the fishery;
      - the catch trend should be analysed based on the data extracted from the FAO statistics database and stock status should be classified following the criteria in Table 1.
      - integration of different information or assessment results may be done informally or based on expert experience.
   a. Where no grey data/information are useful for determining stock status, information from personal communications or informal channels, such as views/opinions of local experts working on the fish species or fisheries, reports of local meetings or newspapers (black information), may also be incorporated in the classification. In addition, a catch trend analysis should also be carried out based on the data extracted from FAO's database.
      - When a clear drop can be identified and the black information is consistent with the catch trend analysis, the stock should be classified following the criteria listed in Table 1.

[2] "Grey literature" refers to working papers and reports of local governments, RFMOs and projects, and "black literature" means personal communications, reports of local meetings, newspapers, etc.

- If the catch trend analysis does not give a conclusive solution about stock status or the black information is not consistent with the results of the catch trend analysis, educated judgement that includes best knowledge from experts on the stock and/or region may be adopted to classify the stock.

a. For stocks that have neither grey nor black information available and for which the time series catch data does not support a clear judgement about stock status, no classification should be made.

Estimating and reporting uncertainty

4. Caution should be exercised with all the qualitative diagnostics that use the grey or black data/information mentioned above.
5. All stock status classifications involve uncertainty, and awareness of the level of such uncertainty can help readers to determine how to make better use of the assessment results. Therefore, a score of uncertainty involved in the classification is provided and listed in the last column of the state of exploitation tables. They are measured by three levels:
   a. Low uncertainty – formal stock assessment at the FAO Statistical Area level or at the regional and national levels forms the foundation of the classification.
   b. Intermediate uncertainty – grey data/information and a catch trend analysis provide the basis for classification.
   c. High uncertainty– black data/information and a catch trend analysis together with other qualitative assessment were used for the classification.
6. If the resulting status assessment of a stock differs from the last assessment, effort should be made to understand the reasons why and to explain the change in the text.
7. Recording briefly how the conclusion of stock status has been reached. This information is not reported here in the report, but retained for internal uses for future assessment and increasing transparency.

DIFFERENCES BETWEEN CURRENT AND PREVIOUS APPROACHES

In FAO's previous assessments, the status of a fish stock/species was classified in one of six categories. The details of this classification are listed in Table 2 (FAO, 2005). The approach used in the current latest assessment differs from previous assessments in the following three important aspects:

- As explained above, only three categories of stock status have been used compared with the six used in previous assessments. This simplification has been undertaken

TABLE 2
Criteria for the classification of fish stocks status in previous assessments

Stock status	Symbol	Description
Underexploited	U	Underexploited, undeveloped or new fishery. Believed to have a significant potential for expansion in total production.
Moderately exploited	M	Stocks are exploited with a low level of fishing effort. Believed to have some limited potential for expansion in total production.
Fully exploited	F	The fishery is being exploited at or close to an optimal yield level, with no expected room for further expansion.
Overexploited	O	The fishery is being exploited at above a level that is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse.
Depleted	D	Catches are well below historical levels, irrespective of the amount of fishing effort exerted.
Recovering	R	Catches are again increasing after having been depleted or a collapse from a previous high.
Unknown	? or blank	Not known or uncertain. Not much information is available for assessment and stock status cannot be determined.

to reflect the underlying uncertainty in many of the assessments. This means that there is a high risk of error in attempts for a more precise assessment into six categories. It is important to note that the three categories used here are not new but are simply the result of aggregating overexploited, recovering and depleted into the one category overexploited, and the categories of moderately exploited and underexploited into the single group non-fully exploited. Therefore, the use of the three categories in this assessment should not in itself have led to any change in the percentages of stocks within the broad categories of overexploited, fully exploited and non-fully exploited.

- There are large differences in the types of fisheries, nature of the stocks and the data and information available from region to region. Therefore, it would be impractical to attempt to impose a rigid and identical framework across all regions. In previous assessments, the choice of approaches was largely left to the responsible authors to use their individual judgement on which data and information to use and how to use them. The process summarized in Figure 1 has been implemented in the current assessment in order to try to obtain greater standardization. Thus, it should improve comparability between the different individuals and groups undertaking the different regional assessments, while still recognizing the need to allow flexibility. The elements and options within the process do not differ significantly from those used in previous assessments. While it should have led to greater standardization and consistency in assessments, the process should not in itself have resulted in any change in percentages of stocks across the different categories.
- The individuals responsible for assessing each region were asked to review the stocks conventionally assessed in their region. They had to consider whether any changes were required to improve the representativeness or quality of the overall regional assessment. Some stocks might have been assessed in the past, but are now omitted because of the inadequate data available. Some stocks that were not fished historically may have been assessed recently owing to their increasing production and socio-economic importance in the region. This may have been because of changes in fish species composition of marine ecosystems or in targeting by fishing fleets.

Overall, the changes to the assessment approach applied for this review are expected to have improved the accuracy of the results and the comparability across regions. This is despite substantial uncertainty inevitably remaining, in particular as a result of the poor information quality for many stocks. It is the opinion of the contributors to the review that the new approach would not have significantly biased the assessment compared with earlier reports. The approach should not have generated either a more negative or a more positive view on the global status of the world's marine fishery stocks. Therefore, the results should be comparable with previous assessments, taking into account the wide confidence intervals that result from high levels of uncertainty.

ACKNOWLEDGEMENTS

FAO initiated an external review on the assessment approaches used in the review of the state of world marine fishery resources in 2009. Andre Punt, Paul Medley, and Graham Pilling provided valuable inputs and constructive recommendations during the review process. This work was accomplished through contributions from all the staff at the Marine and Inland Fisheries Service, who were involved in the review initiative, participated in various meetings and discussions, and made great inputs and recommendations. I am grateful to Kevern Cochrane for useful discussions and great support and would also like to thank David Milton of editing the paper.

REFERENCES

Clark, C.W. 1976. *Mathematic bioeconomics*. New York, USA, Wiley.

Dick, E.J. & MacCall, A.D. 2011. Depletion-based stock reduction analysis: a catch-based method for determining sustainable yields for data-poor fish stocks. *Fisheries Research*, 110: 331–341.

FAO. 2005. *Review of the state of world marine fishery resources*. FAO Fisheries Technical Paper No. 457. Rome. 235 pp.

FAO. 1995. *Code of Conduct for Responsible Fisheries*. Rome. 41 pp.

Goodyear, C.P. 1993. Spawning stock biomass per recruit in fisheries management: foundation and current use. *In* S.J. Smith, J.J. Hunt & D. Rivard, eds. *Risk valuation and biological reference points for fisheries management*, pp. 67–81. Canadian Special Publication of Fisheries and Aquatic Sciences 120.

Grainger, R.J.R. & Garcia, S.M. 1996. Chronicles of marine fishery landings (1950–1994) – trend analysis and fisheries potential. *FAO Fisheries Technical Paper No. 359*. Rome, Italy.

Hilborn, R. 2010. Pretty good yield and exploited fishes. *Marine Policy*, 34: 193-196.

Hilborn, R. & Walters, C. 1992. *Quantitative fisheries stock assessment – choice, dynamics and uncertainty*. New York, USA, Chapman and Hall.

International Council for the Exploration of the Sea (ICES). 2010. *Report of the ICES Advisory Committee, 2010*. ICES Advice, 2010. Books 9.

Jennings, S. & Dulvy, N.K. 2005. Reference points and reference directions for size-based indicators of community structure. *ICES Journal of Marine Science*, 62: 397–404.

MacCall, A.D. 2002. Fishery management and stock-rebuilding prospects under conditions of low-frequency environmental variability and species interactions. *Bulletin of Marine Science*, 70: 613–628.

Murawski, S.A. 2000. Definitions of overfishing from an ecosystem perspective. *ICES Journal of Marine Science*, 57: 649–658.

National Marine Fisheries Service (NMFS). 2010. *Status of U.S. Fisheries – Appendix 1. Report format and description of methodology for determining overfishing and overfished status*.

Pauly, D. 2007. The Sea Around Us project: documenting and communicating global fisheries impacts on marine ecosystems. *Ambio*, 34:290–295.

Quinn II, T.J. & Deriso, B. 1999. *Quantitative fish dynamics*. Oxford, UK, Oxford University Press.

Taylor, B. & DeMaster, D. 1993. Implications of non-linear density dependence. *Marine Mammal Science*, 9: 360–371.

Thompson, G.G. 1992. Management advice from a simple dynamic pool model. *Fishery Bulletin US*, 90: 52–560.

Trevor, A.B., Jensen, O.P., Ricard, D., Ye, Y. & Hilborn, R. 2011. Contrasting global trends in marine fishery status obtained from catches and from stock assessments. *Conservation Biology*, 25: 777–783.

United Nations (UN). 1982. The United Nations Convention on the Law of the Sea [online]. [Cited 20 December 2011]. www.un.org/Depts/los/convention_agreements/texts/unclos/unclos_e.pdf

United Nations (UN). 1995. The United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks [online]. [Cited 20 December 2011]. http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N95/274/67/PDF/N9527467.pdf?OpenElement

Wilson, D., Curtotti, R., Begg, G. & Phillips, K. 2009. *Fishery status reports – status of fish stocks and fisheries managed by the Australian government*. Canberra, Bureau of Rural Sciences and Australian Bureau of Agriculture and Resources Economics.

This publication presents an updated assessment and review of the current status of the world's marine fishery resources. It summarizes the information available for each FAO Statistical Areas; discusses the major trends and changes that have occurred with the main fishery resources exploited in each area; and reviews the stock assessment work undertaken in support of fisheries management in each region. The review is based mainly on official catch statistics up until 2009 and relevant stock assessment and other complementary information available until 2010. It aims to provide the FAO Committee on Fisheries and, more generally, policy-makers, civil society, fishers and managers of world fishery resources with a comprehensive, objective and global review of the state of the living marine resources.

ISBN 978-92-5-107023-9 ISSN 2070-7010

9 789251 070239

I2389E/1/12.11