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Management of tuna fishing capacity: conservation and socio-economics

15–18 March 2004
Madrid, Spain

Cover photo: Large-scale tuna purse-seiner

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Management of tuna fishing capacity: conservation and socio-economics

15–18 March 2004
Madrid, Spain

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Since the FAO Committee on Fisheries adopted the International Plan of Action for the Management of Fishing Capacity in February 1999, FAO has fullfiled a major role in addressing this crucial issue for the conservation and sustainability of fisheries resources. Overcapacity is a problem that contributes substantially to overfishing, the decline of food production and significant economic waste.

In response to the above-mentioned International Plan of Action and at the request made by some countries at the twenty-fourth session of the FAO's Committee on Fisheries for assistance in addressing the problem of tuna fishing overcapacity, FAO formulated the "Management of tuna fishing capacity: conservation and socio-economics" Project. FAO, in its global and multidisciplinary role and involvement and expertise in tuna resources, fishing, processing and trade, was considered an appropriate organization to address the problem. The Government of Japan financed the Project.

The FAO Project established an external Technical Advisory Committee (TAC) to foster the collaboration of tuna fishery bodies and other major intergovernmental and non-governmental organizations involved in tuna fishing, fisheries research and management. The studies included in these Proceedings are a result of the priorities set by the Project in consultation with the TAC in its first meeting (Rome, Italy, 14–16 April 2003). These priorities cover a wide range of subjects, such as tuna fisheries and resources, the estimation of fishing capacity, the tuna fishing industry and the management of tuna fishing capacity. Preliminary versions of papers on these studies were presented and critically reviewed at the second meeting of TAC (Madrid, Spain, 15–18 March 2004). Their final versions presented in this publication benefited from the suggestions for improvements that were received from the TAC and various other fisheries experts.

Abstract

The FAO's Japan-funded Project on the "Management of tuna fishing capacity: conservation and socio-economics" has been formulated by FAO with the objective of improving the management of tuna fisheries on a global scale. Its immediate objectives are to provide technical information necessary for the management of tuna fishing capacity and to identify and resolve the technical problems associated with that management on a global scale, taking into account conservation and socio-economic issues.

This publication presents results of the studies carried out by the Project that were proposed by the Project and considered by its Technical Advisory Committee (TAC) at its first meeting (Rome, Italy, 14-16 April 2003) as being of highest priority. Earlier versions of papers on these studies were presented to the second meeting of the TAC (Madrid, Spain, 15-18 March 2004), where they were critically discussed. These papers were subsequently peer reviewed, revised and edited.

The studies presented in this publication are on the tuna fisheries and resources, the characterization and estimation of fishing capacity, the tuna fishing industry and the management of tuna-fishing capacity. Their results are summarized in the "Overview" of this publication, and detailed information on them is presented in the following four sections associated with these subjects.

The first section describes, on the global scale:

- the development of tuna fisheries since their inception, including (i) the evolution of vessels, fishing gear, navigation and fishing techniques and fishing grounds and (ii) the trends in tuna catches;
- the status of the tuna stocks; and
- the tuna catch data available from the FAO Fisheries Global Information System (FIGIS).

The second section includes three papers on fishing capacity of industrial tuna purse seiners and longliners and on the importance of non-industrial tuna fisheries.

The third section consists of one paper that qualitatively and quantitatively assesses the influence of the tuna market (e.g. prices and imports) on tuna catches.

The fourth section includes two papers that analyse past developments and future options for the management of fishing capacities of the purse-seine and longline fleets.

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Contents

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- Commission for the Conservation of Southern Bluefin Tuna (CCSBT),
- Forum Fisheries Agency (FFA),
- INFOFISH,
- Inter-American Tropical Tuna Commission (IATTC),
- International Commission for the Conservation of Atlantic Tunas (ICCAT),
- Indian Ocean Tuna Commission (IOTC),
- National Research Institute of Far Seas Fisheries - Japan (NRIFSF),
- Organization for Promotion of Responsible Tuna Fisheries (OPRT),
- Secretariat of the Pacific Community (SPC), and
- World Tuna Purse-Seine Organization (WTPO).

We are grateful to these institutions and their scientists for their significant contributions.

In particular, the editors of this publication express their gratitude to the members of the Technical Advisory Committee, i.e. Robin Allen (IATTC), Alejandro Anganuzzi (IOTC), John Annala (Ministry of Fisheries, New Zealand), John Hampton (SPC), James Joseph (Consultant), Victor Restrepo (ICCAT), Peter Miyake (OPRT), Julio Morón (WTPO), Chris Reid (FFA), Suba Subasinghe (INFOFISH) and Ziro Suzuki (NRIFSF) for their cooperation, advice and commitment during the implementation of the Project.

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Preface

Tuna and tuna-like species are targets of important fisheries in both developed and developing countries, and are a significant source of food all over the world. The catch of these species was about six million tonnes in 2002. Albacore, bigeye, Atlantic bluefin, Pacific bluefin, skipjack, southern bluefin and yellowfin, which are frequently referred to as the principal market species of tunas, are the most important species of tunas, in terms of both quantities and market values. They are used mostly for canning and *sashimi* (raw fish regarded as a delicacy in Japan and, increasingly, in other countries). Due to their high economic value and extensive international trade, the principal market species of tunas are a very important global commodity. Their annual catches have increased from less than 500 000 tonnes during the 1950s to more than 4 000 000 tonnes in 2002, having been stable at about the latter level since 1999. The export value of the 2002 catch was about US$5 billion.

Since the 1940s, when the industrial fisheries for tunas began, the numbers of vessels of the traditional tuna-fishing countries have been increasing, and additional countries began participating in tuna fisheries. Also, new developments in fishing technology have dramatically increased fishing capacity worldwide. As a result of these developments, tuna-fishing capacity has become excessive in respect to tuna resources, the demand for tuna products or both. This excess has led to overexploitation, or even depletion, of some tuna stocks.

Research carried out and/or coordinated by regional tuna fishery management organizations and other intergovernmental organizations indicates that most stocks of tuna are fully exploited, and some are overfished, or even depleted. Only a few tuna stocks are underexploited, so there is only a limited potential for sustainable increases in the catches of tunas. In fact, significant increases in fishing effort for tunas would likely lead to a further overexploitation of some stocks, eventually resulting in reductions in overall catches in the long term.

Tuna are fished, traded, processed and consumed almost globally. Vessels registered in coastal countries bordering one ocean frequently fish in other ocean areas. In particular, the industrial fleets often transfer their operations from one ocean to another in response to changing conditions, which makes it difficult to manage fishing capacity on a regional scale. In addition, after capture fish are frequently transported to other parts of the world for processing. Also, substantial illegal, unreported and unregulated (IUU) fishing, which occurs in all oceans, significantly complicates the management of the fisheries for tunas.

In the recent past, due to an excess supply of raw material for tuna canning, the prices paid for the fish were reduced to the point that fishing for some species was no longer profitable. In response, the tuna industry has been trying to overcome this problem independently of governments and intergovernmental organizations. The owners of tuna purse seiners formed a global organization, the World Tuna Purse-Seine Organization, temporarily limiting fishing effort by their vessels. Also, the number of longline vessels supplying the *sashimi* market has been reduced in some countries. However, these actions are not regarded as sufficient in the long term.

Most of the regional tuna fishery management organizations have been attempting to address the issue of tuna-fishing capacity in their areas of competence. However, the problems of managing tuna-fishing capacity are multidisciplinary, involving biological, socio-economic and technological issues, and the conventions of most, if not all, of the tuna fishery management organizations do not encourage their involvement in issues other than biological issues. In addition, the problems are similar in all oceans, so it is more efficient to deal with them on the global scale, eliminating duplication of effort. Also, developing countries need technical support to participate in international discussions on the establishment of international and national regimes for the management of tuna-fishing capacity.

Identification and resolution of the technical problems associated with the management of tuna-fishing capacity on the global scale would:

- make it possible to address the technical problems through intensive, multidisciplinary research into them, preventing the duplication of research;
- enhance the management of tuna-fishing capacity by individual tuna fishery management organizations in the areas of their competence and at national scales; and
- possibly lead to global recommendations and/or decisions being made, making the management of tuna-fishing capacity more effective on global, regional and national scales.

Because of its global and multidisciplinary role and its involvement and expertise in tuna resources, fishing, processing and trade, FAO is an appropriate organization to address the problem of tuna-fishing overcapacity. In response to the request made by several countries at the twenty-fourth session of FAO's Committee on Fisheries for assistance in addressing the problem of tuna-fishing overcapacity, FAO formulated a Project on the "Management of tuna fishing capacity: conservation and socio-economics". The Government of Japan has financed the Project.

The present publication provides information on the technical findings from the studies implemented by the Project.

Acronyms and codes

ACP	African, Caribbean and Pacific Countries
ADB	Asian Development Bank
ADEPALE	Association des entreprises de produits alimentaires élaborés
AIDCP	Agreement on the International Dolphin Conservation Program
ALB	Albacore (*Thunnus alalunga*)
AMSY	Average maximum sustainable yield
ANCIT	Associazione Nazionale Conservieri Ittici e delle Tonnare
ANFACO	Asociación Nacional de Fabricantes de Conservas de Pescados y Mariscos
AO	Atlantic Ocean
ASEAN	Association of Southeast Asian Nations
B_{AMSY}	Biomass at AMSY
BESD	Bigeye statistical document
BET	Bigeye tuna (*Thunnus obesus*)
BFSD	Bluefin statistical document
BFT	Atlantic bluefin tuna (*Thunnus thynnus*)
B_{MSY}	Biomass at MSY
c&f	Cost and freight
CARICOM	Caribbean Community
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CN	Common nomenclature
CPUE	Catch per unit of effort
CU	Capacity utilization
CWP	Coordinating Working Party on Fishery Statistics
DEA	Data envelopment analysis
DFS	Designated fishery licensing scheme
DHA	Docosahexaenoic acid
DOL	Department of Labor
DWFN	Distant-water fishing nation
EAFUS	Everything added to food in the United States
EAO	Eastern Atlantic Ocean
EC	European Community
EEZ	Exclusive economic zone
EII	Earth Island Institute
ENSO	El Niño-southern oscillation
EPA	United States Environmental Protection Agency

EPO	Eastern Pacific Ocean
EPR	GLOBEFISH European price report
EU	European Union
F	Fishing mortality
FAD	Fish-aggregating device
F_{AMSY}	Fishing mortality at AMSY
FAO	Food and Agriculture Organization of the United Nations
FCC	Fish-carrying capacity
FDA	Food and Drug Administration
FFA	Forum Fisheries Agency
FIAC	Fédération française des industries d'aliments conservés
FIDI	FAO Fisheries Department, Fishery Information, Data and Statistics Unit
FIDP	FAO Fisheries Department, Programme Coordination Unit
FIGIS	FAO Fisheries Global Information System
FIIU	FAO Fisheries Department, Fish Utilization and Marketing Service
FIRI	FAO Fisheries Department, Inland Water Resources and Aquaculture Service
FIRM	FAO Fisheries Department, Marine Resources Service
F_{MSY}	Fishing mortality at MSY
FOC	Flag of convenience
FSA	Food Standards Agency
G&G	Gilled and gutted
GATT	General Agreement on Tariffs and Trade
GPS	Global positioning system
GRT	Gross registered tonnage or gross registered tons
GT	Gross tons
H&G	Headed and gutted
HACCP	Hazard analysis and critical control point
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
INC	INFOPESCA noticias comerciales
IO	Indian Ocean
IOTC	Indian Ocean Tuna Commission
IPOA–CAPACITY	International Plan of Action for the management of fishing capacity
IPOA–IUU	International Plan of Action to prevent, deter and eliminate illegal, unreported and unregulated fishing
IQ	Individual catch quota
IREPA	Istituto di Ricerche Economiche per la Pesca e l'Acquacoltura

ISC	Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific
ITN	INFOFISH trade news
ITN–African Edition	INFOPÊCHE trade news–African edition
ITQ	Individual transferable quota
IUU	Illegal, unreported and unregulated
JIMAR	Joint Institute for Marine and Atmospheric Research, University of Hawaii, National Oceanic and Atmospheric Administration
LL	Longline
LOA	Overall length
LOSC	United Nations Convention on the Law of the Sea
LP	Pole-and-line
LSTLV	Large-scale tuna longline fishing vessel
MED	Mediterranean Sea
MEY	Maximum economic yield
MSY	Maximum sustainable yield
NAO	North Atlantic Ocean
nei	Not elsewhere identified
NGO	Non-governmental organization
NMFS	United States National Marine Fisheries Service
NOAA	United States National Oceanic and Atmospheric Administration
NPO	North Pacific Ocean
NRIFSF	National Research Institute of Far Seas Fisheries of Japan
NRT	Net registered tonnage
NSEC	Norwegian Seafood Export Council
OFP	Ocean Fisheries Programme of the SPC
OJ	Official Journal of the European Communities
OPRT	Organization for the Promotion of Responsible Tuna Fisheries
OTH	Other gears
oz	Ounces
PBF	Pacific bluefin tuna (*Thunnus orientalis*)
PL	Pole-and-line
PO	Pacific Ocean
ppm	Parts per million
PS	Purse-seine
RAV	Record of authorized vessels
RDA	Recommended dietary allowance
RFBA	Regional fishery bodies and arrangements
RFMO	Regional fishery management organizations
RVR	Regional vessel register
SAO	South Atlantic Ocean

SBF	Southern bluefin tuna (*Thunnus maccoyii*)
SBR	Spawning biomass ratio
SBR_{AMSY}	Spawning biomass ratio at AMSY
SC	Scientific Committee of the IOTC
SCG	Scientific Coordinating Group of the WCPFC
SCRS	Standing Committee on Research and Statistics of the ICCAT
SCTB	Standing Committee on Tuna and Billfish of SPC
SIDP	Species Identification and Data Programme
SIPAM	FAO information system for the promotion of aquaculture in the Mediterranean
SKJ	Skipjack tuna (*Katsuwonus pelamis*)
SPC	Secretariat of the Pacific Community
SPO	South Pacific Ocean
SSB	Spawning stock biomass
SSB_{AMSY}	Spawning stock biomass at AMSY
SSB_{MSY}	Spawning stock biomass at MSY
SURF	Surface gears
SWO	Swordfish (*Xiphias gladius*)
TAC	Technical Advisory Committee of the FAO Project "Management of tuna fishing capacity: conservation and socio-economics"
TAC	Total allowable catch
TE	Technical efficiency
TIS	Southern bluefin tuna trade information scheme
UN	United Nations
VPA	Virtual population analysis
WAO	Western Atlantic Ocean
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WHO	World Health Organization
WPTT	Working Party on Tropical Tunas of the IOTC
WTO	World Trade Organization
WTPO	World Tuna Purse-seine Organization
YFT	Yellowfin tuna (*Thunnus albacares*)

Overview

1. INTRODUCTION

As mentioned in the Preface, tuna and tuna-like species are an important source of food and are very important economically for many developed and developing countries. Accordingly, FAO has formulated a Project on the "Management of tuna fishing capacity: conservation and socio-economics", which is funded by the Government of Japan.

The ultimate objective of the FAO Project is to improve the management of tuna fisheries on a global scale. Its immediate objectives are to:

- provide technical information necessary for the management of tuna fishing capacity, and
- identify and resolve the technical problems associated with the management of tuna fishing capacity

on a global scale, taking into account conservation and socio-economic issues.

To facilitate the implementation of the Project, FAO created an internal Task Force. Its Members have been nominated by nearly all Services and Units of the FAO Fisheries Department (FI) and a Service of the Technical Cooperation Department that have been involved in the formulation of the Project. The Marine Resources Service of the FI has been leading and coordinating the implementation of the Project.

The Project also created an external Technical Advisory Committee (TAC) to foster the collaboration of the tuna fishery management organizations and other major inter and non-governmental organizations involved in tuna fishing, fisheries research and management. It is composed of technical experts affiliated with these organizations, who are listed in the Acknowledgements. The TAC has been working through correspondence and two meetings, which took place in Rome, Italy, from 14 to 16 April 2003, and Madrid, Spain, from 15 to 18 March 2004.

During the first meeting of the TAC:

- The methods for estimating fishing capacity and its optimal value from the conservation and socio-economic view point and their data requirements were reviewed.
- The applicability of these methods for tuna, particularly in the light of the availability of input data for this estimation, were determined.
- The methods most appropriate for the use by the Project were selected.
- The proposals of the studies to be carried out by the Project were finalized.

The studies implemented by the Project are grouped into the following four subjects:

1. tuna fisheries and resources;
2. characterization and estimation of tuna fishing capacity;
3. tuna fishing industry; and
4. tuna fishing capacity management options and implications.

During the second meeting of the TAC:

- The progress of the research carried out by the Project was critically reviewed.
- Recommendations, particularly on the Project's future activities, were made.
- Research proposals additional to the studies already being completed by the Project at the time of holding the second meeting of the TAC were formulated, recognizing the need for additional funds from the donor to carry them out.

- A statement by the TAC was prepared for use as an information document for the Technical Consultation to Review Progress and Promote the Full Implementation of the International Plan of Action (IPOA) to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing and the IPOA for the Management of Fishing Capacity, which was held in Rome, Italy, on 24-29 June 2004.

The studies completed by the Project are presented in these Proceedings arranged by sections according to the subjects mentioned above.

Thus, under tuna fisheries and resources there are papers on the following topics:

- historical developments in major tuna fisheries (including technological developments);
- tuna catch data available within FAO Fisheries Global Information System (FIGIS); and
- an analysis and classification of the status of the stocks of tuna.

The characterization and estimation of tuna fishing capacity section consists of three papers on:

- an analysis of the fishing capacity of the global tuna purse-seine fleet;
- a review of the fishing capacity of the world longline fleet; and
- a global study on the importance of non-industrial tuna fisheries.

The study of the tuna fishing industry that is presented provides an assessment of the influence of the tuna market (e.g. prices and imports) on tuna catches from qualitative and quantitative point of view.

The final section of the Proceedings, namely, tuna fishing capacity management options and implications, analyses the past developments and future options for managing the tuna fishing capacities of the purse-seine and longline fleets.

This Overview provides a synthesis of the technical findings of the studies implemented by the Project.

2. TUNA FISHERIES AND RESOURCES

2.1 Development of tuna fisheries

Since ancient times, coastal tuna fishing has been carried out in many parts of the world. As a result of increasing demand for tuna for canning, industrial fisheries began during the 1940s and 1950s. During the 1950s, the major industrial fisheries were the Japanese longline fishery and pole-and-line fishery of the United States, both of which operated in the Pacific Ocean. The longline fishery expanded its area of operations, reaching the Atlantic Ocean during the late 1950s. Also, some European pole-and-line vessels, based in local ports, began fishing off the west coast of Africa.

During the 1960s, European pole-and-line and purse-seine vessels, together with Japanese pole-and-line vessels, began fishing for tunas off tropical West Africa. Also, Japanese longliners expanded their fishing operations all over the world, still targeting mostly albacore and yellowfin for canning. During the mid-1960s, vessels of the Republic of Korea and Taiwan Province of China became involved in large-scale longline fishing for tunas. At the end of the decade, extremely cold storage systems were developed for Japanese longliners, which made the fish acceptable for the *sashimi* market, which, in turn, led the vessels to shift their target species from yellowfin and albacore for canning to bluefin and bigeye for *sashimi*. In the eastern Pacific Ocean the pole-and-line vessels of the United States were almost completely replaced by purse-seine vessels. Quotas on the catches of yellowfin in that region were first imposed in 1966.

The European purse-seine fishery in the tropical eastern Atlantic developed quickly during the 1970s. The purse-seine fishery of the tropical eastern Pacific expanded offshore. In this area some vessels of the United States either changed flags to Central and South American countries to avoid strict regulations aimed at reducing the incidental mortality of dolphins, or shifted their fishing effort to the western and central Pacific Ocean, where tunas seldom associate with dolphins.

A purse-seine fishery for tunas began in the western Indian Ocean during the 1980s, when European vessels, which normally fished in the Atlantic Ocean, moved to that area. In the Pacific Ocean the purse-seine fishery expanded its fishing area, particularly in the western and central Pacific Ocean. Countries such as Brazil and Venezuela entered purse-seine fisheries for the first time. During the same period, the numbers of Japanese and Korean large-scale longliners began to decrease, whereas the Taiwanese fleet and the numbers of vessels flagged to third countries of open registry increased rapidly. The regional tuna fishery management organizations introduced more management measures for the tuna fisheries.

Tuna fishing increased greatly during the 1990s. Purse seiners began fishing with fish-aggregating devices (FADs) in the Atlantic Ocean during the early 1990s, and this method quickly came into use in the Indian and Pacific Oceans. New management measures were introduced during this decade, and illegal, unreported and unregulated (IUU) fishing increased, becoming a major problem for the sustainability of tuna resources. Many coastal states had begun to get involved in tuna fishing during the 1980s, and this involvement increased during the 1990s. Partially due to the development of new coastal fisheries, the fishing effort by traditional longlining-fishing countries declined. Another important event was the development of bluefin tuna farming.

2.2 Catches

The global catches of the principal market species of tunas from 1950 to 2002 are shown in Figure 1. The total catch increased steadily from about 400 000 tonnes in 1950 to more than 4 000 000 tonnes in 2002. The catches in the Pacific Ocean have exceeded those of the other two oceans throughout the period. The rate of increase in the catches has been greatest in the Pacific Ocean, followed by those of the Indian and Atlantic Oceans in that order. The catches from the Indian Ocean have exceeded those from the Atlantic Ocean since 1989. Currently, the Atlantic, Indian and Pacific Oceans produce about 10, 23 and 66 percent, respectively, of the total catch. It should be noted that the catches of Atlantic bluefin, bigeye and albacore and eastern Pacific yellowfin and bigeye have been restricted in recent years, while there have been no restrictions on any other stocks, except southern bluefin tuna.

FIGURE 1
Global catches of the principal market species of tunas, by oceans

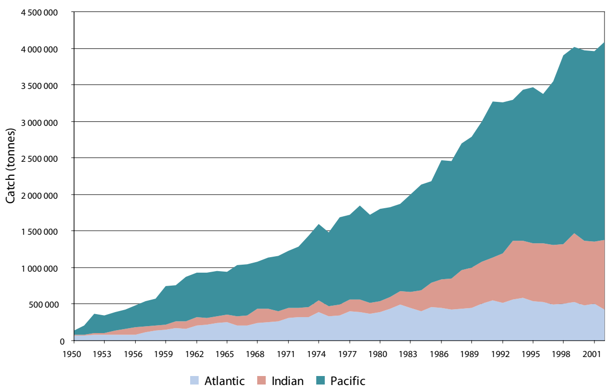
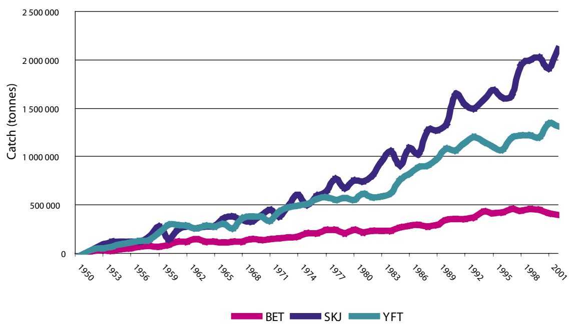


FIGURE 2
Global catches of the principal market species of tropical tunas



2.2.1 By species

The global catches of the principal market species of tropical tunas, bigeye, skipjack and yellowfin, and those of the principal market species of temperate tunas, albacore, Atlantic bluefin, Pacific bluefin and southern bluefin, are shown in Figures 2 and 3, respectively.

Since the late 1960s the greatest catches, by far, have been skipjack and

FIGURE 3
Global catches of the principal market species of temperate tunas

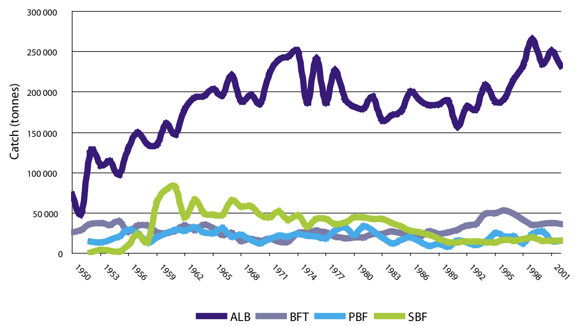
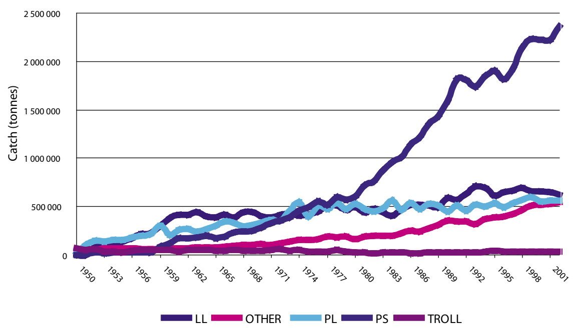


FIGURE 4
Global catches of the principal market species of tunas, by fishing gear



yellowfin (51 and 32 percent of the total catches of the principal market species of tunas respectively, in 2002). The catches of both species have shown rapid increases throughout the period, and their maximum annual catches were taken in 2002. Bigeye (ten percent of the total catch) has also increased nearly continuously, although the catches have been much less than those of skipjack and yellowfin.

The catches of albacore (six percent) have been fluctuating from the mid-1960s to the late 1990s, without a clear trend. The catches of Atlantic bluefin, Pacific bluefin and southern bluefin have been stable or decreasing at much lower levels, accounting for only slightly more than one percent of the total catches of the principal market species in 2002.

2.2.2 By fishing gear

The combined global catches of the principal market species of tunas, by fishing gears, are shown in Figure 4. The purse-seine catches (58 percent of the total catch in 2002) have shown the greatest increase. They became significant only during the late 1950s, and increased at an accelerating rate until 1990, after which the rate of increase began to slow down. The longline catches (15 percent in 2002) increased gradually until 1993, and since then have been declining. The pole-and-line catches (14 percent in 2002) exceeded those of all other gears during the 1950s, but were overtaken by the longline catches during the 1960s. During the 1970s they increased rapidly, exceeding the longline catches again, and have stabilized at about 500 000 tonnes since then.

Recent increases in the catches of "other" gears (13 percent in 2002) are due to the increase in catches by artisanal fisheries (e.g. gillnets, handlines and miscellaneous unclassified gears) in coastal and island areas. The catches by trolling gear (less than one percent in 2002) have declined, stabilizing at about 30 000 to 35 000 tonnes during recent years.

2.2.3 By country

The greatest catches are those of Japan (550 000 tonnes in 2002), the great majority of which comes from the Pacific Ocean. They have been generally decreasing since the mid-1980s.

The catches by Indonesia (500 000 tonnes in 2002), which come from the Pacific and Indian Oceans, have increased rapidly since 1970, and presently are second only to those of Japan.

Vessels of Taiwan Province of China (460 000 tonnes in 2002) entered the tuna fishery during the late 1960s and increased their catches rapidly in all three oceans, but lately those catches have stabilized.

The European catches (mainly those of France and Spain) were limited to the Atlantic Ocean until the early 1980s. The catches have almost doubled (445 000 tonnes in 2002) since the beginning of the purse-seine fisheries for tropical tunas in the western Indian Ocean.

The catches of the Philippines have increased steadily since 1970. Its catches (240 000 tonnes in 2002) come mostly from the Pacific Ocean.

The Republic of Korea (220 000 tonnes in 2002) entered the fishery for tunas during the 1960s, and now its vessels fish in all three oceans. The catches increased rapidly during the 1980s, but stabilized during the 1990s.

The catches of the United States (160 000 tonnes in 2002) are taken mainly in the Pacific Ocean. These catches have been more or less stable since the 1970s.

Mexico (163 000 tonnes in 2002), Venezuela (140 000 tonnes in 2002) and Ecuador (135 000 tonnes in 2002) have participated in traditional fisheries (artisanal and some industrial) for many years, but the catches were low until the early 1980s, when they began to increase rapidly in the eastern Pacific Ocean.

The catches of the Maldives (138 000 tonnes in 2002) have increased greatly since the early 1980s. Pole-and-line fisheries in the Indian Ocean account for almost all of the catch.

2.3 Stock structure

The principal market species of tunas are divided into 23 stocks established by the Inter-American Tropical Tuna Commission (IATTC), the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Indian Ocean Tuna Commission (IOTC), the Interim Scientific Committee (ISC) for Tuna and Tuna-like Species in the North Pacific Ocean and the Secretariat of the Pacific Community (SPC) for stock assessment purposes. As such, the stocks represent effective management units, constituting one, two or three stocks of each species in each ocean. The exceptions are Atlantic bluefin and Pacific bluefin, each of which is restricted to a single ocean, and southern bluefin, which constitutes a single stock in the Atlantic, Indian and Pacific Oceans. The stocks are as follows:

- Atlantic Ocean: Mediterranean albacore, North Atlantic albacore, South Atlantic albacore, eastern Atlantic bluefin, western Atlantic bluefin, bigeye, eastern Atlantic skipjack, western Atlantic skipjack and yellowfin.
- Indian Ocean: albacore, bigeye, skipjack and yellowfin.
- Pacific Ocean: North Pacific albacore, South Pacific albacore, Pacific bluefin, eastern Pacific bigeye, western Pacific bigeye, eastern Pacific skipjack, western Pacific skipjack, eastern Pacific yellowfin and western Pacific yellowfin.
- All oceans: southern bluefin tuna.

2.4 Status of stocks

The maximum annual catches of eight of the 13 tropical tuna stocks have been taken after 1998. All these stocks occur in the Indian and Pacific Oceans. The sizes of these eight stocks are classified by de Leiva and Majkowski (this collection) as either unknown, above their reference points or near their reference points. The maximum annual catches of all four tropical tuna stocks in the Atlantic Ocean were taken before 1995, and their stock sizes are classified as below their reference points, near their reference points or unknown.

The maximum annual catches of only two of the ten temperate tuna stocks have been taken in recent years. The stock sizes and fishing mortalities of these two stocks are unknown. The maximum annual catches of the remaining eight temperate stocks were taken before 1996. For six of these stocks, the stock sizes are below their reference points, near their reference points or unknown and the fishing mortalities are above their reference points, near their reference points or unknown.

For simplicity, the stock sizes and fishing mortalities for the various stocks were assigned to the following categories.

- ***Stock size***: above its reference point, near its reference point, below its reference point, unknown.

- ***Fishing mortality***: below its reference point, near its reference point, above its reference point, unknown.

The numbers of stocks assigned to each category of stock size and fishing mortality are shown in Table 1. The values in Table 1 suggest that the tropical stocks are, in general, in a better condition than the temperate stocks. If we consider only stock size, seven of the 13 tuna tropical stocks are within their safe limits from the conservation perspective (above or near). In contrast, only three of the ten temperate tuna stocks could be considered to be safe. If we consider only fishing mortality, the situation is quite similar. The current fishing mortality is apparently not sustainable for three of the 13 tropical stocks and six of the ten temperate stocks.

There are no estimates of either the stock size or the fishing mortality for about 35 percent of the stocks. This percentage is slightly higher for the tropical stocks than that for the temperate stocks. The status of about 50 percent of the stocks is significantly uncertain.

The status of the tuna stocks across a bivariate system of references related to the stock size and fishing mortality is presented in Figure 5. Seven of the stocks could be considered within safe limits from the conservation perspective (white area). However, the three stocks for which the level of fishing mortality are near the reference points should be closely monitored, so that, if necessary, management actions can be undertaken. Although the stock size and fishing mortality categories assigned to BET-IO (bigeye tuna, Indian Ocean) suggest that the stock is within safe limits, the present level of catches is regarded as not sustainable over the long term.

The remaining eight stocks in the upper row of Figure 5 may be overfished (grey area). Their fishing mortalities should be reduced, their stock sizes should be increased, or both, if these stocks are to be brought up to within safe limits.

3. FISHING CAPACITY

Concepts relating to fish harvesting capacity are not as clearly understood as the biological concept of overfishing. Much of this confusion arises because the terms “overcapacity” and “excess capacity” are frequently used as synonyms even though they are quite different. To make matters even more confusing, the concepts of excess capacity, overcapacity, overfishing and overcapitalization are closely related, yet different.

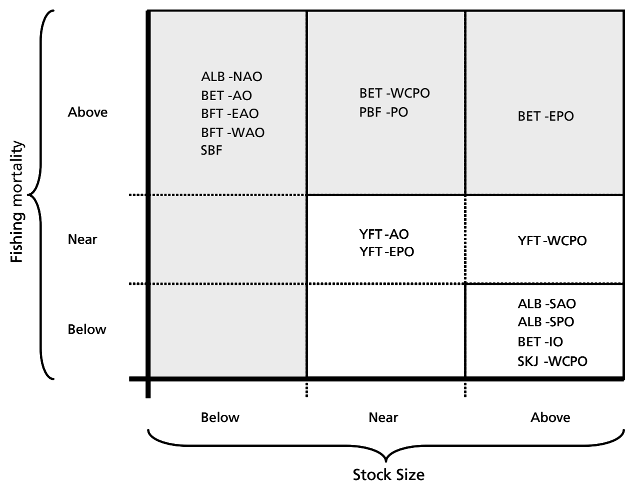
While excess capacity in fisheries remains a short run, self-correcting market phenomenon just as in other commercial activities, it is overcapacity that is a long run, persistent problem that fishery managers need to address through the management process. If fishers have a market incentive to overinvest in capital, i.e. overcapitalization, and other productive inputs used to harvest fish, then the excessive use of capital and labour in a

TABLE 1
Numbers of stocks assigned to the various stock size and fishing mortality categories

	STOCK STATUS					
	Stock size					
	Above	**Above-Near**	**Near**	**Near-Below**	**Below**	**Unknown**
Tropical stocks	4 (1)	-	3 (1)	-	1	5
Temperate stocks	2	-	1 (1)	-	4 (1)	3
Total	6 (1)	-	4 (2)	-	5 (1)	8
	Fishing mortality					
	Below	**Below-Near**	**Near**	**Near-Above**	**Above**	**Unknown**
Tropical stocks	2 (1)	-	3	-	3 (1)	5
Temperate stocks	2	-	0	2 (1)	4 (1)	2
Total	4 (1)	-	3	2 (1)	7 (2)	7

Note: The numbers in parentheses indicate the numbers of stocks for which there is substantial uncertainty (e.g. the stock sizes of four tropical stocks are considered to be above the reference points, but there is substantial uncertainty about one of them).

FIGURE 5
State of tuna stocks across a bivariate system of references. The abbreviations are listed by de Leiva and Majkowski (this collection)



fishery causes biological overfishing to occur. With the appearance of overfishing and resulting declines in stock abundance, overcapacity develops in a fishery when the net benefits to the fishing fleet begin to decline.

In *technological* terms the word "capacity" is used when describing physical measures of the vessel (e.g. hull capacity and the ability to hold fish) as well as the operational or technical efficiency of a fishing vessel and its gear. Thus, in these Proceedings the carrying (hold) capacity is sometimes used as a rough proxy for the fishing capacity of a vessel or a fleet and is assumed to be related to the ability of a vessel to catch fish under normal fishing conditions. Fish-carrying capacity (a statistic that is compiled by the IATTC and other organizations) is measured for most tuna fishing vessels as the tonnage of fish that can be stored on the vessel when it is fully loaded or the storage area, measured in cubic metres.

Understanding these technical distinctions – and their implications for successful fisheries management – is critical for the sustainable development of living marine resources.

3.1 Analysis of the fishing capacity of the global tuna purse-seine fleet

Regional analyses, using Data Envelopment Analysis (DEA), were conducted to measure tuna purse-seine fishing capacity.[1] Due to differing levels of availability of data, the level of aggregation and the period over which the DEA was conducted varied among the different regional tuna purse-seine fisheries, i.e. eastern Pacific, western and central Pacific, Indian Ocean and Atlantic Ocean.

DEA was used to calculate fishing capacity output and capacity utilization. DEA calculates a frontier or maximum landings curve, as determined by the best-practice vessels, given the states of technology, the environment and the resource stocks (fixed inputs), provided that fishing effort (variable input) is fully utilized under normal operating conditions. This frontier represents fishing capacity output. Landings directly on the best-practice production frontier represent full capacity utilization (CU), which is defined as observed output divided by capacity output. CU ranges between 0 and 1, where 0 indicates no observed output (no catches) and 1 indicates that the observed output equals the capacity output. When a vessel produces at less than full capacity, the capacity utilization is less than one, i.e. CU <1.

3.1.1 Eastern Pacific Ocean

The results of the analysis indicate that substantial excess fishing capacity – defined as fishing capacity output minus observed output (landings) – when measured as: (1) potential catch minus actual catch, or (2) potential catch purged of technical efficiency minus actual catch, exists for:

- Skipjack – for all vessel classes and set types utilized by the respective vessel class; and

[1] The Proceedings paper describes "fishing capacity" as the capability of catching fish, sometimes referred to as "fishing power." It is not to be confused with fish-carrying capacity.

- Yellowfin and bigeye combined – for all vessel classes and set types utilized by the respective vessel class.

In short, tuna purse-seine vessels had the ability to catch substantially more of all species during 1998-2002 than they actually caught, a result of both technical inefficiency (or skipper skill) and underutilization of variable inputs (for instance number of days spent fishing).

The greatest contributor, by far, to this excess was Class-6 vessels (more than 363 tonnes of carrying capacity), although there was excess in Classes 2 and 3 (46 -91 tonnes and 92-181 tonnes, respectively) and Classes 4 and 5 vessels (182-272 tonnes and 273-363 tonnes, respectively). Across all vessels it is estimated, after accounting for technical efficiency, that during 1998-2002 the combined catches of yellowfin and bigeye could have been 33 percent greater, while those of skipjack could have been 29 percent greater.

For yellowfin and bigeye it was also estimated that excess capacity – defined as capacity output purged for technical efficiency, minus combined maximum sustainable yield (MSY) – climbed from an excess of about 11 percent in 1998 to an excess of almost 70 percent by 2002. In 2002, therefore, tuna purse-seine vessels had the ability to harvest almost 70 percent more than MSY for yellowfin and bigeye combined.

Technical change was estimated to have increased by about 60 percent during 1998-2002 for the fishery as a whole.

3.1.2 Western and Central Pacific Ocean

The analysis conducted for the WCPO suggests that excess fishing capacity exists for all of the major fleets, i.e. those of Japan, the Republic of Korea, the Philippines, Papua New Guinea, Taiwan Province of China and the United States, and for the other fleets combined.

It is estimated that, on average, during 1998-2002 purse-seine skipjack fishing capacity was around 306 000 tonnes (35 percent) per annum greater than the actual catches (only 137 000 tonnes or 16 percent greater after purging for technical efficiency). Estimated excess fishing capacity, purged for technical efficiency, was at its highest level in 2000. It was hypothesized that this may have been caused by low skipjack prices during the second half of 1999 and throughout 2000, resulting in vessels reducing the number of days spent searching and fishing.

For yellowfin and bigeye combined it was estimated that during 1998-2002 excess purse-seine fishing capacity was around 72 000 tonnes (29 percent) per annum greater than the actual catch (only 12 percent or 31 000 tonnes after purging for technical efficiency). It was also estimated that during 1998-2002, on average, fishing capacity purged for technical efficiency for yellowfin and bigeye combined was in excess of the average catches between 2000-2002 by 47 666 tonnes or 20 percent, but that no excess capacity existed in the fishery in 2002 when measured against average 2000-2002 catch levels.

3.1.3 Indian Ocean and Atlantic Ocean

Overall, it appears that there is excess capacity in the Atlantic and Indian Ocean purse-seine fisheries for tuna. It was estimated that, on an annual basis, there was approximately 61 000 tonnes of excess capacity in the Indian Ocean and 29 500 tonnes of excess capacity in the Atlantic Ocean. If these vessels operated at full efficiency, fully utilized their variable inputs and harvested at levels corresponding to the average annual landings, the fleet size in the Indian Ocean could be reduced from 40 to 31 vessels (22.5 percent) and that in the Atlantic Ocean from 53 to 46 vessels (13.2 percent). These estimates are considered extreme lower-bound estimates due to the limited number of observations and inadequate information for considering different modes of fishing and the fishing activities of individual nations.

3.2 A review of the longline fleet capacity of the world

The regional tuna fishery management organizations maintain lists of vessels more than 24 metres in overall length (LOA) that are licensed to fish for tunas and tuna-like species in their areas of concern. These lists are commonly known as "positive lists".

Some longliners more than 24 metres in LOA can not be considered to be large-scale because they do not fulfil all the requirements needed for consideration as such. It is not possible to decide, on the basis of LOA or gross registered tonnage (GRT) alone whether a vessel should be considered to be a large scale longliner. Additional information, such as target species, freezing facilities, etc., is required, and most positive lists do not provide this type of information. Therefore, for the purpose of this review, large-scale longliners were defined as longliners equal to or greater than 200 GRT or 35 metres in LOA, with freezing facilities (often super-freezers capable of freezing fish below 45°C), licensed to fish in distant waters and targeting primarily fish for the *sashimi* market. However, some flexibility, based on knowledge of the characteristics of the vessels, was incorporated into the final decisions.

It is acknowledged that some of the vessels between 24 and 35 metres in LOA could be considered to be large-scale longliners. In addition, vessels less than 24 metres in LOA, but satisfying the other requirements to be considered large-scale longliners, are proliferating. Unfortunately, since these vessels are not included in the positive lists, they could not be included in this study. Such being the case, the size of the world's large-scale longline fleet given in this review is almost certainly underestimated.

The results of the above processing, by fleets and oceans, are summarized in Table 2. Only the data in the public domain have been used. Duplication of vessels, due to the fact that some of them fish in more than one ocean, was eliminated by comparing the names and characteristics of the vessels in the various positive lists. Vessels engaged in IUU fishing, estimated about 30, are not included in this table. The large-scale longliners were further classified into tuna and swordfish longliners. Only vessels that target swordfish most of the time are considered to be swordfish longliners. Extensive guesswork was involved in many of the decisions, as the target species are not specified in any of these vessel lists used.

In summary, it is estimated, based on the positive lists, that there is a total of 1 484 large-scale tuna longliners. Considering that data obtained from the Organization for the Promotion of Responsible Tuna Fishing (OPRT) are more recent, and include previous IUU vessels, and that there is no positive list for the western and central Pacific Ocean, it is likely that this is an underestimate. Accordingly, this estimate (1 484 vessels) was modified, using the data from OPRT for those fleets for which the data are available (101 additional vessels). Also, the current estimate of 39 IUU vessels was added, bringing the total number of large-scale longliners to 1 615.

Approximately 390 000 tonnes of tunas (albacore, bigeye, Atlantic bluefin, Pacific bluefin, southern bluefin and yellowfin) were caught by large-scale longliners, and 200 000 tonnes of these were caught by other longliners (small-scale longliners and/or longliners targeting swordfish) during 2001. As the *sashimi* market consumes about 600 000 tonnes per year, this estimate appears to be realistic. Division of the catch by large-scale longliners by the number of large-scale longliners indicates that the average catch of these vessels is about 240 tonnes per year. The current economic break-even point for catch per boat is roughly 250 tonnes per year, so a vessel that caught 240 tonnes of tunas per year would have to catch at least 10 tonnes of billfishes to break even.

It is unlikely that all the large-scale longliners are currently fishing at their full capacities, due to economic, social and management restrictions. If all these restrictions were removed, their potential catches, even at the current resource abundance levels, would be much greater than what they are producing. Indeed, the same levels of catches could most likely be made with a smaller fleet size, particularly if similar reductions were made in the sizes of the fleets of purse-seiners and small-scale longliners.

3.3 Global study of non-industrial tuna fisheries

In this subsection non-industrial fisheries are considered to be those carried out by vessels less than 24 metres in LOA, that do not have mechanical freezing facilities and are not capable of remaining at sea for more than about one month. Non-industrial fisheries are divided into two categories, small-scale vessels and medium-scale vessels. Small-scale vessels are undecked vessels that use outboard engines or sails and fish with handlines, rod-and-reel gear, etc. Medium-scale vessels are decked vessels with internal combustion engines that are usually less than 24 metres in LOA and do not have mechanical freezing facilities.

Estimates of regional and global tuna catches by small-scale fisheries are presented in Table 2. (Similar data are not available for the medium-scale fisheries because the data are often combined with data for large-scale fisheries.) Unfortunately, not all of the data are reliable. Since the main objective was to estimate the portion of the catch taken by small-scale fisheries, reliable and crude data are combined in this table. The world-wide catch of tunas by small-scale fisheries is about 320 200 tonnes, or about eight percent of the total world catch.

Some notable features of the results of the study are given below:

- There is a great deal of variation among regions. Small-scale tuna fishing is least important in the Oceania portion of the Pacific, where only about two percent of the tuna catch is from small-scale fisheries, and most prominent in the southeast and east Asia portion of the Pacific, where the small-scale catches are about 20 percent of the total.
- There is also a considerable variation among the regional tuna fishery management organizations in effort devoted to collecting catch information for the non-industrial fisheries.
- In some areas (e.g. Oceania) the catch of tuna by small-scale fisheries is largely the result of effort directed at tunas, whereas in other areas (e.g. the Indian Ocean) much of the catch of tuna by small-scale fisheries is taken by vessels directing their effort at other species.
- Fish-aggregating devices (FADs) seem to have a large effect on the catches of tunas by small-scale gear.
- Recreational fisheries can produce substantial amounts of tunas, but information on these operations is not readily available, except in some cases for the catches by commercial sport-fishing vessels.

4. THE WORLD TUNA INDUSTRY: AN ANALYSIS OF IMPORTS AND PRICES, AND OF THEIR COMBINED IMPACT ON CATCHES AND TUNA FISHING CAPACITY

4.1 The tuna industry

Tuna catches are affected by a wide variety of factors, both human and non-human induced. Human-induced factors include trends in the demand for tuna commodities, operating costs for tuna fishing, development of fishing capacity and technology, the set up of a regulatory framework governing tuna fisheries, and the availability and cost of transport of tuna products. The principal non-human induced factors influencing the availability of tuna resources are climatic and meteorological conditions. Other factors include the balance of the ecosystem, as well as the availability and abundance of bait and predation.

The major species utilized for canning are skipjack, yellowfin and albacore. The main species utilized in the Japanese *sashimi* market are: bigeye; yellowfin; skipjack (which is not strictly considered as tuna in Japan, but is still used to prepare a kind of *sashimi* called *takami*); the three species of bluefin; and, more recently, albacore.

The world imports of fresh, chilled and frozen tuna (net weight) increased from 435 000 tonnes (US$406 million) in 1976 to 1.6 million tonnes in 1998, declined slightly

TABLE 2
Catches of tunas by small-scale fisheries

Region	Catches by small-scale fisheries (tonnes)	Total catches (tonnes)	Catches by small-scale fisheries (percentages of totals)
Oceania	19 000	900 000	2.1
Eastern Pacific Ocean	40 500	750 000	5.4
Western Atlantic Ocean	11 000	112 000	9.8
Eastern Atlantic Ocean	11 000	347 600	3.2
Mediterranean Sea	1 700	28 500	6.0
Indian Ocean	52 000	880 000	5.9
East and Southeast Asia	185 000	928 000	19.9
Total	320 200	3 946 100	8.1

to 1.4 million tonnes in 2000 and then increased to 1.5 million tonnes (US$3 billion) in 2001. The principal imported tuna commodities, in terms of quantity, are frozen skipjack and yellowfin, and, in terms of value, are frozen bigeye and yellowfin. The principal importers of fresh, chilled and frozen tuna are Thailand and Japan, and the main exporters of these are the Taiwan Province of China, Spain, France and the Republic of Korea.

The production of canned tuna (including frozen, pre-cooked loins) increased from 499 000 tonnes in 1976 to 1.4 million tonnes in 2001 (net weight). The main producing countries are Thailand, the United States and Spain. The imports of canned tuna (net weight) increased from 89 000 tonnes (US$191 million) in 1976 to 836 000 tonnes (US$2.0 billion) in 2001. The principal importers of canned tuna are the United States, the United Kingdom and France, and the principal exporter is Thailand, followed by Spain and Ecuador.

4.2 The market for *sashimi*-grade tuna

The imports of bluefin tunas increased from 1986 to 1991 (Figure 6). At the same time the catches of bluefin tuna decreased. As a result of heavy demand and low catches, the prices increased from ¥5 279/kg in 1986 to ¥7 299/kg in 1991. From 1992 to 1995 the imports increased rapidly to almost 25 000 tonnes in 1995 and then declined slightly in 1996. In order to supply the demand for bluefin tunas, catches were increased to a record of almost 84 000 tonnes in 1996. Increasing imports, and hence international demand, during 1991-1996 did not generate a parallel increase in prices due to the increasing catches of fish. In fact, the prices decreased from ¥7 299/kg in 1991 to ¥5 246/kg in 1995 and ¥5 885/kg in 1996.

In the years that followed, the imports of bluefin tunas reached a historical maximum of 33 003 tonnes in 1999, declined slightly in 2000 and then increased to 31 709 tonnes in 2001. As a result of stringent quotas imposed by the ICCAT and CCSBT, the catches declined from 1996 to 1998. In 1999 the catches of bluefin tuna increased slightly, but then declined to 60 368 tonnes in 2001. The prices declined in Japan over the entire 1997-2001 period, reaching ¥4 046/kg in 2001.

The development of tuna farming in the Mediterranean Sea and elsewhere since 1997 has made increasing quantities of cheaper bluefin available in the world market, hence lowering the average bluefin tuna prices. In 2003 the average price of bluefin tuna reached a low of ¥3 936/kg.

The world market for bigeye tuna for *sashimi* is shown in Figure 7. The world imports of bigeye tuna increased from 96 484 tonnes in 1990 to 146 404 tonnes in 2000. The longline catches of bigeye remained quite stable during the same period, fluctuating between 260 000 and 290 000 tonnes. The prices of bigeye in the Japanese market increased from ¥2 947/kg in 1989 to ¥3 324/kg in 1994, and then declined during the years that followed, reaching a low of ¥1 757/kg in 2000.

It is interesting to note that the catches and prices both peaked in 1994. The decline of bigeye prices during the second half of the 1990s was the result of increased availability of cheaper bigeye from imports (and of cheaper bluefin tuna from farming).

4.3 The market for canned tuna

From 1992 to 1998 increasing international demand for canned tuna generated an increase in catches and imports of raw material. However, as the increase in catches was not enough to create a continuous oversupply, the prices also increased. The price declines during 1990-1992 and 1998-2000 were both caused by excess supplies, as the increased catches were not matched by increases in the demand for tuna commodities (both raw material and canned tuna). The price decreased to its lowest level of the 1989-2001 period in late 2000 (Figure 8). The supply-restricting measures implemented by the World Tuna Purse-seine Organization (WTPO) reduced the catches during late 2000 and early 2001, increasing prices, but, as far as skipjack was concerned, it proved to be only a temporary measure.

In a situation for which natural resources are regarded as inexhaustible and for which oversupply conditions do not exist, growing demand for canned tuna would generate an increase in imports of raw material, catches and prices. At the same time, increasing prices of raw material and canned tuna would stimulate the construction of fishing vessels, which would, of course, increase the catches. At the same time, variations in catches (supply) and imports (demand) of raw material have opposite impacts on canned tuna and raw material prices (which have been demonstrated to follow the same trend). If the increase in catches exceeds the increase in imports (creating an oversupply) the prices decline; if the increase in imports exceeds the increase in catches the prices increase.

The amount of canned tuna processed is determined by the supply of raw material available to feed a constantly growing demand, rather than by variations in raw material or canned tuna prices. Catches of tuna and production of canned tuna followed an almost parallel trend in the period under examination. However, the processing of canned tuna has been growing more slowly than the catches, mainly because tuna-processing capacity has been growing more slowly than tuna-fishing capacity. In fact, tuna processing capacity is linked more to state of technology than to the abundance of natural resources and the ability to concentrate on the most productive fishing grounds.

When the market is oversupplied, the positive correlations between catches, imports, processing and prices break down, and prices decline. The decreases in price that

FIGURE 6
World market for Atlantic, Pacific and southern bluefin tunas for *sashimi*

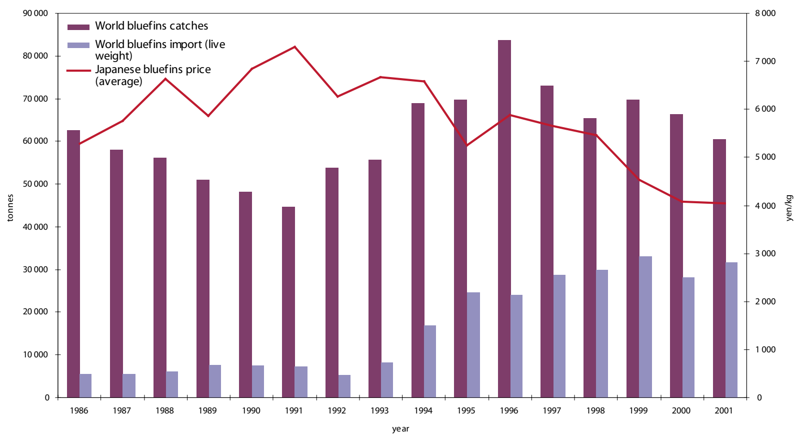
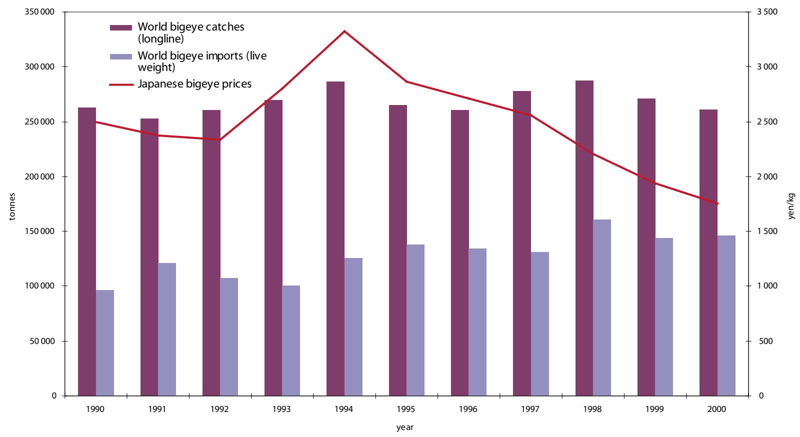


FIGURE 7
World market for bigeye tuna for *sashimi*



occurred between late 1998 and late 2000 were, ultimately, the result of oversupplies caused by the increased capability to catch tuna. The prices of raw material and canned tuna had been elevated since 1992, and had increased since 1996 (Figure 8).

The commercial response was to maximize the catches by maximizing the numbers of days spent at sea and to construct more vessels. In late 1998, however, the abundance of resources, combined with increased fishing capacity, generated large increases in the catches. These continued in the following years until, in late 2000, the WTPO had to implement measures to limit the supply in order to increase the prices of raw material. Had the WTPO not intervened, the continuing excess of supply of catches might have had adverse effects on one or more of the target or non-target species.

5. CURRENT MANAGEMENT MEASURES THAT IMPACT THE CAPACITY OF TUNA FISHING FLEETS

5.1 Inter-American Tropical Tuna Commission (IATTC)

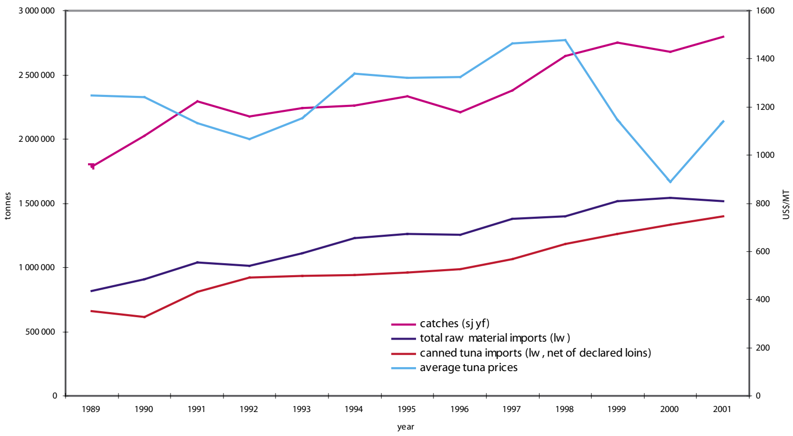
In 1999, for the first time, the IATTC placed limits on the carrying capacity of the purse-seine fleet that operates in the eastern Pacific Ocean. Individual limits were assigned to each of the 13 nations participating in the purse-seine fishery. However, it was not possible to extend the limitation beyond 1999.

In 2000, a resolution was approved to establish and maintain a Regional Vessel Register (RVR) of the vessels authorized by their governments to fish in the eastern Pacific Ocean. In 2002 the Resolution on the Capacity of the Tuna Fleet Operating in the eastern Pacific Ocean, establishing the RVR as the definitive list of purse-seine vessels authorized by the participants to fish for tunas in the eastern Pacific Ocean, was approved. The concept involved in the RVR is that the capacity quotas apply to vessels, rather than to governments. It is also the intent of the program to allow the transfer of vessels on the list to other flags, creating a sort of market for trading carrying capacity.

5.2 International Commission for the Conservation of Atlantic Tunas (ICCAT)

Limits on catches set by ICCAT and allocated to fishing countries and entities provide opportunities for those nations to limit the numbers of vessels authorized to fish, but not many countries have introduced such vessel limits. ICCAT has approved several recommendations calling on fishing nations to limit the numbers of their vessels fishing for bigeye and northern albacore. These vessel limits have been coupled with limits on the catches of those species.

FIGURE 8
Relationship between the canned tuna market (raw material and products), catches and average canned tuna/raw material prices



5.3 Indian Ocean Tuna Commission (IOTC)

The IOTC has established a Record of Authorized Vessels (RAV), which includes vessels greater than 24 metres in overall length (LOA) that are authorized to fish in the Indian Ocean, but the RAV does not impose a limit on the number of vessels. However, the IOTC considers any vessel that is not on the RAV and fishes in the Indian Ocean to be engaged in IUU fishing.

In 2003 a resolution was approved that requires Parties and Co-operating Non-Parties that have more than 50 vessels on the RAV to limit, with some exceptions, the number of their fishing vessels larger than 24 metres in LOA to the numbers registered on the RAV in 2003.

5.4 Commission for the Conservation of Southern Bluefin Tuna (CCSBT)

The CCSBT has created a record of the vessels greater than 24 metres in LOA that are authorized to fish for southern bluefin tuna, and considers any vessel that is not on the list and fishes for southern bluefin to be engaged in IUU fishing.

5.5 Forum Fisheries Agency (FFA)

The FFA maintains a register of vessels that are eligible to apply for fishing licences in the Exclusive Economic Zones (EEZs) of FFA members. Any unregistered vessel found to be engaged in fishing in the EEZ of any FFA member country is not permitted to obtain licences to fish in the EEZ of any FFA member country.

The Palau Arrangement of 1992 for the western Pacific purse-seine fishery limits the levels of purse-seine fishing in the EEZs of eight of the 16 member countries of the FFA, where most of the tuna catch is taken. The arrangement provides an overall limit of 205 purse-seine vessels that will be licensed by the parties for fishing in their waters. Working to ameliorate capacity-related problems, the countries participating in the Palau Arrangement are in the process of considering the introduction of a long-term management system based on national limits on the number of days of purse-seine fishing allowed.

5.6 Other organizations

The Japanese government and the OPRT, an international industry organization, have reduced the number of large-scale tuna longline vessels. So far, about 43 Japanese and Taiwanese longline vessels that were flagged to third countries of open registry have been transferred to the countries corresponding to the citizenships of their owners and either legalized, converted to other uses or scrapped. At present, there are only about 30 such vessels flagged to third countries of open registry, and some of these are inactive.

Industry organizations representing purse-seine vessels from about ten countries have joined the World Tuna Purse-seine Organization (WTPO), an organization that seeks to maintain the prices of purse-seine caught tunas at profitable levels by limiting supply. The members of the WTPO have agreed to reduce the level of fishing effort by requiring that vessels spend more time in port between trips. They also have called for limits on fleet growth. Specifically, the WTPO has proposed the establishment of a world purse-seine and longline vessel register, which would include only vessels authorized by their governments to fish. A new vessel could enter the register only by replacing a vessel of equal or greater size that had been removed from the register.

However, there are large fleets that do not belong to industry organizations that are members of the WTPO. Additionally, a world register of purse seiners and longliners has not yet been created. Nevertheless, the idea of an industry initiative to address capacity concerns relating to overcapacity in the world tuna fleet provides a number of possibilities for helping to resolve these problems.

6. OPTIONS FOR MANAGING TUNA FISHING CAPACITY

The final section of the Proceedings, namely, tuna fishing capacity management options and implications, includes a discussion of potential future options for managing the tuna fishing capacities of the purse-seine and longline fleets, and some points of these are summarised in the sections below.

6.1 Limited entry registers

Limited entry registers of vessels that define the vessels that are authorized to fish in an area can be used to control and curtail the number of vessels allowed to operate in a particular area.

Limited entry registers, used in conjunction with some additional mechanisms, thus offer a potentially effective option for managing tuna fleet capacity. The establishment of such a register, in essence, creates a limited-entry program and a right of access, although such a right would be incomplete because of the lack of definition of exclusive rights to the catch through the setting of individual quotas. In the absence of associated limits on catches for the fishery (total allowable catches) and for the individual operators (IQs), increases in the carrying capacity or efficiency of the registered vessels may be expected to limit the effectiveness of such schemes in managing fishing capacity.

Used in conjunction with limited entry registers, vessel replacement strategies requiring that vessels can be replaced only by vessels of equivalent size could be used to redirect, if not slow, vessel-related technological changes (input substitutions) such as increases in the carrying capacity or efficiency of the licensed vessels. Alternatively, the numbers of vessels allowed in the register could be adjusted downward from time to time to compensate for increases in fishing efficiency. Fishing capacity in a particular fishery could be further reduced through buy-backs of vessels in the register, after which they would be converted to other uses or scrapped.

6.2 Licensing

Another approach to managing fishing capacity is limiting the entry of vessels into a fishery by requiring licences. Similar to a limited entry registry, a licensing system alone does not remove the incentive for fishers to increase fishing capacity or fishing mortality. In fact, without associated limits on total allowable catches for the fishery and for the individual operators (IQs), increases in the carrying capacity or efficiency of the licensed vessels will render a licensing scheme ineffective in managing fishing capacity.

An efficient approach might be to vest the management of the licensing system authority in a regional fishery management organization (RFMO) that would determine the appropriate number of vessels and the catching capacity needed to harvest the allowable catch. A solution of this nature would, however, imply a delegation of rights to the RFMO by flag States and coastal States and would probably face, in many if not most cases, considerable difficulties, particularly with respect to fishing in the EEZs, but also on the high seas. Licensing would be at the vessel level, and the licences would include the gear type and capacity in the licensing unit to avert some undesirable elements of "capital stuffing". Licences could be issued for a limited period of time, they could be held in perpetuity, or they could be held until they were transferred.

As in the case of a limited entry register, the numbers of vessel licences could be adjusted downward from time to time to compensate for increases in fishing efficiency. Fishing capacity in a particular fishery could be further reduced through vessel replacement consolidation schemes or buy-backs of vessels in the register, after which they would be converted to other uses or scrapped.

6.3 Catch quotas

An alternative means of addressing the capacity problem is through the assignment of catch quotas either to nations participating in an international tuna fishery, or to individual participants in that fishery. The use of catch quotas involves determining what the total allowable catch for a fishery should be and the allocation of that total allowable catch among the participants in the fishery.

If individual quotas (IQs) are assigned to operators, the self-regulating or incentive adjusting measure would be particularly effective, as there would be no advantage to the operators to race to take their quotas. On the other hand, if quotas are assigned to countries, then it is necessary to limit the numbers of vessels from different nations allowed by those nations to participate in the fishery to avoid wasteful overcapacity within the respective national fleets.

7. DISCUSSION

The Project has undertaken substantial research into the subjects considered as having high priority for fulfilling its objectives (i.e. tuna fisheries and resources, characterization and estimation of tuna fishing capacity, the tuna fishing industry and tuna fishing capacity management options and implications). Some of these subjects have been addressed comprehensively by the Project, but some of the others could, with more funds and time, be improved or refined.

7.1 Status of tuna stocks

A comprehensive evaluation of the status of stocks of the principal market species of tunas is difficult for several reasons. A uniform and consistent classification of tuna stocks in accordance with some simple, pre-determined criteria is particularly difficult on a global scale. Reference points regarding stock sizes and fishing mortality are the most appropriate, but, due to lack of information, it has not been possible to estimate the reference points for some of the tuna stocks. In spite of these problems, substantial information has been obtained on the status of many of the tuna stocks.

Comparison of the status of the various tuna stocks is difficult, since different methods have been used to estimate the reference points. Consultations among the organizations that conduct the assessments might reduce or eliminate this problem. However, even if the types of reference points and the methods for their estimation were standardized, comparisons of the different stocks would be difficult because estimates of the reference points are based on the age compositions of the catches, and these may differ for different stocks of the same species. According to the

United Nations 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, both target and limit reference points should be established and estimated for each stock. At present, this has not been done.

A quantitative determination of the implications of the stock status for the management of fishing capacity is difficult, as was recognized at the second meeting of the Technical Advisory Committee (TAC). Considerable additional research in this area is needed. Nevertheless, these difficulties in quantitatively determining reductions or increases in fishing capacity should not prevent fisheries managers from using the information on the status of tuna stocks as qualitative indicators of overcapacity. Overfished condition of a stock is usually an indicator of overcapacity.

7.2 Measuring capacity

In accordance with a recommendation of the first meeting of the TAC, Data Envelopment Analysis (DEA) was chosen by the Project to measure the capacity to catch fish in the purse-seine fisheries of the eastern Pacific Ocean, the western and central Pacific Ocean, the Atlantic Ocean and the Indian Ocean. The results were promising, and they could be considerably improved if more detailed data were available, especially for the Atlantic and Indian Oceans.

It was intended that DEAs would also be carried out for the longline and pole-and-line fisheries. The participants at the first meeting of the TAC were optimistic with regard to securing longline data for the DEA, but it was impossible to compile the data before the second meeting of the TAC. At the second meeting of the TAC it was concluded that, at least, aggregated data for the large-scale longliners similar to those for the purse seiners could be obtained. Later, however, it was determined that obtaining such data would be extremely difficult, if not impossible. Furthermore, it was concluded at the second meeting of the TAC that, despite the fact that pole-and-line fishing accounted for 14 percent of the total catches of the principal market species of tunas in 2002, there are not enough data to permit the conducting of a DEA that would provide reasonable estimates of global pole-and-line fishing capacity.

The global study on the importance of the non-industrial tuna fisheries makes it possible to estimate the catches of the small-scale fisheries. This is not possible for the medium-scale fisheries, however, due to lack of information on the activities and catches of the vessels. Some of these vessels have recently incorporated mechanical freezing facilities, so they are able to make longer trips and land fish acceptable for the *sashimi* market. Since presently the registry of tuna vessels is mandatory only for vessels more than 24 metres in LOA, these vessels are not included in the positive vessel lists of the regional tuna fishery management organizations, making it difficult even to estimate their numbers. This could pose a threat to the sustainability of the tuna fisheries, because it is expected that the numbers of medium-scale vessels will increase in the near future.

7.3 Data for analysing tuna imports and prices

The data used for the analysis of the tuna imports and prices, and of their combined impact on catches and tuna fishing capacity, were obtained from various sources, such as the FISH INFOnetwork data, Japanese customs data, FISHSTAT Plus, EUROSTAT and other national and regional organizations.

The data for tunas are more reliable than those for most other fish resources, which is due partly to the introduction of statistical documents on catches and trade and the implementation of measures against IUU fishing. However, there are still problems with vessels (numbers of vessels of various sizes, their equipment, and the species toward which their effort is directed), processing (the amounts of fish of each species that are used to produce various products such as *sashimi,* steaks, canned tuna, pouches, etc.). Some of this information is, in theory, in the public domain, but other information, particularly that on processing is proprietary, and not easily obtainable.

In the future, the results of economic analyses could be substantially improved if:

- The amounts of each species of tuna (and billfish) used for canning, *sashimi* and other purposes could be determined.
- The amounts of each species of tuna that are used for the various canned products could be determined.
- The large amounts of unreported tuna loins (for canning) entering international trade could be identified.
- Industry data were more easily available.

7.4 Management measures

It is evident that, in general, fisheries management measures adopted so far have not prevented the growth of tuna fleets. It is likely that if the *status quo* regarding the management of tunas is maintained, the fleets will continue to grow, placing any measures for the rational management and conservation of the tunas in jeopardy.

It is clear, therefore, that maintaining the *status quo* is not a desirable option for managing fishing capacity or for the conservation of tunas. Based on the analyses carried out by the Project, it can be concluded that the common-property and open-access nature of tuna fisheries has been the major cause of the decline in many of the world's tuna stocks. Consequently, moving away from these concepts toward rights-based management schemes is worthy of consideration. The principal problem is the allocation of these rights, which is a sensitive political issue.

Of the various options presented for the management of fishing capacity, those directed at the vessel level would be the easiest to design and administer. Another important issue is the management of non-industrial fisheries. Presently, most management measures are directed at large-scale vessels, and the non-industrial tuna fisheries have been unregulated, or nearly so. However, the magnitude of the non-industrial tuna catches is increasing, and management plans will eventually have to include this component if they are to be effective.

8. TECHNICAL ADVISORY COMMITTEE RECOMMENDATIONS

Several recommendations based on the technical findings reported in this publication were made at the second meeting of the Technical Advisory Committee (Madrid, Spain, 15–18 March 2004). These are listed below. In addition to the general recommendations of the Technical Advisory Committee (TAC), most of the papers in this publication include specific recommendations on how to overcome problems encountered during the implementation of the studies.

Regarding the collection of data, the TAC recommended that the FAO should:

- Promote efforts to provide external support for the collection of better information on tuna fishing in countries where small-scale fisheries account for a large part of tuna fishing activities.
- Encourage countries to collect information on the characteristics and operation of tuna fishing vessels and/or fleets.
- Promote the development of a global record of tuna fishing vessels.

Regarding the management of tuna fishing capacity, the TAC recommended that FAO promote the following actions:

- A moratorium should be imposed on the entry of additional large-scale tuna vessels into the fisheries until an efficient, equitable and transparent management system of fishing capacity is achieved.
- Within the constraints of capacity limits, the regional tuna fishery management organizations should have a system for allowing the transfer of fishing capacity.

- Any country or fishing entity that has expanded or is expanding its tuna fishing capacity should strengthen its management of fishing capacity as recommended above.
- The regional tuna fishery management organizations should collect information on the numbers, capacities and vessel characteristics for tuna vessels other than purse seiners and longliners (such as pole-and-line vessels and trollers) to determine if excess[2] capacity exists for these fleets.
- Rights-based management of tuna fisheries should be considered, where appropriate, as a long-term solution for the management of excess fishing capacity.
- Mechanisms for managing tuna fishing capacity should include monitoring, surveillance and control systems.

[2] Again, excess capacity is a short-run, self-correcting market phenomenon of commercial activities. It is overcapacity that is a long-run, persistent problem that fishery managers need to address through the management process. If fishers have a market incentive to overinvest in capital and other productive inputs used to harvest fish, then the excessive use of capital and labour causes biological overfishing to occur, stocks to decline and overcapacity to develop.