

Recent developments in the tuna industry

Stocks, fisheries, management, processing,
trade and markets



Cover photograph:

A tuna auction in Japan (courtesy of P. Miyake).

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FAO
FISHERIES AND
AQUACULTURE
TECHNICAL
PAPER

543

Stocks, fisheries, management, processing,
trade and markets

by

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ISBN 978-92-5-106620-1

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Preparation of this document

The Fisheries and Aquaculture Resources Use and Conservation Division (FIR) of the Fisheries and Aquaculture Department of the Food and Agriculture Organization of the United Nations (FAO) is responsible for all programmes and activities relating to management and conservation of fisheries resources. This paper was prepared as part of the FIR work programme to enhance the understanding of the tuna industry, addressing the situation concerning tuna stocks, fisheries, management, processing, trade and markets. It provides an update of the earlier FAO Fisheries Technical Paper No. 467 (2004) on “Historical trends of tuna catches in the world”, extending it substantially into subjects not dealt with in that earlier paper.

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Abstract

This paper provides an updated review of world tuna fisheries. Previous studies (Miyake *et al.*, 2004) discussed the historical development of tuna fisheries, described current world tuna fisheries, and explained the technological developments that have affected fishing operations. The current paper expands the discussion to include socio-economic aspects of the tuna industry as a whole, specifically including recent changes in processing, trade, marketing and consumer preferences.

The first half of the paper introduces the conditions under which the studies were made and the data sources. It first provides caveats and assumptions which are designed to prevent misunderstanding or misinterpretation when using the data. It then reviews the world tuna stock status based on the results of Regional Fisheries Management Organizations (RFMOs) scientific reviews. Even though the biomass of most of the world's tuna stocks is generally above but close to the reference point, for a few stocks fishing mortality is above the maximum sustainable yield level indicating that the stock is being overfished. World tuna fisheries (mostly longline, purse seine and baitboat [pole-and-line] fisheries) are reviewed from the standpoint of catches, technological developments and economics. Finally, tuna management measures taken by RFMOs are reviewed, including those used to mitigate bycatch. Gear and species interactions are specifically discussed in terms of allocations of the stocks between fisheries.

The second half of the paper analyses tuna trade, processing, markets, consumption, price and profits for *sashimi*, fresh tuna steak, *katsubushi* (dried skipjack stick) and canned tuna. The marketing of *sashimi* has changed very substantially from an exclusive Japanese market to a global one. The marketing system is also changing, because instead of being sold in market auctions, entire catches are now bought by one dealer and sold to large supermarkets or other retailers. This trend has had a clear impact on price and has resulted in the reduction of landing values. In the fresh and frozen steak tuna industry, in general, the price of tuna per unit weight is far higher than for canned materials. Since the 1960s, the production of, and demand and market for, canned tuna has increased very rapidly, accompanied by the rapid development of purse seine fisheries in tropical waters. The largest consumer of canned tuna in the 1970s was by far the United States of America, but these levels have been exceeded by European Union markets in the last two decades. The relative importance of the major markets (the United States, the European Union and Japan) has been continuously declining as a percentage of the world market. These trends have been accompanied by the concentration of capital. Another major change has involved the relocation of tuna factories from developed countries to areas closer to raw materials. This also helped the industry by cutting labour and transshipment costs, and facilitated flexible export marketing. Production was formerly dominated by the United States but as production has declined, Thailand has become the top producer in the late 1990s, followed by Spain, as a result of newly developed canning materials in the form of loins.

In conclusion, because of the recent rapid increase in competition among fisheries, species, industries and even products (*sashimi*/fresh tuna vs. canned), the most important and most urgent issue is how to manage and allocate tuna resources among these competitors (e.g. using fishing capacity control measures and/or catch allocations). In order to achieve such an objective it is imperative that socio-economic and ecological considerations are integrated into decision-making processes alongside capacity and

allocation issues. This study does not address the broad socio-economic importance of the tuna industry to the countries in which it operates, but this type of research will be necessary in future in order to solve current fishery management problems.

Miyake, M.; Guillotreau, P.; Sun, C-H; Ishimura, G.

Recent developments in the tuna industry: stocks, fisheries, management, processing, trade and markets.

FAO Fisheries and Aquaculture Technical Paper. No. 543. Rome, FAO. 2010. 125p.

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Acknowledgements

The authors wish to express their gratitude to many people for their assistance in the preparation of this paper, including: Alejandro Anganuzzi (Indian Ocean Tuna Commission [IOTC], Seychelles); Alex Aires-da-Silva, William Bayliff (Inter-American Tropical Tuna Commission [IATTC], United States); Fu-Sung Chiang (National Taiwan Ocean University); Guillermo A. Compeán (IATTC, United States); Philippe Cury (Institute of Research for Development [IRD], France); Juan José García del Hoyo (Modelización Económica y Matemática de Pesquerías [MEMPES], University of Huelva, Spain); John Hampton (Secretariat of the Pacific Community [SPC], New Caledonia); Minoru Honda (Japan Far Seas Purse Seine Fishing Association); David Itano (National Marine Fisheries Services [NMFS], University of Hawaii, United States); Francis Marsac (IRD, France); Mark Maunder (IATTC, United States); Kathleen Miller (University of California-Riverside, United States); Rémi Mongruel (French Research Institute for Exploitation of the Sea, France); Kuo-Tien Lee (National Taiwan Ocean University); Hiroaki Okamoto (National Research Institute of Far Seas Fisheries, Fisheries Research Agency, Japan); Tatsuo Ono (Japan Tuna, Japan); and Ramón Jiménez-Toribio (Modelización Económica y Matemática de Pesquerías [MEMPES], University of Huelva, Spain).

The authors' special gratitude goes to James Joseph (Consultant, United States), Dale Squires (NMFS, United States) and Robin Allen (Consultant, New Zealand) for critical review of the paper and their suggestions.

Valuable statistics and information were provided by Miguel Herrera (IOTC, Seychelles); Michael Hinton (IATTC, United States); Papa Kebe (International Commission for the Conservation of Atlantic Tunas [ICCAT], Spain); Carlos Palma (ICCAT, Spain); Tim Lawson (SPC, New Caledonia); Kazuhiro Oshima (National Research Institute of Far Seas Fisheries, Fisheries Research Agency, Japan); and Peter Williams (SPC, New Caledonia).

Our special appreciation for editing the entire report is extended to Shelley Clarke. As English is not the mother language of any of the authors, her editing was essential and she also gave many peer review comments on the draft. We also greatly appreciated the assistance given by Jacek Majkowski (FAO Fisheries and Aquaculture Department) in providing valuable advice and by Luca Garibaldi, Fishery Statistician, for furnishing statistics.

Abbreviations and acronyms

ACP	African, Caribbean and Pacific
ALB	Albacore (<i>Thunnus alalunga</i>)
AMSY	average maximum sustainable yield
ARA	Amsterdam-Rotterdam-Antwerp
ATL	Atlantic Ocean
B	biomass
BB	baitboat (“baitboat” is used exclusively for “pole and line”)
BET	Bigeye tuna (<i>Thunnus obesus</i>)
BFT	(Atlantic) bluefin tuna (<i>Thunnus thynnus</i>); official FAO name is bluefin tuna but often referred to as Atlantic bluefin tuna
BFTSD	Bluefin Tuna Statistical Document
BFTSDP	Bluefin Tuna Statistical Document Program
BMSY	Biomass at MSY
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLIOTOP	Climate Impacts on Oceanic Top Predators
CLL	coastal small-scale longliners
CPCs	Contracting Parties, Cooperating non-Contracting Parties, Entities or Fishing Entities
CPUE	catch per unit of effort
CWP	Coordinating Working Party on Fishery Statistics
DLL	distant water longliners
E	East
EC	European Commission
EEZ	Exclusive Economic Zone
EPO	Eastern Pacific Ocean
EU	European Union
F	fishing mortality rate (or coefficient)
FAD	fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
FAO/TAC	FAO Technical Advisory Committee on Fishing Capacity
FDA	Food and Drug Administration (United States)
FFA	Pacific Islands Forum Fisheries Agency
FOC	flag of convenience
GG	gilled and gutted
GILL	gillnet
GPS	Global Positioning System
GRT	gross register tonnage
GSP+	Generalised System of Preferences
HAND	handline
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
IND	Indian Ocean
IOTC	Indian Ocean Tuna Commission
IPOA	International Plan of Action (adopted by FAO)
IRD	Institute of Research for Development

ISC	International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean
ISSF	International Seafood Sustainability Foundation
IUU	illegal, unreported and unregulated
JPY	Japanese yen
LL	longline
MED	Mediterranean Sea
MSC	Marine Stewardship Council
MSY	maximum sustainable yield
NMFS	National Marine Fisheries Service (United States)
N	North
NEI	nowhere else included (mostly “flag of convenience”)
NGO	non-governmental organization
OPRT	Organization for the Promotion of Responsible Tuna Fisheries
OTH	other gears
PAC	Pacific Ocean
PBF	Pacific bluefin tuna (<i>Thunnus orientalis</i>)
PNA	Parties to the Nauru Agreement
PPM	parts per million
PS	purse seine
RFMO	Regional Fisheries Management Organization
RP	reference point
S	South
SBF	Southern bluefin tuna (<i>Thunnus maccoyii</i>); official FAO code is SBF but often SBT is used
SC	Scientific Committee
SKJ	Skipjack tuna (<i>Katsuwonus pelamis</i>)
SPC	Secretariat of the Pacific Community
SPRT	sport (or recreational)
SSB	spawning stock biomass
SURF	surface gears
SWO	Swordfish (<i>Xiphias gladius</i>)
T	metric tonnes
TAC	total allowable catch
TAE	total allowable effort
TPC	Taiwan Province of China
TRAP	trap (or set-net)
TROL	troll
UNCLOS	United Nations Convention on the Law of the Sea
VMS	vessel monitoring system
W	West
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WTO	World Trade Organization
WTPO	World Tuna Purse Seine Organization
Y/R	yield per recruit
YFT	Yellowfin tuna (<i>Thunnus albacares</i>)

Executive summary

TUNA STOCK STATUS AND CHANGES IN FISHERIES

World tuna fisheries are reviewed in terms of commercially important species, by ocean and by major fishing gear types. In volume, the most important catches¹ are of skipjack tuna at 50.7 percent of the global total, particularly in the Pacific Ocean, followed by yellowfin tuna at 31.7 percent and bigeye tuna at 10.8 percent. Albacore and bluefin tunas – Atlantic bluefin,² Pacific bluefin and southern bluefin – are caught in much smaller quantities. The Pacific Ocean yields more than half of the world's tuna production (64 percent), followed by the Indian (25 percent) and Atlantic (11 percent) Oceans. The catch by purse seiners has increased very rapidly and now forms the majority of the total yield (from 300 000 tonnes in 1970 to 2.8 million tonnes in 2006). Longline used to be the dominant gear type but it is now rapidly losing its share (from 500 000 tonnes, 34 percent of the total in 1970, to 650 000 tonnes, 15 percent of the total in 2005), though coastal small-scale longlining is increasing.

Stock status is reviewed according to the most recent, formal assessments by each of the tuna Regional Fisheries Management Organizations (RFMOs). The review is based on two aspects: whether the biomass (or spawning biomass) is above or below the reference point (RP); and whether fishing mortality is higher or lower than the level equivalent to the sustainable yield (as represented by the RP, which is generally the maximum sustainable yield [MSY]). Catches of bigeye and yellowfin have continuously increased in the Indian and Pacific Oceans, whereas in the Atlantic they peaked in the 1990s and thereafter decreased or stabilized. Stock biomass of tropical tunas (bigeye, skipjack and yellowfin) is generally above but close to the RP, and the exploitation level is close to the MSY, except for skipjack which still appears to be underexploited. Current fishing mortality coefficients for bigeye and yellowfin are generally below the level of the RP, except those for bigeye in the Pacific Ocean and yellowfin in the Indian Ocean which are above the MSY level. The temperate tunas (albacore, southern bluefin, Pacific bluefin and Atlantic bluefin) are more heavily exploited. In particular, southern bluefin and Atlantic bluefin are both in an overfished state and are currently being overfished.

The technological and physical development of fishing gear and its deployment is continuously progressing. The most recent change with the greatest impact on fisheries was the introduction of fish aggregating devices (FADs) by the purse seine fleet. The recent increase in purse seine catches is directly related to the increase of small-sized tropical tunas caught in association with FADs.

At present, sets on FAD schools take most of the fish in the habitat developed under the FAD, hence the species and sizes are highly variable, including many non-target small tunas and other species. Since the stock size of bigeye is small compared to yellowfin and skipjack, the capture of juvenile bigeye underneath FADs has a more substantial impact on the stock. This has significantly altered the yield per recruit

¹ Percentages represent the five-year average for 2001–2005 (see Section 4.1.2). Data for 2006–2007 were preliminary at the time this report was written.

² The formal taxonomical name is bluefin tuna. However, in order to avoid confusion with Pacific bluefin tuna, it is called “Atlantic bluefin” in this report.

(Y/R) of bigeye stocks as well as the allocation of stocks between longline and surface fisheries (particularly purse seine).

The greater use of at-sea transshipment (mostly by distant water longline fisheries) and increased use of supply vessels (by purse seine) have increased the fishing capacity of the fleets, even if the number and fish holding capacity of the fleet has been held constant.

The development of coastal fisheries, including coastal longline fisheries, is also an important feature of the last two decades. This is primarily related to the establishment of Exclusive Economic Zones (EEZs), but is also very closely linked to cost effectiveness and management schemes aimed at distant water fleets.

The establishment of tuna farms has also had a major impact on fisheries, particularly through changes in market price and trade and market structure. As a result of farming, fishing pressure has increased for both large and small fish.

TUNA MANAGEMENT

Scientists from the RFMOs use the most recent and best available data and information to evaluate the stocks and provide advice for management. Government representatives do not necessarily fully respond to such advice, but many actions have been taken including those responding to environmental or ecosystem concerns (mostly mitigation of incidental bycatch). The adoption and implementation of management measures has become more difficult in recent years due to the global excess fishing capacity. As tuna fisheries are multispecies and multigear, when a regulation is adopted spillover of fishing capacity inevitably occurs and thus global management of fishing capacity is an urgent need.

Management measures, including those to combat and eliminate illegal, unreported and unregulated fishing and other unauthorized activities, can have a negative effect on fishing efficiency. In particular, recent bycatch mitigation measures have had a major impact on fisheries in general, especially longliners. As a result, gains in fishing efficiency have slowed. This is important since it may cause scientists to overestimate increases in catchability, fishing efficiency and fishing capacity for recent years.

In conclusion, most of the long-term changes in the fisheries have acted to increase the fishing efficiencies of all fleets. However, many of the recent changes, particularly for longline fisheries (i.e. tuna stocks are approaching or exceeding their full exploitation level; Y/R is reducing due to increasing juvenile catches; the number of regulations is growing; obligations for bycatch mitigation are expanding; competition among gear types has been accentuated; and both global fishing capacity and operational costs have risen) have had a negative impact on tuna fisheries (e.g. reduced efficiency) and, if not decreased, at least slowed down the trend of increasing catchability.

OPERATING COSTS AND REVENUE

Fishery operating costs were analysed by expenditure item. Case studies for Japanese distant water longline, baitboat and purse seine fleets; the Japanese near-coastal longline fleet; and the Seychelles-based large-scale purse seine fleet were assessed. In general, the average purse seine operation produces a profit; however, the other distant water fisheries are operating almost at a loss. Even purse seine profits are shrinking due to the increasing cost of fuel, labour and materials, while landing values (revenue) cannot be increased. The fuel costs are significant and widely fluctuating. The recent rise in fuel prices did not have as large an effect on the European fleet as on other fleets, due to the favourable monetary exchange rates for euros (because oil prices are generally quoted in United States dollars). In the case of the Japanese fleets, labour costs are very substantial. Replacement of national crews by foreign crews, mostly Indonesian, provides some cost relief.

TUNA MARKET – SASHIMI

Tuna trade, processing, markets, consumption, price and profits are discussed for *sashimi*, fresh tuna steak, *katsuobushi* (dried skipjack stick) and canned tuna.

The *sashimi* market was almost exclusively centred in Japan, but it has recently expanded worldwide. The Japanese domestic supply is slightly above 200 000 tonnes (all tuna combined but excluding skipjack, in round weight), while about 400 000 tonnes of tuna are imported. (These figures are in round weight and thus different from most recorded trade or market statistics.) Except for small amounts of albacore, these fish are usually consumed in fresh form. Slightly less than 300 000 tonnes of skipjack are caught by national vessels and 100 000 tonnes are imported. More than a half of the skipjack are either for canning or *katsuobushi*. Both catch and imports of skipjack have decreased in recent years.

One major problem is that the statistics for markets, trade and production are generally in terms of processed products and it is difficult to relate these to round weight. The decrease in Japanese imports may well be due to the nature of the products imported: in recent years, more and more processed (reduced in volume) products have been imported, for example, *sashimi* sliced blocks rather than gilled and gutted fish.

The marketing of *sashimi* has changed significantly as well. Concentration of trade within a smaller number of dealers (traders), wholesalers and retailers is commonly occurring in parallel with a reduction in trade intermediaries. Instead of fish being sold in market auctions, entire catches are now bought by one dealer and sold by large supermarkets or other retailers. This trend has had a clear impact on price and has resulted in the reduction of landing values.

TUNA MARKET – FRESH AND FROZEN TUNA (NON-SASHIMI)

Many parts of the world, including southern Europe, Asia, the Pacific Island States and Japan, have a long tradition of consuming non-canned tuna. Recently, this type of consumption has expanded throughout the world, particularly in North America. One of the difficulties in assessing statistics for non-canned tuna is separating these quantities from canned materials and from *sashimi*. Uncertainty in product weights due to different processing forms is also a major issue for this review.

In general, the price of tuna per unit weight is far higher for fresh consumption than for canned products. In the United States, recent tuna imports for non-canning purposes ranged from 60 000 to 90 000 tonnes with an increasing trend, while domestic landing of such products ranges from 20 000 to 30 000 tonnes with a declining trend. Total consumption in the United States is estimated at 80 000 to 110 000 tonnes per year

TUNA MARKET – CANNED GOODS

Canning of tuna began as early as the late nineteenth century. Tuna was once a low-value substitute for other fish (e.g. salmon, sardines), but since the 1960s the production, demand and market increased very rapidly, accompanied by the rapid development of purse seine fisheries in tropical waters. World canned tuna production increased from about 200 000 tonnes (net weight) in the mid-1970s to over 1 million tonnes by the early 2000s. The United States was the largest producer in the 1970s, but now only American Samoa is still producing on United States soil, and there is no canning taking place in the mainland United States. As United States production has declined, Thailand, since the late 1990s, has become the top producer and is now responsible for almost 46 percent of the world production, followed by Spain (nearly 10 percent). The Spanish canning industry has been maintained through shipping of newly developed canning materials in the form of loins (cleaned, boiled and prepared, and ready for canning).

The largest consumer of canned tuna in the 1970s was by far the United States, followed by the European Union and Japan. Both the number of countries importing

and exporting canned tuna has increased and the cumulative market share of the top three importing countries (North America, European Union and Japan) has dropped from 96 percent to 74 percent over the last three decades. The gradual expansion of the European Union has allowed it to maintain its market share at above half of the worldwide market; however, the relative importance of the United States market has been reduced by half over time.

The globalization of the canning industry in the last three decades is strikingly apparent. It has been accompanied by the concentration of capital into a small number of operators, in the form of fishing vessels, traders, wholesalers, canneries and/or retailers. This represents one method of reducing the costs of production. Another major change has been the relocation of tuna factories from developed countries to areas closer to raw materials. This has also helped the industry by cutting labour and transshipment costs and facilitated flexible export marketing. In some cases, the establishment of a canning industry has been a condition for obtaining fishing access to the EEZ. Also, the development of products with reduced transshipment costs for materials and lower production costs for industry has also been important (e.g. vacuum-packed *sashimi* blocks and loins).

On the part of retailers, there is a trend toward separation into two product classes of canned tuna, i.e. cheap private brands and expensive, sophisticated products. Naturally, the large wholesalers and retailers depend primarily on private brands. As a result, the value chain flows in reverse to the product flow, i.e. consumers decide the price and industry has to meet this requirement. Because of the globalization of the industry (market, processing and fishery), the key to its existence lies in trimming production costs at each stage and reducing margins between stages of the value chain as much as possible. In order to achieve this, the concentration of capital is occurring at each stage, including retail, wholesale, cannery, cannery supply, fresh fish markets, and the fishing industry itself. Cutting margins between these stages or skipping some of the stages has occurred in both the *sashimi*/fresh tuna and the canning industry. Development of private brands (labels) also serves this purpose.

The consumer market is susceptible to many factors. It can be easily influenced by the mass media or by public concerns at the time. The impact on the market can be unpredictably positive or negative. Therefore, there is always some risk involved for the entire tuna industry. Recently, there are fewer tariff-type trade barriers. This helps to cut production costs and increases the fluidity of trade in tuna products.

CONCLUSIONS

In conclusion, while tuna fisheries' efficiencies are being reduced by many new elements, the market is becoming increasingly dynamic. This results in higher competition among the fisheries, species, industries, and even between products – *sashimi* and fresh tuna vs canned. This scenario is analogous to that of a pie that has already expanded dramatically to its maximum but for which the number of pie consumers has also increased and is still increasing. At present, the most important issue is how to manage the number of potential pie consumers and how to distribute the pie among them (e.g. using fishing capacity control measures and/or catch allocations). In order to achieve such an objective, it is imperative that socio-economic and ecological considerations are incorporated into decision-making processes alongside capacity and allocation issues. This study does not address the socio-economic importance of the tuna industry as a whole to the countries in which it operates, but this type of research will be necessary in the future in order to solve current fishery management problems.

1. Introduction

Miyake, Miyabe and Nakano (2004) reviewed developments and changes in world tuna fisheries from 1950 through 2002. Miyake (2005a) analysed developments in fishing technology and their effects on fisheries, and Miyake (2005b) performed a similar assessment of longline fishing capacity. These studies were detailed and global in scope, but they were limited in one sense because they discussed changes in the fisheries only and focused mainly on the development of fishing technology. Although fishing methods are an essential factor in the fishing industry, there are many other factors which have induced important transitions.

This paper updates the previous studies and also includes a discussion of changes in the socio-economic environment, which have had significant impacts on tuna fisheries. Elements which are expected to have had very strong effects on the development of fisheries and which are included in this paper are:

- tuna stock status;
- developments in fishing technology;
- fishery management measures and compliance;
- fishing operating costs;
- interactions among various tuna fisheries;
- ecosystem considerations, including bycatch;
- developments in processing industries (canning, *sashimi*, fresh including steak forms, and others);
- transportation and trading systems; and
- world market and consumer preferences (demand and price).

Understanding the global, multigear and multispecies nature of the tuna fishery is critically important. Fishing fleets, including those of industrialized countries and often even including those composed of small vessels, have been operating using many different types of gear all over the world for many years. A vessel can fish in three oceans in any given year with any species of tuna as its target. Therefore, any management measure taken for a particular stock of tuna can cause a spillover of fishing capacity to other species and/or areas. The tuna market has also expanded and has become more complex and globalized: tuna commodities are traded throughout the world, the distribution system is very complicated, and consumers' preferences are both diverse and changing over time. Because all of these factors are closely and intricately interrelated, discussion of the entire system is not simple. Therefore, this paper first discusses each factor individually, then provides an overview of the tuna industry in its entirety, highlighting immediate management issues.

Regardless of whether its effects are direct or indirect, one of the most influential factors on the fishery is the natural environment. Despite the importance of this factor, this paper does not address this issue because many studies of this topic have already been conducted and it is also a major subject of research under the Climate Impacts on Oceanic Top Predators (CLIOTOP) programme.¹

In analysing economic issues in this paper, values and costs are given in nominal values in most of the cases, i.e. notwithstanding some exceptions, which are annotated, they are generally not adjusted for inflation. Inflation rates vary among countries and stages of the value chain; therefore, incorporating these rates consistently throughout this analysis would in most cases be impractical.

¹ See www.globec.org/structure/regional/cliotop/cliotop.htm

The shipbuilding industry is an important component of the tuna industry. In general, in the 1960s and 1970s, Japan led this industry, particularly in the longline sector. Since then, Spain has become the major builder of purse seiners, while the Republic of Korea and then later China and Taiwan Province of China have become major builders of longline vessels. Currently, Taiwan Province of China is a leading purse seine builder. This topic, though important, is not pursued further in this paper.

2. Definitions and sources

All catch data used in this paper derives from FAO database compiled from RFMOs' sources. As such, these data should be identical to those held by each RFMO. In the event of discrepancies, the original RFMO databases were used and thus referenced (see Section 4.1 for details). All catch data series run from 1950 through 2007 and consist of those data available as of 31 December 2008. The data for 2007, and possibly even for 2006, should be considered preliminary because some of these data had not yet been received by RFMOs from the flag states by the end of 2008. In such cases, the catch figures from previous years were simply carried over as placeholders. Although the data for 2007 are preliminary (i.e. often incomplete and/or subject to confirmation), any subsequent adjustments are expected to be minor relative to the macroscale overview of the fisheries presented in this paper. More details on data issues are provided in Section 4.1. Sources of information for tuna products, trade and markets are given in the sections in which the data are presented.

This paper covers tunas which are commercially important, i.e. Atlantic bluefin (BFT), Pacific bluefin (PBF) southern bluefin (SBF), albacore (ALB), bigeye (BET), skipjack (SKJ) and yellowfin (YFT). Billfishes (including swordfish) are not included. Abbreviations of frequently used terms, FAO species codes and fishing gear codes are listed at the beginning of this paper. Tuna stock separations (or definitions) used in this paper follow those used by the RFMOs.

In this paper, all data are provided in metric units (including data from the United States and the United Kingdom of Great Britain and Northern Ireland). All the catch or landing weights are given in live (or round) weight (often converted). However, in trade or market statistics, the data are the weight of processed products and, in most cases, the product forms are unknown. When the processed product forms were known, weight was either converted to round weight or stated in the units as given (e.g. gilled and gutted, filleted). When the processed product form was unknown, it was referred to as "processed weight". Therefore, processed weights reported in this paper are not directly comparable to catch or landing weights. In general, processed weight is about 80 percent of round weight in the case of fresh fish, but could be as low as 60 percent for canned material. If the products are vacuum-packed *sashimi* pieces, processed weight could be less than 40 percent of the round weight. Discrepancies such as these make comparing catch statistics with trade or market statistics very difficult. This issue is further discussed in Section 6.

Catch data, by FAO definition, includes discards (live or dead), but in practice reported catch data usually represents retained catches or landings only. Some longline fisheries targeting swordfish or sharks use gear specifications and operational patterns that are different from longline fisheries targeting tunas, but despite these differences they also catch major tuna species as bycatch. This tuna bycatch is included in the data presented in this paper as far as it is retained and reported even though the development of longline fisheries targeting swordfish or shark is not discussed in this paper.

In this paper, some data represent the results of various investigations made by the authors. When these are based on unofficial records, logbooks, censuses/surveys, sales slips and various other unpublished sources, they are referenced only as unpublished data.

3. Tuna stock conditions and scientific recommendations

3.1 DEFINITIONS

All the world's tuna and tuna-like species are the subject of research and management by RFMOs. The major RFMOs responsible for this are the International Commission for the Conservation of Atlantic Tunas (ICCAT) for the Atlantic Ocean; the Indian Ocean Tuna Commission (IOTC) for the Indian Ocean; and the Western and Central Pacific Fisheries Commission (WCPFC) and Inter-American Tropical Tuna Commission (IATTC) for the Pacific Ocean. In the Pacific Ocean, another international organization, the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) is responsible for the provision of conservation and management advice for North Pacific stocks, whose distributions cross the border of IATTC and WCPFC. All of the RFMOs described so far are area based. The only exception is the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), which is species based, as there is only one stock of southern bluefin and it is distributed in three oceans (Atlantic, Indian and Pacific). Therefore, management of southern bluefin is undertaken by CCSBT, even though the other RFMOs are also responsible in principle. Since the major catch of southern bluefin occurs in the Indian Ocean, this paper discusses the southern bluefin catches in conjunction with the Indian Ocean.

The procedures and operating systems, as well as the management objectives defined by their conventions, differ among the RFMOs. The criteria used in this section follow the definitions of the RFMOs and therefore may differ from one another even if the species or stocks are the same. The definitions of stocks follow those by RFMOs and the findings on the status of each stock are those presented by the auxiliary scientific advisory bodies of the RFMOs with the exception of the North Pacific stocks (Pacific bluefin and North Pacific albacore), whose assessments are conducted by the ISC.

For each ocean, the most recent stock conditions (as of 1 June 2009), as agreed by the RFMOs and their scientific advice bodies, have been summarized into a simple table format. This paper does not intend to discuss biological stock conditions in detail. However, the uncertainties and conditions under which the RFMOs reached these conclusions (as described in each source report) should be always kept in mind.

Although there are many diagnostics for judging the stock conditions, the simplest criteria are used in this chapter: whether there is overfishing on a stock and whether a stock is in an overfished condition. In stock assessments, there are many uncertainties in the biological parameters and models used, e.g. in the data sets, in environmental factors affecting the stock abundance, and in changes in catchability and availability. Therefore, the medians from base case runs adopted by each scientific body are used. The annotation “overfishing occurring” refers to a situation in which the current fishing mortality rate (F) exceeds the level that maintains the stock biomass (or spawning stock biomass [SSB]) at the reference point (RP) (i.e. $F_{\text{current}} > F_{\text{RP}}$). “Overfished” status refers to a stock whose biomass (or SSB) has fallen below the level of the RP (i.e. $B_{\text{current}} < B_{\text{RP}}$).

It should be understood that under average conditions a stock which is not in an overfished condition and is not being overfished would stay above the RP. However, even for a stock that is not overfished, if overfishing is occurring, eventually the stock

biomass will fall below the RP. On the other hand, an overfished stock may eventually recover to the RP if overfishing is not occurring, assuming the current biomass relative to the RP is not so low that it negatively affects the spawner/recruit relationship.

This section compiles the conclusions of the scientific advice on stock status given by the scientific advisory group to the RFMO Commissions for each stock in Tables 1, 2 and 3. If biomass and fishing mortality rate are above and below the RPs, respectively, green shading is used to indicate the good condition of the stock. When the median of the biomass and fishing mortality rate are within 10 percent (either above or below, respectively) of the RPs, yellow shading is used. If the median is more than 10 percent but less than 50 percent above or below the RPs respectively, orange shading is used to indicate a warning. When biomass is more than 50 percent lower or F is more than 50 percent higher than the RPs, red shading is used. In terms of stock management, red indicates that very strict regulations are essential even to maintain the present level of stock biomass (and even stricter regulations would be necessary for stock recovery); orange indicates that regulations are required for stock recovery; yellow indicates that management measures are required to maintain the current level of the stock; and green indicates that no regulations are required but that stock monitoring is advisable.

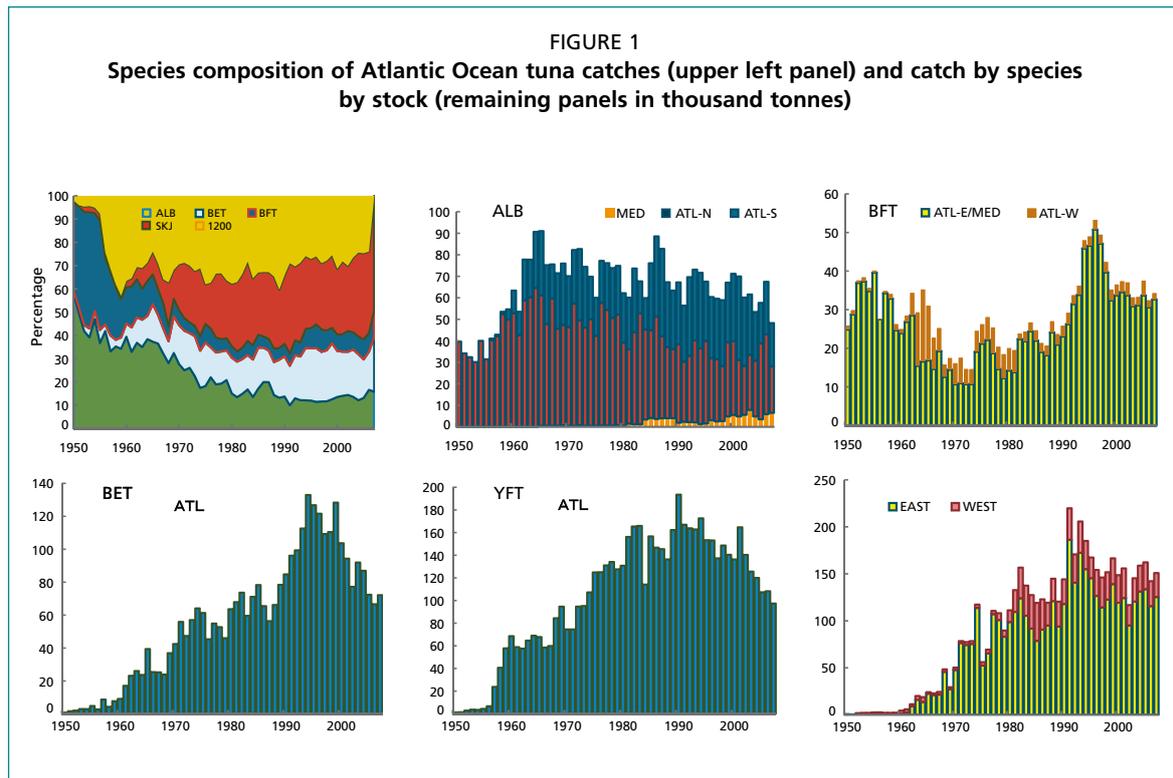
The recommendations are drawn from the scientific advisory groups (e.g. the RFMOs' scientific committees) as described above but do not necessarily reflect the decisions of the Commissions. The decisions of the Commissions are given in Section 5 in a simplified format. For example, the specification of "total allowable catch (TAC)" can range from a "fixed total allowable catch of X tons" to a general, and more ambiguous, recommendation such as "catch should not exceed MSY". This variability in the specificity of management decisions is particularly common in the case of total allowable effort (TAE). As effort is usually hard to define, the recommendations often take forms such as " F should not exceed the current level", which is generally interpreted to mean that the total catch (or individual national catch), or number of vessels, should not exceed the current level. As this paper does not intend to analyse management arrangements in detail, those who are interested in further information regarding these management recommendations should refer to the original reports by the RFMOs.

In this chapter, catches of each tuna stock are given in graphic format to provide an overview. Despite this summarized presentation, the sources and limitations of the data, as discussed in this section, should be kept in mind.

3.2 ATLANTIC OCEAN

Figure 1 gives the Atlantic Ocean tuna catches by species, subdivided into stocks. The only exception is the upper left panel which shows the species composition of Atlantic tuna catches in percentage. Catches of tropical tunas (yellowfin, skipjack and bigeye) in the Atlantic reached their peak in the 1990s and thereafter declined. This can be partly explained by the fact that stocks in the Atlantic reached their full exploitation status and management measures were introduced earlier there than in any other ocean, with the exception of the TAC/time closure in the Eastern Pacific Ocean in 1966. Later, the development of the Indian Ocean fishery absorbed the excess fishing effort from the Atlantic Ocean.

Management by quota has been in effect for Atlantic bluefin in the Western Atlantic Ocean since 1981 and in the Eastern Atlantic Ocean (including the Mediterranean) since 1994. Scientists estimate that between 15 000 and 30 000 tonnes of Atlantic bluefin in the Eastern Atlantic have not been reported in recent years. These estimates are not reflected in the catch figures themselves but are considered in the stock assessments as sensitivity analyses. Besides Atlantic bluefin almost all the tuna stocks in the Atlantic Ocean are under regulation of one type or another (catch, size, effort or time-area closures) and therefore cannot be considered to be unregulated (see



Note: MED = Mediterranean, ATL-N = North Atlantic, ATL-S = South Atlantic, ATL-W = West Atlantic.
Source: FAO and RFMO databases.

TABLE 1
Summary of stock status in the Atlantic Ocean

Stocks	$B_{current} / B_{MSY}$	$F_{current} / F_{MSY}$	Recommendation
ALB – N	0.81 (0.68–0.97)	1.5 (1.3–1.7)	TAC
ALB – S	0.91 (0.71–1.16)	0.63 (0.47–0.9)	TAC
ALB-Med	Unknown	Unknown	
BET	0.92 (0.85–1.07)	0.87 (0.70–1.24)	TAC
BFT – E ¹	High recruit 0.14 Low recruit 0.35	Reported catch 3.04 Estimated catch 3.42	TAC/Size-limits/Time-area closure/Limit fishing capacity
BFT – W ²	High recruit 0.14 (0.08–0.21) Low recruit 0.57 (0.46–0.70)	2.18 (1.74–2.64) 1.27 (1.04–1.53)	TAC
SKJ – E	High probability > 1	High probability < 1	None
SKJ – W	High probability > 1	High probability < 1	None
YFT	0.96 (0.72–1.22)	0.86 (0.71–1.05)	TAC

¹ $SSB_{2007} / SSB_{F_{MAX}}$; F_{2007} / F_{MAX} ; High recruitment (1990s) and low recruitment (1970s) levels are assumed.

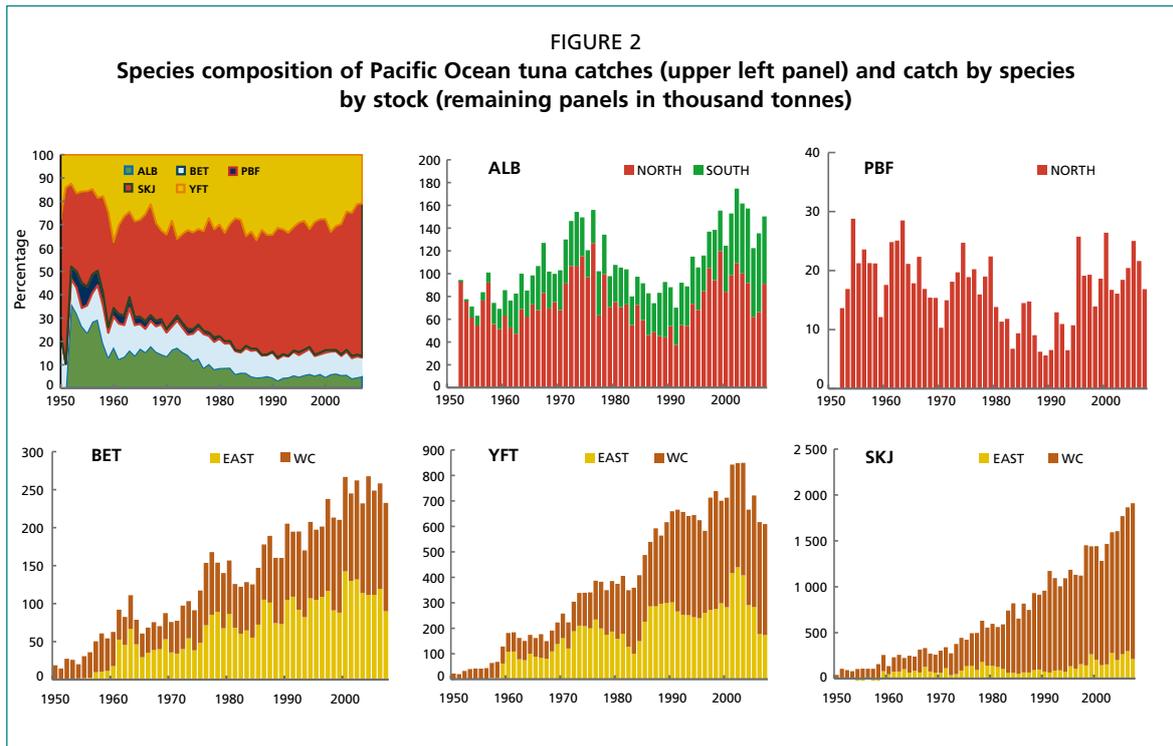
² Relative to MSY, which is calculated conditional on recruitment remaining at recent (1976–2004) levels.

Note: decimals of values coincide with these reported by each RFMO.

Section 5.1 for more detailed information). Table 1 provides a summary of the results of stock evaluations for the Atlantic tuna stocks based on ICCAT (2008) and using the ICCAT reference point of MSY.

3.3 PACIFIC OCEAN

Pacific Ocean catches by stock are given in Figure 2. The upper left panel shows the species composition. As will be discussed in Section 5, the Pacific catches of tropical tunas have maintained a nearly constant increase since 1950. On the other hand, relatively long-term cycles can be observed in the Pacific Ocean’s temperate tuna (albacore and Pacific bluefin) catches. The ISC considers that these cycles represent regime shifts between high and low recruitment periods and that recent recruitments



have been relatively high for both albacore and Pacific bluefin. Pacific bluefin is considered a North Pacific stock, and although there is a negligible amount of catch of this species in the southern hemisphere, all Pacific bluefin catches are discussed here as a North Pacific stock.

Table 2 provides a summary of the assessment results of the Pacific Ocean tuna stocks. Data for BET-East (E), YFT-E, and SKJ-E are taken from the conclusions of the IATTC and WCPFC scientific advisory groups; data for ALB-South (S), BET-WC (Western and Central), YFT-WC, and SKJ-WC are drawn from WCPFC (2008); and data for PBF and ALB-North (N) are drawn from ISC (2008). The reference point adopted by IATTC and WCPFC is MSY, whereas ISC does not yet have defined reference points. For this and other reasons, the stock evaluations of PBF and ALB-N are primarily based on current fishing mortality relative to various potential biological reference points.

TABLE 2
Summary of stock status in the Pacific Ocean

Stocks	$B_{current} / B_{MSY}$	$F_{current} / F_{MSY}$	Recommendation
ALB – N ¹	Likely >1.0	$F_{current} = 0.75 F_{MSY}$	F to be reduced
ALB – S	1.26 (1.26–1.50)	0.44 (0.25–0.44)	
BET – EPO	1.01	1.234	Time closure for PS; quota for LL
BET – WCPO	1.37 (1.02–1.37) ²	1.44 (1.33–2.09)	30% reduction of F
PBF ¹	$SSB_{current} = SSB_{average}$	Possibly $F_{current} \geq F_{RP}$	No increase in F
SKJ – EPO	Not estimated Probably >1	Probably < 1	
SKJ – WCPO	2.99	0.26	
YFT – EPO	0.96	0.89	Time closure for PS
YFT – WCPO	1.17 (1.13–1.42)	0.95 (0.56–1.10)	

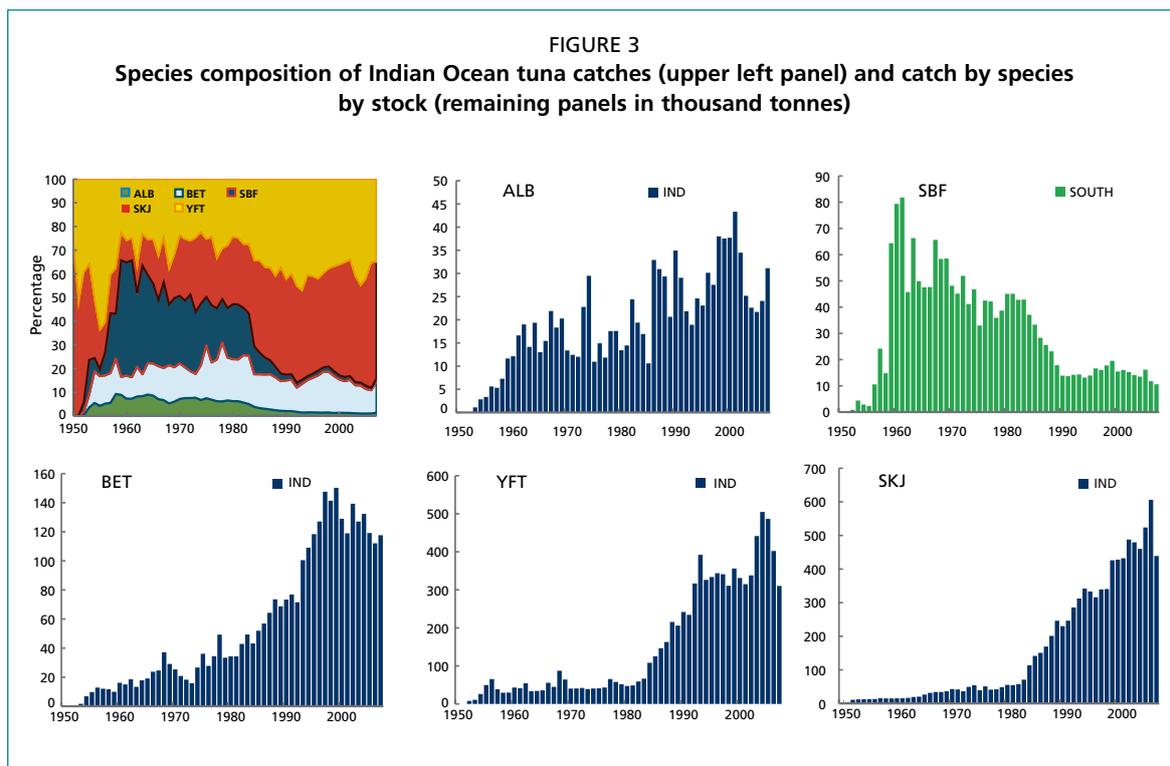
¹ Point estimates are not provided. RP is not defined and various candidates are considered. Hence no clear cut median can be given.

² $SSB_{current} / SSB_{MSY} = 1.19$ (0.76–1.20).

3.4 INDIAN OCEAN

Figure 3 provides an overview of Indian Ocean catches by species. The upper left panel shows the species composition of the Indian Ocean catch. As discussed in detail in Section 5, the Indian Ocean fishery is relatively new. Most of the stocks, particularly the tropical species, began to be exploited only in the 1980s and catches are still rapidly increasing, except for the last few years (data are preliminary). Because the fishing fleets operating in the Western Indian Ocean also operate in the Eastern Atlantic Ocean, the increasing catch in this area has clearly affected the Atlantic catches. This will be discussed further in a subsequent section of this paper.

Table 3 provides a summary of the results of assessments of the Indian Ocean tuna stocks. All data are sourced from IOTC (2008c), except for the southern bluefin data which derives from CCSBT (2008).



Note: IND = Indian Ocean (one stock).
Source: FAO and RFMO databases.

TABLE 3
Summary of stock status in the Indian Ocean

Stocks	$B_{current} / B_{MSY}$	$F_{current} / F_{MSY}$	Recommendation
ALB	> 1	0.48–0.90 ¹	No recommendation
BET	1.34 (1.04–1.64)	0.81 (0.54–1.08)	Catch<MSY and Effort<2004
SKJ	Unknown (High probability >1)	Unknown (High probability <1)	No recommendation
YFT	1.13–0.93	0.9–1.60	TAC and Effort <2007
SBF	0.101–0.127 ²	Not reported	TAC

¹ Given as point estimates of exploitation (harvest) rates (h), $h_{current}/h_{MSY}$.

² $SSB_{current}/SSB_k$ (current SSB relative to the carrying capacity or unfished biomass).

4. Fisheries

4.1 OVERVIEW OF THE WORLD'S TUNA FISHERIES

4.1.1 Catch data sources and uncertainties

All the catch data used in Sections 3 and 4 are taken from the catches (landings) reported to, and published by, RFMOs as of the end of 2008. These data are stratified by species/stock, gear type and flag state, as well as by stock area. It should be noted that these data represent the best available scientific estimates of catch, rather than the data officially reported by national statistical offices.

The catch series begins in 1950. Prior to that time, catch data are highly uncertain as many countries were not reporting by area, species and gear type. In addition, once the Japanese fleet was released in 1952 from its post-war area restrictions, it spread across the world's oceans and began reporting catch data only in that year. This is important because Japanese catches comprised more than 50 percent of the world's tuna catches in these early years.

Furthermore, there are many uncertainties in catch data as reported by these RFMOs. These uncertainties arise mainly from:

- (i) catches by vessels which are not on RFMO-authorized vessel lists;
- (ii) under- or over-reporting by Contracting Parties, Cooperating non-Contracting Parties, Entities or Fishing Entities (CPCs);
- (iii) estimation of coastal small-scale fisheries catches based on sampling, coverage of which varies from year to year;
- (iv) loss of catch in the water before it is brought on-board (through depredation or for other reasons);
- (v) lack of reporting of discards (live or dead);
- (vi) reporting of processed weight instead of round weight;
- (vii) species misidentification; and
- (viii) unreported catches by recreational fishers.

Uncertainty sources (i) and (ii) are generally associated with fishery regulations, such as TACs, and are discussed in more detail in Section 5.1.6. Sometimes under- or over-reported quantities, or data on illegal, unreported and unregulated (IUU) catches which are lacking in their entirety, are estimated by the scientific advisory body of each RFMO. In most instances, these estimates are based on landing data from various ports where sampling is conducted and/or from trade data. With the permission of reporting nations, the RFMOs have adjusted the officially reported national catches for that quantity. However, in usual practice, circumstances do not permit such modification and only those catches officially reported by nations are included. Some RFMOs report these unreported or under-reported catches as "nowhere else included" (NEI) so that the sum of the catches would be closer to the true value.

The uncertainties related to small-scale coastal fisheries, i.e. (iii) above, for which the states do not have sufficient funds and/or capacity to collect adequate catch and size data on landings at their ports can be serious. Considerable effort has been made to remedy this situation through bilateral agreements between coastal states and developed countries and through some assistance provided by RFMOs. The problem is that the estimates are possible only for recent years, resulting in an apparent increase in catches which reflects merely an improvement in sampling coverage. On

the other hand, many coastal states are developing tuna fisheries in their own waters and such fisheries are comprising an increasingly larger portion of world catches. As a consequence, the interpretation of catch trends in coastal fisheries requires special care and attention.

Uncertainty issues (iv) and (v) sometimes occur together. In the case of longlines, many fish that bite the hooks are lost for various reasons before they are brought on-board. Most of these losses are caused by depredation by sharks and/or marine mammals. Depredation rates have been studied systematically and reported by IOTC, and it was discovered that the rate of depredation increases as the catch rate decreases (IOTC, 2007a). Even when the fish are brought on-board, if the damage by shark depredation is high they are generally discarded. It is also known that some of the catches are lost before the nets are hauled up for “mysterious” reasons (Ward, Myers and Blanchard, 2004).

Discards of fish (v) are a substantial source of errors in catch estimates. In general, the logsheets require reporting of discards. However, for many fishers “catch” means only retained catch. Therefore, as described above, even depredated fish in longline fisheries which are brought on-board but discarded are frequently not reported. Also, some management regulations of RFMOs require release of some species, such as billfishes, before they are brought on-board. In earlier years, when catch rates were generally high, longliners retained preferred species and sizes and sometimes discarded low-grade or low-priced tuna. This is no longer practiced by longliners as the catch rates are low, and all fish caught contribute to the revenue so they are retained. However, in purse seine fisheries, particularly in the sets on schools associated with FADs, many fish that are well below the commercial size and/or those in poor condition (e.g. smashed) are discarded. Some regulations (e.g. in IATTC) require purse seiners to retain the entire catch unless it is unsuitable for human consumption, yet there are always some discards occurring and fishers frequently fail to report these discarded components of the catches.

Regarding uncertainty source (vi), in the past, official national statistics were often found to be in weight of processed fish rather than round weight. When such problems were discovered RFMO databases were modified for the entire data series of that country. In many of the cases this problem arises from a lack of communication between statistical departments and scientists.

Species misidentification, i.e. (vii) above, has many aspects. It sometimes represents intentional under-reporting of the regulated species and over-reporting of unregulated species. However, real difficulties in identifying juvenile yellowfin and bigeye do exist because, unfortunately, these two species look very similar in their juveniles stages and they are captured together from the same schools (particularly in FAD fishing). In addition, these juveniles have either no commercial value due to their extremely small size, or they are sold as mixed catch at the same price to the canning industry. Therefore, in the past, fishers generally reported them together as “tuna” or as “yellowfin”. The uncertainty from this source has become more problematic as FAD fishing has increased the catch of small-sized tunas of mixed species.

Species misidentification was first recognized to be an issue in the Atlantic Ocean (Cayré and Fonteneau, 1984). Since then, reported catches by purse seine and later even baitboats have been modified on the basis of species composition sampling by on-board observers and/or sampling at landing ports. In oceans other than the Atlantic the problem was either considered not to be serious (until FAD fishing started) or not recognized to be a problem until much later (Lawson, 2008; Tomlinson, 2002 and 2004; Fonteneau, 2008). Much effort has been devoted to modifying the historical data based on available species composition data (Lawson, 2008). However, the mixing rates of the two species vary by relative stock size, school type, area, season and year. Therefore,

with the exception of the Atlantic datasets, there are considerable uncertainties in the data before 2000.

4.1.2 Trends in the world tuna catches

By ocean

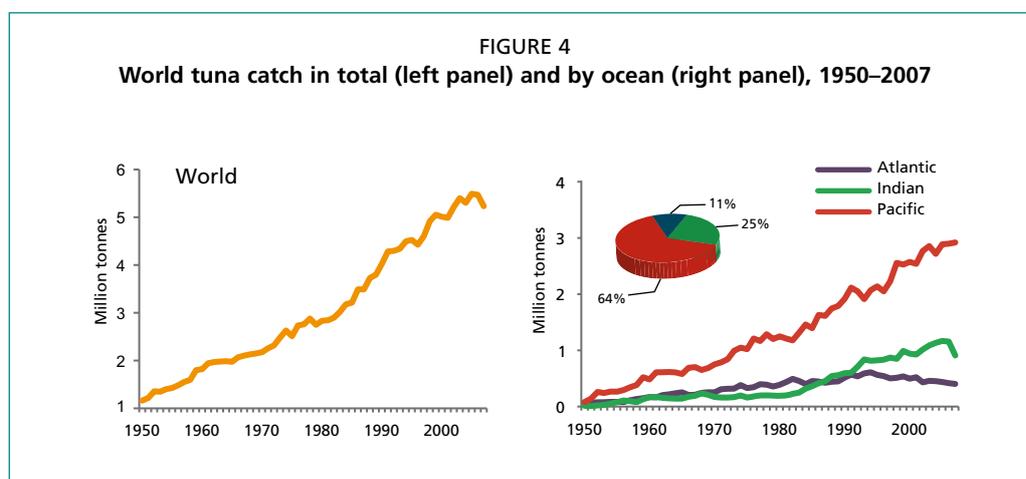
Figure 4 shows the world catches of major tuna species in weight by year (left panel) and by ocean (right panel). The pie chart within the figure represents the catch from each ocean in percentage for the five-year average of 2001–2005 (data for 2006 and 2007 are preliminary).

Global tuna catches have been constantly increasing in all but the last two years. Because the data for these two years are preliminary, there is a chance that catches in these years may have also continued the trend. The increase in catches was particularly noticeable in the 1980s and 1990s in the Pacific and Indian Oceans, and this is reflected in the global total. In contrast, Atlantic catches increased only until the early 1980s, but have since continuously declined. As a result, in recent years, 64 percent of the catch came from the Pacific Ocean, 25 percent from the Indian, and only 11 percent from the Atlantic (average of 2001–2005). More analysis and discussion of this subject is presented in Section 4.1.2.

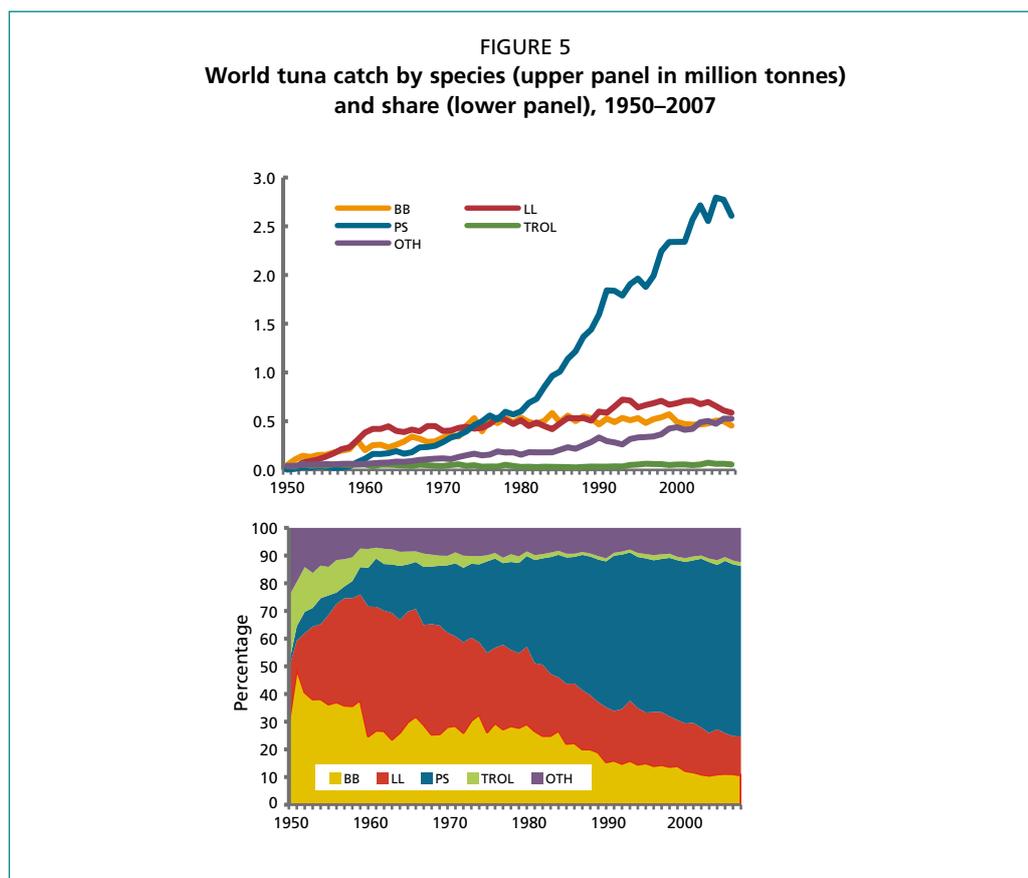
By species

Figure 5 shows total world catches of tuna (in tonnes and in percents) by major species. Figure 6 disaggregates the catches by species and ocean. Please note that the scales on the y-axis differ among oceans and should be reviewed in conjunction with Figures 1, 2 and 3. From these figures, it is evident that the global tuna catch trends by species closely follow the trends shown for the Pacific as the Pacific catches are over 60 percent of the world total.

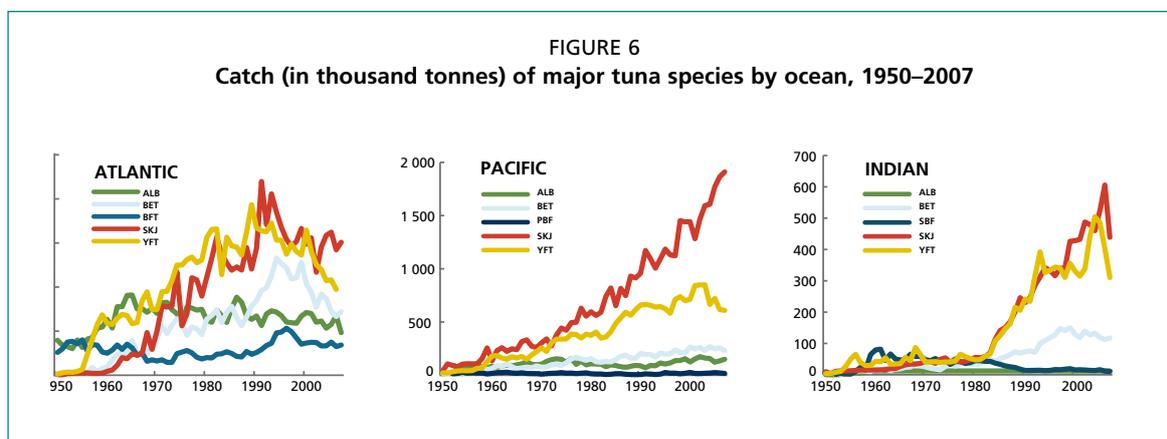
Global skipjack catches have been continuously increasing and in recent years reached 2.5 million tonnes, comprising over 50 percent of world tuna catches. The increase is particularly apparent in the Pacific Ocean, but the skipjack catch level in the other two oceans is close to that of yellowfin even in recent years. The difference between yellowfin and skipjack catches was small even in the Pacific until the mid-1990s, but thereafter the difference became much larger as the yellowfin catch declined. The global catch of yellowfin peaked in 2003 at about 1.3 million tonnes and is now trending downward. The global catch of bigeye increased gradually until the late 1990s, but since then has shown a slight downward trend.



Note: The pie chart in the right panel represents the average share by ocean for the period 2001–2005.
Source: FAO and RFMO databases.



Source: FAO and RFMO databases.

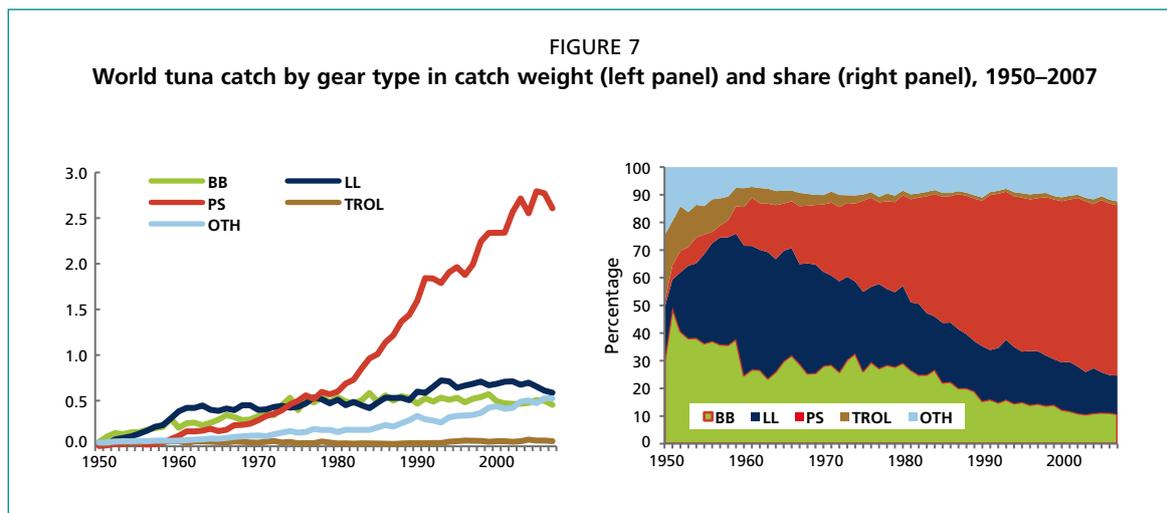


Source: FAO and RFMO databases.

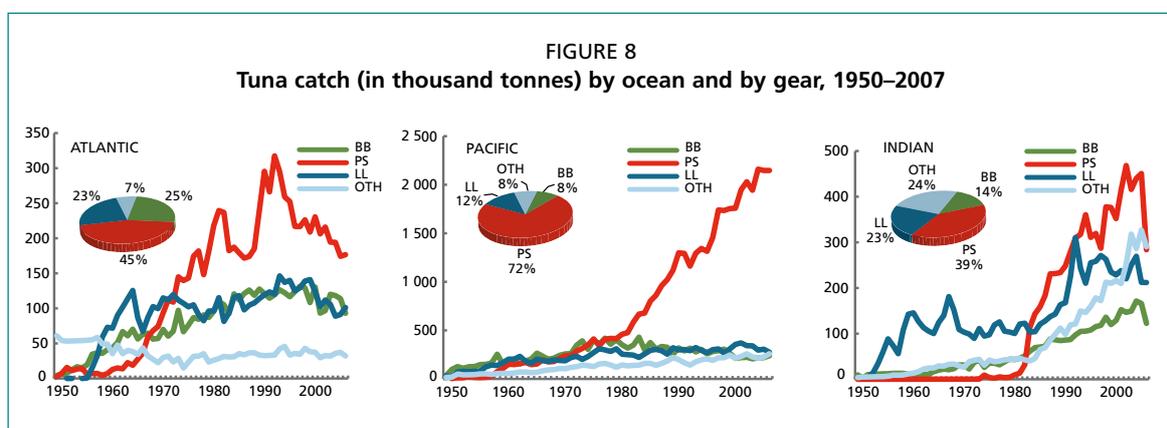
The catch of albacore has been relatively constant. In contrast, catches of Atlantic and Pacific bluefins have fluctuated widely between years and it appears that there are some long-term cycles in the catch quantities. Catch levels of southern bluefin and Atlantic bluefin are very much related to management measures, particularly since 2000. This will be discussed in Section 5.1.

By gear type

In Figure 7, world catches by major fishing gear types are shown in tonnes (left panel) and in percent (right panel). As illustrated in Figure 8, the importance of different gear types varies considerably among oceans.



Source: FAO and RFMO databases.

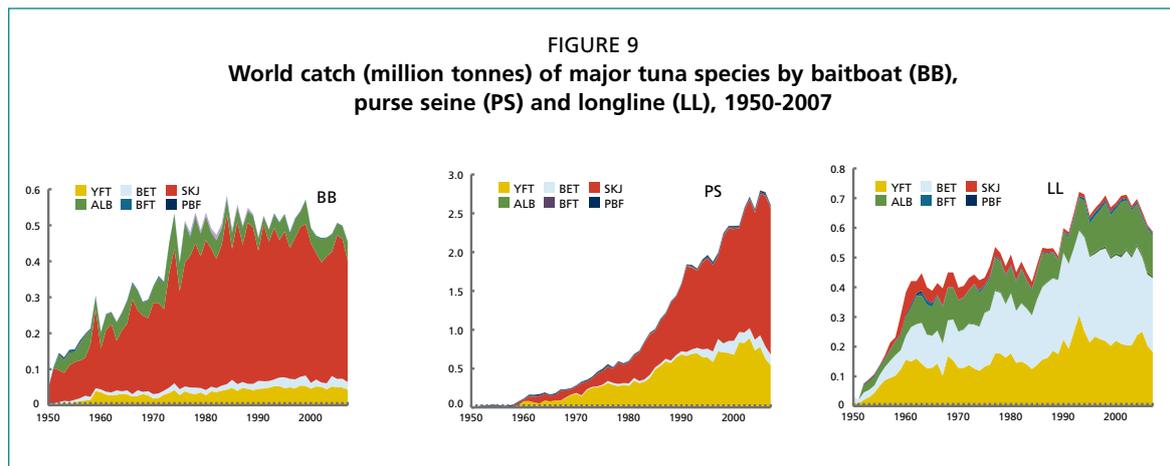


Note: The pie chart represents the average share by gear type for the period 2001–2005.
Source: FAO and RFMO databases.

Since the beginning of the 1980s, the world purse seine catch has rapidly increased to nearly 3 million tonnes (or 70 percent of world tuna catches). This is particularly noticeable in the Pacific and Indian Oceans. In the Atlantic, purse seine catches peaked in the mid-1990s and thereafter started to decline (Figure 8).

Longlines and baitboats used to be the major fishing gear types worldwide (over 80 percent), but these have rapidly declined in share (currently about 10 percent worldwide) despite the fact that catch quantities have been slightly increasing or stable (Figure 7). This trend primarily reflects the situation in the Pacific Ocean, as over 60 percent of the world catch is taken there. Longline gear remains relatively important in the Atlantic and Indian Oceans (23 percent in each), while its share dropped to 12 percent in the Pacific (Figure 8). The catch of “other” and unclassified gear types increased very rapidly in the Indian Ocean (24 percent), representing either statistical improvement or an increase in the catch of coastal developing countries (see below and Section 4.2). These include unknown and small-scale coastal fisheries using a variety of gear types primarily composed of small traps, set nets, ring nets, small seiners, and possibly coastal gillnets.

The global catch by species for three major gear types is shown in Figure 9. It is clear that the catches by baitboats are almost exclusively skipjack with minor quantities of albacore, yellowfin and bigeye. In addition, considerable annual fluctuations in skipjack catches are apparent.



Purse seine catches were previously dominated by yellowfin, but since approximately 1990 the catch of skipjack substantially exceeded that of yellowfin and the proportion of skipjack in the purse seine catches is still increasing. Although not shown in this figure, these tendencies are particularly strong in the Pacific.

Longline catches show a change in target species with time. Until the mid-1970s, albacore, yellowfin and bigeye were caught in relatively similar quantities. Thereafter, bigeye and yellowfin were the most targeted species, while catches of albacore remained stable. This subject is discussed in detail in Section 4.2.3.

Despite the fact that it is not shown in Figure 9, the catch of albacore by troll gear is notable. Although the catches of Atlantic bluefin, Pacific bluefin and southern bluefin are too small to be shown in the figure, they are mostly caught by purse seine and longline and, to a lesser extent, by troll, trap and unclassified gear types.

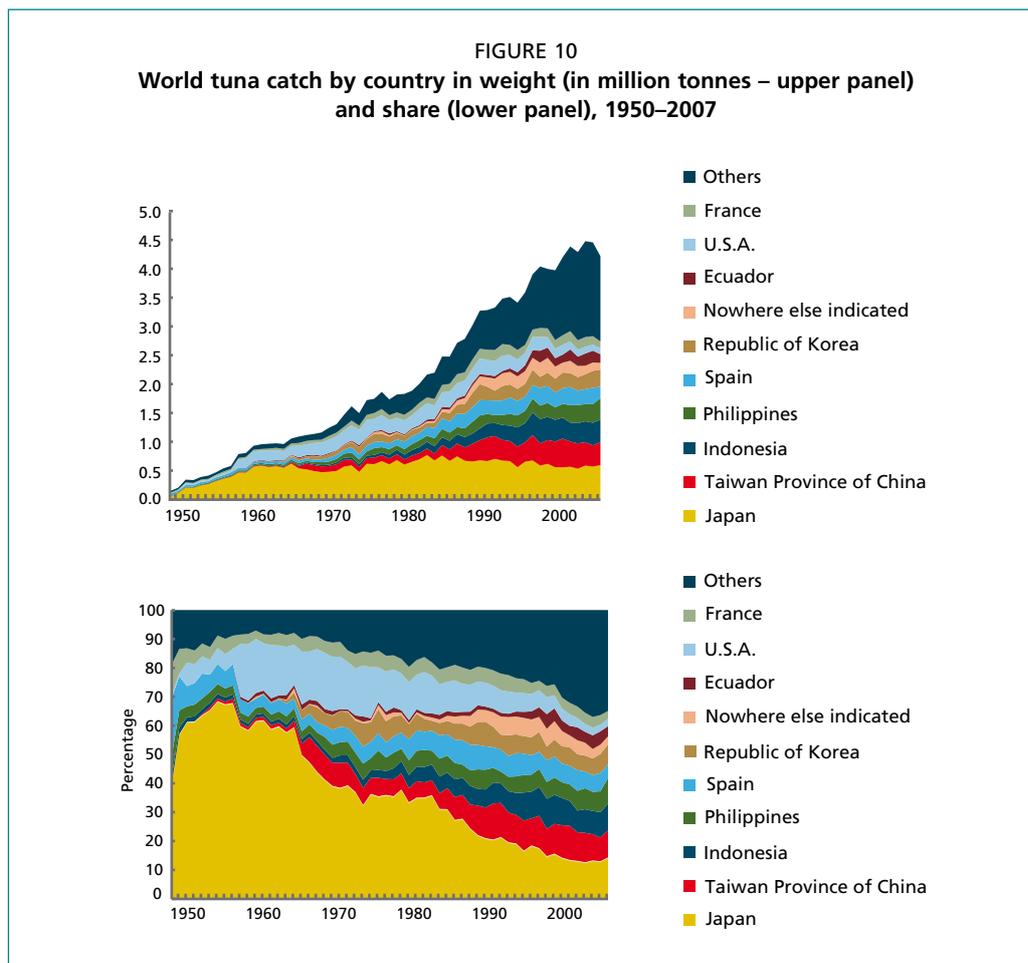
By country

Figure 10 shows global catches of the major tuna species by the top ten countries/fishing entities. The upper panel shows the cumulative catch quantity in tonnes while the lower panel shows the same data in percent. The top ten countries/fishing entities were selected based on their average catches over the last ten years (1998–2007). Most of these countries/fishing entities catch tuna in the ocean closest to them, but some major tuna fishing fleets operate in more than one ocean. Figure 11 shows combined catches of major tuna species, disaggregated by the three oceans, for six countries/fishing entities (Japan, Taiwan Province of China, the Republic of Korea, Spain, France and China).

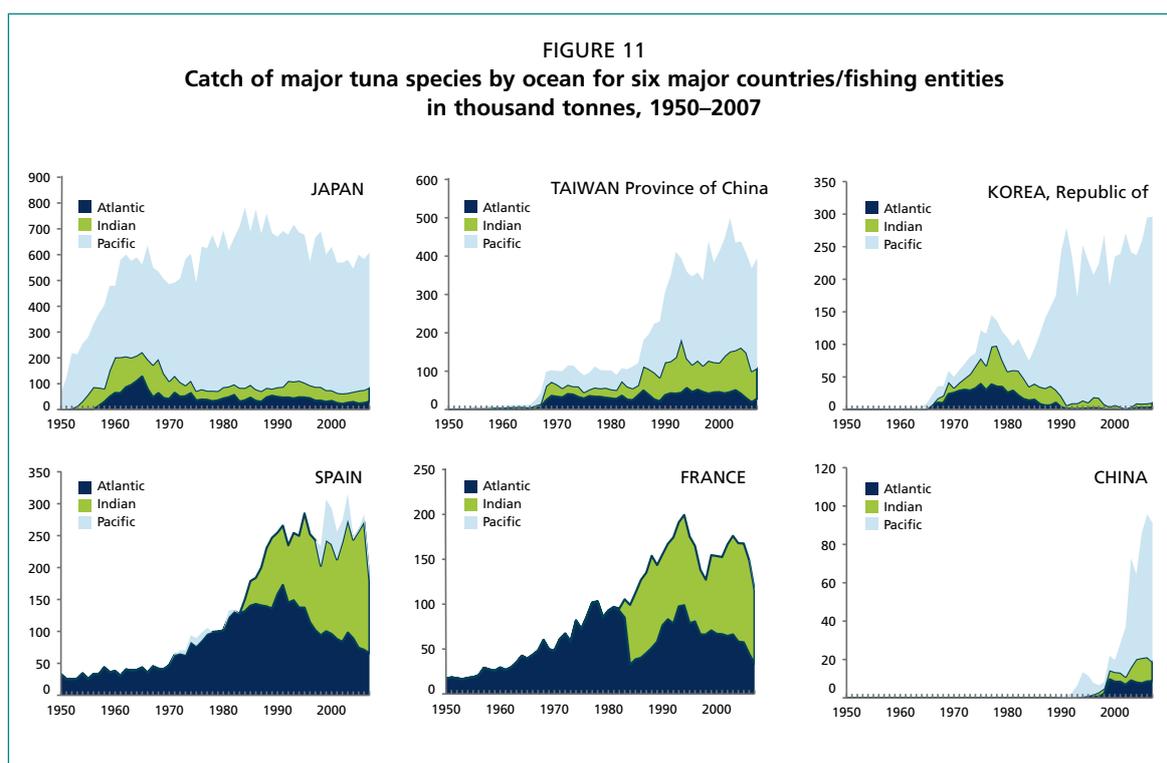
It is evident from this figure that the Japanese catch increased until the late 1960s in the Atlantic and Indian Oceans and in the Pacific until the mid-1980s, but thereafter declined or remained constant. At the same time, the global catch increased very rapidly thereby causing a sharp decrease in the relative importance of the Japanese catch from about 70 percent of the global total in the peak period of the late 1960s to 13 percent in recent years.

The United States also had similar trends. Catches peaked in the early 1960s and thereafter stabilized and declined in quantity, resulting in a rapid reduction in its proportion of the global catch.

In the meantime, Taiwan Province of China and the Republic of Korea developed their fisheries and have increased their catch quantities steadily until the present, maintaining a stable share as the global catch grew. In the early stages of these fisheries, both countries' major fishing grounds were the Indian and Atlantic Oceans. This is because their catches were mostly for export to the European Union and United States



Source: FAO and RFMO databases.



Source: FAO and RFMO databases.

BOX 1

Flag of convenience and IUU

The term “flag of convenience” refers, in principle, to any vessel registered to a country with an open registry rather than the country in which the vessel owner is based. In the 1960s and 1970s, some boat owners used flag of convenience registries for the sake of avoiding stricter maritime regulations by their home country (e.g. on navigation and crew), or to remain unencumbered by their home country’s adoption of limited entry policies for fisheries. In addition, since the 1980s, many RFMOs have adopted various regulatory measures, which are only binding on CPCs. Vessel owners who wanted to escape being bound to such management measures reflagged vessels to non-contracting countries of the RFMOs. Although these are often referred to as flag of convenience arrangements, there are also legitimate vessels flying flags of convenience (e.g. cargo boats, etc.). In order to distinguish these vessels, the term “illegal, unreported and unregulated (IUU)” has been coined and is now commonly used. In its broadest definition, any vessels which do not obey regulatory measures, which are not controlled by their flag states, and/or are not reporting the required fishery information are IUU regardless of whether the vessels belong to CPCs or not. Under a narrower definition, IUU applies only to those fishing activities carried out by vessels which are not on RFMO-authorized vessel lists.

markets for canning. Recently, these longline fleets are primarily targeting *sashimi*-quality tuna for export to Japan. However, the majority of Korean operators have withdrawn from longline fishing in the Indian and Atlantic Oceans and have increased their focus on purse seine fisheries which are concentrated in the Pacific Ocean.

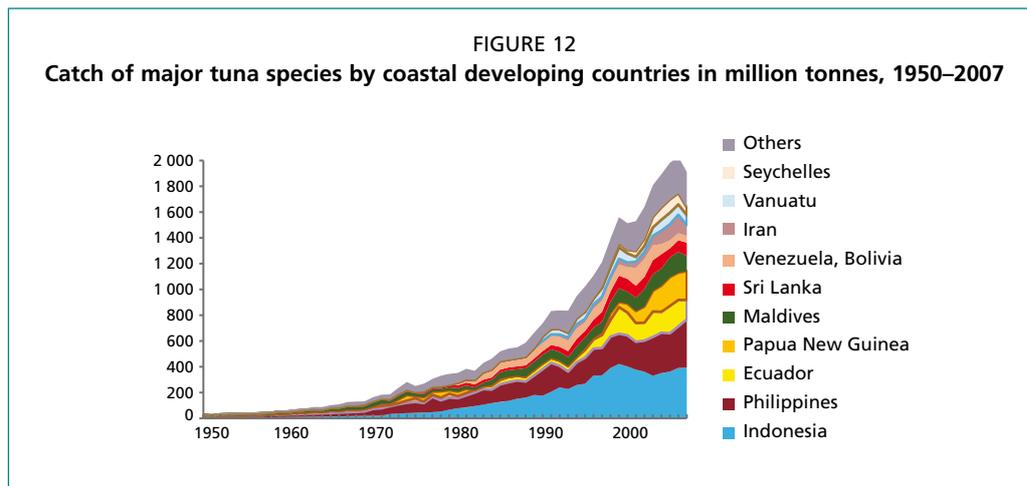
Spanish and French purse seine catches were limited to the Atlantic Ocean until the early 1980s, when fleets expanded their operations into the Indian Ocean. Spanish purse seine fleets expanded into the Pacific in the 1990s, but Spain’s reported catch decreased because many of its vessels changed their flags to South American coastal countries or Pacific Island States. Catches by coastal developing states are discussed in the following section.

Since late 2008 many purse seine vessels fishing in the Western Indian Ocean have moved to the Atlantic or Pacific Oceans due to the expanding piracy in the most productive fishing area, i.e. between Somalia and the Seychelles.

Coastal fisheries

Catches of the top ten developing coastal countries (based on the ten-year average of 1998–2007) are given in Figure 12. Gillett (2005, 2007) estimated the catches of non-industrial fisheries by region. The catches given here are significantly more than those estimated by Gillett (2005, 2007) because the definition of “coastal” used here is different. In order to avoid the inappropriate inclusion of countries with large and longstanding distant-water industrial tuna fleets (e.g. Taiwan Province of China) in this discussion, this paper uses the term “developing coastal states” to refer only to those countries with newly developed fleets.

Catches of developing coastal states were almost non-existent before 1980. However, they have increased at an accelerated rate since. Although some coastal states declared an extended jurisdiction beyond territorial waters in the 1950s and 1960s, rapid development of coastal fisheries was clearly sparked by agreement on the United Nations Convention on the Law of the Sea (UNCLOS) in 1982, which took effect in November 1994. At present, catches of developing coastal states total almost half of the world’s tuna catches and four times more than the Japanese catch.



Note: Bolivarian Republic of Venezuela and the Plurinational State of Bolivia are reported together to protect business confidentiality.
Source: FAO and RFMO databases.

These developing coastal countries' fleets are very diverse. Some fleets are multipurpose and of a truly artisanal and traditional coastal nature. Fishing gear types used by these fleets are categorized as unclassified. The fleets of Indonesia, the Philippines, the Maldives and Sri Lanka are composed of large artisanal fishing vessels. Many of these fisheries operate around anchored FADs (Babaran, 2006). One important issue associated with these fleets is the difficulty of obtaining accurate statistics (as discussed in Section 4.1.1).

Much of the increase in catches by developing coastal states is driven by large industrialized vessels (either longline or purse seine) built through the capital investment of fishery-developed countries. Many of these vessels can be considered flag of convenience, operating either under charter arrangements or in joint-venture type operations. Therefore, strictly speaking, these are not fleets which have been developed by the developing coastal states themselves. However, they are also not IUU fishing vessels because they are properly licensed, registered with RFMOs, and their catches are reported by the developing coastal states. Wherever national catch quotas are adopted, these vessels use the quota of the flag states. From a legal point of view they are legitimate fisheries of the coastal states, and hence they are permitted to, and likely to, fish both within and outside the EEZ of the developing coastal country to which they are now flagged. Some portion of the purse seine fleets of Ecuador, Vanuatu, Venezuela (Bolivarian Republic of), the Seychelles and Papua New Guinea fall into this category. Vanuatu and the Seychelles also have distant water longliners in this category (see Section 5.1.6).

There are also fleets which lie between these two extremes of small artisanal vessels and large flag of convenience vessels. These are small-scale longliners ≤ 24 metres in length originating from Taiwan Province of China. Most of them fish in Philippine, Indonesian and Thai waters (Gillett and McCoy, 2006; Gillett, 2005). Some of these vessels are 23.9 metres in length and hence are not bound by many of the management measures applicable to large-scale longliners despite the fact that they fish in exactly the same manner and have similar deep freezer capabilities.

Although Indonesia, the Philippines and possibly the Maldives have always had traditional coastal fisheries, the catch and share recorded by these countries only began increasing rapidly in the 1990s. While part of this increase is expected to be real, improvements in statistical record-keeping could be a contributing factor (particularly for Indonesia and the Philippines). The increase in the "other" countries' quantities and shares (Figure 10) implies either that tuna fisheries have been expanding worldwide, particularly among developing coastal states, or that more tuna resources in EEZs are now subject to exploitation.

General discussion of catches by ocean, gear type and species

The preceding discussion has presented the catches of major tuna species by ocean, species, gear type and country. This section combines this information to provide an overview of tuna fisheries at the present time.

World tuna catches have been increasing constantly and rapidly. Pacific catches dominate the world catch whereas Atlantic catches have been declining since 1990. The world catch increase is primarily attributable to purse seine catches in the Indian and Pacific Oceans.

Purse seine catches are comprised mainly of skipjack and yellowfin. The largest component of the increase in the world tuna catch consists of skipjack, particularly in the Pacific. Yellowfin catches are about equal to those of skipjack in the Indian and Atlantic Oceans, and thus yellowfin is a much larger component of the total catches in these oceans than in the Pacific.

Although longline and baitboat catches have stabilized in the last few decades, the share of these gear types' catch in the total has rapidly reduced as purse seine catches have expanded. Baitboats have consistently targeted mostly skipjack. The target species of longliners have varied over time: from the late 1960s yellowfin and albacore were the main targets but nowadays bigeye and yellowfin are the primary species sought.

The world tuna fishery used to be dominated by Japan and to a lesser extent by the United States. However, the United States' catch has fallen and the Japanese catch has stabilized in the last few decades, resulting in very rapid declines in their respective shares of the world catch. There has been a clear and rapid increase in catches, both in terms of weight and share, by developing coastal states such as Ecuador, the Philippines and Indonesia.

Geographic parameters for the Atlantic, Pacific and Indian Oceans (excluding the Antarctic Sea) are given in Table 4. The figures for total area, distance at the equator, and area between 20 degrees north and south latitude have been estimated by the authors, and although they are approximations they are useful as a general characterization of each ocean. The area between 20 degrees north and south latitude is considered to be the major fishing area for the tropical tunas, i.e. bigeye, yellowfin and skipjack, although these species, particularly bigeye, are also taken at depth by longliners in temperate waters. Skipjack is also known to make long migrations into temperate waters during the summer months. This distribution conforms to information on the nursery grounds for these species which are known to be in

TABLE 4

Comparisons of characteristics of oceans with catches of tropical (BET, SKJ, YFT) and temperate (ALB, SBF, PBF, BFT) tuna species

	OCEAN			
	Atlantic	Pacific	Indian	Total
Area (million km ²)	73	170	55	298
	24%	57%	18%	100%
Distance at the equator (km)	670	1 890	780	3 340
	20%	57%	23%	100%
Area between 20°N and 20°S (million km ²)	26	80	31	137
	19%	58%	23%	100%
Total tuna catches (1 000 tonnes)	460	2 754	1 065	4 279
	11%	64%	25%	100%
Tropical tuna catches (1 000 tonnes)	364	2 581	1 021	3 966
	9%	65%	26%	100%
Temperate tuna catches (1 000 tonnes)	96	173	44	313
	31%	55%	14%	100%
Tropical tuna catch/tropical area (tonnes per 1 000 km ²)	14.0	32.3	32.9	28.9

tropical waters. Catches given in the table are five-year averages for all gear types combined and consist of catches of tropical tunas representing bigeye, yellowfin and skipjack, and catches of temperate tuna representing albacore and Atlantic, southern and Pacific bluefins. The bottom row of Table 4 shows tropical tuna catch in tonnes per 1 000 km².

Although the area of each ocean does not necessarily correlate with its productivity, it is interesting to consider the relationship between area and tuna catch. The Pacific is the largest ocean by far with 57 to 58 percent of the total regardless of which parameter is considered. While the Pacific would thus be expected to dominate catches, its share is even greater than expected, particularly with regard to tropical species for which its catches are 65 percent of the total. The Indian Ocean's share is also proportionally higher than would be expected: it is only 18 percent of the total area and 23 percent of the tropical area, but its tropical tuna catches are 26 percent of the global total. In contrast, the Atlantic's share is 24 percent of the total area and 19 percent of the tropical area, but only 11 percent of the world's total catch and only 9 percent of the catch of tropical species.

Tropical tuna catches in tonnes per 1 000 km² of tropical area (Table 4) show almost equal values for the Pacific and Indian Oceans but considerably less than half of that for the Atlantic. The tropical tuna catches have increased nearly constantly in the Indian and Pacific Oceans, reaching their highest level in recent years. However, in the Atlantic Ocean, catches peaked in 1991 and thereafter declined. The Atlantic catch of tropical tunas during the peak period was 483 000 tonnes, or 18.6 tonnes per 1 000 km², which is still far less than the other two oceans.

High contributions of the Indian and Pacific Oceans may be related to the abundance of islands in their tropical waters. Both oceans include parts of Indonesia where many islands contribute to complex coastlines and high productivities. The Pacific also has many islands, particularly in the west, and over 80 percent of the Western and Central Pacific Ocean is included within the EEZs of states (mainly island states). On the other hand, the Atlantic has very few islands, with the exception of the Caribbean area, where tuna fisheries are not very well developed and/or not well represented in statistics.

The proportion of albacore caught in each ocean is 54 percent, 19 percent, and 27 percent for the Pacific, Atlantic and Indian Oceans, respectively, while the proportion of area in each of these oceans is 58 percent, 19 percent and 23 percent, respectively. Although the similarity of these figures may be merely a coincidence, they are worth noting for further study.

It is clear from these catch data that the Pacific is by far the most expansive ocean and the most productive for tropical tuna species. In the Atlantic, the production of temperate tunas is reasonably high compared to the total ocean area, but tropical tuna catches are far less than in the other two oceans in terms of both quantity and proportion. The fishery in the western tropical Atlantic has not been as well developed as in the other two oceans and may provide a possibility for further development in the near future. Progressive management measures taken by ICCAT to limit tuna catches, as described in Section 5.1, may be yet another reason for relatively lower catches in the Atlantic. With regard to other species, it is possible that albacore in the southern hemisphere is less exploited in the Pacific and Indian Oceans, as shown in Section 3.

4.2 CHANGES IN FISHERIES PRIMARILY RELATED TO TECHNOLOGICAL DEVELOPMENTS

4.2.1 Historical changes and their causes

This section briefly reviews a previous study by Miyake (2005a), which discussed three general types of technological developments that affect fisheries. These are developments which:

- increase fishing efficiency (i.e. increase the coefficient of catchability or q);
- increase economic gain, even if fishing efficiency is held constant; and
- make the fishing easier, safer and less labour intensive.

In general, fishing efficiency is constantly increasing, based on both technological development and fishers' increasing experience. The catch per unit of effort (CPUE), which serves as an index for stock abundance, is generally a function of catchability (unless it is standardized for changes in catchability using, for example, the depth of longline hooks). Therefore, in general, catchability (q) = fishing mortality (F) / effort, and following from that catch (C) = $q \times F \times N$, where N = stock size in number of fish, and $C/F = q \times N$. Interpreting changes in fisheries can have different consequences for stock assessment depending on whether the changes are related to real differences in efficiencies or only to economic motivation to fish. Miyake (2005a) discussed many technological and related developments which occurred for the fisheries during the period from 1950 to the early 2000s. A summary of the most important key changes and their consequences (as indicated by arrows) is given below.

General changes

- (i) continuous improvement in fishing gear and procedures (net or line materials and gear construction, line/net casting and hauling) → higher fishing efficiency and less labour;
- (ii) improvements in fishing vessels (motorization and increasing engine power, construction materials and increasing length and carrying capacity) which began at the end of the nineteenth century and continues today, especially in coastal fisheries → higher efficiency; and
- (iii) improvements in navigational instruments (satellite positioning has become widely used since the mid-1970s) → safer operation and higher efficiency.

Longliners

- (i) improvements in freezer systems (blast freezing replaced ice wells in 1953 → start of distant water fishing [maximization of economic gain]);
- (ii) introduction of super freezers in the 1960s which allowed for the production of *sashimi*-quality tuna by distant water longliners → longline catches diverted from canning to *sashimi*;
- (iii) introduction of line casting, bait attaching, and other similar devices in the 1960s → labour and cost savings; and
- (iv) deployment of deep longlines in the 1970s for targeting bigeye → changes in fishing area and fishing time leading to economic gains.

Purse seiners

- (i) invention of the power block resulted in a rapid increase in the number of modern purse seiners → replacement of baitboat fisheries in the late 1950s and 1960s;
- (ii) rapid increases in fish holding capacity beginning in the 1960s and continuing to the present → longer cruises and more distant water fishing grounds;
- (iii) various improvements in gear and procedures such as net pursing, catch brailing and storage, conservation of large catches through handling and freezing techniques, and rapid unloading beginning in the 1960s and continuing to the present → time, labour and cost savings;
- (iv) improvements in fishing techniques (setting around dolphins, dolphin mitigation) → some gains in speed (e.g. setting around dolphins) but accompanied by some slowing down of operations due to required mitigation;
- (v) improvements in searching and catch rates through the use of helicopters, bird radar, sonar, Global Positioning System (GPS) and GPS radio buoys → higher fishing efficiency; and

- (vi) establishment of FAD fishing in the 1990s → higher fishing efficiencies and catch rates but also higher catches of juveniles and discards.

Further details on these and other technological changes in tuna fisheries can be found in Miyake (2005a); Ward and Hindmarsh (2006); Anon. (2008a); Itano (2004); Itano, Fukofuka and Brogan (2004); Itano (2007a, 2007b); and Suisanshinchosha (1970).

4.2.2 General review of recent changes

Since the 1980s, the causes of changes in the fisheries have become more complex. The following recent elements, in addition to the list given in 4.2.1, have affected fisheries through fishing technology and other factors (excluding socio-economic factors):

- (i) improvements in the efficiency of FADs and the development of anchored or fixed FADs (see Section 4.2.6);
- (ii) increased use of transshipment (see Sections 4.2.3 and 4.2.5);
- (iii) changes in the relative importance of fishing gear types and target species (see Sections 4.2.6 and 4.2.7);
- (iv) initiation of tuna farming activities (see Section 4.2.8);
- (v) development of small-scale, coastal fisheries (see Sections 4.1.2, 4.2.3 and 4.2.7);
- (vi) management measures (see Section 5.1); and
- (vii) environmental considerations such as undesirable incidental catches and the introduction of various mitigation methods and techniques (see Section 5.2).

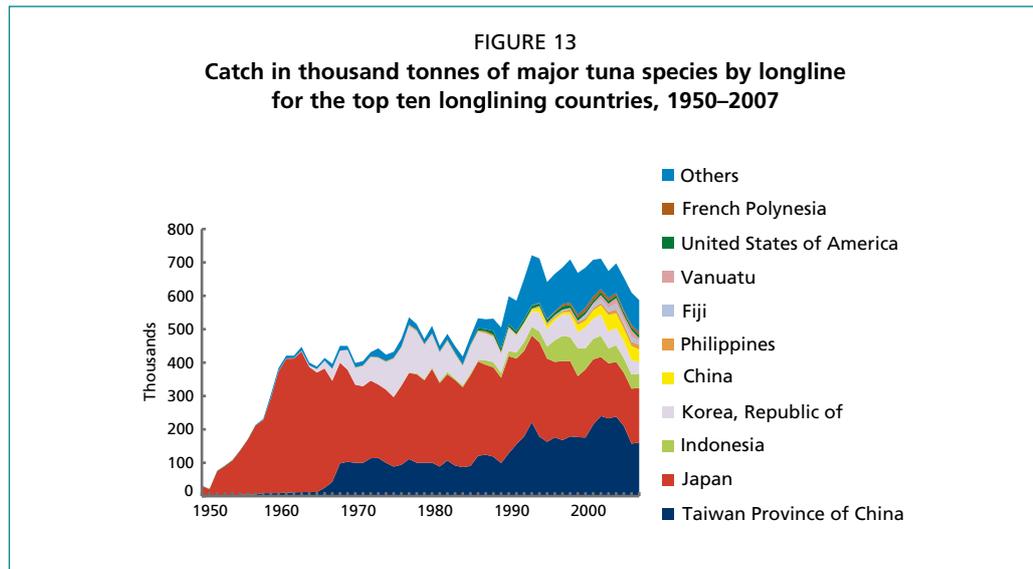
Up until the 1980s, most of the changes in fishing gear and techniques were designed to improve fishing efficiency and increase economic gains (i, ii, iii and iv above are in this category). However, this situation has changed very rapidly in the last two to three decades. The factors listed under (vi) and (vii) result in reduced fishing efficiency and economic gains. These two items will be discussed in Section 5. It is noted that factors (iii), (iv) and (v) are strongly linked to resource allocation issues and will generate profits for certain fisheries while having a negative effect on others. These factors are discussed in Sections 4.2.6 through 4.2.8.

4.2.3 Longline fisheries

Trends in world tuna catches by longline fisheries were discussed in Section 4.1.2. Figure 8 shows these trends for each ocean. In the Atlantic and Pacific Oceans, longline catches have been at about the same level since the 1970s, but in the Indian Ocean longline catches have increased through the 1990s. In addition, the relative importance of longlines in the total catch was highest in the Indian Ocean (> 20 percent). As shown in Figure 9, the major catches in weight of longlines are yellowfin, bigeye and to a lesser extent albacore. However, in terms of price, the Atlantic, Pacific and southern bluefins are the most valuable targets (see Section 6.2).

Fishing fleets choose to undertake operations based on the combination of area, season and target species which will produce the highest profits for them. The most important factors in selecting fishing grounds, seasons and target species are the balance between the fish price and fish abundance among species/stocks and the operating cost. Such a balance changes from time to time. For example, when longliners were catching tuna for canning in the 1950s, they used to target species for which the catch rate was high, the fish price was the best and the fishing operations were easiest (i.e. albacore as a primary target and yellowfin as a secondary one). However, with the commencement of the *sashimi* market, the target changed to bigeye because the fish price was far better even though the catch rate was lower (see Section 6). Even now, some longliners, particularly those from Taiwan Province of China, fish for albacore because the catch rate of albacore is much higher than bigeye and thus offsets the lower albacore price.

Figure 13 gives the total longline tuna catches for the top ten countries/fishing entities. Ranks are based on average catches over the most recent ten-year period



(1998–2007). These figures show that the previous dominance of the Japanese longline fleet has been reduced and now Taiwan Province of China is the top producer. Japan and Taiwan Province of China together catch more than one half of the world's longline catches. Catches by the Republic of Korea have declined substantially while Indonesian catches have increased significantly. Indonesian catches are mostly by small-scale, coastal longlines and the uncertainties discussed above for small-scale, coastal fisheries data apply to this fishery as well.

Although for longlines there have been some technological improvements in the last two decades, including greater freezing power and capacity (resulting in higher quality *sashimi*), and some changes in fishing depth, gear construction and bait choice (Ward, 2008), overall gains in efficiency have been relatively minor. In fact, in contrast to purse seiners, longline fishing efficiency was already nearly maximized in the 1990s.

Major changes in longline fishing operations which have increased fishing capacity include the widespread use of at-sea transshipment and the increasing number of hooks used per day. At-sea transshipment provides a substantial time savings for vessels which need not return to port to offload and resupply, thereby allowing a greater number of fishing days per year. However, in order to eliminate transshipment operations which facilitate IUU fishing, most RFMOs have implemented observer systems on transshipment vessels with costs borne by the fishery. Most of the Asian distant-water longliners make use of at-sea transshipment throughout the world, with the exception of the Western and Central Pacific Ocean where the fishing grounds are usually in relatively close proximity to the home ports.

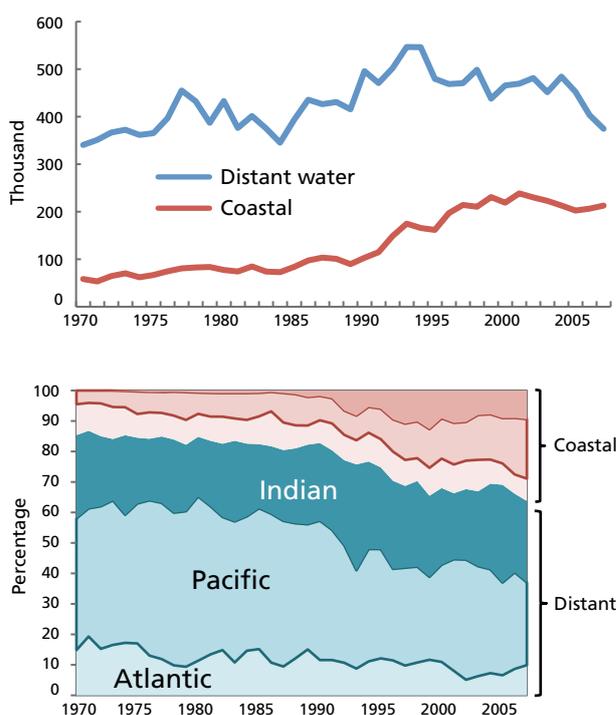
Although the number of hooks per set is physically maximized at about 3 000, in the 1990s some longline vessels of the Taiwan Province of China started to operate three sets every two days instead of the traditional one set per day. In such cases, the number of hooks per set must be reduced (to about 2 000) in order to shorten the operation time, and hence the total number of hooks per day does not necessarily increase. However, operational efficiency increases with shorter lines. This type of operation requires more intensive labour inputs and, probably for this reason, this practice has not spread widely through longline fisheries (personal communication of the authors with fisheries scientists of Taiwan Province of China).

Most distant water longliners (see Box 2) have, over time, adopted operational patterns which result in reductions in fishing capacity, either in terms of reduced fishing efficiency and/or reduced economic gains, for the following reasons:

- most of the fishing crew are foreigners, who are less experienced in fishing, and/or have difficulties communicating with the captain/skipper;
- the average age of key crew members, particularly of captains/skippers, is rising and there is little recruitment of young people to the workforce;
- fishing grounds are becoming increasingly limited due to difficulties in negotiating EEZ access agreements with coastal states, and higher fuel costs;
- landing fees at foreign ports are increasing;
- observer programmes are placing demands on operations, either through fees which must be paid to participate in these programmes or in terms of reducing the number of crew members in order to provide sufficient bunk space for the observer;
- various mitigation measures for incidental catches of non-target species are now required (see Section 5.2);
- vessel monitoring system (VMS) has been introduced and there are now costs associated with operating, maintaining and upgrading the systems (as required by RFMOs); and
- large fish biomass and MSY has been reduced due to increased catches of small fish by other fishing gears (see Section 4.2.7).

Figure 14 shows the catch by distant water longline vessels and small-scale coastal longline vessels (see definitions in Box 2). The upper panel shows combined global catches in weight of major tuna species by these two fleets. The lower panel represents the percentage (by catch weight) of these two fleets by ocean. Since the early 1990s the coastal longline catches have increased rapidly while since the mid-1990s distant water longline catches have been declining. The share of the distant water longline catch in both the Pacific and Indian Oceans is declining rapidly. Conversely, most of the

FIGURE 14
Coastal and distant water longline catch of major tuna species worldwide in thousand tonnes (upper panel) and share by ocean for each category (lower panel), 1970–2007



Source: FAO and RFMO databases.

BOX 2

Definitions of distant water longliners (DLL) and coastal longliners (CLL)

There are no internationally accepted definitions for DLL and CLL. In this paper, DLL is used to refer to longliners generally (but not limited to) >24 metres in total length overall, with super-freezing facilities, and the potential to fish on the high seas and/or in the EEZs of foreign countries. CLL is used to refer to those vessels which fish only within their national EEZ. CLLs mostly use ice wells but may also have freezing facilities. CLLs also include some old ice-well boats >24 metres in overall length. Therefore, CLL may include both large old-type freezer longliners as well as very small artisanal longliners. There are many boats at the margins of this definition, for example, ice-well vessels fishing in foreign EEZs from a base in that foreign country. Some of these are considered here as DLL because of the difficulties of separating them from other DLL. However, in general, small longliners which fish in foreign EEZs with the flag of the coastal state are included in the CLL group (e.g. small longliners of Taiwan Province of China fishing in Indonesian waters with an Indonesian flag). The newly built longliners of 23.9 metres with super freezers are, in principle, included in DLL. Nevertheless, it is often very difficult to associate the coastal landings with the origin of the vessels. For all these reasons, the current division should be considered a practical but arbitrary one.

increase in coastal longline catches (upper panel of Figure 14) in recent years has been in the Indian Ocean and to a lesser extent in the Pacific Ocean. The increase of catches by coastal longliners has contributed to the increase in catches by developing coastal countries (Section 4.1.2).

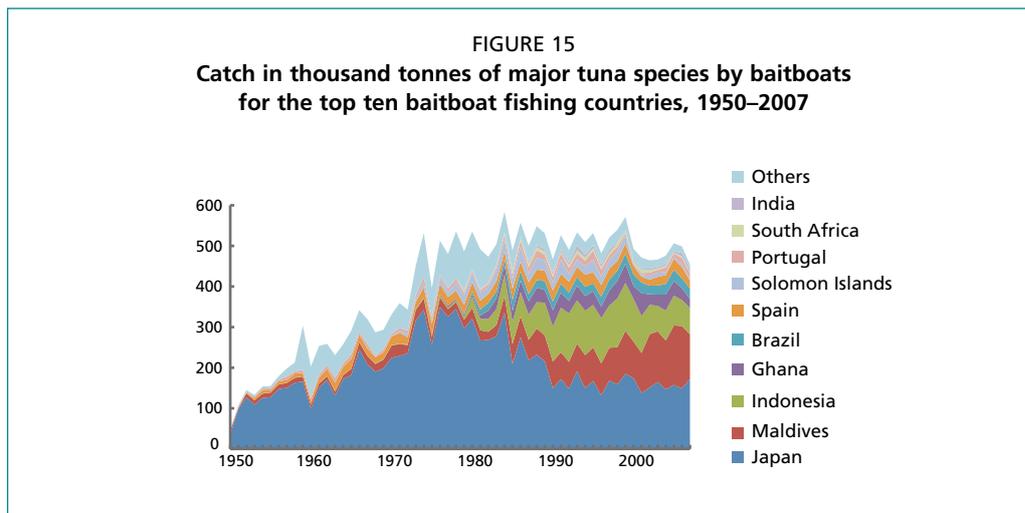
The decrease in distant water longline catches is closely related to the reduction in longline fishing capacity under policies adopted by several distant water longline countries starting in the late 1990s, particularly involving policies to buy-back and scrap vessels. These policies are discussed in detail in Section 5.1.5.

In general, developing coastal states prefer to grant fishing rights in their EEZs to foreign vessels in the form of joint venture or flagging arrangements rather than by selling fishing access rights. This has encouraged the operation of small-scale longliners (e.g. with ice wells) flagged to coastal states, rather than distant water longliners under access agreements, in the longline operations of developing coastal states.

Although the structure of coastal longline fleets is very complicated, in general, the increase in coastal longline catches increases the supply of fresh fish to the market. This has been made possible, to a great extent, by the establishment of air shipping routes from various key ports (e.g. in Thailand, Indonesia, Malaysia, Singapore, Mexico, Spain and Italy) to consumer markets for fresh tuna (mostly Tokyo and Osaka [Japan] and Los Angeles [United States]). If such routes were not well established, the coastal longline catches would not have increased so rapidly (see Section 6.2).

4.2.4 Baitboat fisheries

Figure 15 shows baitboat (also known as pole and line) catches for the top ten countries based on average catches for 1998–2007. The major countries for this gear type are, in descending order by catch quantity, Japan, the Maldives, Indonesia, Ghana, Brazil and Spain. Among these, baitboat catches from the Maldives, Indonesia and Brazil are exclusively coastal, whereas the others are a mixture of coastal and high-seas operations. Ghanaian catches may include those by purse seine due to the fact that baitboats are often used as auxiliary boats for the purse seine fishery and receive a part of the purse seine catch as their share. Almost 75 percent of global baitboat catches are made by the top three countries. The major species caught by the top ten countries are skipjack,



Source: FAO and RFMO databases.

followed by yellowfin (Figure 9); Japan, Spain and Portugal also catch Atlantic bluefin, Pacific bluefin and/or albacore. South Africa and many countries in the southern hemisphere target albacore, which is locally a preferred target due to its higher price.

As was discussed in Section 4.1.2, baitboat catches have been nearly stable since the mid-1970s. However, the proportion of the total catch by country has changed considerably. Japan's catch was reduced almost by one half, with corresponding increases in baitboat catches reported by the Maldives and Indonesia.

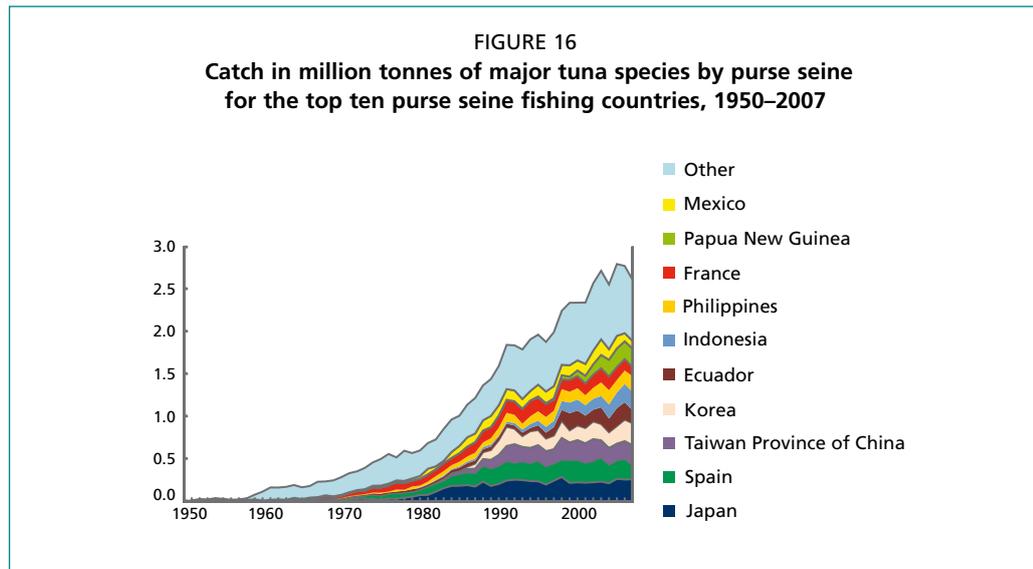
Recent changes in baitboat operations are relatively minor, although it is possible that soaring fuel costs have limited distant water baitboat fishing grounds to more near shore areas. The most recent development is that some baitboat operations have established a *sashimi* market for high-quality frozen skipjack. Also, the increase in demand for soluble, powdered fish flavouring is probably the major factor supporting Japan's ability to maintain its baitboat fishery, even though these flavouring materials can also be provided by purse seine catches (see Section 6.4).

4.2.5 Purse seine fisheries

World purse seine catches are summarized in Section 4.1.2. Purse seine catches have continuously increased since the early 1980s, and at present they comprise 70 percent of all tuna catches. As discussed, the dominance of the purse seine fishery is due to rapid development of this fishery in the Indian and Pacific Oceans (Figures 7 and 8). The most important species in the purse seine catch is skipjack, particularly in the Pacific, followed by yellowfin (Figure 9).

Figure 16 presents the purse seine catch for the top ten countries/fishing entities as determined by average catches over the last ten years (1997–2006). The catches of Japan, Spain, Taiwan Province of China and the Republic of Korea are all at about the same level and have been stable since the mid-1990s. These four countries/fishing entities together take nearly half of the world's purse seine catches. Except for Spain, catches of these countries/fishing entities are almost all from the Western and Central Pacific Ocean. The catches by Ecuador and Indonesia have increased significantly in the last ten years. Some catches attributed to Ecuador, the Philippines and Papua New Guinea derive from vessels reflagged from, or joint ventures with, developed countries (e.g. Spain and Taiwan Province of China).

Technological development of fishing gear and its deployment is ongoing (Section 4.2.1). These developments are primarily aimed at improving fishing efficiency, shortening pursing and fish lifting time, and reducing labour input. Recent developments share many points in common with the factors described above for the longline fleet (Section 4.2.3), and while many developments have acted to increase fishing efficiency, several of them have had a negative effect, as follows:



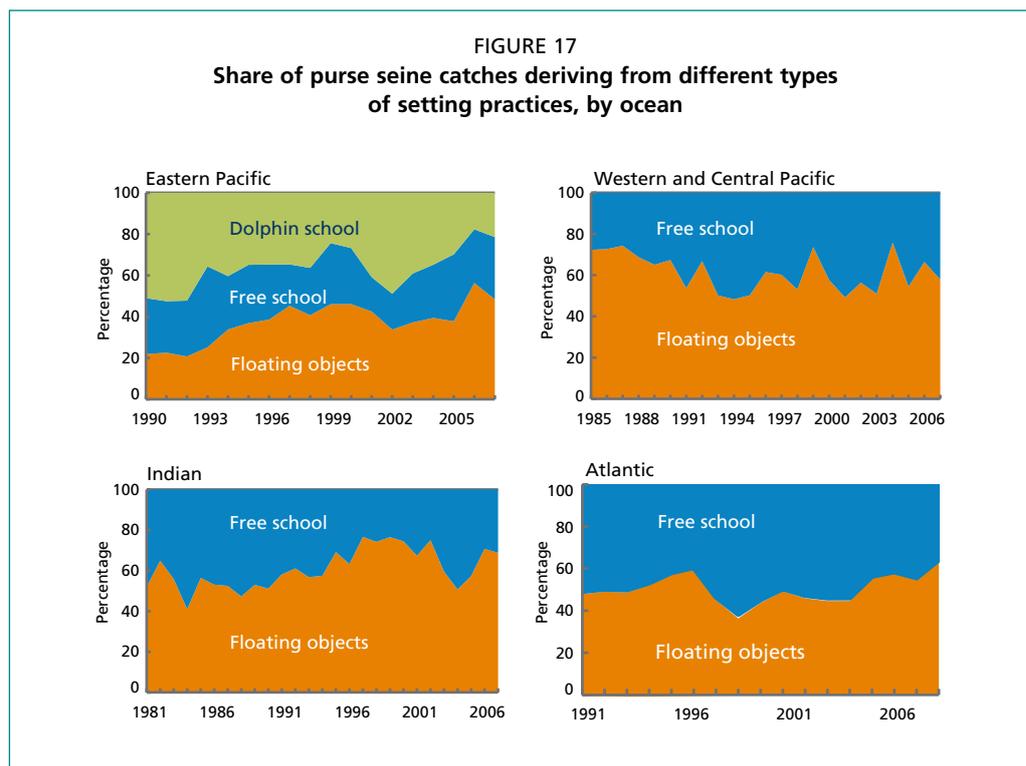
- fishing grounds are more restricted due to access agreements and/or management measures;
- fees for unloading at ports are higher;
- obligations resulting from observer programmes are increasing; and
- the number of required mitigation measures is rising (although it should be noted that requirements for mitigation of incidental bycatch are less for purse seines than for longlines with the exception of measures for dolphins and small tunas, particularly bigeye (see the next two sections).

In many countries, including the European Union (EU), at-sea transshipments for purse seiners are prohibited by law. This is actually a major driving force toward building purse seiners with larger holding capacities, which also consequently results in increased fishing capacity. Even though the number of vessels (or number of fishing licences) may be limited, many older vessels are being replaced with new vessels with larger holding capacities.

One of the major changes for the purse seine fishery in recent years is the more efficient use of tender (or supply) vessels and/or reefers. As explained in detail in Section 4.2.5, the tender boats increase the fishing capacity without increasing the number of fishing licences. Reefers (transshipment vessels with fish in containers) are used in the same way for purse seiners as they are for longliners, most commonly in the Indian Ocean (Itano, 2007a; Itano, 2007b).

Another important factor is the spillover in purse seine effort from one region to another. This occurs, in most cases, as a result of management measures. For example, as most of the important Atlantic tuna stocks came under the quota system in the mid-1980s, many vessels spilled over into the Indian Ocean. Similarly, when the Eastern Pacific Ocean adopted a closed fishing season, some purse seine vessels moved into the Western and Central Pacific (IATTC, 2008). A more detailed discussion of this topic is found in later sections of this paper.

When discussing the development of purse seine fisheries, it is very important to examine the type of schools on which the sets are made. Figure 17 shows the proportion of purse seine catches in weight, by type of school for four ocean regions based on RFMO data (note that the periods covered differ among regions). In the Atlantic, the data cover only European Union purse seiners; minor catches made by other fleets and catches from the Western Atlantic are not included. For the other ocean regions, all catches by large purse seiners are included.



In this Figure “floating objects” includes schools associated with both natural logs and FADs. Until the early 1990s, these are understood to be all-natural logs. Disaggregated data for natural and man-made objects (FADs) are available for some areas, but even in recent years the data are not completely reliable and the boundary between these two categories is blurred because many additional features have been added to natural objects over time. The term “free schools” refers to fish found in the open ocean, not associated with dolphins or floating objects but possibly associated with seabirds.

A detailed discussion on this subject, particularly on FADs, is presented in the following section. However, it should be noted that operations on dolphin schools are observed only in the Eastern Pacific Ocean since tuna schools are associated with dolphins only in that region. When United States fleets were fishing in this area up until the 1990s, dolphin sets were declining, primarily due to mitigation efforts required as a result of pressure from environmental groups and the adoption of dolphin-free labelling schemes (Joseph, 1994; and see below). A secondary reason was the reduced abundance of yellowfin in the area and the reduction in the number of United States purse seiners operating in the area. When Mexico’s fleet became the major fleet in this fishery, the sets on dolphin schools increased again.

4.2.6 Development of FADs and changes in target species

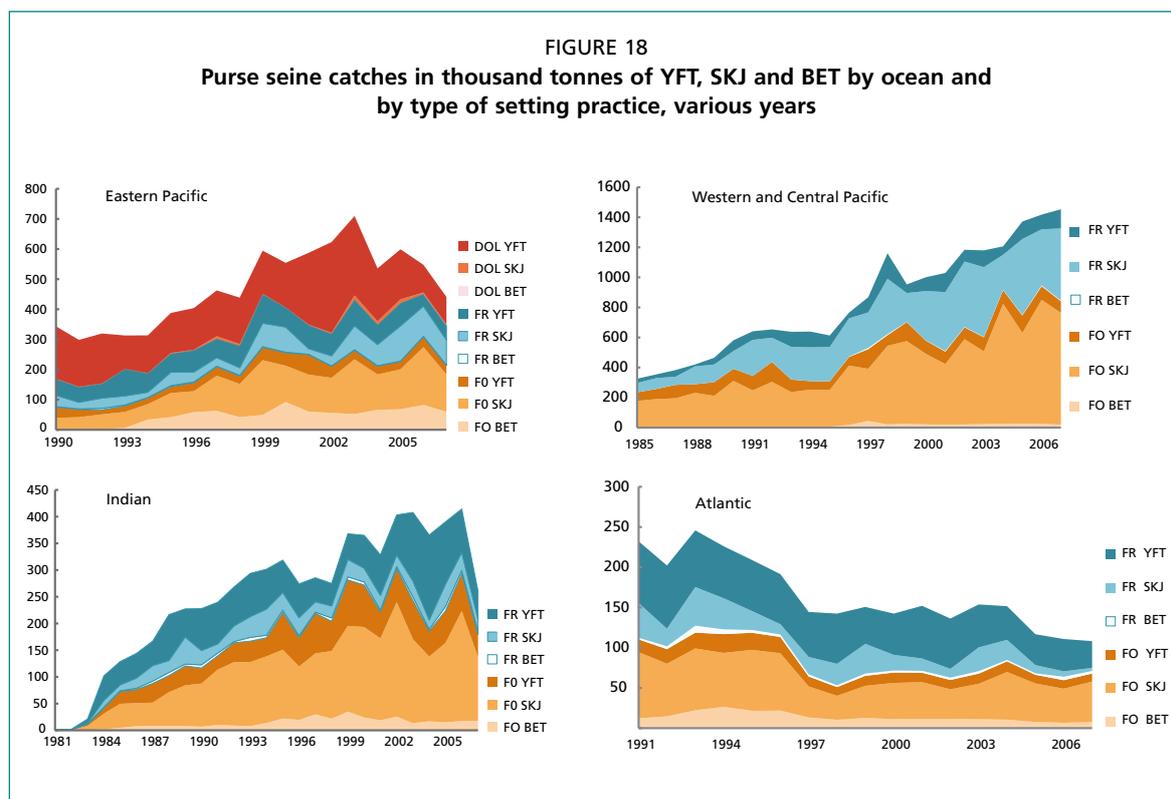
The thermocline in the eastern part of any ocean is shallow, permitting relatively small purse seines to be used for schooling fish. It is considered that such a shallow thermocline keeps the fish in the net near the surface during pursing the net. However, in the western part of the oceans, the thermocline is located at a greater depth and fishing operations similar to those used in the eastern part of the ocean fail to catch tuna. This phenomenon delayed the expansion of purse seine fishing. However, fishing operations on floating objects have been widely practiced in tropical areas for many years. In the Eastern Pacific Ocean, particularly in the Gulf of Panama off Ecuador where natural

logs are found in abundance, log sets have been common since the purse seine fishery was initiated. The floating objects attract fish schools underneath them and those fish remain near the surface while setting and pursing the net. In the Western and Central Pacific Ocean, Japanese purse seining began in the 1960s by adapting a deeper and fast sinking seine and setting on tuna schools associated with natural floating objects. This system has been adopted by other fleets in the Western and Central Pacific Ocean as well as in the Western Indian Ocean since the early 1980s. Therefore, even before the introduction of FADs (in the 1990s), the proportion of catches from floating objects were high in these two areas.

The development of FADs began with fishers attaching reflectors to the logs, and later radio buoys, GPSs and transmitters to track them. These efforts ultimately led to the development of FADs, i.e. man-made floating objects. Operations evolved year by year through fishers' effort to develop new structures and equipment in order to track FADs, attract more fish and estimate the abundance of fish under FADs (Itano, Fukofuka and Brogan, 2004). In addition, greater use of tender vessels, as discussed in the previous section, increased FAD fishing's operational efficiency.

The most recent developments include expansion of the use of anchored FADs, which are commonly found in the coastal waters of Papua New Guinea, the Philippines and Indonesia (Miyake, 2005a; Babaran, 2006). Due to the use of this type of FAD, catches by small-scale, coastal fisheries rapidly increased. In these operations, the target species are small pelagic fish of any kind including juvenile tunas.

Purse seine catches in weight of bigeye, skipjack and yellowfin and by school type are shown in Figure 18. This figure should be read in association with Figures 9 and 17. In Figure 18, catches from schools associated with dolphins are in red; free schools (unassociated schools) are in blue; and those from floating objects are in orange. The weight of catches from both free schools and floating objects increased in all of the ocean regions except the Atlantic. The rate of increase is much faster with floating



objects, particularly since the early 1990s when FADs were introduced. In the Western and Central Pacific Ocean and Indian Ocean, the proportion of catches from floating objects was relatively high (70 to 80 percent) even before the introduction of FADs. On the other hand, in the Eastern Pacific Ocean, the share of floating objects used to be low but increased rapidly since the early 1990s from 20 percent to 50 percent, as catches from schools associated with dolphins declined. In the Atlantic, the proportion of catches taken in association with floating objects is relatively low (around 50 percent) throughout the period. While this may or may not be the result of regulatory measures taken by ICCAT to restrict FAD fishing, it is definitely related to the fact that purse seine fishing is restricted to the Eastern Atlantic because of the shallow thermocline, and thus less dependent on schools associated with floating objects as in the Western Atlantic where FADs are essential.

It is clear that catches from schools associated with dolphins are almost exclusively of yellowfin and include almost no bigeye. In free schools, yellowfin dominate in the Indian and Atlantic Oceans but skipjack-dominated catches are common in the Western and Central Pacific Ocean. In the Eastern Pacific Ocean free school sets, yellowfin were the major species in the past but in the last several years skipjack have dominated. In all of the regions, bigeye catches (in weight) from free school sets are almost negligible. In the catches associated with floating objects skipjack dominated in all of the areas. Yellowfin catches around floating objects are generally much less than skipjack. Bigeye catch around floating objects is higher than that of yellowfin in the Eastern Pacific Ocean, as was also the case in the early 1990s in the Atlantic.

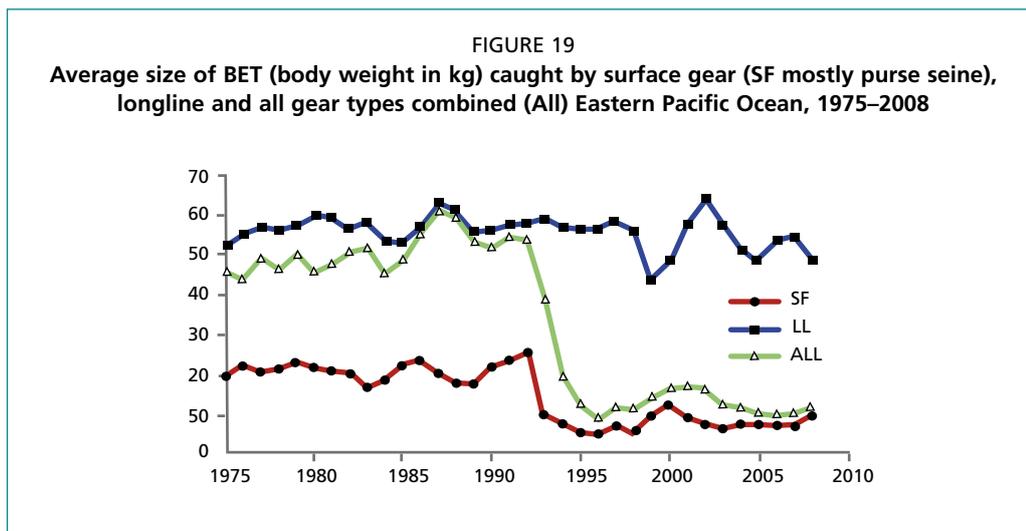
4.2.7 Interactions between fishing gears and species

Tuna fisheries are characterized by their multispecies and multigear nature. This point was highlighted when purse seine catches increased substantially in recent years with the advent of FAD fishing. The key to success in any management plan is to treat all fisheries fairly, but this becomes increasingly difficult to achieve as the number of gear interactions rises.

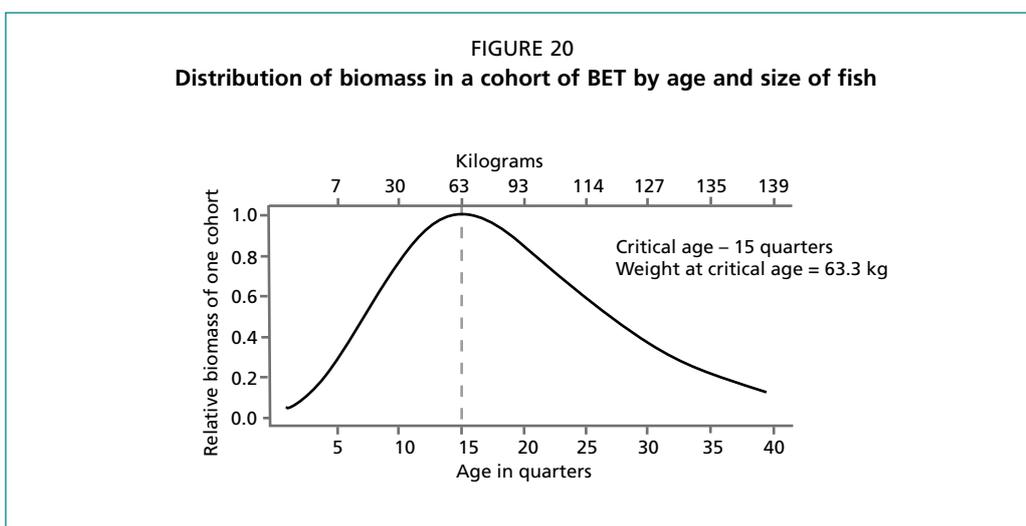
Before the beginning of purse seine FAD fisheries, purse seines and longlines were to some extent sharing tuna stocks with minimal interaction: longlines were targeting large-sized, deep water yellowfin and bigeye, while purse seines were targeting skipjack and relatively small-sized yellowfin in feeding schools near the surface. In the Eastern Pacific Ocean, dolphin school sets contained large-sized yellowfin but almost no bigeye. FAD fishing, in contrast, catches only small-sized tunas without discriminating between species. Under a FAD, a very specific ecosystem is formed and a set on a FAD school includes many non-target fish. Bigeye is one of the major species caught by FAD fishing. In relative terms, the amount of bigeye caught is similar to or less than the amount of yellowfin caught. However, because the stock size of bigeye is far smaller than the stock size of yellowfin, the impact of the purse seine catch on the bigeye stock is much more serious than it is on the skipjack and yellowfin stocks (Aires-da-Silva and Maunder, 2009; Miyake, 2005b; and IATTC, 2008).

The effects of gear interactions between purse seines and longlines on the bigeye stock is used here as a case study. Because bigeye is the major target of longliners, gear interactions have seriously affected the longline fishery in two ways: reduction of SSB and reduction of MSY.

As purse seine catch is almost exclusively juvenile bigeye, yield per recruit (Y/R) has reduced as purse seine catches have increased. This is clearly indicated in Figure 19 (reproduced with permission from Aires-da-Silva and Maunder, 2009), which shows the annual mean weights of bigeye caught by surface gear (almost all of which are purse seiners) and longlines, and the mean weight of the entire catch of bigeye in the Eastern Pacific Ocean. This figure clearly indicates that the mean weight of purse seine catches is declining each year (from 20 kg to <10 kg) while the mean weight in longline catches



Source: Based on Aires-da-Silva and Maunder, 2009.

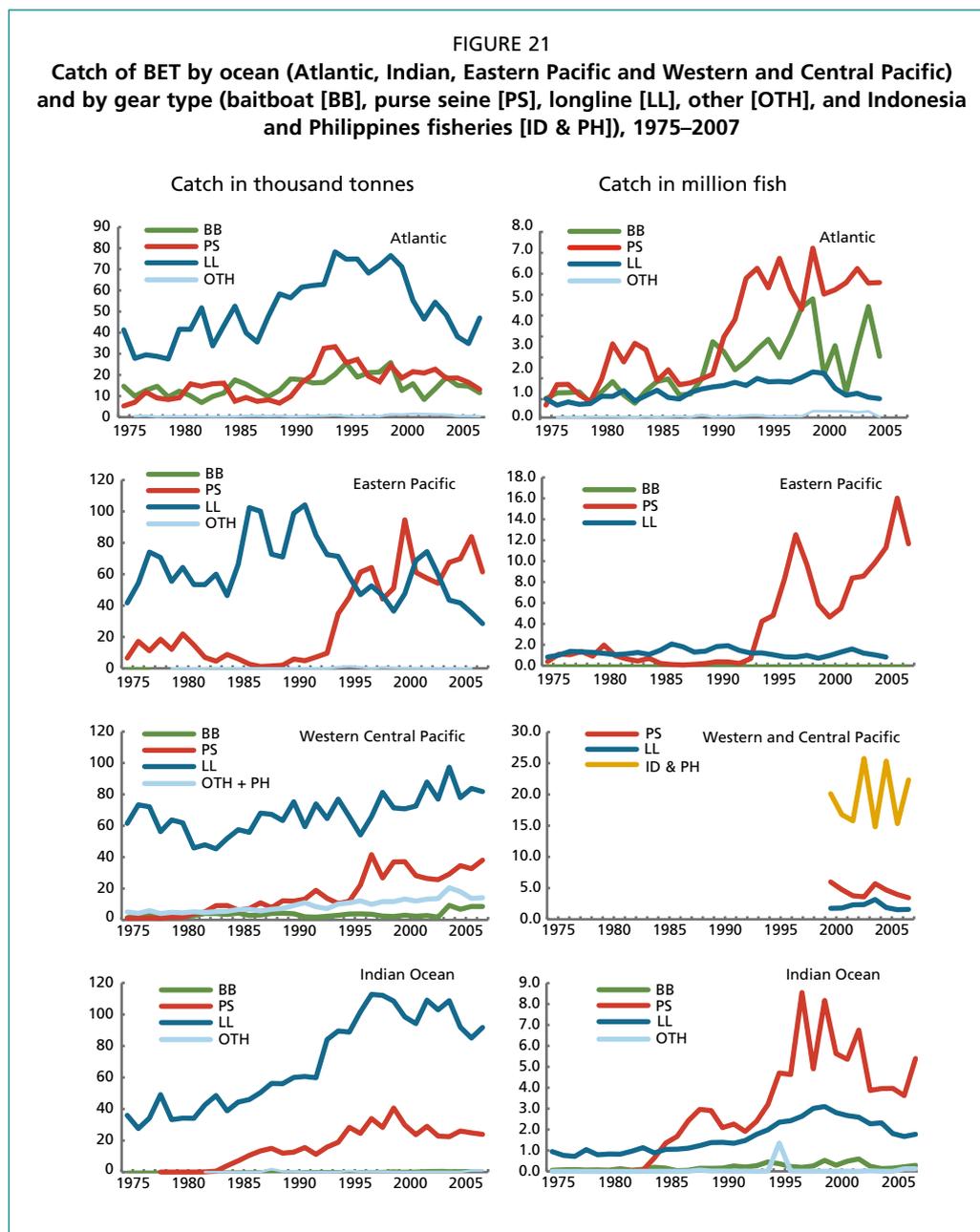


Source: Based on Maunder and Hoyle, 2006.

remains between 45 and 70 kg (annual fluctuations appear to be related to fluctuations in recruitment). The sharp decline in the mean weight of the total catch suggests that the relative amount of purse seine catch is increasing.

Given a certain recruitment, the biomass at an age (size) of a cohort of fish is determined by the balance between natural mortality and growth. Y/R is then dependent on the age-specific fishing mortality on this biomass-at-age structure. Figure 20 (Maunder and Hoyle, 2006) shows the relative biomass of one bigeye cohort by age (or size) estimated using recent fishing patterns (catch curves) and parameters applied in recent assessments. The maximum biomass of bigeye is obtained roughly at an age of 15 quarters (or 3 years, 9 months) and at 60 kg (relatively large as compared to 35 kg for yellowfin). Therefore, based on the data cited above, longlines are catching bigeye at its optimal size (Miyake, 2007). Although there are slight differences in biological parameters for bigeye between oceans, as the catch curves are similar, similar results would be expected for other oceans.

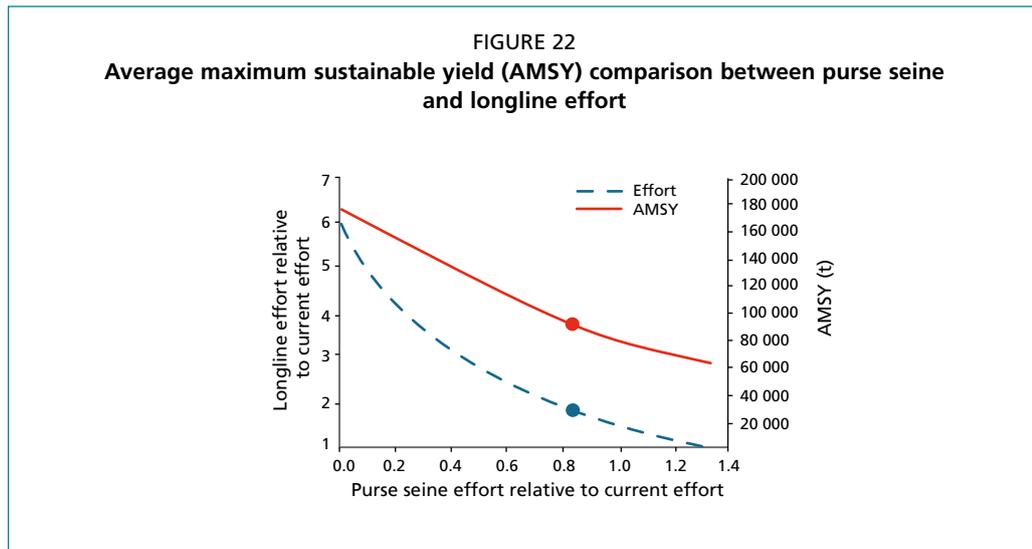
According to stock assessments conducted by RFMOs (see Section 3), most bigeye stocks' biomass is still above or near the MSY level; however, fishing mortality (F) is considerably higher than F at MSY. Figure 21 presents bigeye catches by gear type for four major ocean regions. The left column is presented in catch weight (tonnes), while the right column shows the catch in number of fish.



Source: RFMOs, personal communications.

In most cases, catches are considered in terms of weight. If that is the case, as discussed in Section 4.1.2, longline (including both distant water and coastal) catches have increased steadily at least until the mid-1990s in all areas. After that time catches continued to increase in the Western and Central Pacific Ocean but declined in other ocean regions. Particularly in the Eastern Pacific Ocean, longline catches of bigeye have declined rapidly since the early 1990s, coinciding with the introduction of FAD fishing and the rapid increase in purse seine bigeye catches. In 2000, purse seine catches of bigeye overtook longline catches of bigeye in the Eastern Pacific Ocean and have exceeded them ever since.

In the Atlantic and Indian Oceans, longline bigeye catches in weight started to decline in the late 1990s, which coincided with an increase and then peak in bigeye catches by purse seines (Figure 21). In the Western and Central Pacific Ocean, purse seine catches also increased rapidly in the mid-1990s, but longline catches of bigeye have not declined. In the Western and Central Pacific Ocean, the coastal fisheries of



Source: Copied from IATTC, 2007.

Indonesia and the Philippines also catch large quantities of bigeye, but the catches of these fisheries are not well documented.

Stock impacts are generally better evaluated by number of fish, which are shown in the right panel of Figure 21. According to these data, in all ocean regions, purse seine catches in number of fish are far higher (two to more than ten times) than catches of longlines during the years in which substantial purse seine catches were made. In particular, in the Eastern Pacific Ocean in recent years, purse seine catches exceeded longline catches not only in number of fish but even in weight of catches. One of the reasons is the very high proportion of juvenile bigeye in the FAD fishery off Ecuador. In addition to this, some of Ecuador's purse seiners are now targeting bigeye even though bigeye remains only an incidental catch in other regions. These facts, in association with Figure 20 (which indicates that 1 kg of FAD catch is equivalent to more than 10 kg of longline catch), make it obvious that the current bigeye catch by purse seines, particularly on FADs, is affecting the bigeye stock to an equal or greater extent than the bigeye catch by longlines. In the Western and Central Pacific Ocean, much more of an effect on the bigeye stock is being exerted by the small-sized bigeye catches of the coastal fisheries off the Philippines and Indonesia, which are mostly conducted on anchored FADs.

Another important point is that the MSY itself is reduced when small-sized fish become abundant in the catches. Figure 22 (IATTC, 2007a) shows the average maximum sustainable yield (AMSY) for a given level of fishing effort (purse seines on the x-axis and longlines on the y-axis). The current situation is indicated by the position of the circles. If there were to be less purse seine effort and more longline effort, AMSY would increase. If there were to be no purse seine catch, the AMSY would be twice as large as it is now. If only longlines were to be catching bigeye in the Eastern Pacific Ocean, the calculated MSY would be about 130 000 tonnes, as compared with the current AMSY which is estimated at about 80 000 to 90 000 tonnes. However, it should be noted that it would require more than six times the current (2006–2007) longline effort to achieve that yield.

To sum up the current situation, in almost all oceans, FADs and some coastal fisheries (with anchored FADs) have caused a rapid increase in the catch of juvenile tunas. The catch of such small fish reduces the Y/R as well as the AMSY, both for yellowfin and bigeye. As a consequence, longlines which target spawning-size fish are disproportionately affected as the abundance of large fish declines. This is particularly problematic for bigeye since the total biomass is much smaller than for yellowfin and hence the proportion of the bigeye stock caught by FAD fishing taking small-sized fish

BOX 3 Bluefin farming

The term “bluefin farming” generally refers to bluefin (Atlantic, Pacific and southern) fattening operations. Juvenile or adult bluefins, which are lean in fat content, are generally captured by purse seines and kept in floating cages, fed excessively for a few months and then exported for the *sashimi* market. Purse seine-caught southern bluefin in Australia, Atlantic bluefin in the Mediterranean and Pacific bluefin off the west coast of the United States and near Japan were formerly very cheap products, used only for canning, in the production of “*mojama*” (a salted and dried form), or sold in local fresh fish markets. At that time, some post-spawning bluefins were exported to the Japanese market but were found to be unacceptable due to the low fat content.

Commercial bluefin farming began with Atlantic bluefin in Canada in the 1960s, and spread to Spain in the 1970s, to Australia for southern bluefin in the 1980s, and throughout the Mediterranean for Atlantic bluefin in the 1990s. Small-scale farming was also initiated in Japan with Pacific bluefin. These farmed products brought a good price (not as high as natural, high-quality bluefins but enough to turn a profit) and became very popular in the Mediterranean. In 2002, Mexico began Pacific bluefin farming in the Eastern Pacific Ocean. As a result of this expansion, the quantity of farmed Atlantic bluefin products increased rapidly, and the ex-vessel price of Atlantic bluefin in the Mediterranean as stock for the farms has soared.

In areas where only small bluefins are captured (e.g. Croatia and Japan), these fish can be held in cages for over a year until the fish reach the commercially acceptable size for the Japanese market.

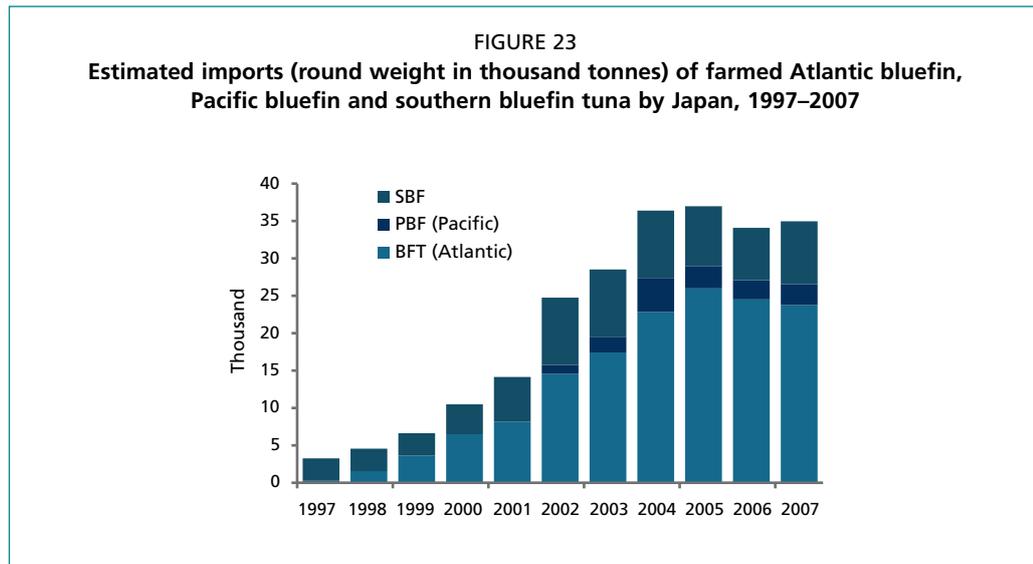
is higher. Therefore, even if stock biomass is above or close to the MSY level, if the total fishing mortality (F) on the stock is excessively high, management to reduce F becomes necessary. This is particularly apparent in the Eastern Pacific Ocean and Western and Central Pacific Ocean.

The target species for purse seines are skipjack and yellowfin, except in Ecuador, where some vessels are targeting bigeye. Despite targeting strategies, when setting on FADs all species are caught together. This situation means that any regulations introduced to protect bigeye would affect the catches of skipjack and yellowfin, even if less stringent (in case of yellowfin) or no regulations (in the case of skipjack) are required for these species. For these reasons, species interactions such as those described in this section are important considerations when formulating management measures. The best solution for all fisheries would be to find a means of avoiding small fish and/or bigeye catches in FAD-related purse seine fisheries. These types of mitigation measures are discussed in Section 5.2.4.

4.2.8 The development of tuna farming

Large-scale southern bluefin tuna farming started in Australia in the late 1980s and Atlantic bluefin began in the Mediterranean in 1997 (see Box 3). These operations developed rapidly and now farming has even been established in the Eastern Pacific Ocean for Pacific bluefin. The history and development of tuna farming activities are well documented in Miyake (2005c, 2007), and a general review of issues relating to Atlantic bluefin farming in the Mediterranean is provided in FAO (2005). As this is a very complicated subject, this section of the paper will only provide a brief summary of key issues. Economic and market analyses are presented in Section 6.2.

Figure 23 shows Japanese imports of farmed bluefin tunas. The country of capture is not shown as it can be different from the country of farming, because stocks of fish



Source: Data provided by ICCAT Secretariat and Japanese custom statistics.

are frequently traded between countries and within the European Union. The data shown in the Figure are estimates based on ICCAT Bluefin Tuna Statistical Documents (BFTSDs) provided by the ICCAT Secretariat and Japanese custom statistics. As much as possible, incidents of double counting of the same fish during import and re-export have been eliminated. The data are in units of estimated round weight upon import. Estimating the live weight of the fish at the time of introduction to the farming cage is very difficult due to uncertainties in growth and mortality rates during the fattening process. As will be discussed in later sections, Japanese imports converted into round weight closely correspond to the estimates of the total farmed tuna output up until 2007 (source data provided by ICCAT).

According to official figures, Spanish production in live weight of Atlantic bluefin tuna in the Mediterranean ranges from 3 000 tonnes (2006) to 6 424 tonnes (2004). Since attaining these figures the production has declined over time. Production was valued at approximately 45 million euros according to the most recent official figures (assuming an average price of 15 euros per kg). Other earlier reports (2001–2002) quote prices at much higher levels: around 30 to 40 euros per kg for Spanish farmed tuna on the wholesale Japanese market and around 22 to 30 euros per kg for ex-farm prices (OFIMER, 2003). At that time, the turnover of the entire Spanish industry was estimated at 150 million euros, i.e. more than three times the current official figure. Most of the Spanish Atlantic bluefin products go to the Japanese market, which has diversified its supply sources in recent years and has accumulated substantial inventories in Japan as well as in Spain. It has been suggested that these factors explain the lower prices now obtained by Spanish farms (Jiménez-Toribio and García-del-Hoyo, 2007). Another factor is likely to be the appreciation of the euro relative to the Japanese yen.

A minor but increasing portion of farmed tuna is either exported to markets other than Japan or consumed in domestic markets (data source: ICCAT). Part of the reason for uncertainty surrounding this issue is that the ICCAT BFTSDs for trade to countries other than Japan appear to be incomplete. If farmed tunas are consumed without entering international trade, e.g. sales of fish within the European Union, they do not require ICCAT BFTSDs. Table 5 shows the numbers of farms and the total farming capacity for each Mediterranean farming country, as registered with ICCAT at the end of 2008. If all the cages are used to their full capacity, up to 58 000 tonnes of Atlantic bluefin can be produced (output). As described below, the amount of Atlantic bluefin needed as input to produce this amount (possibly 48 000 tonnes assuming a 25 percent

TABLE 5
Registered number and capacity of farming cages for BFT in the Mediterranean Sea

Country	Number of farm registries	Total capacity (tonnes)
Croatia	11	7 880
Cyprus	3	3 000
Spain	14	11 852
Italy	15	11 500
Malta	8	11 150
Libya	1	1 000
Morocco	1	300
Tunisia	4	2 400
Turkey	13	8 960
Total	70	58 042

increase in weight during farming as adopted by ICCAT) is substantially in excess of the BFT TAC adopted by the Commission. Therefore, the problem is very similar to that of fishing capacity as discussed in Section 5.1.5.

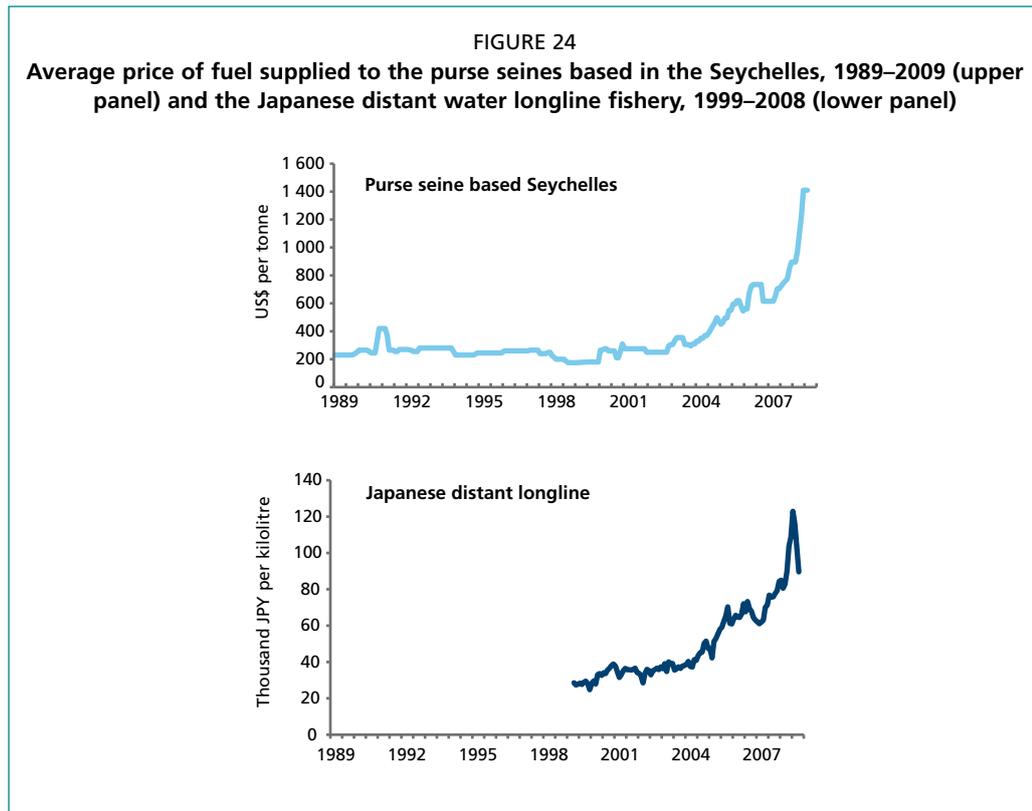
The development of tuna farming is important in two major ways. First, the fishing effort and catch of Atlantic bluefin has increased very substantially in the past few years. Current maximum fishing capacity for Atlantic bluefin is estimated to be over 60 000 tonnes, or 2.5 times the TAC (ICCAT, 2008). ICCAT has taken various measures to control both fishery and farming activities, but agreeing to management measures, and maintaining compliance with these measures, has been very difficult (see Section 5.1). Second, the sudden increase in the supply of tuna with a high fat content has destroyed not only the pricing system of the Japanese market but also the structure of the Japanese market and distribution system, which in turn has affected the tuna fishery as a whole, not only the fishery for Atlantic bluefin tuna. These issues are discussed in greater detail in Section 6.2.2 and 6.2.4.

4.3 OPERATING COSTS

The difference between the revenue (i.e. landed values of the catch) and variable and/or fixed operating costs determines the amount of profit or loss to the fishery. Operational cost-effectiveness is therefore one of the most important factors affecting fisheries trends, but it is a difficult subject to tackle for three reasons:

- confidentiality of financial operations and data in the private sector;
- extreme variability in cost items among countries, areas, fisheries, years and even individual vessels; and
- the effects from other bio-, socio-, and economic factors including government subsidies, which may be direct or indirect.

The instability of the world monetary system is influencing many aspects of the tuna industry and is discussed in various sections of this paper. Operating costs are highly susceptible to such instability. There are three major currencies whose exchange rates influence the world tuna business, namely the United States dollar (US\$), the European Union euro (euro) and the Japanese yen (yen or JPY). Comparisons of operating costs among various locations and fisheries depend on which currencies are arbitrarily chosen as the basis of the analysis. Such choices may or may not be representative of actual currency factors driving the complex international tuna market. These issues will be discussed in further detail in Section 6. Since the purpose of this paper is to provide an overview of current tuna fisheries, several case studies of typical fisheries are used in the following sections to provide a brief qualitative description of the operating costs of fishing activities.



Source: Personal communications with Seychelles Fishing Authority and Japan Tuna Fisheries Cooperative Association.

4.3.1 Fuel price

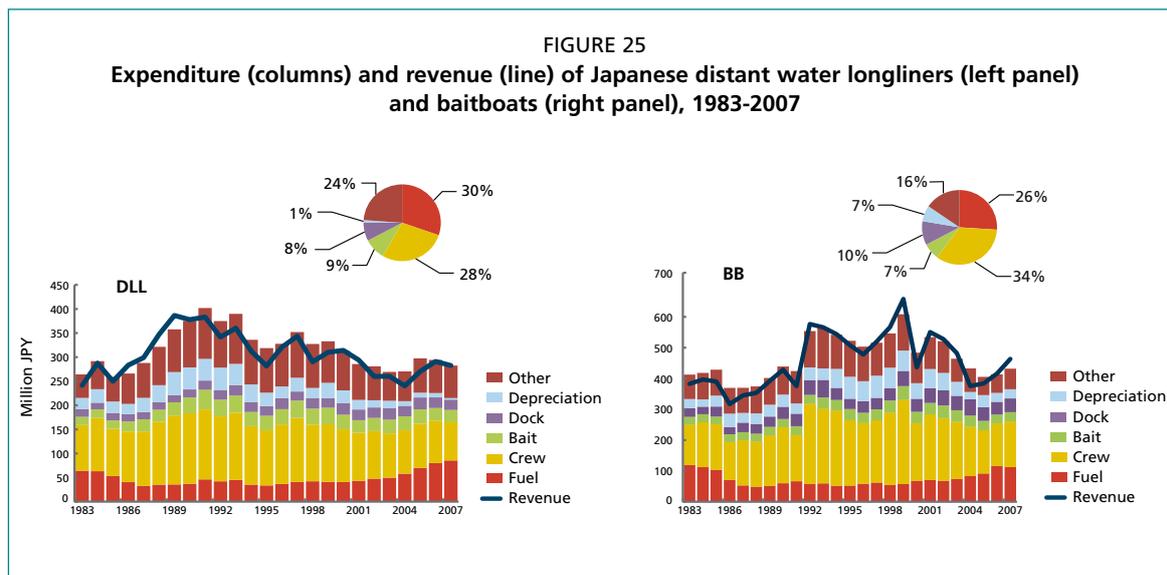
The major variables influencing total fisheries operating costs are fuel and labour. Undoubtedly, the most important influence on the tuna fishing industry in recent years has been the exponential rise in the worldwide price of crude oil, reflected by increasing fuel (gasoline or diesel oil) price as shown in Figure 24. The upper panel shows the monthly unit fuel price for the purse seine fleet based in the Seychelles from January 1989 to June 2008 (personal communications with Seychelles Fishing Authority). The lower panel shows the average monthly unit fuel price paid by the Japanese distant water longline fleet from April 1999 to November 2008 (personal communications with Japan Tuna Fisheries Cooperative Association). The x-axes have been aligned for comparison between the two series. The Japanese price represents the average price of the domestic and foreign port bunkering and transshipment suppliers. Although not shown in this figure, the Amsterdam-Rotterdam-Antwerp (ARA) Gasoil Spot Price FOB (freight on board), a proxy for the world market, shows identical trends (ARA, unpublished data).

The reported reasons for the sharp increase in fuel prices in 2002–2008 are steady growth in demand by China and India and, probably more important, the overheating of investments in petroleum commodities by speculative investment funds. In September 2008, the collapse of the United States' bubble economy resulted in fuel prices falling from US\$140 to US\$35 per barrel by January 2009 (according to the ARA spot price).

4.3.2 Case study 1: Japanese distant water longline and baitboat fisheries

The information for this case study derives from interviews with Japanese distant water longline and large-sized baitboat fishers (survey by the Japan Tuna Fishermen's Cooperative Association). Summary data for both fisheries are given in Figure 25.

The distant water longline data are stratified by target species and vessel size category, which makes them rather difficult to interpret. For the purposes of this paper a typical



Note: Pie charts represent the share of expenditure on each item in 2007.
 Source: Survey by the Japan Tuna Fishermen's Cooperative Association, unpublished data.

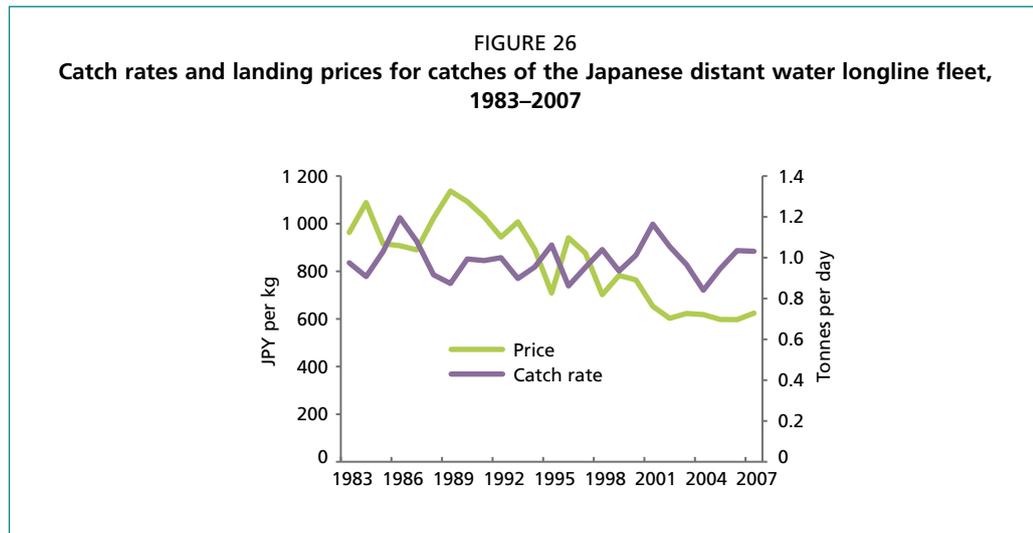
fleet is considered to be composed of vessels of about 300 gross register tonnage (GRT) targeting yellowfin and bigeye. Annual data shown in Figure 25 represent the average per vessel cost of a trip varying in length between 300 and 400 days, i.e. sometimes longer than one year. When a trip covered multiple years, it was assigned to the year in which it terminated. The number of trips in the sample for each year ranged from 30 to 110.

The baitboat data are derived from large vessels (>360 GRT) which make between six and ten trips per year. As there were data available for 20 to 30 vessels in each year, the total sample size in each year varied between 150 and 300 trips.

In both cases, revenue refers to total landing value. Crew costs include wages, crew transport, insurance and meals. Dock costs refer to all costs for maintenance and repair of vessels and fishing gear. Other costs include marine insurance, transshipment fees (only where applicable), port fees, and other miscellaneous costs. Only those costs related to fishing operations are assessed, for example, administrative costs, sales costs and bank interest are not included.

The results of the cost computations for 1983–2007 are shown in Figure 25 for distant water longliners (left panel) and baitboats (right panel). Pie charts inside each panel represent the share of the total for each item in 2007. The length of the bar for each year indicates the cumulative cost and the data series represented by the solid line shows the landed value of the catch (i.e. gross revenue). The average fishing cost (expenditure) and landed value of the catch (gross revenue) are similar, although gross revenue is slightly lower than expenditure, particularly in recent years and for the distant water longline fleet. If the results are considered in terms of net revenues, the discrepancy is even greater as overhead costs such as interest for capital and operating funds, and sales and administrative costs, need to be added to the expenditures. In other words, on average, the distant water longline fleets are operating at a loss. However, if fishers cease operations, all overhead costs become debt, and without further revenue deficits would become even greater. This situation begs the question of why the fleet has not become bankrupt. One explanation may lie in the fact that investment in fisheries is always speculative and, even though the average return on investment may be negative, occasionally a very high profit can be made. This may contribute to a willingness to continue operations rather than declaring immediate bankruptcy and incurring a large debt.

There are several other possible explanations for the apparently unprofitable situation, illustrated by Figure 25. First, as discussed in the following section,



Source: Survey data by the Japan Tuna Fishermen's Cooperative Association, unpublished data.

depreciation costs are an accounting technique and not actually a real expenditure. Second, if vessels are part of a vertically integrated company, i.e. they are selling to a processor or broker which is part of the same company, the ex-vessel price is not a true market price, but instead should be viewed as a transfer price. The vessels may then be run at slight losses in order to insure a steady and reliable supply of fish to the integrated processing company. In spite of this possibility, it should be noted that most longliners are not integrated with land-based fish dealers. Finally, it may be the case that revenue might be under-reported to authorities.

The peak in operating costs for these fleets occurred in 1991 and trailed the peak in revenue by several years. Thereafter, a sharp decline in gross revenue was observed. Figure 26 compares landings (in tonnes) per trip-day and landing value per kg (i.e. ex-vessel price). Both of these data series are in processed weight (gilled and gutted, round or other forms) and do not account for species composition. Based on a comparison of Figure 26 and the left panel of Figure 25, it is clear that gross revenue reflects changes in fish price rather than the catch rate. As the fish price began to decline in the early 1990s reducing gross revenue, vessel owners started cutting expenditures as much as possible. In the distant water longline fishery, the largest savings were achieved by reducing labour costs by replacing Japanese fishing crews with foreign crews (mostly Indonesians). Fuel cost increased during this time (Figure 24) but its share of total expenditure has remained less than the cost of labour until very recently. In addition, depreciation has decreased as vessels became older.

For baitboats, both gross revenue and fishing expenditure per year per vessel are nearly twice as high as for distant water longliners. The discrepancy between the revenue and expenditure is also less for baitboats. Nevertheless, when considering the higher costs of distant water longliners versus baitboats, several important differences should be borne in mind. As explained above, the annual costs for longliners may actually be based on periods greater than one year, whereas for baitboats the figures are strictly annual data. Furthermore, longline vessels targeting Atlantic or Pacific bluefin tunas, even if for only part of the year, for example, until the vessel quota is reached, are economically slightly better off. There are also important operational differences such as the requirement for more skilled labour input on baitboats, which possibly reduces the opportunity for the use of less-skilled foreign crews. In contrast, maintenance and other expenditures for distant water longliners are higher because they are often incurred at foreign ports.

4.3.3 Case study 2: Japanese offshore longline fleet

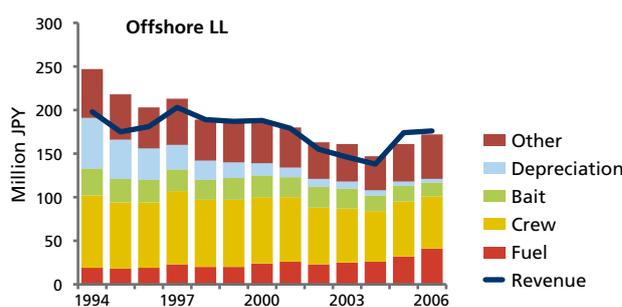
This case study is based on vessels classified as offshore longliners due to their size rather than their actual fishing ground. According to Japan's fishing licensing system, longline vessels >20 GRT and <120 GRT, which target mainly tunas and tuna-like species (including billfishes), are categorized as offshore longline vessels. The fishing grounds of the offshore longline fleet are located almost exclusively in the Western and Central Pacific Ocean but are relatively close to the Japanese coast.

The annual cost and gross revenue (total annual landed value of the catch) data shown in Figure 27 derive from Japanese offshore longline vessels with holding capacities of around 120 tonnes, i.e. the top end of the size range for these vessels. For each year between 1994 and 2006, data from 20 to 40 such vessels were compiled and averaged (Ishimura and Yokawa, 2008). Note that the crew cost in this figure, as in the case of distant water longliners, includes wages, insurance and meals. The category of "other cost" includes all costs other than those for crew, fuel and bait. The proportions of fuel, crew and bait costs are very similar between distant water and offshore longliners.

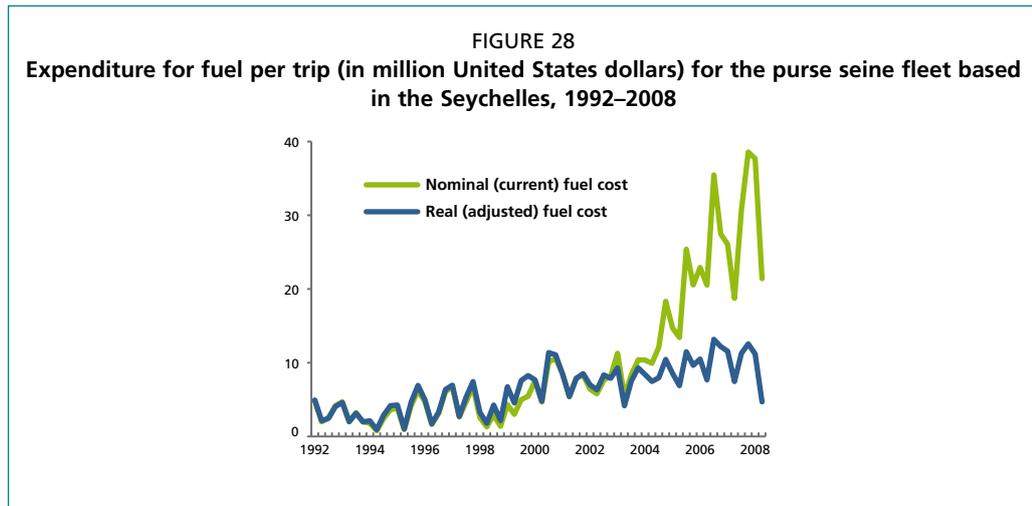
Although these cost and revenue data provide a comprehensive financial profile of the hardships faced by this fleet in recent years, cost data must be carefully interpreted. One of the key issues is depreciation. Depreciation of durable equipment, including vessels and gear, was a substantial portion of the total cost in the early years (22.6 percent in 1994), but has been persistently declining over time. As explained with the case of distant longliners, this variable is only an accounting technique and does not represent real expenditure. Also, this effect is to be expected given that many of the vessels in this sample were built in the early 1990s and depreciation costs are calculated on the basis that durable equipment is arbitrarily considered to be partly used up each year until the end of its operational life. (In addition, the values of fixed assets are usually subject to property taxation and thus tax liabilities are reduced as asset values depreciate.) Vessel refurbishment costs and loan payments, which are included in the "other cost" category, were considerable portions of total costs from 1994 to 2001. The availability of alternative bait (e.g. Pacific sardine instead of saury or squid) and the introduction of foreign labour forces enabled a reduction in bait and crew costs of 50 percent between 1994 and 2006. In this sense, the situation for the offshore longline fleet was similar to that of the distant water longliners except that the reduction in labour costs is far greater for distant water longliners because a larger percent of the crew are foreign citizens.

The trend of increasing fuel cost over time is consistent with the aforementioned global fuel price rise. The increase in the fleet's total fuel costs from 26 million yen per year in 2004 to 41 million in 2006 changed its financial profile substantially as fuel costs

FIGURE 27
Expenditure (columns) and revenue (line) of Japanese offshore longliners, 1994–2006



Source: Authors' surveys.



Source: Personal communications with Seychelles Fishing Authority.

rose from 7 to 23 percent of the total operational cost between 1994 and 2006. Total revenue exhibits fluctuations over time but costs remained higher than revenues for this fleet except in recent years.

4.3.4 Case study 3: Seychelles-based European purse seine fleet

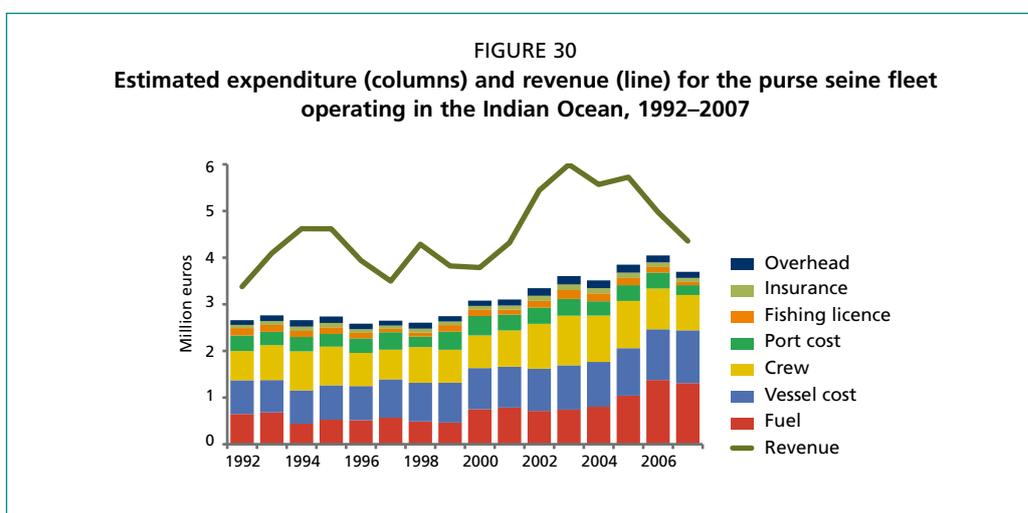
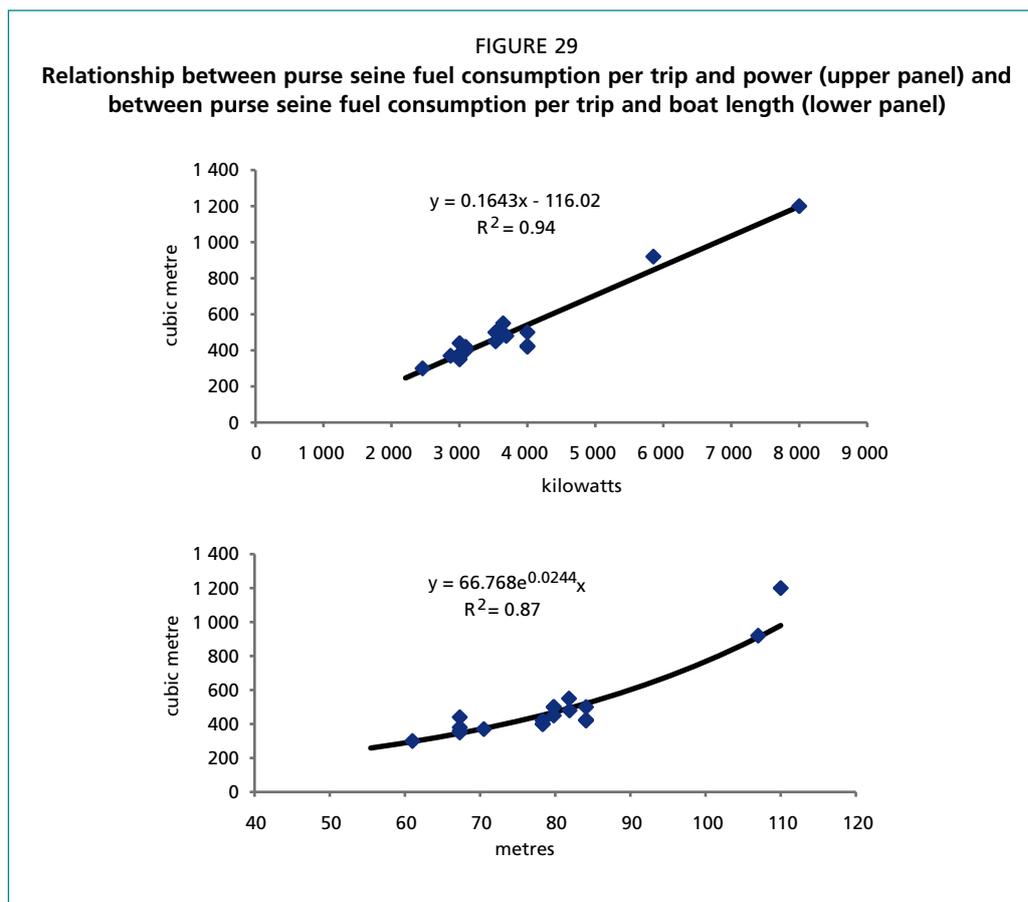
The recent trend of increasing fuel expenditure (Figure 28), caused by soaring fuel prices coupled with increasing fishing effort and larger vessel size, has been dramatic (personal communications with Seychelles Fishing Authority). The green line shows nominal expenses (in United States dollars) of fuel purchased by the entire European purse seine fleet landing at Victoria, Seychelles, from 1992 to 2008. The blue line gives real expenses (in United States dollars deflated by a fuel price index for the Seychelles using 2001 as the base year). The real impact of these rising prices on the profitability of the European fleets has probably been less than suggested by the nominal trend, given that the sales of frozen tuna are in euros, the fuel is purchased in United States dollar, and the euro has appreciated against the United States dollar in recent years.

The fuel (gas oil or diesel oil) expenditure represented an average of 60 percent of the total port call expenditures of the purse seine fleet landing or transshipping at Victoria, Seychelles, until 1999. This percentage increased to 70 percent in the following four to five years and reached as high as 92 percent in 2008. For purse seine fleets in general, regardless of size, in the 1980s and 1990s fuel costs represented an average of 20 percent of the total operating expenditure. In recent years, this amount increased to 50 percent or more for some vessels, a considerably higher percentage of the total expenditures than for either the Japanese distant water longline or baitboat fleets.

Fuel consumption varies according to the size and power of the purse seiner (Figure 29, upper panel). Average consumption is around 430 m³ (i.e. 350 tonnes²) per trip of 45 days. At the peak price in September 2008, the fuel consumption per trip cost 250 000 euros. From a summer 2008 sample of 20 European purse seine vessels (survey by P. Guillotreau) operating in the Indian Ocean, a linear correlation was shown between power in kilowatt and fuel consumed in tonnes: every additional kilowatt increases fuel consumption by 160 kg per fishing trip. The relationship between the length of a boat and its fuel consumption appears exponential rather than linear (Figure 29, lower panel).

Figure 30 shows the estimated costs (expenditures) and gross revenue (sales value) obtained through a survey of 17 French purse seiners carried out in summer 2008, at

² The appropriate coefficient to convert volume (in m³) to weight (in tonnes) varies according to the type of fuel supplied, but in the Seychelles it is 0.815.



Source: Personal communications with Seychelles Fishing Authority.

Victoria, Seychelles (survey by P. Guillotreau). The sales value was computed from French ex-vessel prices (SOVETCO, unpublished data) and catch and species composition data. Costs were estimated using data compiled by the Seychelles Fishing Authority for local economic spending by purse seiners. Local miscellaneous expenditures for port calls have been converted from Seychelles rupees into euros. Crew wages are determined based on a share-type contract under which wages depend on the total value of sales, the crew worker's position, and the characteristics of the vessel (GRT, fish carrying capacity and engine power). Access fees are estimated from the European Union–African, Caribbean and Pacific (ACP) fishing agreement rules (fixed value for a given number of base

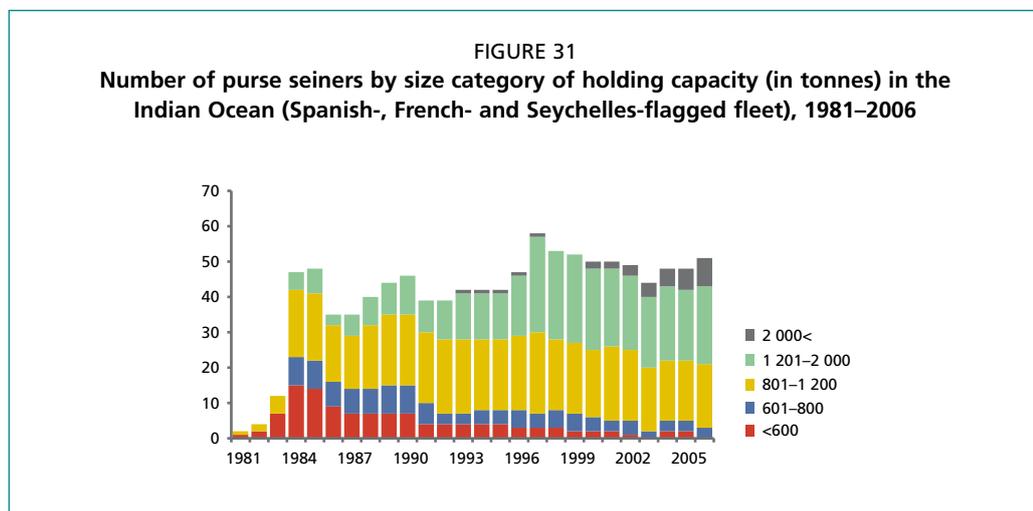
tonnes and 25 or 35 euros per additional tonne). The overhead (3 percent of sales value), insurance (2 percent) and survey costs were also estimated.

Data on some of the fixed costs (e.g. FADs, repair or maintenance of the engine, and/or fishing gear) were lacking and were thus not included; therefore, operating costs are underestimated to some extent. There were also many elements of operating costs which were not estimated (e.g. travel costs for crew, taxes). Furthermore, depreciation costs were not estimated and this may be the source of differences between the figures for this fleet and those for Japanese fleets (Sections 4.3.2 and 4.3.3). As a result of these biases, the profit (30 percent of the sales) is likely to have been overestimated, even though the magnitude of overestimation appears to be minor.

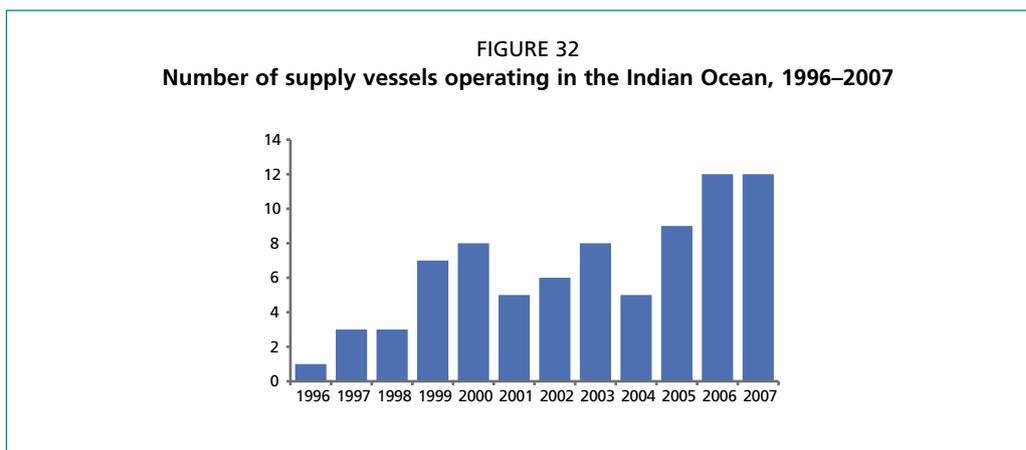
In recent years profit margins are decreasing due to rising fuel prices and, in 2007, lower catches in the Indian Ocean. In the latter part of 2008 and 2009, the operation of purse seines in the most productive area of the Western Indian Ocean became very difficult due to the piracy in the area, and this caused further reductions in catches.

Other factors acting to suppress profits are the increasing costs of constructing and maintaining more sophisticated FADs and greater competition among purse seiners. The French purse seine fleet dispatched 130 FADs annually, whereas the Spanish purse seine fleet released over 300 FADs (Moreno *et al.*, 2007). (It should be noted that costs and earnings may vary considerably between fishing companies.) The average size of fishing vessels has also increased significantly since the late 1990s, as shown by the composition of the fleet by carrying capacity class (Figure 31). The increase in catch, if any, with increasing size of a vessel is not likely to have compensated for this increase in capital expenditure.

The growing fishing effort (or fishing capacity) for this fleet has also been promoted by an increase in use of supply vessels (often called tender vessels), as illustrated in Figure 32. Supply vessels are exclusively used by the Spanish fleet. The use of supply vessels started in the mid-1990s and gradually increased until 2007 when 12 units were deployed (Delgado de Molina *et al.*, 2003; Moreno *et al.*, 2007). Some smaller Spanish purse seine vessels share a supply vessel among two or three purse seiners, whereas each purse seiner in the largest category has its own dedicated supply vessel. The role of the supply vessel is to search for fish schools and to manage the FADs for the mother vessel. This needs to be included as an additional cost for the European Union purse seine fleet, as each supply vessel employs around five to seven crew members, consumes about 80 000 litres of fuel per month, and carries a large amount of expensive electronic equipment. These costs are offset to a large extent by gains in fishing efficiency and catch rate.



Source: Data provided by IOTC.



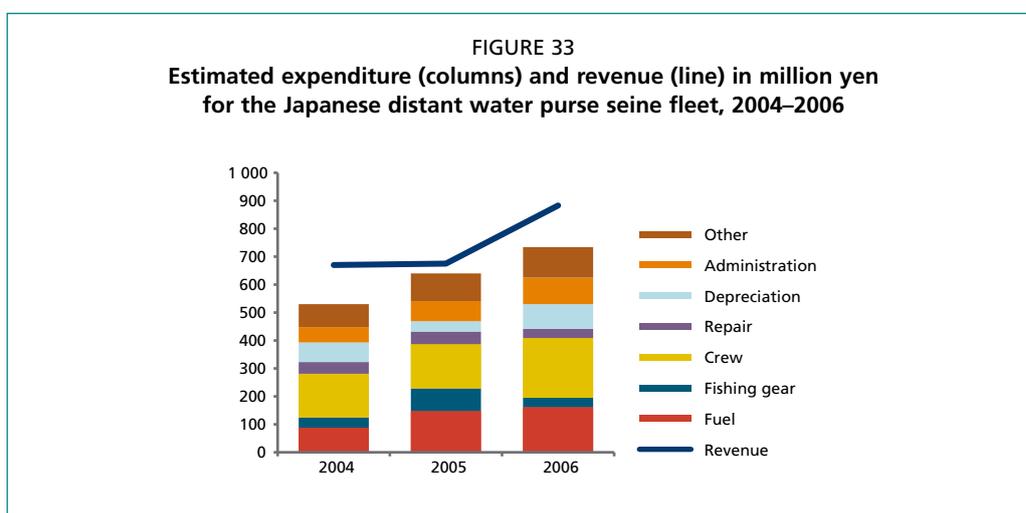
Note: Data are estimated based upon an assumption of one port call every two months.
Source: Data provided by the Seychelles Fishing Authority, unpublished data.

4.3.5 Case study 4: Japanese distant-water purse seine fleet

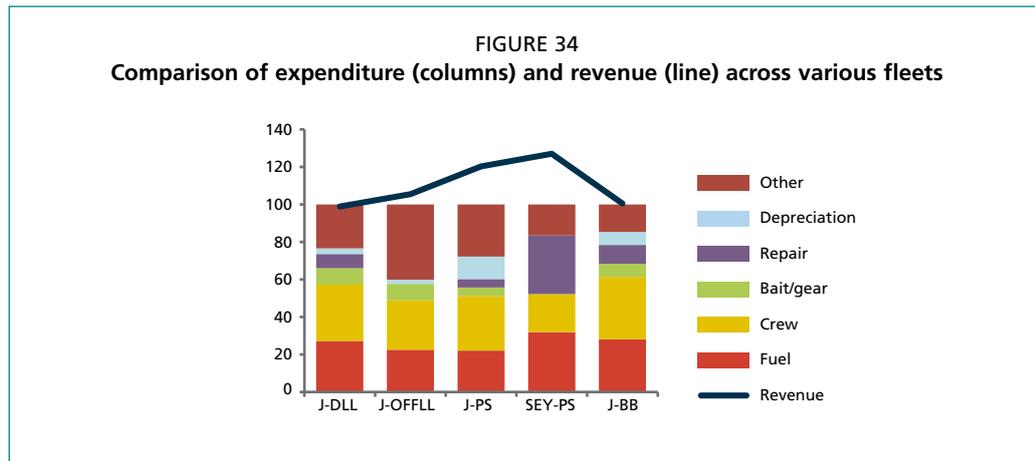
Figure 33 shows operating costs and gross revenue for the Japanese distant water purse seine fleet (Japan Far Seas Purse Seine Fishing Association, personal communication). By law, Japanese purse seiners are limited in size (as of the writing of this paper) to <500 GRT and these vessels fish almost exclusively in the Western and Central Pacific Ocean. Since all the land-based costs (e.g. administration and sales) are included in this data set, the difference between gross revenue and cost should fairly represent profit. However, as the data only cover a three-year period, it is too early to draw firm conclusions from these figures.

4.3.6 Comparisons of the balance between operating cost and revenue among various fleets

Figure 34 compares the cost composition and the gross revenue across the fleets in the case studies for 2006 (i.e. Japanese distant water longline, Japanese offshore longline, Japanese distant water purse seine, Seychelles-based French purse seine and Japanese baitboat fleets). Due to the substantial changes in the economic situation over time, this comparison may not reflect the current situation. In addition, relative rather than absolute comparisons are more meaningful given the variability in exchange rates and the differences in vessel size and target species. For this reason only the proportions of various costs in the total expenditure (i.e. cost shares) are shown and the gross revenue is given only as a percentage of the total operational cost.



Source: Data provided by the Japan Far Seas Purse Seining Fishing Association.



Note: Japanese distant water longline=J-DLL; Japanese offshore longline=J-OFFLL; Japanese purse seine=J-PS; Seychelles purse seine=SeY-PS; Japanese baitboat=J-BB).

Source: Various, see case studies above.

As explained under each case study, the itemization of costs is not consistent among these fisheries. For example, the case study of the Seychelles-based French purse seiners includes licence fees and other port entry costs in the repair costs, but does not include depreciation and gear costs in the overall operational cost. Hence, in this case the total operating cost is underestimated and the percentage of gross revenue to the total cost is overestimated. Even considering these limitations in the data, it is obvious that longliners and baitboats are operating at levels of very low or negative profit, whereas purse seiners are earning a profit. Another reasonable conclusion is that the revenue per unit cost of fuel appears to be higher for the Japanese fleets.

In terms of gear types, tuna caught by longliners would be higher in value per unit weight, whereas the landed quantity per unit cost of fuel would be higher for purse seiners. Because of these differences in profit margins (at least in part), the purse seine fleet is growing while the longline fleet, particularly in distant waters, is shrinking. In the purse seine fleet, the large fixed costs including vessel purchase price undoubtedly play a role in the increasing amount of effort, increasing catches and more generally in the increasing concentration in the purse seine catch-canning value chain. It should be noted, however, that the operation of purse seines is economically more risky than the operating of longlines as it represents a high-risk, high-return type of investment. For purse seine operations, the larger capital costs, larger catches and production scale, and potentially lower number of vessels in the fleet, all provide a greater potential for quasi-vertical integration whereby canners own all or part of a purse seine fishery.

5. Management-related issues influencing tuna fisheries

5.1 MANAGEMENT MEASURES AND COMPLIANCE

In this section, management measures currently adopted by RFMOs are briefly reviewed on a stock-by-stock basis for each ocean. As a general principle, the tables list only current regulations, but in some cases historical measures which have had major effects on the development of the fisheries have also been included as remarks. Any special exemptions for coastal, artisanal, minor and/or developing countries' fisheries which are included in management plans are not specifically mentioned in the tables.

In most cases the information is drawn from the most recent annual reports of the RFMOs or their scientific committees, but these reports however are not referenced individually. As this paper aims to present only a brief summary of management measures, those who are interested in further details should refer to the original RFMO recommendations and resolutions. This paper also does not provide an evaluation of whether the management measures are fully implemented or effective, except in cases where this information is widely available and the RFMOs, or their subsidiary bodies, have reported that the measures are not achieving their objectives.

5.1.1 Atlantic Ocean

Table 6 briefly summarizes the current management measures for Atlantic tuna stocks. TACs have been set for almost all Atlantic tuna stocks since the 1980s, and according to the reports of the ICCAT Compliance Committee (ICCAT Biennial Reports, 2008, 2009a, 2009b), they have been implemented and complied with. The exceptions to this have been in connection with the eastern Atlantic bluefin stock. TACs for this stock have been exceeded in some years, even according to the formal national catch reports (see Section 4.1.1), and there have also been important amounts of unreported catches estimated (ICCAT, 2009a).

Another case is the management measure instituting a minimum size limit of 3.2 kg for yellowfin and bigeye, which was shown through studies to have been widely flouted and was thus abolished. This minimum size limit did not affect any of the Atlantic tuna fisheries with the exception of the Japanese baitboat fleet based in Ghana which, as a result of this regulation, withdrew from this fishing ground and moved to Brazilian waters.

5.1.2 Pacific Ocean

Two RFMOs are directly involved in the management of tuna in the Pacific: IATTC and WCPFC. Northern albacore and Pacific bluefin, which are found in both Convention areas, are assessed by the ISC. Conservation and management recommendations by the ISC are reviewed by both IATTC and WCPFC, and efforts are made to harmonize management measures for these common stocks if adopted. Table 7 briefly summarizes the current management measures for Pacific tuna stocks.

The first management measures for tuna were taken in 1966 in the Eastern Pacific Ocean in the form of a yellowfin TAC with free competition, i.e. the quota was not apportioned by flag state or vessel. Under this measure, which was implemented until 1979, when the catch in the entire Eastern Pacific Ocean approached the TAC, the Director of Investigations of IATTC decided the date of closure. However, each vessel

TABLE 6
Regulatory measures currently applicable in the Atlantic Ocean (including the Mediterranean)
– as of mid-2009

Stocks	Current regulations	Remarks
YFT	<ul style="list-style-type: none"> • Effective fish effort not to exceed 1992 level • PS closure during November 0°–5°N 10°–20°W 	<ul style="list-style-type: none"> • For BET but YFT included
BET	<ul style="list-style-type: none"> • TAC = 90 000 tonnes • Number vessels < the average of 1991–1992 • LL vessels limited for China (45), Taiwan Province of China (98), Philippines (8) • PS closure during Nov. 0°–5°N 10°–20°W 	
SKJ	<ul style="list-style-type: none"> • No regulations 	<ul style="list-style-type: none"> • BET time-area closure affects SKJ
ALB – North	<ul style="list-style-type: none"> • Number vessels < the average 1993–1995 • TAC = 30 200 tonnes for 2008, 2009 	
ALB – South	<ul style="list-style-type: none"> • TAC = 29 900 tonnes until 2011 	
BFT – East	<ul style="list-style-type: none"> • TAC 22 000 tonnes (2009), 19 950 tonnes (2010), 185 000 tonnes (2011)*¹ • Allocation to CPCs (and possibly individual quota for vessels <24 m)* • Restriction on overage and underage permits* • For LL>24m, east of 10°W and south of 42°N closed June 1 – end of the year, west 10°W, north of 42°N closed February 1 – July 31* • For PS, no fishing from June 15 – April 15*² • For BB and TROL, closed October 15–June 15* • For SPORT, closed October 15–June 15* • No aerial searching • Size limit > 30 kg (8 kg for BB in E. Atlantic, Adriatic for farming, Mediterranean artisanal coastal fisheries) • Fishing capacity limited to matching quota and the difference should be reduced to 20% by 2010* • Catch document system 	<ul style="list-style-type: none"> • TAC since 1995 • Current regulations: • For LL>24m, east of 10°W and south of 42°N; June 1– December 31 • For PS, no fishing from July 1–December 31* • BB November 15 – May 15 • Size > 30 kg (8 kg for BB in E. Atlantic, Adriatic for farming, Mediterranean artisanal coastal fisheries)
BFT – West	<ul style="list-style-type: none"> • Country quota with TAC = 2 100 tonnes including dead discards* • Size limit > 30 kg or 115 cm • No fishing on spawning stock in Gulf of Mexico 	<ul style="list-style-type: none"> • TAC since 1980

* These measures were adopted in 2008 and took effect in mid-2009.

¹ TAC revised to 13 500 tonnes in 2010 (November 2009).

² PS closure changed from June 15 to May 15 (November 2009).

that left port before the closure date was allowed to complete its trip. This measure had the unintended consequence of encouraging the construction of purse seiners with greater holding capacity.

For many years following 1979 no regulations were implemented because biomass was greater than B_{MSY} . One of the reasons for this is the curtailment of the United States' fleet's fishing operations under regulations relating to mitigation of dolphin mortality. Regulatory measures were introduced again in 2002, when TACs similar to those implemented during 1966–1979 were enacted. From 2004 to 2007, a closed period was introduced for the purse seine fleet – instead of a TAC – and a flag state quota for bigeye catch by longliners was set. In 2008, the Commission (IATTC) could not agree on management measures by consensus and only unilateral voluntary measures, similar to those applied in 2007, were adopted by CPCs. A new regulation was adopted in 2009, which applies for the period 2009–2011.

TABLE 7
Regulatory measures currently applicable in the Pacific Ocean – as of mid-2009

Stocks	Current regulations	Remarks
YFT-EPO	<ul style="list-style-type: none"> For 2009: 59 days closure, either from 1 August to 28 September, or from 21 November to 18 January (2010) For 2010: 62 days, either from 29 July to 28 September, or from 18 November to 18 January 2011 For 2011: 73 days, either from 18 July to 28 September, or from 7 November to 18 January 2012 The area surrounded by 96°–110°W and 4°N–3°S is closed from 29 September to 29 October 	<ul style="list-style-type: none"> (Until 2007) 42 days closure, 1 August to 11 September; or 20 November to 31 December Retain all the catches
YFT-WCPO	<ul style="list-style-type: none"> PS fishing shall reduce fishing mortality by 30% by 2011 in the area of 20°N–20°S: <ul style="list-style-type: none"> In EEZ, PNA will close FADs fishing 1 August to 30 September and the same closure for non-PNA with observers or total closure In high seas, the same as above with observers or total closure or reduction of catch quota by 10% in 2009 No transfer of effort to other area PS vessel days effort in high seas not to exceed 2004 or 2001–2004 average 	<ul style="list-style-type: none"> No increase of effort from current level LL BET catch not to exceed 2001–2004 average for 2005–2008
BET-EPO	<ul style="list-style-type: none"> For 2009: 59 days closure, either from 1 August to 28 September, or from 21 November to 18 January (2010) For 2010: 62 days, either from 29 July to 28 September, or from 18 November to 18 January 2011 For 2011: 73 days either from 18 July to 28 September, or from 7 November to 18 January 2012 The area surrounded by 96°–110°W and 4°N–3°S is closed from 29 September to 29 October The area surrounded by 96°–110°W and 4°N–3°S is closed from 29 September to 29 October 	<ul style="list-style-type: none"> (Until 2007) 42 days closure, 1 August to 11 September; or 20 November to 31 December, for PS Retain all the catches Country quota for LL (2001 level)
BET-WCPO	<ul style="list-style-type: none"> PS fishing shall reduce fishing mortality by 30% by 2011 in the area of 20°N–20°S: <ul style="list-style-type: none"> In EEZ, PNA will close FADs fishing 1 August to 30 September and the same closure for non-PNA with observers or total closure In high seas, the same as above with observers or total closure or reduction of catch quota by 10% in 2009 LL BET catch to be reduced by 30% (10% each year) by 1 January 2012; YFT catch not increased from 2001–2004 No transfer effort to other areas PS vessel days effort in high seas not to exceed 2004 or 2001–2004 average 	<ul style="list-style-type: none"> No increase of effort from current level LL BET catch not to exceed 2001–2004 average for 2005–2008
ALB-N	<ul style="list-style-type: none"> No increase of effort above current level 	
ALB-S	<ul style="list-style-type: none"> No increase of vessels south of 20°S from 2000–2004 level 	
PBF	<ul style="list-style-type: none"> No management measures 	

In the Western and Central Pacific Ocean, a number of small island developing states collectively referred to as the Parties to the Nauru Agreement (PNA) enacted measures to limit the number of purse seiners that can operate in the EEZ of PNA members' states to 205. This measure was changed in 2007 to a Vessel Day Scheme (VDS), which limits the total number of vessel-fishing days in the area. The United States fleet is exempted from this system for the states with which a multilateral access treaty was agreed upon. Although the VDS is not a WCPFC management measure, under the Convention, the WCPFC member states must treat it as a binding measure (MRAG, 2006).

In 2005, WCPFC adopted a management measure which requires that effort and/or catches of bigeye and yellowfin should not exceed the current level (2002–2004). The

first concrete management measure limiting tuna catches in the WCPFC Convention area was adopted in December 2008. The management measure is very complicated due to the need to respect the subregional agreements such as that of the PNA, but the overall intention is to reduce fishing mortality for bigeye by 30 percent within three years. Although the eventual effect of this regulation can only be evaluated with time, it is expected to have a major effect on various Pacific fisheries which have grown continuously over the last few decades. Furthermore, even though the primary objective is to reduce fishing mortality on bigeye, the measure, if properly complied with, will also have a substantial effect on catches of yellowfin and skipjack (see Section 4.2.7).

5.1.3 Indian Ocean

Table 8 briefly summarizes the current management measures for Indian Ocean tuna stocks. In the Indian Ocean, the IOTC meeting schedule is such that there is a greater lag between the provision of scientific advice and the adoption of management measures in this Commission than in other Commissions. This causes delays in decision-making by this Commission. In addition to this, although the stock status in the Indian Ocean is believed to be better than in other oceans (see Section 3.4), and although there are many regulations concerning capacity control and mitigation of incidental catches, no definite management measures such as TAC or effort control have been implemented.

5.1.4 General management measures

Many management measures have been adopted by RFMOs that are not directly related to the conservation of tuna stocks but nevertheless have an effect on tuna fisheries. Recently, there have been efforts to coordinate the scheduling of RFMO annual meetings thereby facilitating the diffusion of management measures taken by one RFMO into the others. This in theory should lead to greater compatibility in the management measures taken for the world's oceans. As fishing vessels are mobile, the adoption of management measures for one ocean but not for another will lead merely to a shifting of overfishing or overcapacity problems from one area to another. If management measures are adopted in two oceans but are not identical, this may also cause practical problems for fishing fleets moving between oceans (e.g. different VMSs). For these reasons, there is an ongoing effort among all tuna RFMOs to harmonize their management measures. These efforts include, *inter alia*, the Joint Meetings of Tuna RFMOs at Kobe, Japan, in 2006, and at San Sebastián, Spain, in 2009, as well as the FAO-Tuna RFMOs biennial meetings.

Table 9 describes the management measures adopted in each ocean in a qualitative manner. Although the information is highly summarized, more details can be found in other specific sections of this paper (e.g. fishing capacity, bycatch mitigation) and also in the original RFMO reports.

TABLE 8

Regulatory measures currently valid in the Indian Ocean – as of mid-2009

Stocks	Current regulations	Remarks
ALB	Number of SWO and ALB fishing vessels shall be held at 2007 levels	
BET	Limit catches to the recent levels. (Taiwan Province of China: 35 000 tonnes) since 2005	
SBF*	TAC and country quota	Voluntary catch limit (since 1984) and TAC by the Commission (since 1994)

*SBF: The management measures for SBF are by CCSBT and are valid worldwide.

TABLE 9
Other various management measures adopted by RFMOs

Items	Atlantic Ocean (ICCAT)	Eastern Pacific Ocean (IATTC)	Western and Central Pacific Ocean (WCPFC)	Indian Ocean (IOTC)	Worldwide for SBF (CCSBT)
Statistical document	BFT, BET*			BFT, BET*	SBF
Catch document	BFT				SBF (2010-)
Port inspection	Yes	Yes	Yes	Yes	Yes
At-sea inspection	Yes	Yes	Yes		Yes
Observer programme	Yes	Yes	Yes	Yes	Yes
Regional programme	Yes	Yes	Yes		
Transshipment	Yes	Yes		Yes	
Farming sites	Yes				
VMS	Yes	Yes	Yes	Yes	Yes
Fishing capacity control					
Vessel limits	Individual	Total fleet	Some	Total fleet	
Carrying capacity control		Vessel registry			
Vessel registry		Yes		Yes	
Positive vessel list	Yes	Yes	Yes	Yes	Yes
IUU vessel list	Yes	Yes	Yes	Yes	Yes
Mitigation					
Sharks	Fins<5%**	Fins<5%	Fins<5%***	Fins<5%	Fins<5%
Sea turtles	Release tool	Release tool	Release tool, Circle hook	Release tool	Release tool
Seabirds	Tori pole		Two types	Two types	Tori pole
Small tunas	Time-area closure	Full retention			
Others					

*Frozen but not for canning.

**Some species have to be released.

***Starts in 2011. Fins should be identifiable with matching carcass.

5.1.5 Fishing capacity

It is widely acknowledged that all tuna RFMOs are finding it more and more difficult to reach consensus on management measures. For example, IATTC adopted bigeye and yellowfin regulations for 2009–2011 only after failing to reach agreement in 2008. ICCAT also had great difficulty in adopting and implementing measures for the eastern stock of Atlantic bluefin, as did WCPFC in adopting the bigeye and yellowfin measure in 2008. The fundamental reason for such difficulties is the increasing fishing capacity which far exceeds the level necessary to harvest the world's tuna stocks at a sustainable level. Unfortunately, fishing capacity is often confused with fish carrying capacity. Fishing capacity is the capability of a fleet to catch fish relative to a reference point for tuna stocks. The most commonly used proxies for fishing capacity are, for longline fleets, the number of vessels and for purse seine fleets, the carrying capacity. The global increase in fishing capacity relates to the increase in the number of vessels and their size, as well as the increase in catchability due to technological advancement and at-sea transshipment.

The problem of excess fishing capacity has been recognized for over two decades. An International Plan of Action (IPOA) on fishing capacity was agreed upon by FAO in 1999 (Kirkley and Squires, 1999). However, progress with managing fishing capacity has been very slow, despite the fact that many studies of the issue have been conducted (e.g. Gillett, 2003; Joseph, 2003; Reid *et al.*, 2005; Miyake 2005b; Joseph, 2005; and Takase, 2005) and that FAO has created a Technical Advisory Committee on

Management of Tuna Fishing Capacity (the final report of this group was published as an FAO publication in 2005 [Bayliff, de Leiva Moreno and Majkowski, 2005]).

As reiterated throughout Bayliff, de Leiva Moreno and Majkowski (2005), modern fishing vessels are highly mobile. Thus, wherever regulatory measures are introduced, fleets have the potential to switch immediately to other less regulated fishing grounds or species (i.e. spillover effects). This is the reason that the management of fishing capacity must be considered on a global basis, and that harmonization among RFMOs is required.

FAO's Technical Advisory Committee on Management of Tuna Fishing Capacity: Conservation and Socio-economics identified that the current tuna fishing capacity is at least 30 percent higher than necessary to harvest a sustainable yield from current tuna stocks (Anon., 2007). The situation is further deteriorating due to the perpetual expansion of fishing fleets since the time of the FAO analyses, and the continuing exploitation of stocks at levels of fishing mortality higher than those corresponding to the MSY (see Section 3). The Committee recommended a moratorium on new vessels and rights-based management of fishing capacity, including development of an appropriate system to transfer capacity from developed to developing countries. This view has been further developed in several ways. In 2007, a meeting of the Joint Tuna RFMOs held in Kobe, Japan, emphasized the need to harmonize various management measures. Accordingly, many RFMOs either established an ad hoc group to study the management of fishing capacity and/or included this subject in their meetings' agenda. Also, many international meetings on this topic have been held, all of which supported the scheme and proposed further actions (e.g. IATTC and World Bank, 2008). However, these discussions usually focused on how to limit the number of vessels and/or fish-holding capacity without considering other aspects of the problem such as socio-economic issues.

As shown in Table 9, almost all the RFMOs have some kind of capacity control. These controls take many different forms, ranging from "the number of fishing vessels should not be increased from the current level" to a strict regional vessel registry system as adopted by IATTC in 2000. Another form of capacity control was adopted by IATTC in 2002 involving a limit of 158 000 m³ for the total fish-holding capacity of the entire Eastern Pacific Ocean purse seine fleet.

In limiting the number of vessels, the IOTC is more advanced than the other RFMOs. It has not permitted any new entries into the fishery since 2003 unless the new entry is replacing a currently registered vessel (IOTC, 2008a). It should also be noted that in previous years the PNA agreed not to increase the number of purse seiners in their EEZs above 205 (see Section 5.1.2 and 5.1.4).

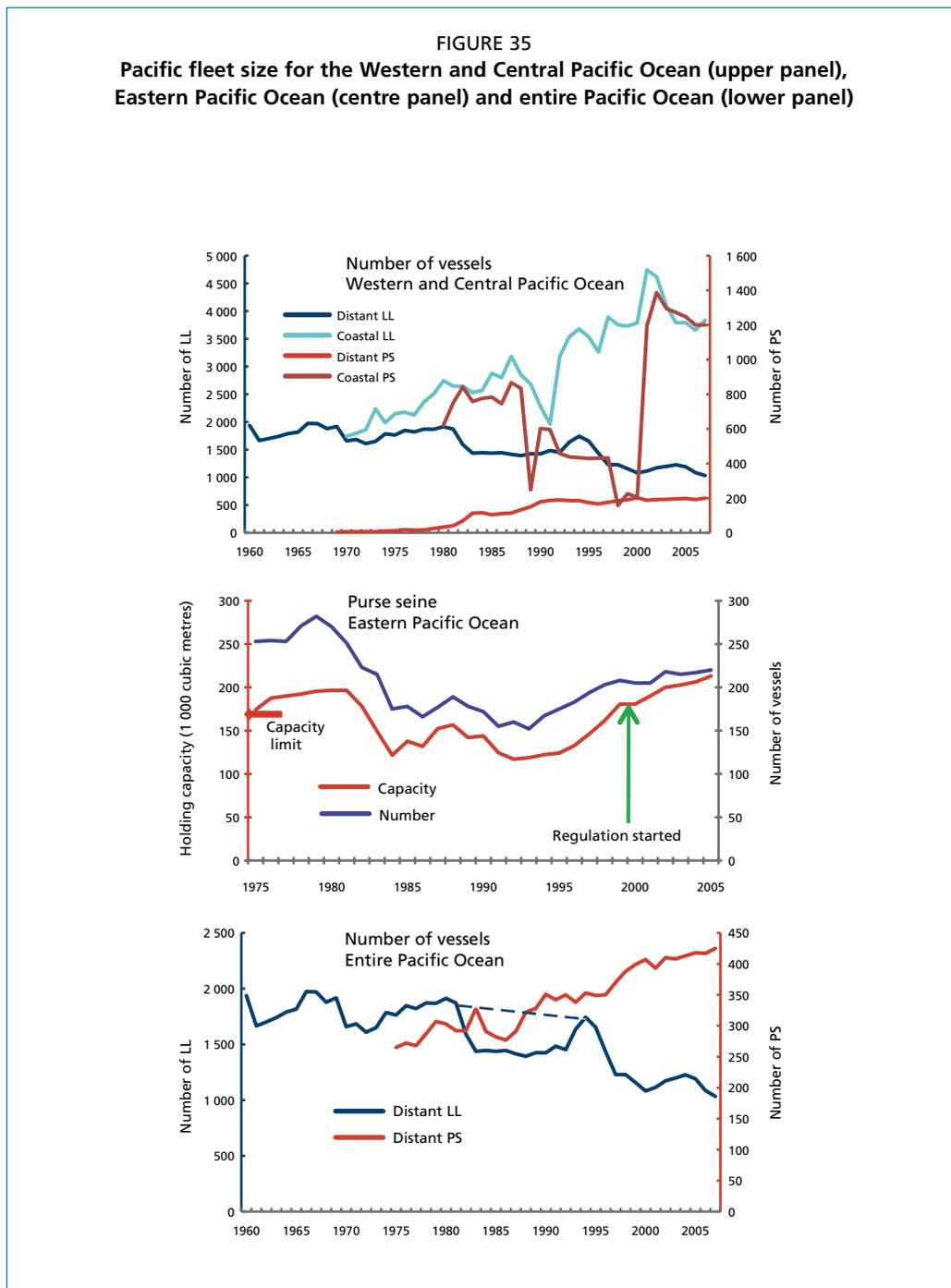
Several measures for the reduction of fishing capacity in longline fleets have been adopted by CPCs of the RFMOs, either individually or collectively. A programme to reduce longline fleets through buy-back and scrapping has been undertaken since the late 1990s by Japan, Taiwan Province of China, the Republic of Korea and later China and is described in Section 5.1.6 (IATTC and World Bank, 2008; Organization for the Promotion of Responsible Tuna Fisheries [OPRT]³).

In the case of both IATTC and IOTC, there are two basic practical problems encountered when trying to reduce fishing capacity: small vessels, and discrepancies between the numbers of active and registered vessels. As management measures are generally applicable only to vessels >24 metres in overall length, smaller boats are excluded. Nevertheless, small vessels often represent a substantial portion of the total fishing capacity. In addition, in order to maximize potential fishing rights, CPCs tend to register all of the boats licensed to fish in the particular area, even if all of these vessels are not necessarily active. The inactive vessels offer a potential increase of

³ See www.oprt.or.jp

fishing capacity when biological, social or economic conditions change. Both of these issues create problems for positive vessel lists as discussed below.

It is very difficult to estimate the number of fishing vessels actively fishing in an area. For the Indian and Atlantic Oceans only partial estimates are available. For the Eastern Pacific Ocean, estimates of active vessels are available for large purse seiners in terms of number and holding capacity in cubic metres (IATTC, 2008), while in the Western and Central Pacific Ocean, an estimate of the number of active coastal and distant water longliners and purse seiners is available (Lawson, 2008). The upper panel in Figure 35 shows the number of coastal and distant water longliners and purse seiners in the Western and Central Pacific Ocean based on SPC-OFP (2008) and Lawson (2009). Gillett (2007) also estimated the number of longline vessels and produced estimates



Source: Data provided by RFMOs.

which are only slightly different from these data. The separation of coastal and distant water longliners is based on expert judgement using information on the number of vessels and trips per country, species composition and catch per vessel. The record of the number of distant water longliners and purse seiners is quite complete. The number of distant water longliners matches figures held by the Organization for the Promotion of Responsible Tuna Fisheries (OPRT); see the following section. From these data it is evident that the number of distant water longliners is decreasing while the number of purse seiners is rapidly increasing, confirming and explaining the increasing catch by purse seine vessels in the Western and Central Pacific Ocean.

In contrast, the number of coastal vessels, particularly purse seiners, is highly uncertain. Large fluctuations appear to represent differences in reporting rates rather than changes in fleet size. The middle panel shows the number and holding capacity of large purse seiners in the Eastern Pacific Ocean (IATTC, 2008). The vertical green line indicates the date of implementation of the regional fishing vessel registry system; the small red bar on the Y axis shows the agreed target capacity level. With reference to the increase in purse seine fish holding capacity as discussed in Section 4.2.5, it is important to note that larger vessels are not necessarily more efficient in fishing. According to IATTC (2008), the catch per m³ of holding capacity is highest for vessels in the range of 1 100 to 1 500 m³, although larger vessels may have a different type of advantage such as the capability to stay at sea for a longer period of time before filling up the fish wells, as discussed previously.

The lower panel shows the total number of distant water longliners and purse seiners in the entire Pacific. It was assumed that all the distant water longliners that were active in the Eastern Pacific Ocean also operated in the Western and Central Pacific Ocean, and hence were double counted when the numbers from the two registers were added. The figures for longliners were thus adjusted based on this assumption. For purse seiners, there may be approximately ten purse seiners which are double counted; therefore, without further investigation an assumption was made to count these vessels only once in this analysis.

In conclusion, the need for management of fishing capacity is widely recognized. The control of fishing capacity alone cannot solve all conservation problems, but it will facilitate the establishment of other regulations such as TACs and time-area closures. Furthermore, despite the necessity of rights-based approaches, developing a practical and effective system which allows for the smooth handover of rights held by current users to new users is likely to be fraught with difficulties. There is also the problem of allocation of rights between fisheries, e.g. between gear types. Resolution of these issues is likely to be the key factor influencing the tuna industry as a whole.

From the examination of information on catch trends by gear type, development of coastal or small scale fisheries, management measures taken for fishing capacity of various gear types and trends in fleet size and capacity (in terms of number of vessels and fish-holding capacity), it is apparent that distant water longline fishing capacity is declining while purse seine and coastal longline capacities are increasing. These trends would be expected to result in increasing catches of small fish, lower Y/R and MSY, and more difficult fishery management on a global basis for all stocks, with the exception of skipjack (see Section 4.2.7). Such trends are predicted based on the current environment, i.e. the low price for *sashimi* despite the high cost of its production and an increasing demand for canned products based on the high efficiencies associated with purse seine fisheries. However, if demand for canned tuna does not increase, and/or the price of *sashimi* goes up reflecting higher production costs and declining longline catch rates in the near future, the trends may be reversed.

5.1.6 IUU problems and trade measures

When ICCAT implemented several restrictive management measures in the 1980s, some fishing vessels of CPCs changed their flags to non-contracting parties, mostly with open registries, and continued unregulated fishing (Box 1). As the management measures were not binding upon the non-contracting states, this provided a useful opportunity for the operators to fish in an unrestricted manner and such flag of convenience (FOC) operations increased rapidly. Such operations came to be labelled as IUU fishing and the world became aware that IUU catches undermine the effectiveness of management measures, increase uncertainties in scientific research, and in the end endanger tuna stocks.

The bottom panel of Figure 35 shows the fishing capacity in the entire Pacific. The apparent decline in the number of distant water longlines during the early 1980s to late 1990s most likely represents a conversion of vessels to IUU fishing activities. The number of IUU distant water longliners at that time is estimated to be around 300 vessels (Miyake, 2005b), and if so, the actual number of distant water longliners did not decline so rapidly (dotted line in Figure 35).

Because ICCAT was the first RFMO to initiate strict tuna regulation (initially on Atlantic bluefin and bigeye catches in the 1980s and 1990s, respectively), the IUU fishing problem was first recognized as a serious problem by ICCAT. Since 1993, ICCAT has implemented a system referred to as the Atlantic Bluefin Statistical Document Program (BFTSDP). All of the ICCAT CPCs can only import BFT (at first it was in frozen form only, but later fresh forms were also covered) if accompanied by a document showing from which vessel the product originates, as certified by the flag state or its authorized agency. This system was expanded later to bigeye (although catches destined for canneries are exempted from the scheme) and swordfish. IATTC and IOTC have adopted similar systems.

The BFTSDP itself does not itself restrict the import of illegally caught products, but it does help to identify flag states which operate IUU vessels and to approximate the amount of such catches. In 1994, ICCAT adopted an Action Plan (implemented in 1995) which specified non-discriminatory trade restrictive measures that could be taken against the countries involved in IUU fishing, if steps to identify such activities are properly taken by the Commission and if flag states fail to rectify their IUU fishing activities. As a result, trade sanctions were adopted for several IUU vessel flag states. Such action was very effective in curbing IUU fishing activities. In 2007, ICCAT adopted a Catch Documentation Program for Atlantic bluefin to replace the BFTSDP. The new scheme not only covers all Atlantic bluefin trade but also applies to all catches of Atlantic bluefin which must be reported and checked at the point of landing.

Along with these actions to combat IUU fishing, distant water longline countries established the Organization for the Promotion of Responsible Tuna Fishing (OPRT), which coordinated the buy-back and scrap policy to reduce fishing capacity by major distant water longline countries (IATTC and World Bank, 2008; Box 4). Table 10 lists the number of distant water longline vessels of OPRT members. The total number of distant water longliners registered with OPRT had increased between 2001 and 2004, as IUU vessels were integrated into the system and legalized. Thereafter, the number of vessels started to decline due to the buy-back and scrap policy.

In conjunction with trade actions, ICCAT, and later all the other RFMOs, developed lists of IUU vessels. They adopted several conditions to identify, recognize, and list or unlist a vessel as an IUU vessel. For this purpose, the data collected from the BFTSDP was very useful. At year-end 2008, there were 22, 22, 3 and 2 distant water longline vessels on the ICCAT, IATTC, IOTC and WCPFC IUU vessel lists, respectively. Because more than ten vessels are duplicated among the lists, the actual number of IUU distant water longliners is likely to be less than 30.

BOX 4

Buy-back and scrap policy

A buy-back and scrap policy was adopted by Japan and later by Taiwan Province of China. It consisted of the following steps:

1. All flag of convenience (FOC) and/or IUU longliners owned or operated by Japanese or Taiwan Province of China nationals were re-registered to their home countries.
2. Both countries have limited entry systems. The limit was reduced, for example, by 20 percent in Japan. The government then repurchased the licences of those who volunteered to cease fishing so that total GRT was brought within the decreased limit. (Hence, the bought-back vessels did not add capacity to the national fleet.)
3. The funds for the buy-back were initially provided by government loans and ultimately by the contributions of boat owners who decided to continue fishing.
4. The vessels for which the licences were bought back were all scrapped.

In Japan, most of the buy-backs proceeded from Step 2, as very few FOC/IUU vessels were operated by Japanese owners. Japan also paid for the buy-back of Taiwan Province of China IUU vessels, which had been built in Japanese shipyards but were at the time operated by Taiwan Province of China owners and/or reflagged to Taiwan Province of China or to other countries.

In the end, about 15 percent of the total number of distant water longliners were scrapped. The Organization for the Promotion of Responsible Tuna Fisheries was established to promote this system and is now tracking and monitoring all the ex-IUU vessels reflagged to third countries, such as Vanuatu and the Seychelles. Those distant water longliners are now properly licensed by and reporting to the new flag states.

TABLE 10
Number of distant water longline vessels registered with OPRT by flag countries or fishing entity
(as of March 2009)

	November 2001	March 2002	March 2003	March 2004	March 2005	March 2006	March 2007	March 2008	March 2009
Japan	495	490	495	473	434	381	363	360	254
Taiwan Province of China	562	562	599	597	600	526	420	392	369
Korea, Republic of	–	183	176	174	172	172	160	156	148
Philippines	–	6	17	17	18	26	28	28	26
Indonesia	–	–	14	14	14	14	15	17	17
China	–	–	–	105	113	113	117	121	136
Ecuador	–	–	–	–	5	4	4	4	5
Seychelles	–	–	–	–	–	–	–	27	27
Vanuatu	–	–	–	48	48	48	48	48	48
Fiji	–	–	–	–	–	–	–	–	19
Total	1 057	1 241	1 301	1 454	1 425	1 305	1 176	1 153	1 049

Meanwhile, the RFMOs recognized that some of the vessels that were not listed on the IUU vessel lists did not have authorization from CPCs to fish in the RFMO area. Therefore, it was decided to develop lists of legally authorized fishing vessels (“positive lists”). Consequently, all the RFMOs, in addition to adopting IUU vessel lists, have adopted so-called positive lists, which are lists of tuna fishing vessels that are authorized to fish by the flag states of CPCs of the RFMOs. Some RFMOs and some countries have adopted regulations that prohibit catches made by a vessel not included on the positive list from being imported. As discussed above, flag states tend to list

all potential fishing vessels on the positive lists regardless of whether they are actively fishing, and thus the positive lists are not useful in estimating active fleet sizes.

5.2 ECOSYSTEM CONSIDERATIONS – BYCATCH⁴ ISSUES

Since the late 1980s, global interest in ecosystems has been heightened and this has begun to have a major effect on tuna fisheries. This paper does not intend to present a detailed discussion of bycatch in terms of species, biology, ecology and interactions with the fisheries. However, the multispecies nature of tuna fisheries does not allow a simplistic focus on target species alone.

The first bycatch-related conflict with tuna fisheries was the issue of fishing on schools associated with dolphins in the Eastern Pacific Ocean (Joseph, 1994; Teisl, Row and Hicks, 2002). As a result of increasing interest in reducing incidental mortality of other species due to tuna fishing, FAO agreed to three IPOAs – on sharks, seabirds and turtles – in 1999. Since then, RFMOs have paid considerable attention to bycatch problems and initiated measures to mitigate incidental mortality to these animals even though RFMOs' Conventions do not clearly define responsibilities for conservation of most of these species.

Current management plans and research on mitigation for these marine animals are briefly summarized below. In addition, RFMOs are keenly interested in mitigation of small tuna catches of target species in order that these resources may be utilized more effectively. Therefore, research on mitigation of catches of small tunas is also summarized.

Table 9 provides a summary of management measures adopted by RFMOs. It should be noted that this paper does not aim to pass judgement on these management measures but only to report factual information about them.

5.2.1 Sharks

One key difference between shark bycatch and sea turtle and seabird bycatch is that sharks have been widely used as human food. In fact, many fisheries target sharks. The concern regarding sharks therefore is related to whether the catch is fully utilized and whether it is sustainable. For this reason, shark management plans include various aspects such as stock assessments, enforcement of full utilization requirements, and mitigation of undesirable and/or non-sustainable impacts.

Statistics on shark catches have been poor in all oceans because they are often considered bycatch and many of the reporting systems have allowed all shark species to be combined into a single reporting category. However, since the adoption of the IPOA-Sharks, many RFMOs have started to require reporting of catch statistics by species. Nevertheless, these data are expected to represent only retained catches of major species. Mining of historic catch data is difficult but has been attempted for some species (Nakano and Clarke, 2006). In addition, ICCAT shark stock assessments have used known ratios of shark and tuna catches from fleets which report sharks (ICCAT, 2007) as well as estimates based on shark fin trade data (Clarke, 2008) as alternatives to reported shark catch data. Despite the use of these techniques, shark stock assessments entail considerably more uncertainties than tuna stock assessments.

ICCAT has prohibited catches of certain species of elasmobranchs (sharks, skates and rays) which are considered to be overexploited. In addition to this, all tuna RFMOs have adopted measures stating that the whole carcass of sharks should be retained if the shark fins are retained. At present, most of these measures state that the fins must be less than 5 percent of the weight of sharks; however, the form of the shark weight, i.e. dressed versus live, varies among the measures. The appropriateness of the 5 percent

⁴ IATTC defines bycatch as anything caught and discarded. In this paper a more general definition is used, i.e. non-target fish (of species or size) caught during fishing activities regardless of whether they are retained, discarded or released alive.

fin to carcass ratio has been studied by various researchers (Kim *et al.*, 2007a; Hareide *et al.*, 2007; IOTC, 2007b; IOTC 2008b). The scientific conclusions so far are that one ratio such as 5 percent is not appropriate for all species, and that the appropriate ratio for any given species may vary with area and time, size of fish and the way the fins are cut. Some countries have adopted domestic regulations stating that no fins can be unloaded unless they are physically attached to the carcass. This type of regulation would have a major effect on distant water longliners operation and may cause dead discards of sharks to increase.

Another major issue for tuna fisheries is the damage to tunas caught on longline hooks by sharks. Depending on area and season, such depredation rates can be high and thus cause substantial losses to the value of the catch. For this reason there is much interest among fishers in finding ways to decrease shark depredation.

5.2.2 Sea turtles

Most of the information on the interaction of sea turtles with tuna fisheries is focused on longlines, despite the fact that they are also caught in purse seines. In the case of purse seines, the mortality appears low if the sea turtle is released. As many studies have been conducted on interactions between sea turtles and tuna fisheries, it is not possible to cite all of them here. Summaries and details of the studies can be found in the reports of the working groups on ecosystem and bycatch of each RFMO (e.g. ICCAT, 2008, ICCAT, 2009b, IOTC, 2007b; IOTC, 2008b).

According to the various studies concerning longline fisheries, most of the incidental hooking of sea turtles occurs with shallow (<200 metres from the surface) hooks (particularly of longlines targeting swordfish). However, deeper hooks may also catch sea turtles as the hooks pass through the shallow layers during casting and hauling.

It has been demonstrated that circle hooks reduce sea turtle bycatch rates considerably from conventional J-shaped hooks and particularly reduce the mortality of sea turtles as they do not swallow the circle hooks as deeply as they do with the conventional “J” hooks (e.g. Itano, 2006). Various studies have indicated however that the catch rates of target species may also be affected by substituting circle hooks for J hooks. The effects are quite variable by area, time of day, season, size of hooks used and target species. Some investigations of circle hooks show higher catch rates for target tunas whereas others show lower rates for target species (e.g. Watson *et al.*, 2005; Ariz, *et al.*, 2008; Domingo *et al.*, 2008; Kim *et al.*, 2007b; IOTC, 2008b).

All of the RFMOs have adopted management measures requiring that tuna fishing vessels carry equipment to release hooked sea turtles with the minimum amount of damage. In addition, WCPFC adopted a measure in 2008 which states that swordfish longliners fishing in shallow (<100 metres) waters should use only large circle hooks and only whole finfish as bait. This regulation will be implemented in 2010. Thus far, no other RFMO has adopted any requirements for the use of circle hooks, but such requirements may be adopted in the near future.

Potentially, the effects of regulations requiring circle hooks on tuna fisheries would be that the catch rates of target species might be reduced, the baiting of hooks might take more time or become more complicated, and the cost of hook substitution could be an issue.

With regard to the purse seine fishery, IATTC adopted a regulation requiring that all sea turtles captured in purse seines must be immediately released to the sea.

5.2.3 Seabirds

As for sea turtles, most of the information on interactions of seabirds with tuna fisheries is focused on longlines, particularly at relatively high latitudes in both the northern and southern hemispheres. Overlaps in time and area between the distribution of seabirds and the distribution of the tuna fishery and the rates and depths of seabird

TABLE 11
Seabird mitigation options (one method has to be chosen from each column)

Column A	Column B
– Side setting with a bird curtain and weighted branch lines	– Tori line
– Night setting with minimum deck lighting	– Weighted branch lines
– Weighted branch lines	– Blue-dyed bait
– Tori line	– Deep setting line shooter
– Weighted branch lines	– Underwater setting chute
	– Management of offal discharge

hooking have been studied intensively and are well summarized in IATTC (2007) and Melvin and Barry (2006). The development of various mitigation methods has been incentivized because seabirds are unwanted bycatch. Due to the variability in seabird and tuna fishery interaction rates among areas/time periods, the mitigation measures adopted by various RFMOs also vary (Table 9).

The strictest measures have been taken by WCPFC (Table 11) and IOTC. For example, the CPCs will require their longline vessels to use at least two of several clearly defined mitigation measures (for example, the length of the Tori pole, i.e. a line with streamers). On the other hand, ICCAT and CCSBT require longliners to use Tori poles in certain designated fishing areas. IATTC has discussed this issue but has not yet adopted any regulations. These types of regulations have a negative effect on the efficiency of longlines, by restricting the duration of some operations and increasing operating costs.

5.2.4 Small tunas

Small tunas caught by purse seines, particularly from the schools associated with FADs, are discussed in many places in this paper (notably in Sections 4.2.6 and 4.2.7). There are two basic problems inherent in the catch of small tunas: a reduction of Y/R or MSY, and a high fishing mortality on bigeye, which is not the major purse seine target species. Restriction of fishing on FAD schools to protect small bigeye would affect purse seine catches of skipjack (and yellowfin), which in most cases do not warrant such management for their own sake.

A minimum size limit of 3.2 kg for yellowfin and bigeye was adopted by IATTC and ICCAT but was later rescinded as it was not effectively enforced. ICCAT has adopted area-time closures for FAD fishing and, more recently, limited all purse seine fishing to a smaller area. IATTC previously adopted a measure requiring full retention of all captured tuna, unless they were not fit for human consumption, but these regulations have been discontinued. There are no other regulations mitigating the catch of small fish.

Techniques to reduce or effectively mitigate the catches of small bigeye would benefit both longlines and purse seine fisheries as well as tuna resources. Hence, much research on this topic has been conducted, including:

- surveys on fish behaviour under FADs (Itano, Holland and Dagorn, 2006; Moreno *et al.*, 2007; Satoh *et al.*, 2008; Schaefer, 2008);
- methods to identify fish species in the school;
- type or construction of FADs (Schaefer and Fuller, 2008);
- gear characteristics (Cleridy *et al.*, 2007; Itano, 2006; Itano, 2007a; Itano, 2007b);
- fishing methods (e.g. depth of nets) (Itano, 2007b); and
- fish escaping racks (Anon., 2008b).

At present, no effective measures to fully mitigate the catch of small fish have been found. However, such research should be strongly encouraged for its ability to solve many of the problems facing bigeye stocks, to profit both longline and purse seine sectors, and to provide for a dramatic shift in tuna fishing operations.

6. Trade, processing, markets and consumption

6.1 DATA UNCERTAINTIES IN TRADE, PROCESSING AND CONSUMPTION

The quantity (weight) of various products such as fresh/chilled or canned products is not directly comparable among each other or with catch weights. These products are generally quantified in processed weight (e.g. net canned weight, weight of fresh fillet, loins, and gilled and gutted) and cannot be compared unless a common unit, such as round weight, is given or if the processed forms of products are well specified and the conversion factors are known. However, conversion factors are quite variable among product types, processors, species and sizes of fish. Furthermore, product types are often not specified in trade and market data, thus the reported statistics cannot be converted into round weight (Box 5).

Furthermore, product classifications in trade, consumption and market statistics, even if specified, are often inconsistent or ambiguous. For example, frozen fish can be classified as fresh fish if the fish is thawed and then sold as fresh. In addition, so-called fresh fish can be used for both *sashimi* consumption and steak-type cooking and there is no way to isolate these two products in the statistics. As well as other forms being called fresh, fresh fish can be described as other forms, e.g. ice-kept (fresh) albacore can be used for canning.

BOX 5

Product type and conversion factors

Round weight refers to the wet weight of whole fish. Most of the fish caught by industrial surface gear types are frozen in round form – because most of the fish are relatively small and caught in bulk – and stored directly into fish wells for brine freezing.

Industrial longline catches are generally processed on-board before freezing. Small albacore are generally kept in round form, but large albacore and other species are gilled and gutted (GG), i.e. gills, fins and viscera removed. Billfishes (including swordfish) are dressed, i.e. head, fins and viscera removed.

After being unloaded, fish can be further processed. For the fresh fish market, some bluefins are sold only for their high fat content belly meat (only the belly is cut off in a diamond shape). Some large fish are sold as fillets (sliced off the bone on both sides), blocks or loins (each fillet cut further into dorsal and ventral parts), or small blocks (ready to be sold in supermarkets as *sashimi*). Tuna to be used for canning are at present usually transshipped as loins. These loins consist of fully cleaned fish ready for vacuum packing (i.e. filleted, skin removed, bones taken out and boiled).

Canned products are expressed in net weight, i.e. the total weight of a whole packed can minus the weight of the container.

The following factors are used by ICCAT for conversion to round weight of various products of farmed Atlantic bluefin:

Belly meat: 10.29	Dressed: 1.25	Fillet: 1.67
GG: 1.13	Others: 2	Round: 1

However, factors for converting products to live weight are highly variable depending on area, time, species and size of fish.

In the Eurostat database there is a category entitled “frozen tuna, excluding for processing (aggregated HS codes 03034190 to 03034990)”. This includes products for the fresh fish market as well as those for further processing. Similar problems also arise in FAO’s Commodities Production and Trade database, because Eurostat reports data for the European Union to this database. If the fish for the fresh fish market have to be estimated, it is important to consistently and accurately distinguish fresh fish between market and canning uses through ancillary information on importers and exporters, species, and/or values per unit weight. For example, skipjack and yellowfin imported by Spain from, for example, Puerto Rico, the Seychelles, Senegal, Ghana, Ecuador and Côte d’Ivoire, are considered to be for canning. It should be noted that many past reports analysed the tuna trade and market but ignored the issues involving product types.

A further complication is that in Japanese market and consumer statistics “tuna” includes billfishes (swordfish and marlins), but skipjack is excluded and grouped with bonito, little tuna, black skipjack and frigate tunas. The reason is that tuna-like fish caught by longliners (tunas and billfishes) and those caught by baitboats (skipjack and other skipjack-like fish) are considered to be two different categories in Japanese terminology. As there are some differences in cooking methods, many Japanese do not recognize skipjack as tuna. Even now skipjack cannot legally be labelled as tuna according to Japanese food regulations. Therefore, canned tuna sold in the Japanese market is classified separately from canned skipjack. When interpreting Japanese reports and statistics, these differences should be kept in mind in order not to misinterpret the data.

Since the European Union is considered to be one market, it is difficult to track the movement of fish among the member states since such movements are not considered to be international trade. In many countries, including the European Union, some tuna products imported from one country are re-exported to another after further processing. The FAO database contains re-export data, but the countries supplying data to FAO may not record re-exports separately and thus some of the FAO “export” data is suspected to actually be re-exports.

In this document, tuna prices are discussed in various sections. The price cited for products being traded generally refers to the declared (on import or export) product value divided by product weight. These data are the basis for the value data reported in the FAO Commodities Production and Trade database. However, the average price of fish sold (or auctioned) in the market refers to the actual price recorded in sales slips. Ex-vessel prices generally refer to the total sales (in value) divided by the weight of fish. The issues described above concerning incompatibilities between different product weight types are thus also applicable to fish price per unit weight.

6.2 SASHIMI INDUSTRY

In this document, fresh consumption refers to both tuna consumed raw (*sashimi*) or cooked (steak-type) regardless of whether the original material was fresh or thawed tuna. Therefore, even frozen fish can be included in fresh consumption. For the definitions of *sashimi* and *sushi*, refer to Box 6.

Consumption of tuna in fresh form has occurred for many years in many parts of the world. In the Atlantic, Pacific and Indian Oceans various artisanal fisheries near islands in tropical waters, as well as around Japan, have provided both fresh and dried fish for local consumption for centuries (Miyake, Miyabe and Nakano, 2004; Miyake, 2007). Many skipjack and tuna bones have been found in village ruins dating from around the second century before Christ in Japan. European and Mediterranean countries are no exception. Migration routes and cooking methods of Atlantic bluefin were described by Aristotle, and tuna trap catch data around the Mediterranean are available from the eighth century (Miyake, Miyabe and Nakano, 2004; Sara, 1983). The

BOX 6

Sashimi and sushi

Sashimi and *sushi* are now internationally recognized terms, but they are frequently misused. *Sashimi* is sliced raw fish meat served on a plate with various vegetables for decoration.

Sashimi is generally eaten after dipping in soy sauce spiced with a vegetable such as ginger, horseradish or radish. Until the 1950s, the red meat of tuna was the most popular for *sashimi*. However, over the last several decades Japanese tastes have changed, which is mainly due to media influence (see Section 8), and the preference now is for “*toro*”, the peripheral layer of the fish belly. On this basis, tuna species with high fat content, i.e. primarily bluefins but also bigeye and yellowfin, are the most highly valued species. Albacore, which was previously appreciated for its red meat, is only still popular in the western part of Japan.

Fat content is very closely related to the size of fish and the seasonality of the catch. Those caught in cold water feeding grounds and just before spawning have the highest fat content. Consumers in eastern Japan have a stronger preference for fatty dark red meat and hence Atlantic bluefin, Pacific bluefin, southern bluefin and bigeye are preferred. In western Japan, pink-coloured meat is preferred and thus yellowfin and striped marlin are preferred.

Sashimi is often laid on top of vinegar-treated rice, and thus called *sushi*. The original *sushi* is a Japanese traditional food of rice and raw fish pickled for many days and/or months together with yeast so that it becomes fermented and sour though not rotten. *Sushi* is not limited to tuna but tuna is one of the primary *sushi* materials. Because Japanese like red and white colours interspersed as symbols of good fortune, it is essential to include both white meat and red meat in *sushi*.

Norwegian purse seine fishery and the Bay of Biscay albacore fishery also have long histories of providing products for local fish markets.

Statistics for fresh fish products tend to aggregate *sashimi* and other fresh fish for cooking. Therefore, it is very difficult to understand the *sashimi* market separately from the steak-type fresh fish market. However, until the 1990s, *sashimi* was almost exclusively consumed in Japan, and most Japanese fresh tuna (including frozen but sold as fresh) was primarily used for *sashimi*. For this paper, the review of *sashimi* covers only the Japanese market over the last two to three decades.

6.2.1 Some history and facts on *sashimi* culture

When cold chain distribution became firmly established in the 1940s and 1950s, *sashimi* and *sushi* spread throughout Japan. The market grew faster and further particularly after the establishment of super-cold freezer chains. Taste for *sashimi* has spread rapidly to Europe and North America, mostly due to people’s preference for healthier food but also due to the fact that people have become much less conservative in trying foreign food (see Sections 6.3.2 and 6.3.3). Nevertheless, the Japanese market is still the largest and most influential market for *sashimi*-quality tuna and for this reason the discussion in this section concentrates on Japanese markets and consumers.

The most preferred tuna species are bluefins (Atlantic bluefin, Pacific bluefin and southern bluefin), followed by bigeye and yellowfin. Albacore was not eaten as *sashimi* or *sushi* until the 1980s. In the late 1980s, the Japanese industry launched a publicity campaign to encourage albacore to be eaten as *sashimi*. When Japanese started to be attracted to fatty tuna, they associated fatty tuna meat (which is generally whiter than

lean meat) with light-coloured albacore meat. This association, though mistaken, also promoted consumption of albacore *sashimi*. When examining the history of the Japanese tuna industry it is important to note a history of substitutions between species, between fresh and frozen tuna, and between domestic and imported tuna (Yamamoto, 1994; Owen and Troedson, 1994; Bose and McIlgorm, 1996). Chiang, Lee and Brown (2001) examine the impacts of inventories on tuna auction prices in Japan and claim that frozen tunas are more likely to be close substitutes for fresh tuna of the same species than substitutions of fresh fish of other species (see Section 6.2.4).

Skipjack is not considered a tuna by Japanese markets and consumers. It is traditionally prepared in seared form (slightly grilled on the outside) with vinegar, soy sauce, ginger and either garlic or onion. In the late 1990s, the tuna industry launched a strong campaign to eat frozen skipjack as *sashimi*, which has resulted in some consumption of skipjack in this form. However, the proportion of consumption of real *sashimi* skipjack is still minor. On the other hand, in many Pacific Islands skipjack is the primary material for tuna *sashimi* and the consumption of skipjack is substantial.

6.2.2 Supplies for *sashimi* (or fresh fish market)

Until the 1960s, all tuna fishing vessels unloaded directly to markets where fish were sold through auctions. However, as super-freezer technology began to produce frozen tuna suitable for the *sashimi* market, the situation changed completely. When Japanese fishing vessels or transshipment vessels carrying catches made by Republic of Korea or Taiwan Province of China arrived at Japanese ports, fish were directly transported to land-based super freezers by a buyer or a trader who had financed the fishermen to conduct the catching operations.

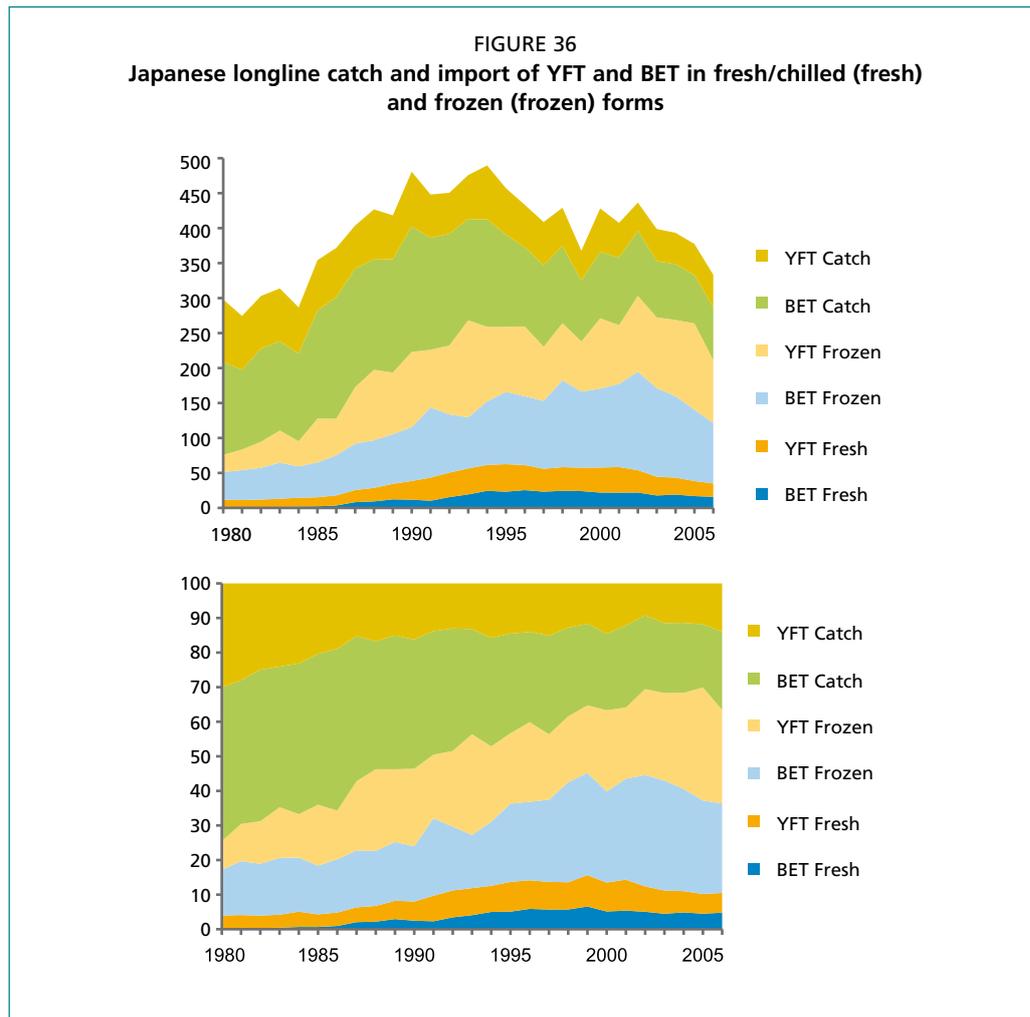
Since the 1970s, landings at foreign ports to offload tuna for onward shipment to the Japanese *sashimi* market became quite common, and later at-sea transshipment became the major supply route (see Section 4.2.3). This reduced costs by avoiding unnecessary transit of the fishing vessels between Japanese ports and fishing grounds.

Figure 36 shows Japan's national catches (catch) and imports (fresh/chilled combined [fresh] and frozen [frozen]) of yellowfin and bigeye. The catch data are in round weight and derive from the same sources as used in the previous sections. Import data are taken from the FAO Commodities Production and Trade database, and are in various units of product weight, hence they are not directly comparable. Data for 2007 and 2008 are incomplete, particularly for imports, and are not shown. The upper panel gives the quantity and the lower panel shows their proportions.

In this figure the Atlantic, Pacific and southern bluefins are not included as their quantity is minor when compared to that of bigeye and yellowfin and because the import data for these species appear to be incomplete. Japan's imports of Atlantic bluefin and southern bluefin are predominantly those of farmed tuna, which are discussed separately in Section 4.2.8. Albacore are also not included in Figure 36, because only a portion of domestic catches are used for *sashimi* and albacore imports are generally used for canning.

From Figure 36 it is clear that Japan's catches and imports both steadily increased until 1995 and thereafter the catch decreased while imports continued to increase until 2002. Since 2003, both catches and imports have declined. Judging from the latest online market reports for the Tokyo Central Wholesale Market (Tsukiji), it seems that this tendency continued in 2007 and 2008. It is particularly noticeable that the share of market supply of *sashimi* derived from domestic production (i.e. catch by Japanese flagged vessels) decreased from over 70 percent in 1980 to less than 40 percent in recent years.

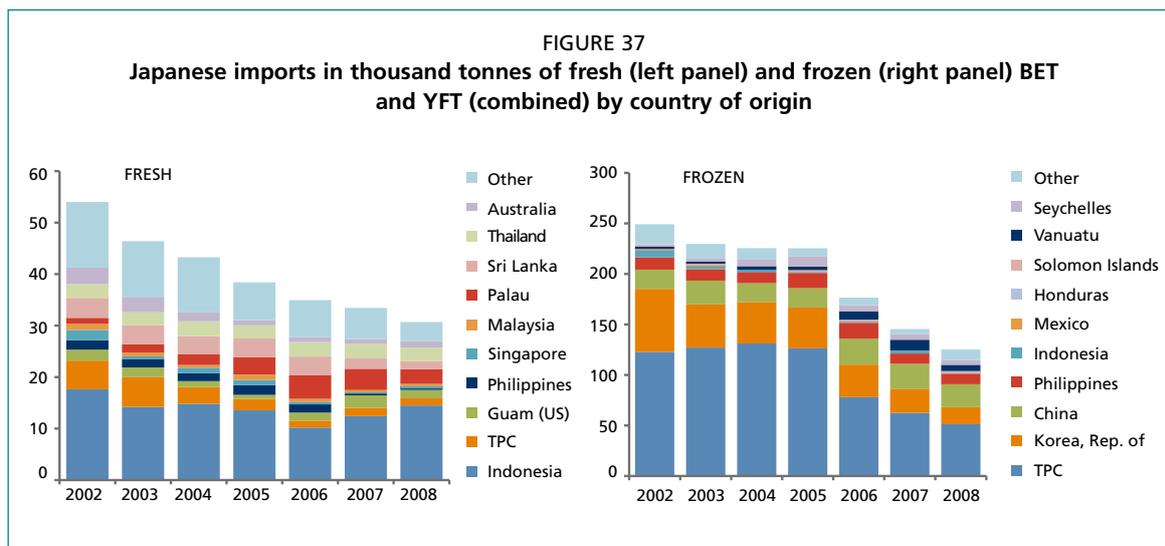
Japan's domestic supplies are fairly accurately recorded based on catch data in round weight. They have shown a continuous decline from 250 000 to about 180 000 tonnes during this period. Although there are some uncertainties, imports appear to have



Note: Quantity in thousand tonnes (upper panel) and share in percent (lower panel).
Source: FAO Commodities Production and Trade database; RFMO catch databases.

decreased somewhat from a peak in 2002. The decrease in imports should however be viewed with caution because the amount shown represents the weight of processed products. In earlier years, fish used to be imported in gilled and gutted form (slightly less than 90 percent of round weight). However, more recently, products have been imported in more reduced forms, for example, as small, vacuum-packed blocks ready to be sold as *sashimi*. Assuming the conversion factor for gilled and gutted weight to *sashimi* block weight would be less than 0.5, the imported weight of the same fish is less than half what it used to be. At least a part of the decline in imports therefore reflects changes in product form.

Understanding which countries are supplying tuna to the Japanese market is difficult because the statistics are complicated and there are discrepancies between sources. The best source of data is Japan's Ministry of Finance customs data, but reporting format and procedures have changed over the years, and like all trade data are subject to variation over time due to changes in product form. Due to a change in reporting procedures in 2001, only the data since 2002 are given in Figure 37. Despite identifying these data as the best source, it should be noted that they do not match the FAO Commodities Production and Trade database. The major supplier (~50 percent) of fresh tropical tuna is Indonesia (left panel), while Taiwan Province of China has been and is still dominating frozen tuna imports (right panel). The country of origin shown is inconsistent as it may be either the point of export (Singapore, Malaysia and Guam) or the flag of the fishing vessel.

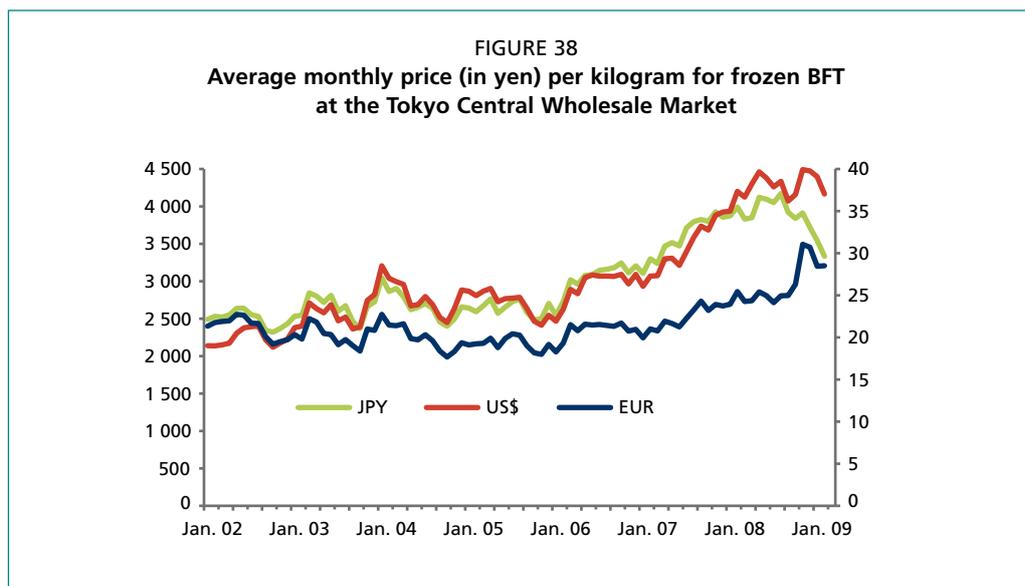


About 40 000 to 50 000 tonnes (if Atlantic and southern bluefins are included, the figure rises to about 60 000 tonnes) of tuna are imported in fresh or chilled form, while frozen tuna imports total between 150 000 and 250 000 tonnes. Both quantities have been declining during this period, in parallel with the trends shown in Figure 36. In fact, as shown in Figure 36, 2002 represents the historic high for tuna imports.

Frozen tuna are mostly transported by freezer reefers, but most of the fresh fish are transported by air. Air transport began in the 1960s when Atlantic bluefin caught by trap in Magnolia Bay, Canada, was flown to Japan. Because the price of Atlantic bluefin in Japan in the 1980s was extremely high – about US\$100 to US\$300 per kg at the Tsukiji Market – the cost of air freight was justified. The first large-scale air transport involved Atlantic bluefin caught off New England in the United States and transported via New York to Narita International Airport. This operation established both trade routes and efficient shipping technology involving wrapping fish with large plastic sheets and packing them with ice in a cardboard box. Later these techniques were applied in many other places, from Spain and Paris (France), for wild Atlantic bluefin; Australia for southern bluefin; Singapore, Jakarta (Indonesia), and Bangkok (Thailand) for bigeye and yellowfin; and, most recently, from Tijuana (Mexico) for farmed Pacific bluefin.

The establishment of regularly scheduled air transport routes enabled the development of small coastal longline fisheries based on fresh (iced) fish, as well as Atlantic, Pacific and southern bluefin farming. Although in some cases the development of such fisheries was enabled by air transport routes, in other cases air transport routes developed because of these fisheries. One example of the latter was the development of tuna air freighting from southeast Asia to the United States (primarily Los Angeles) to coincide with the sharp increase in the market for tuna steaks in the United States. This kind of “chicken and egg” situation is apparent in many aspects of the tuna industry (e.g. development of the canning industry and the purse seine fleet).

Atlantic bluefin farming began as an important activity in Spain and later spread throughout the Mediterranean (see Section 4.2.8 and Box 3). In response to supply and demand, Atlantic bluefin are landed, bled, processed (generally gilled and gutted or dressed), super frozen (-60 °C) and shipped to Japan by sea (reefer container), or sent in fresh form by air freight reaching the Japanese market within 48 hours after harvest. The combination of farming operations and air freight have a special advantage in that fresh fish can be shipped by air year-round in response to market demand.



Note: Price equivalents in dollars (US\$) and euros (EUR) are calculated using the exchange rate at the time of sale.
Source: Tokyo Central Wholesale Market and Japan Statistics Bureau.

Almost all of the Mediterranean farmed Atlantic bluefin were exported to the Japanese market until 2007 (ICCAT Secretariat, BFTSDP unpublished data). However, as production costs went up due to increasing prices of stocking, labour and bait, and the prices paid by the Japanese market fell, particularly due to the increased value of the euro, fish farmed in developed countries such as Spain and Italy earned very little or no profit in the Japanese market. At the same time, Mexico started producing farmed Pacific bluefin with a lower production cost and became very competitive with European products in the Japanese market. As a result, a portion (assumed to be <5 percent in early 2008) of Mediterranean-farmed Atlantic bluefin has been sold into the European market, mostly into Spain, France, Italy and the United Kingdom of Great Britain and Northern Ireland (ICCAT Secretariat, BFTSDP unpublished data). Almost all the farmed Atlantic bluefin from Croatia, Malta, Tunisia and Turkey is still exported to Japan as the economic break-even point in production cost is less for these operations than it is for the operations in Spain and Italy. More discussion of farmed tuna is provided in Section 4.2.8.

Figure 38 shows monthly frozen bluefin prices per kg at the Tokyo Central Wholesale Market in yen (left axis), and in United States dollars and euros (right axis) using official monthly monetary exchange rates (Statistics Bureau, Japanese Cabinet Bureau, unpublished data). Frozen Atlantic bluefin prices are shown because they are likely to be most representative of Mediterranean farmed tuna prices. The data indicate increasing prices in yen from early 2006 until recently, whereas the price in euros has been stable or increased at a much lower rate. The increase in the Japanese price was due either to market conditions or exchange rates. In either case, the European farmers could not take advantage of the increase in the price in Japan. Since late 2008, the Australian dollar lost much of its value against the yen resulting in low-priced southern bluefin imports to the Japanese market and higher profits to Australian farmers.

6.2.3 Processing for sashimi

Japanese fish markets (e.g. the Tokyo Central Wholesale Market [Tsukiji]) used to be landing points where fishing vessels unloaded tuna catches and sold them at auction. The procedures and functions of Japanese markets have changed substantially in the last few decades and most markets are now functioning only as city centre markets rather than as landing markets. Despite this change, a substantial portion of tuna

supplies are sold in city centre markets such as Tsukiji via auctions. These fish are in gilled and gutted form and are prepared so that auctioneers can examine their quality.

When longline vessels capture tuna, they first bleed the fish by cutting the caudal blood vessels and/or the gills. Except for very large fish, most tunas have their gills, guts and fins removed; albacore is an exception as this species is generally kept in round form. Fish are then kept in iced seawater for a short period to prevent a rise in body temperature before being frozen via air blast methods. Fresh fish longliners keep fish in ice wells with iced seawater (occasionally wrapped in plastic bags).

Since the late 1980s, a new system has been introduced, mainly for Atlantic bluefin. When the buyers at foreign ports find inferior quality Atlantic bluefin (particularly in the Mediterranean area where, for example, fish are too small or too lean for the Japanese market), they cut off only the belly meat – the only part of any value in the Japanese market – for export to Japan. The remainder of the carcass is sold at the local market.

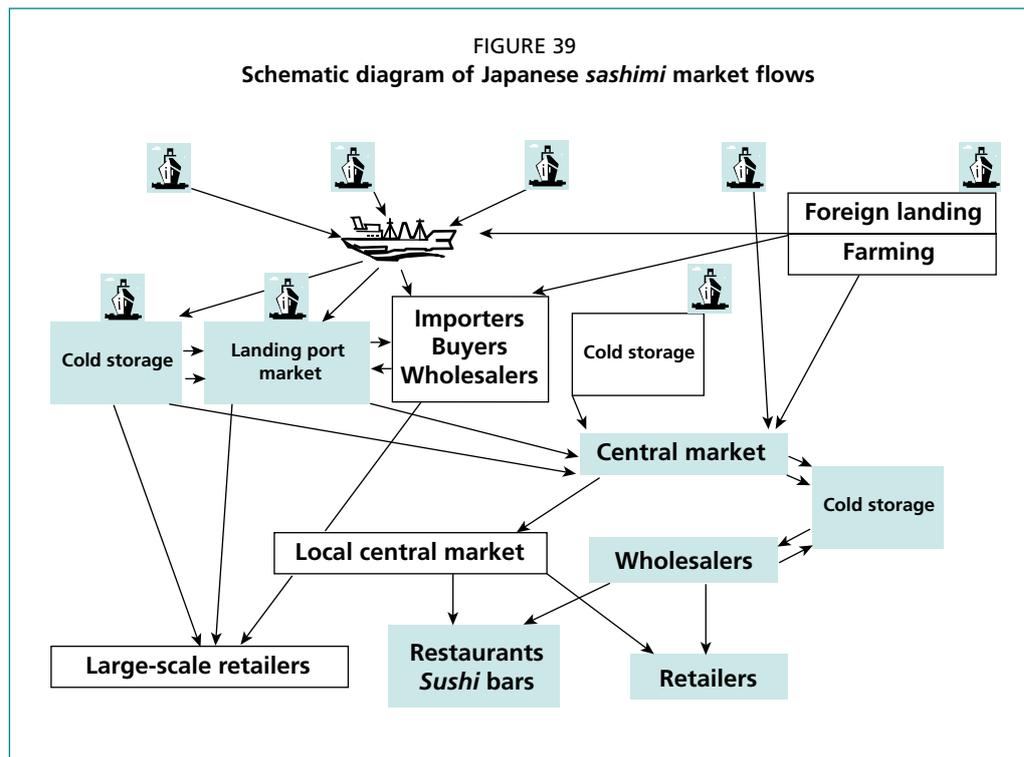
Even after farming started, the prices paid for belly meat and other meat have been different. For this reason, some farmers sell belly meat separately from other meat. When the belly meat is removed, the remainder of the carcass is processed into dressed, block or filleted products. This separation of products can create problems for trade tracking systems, such as the ICCAT Atlantic Bluefin Statistical Document Program, since belly meat and other meat may be recorded on different forms. Unless these forms are linked or cross-checked this could lead to double counting when estimating round weights from product weights.

The most recent change in the processing of *sashimi* is that some companies have started to prepare vacuum-packed portions designed to appeal to supermarket retail consumers (i.e. ~20 cm x 6 cm x 2 cm sliced blocks). These portions are mainly prepared in developing countries near the points of landing using low cost labour. This practice saves shipping costs, saves labour costs in Japan, provides more convenient products for handling, and allows traders to increase profits by selling products directly to the retailers by skipping intermediate steps in the supply chain.

6.2.4 Marketing system and price-making mechanism for *sashimi* products

Figure 39 diagrams the distribution system in Japan for fresh fish including tuna. Some features of the market system shown possibly originated even from the eighteenth century, and is one of the most traditional and complicated in the world. Landing port markets are generally operated by local governments or fisheries cooperative associations. The fish unloaded at landing port markets can be sold locally through auctions, or prepared and sent to central markets. Some are directly sold (without passing through auctions) to a buyer or a wholesaler, or sometimes to a large-scale retailer. The central wholesale market is the focal point of the entire system (Bestor, 2007). It used to serve as a landing point as well as a central wholesale market but now it serves only the latter function, mainly in the form of the auctions. Auctions are conducted, in the case of tuna, fish by fish. Only authorized wholesale buyers can participate in the auctions. They are given a chance to examine the fish quality prior to the auction and at this point each fish is marked to show its weight, where it was caught and by whom it was caught. The wholesalers immediately take their purchased fish to their stalls inside the market and cut them into several pieces to sell to retailers. Some wholesalers also function as retailers or operate *sushi* or other restaurant chains.

Most of the fresh fish are those brought in by coastal fishers via landing port markets and then further transported by truck. Some iced fresh fish from foreign ports are brought in by air and then by truck from the airport. These fresh fish are more likely to be sold through traditional routes, i.e. via auctions to wholesalers and retailers. Large restaurants and *sushi* bars go directly to the central wholesale markets and buy fish from wholesalers, skipping retailers.



Marketing routes of frozen tuna are more complicated. Generally, super-frozen fish must be kept constantly under super-cold storage; therefore, time spent in transshipment or unloading must be minimized. Imported frozen tuna are unloaded from transshipment vessels to the super-freezer storage areas by the importer. Fish caught by domestic longliners are either unloaded at the home port and immediately placed in storage or transshipped by deep-freezer cargo ships. Traditionally, it is the domestic longline owners who handle the sales of fish, taking them out of storage and offering them at auctions in response to market conditions. Recently, however, most of the domestic longline fish are purchased by buyers even before they are unloaded and handed over to them. This is because in many cases buyers finance the vessel owners' fishing operations and agree to buy the entire catch at a prenegotiated price.

When the fish owners or traders decide to sell the fish in the central wholesale markets through auctions, fish are delivered to the market and laid out for a few hours before the auction to begin thawing. Thereafter, the routes would be very similar to those for fresh tuna, as described above. However, most of the tuna kept in cold storage by the buyers or traders often bypasses the market auctions and is instead sold directly to large-scale retailers, including chain retailers and supermarkets. These large-scale buyers even buy fish directly from fishing vessels. This gives large-scale retailers the power to control the price, and thus reduces prices for consumers. Such direct marketing chains have become more and more common, particularly with the increase in Atlantic bluefin farming operations, and they now are applied even to fresh tunas. This in turn has led to a greater volume of imports of vacuum-packed *sashimi* blocks which, if processed in the country of landing, avoid the cost of transshipment at sea.

Under the traditional system, the difference between auction and retail prices used to be substantial. For example, fish sold at auction for 1 200 yen per kg could be sold by a retailer for 3 000 yen per kg. However, the auction price is based on gilled and gutted form and the retail price is based on *sashimi* blocks; therefore, the prices are not directly comparable. Also, retailers quote a wide range of prices for the same fish depending on the particular portion. Therefore, if the auction price is compared with

the *toro* (fatty belly meat) price of the retailers, the difference would be several-fold. Regardless of the magnitude of the difference, the bulk of the difference used to be the profit of the retailers and intermediate distributors.

When direct sales from fishers to the large retail chains and/or from fishers to wholesalers began to substitute for the function of the auction, a price revolution in the market ensued. First, small retailers (fishmongers) began to disappear as more people began to purchase fish in supermarkets. Under such circumstances, price decisions were no longer made at auction but rather by large-scale distributors. Second, the profits of small-scale retailers were severely curtailed. At present, the competitive strategy of the small-scale retailers is to offer high-quality fish at a higher price. Current supermarket prices (i.e. prices at large distributors) are only about 20 percent more than the ex-vessel price. To some extent, the Japan market system is beginning to resemble the United States market system (see Section 6.3.3).

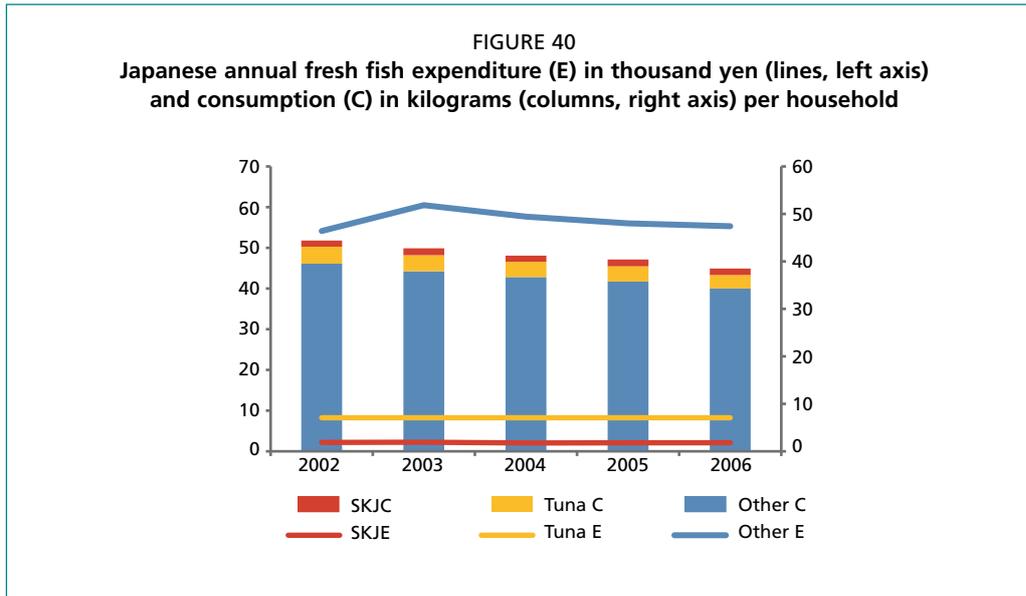
6.2.5 Sashimi consumption

Table 12 shows the average annual expenditure (in yen) per household on consumer goods in Japan for 2002–2006. The expenditure for consumer goods is about half of the total household expenditure. Therefore, the percentage of the total household expenditure represented by the figures for food, seafood, fresh fish, and tuna and skipjack in the table are about half of the values given. On this basis, these data suggest that Japanese spend only 3 to 4 percent of their budget for consumer goods on seafood, and only 10 percent of their food expenditure is for seafood. Approximately 2 percent of the consumer goods budget is spent on fresh fish and only 0.3 percent on tuna; therefore, the Japanese spend very little on tuna but relatively more on fresh fish items.

Figure 40 shows household fresh fish – tuna, skipjack and other – consumption (in kg) and expenditure (in yen). According to this figure, fresh fish consumption per household per year is only 50 kg. Because per capita Japanese seafood consumption is about 60 kg per year, these figures suggest that much of the seafood consumption is in forms other than fresh fish. Total fresh tuna consumption per household is only 2.8 to 3.5 kg per year while skipjack consumption is about 1.5 kg per year. Again, these figures appear to be an underestimate, but this may be because consumption in establishments (restaurants, *sushi* bars and dining facilities of firms and schools) is not included. Regardless of the form and species of consumption, the figures indicate that seafood consumption has consistently declined over the past six years and, in fact, this tendency has been reported for many years (e.g. Anon., 2009).

TABLE 12
Expenditure (in yen) per household, 2002–2006

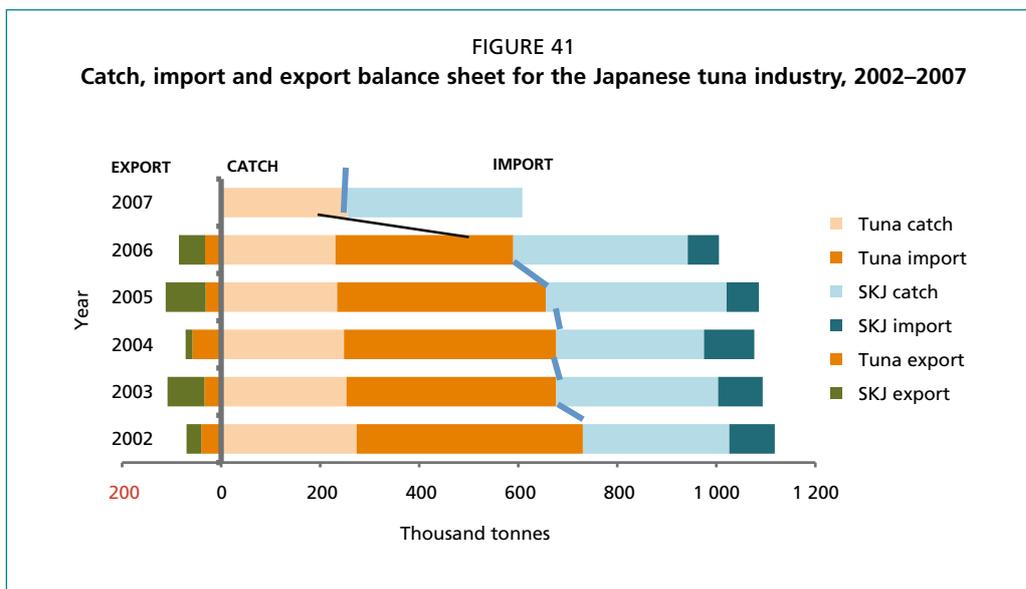
	2002	2003	2004	2005	2006
Consumable goods	3 671 438	2 702 429	2 720 991	2 704 374	2 647 877
	100%	100%	100%	100%	100%
Food	939 218	820 769	819 695	808 962	799 496
	26%	30%	30%	30%	30%
Seafood	104 753	98 897	95 017	93 041	91 943
	2.85%	3.66%	3.49%	3.44%	3.47%
Fresh fish	64 564	60487	57670	56018	55315
	1.76%	2.24%	2.12%	2.07%	2.09%
Tuna and skipjack	10 427	9 877	9 346	9 028	8 741
	0.28%	0.37%	0.34%	0.33%	0.33%



Source: Japan Ministry of Agriculture, Forestry and Fisheries.

Until the late 1990s, the *sashimi* market was practically monopolized by Japan. Even now, a substantial majority of consumption occurs in Japan. Due to a preference for healthy food and the globalization of food culture, *sashimi* consumption has spread to Europe and the United States. It is very difficult to estimate the quantity of *sashimi*-type tuna consumed on each continent, but judging from the number of Japanese restaurants and the amount of *sashimi* or *sushi* assumed to be served in these restaurants, it is estimated that somewhere between 7 000 and 10 000 tonnes of tuna are consumed as *sashimi* in Europe and possibly 20 000 tonnes in the United States (author's estimates). However, there is only a limited basis for such estimates.

Figure 41 shows Japan's catch (data source as described before) through 2007, import and export quantities of tuna and skipjack in kilograms based on unpublished national customs data and the FAO Commodities Production and Trade database through 2006. As explained in Section 6.1, Japan's tuna trade data include billfish and swordfish. In addition, catch figures are given in round weight, but data for import and export are in processed weight. To make these data equivalent, the following adjustments were made:



Note: All figures shown have been converted to round weight. Trade data for 2007 are not available.

- only imported and exported quantities reported as fresh/chilled/frozen tuna and skipjack are considered;
- weights of imported and exported tuna were divided by 0.8 to roughly convert into round weight;
- skipjack imports were assumed to be reported in round weight;
- skipjack exports in fresh/frozen form were considered to be reported in round weight; and
- canned skipjack weights were converted to round weight by dividing by 0.6.

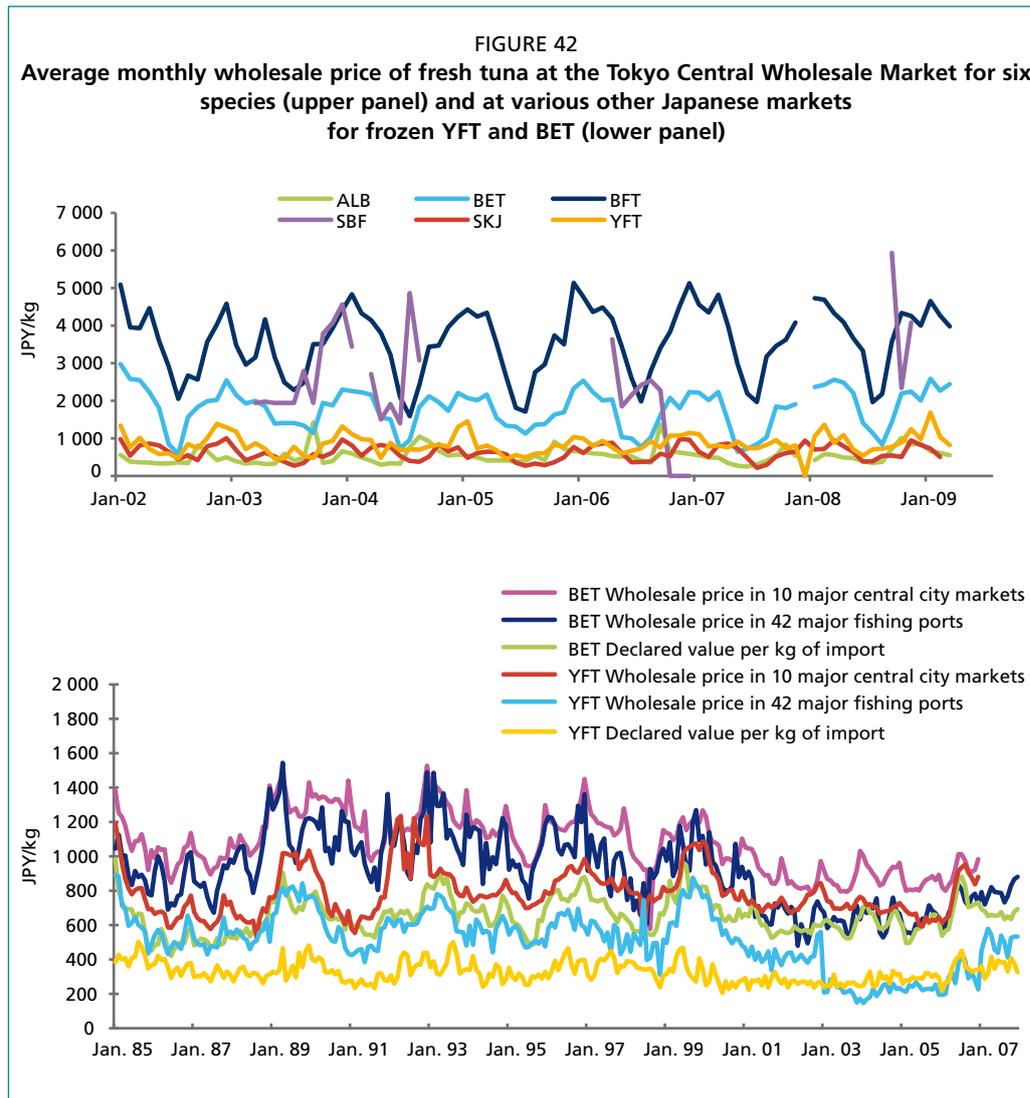
As a result of these adjustments, the values shown in this figure are quite different from those appearing in other published literature and statistical tables which generally do not distinguish between round and processed weights. In round weight, Japan consumes about 700 000 tonnes of tuna and almost 400 000 tonnes of skipjack. The majority of the tuna catch and all of the imported tuna (fresh, chilled and frozen) are considered to be consumed as fresh fish (primarily as *sashimi*), but since imports may include billfishes some of the imports may be consumed in cooked or processed form (e.g. *surimi* for fish sausages). In the case of skipjack, it is difficult to separate the forms of utilization (see Section 6.4). The declining trend in imports has been discussed in Section 6.2.2.

Some of the exported tuna are reprocessed in a third country into vacuum-packed *sashimi*-size packages and reimported to Japan. The quantity is not known at this time but it is thought to be increasing.

6.2.6 *Sashimi* markets

As explained in earlier sections, the Japanese *sashimi* market is complex and sensitive to species, quality, origin and amount of fish in the inventory (in cold storage). The range of price variation according to the quality of fish is huge and like nothing seen in any other market. Depending on quality, fresh bluefin can cost from 200 yen per kg to 20 000 yen per kg on any given day. This wide range of prices is typical of the Japanese market and results from its sharp focus on product quality grading; it is not likely to be observed in any other country. The most indicative price index is probably the wholesale (auction) price at the Tokyo Central Wholesale Market (Tsukiji). Figure 42 gives monthly average prices of tuna (in yen per kg) in Japanese auctions. The upper panel shows prices for fresh domestic tuna by species at the Tsukiji Market. The lower panel shows frozen and fresh yellowfin and bigeye ex-vessel and auction prices for domestic tuna and imported tuna (please see Section 6.1 for definitions of these prices). These figures show that bluefins (including Pacific bluefin) prices are by far the highest but are variable, while bigeye prices are intermediate but more stable. Yellowfin, albacore and skipjack prices are low and relatively more stable. There should be no southern bluefin fresh domestic fish as it is assumed that all southern bluefin tuna are brought to market in frozen form. Therefore, the southern bluefin shown in Figure 42 are likely to be frozen fish which are improperly recorded as fresh.

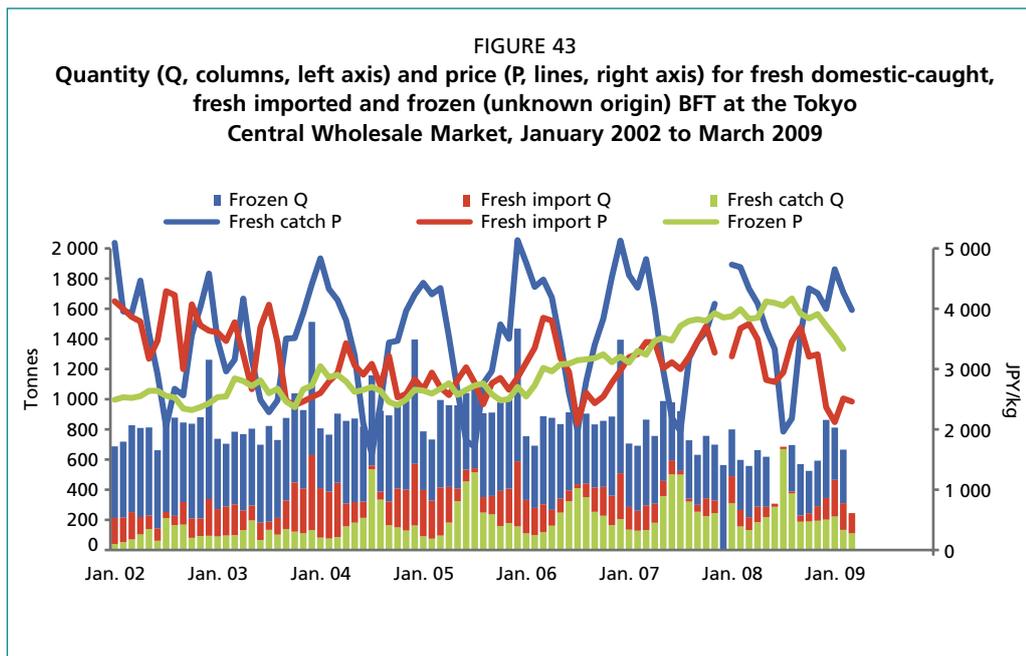
As bluefin (Atlantic and large-sized Pacific) prices are an overall indicator of tuna prices, a special review of bluefin prices and supplies has been prepared. Figure 43 shows the average monthly prices in yen per kg and quantity in tonnes sold at Tokyo Central Wholesale Market for domestic-caught fresh Pacific bluefin, imported fresh Atlantic and Pacific bluefins, and frozen bluefins. Frozen bluefin are mostly imported farmed Atlantic and Pacific bluefins but also include some domestic Atlantic bluefin catches. Prices and supplies both peak between December and January, reflecting high demand during the New Year festivities in Japan. Tuna is a must-have item at this time of year (as turkey at Thanksgiving in the United States) and people tend to splurge on purchases. Pacific bluefin tuna supplies are also relatively high at mid-year.



Source: Tokyo Central Wholesale Market: www.shijou-tokei.metro.tokyo.jp/asp2/smenu2.aspx?page=1&mode=2&smode=10 and Japanese Statistical Bureau: www.e-stat.go.jp/SG1/estat/List.do?lid=000001037877

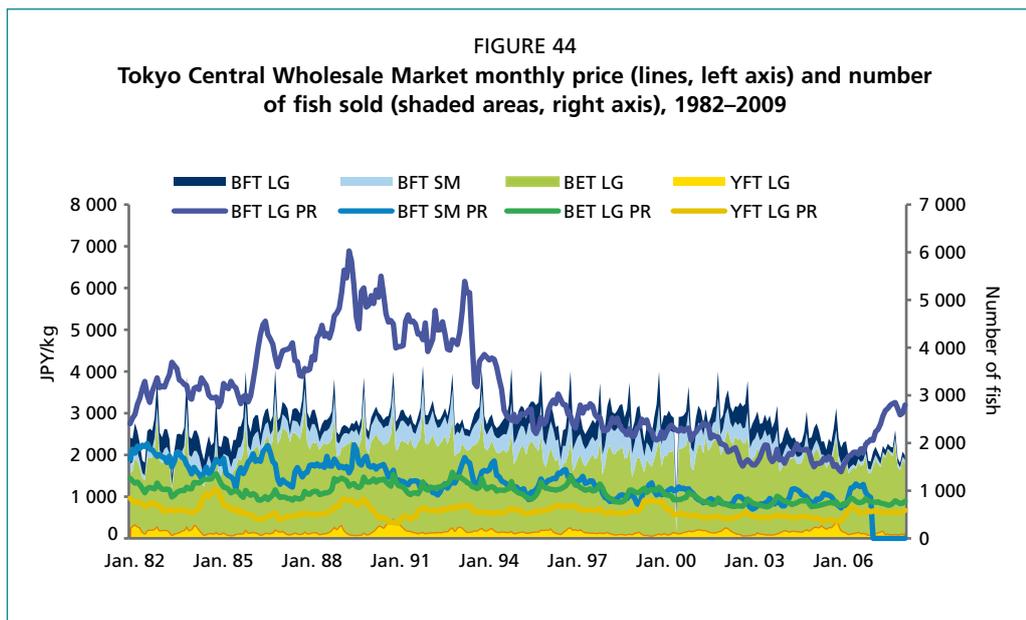
These are mostly smaller fish caught by purse seines in nearshore waters and hence the price is relatively low. It is interesting to note that the price of frozen bluefin is fairly stable throughout the year with a constant increasing trend until mid-2008 and a sudden drop thereafter. These are closely related to exchange rates as discussed in Section 6.2.2 and shown in Figure 38.

A similar figure is presented for long-term price trends (January 1982 to January 2009) in Figure 44. Prices are monthly averages in yen per kg and quantity is in number of fish rather than weight. The product classifications differ from the previous figures and include large BFT (>40 kg GG), small BFT (<40 kg GG), large bigeye (>40 kg GG) and large yellowfin (>25 kg GG), with frozen, fresh, domestic and imported tunas combined in each category. As the quantities of small bigeye and yellowfin are negligible, the price trends are not shown. This figure shows clear tendencies in the Japanese market. In terms of price, Atlantic and Pacific bluefins peaked during the period from 1989 to the early 1990s. Thereafter, when the Japanese economy entered its recession, the price began to decline. In the mid-1990s, prices dropped faster and further reflecting the sudden increase in imports of Mediterranean farmed Atlantic bluefin. Atlantic and Pacific bluefin prices started rising again in 2006, possibly as a reflection of a change in distribution chains, i.e. only expensive fish (imported and



Note: BFT may include PBF.

Source: Tokyo Central Wholesale Market: www.shijou-tokei.metro.tokyo.jp/asp2/smenu2.aspx?page=1&mode=2&smode=10



Note: See text for detailed explanation of legend keys.

Source: Tokyo Central Wholesale Market: www.shijou-tokei.metro.tokyo.jp/asp2/smenu2spx?page=1&mode=2&smode=10

domestic) are still sold at the Tsukiji Market whereas cheap imports of farmed BFT are now sold directly to retailers.⁵

The majority of sales at Tsukiji Market are comprised of bigeye of over 40 kg. Yellowfin sales are minor, as would be expected in eastern Japan since there is a regional preference there for BFT and bigeye (see Box 6 in Section 6.2). Bigeye prices are higher than those for yellowfin throughout the time series, but both have slightly downward trends.

⁵ Given that inflation and/or deflation rates are low (<1 percent), most of the arguments in this study, though based on nominal prices, directly reflect demand and supply. However, import prices are subject to exchange rate and inflation rate fluctuations in the country of origin.

BOX 7

Sashimi and sushi consumption in France

Commercial *sashimi-sushi* restaurants have increased substantially over the past decade with 400 to 500 now open in France (more than half of them are in the Paris region). Consumption of tuna *sashimi* per restaurant is estimated at between 1 and 30 kg per day. On average, between 80 and 90 *sashimi-sushi* meals per restaurant are served each day. Tuna accounts for only 5 percent of the fish consumed in these Japanese-style restaurants by weight, but 26 percent by value (Gira Foodservice, 2008). Typical consumers are young (less than 35 years old) and from the upper class. Overall, 4.1 percent of French households buy *sashimi-sushi* products at least once a year (TNS Worldpanel, 2008).

6.3 FRESH TUNA INDUSTRY, INCLUDING STEAK BUT EXCLUDING SASHIMI

This section discusses tuna consumed in fresh form (including originally frozen materials) other than that consumed as *sashimi*. However, as noted previously, the separation of fresh tuna into *sashimi* and “for cooking” categories is difficult.

6.3.1 Fresh tuna consumption in Japan

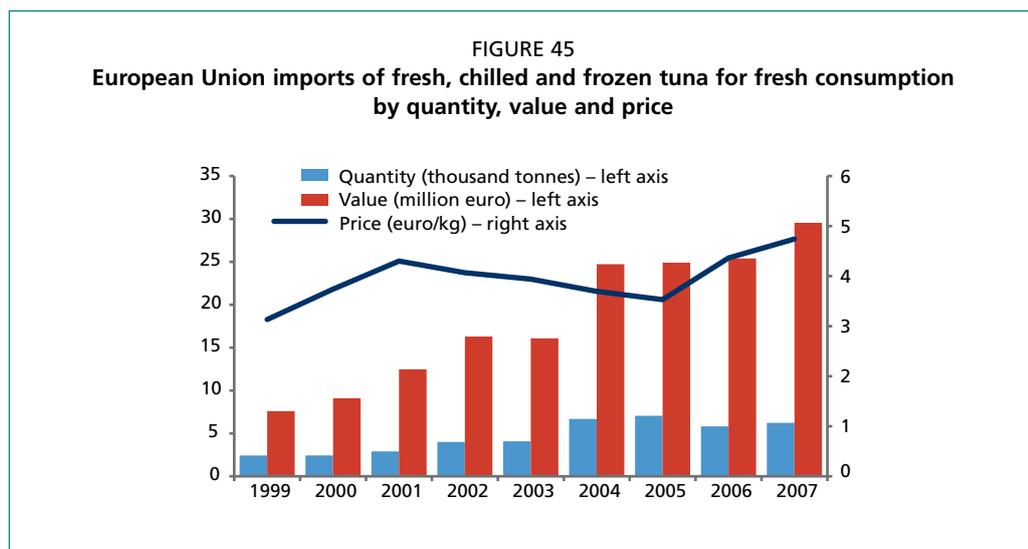
As discussed in Section 6.2, all fresh, chilled and frozen tuna sold in Japanese markets is considered to be *sashimi*. Despite this convenient classification for the purposes of this paper, some tuna, and most skipjack and billfishes, sold in Japanese markets is consumed in cooked form. These cooked forms may consist of: cooked with soy sauce and sugar for preservation purposes; teriyaki; and cooked with vegetables in soup. Recently, consumption of heads, viscera and eyeballs is increasing. Collars are becoming popular as a grilled item. In many landing ports, in places such as Taiwan Province of China, the Republic of Korea, Thailand and even Spain, (farmed tuna) heads, eyeballs and collars are exported separately from the carcass to the Japanese market.

6.3.2 Fresh tuna consumption in Europe, including frozen products and sashimi

The trade of fresh, chilled and frozen tuna fillets for direct consumption is rapidly increasing in Europe. However, as discussed in Section 6.1, there is some uncertainty in the trade statistics between tuna imported for direct consumption and tuna imported for further processing (e.g. canning). Therefore, it is not possible to precisely identify the destination of products (Oceanic Développement, Poseidon and Megapesca, 2005).

Figure 45 shows European Union imports of fresh, chilled and frozen tuna, which are considered to comprise the fresh tuna market. The quantities shown in this figure are processed product weights and can be substantially underestimated due to misreporting and/or misclassification in customs statistics. The amount of tuna imported for direct consumption by the European Union is estimated at 40 000 to 50 000 tonnes per year with a total value of more than 200 million euros (Oceanic Développement, Poseidon and Megapesca, 2005). The main exporters to the European Union market of this product type are Yemen, South Africa, Morocco, Sri Lanka, Viet Nam, Senegal, Namibia and Indonesia. The main European importers are Spain (half of all imports) and Italy (one third of all imports), reflecting the importance of traditional fresh tuna cooking in southern Europe.

Table 13 gives a summary of French tuna consumption by households (OFIMER, 2003) and establishments (including restaurants, schools, etc. [Gira Foodservice, 2008]). Two thirds of the tuna for direct consumption by households are purchased in supermarkets, whereas 99 percent canned tuna are purchased in supermarkets.



The consumption of seafood in restaurants has increased by 30 percent over the past decade. Commercial (private) restaurants represent one third of this consumption, and franchised restaurants two thirds.

In Spain, total expenditure on domestic consumption of fishery products amounted to 10.3 billion euros in 2005, of which nearly 60 percent was on fresh products and 25 percent was on frozen products. Approximately 1.5 million tonnes of fish products are consumed yearly. Tuna products represent slightly over 279 000 tonnes (round weight equivalent, based on the average of 2003–2005), which equates to 15.7 percent of all seafood products (MAPA, INE and ANFACO, unpublished data). Of this volume, 75 percent is consumed as canned fish and 25 percent is consumed as fresh or chilled tuna (mostly as fillets). The total value of tuna consumption by Spanish households is 1.15 billion euros, out of which 52 percent is fresh or chilled tuna and 47 percent is canned tuna. Canned tuna is distributed directly by canning factories to wholesalers and 80 percent of household purchases take place in supermarkets and large department stores (see Section 6.5 regarding the share of private labels).

Spain used to consume all its Atlantic bluefin catches in fresh, dried or canned form, but since the late 1980s some, and since the late 1990s nearly all, Atlantic bluefin have been exported to Japan (either wild or farmed tuna). However, when farming cost increases were not matched by the Japanese market prices in euros, some bluefin were again consumed by the domestic market (2006 to the present). It is interesting to note that previously Atlantic bluefin were only utilized along the Mediterranean coast and were cheaper than albacore, but now Atlantic bluefin are consumed in all major European Union cities and sold at a higher price than albacore (see Section 4.2.8 for

TABLE 13
Tuna consumption in France by households (2003) and establishments (2007)

		Fresh	Frozen	Canned
Households	Quantities (tonnes)	3 835	577	67 022
	Value (euros)	55 000	9 000	438 000
	Price (euros/kg)		14.5	Not available
Establishments	Quantities (tonnes)	2 929	1 414	Not available
	Value (euros)	28 000	11 000	Not available
	Price (euros/kg)	9.70	7.90	Not available

details). It appears that the majority of Atlantic bluefin sold in Spain is still used for cooking rather than *sashimi*.

In Italy, bluefin were also traditionally consumed in fresh as well as canned forms. However, since the 1980s, a substantial portion of wild tuna, and since the early 2000s, most of the farmed Atlantic bluefin have been exported to Japan. In many Mediterranean countries (Algeria, Croatia, Malta, Morocco, Tunisia and Turkey) the situation has been very similar.

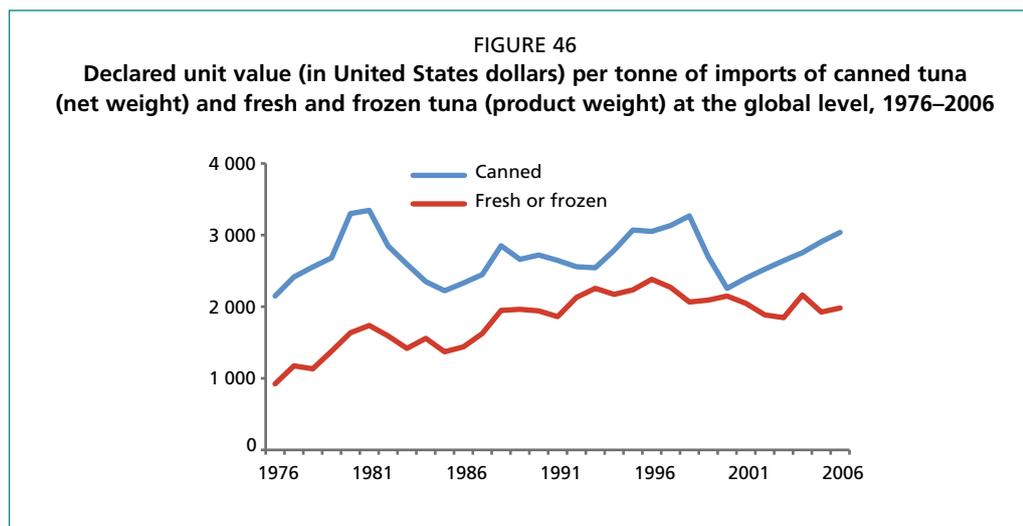
Fresh fish consumption in the rest of the Europe has been very low with the exception of Norway prior to 1960. However, as in France, the number of Japanese restaurants serving tuna *sashimi-sushi* has been increasing, particularly in the big cities (e.g. Amsterdam, Frankfurt, London). Total estimates of consumption of fresh tuna in these areas are not available.

From the nineteenth century until the 1970s the French annually caught between 2 000 to 6 000 tonnes of albacore with trolling gear and later with gillnets. After the banning of drift gillnets, albacore catches declined until 2002–2003, but eventually the albacore fishery was supplemented by pelagic trawlers when the anchovy fishery closed in June 2005. These French-caught albacore are landed at Atlantic fish auction markets and sold to local wholesalers before reaching wholesalers in Rungis (Paris). Sometimes these fish are supplied directly to retailers, most likely to supermarkets rather than fishmongers. Due to the poor quality of trawled fish compared to troll or longline caught tuna, prices are very low and half of the fish was withdrawn from the market in 2005 and 2006 using the European Union Common Organisation of Markets mechanism (i.e. a minimum price is applied to the withdrawn fish, which is frozen and then sold to Spanish canneries). As an example, during the 2007 season, the average price of albacore sold by trawlers (84 percent of landings) was 2.34 euros per kg as compared to the 3.84 euros per kg for catches by trolling and small purse seine, also known as *bolinche* (12 percent of landings; OFIMER, 2003). Undervaluation of fresh albacore is consequently observed. The average price for 2003–2007 was 0.46 euros per kg lower than that for 1990–2002. The whole market has been thus driven down in value by the introduction of pelagic trawlers.

6.3.3 Fresh tuna consumption in North America, including *sashimi* products

United States landings of yellowfin and skipjack dropped sharply in the mid-1980s, reflecting the departure of United States-flagged purse seiners from the Eastern Pacific Ocean and the disappearance of canneries from the United States mainland (discussed in Sections 4 and 6.5). After 1990, the United States catches dropped to only 5 000 tonnes. On the other hand, the price per tonne of tuna, particularly of yellowfin, as paid by canneries jumped from US\$1 000 to US\$1 500 in the early 1990s to US\$3 000 and more recently to US\$5 000, about the same level of price as paid for *sashimi* in Japan (Figure 46). These prices clearly indicate that current yellowfin landings are mostly for the domestic fresh tuna market (*sashimi* and steak) and not for canning as they used to be. Most of the recent landings of yellowfin and bigeye are by the traditional Hawaiian longline fishery which began operating over a century ago. Some yellowfin catches are also made in the Gulf of Mexico by ethnic Vietnamese who have immigrated to the United States; these catches are exclusively for the fresh fish market.

The decline in United States Atlantic bluefin catches since 1980 is at least partly the result of the ICCAT quota system. Almost all of the catches since then have been exported to Japan. This is clear from the comparison of ex-vessel fish price per unit weight to United States domestic and Japanese market prices (Figures 47 and 44, respectively). The decline of United States Atlantic bluefin catches is due to Mexican government regulations, which have eliminated access of United States commercial fishing vessels to the fishing grounds off Baja, California, where most Eastern Pacific Pacific bluefin tuna are distributed.



Source: FishStat Plus, FAO.

United States total tuna supply in recent years

Table 14 shows tuna landings in the United States by domestic fishers (excluding landings made in United States territories and those landed by foreign fishers). Figure 47 shows United States domestic landings and ex-vessel prices for all tuna species since 1950, with the exception of bigeye which has been only available since 1974. Yellowfin landings before 1974 included minor quantities of bigeye, since the price paid by canneries was the same for both species. The domestic fishery supply of tuna for the canning industry peaked in 1987 at 230 600 tonnes and thereafter declined rapidly. Indications of this can be seen in Figure 47, as landings of species supplied for canning (e.g. skipjack) dropped sharply while the prices of tuna in general increased indicating that tuna landed by domestic fishery supplied more to the fresh/steak market rather than to the canning industry.

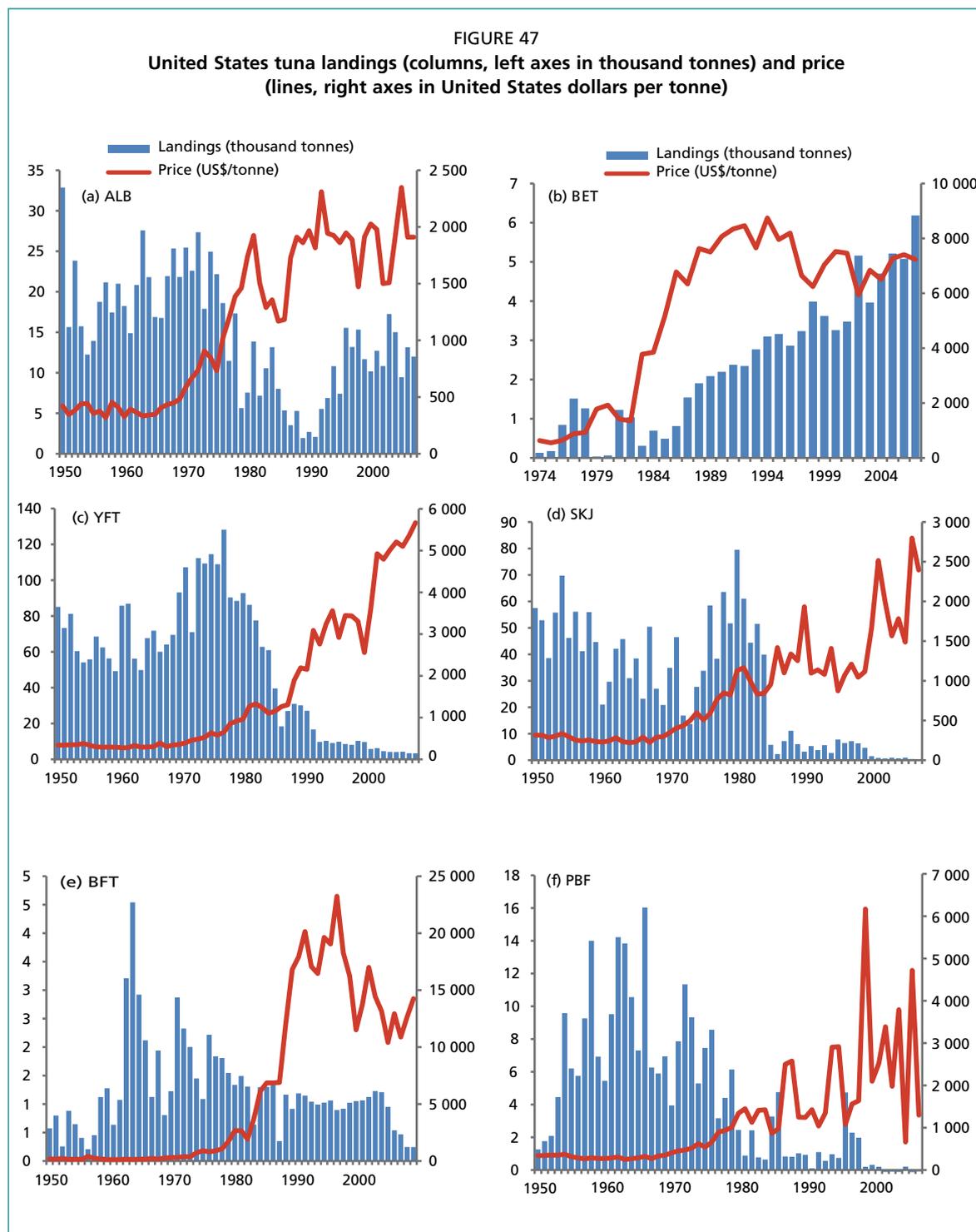
Bigeye is an exception to this trend as it shows an increase in landings, while the price has been high even in earlier years. This is likely to be an artefact of the improvement of reporting (i.e. separation of bigeye from yellowfin in the statistics); in earlier years only large fish for fresh fish consumption were identified as bigeye.

Table 15 gives the commercial tuna landings by United States-flagged vessels (including landings of tuna at foreign ports and those landed at American Samoa by foreign-flagged vessels), and United States imports and exports for 1986–2008 (United States National Marine Fisheries Service, unpublished data). Landings and imports are categorized as “Canning” and “Other”. Exports are aggregated; however, it was assumed that most are fresh or frozen, rather than canned. Data in this table may suffer from the problem described above involving aggregation of different product types without first converting to a common unit such as round weight. Notwithstanding these uncertainties, it was assumed that the “Other” products under both landings and imports are mostly for the fresh fish market. Exports are also assumed to be fresh

TABLE 14

United States tuna landings by United States-flagged vessels (in thousand tonnes)

Species	2001	2002	2003	2004	2005	2006	2007
ALB	12.7	10.8	17.3	15.0	9.4	13.1	12.0
BET	3.5	5.2	4.0	4.7	5.2	5.1	6.2
YFT	4.6	4.2	4.1	4.3	3.4	3.4	3.8
BFT and PBF	1.4	1.2	1.0	0.5	0.7	0.2	0.3
SKJ	0.9	0.7	1.0	0.7	1.0	0.4	0.3
Total	23.1	22.0	27.3	25.2	19.7	22.3	22.6



products. Figure 48 shows an assumed fresh fish balance sheet (domestic catch + import - export). Domestic catch, imports and exports (as negative values) are tallied to produce the line representing the assumed United States consumption of fresh tuna.

United States fresh and chilled tuna supplies

As shown in Table 15, United States consumption of fresh and frozen non-cannery grade tuna (given as "Other") in recent years is mostly supplied from imports. Table 16 provides further detail on fresh and frozen tuna imports to the United States, excluding

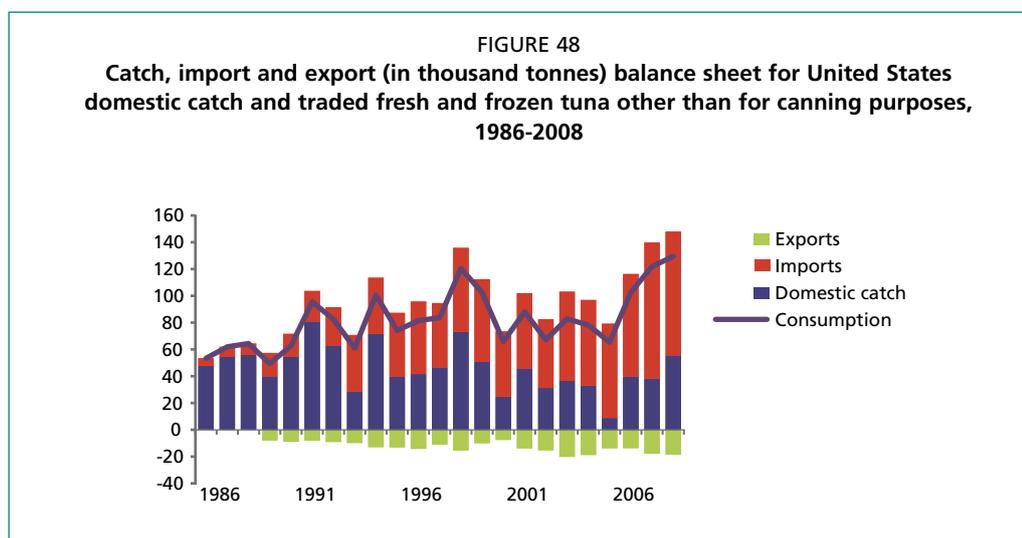
TABLE 15
United States fresh and frozen tuna supply, 1986–2008 (in thousand tonnes)

Year	United States commercial landings ¹			Imports ²			Exports	Total Supply
	Canning	Other	Total	Canning	Other	Total		
1986	206.3	47.7	254.0	252.0	5.7	257.7	0.0	511.6
1987	230.6	54.4	285.0	255.2	7.6	262.8	0.0	547.8
1988	220.9	55.8	276.7	244.5	8.6	253.1	0.0	529.8
1989	205.3	39.9	245.2	284.1	17.5	301.6	-7.9	538.9
1990	177.9	54.5	232.4	239.0	17.2	256.2	-9.0	479.6
1991	157.2	80.8	238.1	263.1	22.8	286.0	-8.0	516.0
1992	197.9	62.6	260.5	219.1	28.8	248.0	-9.1	499.4
1993	193.4	28.6	222.0	205.7	42.2	247.9	-9.8	460.0
1994	182.4	71.6	254.0	213.2	41.9	255.1	-12.9	496.1
1995	184.8	39.5	224.3	241.2	47.8	289.0	-13.1	500.2
1996	165.6	41.6	207.1	257.5	54.1	311.7	-14.2	504.6
1997	160.7	46.6	207.3	212.3	48.0	260.3	-10.9	456.7
1998	144.4	73.2	217.7	268.1	62.6	330.7	-15.4	532.9
1999	167.4	50.7	218.1	259.7	61.7	321.4	-10.0	529.5
2000	128.0	24.8	152.8	250.0	48.6	298.6	-7.6	443.8
2001	104.9	45.5	150.3	197.2	56.5	253.7	-13.9	390.1
2002	123.5	31.2	154.8	192.9	51.3	244.2	-15.3	383.6
2003	76.8	36.5	113.3	242.7	66.6	309.4	-20.2	402.5
2004	67.3	33.1	100.3	211.7	63.8	275.6	-18.8	357.1
2005	71.2	8.8	80.0	212.6	70.4	283.0	-13.8	349.3
2006	52.0	39.8	91.8	223.7	76.5	300.3	-13.7	378.4
2007	56.5	38.2	94.7	204.5	101.5	306.0	-17.8	382.8
2008	80.1	55.5	135.6	195.6	92.4	288.0	-18.5	405.2

¹ Includes quantities of fish landed at other ports by United States-flagged vessels.

² Includes landings in American Samoa of fish caught by foreign-flagged vessels.

American Samoa, by species based on United States customs data. Although only non-canning products are summarized, it is suspected that quantities of frozen albacore, and fresh and frozen skipjack, may include materials for canning, particularly for earlier years (possibly until 2004). Therefore, the total given in the Table 16 is likely to represent an overestimate of non-canning grade tuna imports, particularly for earlier years. Even so, because tuna canning has diminished to nil in the mainland United States in the last few years, almost all of the imports since 2004 should be of non-canning grade tuna. Some of these imported tuna are known to be re-exported (e.g. based on the ICCAT Bluefin Tuna Statistical Document Program), particularly the



Source: National Marine Fisheries Service (United States).

TABLE 16
Fresh and frozen tuna imports by the United States (in thousand tonnes)

	2001	2002	2003	2004	2005	2006	2007	2008
FRESH								
ALB	1.1	1.3	1.1	1	0.7	0.9	0.9	0.7
BET	4.7	6.3	7.3	6.8	5	4.9	5.6	5.5
YFT	15.6	16	15.3	15.6	17.1	17.8	18	15.9
BFT and PBF	0.6	0.7	1.4	1.5	1.6	1.1	1.1	0.4
SBF	0	0.4	0.2	0.2	0.1	0.1	0	0
SKJ	0	0	0	0	0	0.1	0	0
Unspecified	1.1	0.1	0.4	1.4	0.9	0.4	0.1	0.2
FROZEN								
ALB	40.4	11.9	12.6	4.9	1	0.7	0.7	1.6
BET	0.1	0.3	0.6	1.2	1.5	1.5	1.5	2.6
YFT	4	4.6	5.6	5.8	6	5.4	5.5	3.8
BFT and PBF	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1
SBF	0	0.2	0.1	0	0.2	0.1	0.1	0.1
SKJ	0.4	0.8	0.2	0.1	0.7	0.9	0.8	0.7
Unspecified	32.5	35.4	44	44.6	47.7	51.4	60.5	62.2
Total	100.4	78.1	88.8	83.3	82.7	85.3	95.1	93.9

Source: Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division, Silver Spring, Maryland.

Atlantic and Pacific bluefins. Therefore, it should be kept in mind that not all tuna imported to the United States is consumed there.

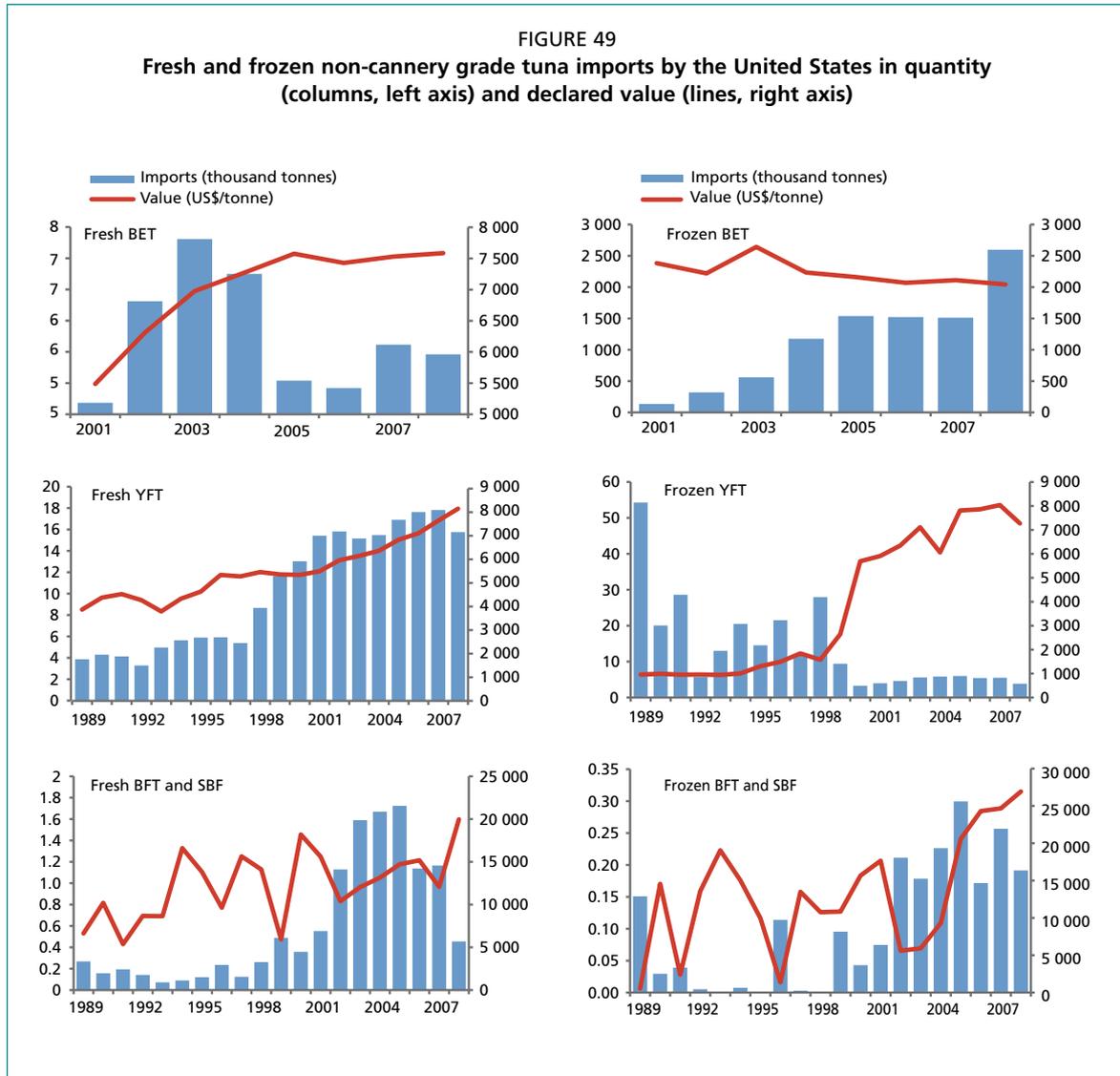
There are some discrepancies between the quantities shown in Table 15 as imports in the “Other” category and those given in Table 16. Since the databases are different, the product categories and definitions of non-canning tuna might be different. In particular, in Table 16 large quantities of tuna are classified in an unspecified category and this could easily lead to discrepancies with Table 15.

Considering Tables 15 and 16 and Figure 49, it is assumed that during the period 2001–2008, United States tuna landings for non-canning grade tuna varied between 20 000 and 30 000 tonnes with a declining trend, whereas imports ranged around 60 000 to 90 000 tonnes with an increasing trend. The total fresh and frozen fish consumption other than canning is estimated to have ranged between 80 000 and 110 000 tonnes.

The fresh and frozen tuna imports and prices for 1989–2007 are shown in Figure 49. Imports of fresh and chilled yellowfin have more than tripled since 1989 and *sashimi*-grade yellowfin now accounts for about 50 to 60 percent of the total. As mentioned earlier, because all canneries in the mainland United States have closed, both the landings and imports of frozen yellowfin and skipjack are only around 38 000 tonnes. The imports of both *sashimi*-grade frozen bigeye and frozen Atlantic, Pacific and southern bluefin tunas have increased dramatically. It should be noted that this figure does not show re-exports. As explained in the previous paragraph, and according to Japanese statistics, much of the bluefin tuna and some bigeye imported by the United States is re-exported to Japan and hence is not consumed in the United States.

One important factor when examining trends in the tuna trade is changes in the types of processed products imported, even for the fresh fish market. Products are becoming more and more reduced, i.e. previously products used to be gilled and gutted or dressed, but now most of the products are in blocks, filleted or sliced ready for retailing (pouched). This trend is the same as that observed in the Japanese market. Much of the decrease in imported quantities can be attributed to these changes in product form.

The origin of the imports of fresh and chilled and fresh yellowfin in 2008 is given in Figure 51. The Philippines is the leading supplier contributing 17 percent by weight. Price (i.e. declared custom values divided by quantity) in 2008 rose to US\$8 149 per



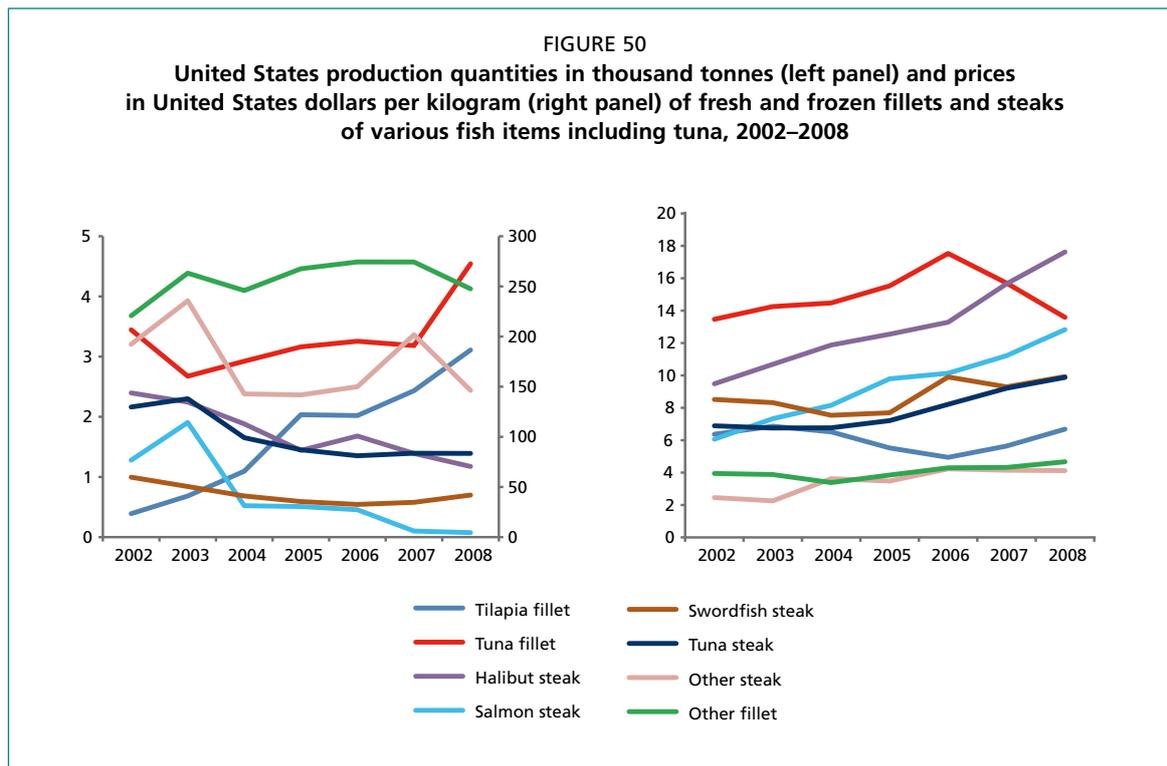
Note: BFT may include PBF.

Source: National Marine Fisheries Service (United States).

tonne, similar to the average price for fresh yellowfin imports in Japan (US\$8 368 per tonne).

United States tuna fillets, steaks, loins and pouches market

The United States' production quantity and prices of fresh and frozen processed fillets and steaks for selected species from the National Marine Fisheries Service can also be seen in Figure 50. These data show that the domestic production of tuna fillets and steaks in total has declined by approximately 1 000 tonnes from 5 607 tonnes in 2002 to 4 570 tonnes in 2007, while tilapia fillet production has increased dramatically from 390 tonnes in 2002 to 2 426 tons in 2007. Both the prices of tuna fillets and steaks show an increasing trend similar to that of salmon and other steaks, while the tilapia fillets are becoming cheaper. The United States fresh fish marketing system for tuna is the same as that for any other fresh fish: fish are landed at ports, sold to a broker or a wholesaler (sometimes via auctions), and are then passed on to restaurants and retailers. In the case of albacore, the majority is sent to the key city market by wholesalers who buy fish in the local port auctions. Recently, some fishers' cooperatives send catches directly to the central markets, brokers or even to retailers and restaurants.



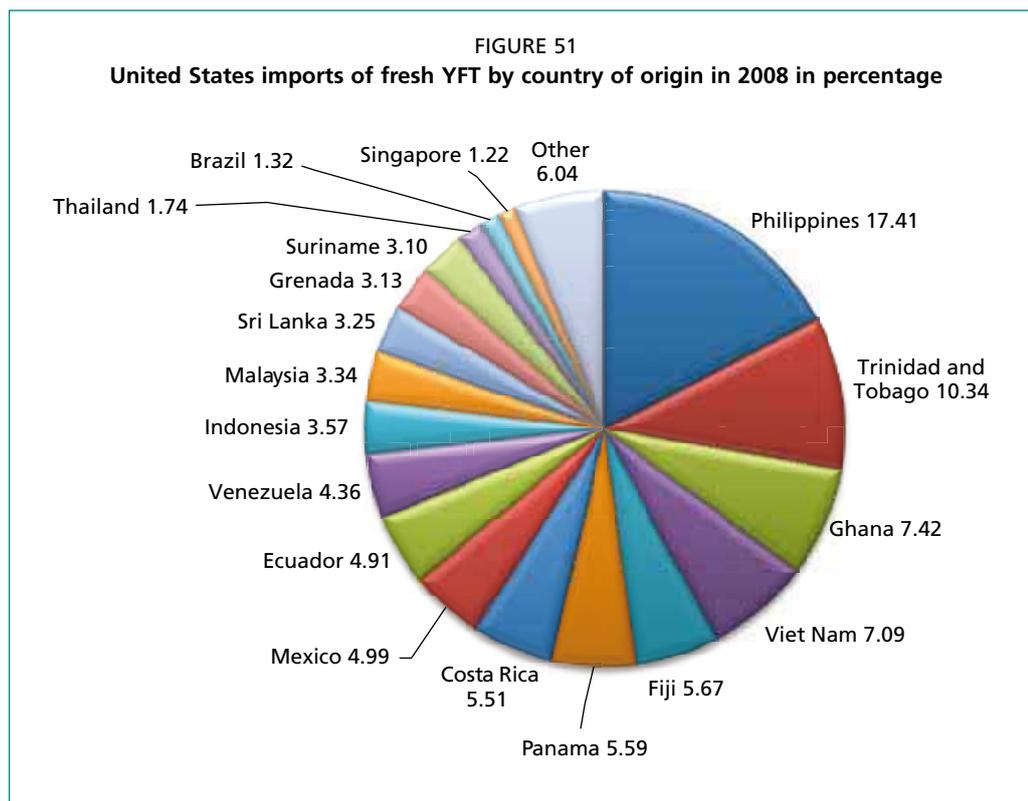
In the United States, eating fresh tuna became popular only in the late 1990s. The most popular tuna is the so-called “ahi”, the Hawaiian name for bigeye, but in reality “ahi” can be either yellowfin or bigeye. “*Tombo*” is the Japanese colloquial name for albacore and albacore is also sold in the United States market as *tombo*. *Tombo* are mostly served as seared steaks. If the quality is good (though not necessarily), *sushi* restaurants as well as households may use albacore for *sashimi* and *sushi*. This makes it difficult to separate *sashimi* from fresh fish consumption categories.

Originally, most of the United States’ tuna supply was provided by the Hawaii-based longline fleet, but most tuna are now imported from various coastal nations (see Figure 51). In the United States, except in Honolulu and Hilo in Hawaii, a fish market is a place where fish retailers are gathered, which serves as a focal point for both fish sales and tourism. Real markets in the sense of those in Japan and Europe, i.e. where auctions take place, in general, do not exist in the United States. The traders, buyers, and/or wholesalers import tuna and distribute it among their customers, which include restaurants, supermarkets, retailers and so-called fish markets.

6.4 SPECIAL SKIPJACK PRODUCTS (KATSUOBUSHI AND POWDERS)

Skipjack are utilized in many Asian countries as salted and dried products. Major countries of consumption include the Maldives, Sri Lanka and Japan. Consumption of skipjack in Japan is very complicated and no systematic research or survey has been found during the research for this paper. Statistics are also confusing and categories often vary between databases.

In Table 17, the category of skipjack sticks includes the two subcategories of “*bonbushi*” and “*arabushi*” (see Box 8 for product definitions). A conversion factor of 5.6 was used to estimate round weight (Katsuobushi Association, personal communication). The same factor was also applied for skipjack flakes. A factor of 1.7 was used for boiled skipjack. The appropriate factors may vary considerably depending on the producers, the original materials and the size of the fish. The resulting estimated round weight appears to be an underestimate.



Note: Percentages based on a total of 15 903 tonnes.
Source: National Marine Fisheries Service (United States).

The skipjack flakes shown in Table 17 are actually made from skipjack sticks but are presumed not to be double counted in the statistics. On the other hand, skipjack sticks (particularly *arabushi*) are used to make a powdered soluble skipjack product. Possibly more than half of the skipjack sticks are used for that purpose.

Considering this information in combination, it seems that about 350 000 to 400 000 tonnes of skipjack (on a round weight basis) are supplied each year to Japan, of which 320 000 to 340 000 tonnes are processed into *katsuobushi* (including boiled or soluble products). About 50 000 tonnes are exported. Fresh fish consumption amounts to about 25 000 tonnes. Compared with other sources of information, fresh

TABLE 17
Production of smoke dried SKJ and estimated round weight of raw materials in tonnes

	2002	2003	2004	2005	2006	2007
PRODUCT WEIGHT						
SKJ smoke dried	35 839	35 974	38 258	40 084	38 735	34 662
SKJ boiled	4 299	3 932	3 825	3 812	3 726	3 550
SKJ flaked	20 547	20 796	20 871	20 743	21 060	21 268
ESTIMATED ROUND WEIGHT						
SKJ smoke dried	199 106	199 856	212 544	222 689	215 194	192 567
SKJ boiled	7 165	6 553	6 375	6 353	6 210	5 917
SKJ flaked	114 150	115 533	115 950	115 239	117 000	118 156
Total	320 421	321 942	334 869	344 281	338 404	316 639
SKJ SUPPLY						
Domestic catch	295 793	327 064	298 432	365 095	352 358	353 241
Import	73 451	71 940	81 218	52 056	50 457	n.a.
Total	369 244	399 004	379 650	417 151	402 815	353 241

BOX 8

Katsuobushi (dried skipjack stick)

In principle, *katsuobushi* can be categorized as “*honbushi*” (dried, smoked and moulded); “*arabushi*” (dried only); “flaked *katsuobushi*” (of either *honbushi* or *arabushi*); and “*namaribushi*” (boiled).

Katsuobushi (honbushi) is traditionally manufactured according to the following process:

- Fins, viscera and head are removed and the fish is cut into four (two pieces each of dorsal and ventral parts), bones removed.
- Drying, smoke drying, and moulding are repeated. The purpose of moulding is to break down the protein chain into a shorter chain of amino acids to improve taste and to remove fat through decomposition.

As the processing is very complicated and requires much labour and time, so-called *arabushi* is now more common. In the production of *arabushi*, the moulding process is skipped and often even smoking is skipped, but machine drying is applied.

The product is a very hard fish stick, which is shaved using special equipment into very thin flakes. These flakes are soaked in boiling water for a short period to extract the taste and flavour and are then removed by filtering. The remaining broth is then used as a fish-based soup stock for various soups and cooking. Recently, many families buy products which are already flaked. Better quality products are sold as sticks which are not yet flaked.

Products which even skip the shaved form, i.e. powdered extracts from dried skipjack, have become very popular since the 1980s. Soluble powder can simply be added to boiling water to make fish broth. Since it is very condensed, the conversion of that product to round weight of skipjack is very difficult to obtain. In the last few years, soluble products are even produced in coastal landing ports of foreign countries and imported to Japan. The import of such products makes it impossible to estimate how much skipjack is imported and/or consumed in Japan, particularly when the product type is not known for imports.

Other than in Japan, salted and/or dried skipjack are consumed after soaking in water for many hours, as fish flesh, similar to *bacalao* (salted dried cod).

consumption of skipjack would be about 100 000 tonnes and hence 25 000 tonnes represents a considerable potential underestimate. This is either due to:

- (i) the conversion from skipjack stick to round weight is incorrect;
- (ii) there is an underestimate of the total skipjack available in Japan;
- (iii) there is possible species misreporting in the trade database (e.g. skipjack is included as tuna in countries other than Japan);
- (iv) the trade data are incomplete; and/or
- (v) product weight rather than round weight is reported in the import statistics (reported weight of imported, soluble powders would cause substantial underestimates of round weight – see Section 6.1).

6.5 CANNING INDUSTRY

6.5.1 Brief history

Europe

After the creation of the first sardine canneries in France in 1822, French companies in the 1860s and 1870s started to develop plants abroad in Portugal, Spain, Algeria and Morocco. Albacore began to be used in the 1860s and was used increasingly in the 1880s to the 1900s, when sardines were in short supply compared with the capacity

of the canning industry at that time (d'Avigneau, 1958). In Spain, only seven sardine canneries were operating in 1879, whereas by 1907 there were 106 plants (Guillotreau and Ferreira Dias, 2005).

There was an apparent linkage between tuna and sardines in the canning industry: when the supply of sardines ran short or canned sardines became unpopular, tuna partly substituted for them (Odin, 1894). At that time, Atlantic bluefin was not segregated and was packed just like albacore. More evidence of substitution is provided by price data showing that the price of tuna dropped in years when sardines were available in large quantities. Despite the substitution effect, tuna were considered more of a luxury good and its price was twice that of canned sardines in 1868. Tuna was first canned in vegetable oil but a new formulation, tuna “*au naturel*”⁶ or in brine, appeared for the first time in 1936.

Spain's tuna canning industry also started in the early twentieth century focusing mainly on albacore and to some extent on Atlantic bluefin. In the Canary Islands, the packing of locally caught bigeye and skipjack occurred as early as the 1950s. The expansion of tuna canning began only when Spain's tropical tuna fishing fleet developed in the late 1960s to early 1970s. The industry expanded together with the development of the Spanish purse seine fishery and currently Spain is one of the few European Union member states in which major tuna canning operations still exist.

Currently half of the materials used in canned tuna for the French market (in round weight equivalent) is yellowfin. The remainder is skipjack (42 percent) and albacore (8 percent) (ADEPALE, 2008).

North America

In the United States the production of canned albacore started in 1906, and large-scale production followed in 1911. By 1917, there were 36 tuna packers with over 1 800 workers along the West Coast of the United States (Scofield, 1954). United States companies began their canning operations in Hawaii in 1917, where they packed bigeye and Pacific bluefin, and in 1937 tuna canning had spread to the Atlantic Coast and the Pacific Northwest (United States Department of Labor, 2003). The largest canning operations at that time were for salmon taken in Alaska and the Pacific Northwest, and albacore and Pacific bluefin taken by troll gear in the Pacific Northwest. White meat tuna (albacore) in oil was already a luxury item then.

In the 1950s when baitboat tuna fishing developed very rapidly in the Eastern Pacific Ocean, the canning industry developed in parallel, particularly in the San Pedro area near Los Angeles. West coast tuna canning production increased rapidly in the period between the 1960s and the late 1970s. At first, canned light meat tuna (i.e. any tuna except albacore) was marketed as a low-priced substitute for canned salmon and it was then promoted further as a low fat, healthy protein source. In the 1970s, the United States industry faced “low-cost competition” from Japan (for albacore) and later from Thailand and other Asian countries. As a result, the bulk of its production was moved either to its territories in American Samoa or Puerto Rico,⁷ where minimum wages were lower than on the mainland, or to Southeast Asian countries. Since 1979, 11 canneries based in the United States and its overseas possessions have closed (Campling, Havice and Ram-Bidesi, 2007).

⁶ Tuna «*au naturel*» (in brine) was introduced in 1936 by M. Firmin Tristan, a manufacturer located on the Isle of Groix (France). Raw fish is put into a tin can and covered with brine before sealing and cooking directly inside the autoclave. This “raw pack” process remains today as a specialty in France, and most of the large yellowfin tuna processed by the Indian Ocean canneries is packed in this way for the French market.

⁷ Shortly after initiation, Puerto Rican operations were closed and moved to American Samoa or South American countries.

Japan

The Japanese tuna canning industry began only after the end of the First World War when the former German colonies of Micronesia were placed under Japanese Trusteeship permitting the Japanese tuna industry access to the resources of more than 1 400 islands in the area. A Japanese government organization, the Agency for Management of Tropical Territories, was created in 1922 in order to subsidize the building of modern vessels, cold storage and canneries (Matsuda and Ouchi, 1984; Gyosen Kyokai, 1986). The catches in these equatorial islands were mostly skipjack and yellowfin which were made into *katsuobushi*. Japanese firms exported canned albacore to the United States market at that time, although albacore should have been only a minor component of catches in this area.

6.5.2 Development of the modern canning industry and its globalization

Capital investment accompanied and facilitated the development and expansion of tropical tuna fisheries. In Europe and Africa, this began with baitboat fishing as early as 1956 in Dakar (Senegal) and Pointe-Noire (Republic of the Congo).

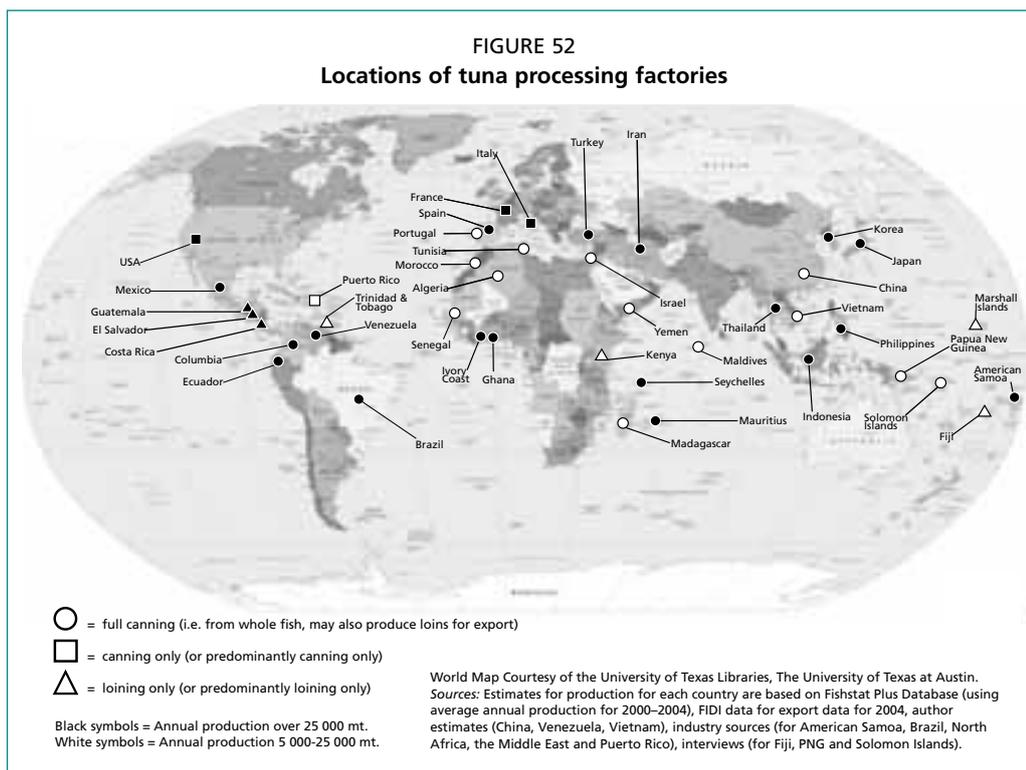
Abidjan (Côte d'Ivoire) became a new site for European investments in the 1970s when European purse seines became the major fishing gear for tropical tuna (skipjack and yellowfin) in the Gulf of Guinea. When this fleet expanded to the western Indian Ocean in the early 1980s and 1990s, they began to supply new canneries in Madagascar, the Seychelles, Mauritius and Kenya (see Section 4.2.5).

The longstanding “big three” United States processors – StarKist, Bumble Bee and Chicken of the Sea (now part of Thai Union group, formerly Van Camp) – established tuna canneries in Puerto Rico, Ecuador and American Samoa in the 1960s. StarKist also established canneries in Tema (Ghana) and developed baitboat fisheries in Ghanaian waters using Japanese, then Korean, and finally local fleets. Between 1990 and 2001, nearly all plants located in the mainland United States and Puerto Rico closed down because of high labour costs and withdrawal of United States purse seine fleets from the Eastern Pacific Ocean due to high operating costs and problems with dolphin mitigation (see Sections 4.1.2, 4.2.5 and 5.2). The last tuna canning factory in the United States mainland closed in 2007; United States canning production statistics for recent years reflect operations in American Samoa. Thailand and other Southeast Asian countries such as the Philippines and Indonesia have replaced the United States canning operations as the new major processors. More recently canning capacity has expanded in Central America (Ecuador, Mexico and Colombia).

Many mergers and acquisitions among companies have taken place, first on a domestic basis then shifting toward more global corporate structures. As in many other businesses, the former large food conglomerate owners of the canneries (Heinz, Unilever, Nestlé, Mitsubishi) are gradually selling their units to financial holding companies such as the Bolton Group, ONA-Optorg, Connors Bros. Income Funds, Centre Partners Management, Emerging Capital Partners, and Lehman Brothers⁸. This shift in canning, as well as production of loins, accompanies an increasing tendency to outsource processing operations to low-cost countries which have different policies for industrial management and which are located closer to the fishing grounds (e.g. Thailand, the Philippines, Indonesia, Papua New Guinea and Ecuador). As a consequence, the number of countries involved in production and export of canned tuna has increased.

The five main producing countries have changed considerably over the past few decades. The dominance (in volume) of the top five countries decreased from 85 percent in 1976 (United States, Japan, Italy, Spain and France) to 75 percent in 1986 (United States, Thailand, Japan, Italy and Spain) and to 63 percent in 1996 (United

⁸ The United States investment bank Lehman Brothers, the major shareholder of MWBrands (owner of canneries in Seychelles, Ghana, France, Belgium and Portugal), declared bankruptcy as a result of the financial crisis of September 2008.



States⁹, Thailand, Spain, Italy and Japan) before increasing slightly in 2006 to 66 percent (Thailand, Spain, United States, Ecuador and the Islamic Republic of Iran). Despite increasing capital concentration in a limited number of multinational companies, these trends demonstrate that more countries are now participating in the global production of canned tuna. Figure 52 shows the large number of locations of tuna processing factories globally as of 2006. The black symbols indicate an annual production of over 25 000 tonnes. The figure shows that specialization is occurring between pure canning (squares) and loin production (triangles), although there are still some facilities (circles) which are producing both products.

6.5.3 The supply of tuna for the canning industry and changes in processing methods

Canneries have two ways of receiving tuna supplies. The first way involves landings from fishing vessels based at the cannery port and/or owned or financed by canneries. This traditional type of operation was practiced, for example, in San Pedro (United States) and Tema (Ghana). This type of supply is still common, particularly for processing plants based in island states, for example, the Seychelles, Samoa and Papua New Guinea. The second way involves supplying fish by reefers or transshipment vessels. This method is becoming more common, e.g. for canneries in Thailand and Spain, as the transportation of loins increases as explained in Section 6.5.6. Many factories use both systems.

Tuna was initially canned in vegetable oil but later, in 1936, canning in brine was invented (see Section 6.5.1). Since the 1960s, packing in brine has dominated. This is mostly due to a preference by consumers for products with lower calories, but it is also convenient for the producers as it reduces the cost of packing. Nevertheless, even now, expensive, high-quality canned tuna is packed in olive oil. Although most tuna is packed in brine or oil alone, in many countries various non-tuna materials are added

⁹ The United States canning figures include operations in Puerto Rico, although more recently almost all production is from American Samoa.

such as protein substitutes (e.g. made from soybeans), chilli peppers, onions, spices and/or soy sauce.

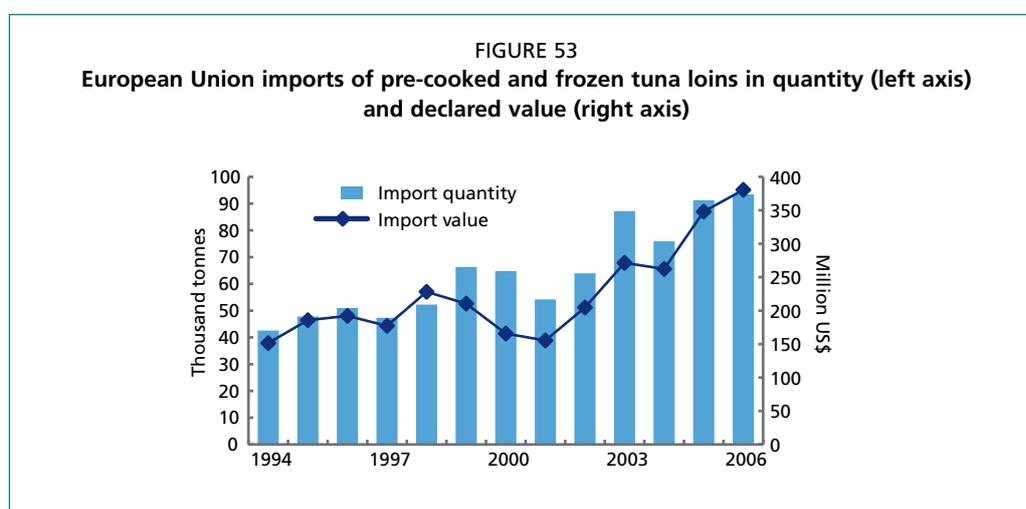
Until the 1990s, almost all fish landed at or transported to factories were cooked, prepared and packed at the same location. Recently, this has changed with the development of loins (generally of small fish). Use of tuna loins for canning began as early as the 1960s by United States processors, but the large-scale commercial utilization of loins only began recently when canneries in Puerto Rico increasingly used loins in their processing operations. One of the reasons is that the United States' catch in the Eastern Pacific Ocean started declining as a result of mitigation measures designed to reduce dolphin mortality under the United States Marine Mammal Protection Act. Consequently, the canneries needed supply from other areas and loins represented the easiest way of transshipping the product at a lower cost. Bumble Bee opened a new cannery in California in 1990 even though the United States purse seine fishery in the Eastern Pacific Ocean was already in decline because this new cannery could rely exclusively on loins for its supply (United States Department of Labor, 2003).

Another reason for the development of loins is that in order to reduce the average mercury content and keep it below the mercury standard set by the United States Food and Drug Administration (FDA) for canned goods, canneries began packing large yellowfin (which has relatively higher mercury content) mixed with skipjack (which has very little mercury content). Imported skipjack loins were quite convenient for this practice.

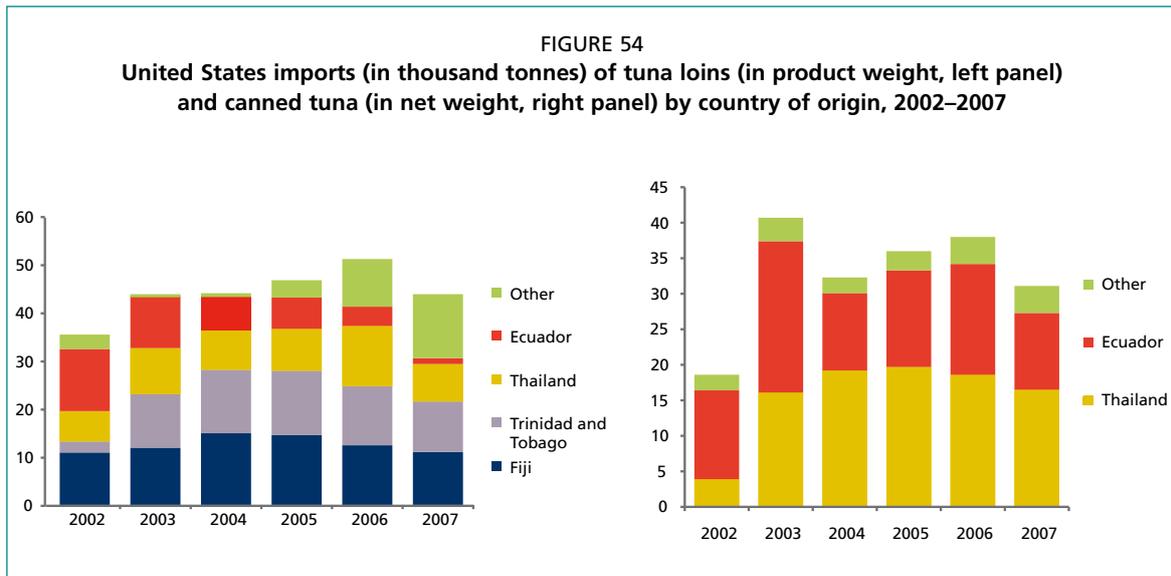
In Europe too, imported loins are increasingly used by the processing industry, since it reduces the most labour-intensive part of packing and thus reduces cost (Figure 53). Around 80 percent of the labour cost for producing a can of tuna is incurred in cooking, cleaning and loining the fish. Transshipment costs are also reduced when loins are transported instead of whole fish, as loins represent only ~60 percent of round weight and can be shipped in containers instead of bulk reefers.

Several canneries in the European Union and Japan import frozen loins, defrost them and pack them directly into cans. As a result, there is a booming market in the European Union for tuna loins. In France and Italy, the proportion of round frozen tuna imported by processors has been reduced to zero.

Tuna loins (Combined Nomenclature [NC previously used by European Union] commodity codes 1604-1412, 1604-1416, 1604-1931) imported as canning materials, are classified separately from tuna fillets for human consumption (Harmonised System [HS currently used by European Union] codes 03041 and 03042). The canneries face problems in securing a sufficient supply of duty-free loins from African, Caribbean and Pacific (ACP) and Generalised System of Preferences (GSP+) countries (see Box 11; Campling, 2007).



Source: FAO Commodities Production and Trade database.



United States imports (by country of origin) of tuna loins are shown in Figure 54 (left panel) and indicate a stable annual level of 40 000 to 50 000 tonnes. United States imports of tuna pouches (canned tuna) are given in Figure 54 (right panel). Ecuador used to be the top exporter to the United States market but was recently replaced by Thailand. The decline in Ecuadorian exports to the United States in 2007 is probably because Ecuador found the European market more attractive, especially for tuna loins. This is possibly due to the strong euro and also because many Spanish vessels have reflagged to Ecuador and strengthened the relationship. Exports of tuna pouches to the United States market also plummeted further when the United States government's Andean Trade Promotion and Drug Eradication Act expired in December 2009 and negotiations for a Free Trade Agreement between the two countries were terminated (United States Department of State, 2009).¹⁰

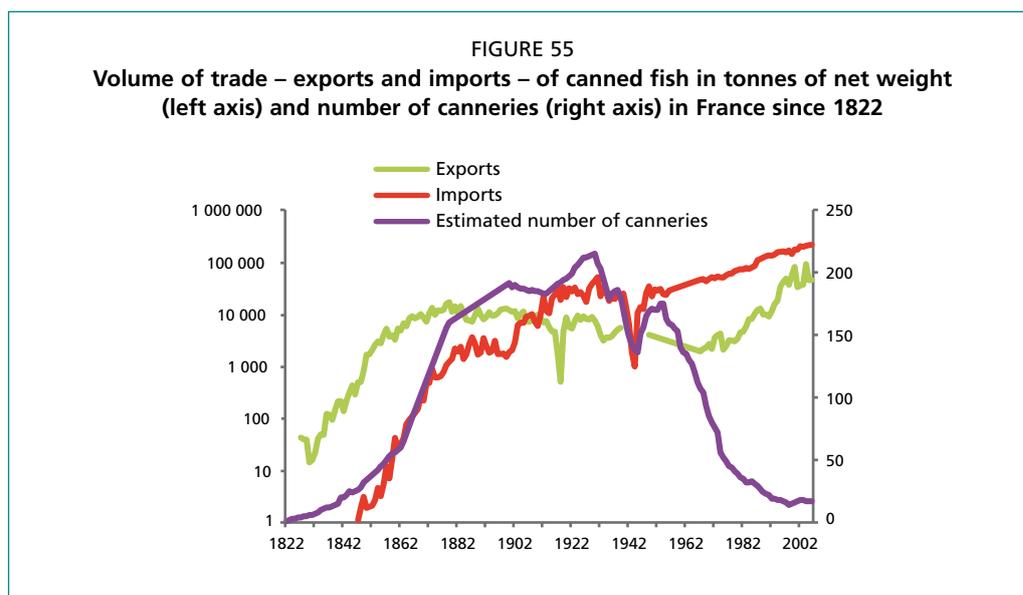
6.5.4 Concentration of the canning industry

At the inception of the tuna industry nearly two centuries ago in Europe, important advantages for a cannery were its proximity to fisheries (sardines, then tuna) and low labour costs. With the growing share of canned tropical tuna in the global market, comparative advantages shifted to increasing economies of scale as the most important factor, and this began a trend toward concentration in the industry.

France pioneered the world's fish canning industry exporting 70 percent of its products until the mid-nineteenth century, mainly to the United States to supply demand from gold rush consumers (Guillotreau and Ferreira Dias, 2005). After the Second World War, the number of French canneries significantly decreased. Not only did most of the plants relocate to the former African colonies after the development of the tuna fisheries in the eastern tropical Atlantic Ocean, but the remaining canneries in France rapidly merged and concentrated (Figure 55). From this figure, it is clear that concentration in the canning industry has occurred concurrently with a two-way trade of products (i.e. imports of raw materials and exports of processed products), as predicted by the life cycle theory of Vernon (1966).

In Spain, according to Carmona-Badía and Fernández González (2001), the fish canning industry was traditionally also characterized by a high number of small firms. In Spain too, concentration has advanced substantially over the past century (see Table 18), and the restructuring process is ongoing.

¹⁰ See www.state.gov/r/pa/ei/bgn/35761.htm



As a result of this concentration process in the industry, productivity has improved due to a lower number of firms producing higher volumes. The Spanish production of canned tuna, in product weight, increased fourfold from 1986 (60 000 tonnes) to 2004 (240 500 tonnes).

Like many other large industries, the worldwide tuna market is now controlled by a few major multinational firms surrounded by a number of smaller competitors. Based on exhaustive data available for the year 2003 the concentration of the sector has been assessed. The information available on market shares (in volume) was vast but variable:

- First, different sources (Oceanic Développement, Poseidon and Megapesca, 2005; Campling, Havice and Ram-Bidesi, 2007; GLOBEFISH, 2007; and Seafood International, 2005) were used to reconstruct the global industry structure (production in net weight by firm).
- Second, national and international production and trade statistics were combined with the reconstructed industry structure in order to assess the concentration of regional markets (imported and exported tuna were divided by 0.8 to roughly convert into round weight).
- Finally, it was confirmed that the resulting global structure was consistent with the partial market concentration structure described in professional sources and the grey literature (imports were assumed to be reported in round weight).

At the global level, the processing capacity of the major firms is tremendous and the five leading countries supply nearly half of all canned tuna in the world market. As reported previously, this high level of concentration is a result of large economies of scale in both the fishing and canning segments of the supply chain.

TABLE 18
Concentration ratios in the canning sector in Spain

	Cumulative market shares of the top five firms (%)	Cumulative market shares of the top ten firms (%)
1908	19.6	30.5
1933	47.8	63.9
1944	28.1	41.4
1959	20.8	31.5
1995	48.7	67.3

Source: Carmona-Badía and Fernández González (2001).

BOX 9

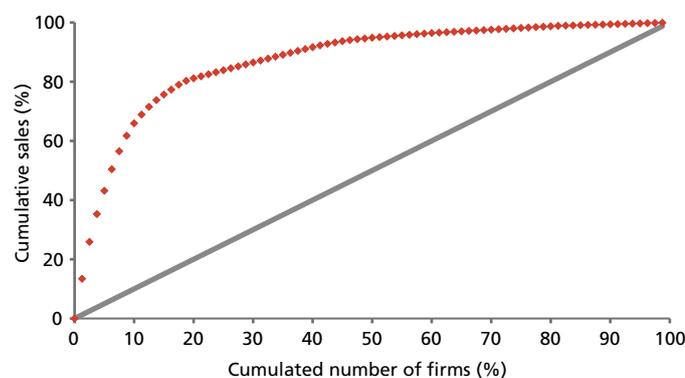
Concentration in the *sashimi* industry

In the case of longline fisheries, there is very little concentration of the industry. In marketing, the control of large brokers is strong as discussed in Section 6.2.2, but not as much as in canned tuna. In the case of canned tuna, the most important element of production cost is related to the canning factories and the mass supply of materials to the factory. In the *sashimi* market, the major production cost is only the longline fishing operation cost. Multi-vessel owners have fared better economically than single vessel owners. The cost effectiveness for operating many vessels is part of the reason, but the same effects can be realized by joining fishermen's associations. Therefore, the ability to distribute financial risk among vessels is the most important reason for the survival of multi-vessel owners. If financial risks are not distributed, one vessel owner can immediately enter bankruptcy if one trip produces a very large deficit.

Tuna are highly migratory species and fishing them for the canning industry requires a large capital investment (e.g. as illustrated by the increasing size of industrialized purse seiners around the world). However, it is also the case that globalization and the extended scale of world markets has resulted in increases in marketing and transportation costs. The fixed costs are therefore large enough to justify mergers and acquisitions by the leaders in the tuna industry so that they can lower their average production costs and transfer the cost reduction to the consumer. This type of concentration at the global level can also be seen within the level of the European Union and the United States, the two major canned tuna markets in the world. The analyses indicated that the concentration is greater in the United States, where the three leading companies hold 75 percent of the market in volume and 85 percent in value. In the European Union, the market is less concentrated (Figure 56). By volume, the five leading companies (Trinity Alimentary, StarKist, Isabel Conservas Garavilla, SALICA Albacora and Jealsa) hold 50 percent of the market, and the ten leading companies hold 72 percent.

The reasons for this oligarchic situation are related specifically to the following three trade rules that protect the European industry:

FIGURE 56
Lorenz curve of the European canned tuna oligopoly showing the cumulative sales by firms in tonnes in 2003



Note: The horizontal axis represents the cumulative percentage of firms (starting with the leaders) and the vertical axis shows the cumulative percentage of market share (i.e. sales in quantity by net weight on the European market).

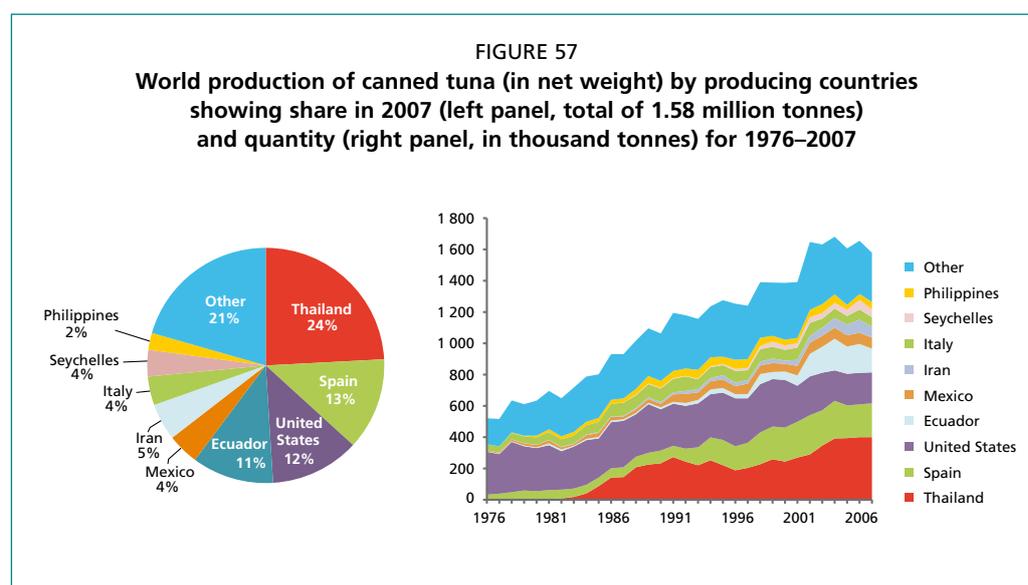
Source: R. Mongruel, 2002.

- The “compensatory allowance for tuna” guarantees a minimum price to the fishing companies supplying the European-based canning industry regardless of how low international prices may fall.
- The common customs tariff (20.5 to 24.0 percent) on canned tuna protects European processing firms from global competition.
- European Union preferential trade tariffs impose the European Union’s sanitary conditions on the exporters and require the use of raw materials which qualify under other direction “rules of origin” as tuna supplied either by the beneficiary countries or by European producers. These preferential trade tariffs facilitate the reimportation of canned tuna processed by subsidiary companies of the European firms located in Africa, Latin America and Pacific Island countries, and from local companies that use tuna caught by European Union vessels (Mongruel, 2002; Kaczynski and Fluharty, 2002; and Campling, Havice and Ram-Bidesi, 2007).

This type of industry concentration is also highly apparent in the trading of canned tuna and will be discussed in the following sections.

6.5.5 World production increase

As shown in Figure 57, canned tuna production has constantly increased: from 600 000 tonnes in the mid-1970s to 1.7 million tonnes in 2006. Until the mid-1980s, production was dominated by the United States, the European Union and Japan, which together accounted for more than two thirds of the world production. However, more recently, new countries have started to enter into the picture. In particular, the entry of Thailand into the industry in the early 1980s and its development thereafter has reduced the dominance of the European Union and United States canneries. In the last two decades, development of new producers in Southeast Asia (Indonesia, the Philippines), central America (Mexico), and the Indian Ocean (Madagascar, the Seychelles, Mauritius and increasingly the Islamic Republic of Iran) were notable. Just prior to 2000, Ecuador began to play a key role among the producers of canned tuna. In 2006, Thailand, Spain, the United States (American Samoa), Ecuador, the Islamic Republic of Iran, Mexico and the Seychelles produced 80.5 percent of the world total. Past major producers (the United States [mainland], European countries and Japan) lost their share of production, with the exception of Spain, because of an inability to compete with production costs in countries which have an advantage in terms of accessibility to materials and lower labour costs.



Source: FAO Commodity Product and Trade database.

only 7 to 8 percent of total tuna canning costs, compared with 60 percent of net fishing costs (Campling and Doherty, 2007). Therefore, many canneries have been developed in locations near tuna fishing grounds (e.g. the Pacific and Indian Ocean Island States). The advantage of easy accessibility to the tuna stocks is also closely related to the access agreements for EEZs and port facilities for transshipment. However, for many small island economies, such as American Samoa, the Seychelles, Mauritius, the Solomon Islands and the Marshall Islands, the scope for further development of the canning industry is limited due to the lack of infrastructure (capital, land and harbour facilities) and the need to import supporting items at high costs (labour, tin, fish, oil and vegetables).

Furthermore, some states have only limited tuna resources available within their EEZs and transshipment costs of materials are increasing. Canning industry competitiveness is increasingly sensitive to trade restrictions and policies (e.g. World Trade Organization [WTO] negotiations and erosion of preferences for products originating from ACP countries). For instance, a reduction of tariffs within international trade agreements or a new definition of the rules of origin may rapidly affect the existing competitive advantages (United States House of Representatives, 2004; Peacock, 2006; Campling, 2008). Potential newcomers to the industry may jeopardize the existing tuna canneries, particularly those in such locations as China, Viet Nam and the Republic of Korea which do not neighbour the EEZs with abundant tuna.

The most recent production and maximum production capacity of canned tuna and loins is given in Table 19. Canned tuna production in the Western and Central Pacific is almost half of the total world production (if Thailand, Indonesia and the Philippines are included in this region), and together with the Eastern Pacific, three quarters of total production originates from the Pacific. In fact, the Pacific's share of global canned tuna production is similar to its share of the global tropical tuna catch. The share of canned product for the Atlantic is larger than its catches, and the Indian Ocean share of canned product is smaller than its catches. This may reflect the fact that the longstanding European canning industry is still obtaining relatively low-cost materials from the Indian Ocean due to the development of loin products.

Table 20 shows recent Japanese production of canned tuna. As mentioned earlier, cans sold in the domestic market are recorded separately as tuna and skipjack. Most likely the tuna and skipjack mixed category corresponds to canned tuna for export. Compared with the fresh fish market, which consumes about 700 000 tonnes of tuna, canning is still a minor industry in Japan.

BOX 11

Systems for reduced tariff

The Generalised System of Preferences (GSP+) regime (formerly called the GSP anti-Drug regime and initially established in 1990) is available to countries having ratified a number of international conventions on labour and human rights, and on the environment and good governance. Eligible countries are found in Central and South America, including Bolivia (Plurinational State of), Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Peru and Venezuela (Bolivarian Republic of).

The African, Caribbean and Pacific (ACP) group of states signed the first international trade agreement with the European Union in 1975 at Lomé (Togo). This agreement gives preferential access (including duty-free access for most seafood, agricultural and industrial products) to European Union markets. This agreement has been revised and extended several times and is now embodied in the Cotonou (Benin) agreement of 2000, which covers 79 ACP states.

TABLE 19
Production capacity of canned tuna and loins in 2008

Ocean	Countries	Number of companies	Capacity (tonnes/day)	Annual production (tonnes)	World production (%)
Western and Central Pacific	Thailand	15	2 770	736 000	23.5
	Samoa	2	900	212 500	6.8
	Fiji	1	145	18 400	0.6
	Papua New Guinea	3	410	59 800	1.9
	Indonesia	6	500	20 000	0.6
	Philippines	5	640	225 000	7.2
	Solomon Islands	1	50	5 000	0.2
	Marshall Islands	1	100	5 000	0.2
	Korea, Republic of	3	550	110 000	3.5
	Japan	14	400	77 500	2.5
	China	2	150	20 000	0.6
	Viet Nam	3	250	45 000	1.4
	Subtotal	56	6 985	1 534 200	49.0
	Eastern Pacific	Ecuador	14	1 510	362 400
Mexico		12	775	186 000	5.9
Colombia		3	355	85 200	2.7
Venezuela (Bol. Rep.)		4	240	57 600	1.8
Costa Rica		1	75	18 000	0.6
El Salvador		1	250	60 000	1.9
Guatemala		1	80	19 200	0.6
Subtotal		36	3 285	788 400	25.2
Indian	Mauritius	2	400	90 000	2.9
	Seychelles	1	350	75 000	2.4
	Madagascar	1	150	20 000	0.6
	Kenya	1	100	12 000	0.4
	Iran	Many small plants	400	75 000	2.4
	Subtotal	5	1 400	272 000	8.7
Atlantic	Ghana	3	250	25 000	0.8
	Côte d'Ivoire	3	300	60 000	1.9
	Italy	6	450	108 000	3.4
	Spain	+/-25	1 000	220 000	7.0
	France	2	200	36 000	1.1
	Israel	3	50	10 000	0.3
	Portugal	2	200	18 000	0.6
	Turkey	1	250	20 000	0.6
	Trinidad and Tobago	1	120	20 000	0.6
	Brazil	2	150	20 000	0.6
	Subtotal	48	2 970	537 000	17.1
Total	92	3 131 600	100.0		

Note: The division by ocean indicates the production site rather than the origin of the raw materials.

Source: McGowan, 2008.

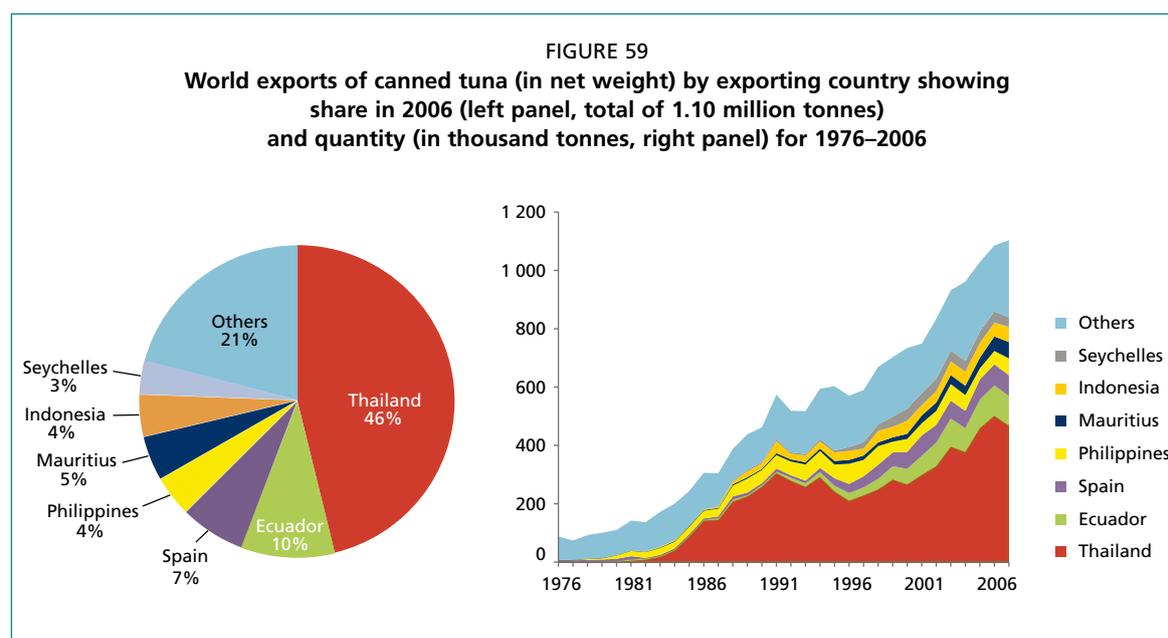
6.5.6 World trade in canned products

In 2006, according to the FAO Commodities Production and Trade database, global imports of canned tuna represented 1.24 million tonnes (net weight) valued at US\$3.76 million. In 2006, the total traded quantity in net weight represented 13 times the level in 1976. The nominal average price increased by 40 percent between 1976 and 1996 but has remained remarkably constant since then, representing a decreasing trend in real value. Canned tuna products were initially considered to be a cheap substitute for canned salmon, whose production fell and whose price increased in the 1950s.

TABLE 20
Japanese canned tuna production in net weight (tonnes) and cases (in thousands)

	2007		2006		2005		2004		2003	
	Net wt	Cases								
Tuna	35 600	7 850	42 607	9 134	45 739	9 669	46 410	9 119	49 427	10 332
Skipjack	12 068	2 932	10 849	2 494	10 533	2 413	11 924	2 697	11 586	2 618
Total	47 667	10 783	53 456	11 629	56 272	12 082	58 335	11 816	61 013	12 949

Source: Statistical Bureau, Ministry of Agriculture, Forestry and Fisheries, Japan.



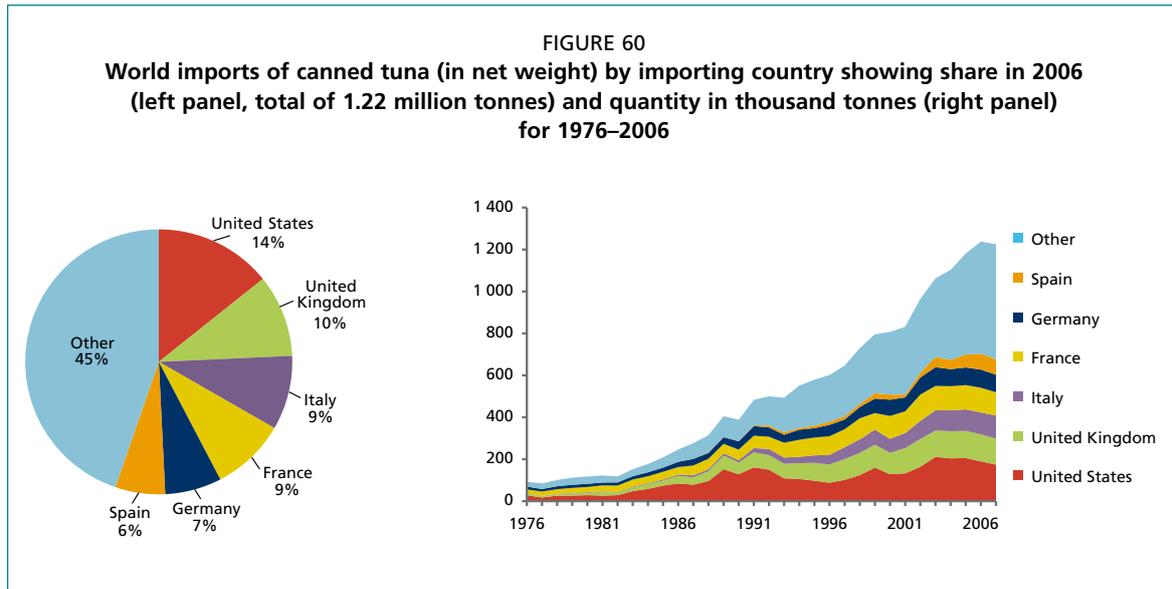
Source: FAO Commodities Production and Trade database.

Since then, canned tuna has always represented a low-cost and handy food for most consumers: in the United States, the psychological limit of 1 United States dollar per can has been an established price barrier.¹¹ Figure 59 shows the share of each of the world's top exporters of canned tuna in 2006 (left panel), indicating that Thailand accounts for 46 percent of world exports. Time trends in exports (right panel) reveal that Thailand has had a rapid, general increase which drives the world total. Except for the European Union countries, who are major consumers, the largest producers are also the largest exporters (e.g. Thailand and Ecuador).

Figure 60 shows the shares (left panel) and quantity (right panel) of world imports of canned tuna (prepared and preserved tuna) by importing country. However, as discussed in Section 6.1, the classification of products is uncertain and those shown here may well include commodities other than canned goods (e.g. loins). The top five importers in quantity are the United States, the United Kingdom of Great Britain and Northern Ireland, France, Italy and Germany, together representing about 50 percent of world imports in 2006. The world imports increased from 285 000 tonnes in 2000 to 570 000 tonnes in 2006.

As seen for exporting countries, the number of importing countries and their shares have increased and the cumulative market share of the major markets (i.e. United States, European Union, Japan) has dropped from 96 percent to 74 percent over the last three decades. The gradual widening of European Union membership has allowed the

¹¹ This is the reason behind the recent addition of protein substitutes to canned materials to reduce the cost and the appearance on the market of smaller-sized cans.



European Union to maintain more than half of the worldwide market, but the relative importance of the United States has been cut in half (Figure 60).

Exporters of canned product to the European market – the Asian countries such as Thailand, the Philippines and Indonesia, and Ecuador – have sharply increased their trade. This is mainly due to the reduction in tariff rates (24 percent to 12 percent) between 2003 and 2008 for Asian countries and to the GSP+ preferential trade regime (Box 11). The GSP+ has resulted in significant flows of European Union investment (essentially by Spanish companies) to several Latin American countries (Campling, 2007; Oceanic Développement, Poseidon and Megapesca, 2005). The investments have taken the form of establishing canning facilities as well as adding modern purse seiners to the Eastern Pacific Ocean fleet. Such investments have caused the market share of Ecuador to double from 10 to 19 percent over the last five years.

This expansion has been detrimental for traditional European Union partners like the Seychelles (drop in share of 21 to 13 percent), Côte d'Ivoire (drop in share of 15 to 11 percent) and Madagascar (drop in share of 6 to 3 percent). Since exports often derive from only one or two canneries in most exporting countries, for example, the Seychelles, Mauritius, Ghana, Côte d'Ivoire, Madagascar, Kenya, Fiji, the Marshall Islands, El Salvador and Guatemala, market shares are subject to changes in international investment since decisions made by a single company may have severe implications for the host country and its trade. In a large number of small island states, canned tuna is the only export product and therefore represents a critical source of foreign currency.

The European Union consumer market now exceeds 1.5 billion euros in value and approaches 700 000 tonnes (net weight) after a 5 percent increase per year between 2000 and 2005 (ADEPALE, 2008). The five largest member states in terms of consumption are Italy (21 percent of the total quantity), the United Kingdom (21 percent), France (20 percent), Spain (15 percent) and Germany (11 percent). In consumption per capita, Spain comes first with 2.22 kg annually, followed by Italy (2.11 kg) and the United Kingdom (1.99 kg). The average European consumption per capita is 1.53 kg.

The European canned fish market can be classified as follows:

- Northern European countries (the United Kingdom and Germany) consume low-priced skipjack products (in oil or brine) imported from Southeast Asia.
- Southern European countries (Italy and Spain) are both domestically processing and importing yellowfin-based products at higher prices.

BOX 12

Concentration in the tuna trading industry

Although less well known, the tuna trading industry shows even more concentration than the canning industry (discussed in Section 6.5.4). The tuna trade is composed of three very influential firms and a small fringe of powerful traders. These three leaders (ITOCHU Corporation, FCF Fishery Company Ltd [FCF], and TriMarine) control 75 to 80 percent of the supply to the Thailand canning industry (Campling, Havice and Ram-Bidesi, 2007).

FCF, located in Kaohsiung, Taiwan Province of China, and established in 1972, is probably the biggest of all and is present in every major marketplace for cannery-grade tropical tuna (e.g. Indonesia, Thailand, American Samoa, the Philippines). The company buys fish from Asian purse seiners, mostly those from Taiwan Province of China, but occasionally from United States vessels, to sell to the canneries.

Itochu, headquartered in Tokyo, Japan, is a traditional trading company established in 1858. Tuna represents 70 percent of the goods handled by the seafood department of the firm, though Itochu seafood division is a very minor part of their business. Itochu's strategic position is similar to FCF's but ITOCHU is more involved in the longline *sashimi* value chain due to the strong demand in the Japanese market for these tuna products. In both cases, fishing boat owners are provided with operating funds by these traders and are in return obliged to sell the products to their sponsors.

TriMarine's market, although the smallest of the "big three" in terms of sales value, comprises approximately 400 000 tonnes of frozen tuna annually (Campling, Havice and Ram-Bidesi, 2007). Interestingly, this company (which sells to the Thailand packers, as well as to the traditional United States firms based in American Samoa and Bolton Alimentari in the European Union) has vertically integrated by taking over the ex-StarKist (United States) purse seiner fleet in 2001 before reducing it from 14 to 7 vessels five years later under United States, Panamanian and Solomon Islands flags (Campling, Havice and Ram-Bidesi, 2007). As is typical of modern global organizations involved in the tuna industry, TriMarine has developed subcontracting agreements with a few canneries – three plants in South America, Wanaichi (Kenya) and Soltai (Solomon Islands).

- France is an intermediate market where both types of products are consumed, the most important product being "thon au naturel", which is canned tuna in brine that is only cooked once after being packed; the process is known as "raw pack" among packers.

This market situation has not changed much over the last few decades. However, there has been a major change in the supply side of the market. Spain now dominates supplies to the Italian canned tuna market, mainly due to the establishment of Italian-Spanish joint ventures which have resulted in many of the former market-leading Italian firms being moved to Spain (Josupeit, 2007).

6.5.7 Price and market demand for canned products

The previous sections discussed production and import and export of canned tuna products. In order to provide an overview of the global canning industry, the balance sheets for three major markets – the European Union, the United States and Japan – are presented in Figure 71. Consumption is estimated by the following equation:

Consumption = Production + Import - Export - Re-export (- Non-human Consumption).

It is important to be aware that problems arise when the quantities used in the equation are given in different units (see Box 5). In addition, the amount which is used

for non-human consumption is not available. Therefore, this equation is best used to illustrate general trends rather than precise estimates of consumption.

Applying this methodology shows that the United States produced 198 000 tonnes, imported 174 000 tonnes, and exported 1 500 tonnes of canned tuna in 2007. The United States' apparent consumption is thus 372 000 tonnes, which is equivalent to 42 million standard cases in 2007. Meanwhile, the 27 member states of the European Union set the record for high consumption of 92 million cases.

Private labels in 2006¹²

In the European Union, the United States and Japan, supermarkets occupy a tremendous share of the sales of canned tuna. In France, the market share of supermarkets for sales of canned fish has risen from less than 20 percent in 1980 to 89 percent in 2007 (OFIMER, 2003). In the United States, the top ten supermarkets accounted for 39 percent of national grocery sales in the early 1980s and 70 percent in 2007. This is also the case for canned tuna products. Low-cost canned tuna products have been increasingly produced by canneries under direct contract to the retailers (or by processors) and sold under private (supermarket) labels. Private or own labels (of retailers) provide the retailer with higher profit margins, despite lower sales prices.

In the United States, private label sales accounted for only 14.5 percent of the canned tuna market (Campling, Havice and Ram-Bidesi, 2007), but this share is much higher in the European Union. In 2007, the market share of retailers' private labels represented 33 percent (238 million euros) of the French canned tuna market and this has not changed over the last decade (AC Nielsen, unpublished data). In Spain, retailers' private labels reached 54 percent of the market (305 million euros), and can even be higher for some market segments (e.g. 59 percent for canned yellowfin in vegetable oil or 70 percent for canned skipjack (Lamas and Moreno, 2007).

One report estimates that private label products are priced for retail at 20 to 40 percent less than equivalent brand labels, and are purchased by the segment of society that is the most hard-hit by recession. Supermarkets are consequently investing more in their own-label product lines. While it is possible that several major canned tuna brands could be negatively impacted, given that canned tuna is generally a low-cost source of protein, it may prove "recession proof" (FFA Trade Bulletin, 2009).

World market structure

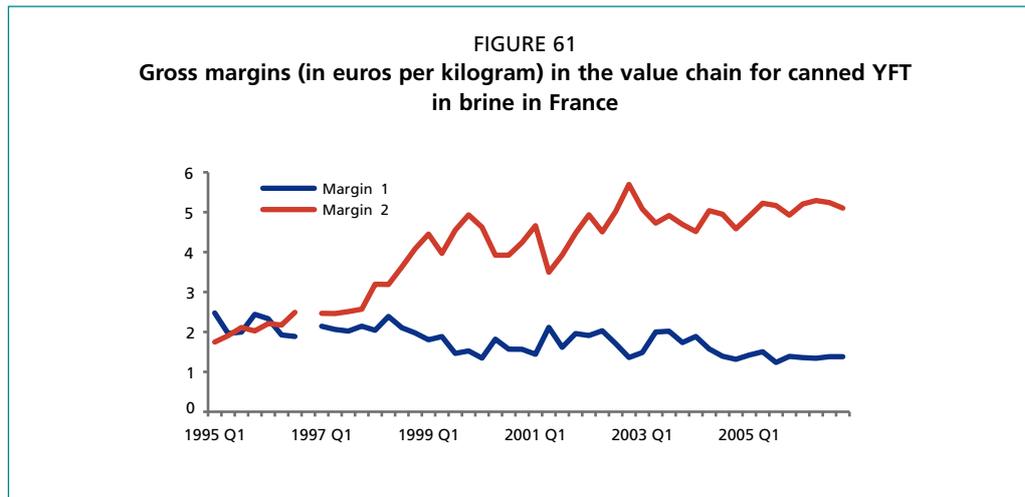
Beyond the private labels, the market power of retailers is exercised through vertical supply chain pressure on the upstream sectors, i.e. the fishers and the canneries. Powerful retailers may get "rear (back) margins" from the processors through commercial cooperation conditions, for example, in the form of business allowances, advertising, brochures, damaged goods and new stores. According to processors and experts, rear margins charged by the supermarket chains to the processors can represent up to 40 percent of the retail price of branded canned tuna. As a result, the distribution of gross added value between the shipowner, the cannery and the retailer has changed, as shown by the example of the French value chain of canned yellowfin in brine (Figure 61).

In this figure, three prices (in euros per kg of net weight) have been considered:

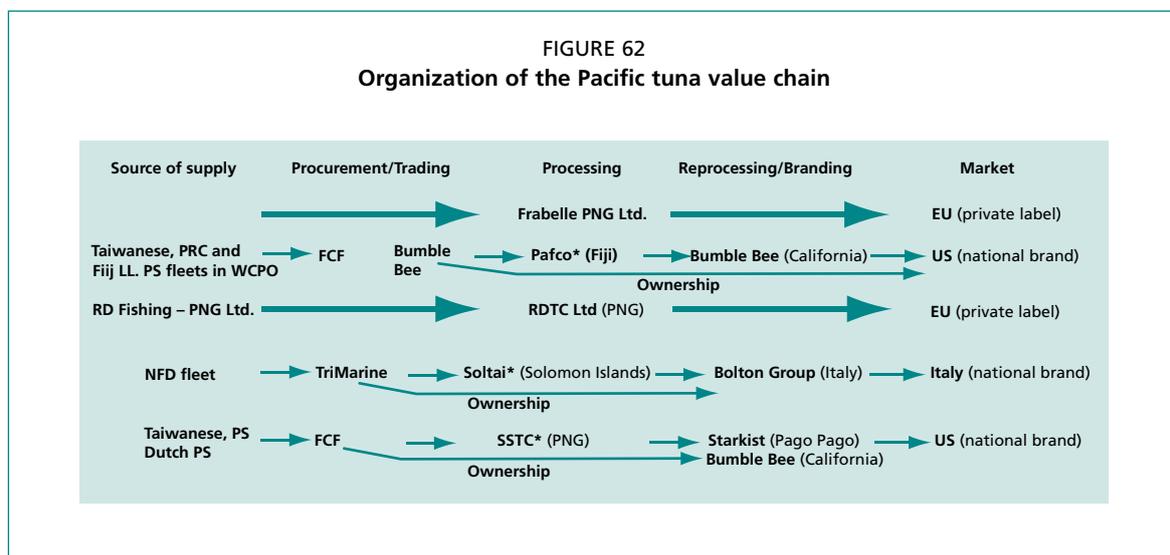
- ex-vessel freight-on-board price of frozen tuna in the Indian Ocean (SOVETCO, unpublished data);
- French import price of canned tuna in brine originating from countries outside the European Union (Eurostat-Comext);¹³ and
- retail price of canned tuna in brine (OFIMER, 2003).

¹² This amount was slightly reduced to 87 million cases in 2007.

¹³ See epp.eurostat.ec.europa.eu/newxtweb/



Note: See text for definitions of Margins 1 and 2.



Note: Asterisks represent processing agreements with the owners of the fish.

Source: Campling, Havice and Ram-Bidesi, 2007.

Two gross margins have been calculated from these prices: Margin 1 (cannery margin) is the difference between the first and second prices; and Margin 2 (retail gross margin) is the difference between the second and third prices. The annual change in these margins is shown in Figure 61. The cannery margin clearly shows a decreasing trend whereas the retail gross margin has increased proportionally. This indicates that retail prices now include rear margins, which means that consumers could have paid less than what they are paying now.

A typical example of the evolution in the relationships between processors, traders and retailers is illustrated by the complex organization of procurement and trading along the tuna value chain of the Pacific Island countries (Campling, Havice and Ram-Bidesi, 2007) as seen in Figure 62. Two types of firms coexist in the world tuna canning industry: (1) processing firms which are vertically integrated, owning both vessels and canneries; and (2) processing firms which only focus on processing. Some companies in the latter group operate as simple contractors for multinational trading, processing or retailing groups. This is the case of PAFCO (Fiji), Soltai (Solomon Islands) and South Seas Tuna Corporation (Papua New Guinea) in the Western and Central Pacific. These firms may have their own labels, but the raw fish supplied by FCF or TriMarine (two of the major traders) are processed under United States or European Union labels. Another example is the French company Saupiquet (Bolton Group), which

subcontracts to Thai processing plants to produce most of its yellowfin in brine sold in France under its domestic brand name. The company has shifted gradually from a manufacturing group to a firm without plants.

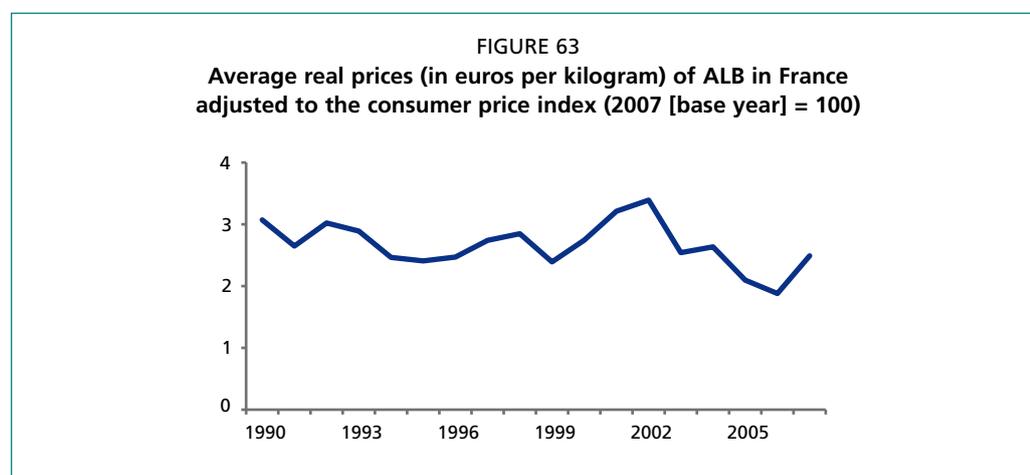
Price formation

Prices have been fairly stable for both fresh and frozen and canned tuna products since the early 1990s, meaning, in effect, that they have decreased in real terms throughout time because of inflation (Figure 63).

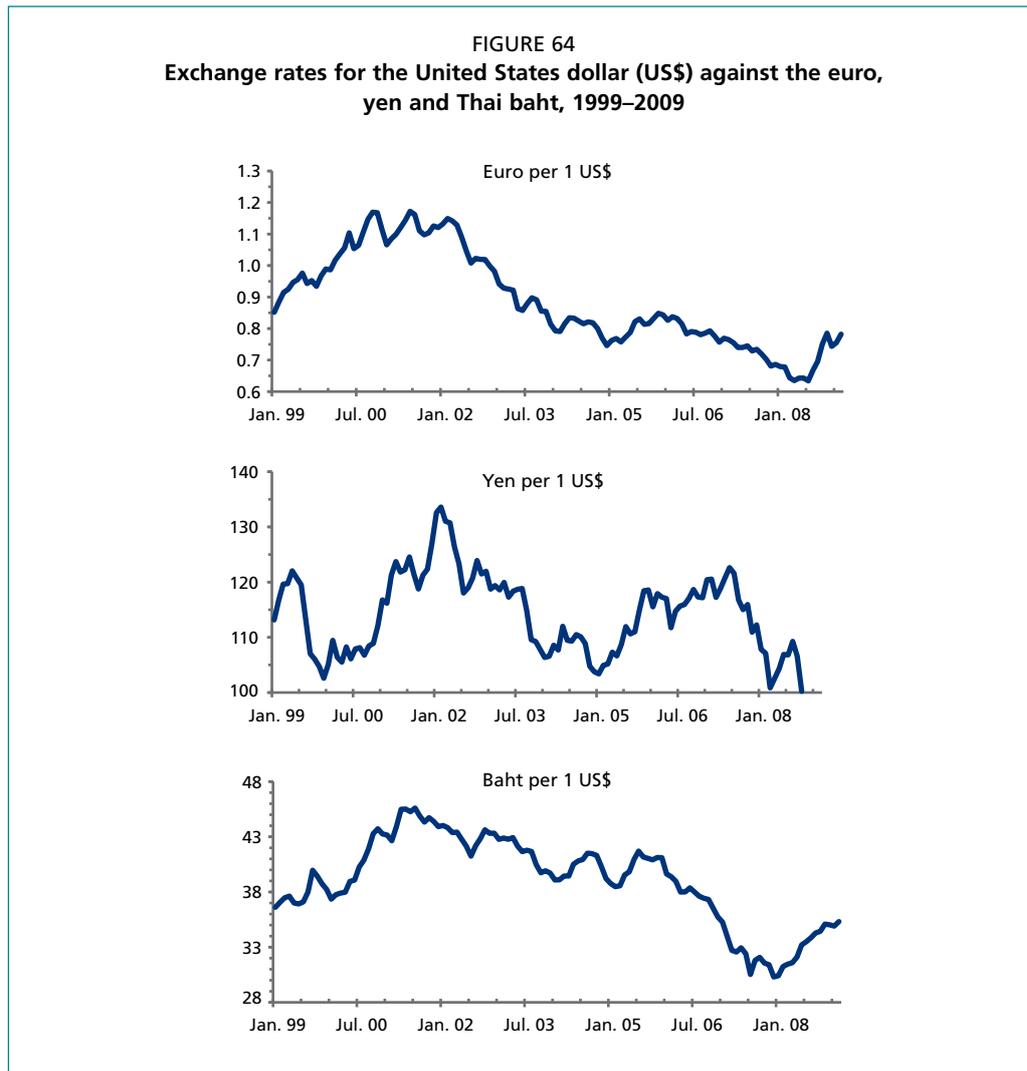
According to Squires *et al.* (2006), Jeon, Reid and Squires (2008), and Jiménez-Toribio, Guillotreau and Mongruel (2009), there is clear evidence that the major marketplaces for frozen skipjack (Japan, Thailand, American Samoa, Puerto Rico, Ecuador, Côte d'Ivoire and Spain) are strongly integrated in the sense that prices in these markets move together in the long run, allowing for short-run deviations. Market leadership can be identified in both the American marketplaces and Thailand, but the other locations are characterized as being market followers rather than leaders (Squires *et al.* 2006; Jeon, Reid and Squires, 2008).

Regional prices in local currencies of the canning materials, once converted into dollars, are very closely related to the world prices in dollars, particularly for cannery-grade skipjack (Sun, 1999; Squires *et al.*, 2006; Jeon, Reid and Squires, 2008; Jiménez-Toribio, Guillotreau and Mongruel, 2009). The high level of concentration of both the trading and processing industries allows for this permanent trade-off between the different production sites by the large traders (e.g. FCF, TriMarine, ITOCHU, Mitsubishi and SOVETCO), hence a high level of convergence in prices is observed. Because the monetary exchange rates can fluctuate substantially, rapidly and independently among different currencies (see Figure 64), price adjustments have to be done almost instantly to account for dollar rates, as well as the rates of other international currencies like euros or yen, and to account for freight rates. In the short-run, a depreciation of the dollar against the euro as seen in late 2007 to early 2008 can make the Central and South American (i.e. Ecuador, Mexico and El Salvador) supplies more competitive.

Recently, the Indian Ocean canneries (e.g. the Seychelles) faced a shortage of local landings. This situation in the Seychelles was further complicated by the sudden drop in the value of the local currency, the Seychelles rupee. Tuna landed in the Seychelles, and most of the other inputs (fuel, some of the labour, tin), are not purchased in Seychelles rupees but in dollars or euros. For example, foreign workers from the Philippines, which represent half of the labour force, were reluctant to work in the Seychelles in 2008 after wages declined in terms of dollars to the point where they were no longer attractive (personal communication to authors by Indian Ocean Tuna Ltd.). In addition, while the procurement of raw tuna depends on the parity between euros



Source: OFIMER, 2003.

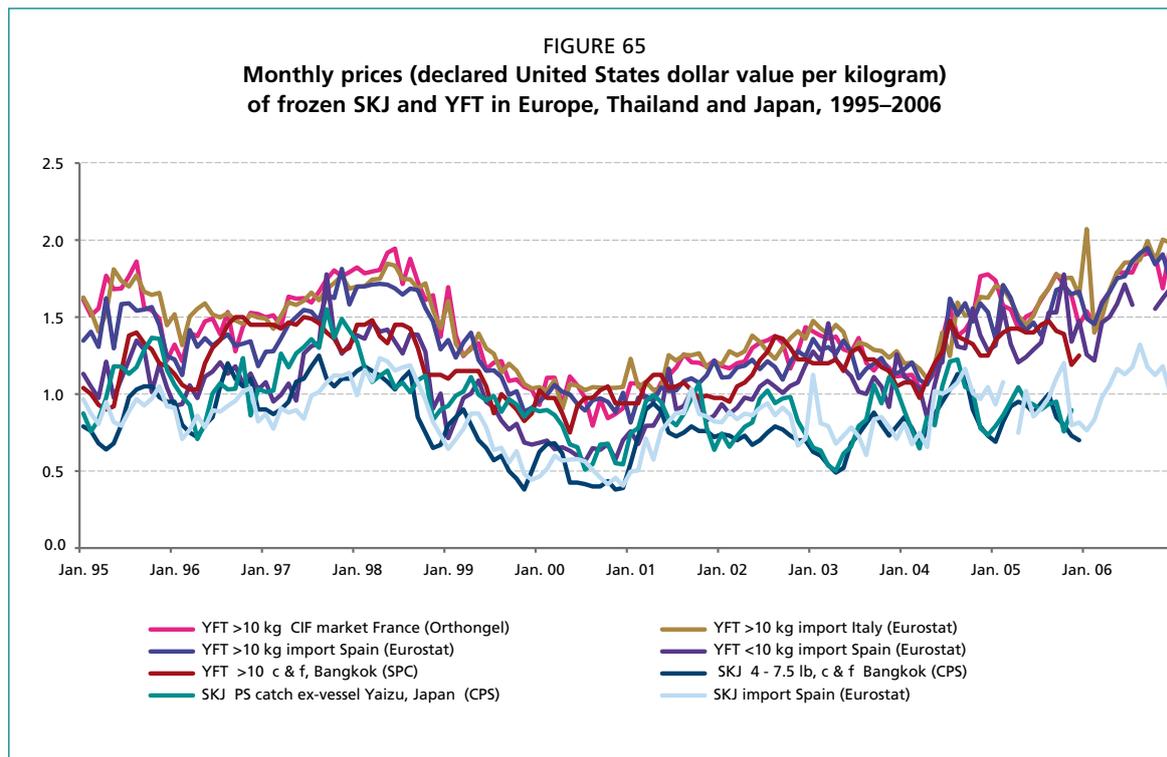


and dollars, this is mitigated to some extent because cheaper materials may incur higher shipping costs or may arrive in poor condition for canning (e.g. badly frozen and stored). For example, Ecuador is so distant that the value of the dollar needs to be very low to make Ecuadorian loin products competitive for the Indian Ocean canneries. Nevertheless, on two occasions in the past three years such tuna have been supplied to Indian Ocean canneries. This was an exceptional case, however, because the high cost of long-haul transportation reduces profits and could not be supported under normal circumstances.

Japanese vessels fishing to supply canneries are suffering under the appreciating yen because most of their costs are paid in yen while the sales are in dollars. The situation is exacerbated because Japanese canneries appreciate low-priced materials but are discouraged from producing products for export markets under strong yen conditions.

Thailand, as a major processing site, and more recently Latin America, leads global prices, in particular driving prices throughout Europe, the southwestern Pacific islands, the Indian Ocean islands and Africa (Jeon, Reid and Squires, 2008; Squires *et al.*, 2006). Japan may sometimes show independent behaviour, presumably because of the influence of the *sashimi* market¹⁴ (Bose and McIlgorm, 1996). Abidjan (Côte d'Ivoire)

¹⁴ Japan is the only substantial marketplace in which canned tuna is not the leading product. Japanese firms produce canned tuna mostly for domestic consumption, and also supply an important domestic market for *sashimi*, *katsubushi* and soluble fish powders (see Section 6.4).



is clearly a price follower, responding to the prices in Bangkok (Thailand) or American Samoa, though somewhat lower. These purse seine-caught frozen fish markets are themselves strongly influenced by the level of the United States demand for canned tuna. Comparisons of United States import prices of canned tuna from Asia (Thailand and the Philippines) to import prices paid by European Union member states (United Kingdom and Germany) show the substantial United States market leadership upon the European Union markets (Jiménez-Toribio, Guillotreau and Mongruel, 2009). Recently, global integration of canned tuna markets between Asia, the United States and the European Union has become more evident than ever.

Uniformity of prices in the world market is less clear for bigeye and yellowfin (Bose and McIlgorm, 1996; Squires *et al.*, 2006). No significant correlation was found between the price series of skipjack and that of yellowfin in Pago Pago (American Samoa), most likely due to the wide variation in the size of yellowfin landed there. Yellowfin contributes up to 25 percent of the supply to the American Samoa canneries.

In the southern European markets (i.e. in Spain, France and Italy), which are more yellowfin orientated, there appear to be strong linkages between the prices of yellowfin and skipjack. Even in Thailand, this type of linkage is observed with the most valuable yellowfin determining the price of the less valuable skipjack (Figure 65) (Jiménez-Toribio, Guillotreau and Mongruel, 2009). If the prices of both species are linked together in the long run, they exhibit a constant difference over time due to the yield of materials (see Box 13).

Figure 66 shows the monthly reported export price of canned skipjack from Thailand by destination country. Because large quantities of Pacific tuna as well as Indian Ocean tuna are easily supplied, Bangkok is clearly the key marketplace where prices are formed and from there are imposed on peripheral markets. However, the price (both for fish to be packed and canned products) flexibility, which means the extent to which price changes when catches fluctuate, in Bangkok seems to respond more to demand conditions in the market for canned products (particularly in the United States) than to supply conditions (Sun and Hsieh, 2000).

BOX 13

Price standards for tuna canning

In general, in the canning industry, frozen skipjack prices are standardized for the following reasons:

- skipjack are fairly uniform in quality by season and area and similar in size throughout the world;
- skipjack is used almost exclusively for canning (except for use for *katsuobushi* and a minor fresh fish market) and hence does not compete with other products; and
- most of the landings are in round, frozen form, and hence the price is comparable regardless of landing point.

The price difference between yellowfin for canning and skipjack is mostly due to the difference in conversion rate (round to canned products). Price differences by size of yellowfin can also be considered a form of conversion rate difference because larger fish have higher conversion rates. There are three general size categories used by canneries:

- large yellowfin (weighing >10 kg);
- mixed fish (juveniles of yellowfin and bigeye weighing <10 kg and skipjack weighing >1.8 kg); and
- small skipjack (weighing <1.8 kg).

With the bones, skin and guts removed, the yield for pre-cooked mixed tuna is 40 percent, whereas the raw pack process (i.e. the fish is cooked once in the sealed can) for large yellowfin has yields of 55 to 57 percent. Consequently, the relative price difference between large yellowfin and mixed tuna is approximately the same as the relative price difference between mixed fish and small skipjack.

In the Indian Ocean for 1992–2007, the price per kg of large yellowfin represents 1.54+/-0.16 times the price of mixed tuna and mixed tuna represents 1.52+/-0.20 times the price of small skipjack. This important difference makes free schools of large yellowfin more valuable and sought after by the purse seine fleet than the FAD associated mixed fish or small skipjack. However, the proportion of positive sets on FADs for purse-seine vessels is about 90 percent, compared with only 50 percent on free schools (Campbell and Nicholl, 1994) and the fishing seasons for each differ, at least in the Indian Ocean (Moreno *et al.*, 2007) and Eastern Pacific Ocean. FADs are responsible for the expansion of fishing grounds and seasons. This is why so many purse-seine vessels choose to fish with FADs despite the relatively lower prices for the resulting mixed species tuna catches. Furthermore, the catch quantity per unit of fuel is highest for FAD fishing, i.e. production costs are lower for FAD fishing (see Section 4.2.7).

In the fishing industry, supply is the natural candidate for uncertainty. However, in the case of tuna, the variability of demand could be the dominant force driving the market as well as affecting the supply. Market demand for tuna is strongly affected by the availability of many substitute products and other external elements such as health and safety concerns, preferences for low-fat and high-protein foods, environmental concerns, trade barriers, exchange rates, and/or the global economy. This is a major theme of this paper (in particular, see Section 8). The dolphin issue in the Eastern Pacific Ocean (Section 5.2) is a typical example of how external elements can distort the market.

Producers are also concerned about the interest on the demand-side regarding the addition of new ingredients to canned tuna products. The addition of vegetables and other low-cost fillings adds value to the products but reduces the volume of tuna used for production. However, producers can organize themselves to counteract such demand-driven market forces.

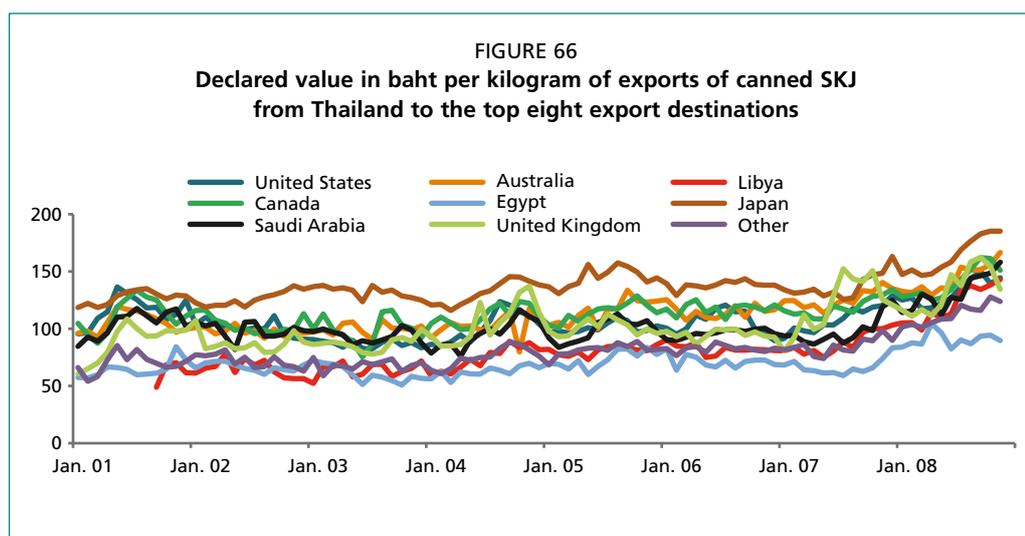


Figure 65 indicates a dramatic decline of all tuna prices in 1999 and 2000. Catches were exceptionally good in these two years, particularly in the Pacific Ocean (both Eastern and Western), and the United States demand for frozen tuna was slowing down as United States packers adding vegetable material and hydrolysed protein to tuna cans, reducing by 20 percent the quantity of fish packed in a tuna can (Morón, 2002). To cope with this marketing problem, purse-seine owners decided to organize themselves and created the World Tuna Purse Seine Organization (WTPO) in March 2001. Like any other cartel of producers, the WTPO members adopted, on a voluntary basis, self-limits on their catches in order to restore market conditions. The adopted measures were effort reduction (including maintaining the purse-seine vessels in port), catch limits and time-area closures. Soon after the measures were implemented, within a few months, prices recovered to the previous average levels. Although still in force, the WTPO has not taken any equivalent measures affecting price mechanisms since then.

Recent studies have assessed gross margins (i.e. differences between prices at different stages of the same production process or value chain) and stressed the high-quality level of vertical pass-through between the price of frozen fish and canned skipjack. In other words, these studies found that the margin at each stage is tight, except for the case of yellowfin in brine sold by supermarkets, as mentioned above, and that changes in prices of frozen tuna are rapidly transferred to consumers of canned tuna in Europe (Jiménez-Toribio, Guillotreau and Mongruel, 2009). This is valid for most of the canned tuna value chains in the world: at every stage of the chain, markets are highly competitive and unit margins are tight for all the stakeholders.

There might be some exceptions to this general principle on the retail side. A typical exception is the product of yellowfin in brine consumed in France and Italy, where private brands play an important role in differentiating such products. The consumers pay more for branded products and the profit margin is captured by the retailers (see the concept of “rear margins” in Section 6.5.7).

United States canned tuna supply and consumption

As explained in previous sections, the United States market has the greatest influence on the canned tuna industry. Given this influence, and the fact that the European Union market has been described already, this part focuses on the United States market.

The supply of canned tuna in the United States market is given in Figure 67 and shows an annual fluctuation between 350 000 and 450 000 tonnes from 1989 through 2007. Consumption was lowest in 2001 and United States domestic production

BOX 14

Flexibility and elasticity of demand for tuna products

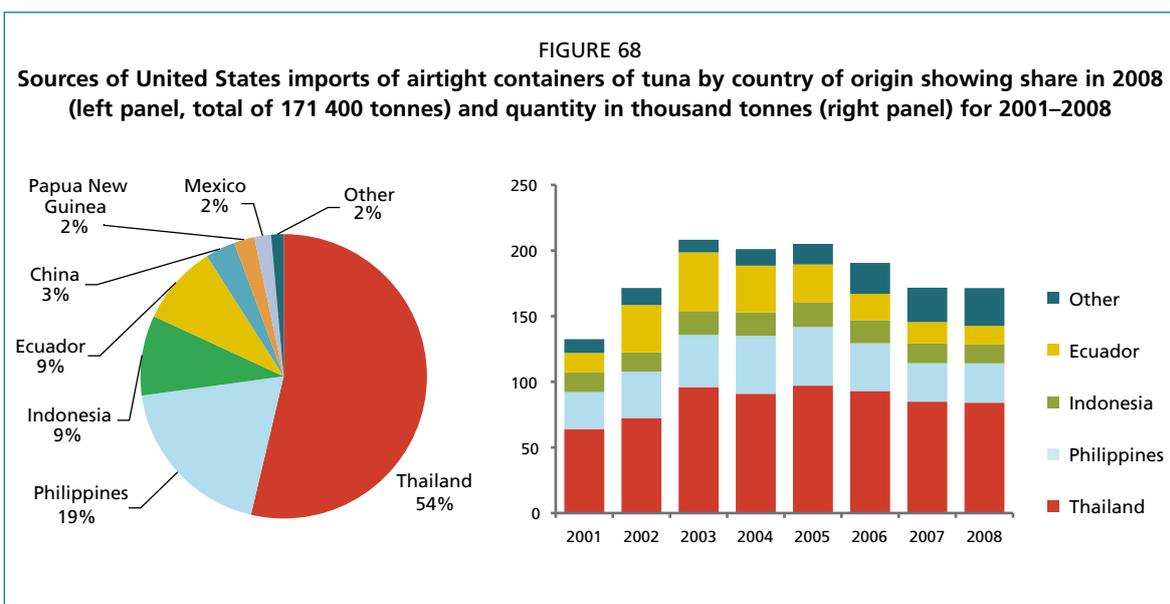
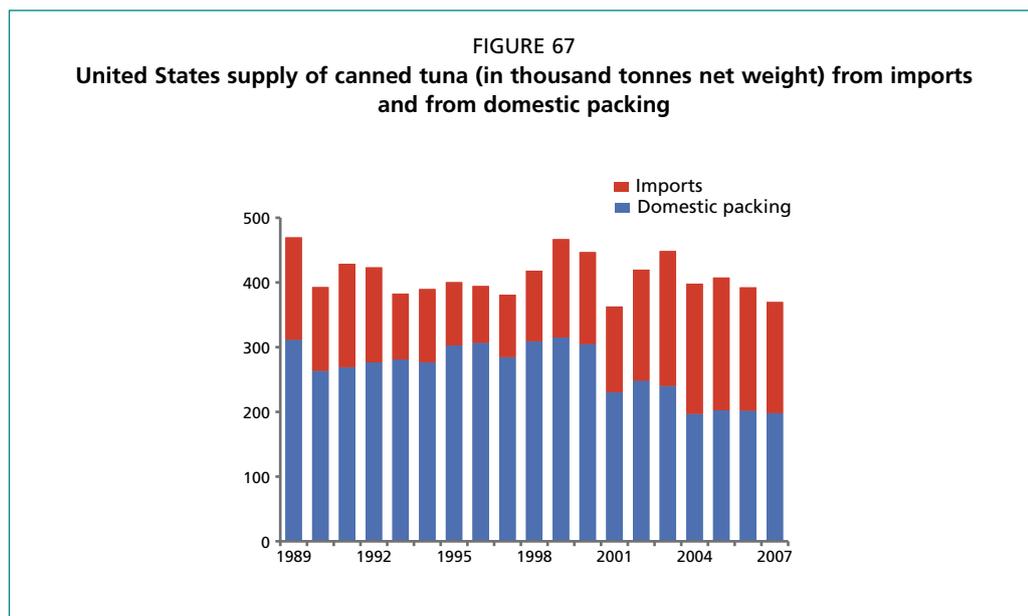
Economists often refer to demand elasticity (the percentage change in quantity demanded in response to a 1 percent change in market price) and to flexibility (percentage change in prices in response to a 1 percent change in quantity supplied or demanded) coefficients to analyse the demand conditions on the market (greater or smaller than unity). Several estimations of such coefficients are presented in the literature on tuna markets.

The elasticity of demand for the catch of the purse seine and baitboat fleets supplying the canning industry from the Western and Central Pacific region was estimated in terms of adjusted value to be 1.55 (i.e. a 1 percent increase of prices of frozen tuna results in a 1.55 percent decrease of the demand from the canning industry). The same coefficient for the longline fleet and the *sashimi* market was 2.53 (Bertignac *et al.*, 2001). In other words, demand is more elastic for *sashimi*-grade tuna than for cannery-grade tuna, perhaps because the number of substitutes is greater in the former case (more species, more marketplaces), and because inventories may affect the level of prices. The inverse value gives a proxy of flexibility coefficients, respectively 0.65 and 0.40 (i.e. a 1 percent increase of catches leads to a price cut between 0.40 and 0.65 percent). These values are very consistent with estimates for the Indian Ocean by Jiménez-Toribio, Guillotreau and Mongruel (2009) as observed in a transfer function model of French frozen yellowfin tuna sold to the canning industry (elasticity value between 1.55 and 1.24, i.e. flexibility of 0.65 to 0.81). However, lower flexibility coefficients between 0.05 and 0.20 (according to the season) were found for Taiwanese exports of frozen tuna to Thai canneries (Sun and Hsieh, 2000). This indicates the responsiveness of the Bangkok prices to changes in catches of the Taiwan Province of China (about 25 percent of the supply) is fairly low and there is a certain rigidity in demand or a high level of elasticity (i.e. the demand is sensitive to price changes), hence fishers have low market power as compared with canneries (see discussion about WTPO in 6.5.7). When generalized to the entire supply of tuna in the region represented by the Pacific Islands Forum Fisheries Agency

(FFA), the flexibility is estimated at 0.52 for skipjack, i.e. a 1 percent increase in the quantity of skipjack supplied by the FFA region would result in a 0.52 percent fall in the Bangkok landing price (Owen, 2001; Reid, Vakurepe and Campbell, 2003). The own-price flexibility for tuna in the Spanish market was estimated at 0.30, nearly the same level (Nielsen, 1999).

One of the studies (Reid, Vakurepe and Campbell, 2003) proposes a comprehensive survey of the estimated elasticity and flexibility coefficients found in the literature for the retail market. For the United States retail market of canned tuna, the own-price elasticities of demand were found to be between 0.20 and 0.16 (Campbell, 1995). Values below unity were also found for the United Kingdom canned tuna market, i.e. 0.19, 0.57 and 0.80, respectively, for canned tuna in sauce, in brine and in oil (Jaffry and Brown, 2008). These low values are quite normal for such necessity goods: in most markets, canned tuna is considered to be a rather low-valued product, and subject to possible substitution effects (Babula and Corey, 2005). Consequently, demand is normally not very sensitive to price changes, giving the retail sector a potential opportunity to exercise market power. Elasticity was estimated to be a bit higher in Japan, at 0.93 for canned products (Wessells and Wilen, 1994). But elasticity referring to all types of tuna products may even indicate higher rates. According to other studies, it was estimated at 1.39 for high-valued fish and 1.07 for tuna for family consumption (Reid, Vakurepe and Campbell, 2003; Eales, Durham and Wessells, 1997; Eales and Wessells, 1999; Tada, 2000), and can be in the range of 0.72 to 1.67 for high-quality fish (Reid, Vakurepe and Campbell, 2003).

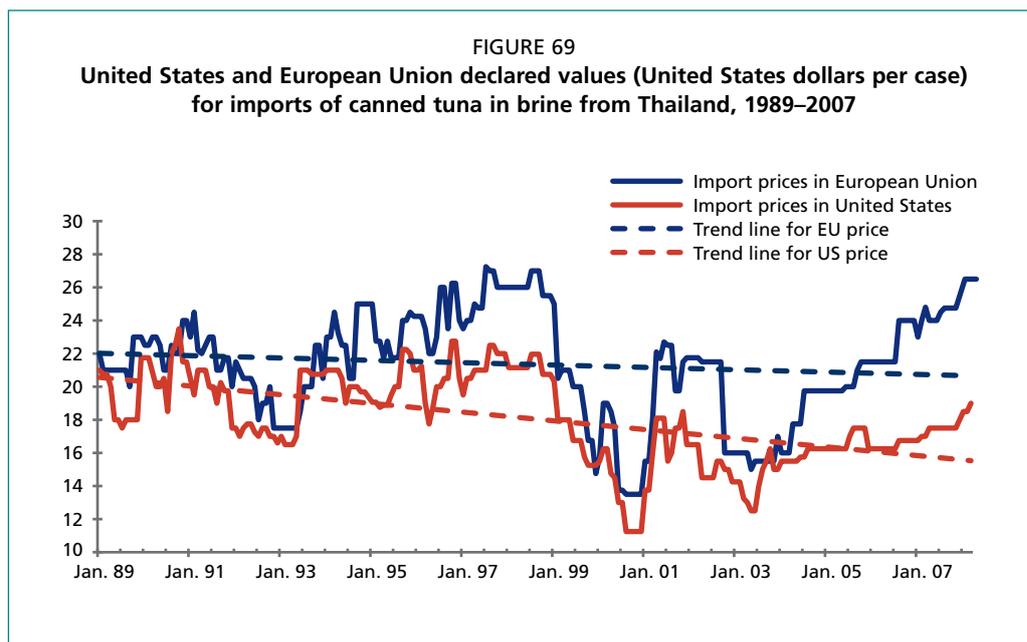
In conclusion, demand for raw tuna can be considered to be fairly elastic, which reflects the fact that the ex-vessel market is very competitive and that regional changes in tuna catches have a limited impact on market prices because the latter are mostly determined on the demand side. On the other hand, the demand for canned tuna is rather inelastic, which provides opportunities for market power at the retail level.



has been at a low level since 2000 (due to a reduction in United States tuna fishing activities), which has been partially replaced by an increase in imports.

Canned tuna production in the continental United States, American Samoa and Puerto Rico (supplied by domestic catch and imports) was 198 100 tonnes, valued at US\$702.4 million in 2007. These figures represent a decrease of 3 800 tonnes and US\$2.3 million from 2006 levels. White meat tuna (albacore) packing was 79 800 tonnes (40 percent of the tuna packed) in 2007. Light-meat tuna (bigeye, Pacific bluefin, yellowfin and skipjack) comprised the remainder (118 300 tonnes).

Figure 68 presents the amount of United States canned tuna imports by country of origin for 2001–2008 (right panel) and the share of the major exporters to the United States market for 2008 (left panel). Since Thailand is the world's major canned tuna producer, it is not surprising that more than half of all United States imports originate there.



Source: Globefish.

Figure 69 shows canned tuna import prices in the United States and European Union from 1989 to 2007. The United States price began declining at the beginning of 2000, while the European Union price has been stable throughout. Starting in 2007 and early 2008, the United States canned tuna price increased by US\$2 per carton, while European Union prices increased by US\$3 per carton. These different trends probably reflect currency exchange rates as discussed earlier in this section.

Thailand's monthly export prices in baht are compared by destination in Figure 66. This figure indicates that the average price of exports to the United States is higher than the average price of exports to any other destination with the exception of Japan, Australia and Canada which are systematically higher. A recent fall in the value of the baht against the United States dollar will help most of the Thai exporters since canned tuna, even at the same price in baht, will be cheaper to import in the United States. Starting in 2007, import prices increased in all of the main markets, and canned tuna prices soared for the first time in 20 years.

Table 21 compares United States per capita consumption of meat, eggs and dairy products from 1997 through 2007 and shows increasing tendencies toward poultry and seafood consumption. In Figure 70, seafood consumption per capita in the United States is given by product type. As of 2007, fresh and frozen fish and shellfish accounts for 5.5 kg and the canned fish and shellfish accounts for 1.8 kg, of which canned tuna accounts for 1.3 kg. This consumption per capita of canned tuna was at the lowest level over the past 20 years, even though the per capita consumption of fresh and frozen fish and shellfish have shown a growing trend over a long period.

A study by Teisl, Roe and Hicks (2002) demonstrated a significant downward trend for consumer expenditure share of canned tuna, which drops from about 22.7 percent to 15.5 percent of total expenditure on canned meat (including tuna, luncheon meat, seafood and red meat) between 1988 and 1995. The study indicated that the dolphin-safe labelling policy, announced by the three largest tuna canners in the United States in April 1990, resulted in only approximately 1 percent higher in expenditure share than the estimated expenditure share in the absence of the label. The negative time trend for canned tuna could also be a result of the changing quality of canned tuna due to the dolphin-safe criteria. In particular, this may have occurred as a result of the shift of the fleet from the Eastern Pacific Ocean to the Western

TABLE 21

United States per capita consumption (kg) of meat, eggs and dairy commodities, 1997–2007¹

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Red meat ^{2,3}	49.5	51.4	52.2	51.6	50.6	51.8	50.7	51.0	50.1	49.9	50.2
Poultry ^{2,3}	28.9	29.2	30.6	30.8	30.8	32.1	32.4	33.1	33.5	33.7	33.4
Fish and shellfish ²	6.5	6.6	6.7	6.9	6.7	7.1	7.4	7.5	7.3	7.5	7.4
Eggs ³	13.7	14.0	14.6	14.7	14.8	14.9	14.9	15.0	14.9	15.0	14.6
Dairy ⁴	257.5	259.8	265.1	268.3	265.1	265.3	269.4	269.1	271.4	275.1	275.2

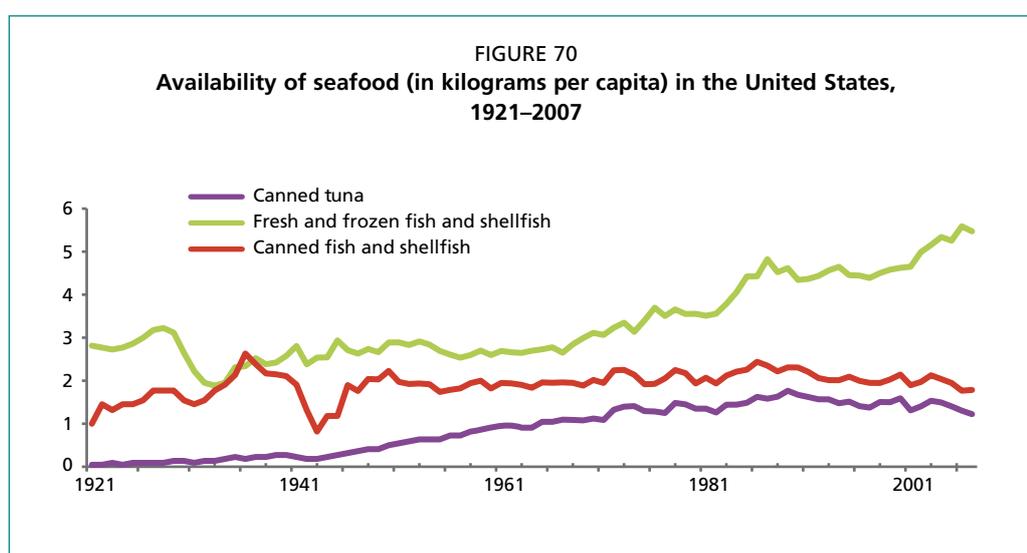
¹ In kilograms retail weight unless otherwise stated. Consumption normally represents total supply minus exports, non-food use and remaining stocks.

² Boneless, trimmed weight.

³ Excludes shipments to United States' territories.

⁴ Dairy products equivalent (milk-fat basis) includes condensed and evaporated milk and dry milk products.

Source: United States Department of Agriculture/Economic Research Service.



and Central Pacific Ocean and the development of FAD fishing, which in turn has resulted in most canned tuna now being made from lower quality small yellowfin and skipjack.

7. Trade and consumer preferences

7.1 RESTRICTION ON TRADE

As has been shown in Sections 6.5.6 and 6.5.7, some trade and/or tariff barriers exist in the world tuna trade. Such barriers affect the trade of tuna products either through direct restriction of import/export, or indirectly through raising prices by means of a tariff. In the long run, non-uniform tariffs can change the relative competitiveness of various countries as discussed in Section 6.5.7.

In general, due to the WTO regulations, the world is advancing towards free trade with low tariffs. However, there are still some local tariffs raised to protect domestic products and some special arrangements for relaxing tariffs such as those described in Box 11.

Other types of trade restrictions exist for conservation purposes. The most typical type is trade sanctions adopted against flag states involved in IUU fishing. For example, ICCAT adopted management measures that enable the Commission to recommend that its CPCs prohibit receipt of certain species of tuna from a country which has been identified and notified of its IUU fishing status but has yet not rectified it in accordance with international trade regulations. In the past, such sanctions have been taken against several countries. Such trade sanctions were very effective in reducing IUU fishing activities as discussed in Section 5.1.6. Recently, more countries including the European Union are unilaterally adopting policies to prohibit import of IUU-caught tuna or any tuna from countries identified as having been involved in IUU fishing activities.

The most restrictive of trade-based actions is when a species is listed in Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In the past, one unsuccessful attempt was made to list the Atlantic bluefin tuna in Appendix 1, and had this effort been successful it would have had a tremendous impact on tuna fisheries and markets. At the time of writing this report, the Atlantic bluefin tuna has once again been proposed for listing, this time by Monaco, in Appendix 1 of CITES.

Under a Memorandum of Understanding between the two organizations, an FAO expert panel advises CITES on the scientific, legal and technical aspects of commercially exploited aquatic species listed or proposed for listing in the CITES Appendices. Classifications similar to those under CITES are made by IUCN which list stocks according to its own criteria for extinction risk on its Red List.

7.2 EFFECTS OF MEDIA AND PUBLIC CAMPAIGNS ON THE MARKET

The following examples illustrate how the mass media has affected the tuna fishery and its market. The magnitude of the effects are substantial, and most likely are stronger than any other factors discussed in this paper (with the exception of listing tuna in the CITES Appendices).

The issue of the mercury and methyl mercury contents of canned tuna has continuously affected United States tuna sales for the last forty years. The first widespread publicity regarding mercury risk in the United States came in 1970 when methyl mercury was discovered in FDA inspections of canned tuna. After much scientific research and debate, the FDA changed its limit for mercury content from 0.05 ppm to 0.1 ppm (parts per million).

Since then, all tuna products have cleared the FDA limit. Nevertheless, on occasion, the mass media suddenly take up the campaign that the mercury content of tuna and tuna-like fish poses a risk to human health. Regardless of whether or not such

campaign is based on scientific evidence, it immediately affects tuna consumption but only for a short time as the campaign gradually dies away. Japanese *sashimi* eaters seem to be less susceptible to such campaigns, because of their own experience of eating *sashimi* throughout their lifetime and over many generations, coupled with their life expectancy being the longest in the world.

Another interesting example of the effects of the mass media on the tuna market is the marketing of farmed Atlantic bluefin in Japan. When these farmed tuna were introduced to the Japanese market, all the media reported that this product was full of fatty meat, delicious and affordably priced. This type of reporting firmly established the market for farmed tuna in Japan and also promoted the false belief among Japanese that the fatter the meat is, the better the product.

Another example is that one well-known scientific journal published a report stating that almost all tuna species are endangered. Many tuna scientists involved in the stock assessment work in RFMOs counterargued that this report had misinterpreted some of the data; nevertheless, the original report (only) has been cited many times by organizations and the mass media when attacking tuna management. This has resulted in a negative impact on the tuna industry.

On the other hand, the effect of the mass media can also be positive for the tuna market. The widespread popularity of *sashimi* and *sushi* (as well as tuna steak) in the world today owes mostly to reports by the media stating that Japanese food is healthy and the cause of the long life expectancy of the Japanese people.

In the 1960s, public sentiment for protecting dolphins during tuna catching operations became very strong. At that time, over 80 percent of tropical tuna were taken by United States purse seines in the Eastern Pacific Ocean setting on dolphin-associated tuna schools. The United States Marine Mammal Protection Act mandated a reduction in the mortality of dolphins associated with fishing activities and caused the United States fleets to leave the Eastern Pacific Ocean. This completely changed the structure of the United States tuna industry as already discussed in this paper in various sections.

Furthermore, this public sentiment forced the establishment of dolphin-free labelling for tuna products not associated with dolphin mortalities. This has had some impact in market shares among various manufacturers, and resulted in trade friction between the United States and other countries. At present, there are almost no retailers who will accept canned tuna which is not labelled as dolphin free.

7.3 CONSUMER TENDENCIES AND PREFERENCE REGARDING SUSTAINABILITY

No matter how much production cost is cut, fishing efficiency is increased, and better products are provided, and the final decision is in consumers' hands. The way in which consumers' opinion is shaped by various sources has been discussed in Sections 6.5.7 and 7.2.

Recently consumers' interest is more and more attuned to sustainable utilization of limited marine resources. This move is primarily promoted by environmental non-governmental organizations (NGOs); however, the idea is not new and has been advocated throughout the past several decades by many scientists working on fisheries. The objective of almost all RFMOs, as defined by their Conventions, is precisely the maximum sustainable use of marine resources.

As has been shown in this paper, often scientists' advice for the most appropriate sustainable use of tuna stocks has not been fully accepted or implemented by the administrators (and often by the tuna industry) due to compromises or trade-off for political or economical benefits. Therefore, it is true that pressure from the consumers for sustainable use of the resources would give further impetus to administrators to follow the scientific advice.

BOX 15

Mercury content of tuna

Mercury naturally exists in the earth's soils and sediments and dissolved in seawater. It is found in particular abundance in ore, especially coal, which is used extensively in the production of electricity. Coal power plants are thus partly responsible for extracting the mercury into the water, air and soil. Where mercury is found in large bodies of water, bacteria alter most of the mercury by attaching a methyl group to each mercury atom, resulting in the more hazardous compound methyl mercury.

All marine animals are exposed to and accumulate methyl mercury to a greater degree than non-marine animal life. Animals at higher levels in the food chain accumulate more mercury with age (e.g. swordfish and large bluefin).

In the past, much research has been conducted on the effects of mercury in fish on human health. Scientists have found that selenium contained in the muscles of many marine animals, particularly in tuna, acts to bind methyl mercury and converts it to a less hazardous form of mercury. Based on this research, the United States Food and Drug Administration changed the limit for mercury content in canned tuna from 0.05 ppm to 0.1 ppm.

Some organizations have begun labelling the marine products sold by retailers with regard to whether these products represent sustainable use of seafood resources. The most widely recognized ecolabel in the world has been created by the Marine Stewardship Council (MSC). It aims at certifying that the targeted resource stock is sustainably exploited, the ecosystem including habitat and trophic interactions is protected, and that a proper and responsible management system is in force. In 2007, the first tuna fishery in the North and South Pacific, i.e. the American albacore tuna fishery, was certified by the MSC.

The tuna canning industry took an important step recently by establishing the International Seafood Sustainability Foundation (ISSF). The core supporters of this organization are the tuna packers and traders, environmental NGOs and tuna scientists. ISSF's goals are to work together with RFMOs to maintain long-term sustainability based on scientific advice and reduction of bycatch.

Such attempts to exert change through consumer choice should be seen as a long-term prospect. The dolphin-safe ecolabel campaign by the United States tuna industry took at least four years to produce its first effects on demand and, though a positive impact was subsequently demonstrated, it remained unclear whether the impact was due to the ecolabel itself or to other media campaigns (Teisl, Roe and Hicks, 2002).

As this kind of labelling helps retailers promote their products, it has spread rapidly around the world through the efforts of groups including NGOs (some not-for-profit and some commercial) as well as governments. Among the various labelling schemes, there is considerable variation in the criteria used to define sustainability. Some criteria include only the sustainability of the target species (e.g. tuna) while others have criteria which include everything taken by the fishing gear targeting the species (e.g. bycatch).

Since the influence of such labelling may have major effects on the tuna industry as a whole, this subject is currently an important issue for the marketing sector of the tuna industry and, eventually, more broadly for the entire industry.

8. Discussion

In this report, the following topics were independently reviewed:

- A. Status of all tuna stocks worldwide, based on the latest scientific assessments by RFMOs.
- B. World trends in tuna catches by species, ocean, gear type and country.
- C. Changes of tuna fisheries in terms of:
 - (i) technology;
 - (ii) management measures;
 - (iii) operating costs and profit (or loss);
 - (iv) fishing capacity;
 - (v) IUU fishing problems; and
 - (vi) bycatch and its mitigation.
- D. Seafood industry from the point of view of products, i.e. *sashimi*, fresh or steak forms, canning and other products, in terms of:
 - (i) brief history of development;
 - (ii) processing procedures;
 - (iii) supply of materials for the industry;
 - (iv) change in production processes and procedures; and
 - (v) changes in capital investment.
- E. Trade of raw materials and final products.
- F. Marketing of products, quantity and price.
- G. Public concerns and preferences.

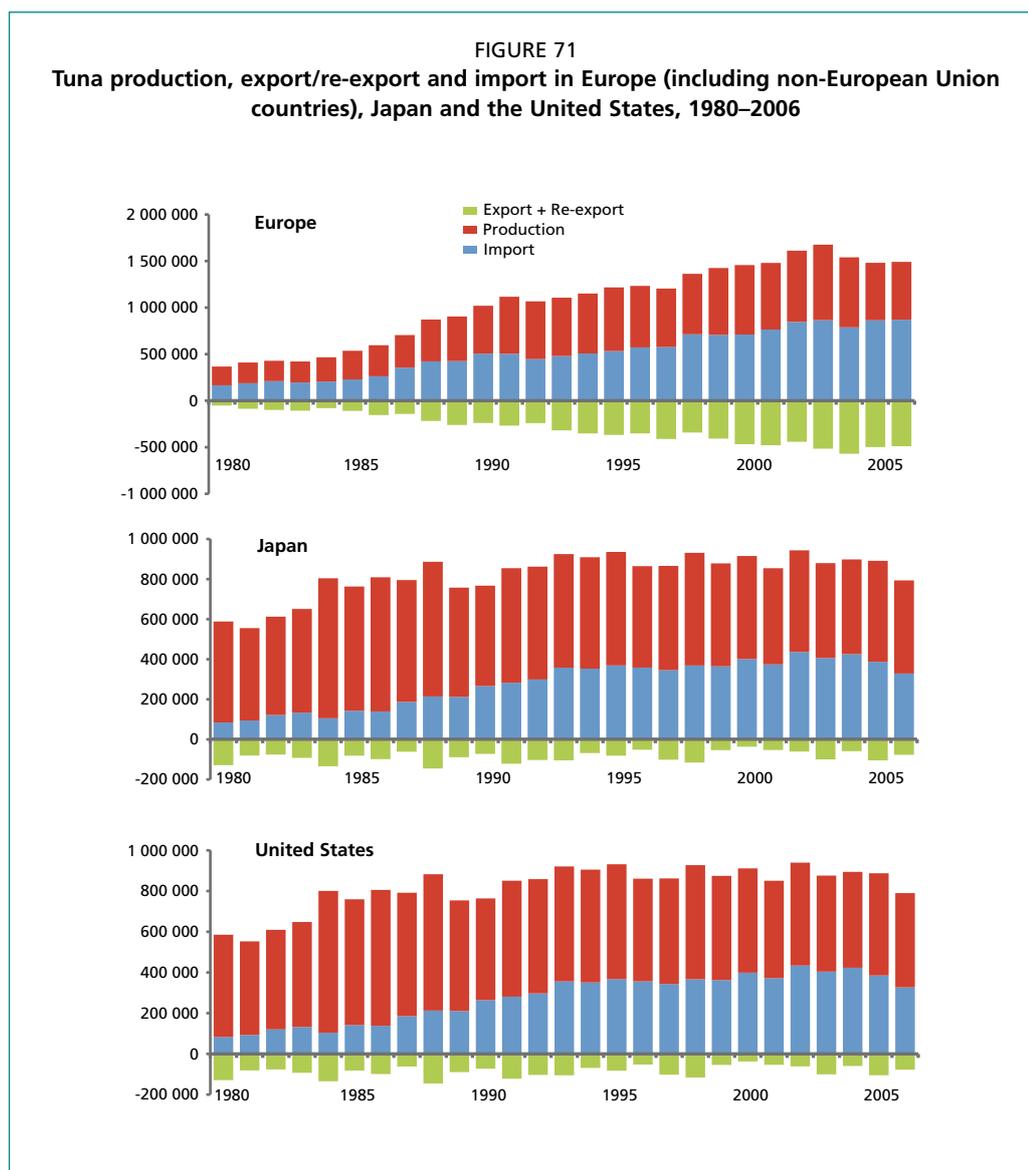
Many relationships and synergies among these issues were also highlighted. From fishing to consumers, all physical, biological, social and economic elements are interrelated and interactive. Therefore, to see all these factors as one equation requires a multidimensional perspective. This report attempted to cover the breadth of this perspective but could obviously not go into great detail on each topic.

This report devotes much of its attention to the relationships between industries involved in fishing, processing, trading and marketing. Although each product and each stage are discussed in this report, the entire picture of the industry is difficult to grasp. Although more and more countries are getting involved in the tuna industry in recent years, the major markets which are influencing the entire industry are certainly still those of the European Union, Japan and the United States, where only two major categories of tuna products are consumed, i.e. fresh and frozen and canned.

It would be useful to summarize the entire review into one generalized overview of the market. Figure 71 gives quantities of production, imports, and exports/re-exports of both fresh and frozen and canned products in these three major markets, i.e. a balance sheet of these products in each market. The result is assumed to be equivalent to the consumption in each market as follows:

Consumption = Production + Import - Export - Re-export (- Non-human Consumption).

It should be noted that the amount which corresponds to non-human consumption is unavailable. It should also be noted that the data source of these figures is the FAO Commodities Production and Trade database. The uncertainties and limitations in using this information have been well covered in Sections 6 through 8 of this report and are hence not repeated here. However, it should be borne in mind that the figures are given in weight of products, which very likely contain different units. Also Europe includes some non-European Union nations.



Note: All tuna product weights are combined.

Source: FAO Commodities Production and Trade database.

While reviewing these issues, several subjects emerged as clear focal points for the tuna industry. The whole industry has been changing rapidly at every stage from fishers to consumers. One typical characteristic of the tuna industry is that the final price is not decided by the production cost but rather by the consumer, thus consumption would be negatively correlated with price. At the same time, supply and demand are both increasing rapidly on a global basis and over the long term. This means that the industry has to meet increasing demand but with a lower production cost. The results are the horizontal and vertical concentration of capital and business structures, shortcuts around intermediate dealers, and reduction of production costs. These effects are occurring at almost every stage, from fishery to trade, and from processing to marketing and retailing.

It is also important to remember that the fishery is multigear, multispecies and multiproduct. Therefore, the cost effectiveness and economic structures are competitive but at the same time substitutable among species, fisheries and products. This characteristic may also contribute to the concentration of the industry.

9. Conclusions on the future of the tuna industry

Most of the RFMO conventions define MSY as the reference point for stock management. Under such definition, almost all the world's tuna stocks are nearly fully exploited and some are overexploited. Some of the stocks which are not yet overexploited are being overfished (i.e. fishing mortality is higher than the level corresponding to MSY). Therefore, it is a crucial time to establish proper management of the stocks and to thus decide the future of tuna resources. The sustainable use of the stocks is crucial for the industry.

The most serious difficulty in management is the increasing fishing capacity compared to the available stocks. Therefore, in terms of proper management, global control of fishing capacity, not only that of industrial fisheries but also of small-scale coastal fisheries, is the key to success. There are many options for holding fishing mortality at a proper level, such as catch quotas, effort control, time-area closures, size limits and many others. However, all of these will be very difficult to agree upon in an international forum as long as there is an excess of fishing capacity.

Up until the end of the twentieth century, the tuna fishing industry was singly focused on how to increase efficiencies in fishing, processing and trading in order to increase profit. Under current circumstances, consideration of ecosystems and the sustainability of both target and non-target species, as well as many other socio-economic factors (such as rising costs of fuel and labour and strict regulations on industrial waste discharges and emissions) are necessary. Sometimes these considerations result in an increase in cost and a decrease in efficiency for the industry. Over the past several decades consumers have enjoyed a constant increase in fish supply and the ready availability of low-priced products, but now they must also assume the increased production costs associated with the factors listed above.

This scenario is analogous to that of a pie that has already expanded dramatically to its maximum, but for which the number of pie consumers (i.e. fishers) has also increased and is still increasing. At present, the most important issue is how to manage the number of potential pie consumers and how to distribute the pie among them (e.g. using fishing capacity control measures and/or catch allocations). This problem involves many complicated aspects including allocations between developed and/or distant water fishing nations and coastal and/or developing countries, among fishing gears, and between products (e.g. fresh fish versus canned fish).

As shown in this report, the industry has shown great changes at all stages in response to a variety of socio-economic factors, while management has remained focused on the biology of individual stocks. When the tuna industry is as complicated as it is now (interaction among species, fishing gear types, areas, products and consumers, and individual country's economic situations), then management needs also to be realistic and practical to succeed. For example, if the maximum biological gain is to be the goal, all tuna should be taken at the size where biomass is maximized (see Section 4.2.7) assuming that the spawner-recruitment relationship is not affected by catching fish at this critical level. However, if we try to do this, the production cost would be far more than current cost (i.e. most of the fish would have to be taken by longline and the effort would thus need to be increased by up to tenfold over the current level). Even then, the resulting products may not meet the markets' demands (e.g. too costly or too large for canning).

The current share of catches, mix of fisheries, status of stocks, and structure of industries and market, in short, the current landscape of the industry in all its complexity has been formed through the balance of all these bio- and socio-economic conditions and factors. There is no doubt that a slight change in one segment can alter the balance substantially. For example, as seen recently, an increase in fuel prices had a major effect on fishing grounds, target species, relative profitability among fisheries and product types and, in the end, the retail price of various products. Understanding the entire tuna industry is critically important for proper management.

Also, it is now time to solve the allocation problem (including all types of allocations such as allocation of TAC among countries, products and fisheries), and to approach it through established principles rather than leaving it up to ad hoc balancing of bio- and socio-economic factors.

Although this report has covered many aspects of the economic and social importance of tuna fisheries, it could not go into detail on the relative importance of the industry to the many different states involved in it. This kind of research would need not only to examine the states' economic characteristics but also their sociological characteristics including culture and eating habits. This important aspect of the allocation issue remains a rich and essential field of research for the future.

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This technical paper reviews world tuna fisheries, including fishing operations, stock conditions, management measures and socio-economic aspects of the tuna industry such as recent changes in processing, trade, marketing and consumer preferences. It concludes that, because of the recent rapid increase in competition among fisheries, species, industries and even products (*sashimi*/fresh tuna versus canned), the most important and most urgent issue is how to manage and allocate tuna resources among these competitors (e.g. using fishing capacity control measures and/or catch allocations). In order to achieve this objective, it is imperative that socio-economic and ecological considerations are integrated into decision-making processes alongside capacity and allocation issues. Although this study does not address the broad socio-economic importance of the tuna industry to the countries in which it operates, this type of research will be necessary in the future in order to solve current fishery management problems.

