C1. TUNA AND TUNA-LIKE SPECIES

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INTRODUCTION

The sub-order Scombroidei is usually referred to as tuna and tuna-like species (Klawe, 1977; Collette and Nauen, 1983; Nakamura, 1985). It is composed of tunas (sometimes referred to as true tunas), billfishes and other tuna-like species. They include some of the largest and fastest fishes in the sea.

The tunas (*Thunnini*) include the most economically important species referred to as principal market tunas because of their global economic importance and their intensive international trade for canning and sashimi (raw fish regarded as delicacy in Japan and increasingly, in several other countries). In fact, the anatomy of some tuna species seems to have been purpose-designed for canning and loining. Tunas are sub-classified into four genera (*Thunnus*, *Euthynnus*, *Katsuwonus*, *Auxis* and *Allothunnus*) with fifteen species all together.

From the genus Thunnus, the principal market tunas are albacore (*T. alalunga*), bigeye tuna (*T. obesus*), Atlantic bluefin tuna (*T. thynnus)*, Pacific bluefin tuna (*T. orientalis)* southern bluefin tuna (*T. maccoyii*) and yellowfin tuna (*T. albacares*). Skipjack tuna (*Katsuwonus pelamis*) is the seventh principal market tuna species. Their superbly efficient metabolic system includes a circulatory system that allows them to retain or dissipate heat as required for peak biological performance and efficiency. They are all oceanic (Figure C1.1), capable of long migrations or movements, constituting one or two stocks in each ocean. The exceptions are Atlantic and Pacific bluefins, which do not occur only in their eponymous oceans. Southern bluefin constitutes a single stock extending in the Atlantic, Indian and Pacific Oceans.

Because of the economic situation in Japan in recent years, prices of bluefin tuna, the species most valued for sashimi, although still high compared to other species, have decreased somehow. For a whole fish, fisherman may get between US$30 and US$40 per kg with some getting closer to US$100. Not long ago, a fish of exceptional quality reached US$500 per kg and more recently even more, but such prices referring to very few single fish do not reflect the situation with the market. Bigeye are also well priced on the sashimi markets. Although yellowfin are also very popular on these markets, the prices they bring are much lower. For canning, albacore fetch the best prices due to their white meat, followed by yellowfin and skipjack for which fishermen are paid much less than US$1 per kg. The relatively low prices of canning-quality fish are compensated by their very large catches, especially in the case of skipjack and yellowfin. Longtail tuna (*T. tonggol*) is becoming increasingly important for canning and the subject of substantial international trade. The consumption of tuna and tuna-like species in forms other than canned products and sashimi is increasing.

The tunas other than the principal market species are more neritic (living in water masses over the continental shelf). They include longtail tuna, blackfin tuna (*T. atlanticus*), black skipjack (*E. lineatus*), kawakawa (*E. affinis*), little tunny (*E. alleteratus*), bullet tuna (*A. rochei*) and frigate tuna (*A. thazard*).

The billfishes (Istiophoridae) are composed of marlins (*Makaira* spp.), sailfish (*Istiophorus* spp.), spearfish (*Tetrapturus* spp.) and swordfish (*Xiphias gladius*, only species in the genus). With the exception of two species (Mediterranean and roundscale spearfish), all billfishes have very wide geographical distributions, but not all species occur in all oceans. Billfishes are mostly caught by longlines as by-catch except swordfish which are targeted in certain regions using also longlines and harpoons. Billfishes are also taken in sport fisheries, where they are greatly valued. They are all excellent seafood.

Other important tuna-like species include slender tuna (*Allothunnus fallai*), butterfly kingfish (*Gasterochisma melampus*), wahoo (*Acanthocybium solandri*), bonitos (*Cybiosarda*, *Orcynopsis* and *Sarda*), Spanish and king mackerels, seerfishand sierra (*Scomberomorus* spp.). Other important tuna-like species represent a significant potential especially for developing countries where mostly artisanal and recreational fisheries are now catching them. Slender tuna and

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butterfly kingfish (with a circumpolar distribution in the Southern Ocean) are now caught mostly as by-catch of the Japanese longline fishery targeting southern bluefin tuna.

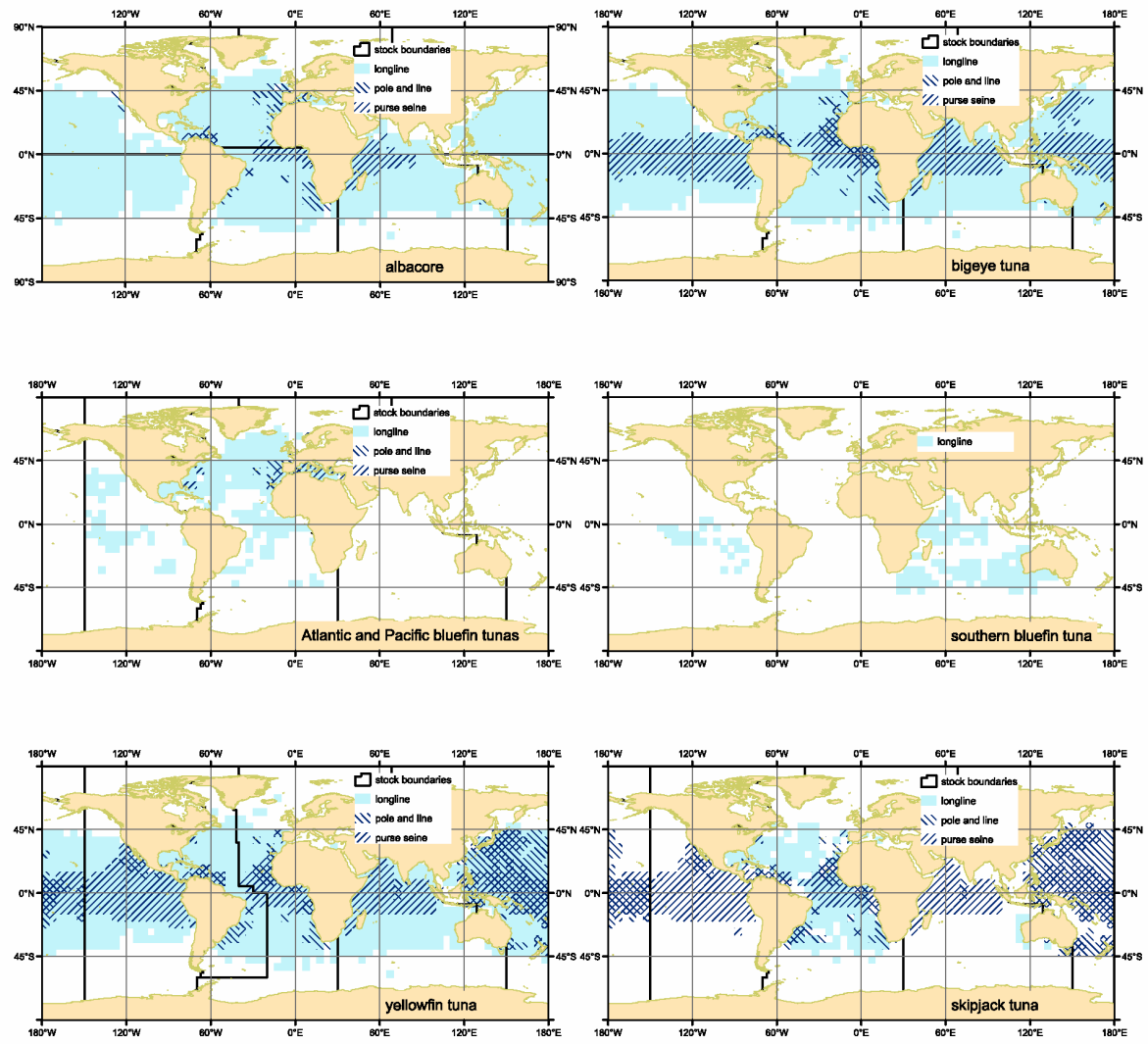
The 1982 UN Convention on the Law of the Sea classifies the principal market tunas, billfishes, blackfin tuna, bullet and frigate tuna, little tunny and kawakawa as highly migratory even though little tunny and kawakawa are mostly confined to the continental shelf and upper slope. Black skipjack is not classified as highly migratory, but it is probably more oceanic than little tunny and kawakawa.

Further information on some global aspect of tunas and tuna-like species can be found in Allen (2002) and Joseph (1998, 2000, 2003). Information references at regional scale are given in the respective resources status sections.

FISHERIES

Since the nineteenth century (and even from more ancient times), traditional tuna fishing has been carried out in various parts in the world. Those fisheries were local and generally near the coasts. In the Atlantic, they included purse seining for bluefin tuna off Norway, trolling for albacore in the Bay of Biscay, trap fishing near the Strait of Gibraltar and North African coast, swordfish fishing in the northwestern Atlantic and in the Mediterranean, bigeye and skipjack fishing near islands and artisanal fishing along the African coasts. In the Pacific, various artisanal fisheries operated near islands in the tropical waters (albacore trolling off west coast of US, baitboat fishing for yellowfin and skipjack off the coast of US, pole and line fishing for skipjack near Japan and many other fisheries for

Figure C1.1 - Distribution of tuna species and their respective fisheries operation area



various tunas along Japanese coasts). Off South America, coastal fisheries operated using baitboats and small seines. In the Indian Ocean, skipjack fishing off Sri Lanka, India, and Maldives was carried out. Off Australia, longline fishing was carried out for southern bluefin tuna. Many other artisanal fisheries for tuna-like fishes existed in tropical or subtropical areas all over the world.

As the results of increasing demand for canned tuna, industrialized fisheries started during the 1940s and 1950s. They included Japanese longline and baitboat fishing in the Pacific and US baitboat fishing off California along the Mexican coasts, while the traditional fisheries continued. After the World War II, the fishing areas for the Japanese tuna fishery were limited to its coast until 1952. However, since then, the fishery, particularly the longline ones, expanded the fishing area very rapidly. In late 1950s, its fishing areas reached even to the Atlantic Ocean. Also in the late 1950s, some European pole and line fishing started off the African coasts from local harbours.

In the 1960s, Spanish and French boats with pole and line and purse seines started tuna fishing off west Africa. Also, Japanese longliners expanded their fishing area all over the world, mostly fishing albacore and yellowfin for canning. In the middle of the 1960s, Korea and Taiwan Province of China started large-scale longline fishing to export tuna for canning, learning the techniques from Japan. At the end of this decade, the Japanese longline industry developed an extremely cold storage system used for new frozen products for the sashimi market. Consequently, Japan switched the target species from yellowfin and albacore to bluefin and bigeye. US pole and line fishing off Central and South America were almost completely replaced by purse seiners in the 1960s. Also, the purse seining of tuna with dolphin was developed.

In the 1970s, purse seine fisheries of European countries developed quickly in the east tropical Atlantic and attained the first peak of their catches of yellowfin and skipjack. Also, the purse seine fishery developed further in the east tropical Pacific. A strict regulation for the reduction of mortality of dolphins caught with tuna fishing was implemented in this area. Consequently, the US flag vessels started changing the flags to other central and South American countries. Also, some fishing effort was shifted to the central and western Pacific where no dolphin fishing occurred.

Since the development of extremely cold storage, some longliners gradually changed target from yellowfin (for canning) to bigeye (for sashimi). This shift was first seen among Japanese longliners, but it gradually expanded to the fleets from Korea and Taiwan Province of China. To catch bigeye, whose habitat is much deeper than that of tropical tunas, long lines were set deeper and deeper. This change in fishing strategy implies changes in fishing areas, leading to modifications in target and by-catch species.

In the 1980s, new purse seine fishery started in the western Indian Ocean; many French seiners from the eastern Atlantic moved to the Indian Ocean. In the Pacific Ocean, the purse seine fishery expanded its fishing area, particularly in the south, central and western Pacific. Purse seine fishing efficiency increased with modern equipment such as bird radar and the use of helicopters. During the 1990s, many new countries entered into large-scale industrial fishing, mostly purse seining (e.g., Mexico, Venezuela and Brazil). Small-scale longline fishing operations by coastal countries in various areas (e.g., Mediterranean countries, Philippines and Indonesia) also started. The Japanese longline fleet started to reduce its size in the 1980s. At the same time, Taiwan Province of China longliners and others flying flags of convenience increased rapidly.

Particularly in the 1980s, management regulatory measures for tuna fisheries were introduced by tuna fishery bodies, which also affected fishing patterns and country shares of catches. In the 1990s, more management measures were introduced, this resulted in an increase in illegal, unreported and unregulated (IUU) fishing. IUU fishing became a large hazard for proper management of fish resources. In general, the tuna fishing capacity extensively increased during the 1990s. Recent increases in the catches sometimes caused over-supply to the market, particularly for skipjack because of large purse seine catches.

Starting in the 1980s and increasingly in the 1990s, many coastal states started new tuna fishing by chartering boats of flag of convenience. This occured in all oceans. Some of these chartered vessels changed flags to the coastal states and possibly this tendency will be intensified in the near future. Partially due to the

development of these new coastal fisheries, the fishing effort by traditional longline countries started to decline.

Purse seiners started fishing around Fish Aggregating Devices (FADs) in the Atlantic in the early 1990s, and this method expanded to the Indian and Pacific Oceans. The FAD fishing is less selective for fish species and size. The fishing efficiency, size of fish taken, species composition and incidental catch changed drastically with the adoption of this new practice.

Tuna farming started in the 1990s. This new industry resulted in a better price being paid to the fishermen and an increasing demand for specific sizes and species. Through farming/fattening process, the relatively small tunas taken by purse seiners which used to be sold only for canning can now be used for the sashimi market. Until now, bluefin tuna is the main species used in farming, but farming is extending to bigeye and yellowfin tuna. Bluefin farming is expanding, now including Australia, Japan, Mexico and several Mediterranean countries (particularly Croatia, Italy, Malta, Morocco, Spain and Turkey).

Presently, on the industrial scale, tuna and tuna-like species are mainly caught with purse-seine, longline and pole-and-line over wide areas in oceans (Figure C1.1, and Carocci and Majkowski 1996, 1998, 2001). Other gears used are troll lines, handlines, driftnets, traps and harpoons.

The industrial tuna fisheries are very dynamic and fleets, especially distant-water fishing fleets, can react very quickly to changes in stock size or market conditions. For example, in the early 1980s, many French and Spanish purse seiners from the Atlantic moved to the Indian Ocean, contributing to the doubling of the Indian Ocean catches in the 1980s. Some of these vessels have now moved back to the Atlantic. Similarly, US purse seiners moved from the eastern Pacific to the western part of the Ocean.

The purse seine and pole-and-line are used to catch fish found close to the surface (e.g. skipjack and relatively small individuals of yellowfin, albacore and bluefin). Longlines are

Table C1.1: Industrial tuna fisheries operating entirely or partially on the high seas.

AREA	GEAR	MAIN VESSEL FLAGS	TARGET SPECIES
North East Pacific	Longline	Japan	Albacore
	Troll	Canada and United States	Albacore
South East Pacific	Longline	Japan, Rep. of Korea and Taiwan Province of China	Albacore, bigeye and yellowfin
	Longline	Chile and Spain	Swordfish
East Pacific	Purse seine	Ecuador, Mexico, Vanuatu and Venezuela	Skipjack and yellowfin
West, Central and South Pacific	Longline	Japan, Rep. of Korea and Taiwan Province of China	Albacore, bigeye and yellowfin
	Pole and line	Japan	Skipjack
	Purse seine	Indonesia, Japan, Philippines, Rep. of Korea, Taiwan Province of China and United States	Skipjack and yellowfin
East Indian	Longline	China, Belize, Honduras, Indonesia, Japan, Panama, Rep. of Korea and Taiwan Province of China	Albacore, bigeye, southern bluefin, swordfish and yellowfin
East Indian	Purse seine	France, Indonesia, Japan, Liberia and Spain	Skipjack and yellowfin
West Central Indian	Gillnet	India, Iran and Sri Lanka	Skipjack and yellowfin
	Longline	China, Belize, Honduras, Indonesia, Japan, Panama, Rep. of Korea and Taiwan Province of China	Bigeye and yellowfin
	Pole and line	Maldives	Skipjack and yellowfin
	Purse seine	Belize, France, Japan, Netherlands Antilles, Seychelles and Spain	Skipjack and yellowfin
East Atlantic	Longline	Belize, Honduras, Japan, Libya, Panama, Philippines, Portugal, Rep. of Korea, Taiwan Province of China and Spain	Albacore, bigeye, Atlantic bluefin, swordfish and yellowfin
	Pole and line	France, Ghana, Namibia, Panama, Portugal, Rep. of Korea, Senegal, South Africa and Spain	Albacore, bigeye, skipjack and yellowfin
	Purse seine	France, Ghana, Morocco, Spain and Vanuatu	Bigeye, skipjack and yellowfin
	Troll	France, Ireland and Spain	Albacore
West Atlantic	Longline	Brazil, Japan, Taiwan Province of China, Spain, Uruguay, United States and Venezuela	Albacore, bigeye, Atlantic bluefin, swordfish and yellowfin
	Pole and line	Brazil, Japan, Venezuela and Taiwan Province of China	Skipjack
	Purse seine	Brazil and Venezuela	Skipjack and yellowfin
West Central Atlantic	Longline	Japan, Portugal, Spain, Taiwan Province of China and United States	Bigeye and Atlantic bluefin (in some areas and periods)
West Mediterranean (Tyrrhenian, Ligurian, Strait of Sicily)	Gillnet	Italy and Morocco	Atlantic bluefin and swordfish
	Longline	Belize, Italy, Japan, Libya, Malta, Panama, The Philippines, Spain and Taiwan Province of China	Atlantic bluefin and swordfish
	Purse seine	Algeria, France, Italy, Tunisia and Spain	Atlantic bluefin
Central Mediterranean (Adriatic and Ionian)	Purse seine	Croatia and Italy	Atlantic bluefin and swordfish
	Longline	Cyprus and Italy	Atlantic bluefin
East Mediterranean (Aegean and Marmara)	Longline	Greece	Atlantic bluefin and swordfish
	Purse seine	Turkey	Bonito and Atlantic bluefin

used for fish found at greater depths (e.g. large individuals of bluefin, bigeye, yellowfin, albacore and billfishes). Most purse seine and pole-and-line catches are canned. Longline catches with the exception of those of albacore are mainly sold on the sashimi market to be consumed raw, traditionally in Japan, but now also in several other countries. The use of pole-and-line and large-scale longlining has been generally declining, while purse seining is increasingly used, resulting in increased catches of skipjack, small to medium yellowfin and small bigeye, while catches of large yellowfin and the other principal market tunas have remained relatively stable. Information on industrial tuna fisheries entirely or partially on the high seas is summarized in Table C1.1.

Small-scale longlining for high-quality fish for the sashimi market is increasingly being used by Taiwan Province of China and mainland China as well as other developing countries. This contributes to a general trend of rapidly increasing importance of developing coastal countries (including island countries of the Indian and Pacific Oceans) in tuna fishing. This increasing importance of developing countries results from the purchase of purse seiners and from the intensification of artisanal fisheries. Catches from these fisheries may still be underestimated despite the fact that the rate of non-reporting of catches in developing countries is being reduced.

Further information on tuna fisheries can be found in Miyake, P.M., Miyabe, N. and Nakano, H. (in prep.).

PROFILE OF CATCHES

Similarly to most sections of this volume, catch profiles in this section are based on FAO catch statistics. Tuna fishery bodies, international technical programmes, and tuna fishing countries may have more accurate and/or up-to-date statistics. Home pages of several of theses bodies and programmes are listed in the Resource Status section below. These statistics have also been collated by FAO on the global scale and they are available from the FAO web page.

The global production of the principal market tunas increased relatively steadily from less than 0.5 million tonnes in the early 1950s to the peak of 4.1 million tonnes in 2002 (Figure C1.2). Between 1970 and 1978, the catches of principal market tunas increased significantly as a result of the expansion of fisheries in the eastern Atlantic and the development of new offshore fishing grounds in the eastern Pacific. Between 1978 and 1984, many vessels moved to the western Pacific and the western Indian Ocean, developing new fisheries there.

Tuna catches are unlikely to continue to grow, having been relatively stable since 1998 (Figure C1.2). They may even decline, if the management of tuna fisheries is not successful.

Main species

Skipjack, which is used mostly for canning, account for the greatest proportion of the world catches of tuna (Figure C1.2). Its catches tended to increase over the entire period of its exploitation. In 2002, the skipjack catch was about 2.0 million tonnes (the highest on record), representing about half of all principal market tuna landed, almost entirely for canning. In the early 1980s, catches of skipjack increased steadily as a result of expansion of fishing effort into the tropical western and central Pacific and into the western Indian Ocean.

Yellowfin is commercially the second most important species of tuna by volume. Catches increased until the early 1990s. Since then, they have remained relatively stable at around 1 million tonnes. In 2002, the catch reached about 1.3 million tonnes (Figure C1.2). Most yellowfin are used for canning, but more and more of the catches are being sold in fresh fish markets (also some as frozen fish). Catches in the Atlantic (Table D17) shown little change over the last two decades, and fluctuated between 129 000t and 156 000t in 1995 to 2002. Catches from the Indian Ocean increased to the maximum of over 300 000t in 1993 due to increased fishing effort, fluctuating between 245 000 and 300 000t in 1995 to 2002. Catches of yellowfin from the Pacific, like those of skipjack, increased consistently until 1976, when they stabilized. They did not begin to rise again until the early 1980s, when large fleets of purse-seine vessels began to fish in the tropical western and central Pacific. Between 1996 and 2002, catches increased from 597 000t to 906 000t.

Bigeye, the third most important species in terms of landed volume (Figure C1.3) is similar in appearance to yellowfin. However, unlike yellowfin, bigeye tuna are primarily creatures of

the deep, spending most of their lives in cold waters below the upper mixed layer of the ocean where they were traditionally captured mainly by longline gear. Their high fat content (for insulation from the cold water) make them desired for the Japanese sashimi market. The rapid and substantial increase in catches in the mid 1970s resulted from modifications of longline gear which enabled it to be used in much deeper water than previously. However, more recently the longline catches of large bigeye have been declining, while purse-seine catches of smaller bigeye have been rapidly increasing, resulting in continuous large increases of total catches for the species to the peak of 431 000t in 2000.

World production of albacore, used mostly for canning, increased from 1950 to the late 1960s. It has fluctuated without a clear trend since with catches of 238 000t in 2002. (Figure C1.3). During the 1980s and early 1990s, driftnet fisheries made large catches of small albacore on the high seas in the south-western and north-eastern Pacific. With the termination of these fisheries, the total albacore catch in the Pacific declined.

Atlantic, Pacific and southern bluefin contribute relatively little in terms of volume to the total catches of principal market tunas (Figure C1.3), but their individual value is high due to their use for sashimi. Catches of Atlantic bluefin followed a generally declining trend from the early 1950s to the early 1970s. During the next decade and half, catches fluctuated without trend. In the early 1990s, catches increased rapidly to 53 000t in 1996 due to improved reporting in the Mediterranean Sea. Catches declined after 1996 and they have stabilized at 36 000t in 2000-2002. The catch of Pacific bluefin peaked at 32 000t in 1961. The smallest catch was 6 000t in the early 1990's. Catches have fluctuated upwards since, being in the order of 17 000 in 1999-2000, but decreasing to 9 000t in 2001-2002. Catches of southern bluefin increased steeply from 14 000t in 1952 to 53 000t in 1961. They fluctuated without trend between 40 000t and 55 000t until 1974. Catches decreased steeply and steadily from 47 000t in 1980to 12 000t in 1991. They have remained between 11 000t and 17 600t since, with 15 000t reported in 2002.

The catches of tunas and tuna-like species other than the principal market tunas also significantly increased from about 0.5 million tonnes in the early 1970s to nearly 2.0 million tonnes in 2002 (see Table D17). Only less than 10 percent of them are composed of billfishes, taken mainly in the Pacific and Atlantic. In terms of volume, the most important species of tunas and tuna-like species other than the principal market tunas (i.e., small tunas and tuna-like species) are: Japanese Spanish mackerel, frigate and bullet tuna, kawakawa, narrow-barred Spanish mackerel, swordfish, longtail tuna, Indo-Pacific king mackerel, seerfishes, Atlantic bonito, Indo-Pacific blue marlin, Eastern Pacific bonito, Indo-Pacific sailfish, king mackerel, striped marlin and Atlantic Spanish mackerel.

Figure C1.2 - Annual nominal catches ('000t) of selected tuna, World Oceans (all Areas)

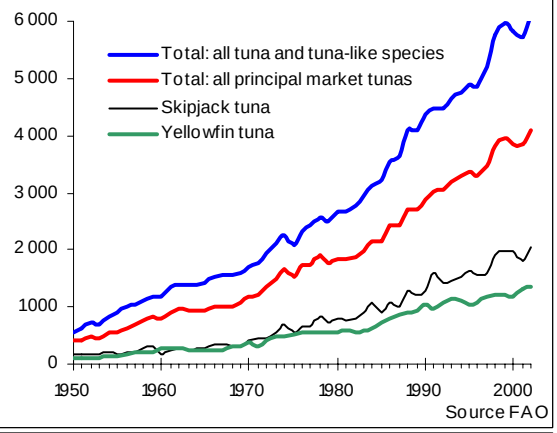
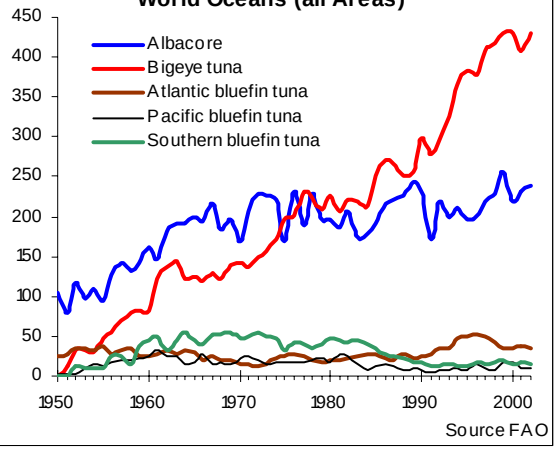


Figure C1.3 - Annual nominal catches ('000t) of selected tuna, World Oceans (all Areas)



Main areas

Historically, the largest proportion (Table D17) of principal market tunas has been always taken from the Pacific (Figure C1.1). Between 1998 and 2002, the annual catch of these species in that Ocean remained quite stable at about 2.5 million tonnes. This represents approximately

65 percent of global annual catch of principal market tunas. Skipjack and yellowfin contribute about 85 percent of the total catch of principal market tunas in the Pacific.

Till the mid 1980s, catches of principal market species in the Atlantic and the Mediterranean Sea were greater than those in the Indian Ocean. About at that time, they become smaller than those in the Indian Ocean. During the last decade, catches of principal market tunas in the Atlantic remained stable, with an average of 0.5 million tonnes annually, representing almost 15 percent of global landings of principal market tunas. In 2002, Atlantic landings were 429 000t. Bigeye, skipjack and yellowfin contribute about 80 percent of the total catches of principal market species there.

Prior to the 1980s, the catch from the Indian Ocean accounted for less than 8 percent of world production of principal market tunas. Due to the expansion of tuna fishing operations in that Ocean, catches of skipjack and yellowfin increased rapidly in the 1980s. Consequently, catches of principal market tunas in the Indian Ocean surpassed those in the Atlantic Ocean, accounting for about 20 percent of global landings of principal market tunas in 2002 (i.e., around 964 000t). Presently, skipjack and yellowfin contribute about 83 percent of the total catches of principal market tunas from the Indian Ocean.

Principal market tuna catches of Japan and Taiwan Province of China are presently largest (more than 0.5 and 0.4 million tonnes caught in 2002, respectively) among those of all countries. Traditional tuna fishing countries include also Spain (277 453t in 2002), Republic of Korea (257 570t in 2002), USA (154 153t in 2002) and France (161 230t in 2002). In addition, recent catches of Indonesia (406 175t in 2002), the Philippines (211 964t in 2002), Ecuador (135 362t in 2002), Mexico (160 151t in 2002), Venezuela (135 956t in 2002) exceeded those of some traditional tuna fishing countries, reflecting a general trend of increasing importance of non-traditional tuna fishing countries (mostly developing countries). Particularly off Southeast Asia, in both the Indian and Pacific Oceans, tuna fisheries are growing, including the artisanal sector catching mostly small tunas, skipjack and yellowfin. This sector's growth has been also significant in the entire Indian Ocean. Other important countries catching principle market tunas include: Maldives (137 050t in 2002), Papua New Guinea (121 579t in 2002), Ghana (61 279t in 2002) and Sri Lanka (61 183t in 2002).

RESOURCES STATUS

Summary on the status of various stocks of tuna and tuna-like species is given in Table D17. This information is taken from publications available just before the preparation of this review and from web pages of, mainly, the Commission for the Conservation of Southern Bluefin Tuna (CCSBT, http://www.ccsbt.org/); the Inter-American Tropical Tuna Commission (IATTC, http://www.iattc.org/); the International Commission for the Conservation of Atlantic Tunas (ICCAT, http://www. iccat.es/); the Indian Ocean Tuna Commission (IOTC, http://www. iotc.org/) and the Secretariat of the Pacific Community (SPC, http://www.spc.org.nc/).

The knowledge and data on the principal market tunas is generally much better than for other species of tuna and tuna-like species. They have been studied for many years and more research effort is devoted to them. However, even for these species, significant uncertainties exist in the basic biological knowledge and data. For example, recent research indicates that the life span of southern bluefin tuna, one of the best studied tuna, may be considerably longer than previously believed. For Atlantic bluefin tuna, another well-studied species, officially reported catches may be significantly smaller than those actually taken, according to information from a trade-based statistical programme (Miyake, 1998) recently introduced by ICCAT. When considering the information on the stock status, uncertainties in stock assessment need to be taken into account.

Most tropical principal market tunas have reacted well to exploitation due to their very high fecundity, wide geographical distribution, opportunistic behaviour and other populations dynamics that make them highly productive. With proper management, they are capable of sustaining high yields. The possibilities of overexploitation and stock depletion should not be underestimated, however.

In the western and central Pacific, there is still a potential for significant increases in catches of skipjack. Higher catches of skipjack might be sustained also in the eastern Pacific and possibly, also in the Indian Ocean, but this is uncertain.

Concerns is also increasing over the overexploitation of bigeye, another species highly desired for sashimi, which is tropical and has a life span shorter than bluefin. In addition to possibly causing over-fishing, the increasing purse seine catches of small bigeye may negatively affect the longline catches of large bigeye, which has much higher prices.

The remaining stocks of tropical principal market species are close to being fully exploited.

Already the temperate species of bluefin, most desired for sashimi, are overexploited, if not depleted. The Western Atlantic bluefin stock is depleted as is the southern bluefin. The yield-per-recruit of Pacific bluefin could be increased if catches of small bluefin taken by trolling and purse seining are reduced.

The stocks of temperate species of albacore used mostly for canning are moderately exploited in the South Atlantic and the South Pacific, fully to overexploited in the North Pacific and overexploited in the North Atlantic. The status of albacore in the Mediterranean Sea and in the Indian Ocean is unknown.

The status of many other tuna and tuna-like species is highly uncertain or simply unknown especially in the Pacific. Therefore, the intensification of their exploitation raises concerns. Significant uncertainties in the status of many billfishes represent a serious conservation problem. In the Atlantic, they seem to be overexploited. Because of commercial exploitation, there is more known about swordfish than other billfishes, particularly in the Atlantic and the Mediterranean Sea where the stock are either fully or overexploited and in the Mediterranean Sea where the stock seems to be fully exploited. There are concerns also about the intensification of fisheries targeting swordfish in the Indian Ocean.

FISHERIES CONSERVATION AND MANAGEMENT

States fishing tuna and tuna-like species cooperate regarding conservation and fisheries management within several international frameworks (FAO, 1994; Marashi, 1996; Beckett 1998), particularly: (1) the recently created Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean; (2) the Commission for the Conservation of Southern Bluefin Tuna (CCSBT); (3) the Inter-American Tropical Tuna Commission (IATTC) for the eastern Pacific; (4) the Indian Ocean Tuna Commission (IOTC); and (5) the International Commission for the Conservation of Atlantic Tuna (ICCAT).

IATTC is the oldest tuna fishery body established in 1950, while IOTC is the youngest, operational since 1998. In addition to their responsibilities in conservation and fisheries management, CCSBT, IATTC, ICCAT and IOTC facilitate the data collection, collation, processing and dissemination, stock assessment, other research and their co-ordination for their areas of competence and some of them, also in adjacent waters to which the stocks extend from their area of competence. IATTC carries out intensive research, having significant research capacity, while the role of CCSBT, ICCAT and IOTC in research is mostly limited to the co-ordination of activities of their member countries.

Some countries fishing tuna in the Mediterranean Sea (which is included in the area of competence of ICCAT) are not members of ICCAT, but of the General Fisheries Commission for the Mediterranean (GFCM). Therefore, ICCAT closely collaborates with GFCM regarding tuna and tuna-like species. IOTC and GFCM are fishery bodies of the Food and Agriculture Organization (FAO) of the United Nations. Before the creation of IOTC, the FAO/UNDP Indo-Pacific Tuna Programme (IPTP) co-ordinated and carried out tuna research in the Indian Ocean and the Pacific off Southeast Asia. Before its termination, it transferred the responsibility for the data collation, processing and dissemination for tuna and tuna-like species in the Pacific off Southeast Asia to the Southeast Asian Fishery Development Center (SEAFDEC).

The Secretariat to the South Pacific Community (SPC), having a significant research capacity, fulfils technical functions similar to the tuna fishery bodies, but its responsibilities do not extend to fisheries management. The recently created Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean will fulfil

that responsibility. The Forum Fisheries Agency (FFA, http://www.ffa.int/) is involved in negotiating and regulating access of distant water tuna vessels to its area of competence in the South Pacific. However, contrary to fishery bodies, its membership does not include non-coastal states.

Cooperation must also extend beyond the scale of single oceans. Industrial tuna fleets are highly mobile and the principal market tunas are intensively traded on the global scale. In addition, many tuna research, conservation and management problems are similar in all oceans. Therefore, there is a need for exchange of information and collaboration on the global scale regarding fisheries for tunas and other spieces with wide global distribution. An important example of such a collaboration is the formulation, in 1995, of the Agreement for the Implementation of the Provisions of the UN Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (sometimes referred as the Fish Stocks Agreement). The United Nations facilitated the conclusion of this Agreement and FAO actively assisted, from the technical point of view, in reaching the Agreement (Doulman, 1995).

In December 11, 2001, the above-mentioned 1995 Agreement entered into force, becoming a new legal basis for conservation and fisheries management of tuna and tuna-like species (supplementing the UN Convention on the Law of the Sea of 10 December 1982). In 1995, the Code of Conduct for Responsible Fisheries was completed within the framework of FAO (FAO, 1995). Though not legally binding, the Code provides a norm for all fisheries and related activities. The Agreement and the Code pose new requirements for conservation, fisheries management, technology and research regarding tuna and tuna-like species, which are likely to affect various sectors of the tuna industry (Mahon, 1996). As a result, the high seas will no longer be perceived as areas where unrestricted fishing is allowed.

The precautionary approach incorporated into the Fish Stocks Agreement and in the Code may affect the exploitation of tuna and tuna-like species. It calls on states to be more cautious where information is uncertain, unreliable or inadequate (FAO, 1996; Majkowski, 1998). Adequate information is available for most stocks of principal market tunas to determine whether they are fully exploited or overexploited. However, for many other tuna and tuna-like species, this is not the case. Within the context of the precautionary approach, the absence of adequate scientific information should not be used as a reason for postponing of failing to take conservation of fisheries management measures. In March 2000, FAO co-organized, jointly with CCSBT, IATTC, ICCAT, IOTC and SPC, a global Expert Consultation on Implications of the Precautionary Approach for Tuna Biological and Technological Research in Thailand (FAO, 2001).

FAO is involved in the consideration of many other global issues involving tuna and tuna-like species. For example, at present, executing a technical, multi-disciplinary Trust Fund Project (GCP/INT/851/JPN) on the Management of Tuna Fishing Capacity: Conservation and Socio-economics. The Technical Advisory Committee for the Project is composed of experts affiliated with CCSBT, FFA, IATTC, ICCAT, INFOFISH (http://www. infofish.org/), IOTC, SPC and international associations of tuna longliners and purse seiners. The Project's activities involve global studies and an Expert Consultation on the Management of Tuna Fishing Capacity, Conservation and Socio-economics.

Also, FAO collates data on nominal catches of all fish species including tunas and separately, specifically of tunas The first data set for all species is based mostly on official national statistics; it does not enable to distinguish among different fishing gears. The second data set specifically for tunas allows this, being mainly based on statistics of international organizations involved in tuna fisheries research (Carocci and Majlowski, 2001). Both sets can be accessed from the FAO web page. FAO also collates data on the geographical distribution of catches of tunas and billfishes on the global scale. On the basis of these data, paper, CD and Internet versions of an Atlas of Tuna and Billfish Catches have been prepared (Carocci and Majkowski 1996, 1998, 2001). These data as well as information on tuna resources, fisheries and their management are being incorporated into FAO's Fisheries Global Information System (FIGIS).

For many tuna fishing fleets, there is insufficient control of their capacity, actual fishing effort and catches. Recently, concerns on a possible over-

capacity of tuna fleets have emerged (Joseph, 2003). As a result, FAO formulated and implements a project on the management of tuna fishing capacity. This project is carried out in collaboration with the tuna fishery bodies and arrangements and other international organizations (including those of the tuna fishing industry) involved in tuna fishing, fisheries research and management. Its objectives is (i) to provide necessary technical information and (ii) to identify consider and resolve technical problems associated with the management of tuna fishing capacity on the global scale, taking into account conservation and socio-economic issues.

One of the prime global conservation problems for fishery bodies dealing with tuna and tuna-like species is the depletion of stocks of bluefin. But this concern has also been discussed within the context of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

However, with the exception of bluefin tuna, serious over-fishing has been largely avoided for various reasons, including the high productivity of tuna species and possibly, decreases in fish prices to uneconomical as markets become saturated. Particularly, recently, the global over-production of canned tuna led to drastic reduction of prices of some species for canning. With the fully exploited status of most stocks of tuna and tuna-like species, more concerns related to their conservation and fisheries management are likely to arise. In addition to the concern for bluefin, some stocks of albacore, bigeye, swordfish and some other billfishes merit some close attention. In the case of bigeye, these concerns are caused by significant global increase of purse seine catches of juveniles. Without adequate fisheries management, future catches of some species may decline in the long term due to over-fishing.

With the present status of stocks, the catches of principal market tunas should not increase on the global scale in a near future unless future technological developments will allow to increase catches of skipjack without increasing those of bigeye and yellowfin. As mentioned before, there is a potential to significantly increase catches of skipjack in the western and central Pacific and also, to some extent, in the eastern Pacific. However, in these areas, skipjack is taken together with small bigeye and yellowfin and such an increase, at least, for bigeye and possibly, also yellowfin, is not desirable. In general, the multi-species nature of many tuna fisheries makes it difficult to selectively control the fishing mortality because several species are frequently caught together.

The overall yield from tuna and tuna-like species depends on the combination of fishing techniques and fishing effort; and the various fishing methods have different effectiveness and selectivity characteristics when targeting various age groups. Improvements in the yield might be achieved in some cases (e.g. albacore and yellowfin in the Atlantic and also in other oceans, bigeye and northern and southern bluefin tuna) by protecting small or immature fish and targeting older age groups. Problems occur with compliance to the present size regulations (e.g. within the framework of ICCAT, especially for Atlantic bluefin in the Mediterranean Sea and in the eastern Atlantic). The intensification of fishing around FADs also raises concerns because such fishing tends to result in large catches of small fish. In the eastern Atlantic, for example, the problem has become so acute that the industry (French and Spanish purse seiners) is placing self-imposed controls on the use of FADs. In general, the protection of fish of small size may not necessarily result in increases in a local yield from an area with intense emigration. In addition, protecting smaller individuals of species with high natural mortality like skipjack may not always give noticeable results from the conservation point of view.

Bio-economic interactions among fisheries need to be scientifically addressed for the resolution of fisheries management problems. Co-ordinated effort in this direction was initiated by FAO's Trust Fund Project: "Cooperative Research on Interactions of Pacific Tuna Fisheries" (Shomura, Majkowski and Langi, 1993a, 1993b, and Shomura, Majkowski and Harman, 1995, 1996). At present, with the completion of this project, this effort is continued by regional and national institutions.

The magnitude of incidentally caught species (by-catch), their discards as well as catch of small individuals of target species and the status of stocks of the by-catch species have been another area of concern (Alverson *et al.*, 1994; Bailey *et al.*, 1994; Joseph, 1994; Hall, 1996, 1998, IATTC, 1998). Generally, by-catches of tuna fisheries are relatively low. However, they include species of dolphins, turtles, seabirds and

sharks, which receive particularly high attention from the international community.

In the future, a greater utilization of by-catch species may be expected. Fishing may become more selective through gear modifications and changes in fishing areas and seasons. Also, more research is likely to be undertaken to determine the status of stocks of species incidentally caught. There is already some improvement in the collection of data on by-catch.

There are various management measures imposed for tuna fisheries on regional scales, particularly in areas where tuna fishery bodies have been operational for a long time. This is the case in the Atlantic and the Mediterranean Sea (ICCAT) and the eastern tropical Pacific (IATTC). In the case of ICCAT, they include size limits for bigeye, bluefin and yellowfin, fishing effort restrains for yellowfin and bluefin, catch limits for albacore, bigeye and bluefin and restrictions on the use of FADs. Some other measures include seasonal and geographical closures in the Mediterranean Sea.

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