

chapter 5

TUNAS



■ Introduction and species identification

Tunas belong to Actinopterygii (ray-finned fishes), order Perciformes, family Scombridae which contains about 32 species and subspecies. Two species of special commercial interest to fisheries and capture-based aquaculture are considered in this report: the northern bluefin tuna *Thunnus thynnus* [two subspecies were recognized by Gibbs and Collette (1967): *Thunnus thynnus thynnus* (Linnaeus, 1758) in the North Atlantic and *Thunnus thynnus orientalis* (Temminck and Schlegel, 1844) in the North Pacific] and the southern bluefin tuna *Thunnus maccoyii*. The Integrated Taxonomic Information System (www.itis.usda.gov) states that *Thunnus orientalis* was “formerly included in *Thunnus thynnus* (Linnaeus, 1758) as a subspecies”. However, Collette *et al.* (2001) support treating this Pacific taxon as a full species (*Thunnus orientalis*), quite separate from the Atlantic taxon (*Thunnus thynnus*). Our report follows the old approach.

The Atlantic subspecies of the northern bluefin tuna (*Thunnus thynnus thynnus*) is found from Labrador and Newfoundland south into the Gulf of Mexico and the Caribbean Sea and is also known off Venezuela and Brazil in the Western Atlantic; in the Eastern Atlantic it occurs from the Lofoten Islands off Norway south to the Canary Islands and the Mediterranean Sea. There is also a population off South Africa. The Pacific subspecies (*T. thynnus orientalis*) is known from the Gulf of Alaska to southern California and Baja California in the Eastern Pacific; in the Western Pacific it occurs from Sakhalin Island in the southern Sea of Okhotsk south to the northern Philippines.

Northern bluefin tuna are highly migratory, according to Annex I of the 1982 Convention on the Law of the Sea (www.oceanlaw.net/texts/losc.htm; FAO 1994). A pelagic species, it can be found seasonally coming close to the shore and can tolerate a wide range of temperatures. The fish shoal by size, sometimes together with albacore, yellowfin, bigeye, skipjack, etc. The northern bluefin tuna is one of the most important species in Japanese fisheries; its meat is utilized fresh for “*sashimi*” and, due to massive overfishing, it has become increasingly rare (Muus and Nielsen 1999).

During the spawning season, adult southern bluefin tuna (*Thunnus maccoyii*) migrate to tropical seas, off the west coast of Australia, up to 10°S. It is considered a highly migratory species (FAO 1994). Within 100 years its population will be below 500 mature individuals if the current exploitation continues (Matsuda *et al.* 1998). This species is highly prized in Japan for the “*sashimi*” market and specialized fisheries for *sashimi*-quality fish have been recently developed in New Zealand. Overfishing is severe for *T. maccoyii* and it was suggested the species should be declared an endangered species under the Endangered Species Act (1992) and listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Tables 42-43 summarize the characteristics of the northern and southern bluefin tunas, while Figures 70-73 illustrate their appearance and geographical location.

Thunnus thynnus (Linnaeus, 1758)

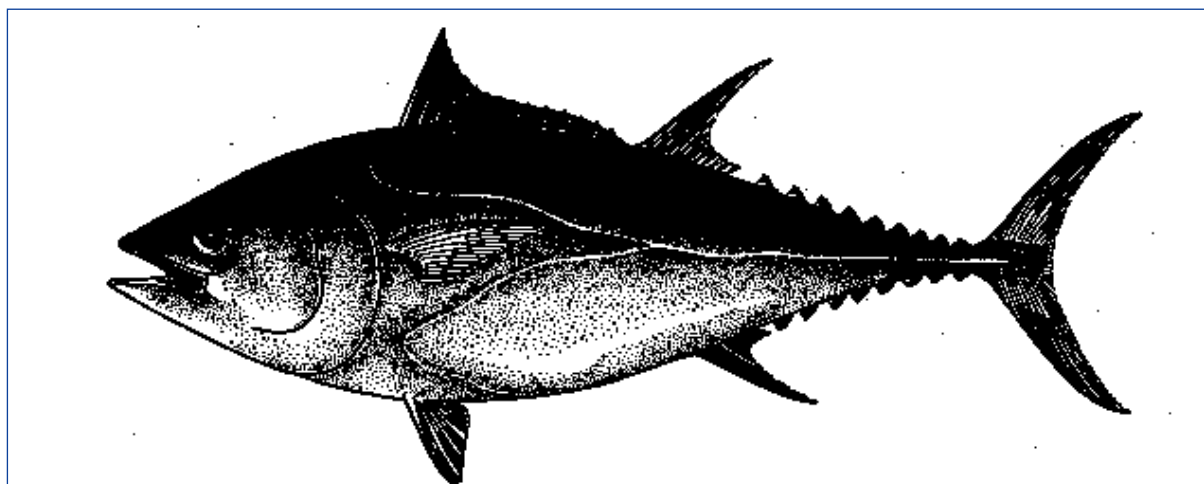


Figure 70. Northern bluefin tuna (*Thunnus thynnus*) (FAO)

Table 42. Characteristics of the northern bluefin tuna (*Thunnus thynnus*)

(FishBase 2002, modified)

Common name	Northern bluefin tuna.
Size and age	Maximum size of 458 cm TL (male/unsexed) and maximum weight 684 kg. Life span approximately 15 years.
Environment	Brackish and marine species.
Climate and latitude	Subtropical climate (70°N-40°S).
Resilience	Minimum population doubling time of 4.5-14 years, with low resilience (Collette 1999).
Distribution	The Atlantic subspecies is found from Labrador and Newfoundland south into the Gulf of Mexico and the Caribbean Sea to Venezuela and Brazil in the Western Atlantic; in the Eastern Atlantic from the Lofoten Islands off Norway south to the Canary Islands and the Mediterranean Sea. There is also a population off South Africa. The Pacific subspecies from the Gulf of Alaska to southern California and Baja California in the Eastern Pacific; in the Western Pacific from Sakhalin Island in the southern Sea of Okhotsk south to the northern Philippines.
Biology and ecology	This pelagic species can be found seasonally coming close to shore, and can tolerate a wide range of temperatures; it feeds on small schooling fishes (anchovies, sauries, hakes), squids and red crabs.
Importance	This is one of the most important species in Japanese aquaculture and fisheries; its meat is utilized fresh for <i>sashimi</i> and also canned (Frimodt 1995); it has become rare because of massive overfishing (Muus and Nielsen 1999).

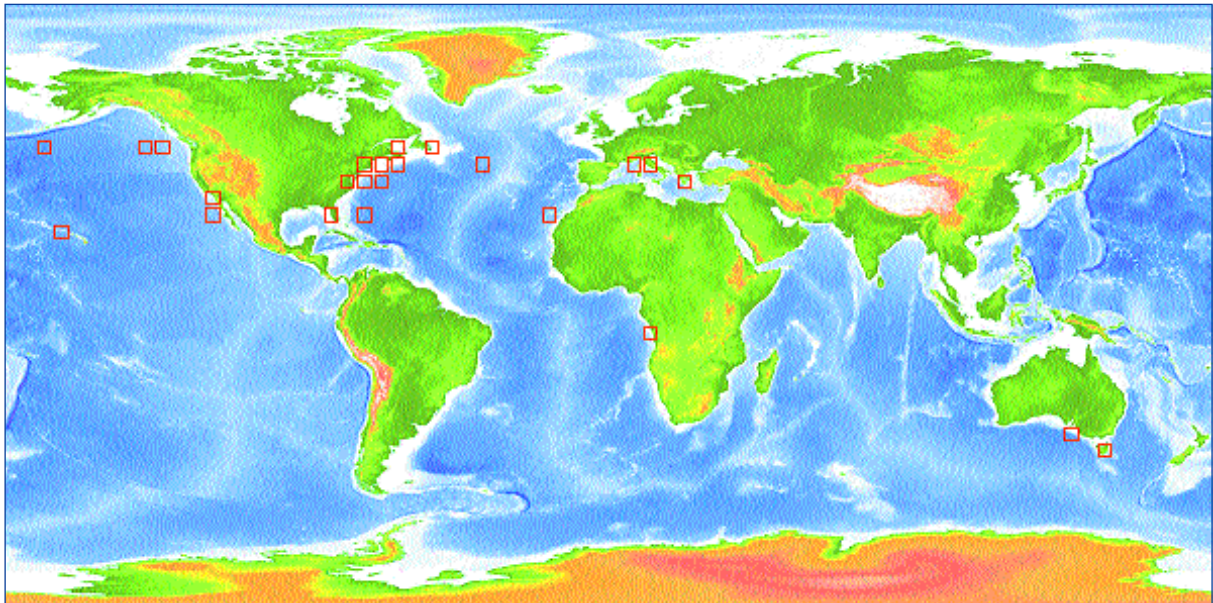


Figure 71. Zoological sites sampled for geographic distribution (indicated by the red squares) of *Thunnus thynnus* (FishBase 2002)

Thunnus maccoyii (Castelnau, 1872)

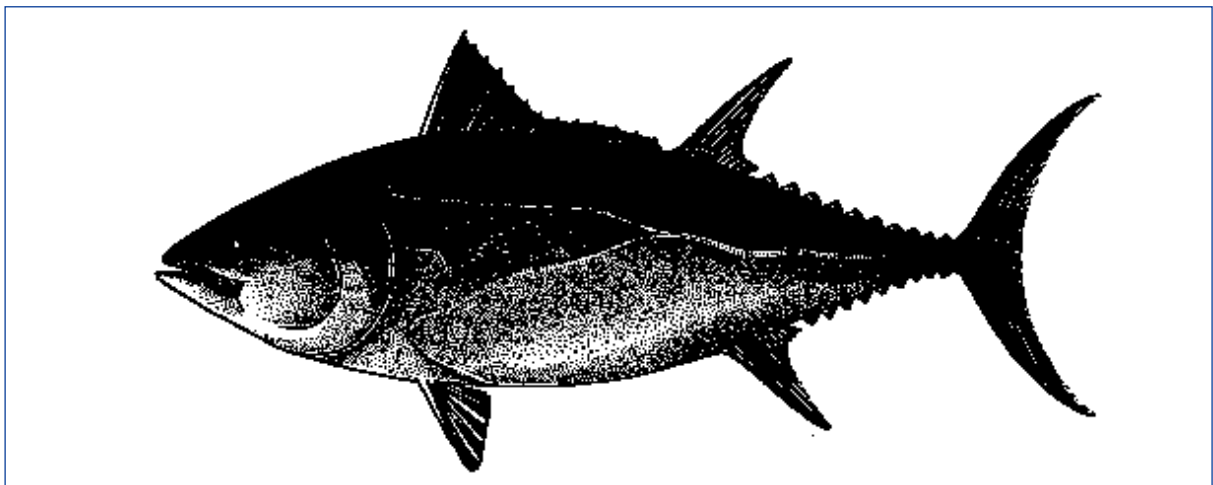


Figure 72. Southern bluefin tuna (*Thunnus maccoyii*) (FAO)

Table 43. Characteristics of the southern bluefin tuna (*Thunnus maccoyii*) (FishBase 2002, modified)

Common name	Southern bluefin tuna.
Size and age	Male specimens reach 245 cm FL and a maximum weight of 260 kg; maximum life span 20 years.
Environment	Pelagic, marine species.
Climate and latitude	Subtropical climate (5-20°C) between 10°S and 60°S.

Resilience	Doubling time of 4.5-14 years and low resilience (Collette and Nauen 1983).
Distribution	It can be found in the Southern Hemisphere in temperate and cold seas, mainly between 30° and 50°S, to nearly 60°S. At spawning season, adults migrate to tropical seas off the west coast of Australia, up to 10°S.
Biology and ecology	By maturity, most Southern bluefin tuna lead an oceanic, pelagic existence (Kailola <i>et al.</i> 1993). Spawning fish and larvae are encountered in waters with surface temperatures between 20-30°C. <i>T. maccoyii</i> is an opportunistic feeder, preying on a wide variety of fishes, crustaceans, cephalopods, <i>Sarpa salpa</i> , and other marine animals.
Importance	This species is very prized in Japan for the <i>sashimi</i> market and in New Zealand specialized fisheries for <i>sashimi</i> -quality has been developed. <i>T. maccoyii</i> is threatened by overfishing, was called to be declared an endangered species under the Endangered Species Act (1992) and listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

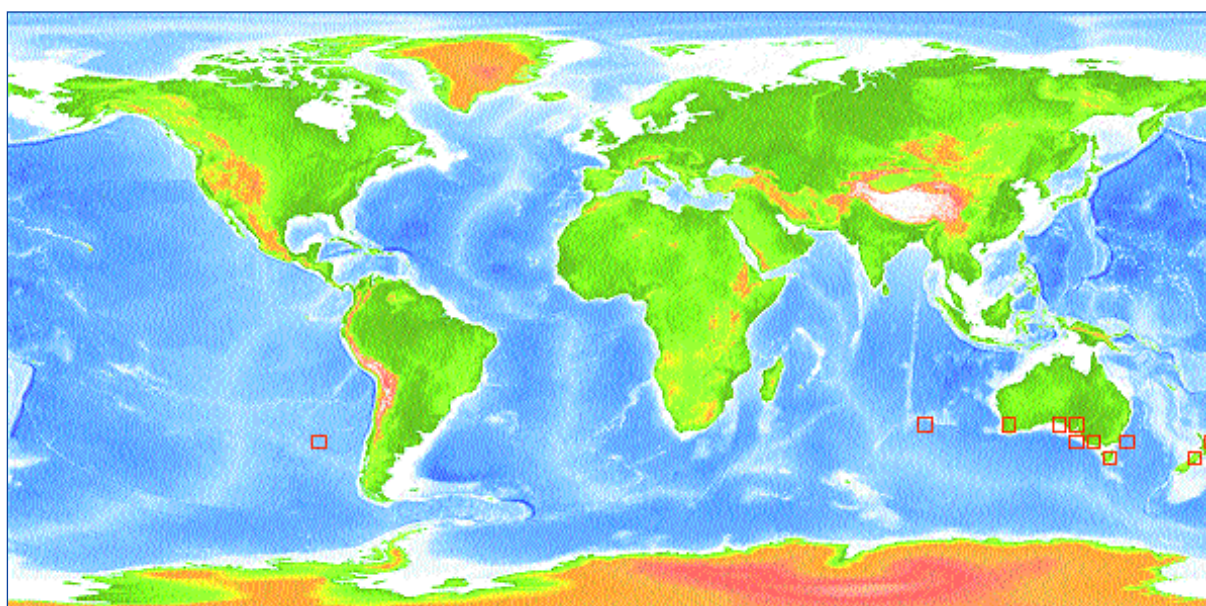


Figure 73. Zoological sites sampled for geographic distribution (indicated by the red squares) of *Thunnus maccoyii* (FishBase 2002)

■ Fishery trends

Both southern and northern bluefin tunas are captured worldwide. Because of their flesh quality, bluefin tuna are among the most desired and expensive species; the Japanese market (“*sushi*”¹ and “*sashimi*”² tradition) is the main driving force for the fishery. Overfishing in many areas could adversely affect stock status. The northern bluefin tuna fisheries are therefore regulated by the International Convention for the Conservation of Atlantic Tunas (ICCAT), and the southern bluefin tuna by the Commission for the Conservation of Southern Bluefin Tuna (CCSBT). As a consequence of overfishing, regulations and quotas are annually established or revised by these regional management bodies. The global catch of all bluefin tunas was higher in 2000 (65 426 tonnes) than in 1991 (45 499 tonnes) but was well below the peak in 1996 (Figure 74).

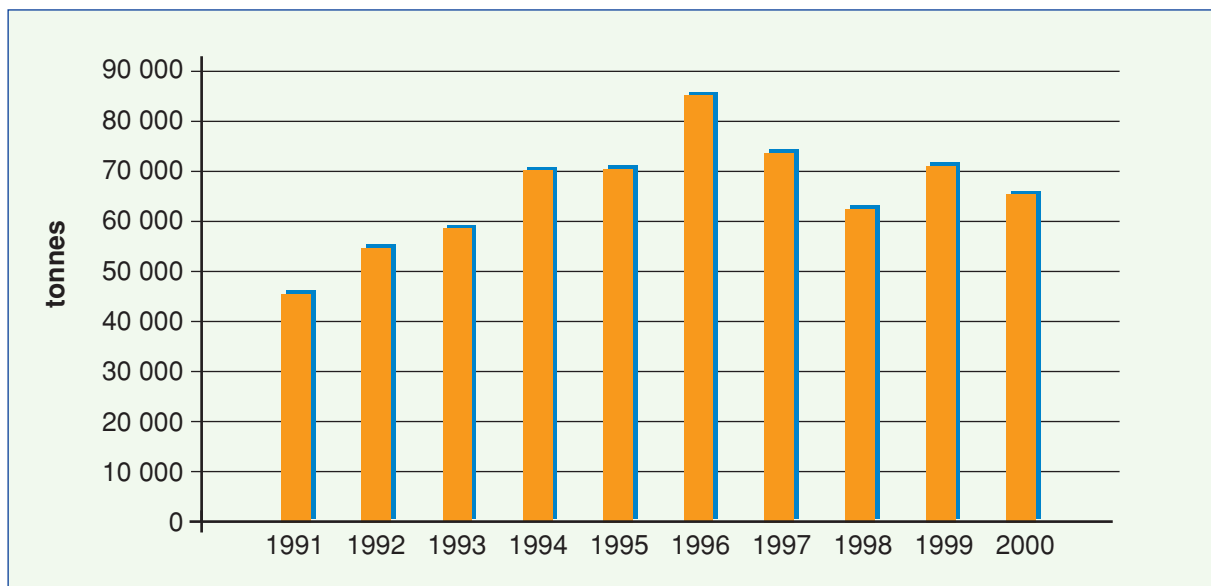


Figure 74. Global trends in the total bluefin tuna catch 1991-2000 (FAO 2002b)

Bluefin tuna fishing is mostly carried out using purse seines, longlines, traps, hand lines and harpoons (a traditional activity in the Straits of Messina, Italy), driftnets (now almost totally banned globally), etc. In 2000, the leading bluefin tuna fishery continent was Asia (25 762 tonnes), followed by Europe (20 288 tonnes), Africa (8 989 tonnes), Oceania (5 664 tonnes), North America (4 030 tonnes) and others (693 tonnes). The impact of intensive fishing is compounded by new fishing technologies, which make it possible to detect bluefin tuna shoals, e.g. helicopters and true-motion sonar systems; and a large proportion of the world’s bluefin tuna are now caught by industrial fisheries. The Mediterranean and the Black Sea areas accounted for 37% of the total catch of bluefin tunas in 2000, followed by the Northwestern Pacific (17%) and the Eastern Indian Ocean (14%) (Figure 75). At that time, Japan was the leading tuna fishing country with a catch of 18 984 tonnes, followed by France and Spain (Figure 76).

Purse seine fisheries have become the most important provider of tunas for capture-based aquaculture. Due to the technological developments of fishing operations, purse seining is more efficient than longlining as it targets identified shoals. The pressure on bluefin tuna fisheries in the Mediterranean area has increased considerably over recent years. International organizations such as the Conference on the International Trade of Endangered Species (CITES) have warned

1 Japanese cold snack of cold rice, flavoured and garnished (in this case with tuna)

2 Japanese dish of garnished raw fish in thin slices

about a decline in the abundance of resources and the risk of their exhaustion. It is vital for future fisheries management to follow a precautionary approach, maintaining the status of these stocks in the absence of sufficient information, and to ensure that the existing equilibrium is not disrupted further (FAO/GFCM/CGPM 2003).

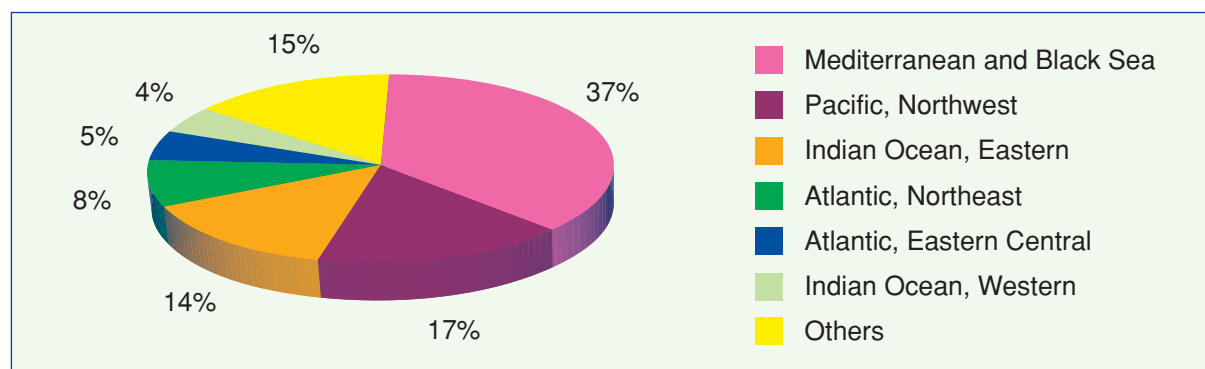


Figure 75. Total bluefin tuna catch by area in 2000 (FAO 2002b)

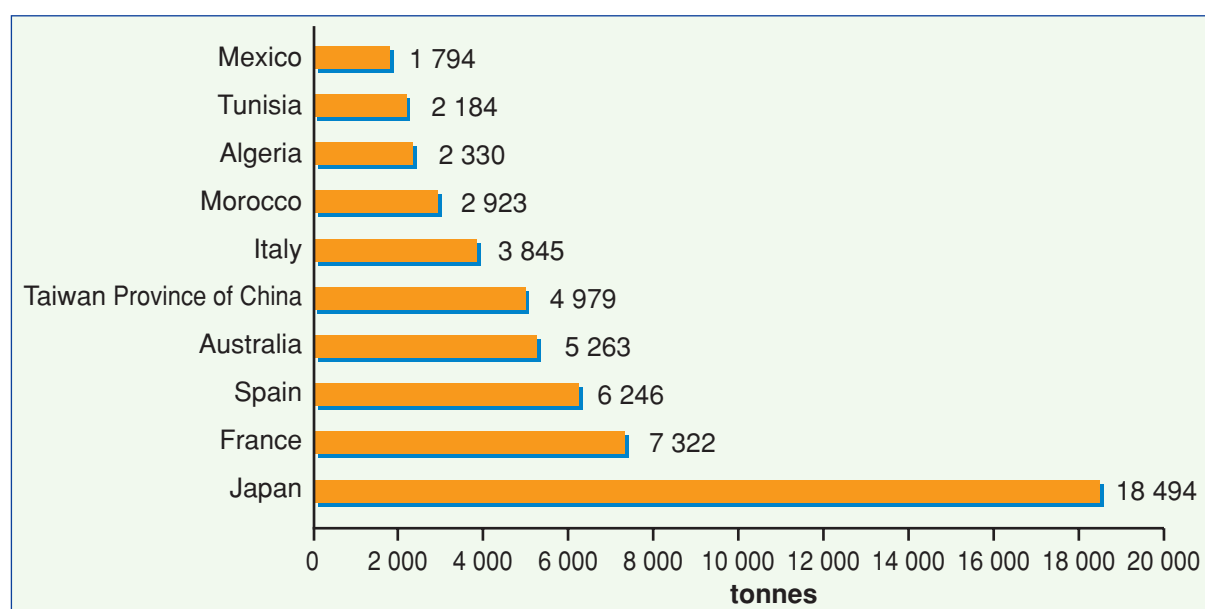


Figure 76. Capture fisheries for bluefin tuna: the top ten countries in 2000 (FAO 2002b)

■ Northern bluefin tuna

The catch of northern bluefin tunas (*Thunnus thynnus*) was greater in 2000 than in 1991 but peaked in 1996 (Figure 77).

Europe was the leading continent in 2000 (20 288 tonnes), followed by Asia (16 471 tonnes), Africa (8 987 tonnes) and North America (4 030 tonnes). Oceania ranked last with 21 tonnes.

The Mediterranean and the Black Sea are the major fishing areas, with 48% of the global catch in 2000 (Figure 78). The fishery was the first industrial fishery in the world using the traditional tuna trap, based in several places along the Mediterranean coastline. Economic support from Japanese interests to North African countries during the 1980s and 1990s, and joint ventures with European companies, have increased the fishery activities of Mediterranean countries and their commercial capacities (De la Serna *et al.* 2002). The Mediterranean is followed by the Pacific Northwest (22%) and the Northeastern Atlantic (11%) as the major capture areas (Figure 78).

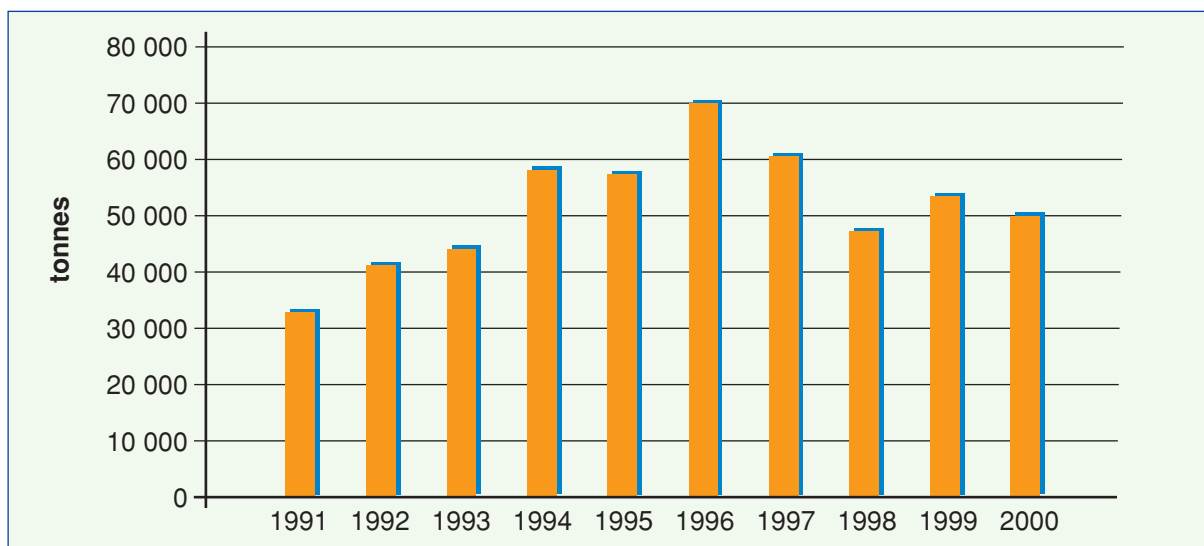


Figure 77. Global catch of northern bluefin tuna (*Thunnus thynnus*) 1991-2000 (FAO 2002b)

In 2000, Japan was the leading country with 12 163 tonnes (10 040 tonnes in Northwest Pacific, 890 tonnes in Mediterranean and Black sea, 553 tonnes in Northeast Atlantic, etc.), followed by France with 7 322 tonnes (Figure 79). In 2000, the catch of industrialized countries totalled over 30 000 tonnes, accounting for 67% of the total.

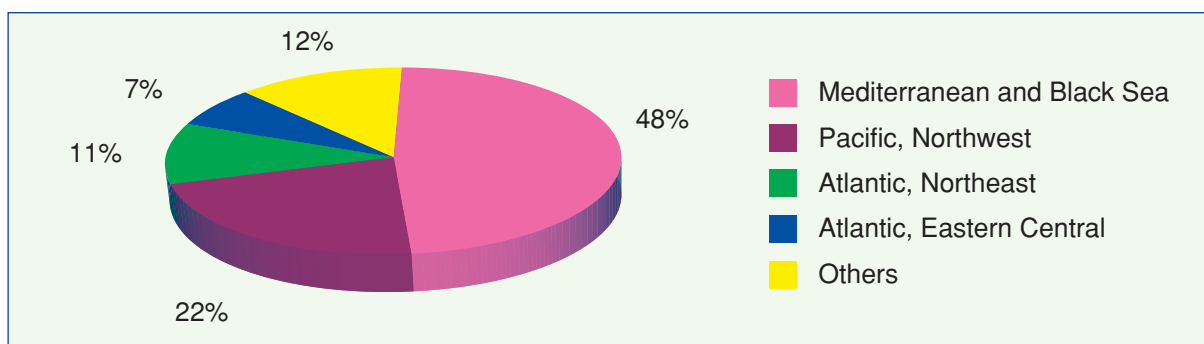


Figure 78. Global catch of northern bluefin tuna (*Thunnus thynnus*) by area in 2000 (FAO 2002b)

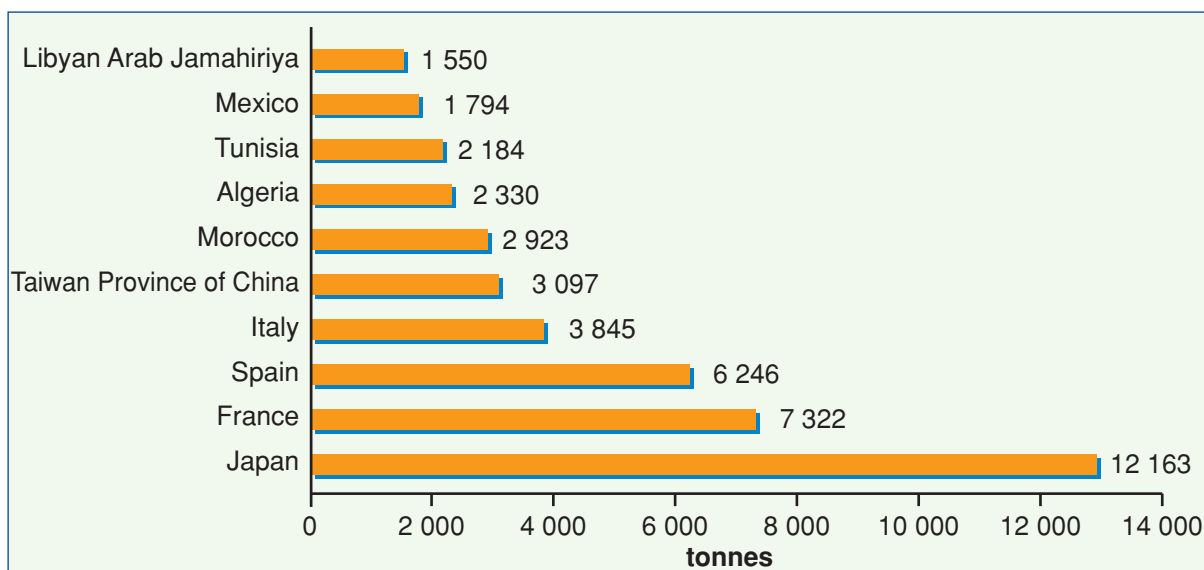


Figure 79. Capture fisheries for northern bluefin tuna (*Thunnus thynnus*): the top ten countries in 2000 (FAO 2002b)

■ Southern bluefin tuna

Southern bluefin tuna (*Thunnus maccoyii*) data shows a cyclical trend (Figure 80); the extremes during the decade 1991-2000 were from just over 12 000 tonnes to nearly 18 000 tonnes.

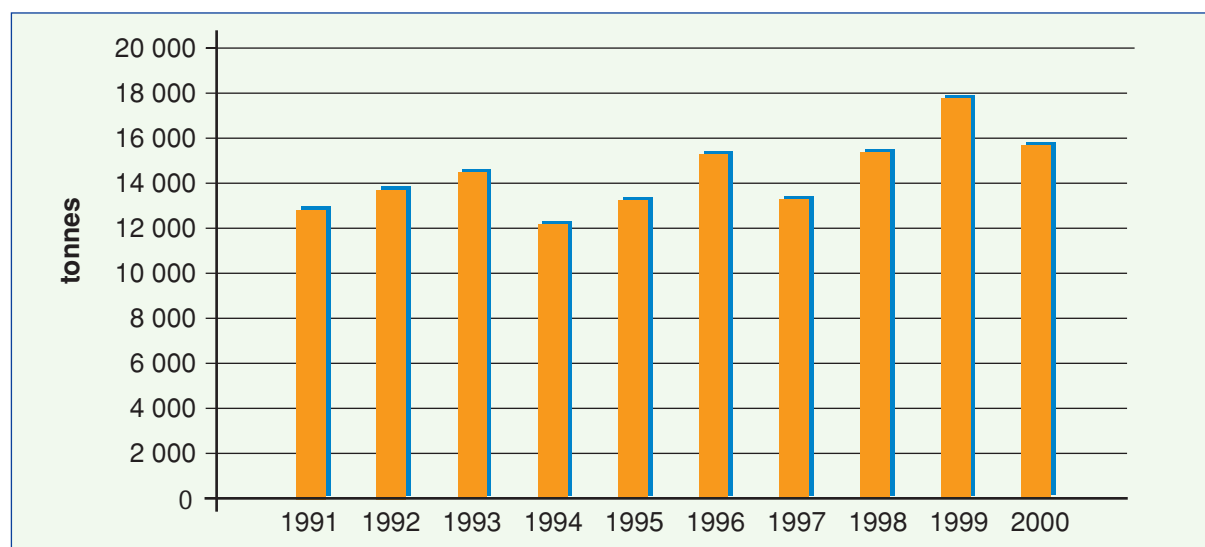


Figure 80. Global catch of southern bluefin tuna (*Thunnus maccoyii*) 1991-2000 (FAO 2002b)

In 2000, southern bluefin tuna (*Thunnus maccoyii*) was captured mainly in Asia (9 291 tonnes) and Oceania (5 643 tonnes). Total captures for 2000 amounted to 15 629 tonnes. The Eastern Indian Ocean area accounts for nearly 60% of the total with a catch of 9 317 tonnes (Figure 81). During the past two years (2001-2002), the main fishery area in Australia is around Port Lincoln (South Australia), with purse seine fleets as the main catching method.

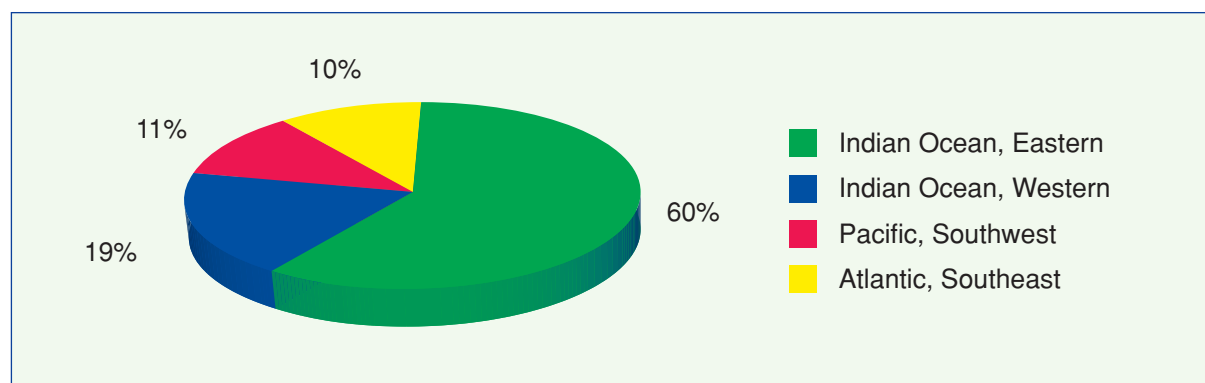


Figure 81. Global catch of southern bluefin tuna (*Thunnus maccoyii*) by area in 2000 (FAO 2002b)

In 2000, Japan was the leading fishing country with 6 331 tonnes, followed by Australia with 5 263 tonnes (Figure 82). In that year, most southern bluefin tuna (76%) was caught by the fishing fleets of industrialized countries. 12% was caught by Taiwan, Province of China.

The capture-based aquaculture of southern bluefin tuna began as a result of the declining Australian fishery for this species. The Australian catch peaked in 1982 at 21 500 tonnes (Fishstat Plus 2002) but, owing to increasing concerns about the sustainability of the fishery, a TAC (total allowable catch) system was implemented by the CCSBT to limit and manage the catch. Steadily reducing TACs (14 500 tonnes in 1984, 6 250 in 1998 and 5 265 tonnes since 1990) provided the necessary incentive for southern bluefin tuna fishing operations to investigate the potential for

capture-based aquaculture (Clarke 2002). Today, Australian bluefin tuna is mainly sold to Japan; in 2001, 99% of the Australian bluefin tuna farmed in Port Lincoln (South Australia) was exported to the Tsukiji market, Tokyo.

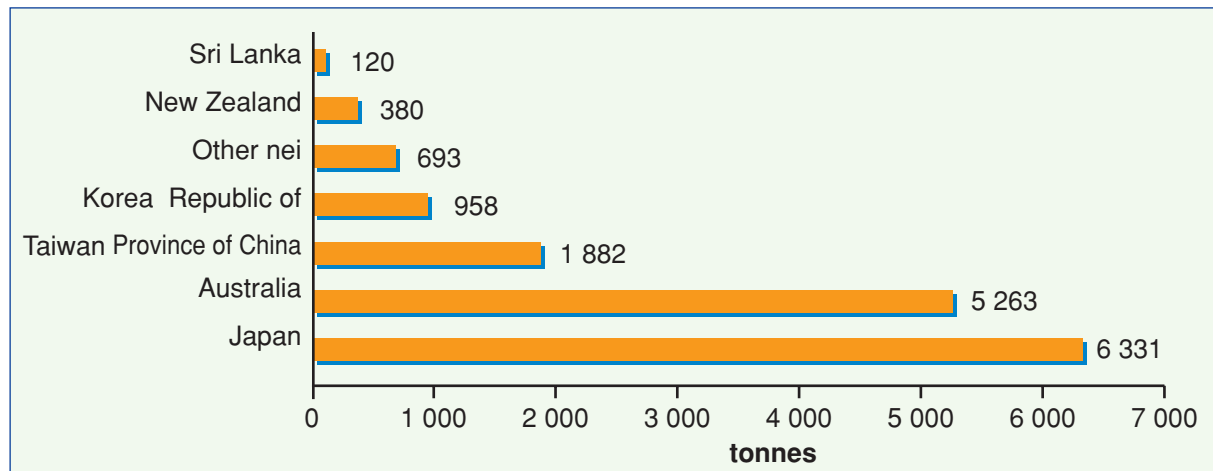


Figure 82. Catch of southern bluefin tuna (*Thunnus maccoyii*) by country in 2000 (FAO 2002b)

Japan is the main market for the bluefin tuna caught in the global fisheries: the Japanese custom to eat fresh tuna as “sushi” and “sashimi” is the driving force behind the development of tuna fishing, and is also supporting the development of the capture-based aquaculture sector, worldwide.

■ Availability of “seed” for capture-based aquaculture

Bluefin tuna shoal by size, sometimes together with other species (e.g. yellowfin, albacore or skipjack). Natural stocks are known to fluctuate considerably year-by-year, and these fluctuations are attributed to either food availability and/or predation at some period of their early life history – the so-called “critical period” (Cushing 1974, 1990). “Shoalfishes” normally adopt ecologically antipredatory behaviour (Masuda and Tsukamoto 1999). This mechanism is of vital interest to fishermen, because it largely determines the success or failure of fishing techniques and tactics and, due to this behaviour, bluefin tuna schools have been heavily exploited. Tuna prey on other schooling fish e.g. anchovies, and the effect of their capturing activities are visible on the sea surface. This predatory behaviour allows fishermen to easily detect bluefin tuna schools.

As bluefin tuna are widely distributed and migrate for thousands of kilometres, a general understanding of tuna movement and migrations is necessary for a more accurate analysis of bluefin tuna size availability for capture-based aquaculture. In the northeastern Pacific *Thunnus thynnus* tend to migrate northward along the coast of Baja California and California, from June to September. Off the Pacific coast of Japan, they migrate northward in summer and southward during winter. Adults may enter the Sea of Japan from the south in early summer and move as far north as the Okhotsk Sea; most leave the Sea of Japan through the Tsugara Strait, north of Honshu (www.fao.org/fi/sidp/species/th_th_ht.htm).

There are only two confirmed spawning locations: the Gulf of Mexico in the Western Atlantic and the Mediterranean Sea in the Eastern Atlantic. Spawning in the Gulf of Mexico occurs between mid-April and mid-June when females (typically 8 years old) each release approximately 30 million eggs. According to Buck (1995), sexual maturity is reached at the age of 5 to 8 years,

depending on the stock. Some fishery biologists believe that eastern Atlantic bluefin tuna reach sexual maturity several years earlier than those in the western Atlantic (possibly as young as ages 4 or 5), a claim disputed by some other biologists. All the bluefin tuna collected during the spawning season in the Balearic Islands in 2001 were between 19 and 34 kg and had fully matured (spawning) ovaries – a fact that would apparently confirm that the eastern stock of Atlantic bluefin tuna are able to spawn from 3 years old (Abascal, Megina and Medina 2003). Further studies of bluefin tuna biology are clearly necessary. In 2002, a captive-raised bluefin tuna (145.6 cm total length, 35.2 kg body mass) was found to be a hermaphrodite, the first record of hermaphroditism in this species (Sawada *et al.* 2002). The highest density of bluefin larvae, the primary indicator of spawning, occurs in the northern Gulf of Mexico, with lesser larval concentrations appearing off the Texas coast and in the Straits of Florida (NRC 1994).

In the Eastern Atlantic, spawning occurs exclusively in the Mediterranean: usually from May to July in the Balearic Sea, the South Tyrrhenian Sea, and in the southern Mediterranean. Aggregations of juveniles have been reported in the eastern Aegean sea, in the Southern Adriatic Sea, in the Tyrrhenian Sea, in the Ligurian Sea and in the Balearic area, sometimes close to the coast (De la Serna *et al.* 2003). The larval abundance of tuna around the Balearic Islands was determined between June 15 and July 10, 2001, as part of a Spanish research project. The highest abundance was observed south of Minorca and along the midsection of the Mallorca channel (García-Gómez *et al.* 2003).

Bluefin in the South Atlantic belong to a distinct southern population, the southern bluefin tuna (Figure 83), with known spawning areas south of Java, Indonesia. The aggregations of southern bluefin tuna juveniles swim near the surface during their migration between the spawning areas and western Australia, where individuals of class O are concentrated to the dispersion areas, close to Tasmania and New Zealand.

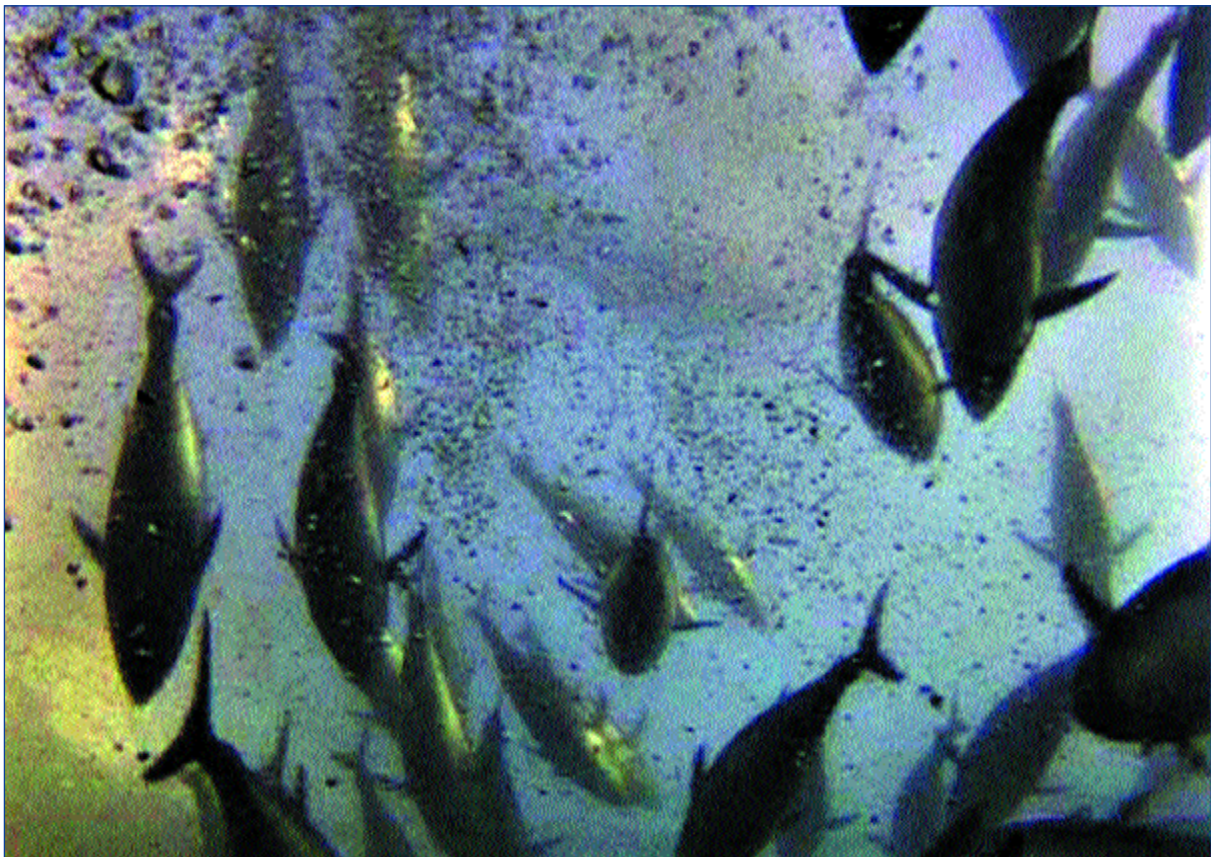


Figure 83. Southern bluefin tuna (*Thunnus maccoyii*) (Photo: L. Mittiga)