CCSBT-ERS/0602/Info11

Report on the Assessment of Implementation of Japan's National Plan of Action for the Conservation and Management of Sharks of FAO (Preliminary version)

March 2005

Fisheries Agency, Government of Japan

Introduction

At the 23rd FAO Committee on Fisheries in February 1999, an International Plan of Action on this subject (IPOA-SHARKS) was adopted. Following this decision, Japan developed its National Plan of Action (Shark-plan) through examination and deliberation by the national discussion committee as well as discussion within the government, and reported it to the 24th FAO Committee on Fisheries in March 2001.

Japan is now striving to ensure scientific knowledge and information regarding shark resources under this National Plan of Action, and also to ensure rational conservation and sustainable use of shark resources based on such proper knowledge.

This document reports to the 26th FAO Committee on Fisheries in March 2005 about assessment of the National Plan of Action and the situation of its implementation in accordance with paragraph 28 of the IPOA-SHARKS.

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1. General Description of Shark Fisheries and Shark Populations

World Shark Fisheries

FAO capture production data show that global catches of sharks, skates and rays (elasmobranchs) have continuously increased from the 200,000 mt per year level in the 1940s to the 800,000 mt per year level in 2001. In contrast, elasmobranch catches by Japan exceeded 100,000 mt per year in the 1940s, but have continuously declined since then to 25,000 mt per year in 2002. This decline in catches by Japan reflects a decreasing demand for shark, skate and ray products (Fig.1).

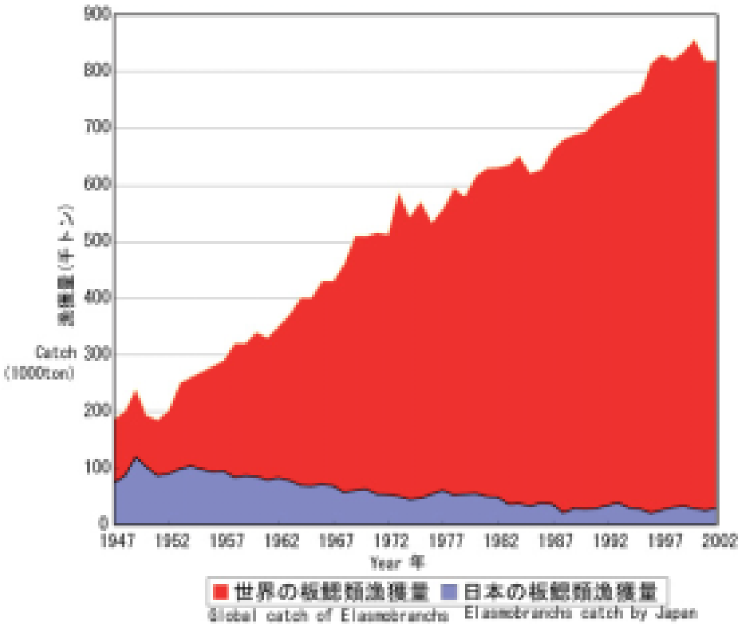


Fig. 1. Elasmobranch catches by Japan and worldwide (FAO 2003)

Table 1 summarizes catches of elasmobranchs by major fishing nations from 1990 to 2002 based on FAO capture production statistics. In recent years, Asian countries have reported increasing catches, with Indonesia harvesting 70,000-120,000 mt per year, India 50,000-130,000 mt per year, Chinese Taipei 40,000-80,000 mt per year and Pakistan 40,000-50,000 mt per year. Outside of Asia, Spain, Mexico, and the United States also report substantial catches, with Spain harvesting 10,000-100,000 mt per year, Mexico 30,000-40,000 mt per year, and the United States 30,000-50,000 mt per year. Catches by Japan in recent years have hovered around the level of 20,000-30,000 mt per year.

Table 1. Elasmobranch catches by major fishing nations between 1990 and 2002 (Unit: 1,000 mt) (FAO 2003)

Year	Indonesia	India	Chinese Taipei	Pakistan	Spain	Mexico	USA	Japan	Others	Total
1990	73	51	76	40	14	45	35	32	326	692
1991	77	56	69	45	15	41	36	33	342	714
1992	80	60	65	46	10	43	54	38	332	728
1993	87	77	56	46	12	44	38	39	344	743
1994	93	84	39	50	21	43	38	34	355	757
1995	98	77	44	50	24	43	38	31	357	762
1996	94	132	41	51	19	45	52	24	355	813
1997	96	72	40	48	99	36	40	29	369	829
1998	111	75	40	54	67	37	45	34	358	821
1999	108	77	43	55	67	35	38	33	378	834
2000	114	76	46	51	82	35	31	32	390	857
2001	119	73	42	49	69	33	22	28	384	819
2002	115	67	44	50	63	30	24	28	398	819

Elasmobranch fisheries in Japan

Japan's elasmobranch catches exceeded 70,000 mt per year in the 1950s, but then gradually declined to 20,000-30,000 mt per year in recent years. The main cause of the decline was the decrease in landings of benthic sharks and rays from the bottom trawl fishery. However, catches of pelagic sharks by longline fisheries also gradually decreased from the 20,000 mt per year level in the 1980s to 15,000-20,000 mt ton per year level in the 1990s. Catches by longline fisheries comprised 85-92% of the shark catches in this period.

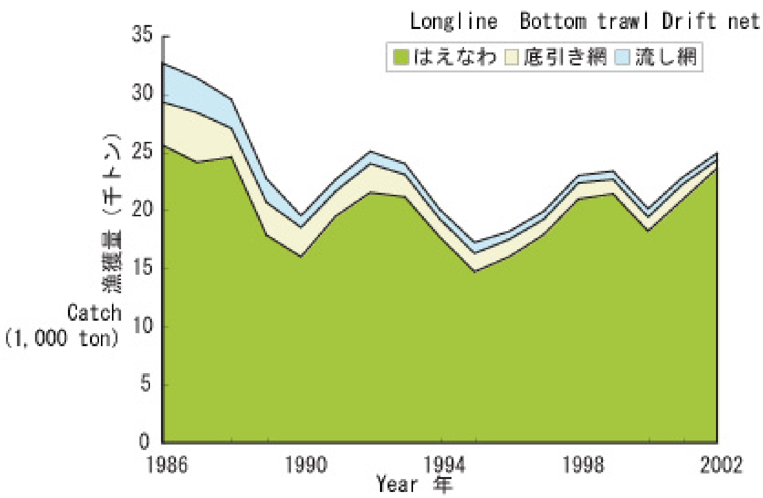


Fig. 2. Shark catch by type of fishery, (Statistical Information Division, Ministry of Agriculture, Forestry and Fisheries, 1988-2004)

In terms of number by species (Fig.3), blue shark is the most commonly caught species in tuna longline fisheries. This species often used to be discarded at sea, except in near-shore fishing grounds, because of its low market value in Japan. However, in recent years as their commercial value as food products has increased in overseas markets, landings at major overseas ports have also increased. Landings of blue shark in 1990-2003 were 10,000-15,000 mt per year, accounting for 73.1% of the total landings of pelagic sharks.

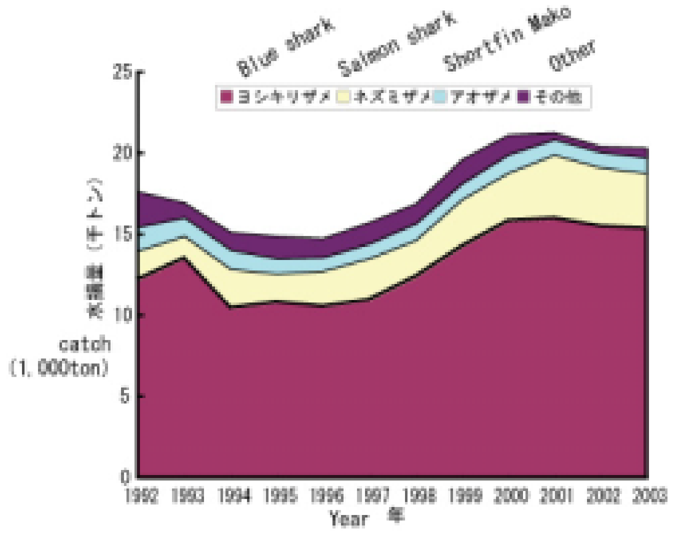


Fig. 3. Landed weight of pelagic sharks by species (Fisheries Agency/Fisheries Research Agency, 1994-2005)

Distant-water longline vessels often land shortfin mako sharks in Japan because of their high-quality meat and high commercial value. Landings of shortfin mako in 1992-2003 were 800-1,500 mt per year, accounting for 5-8% of the total landings of pelagic sharks.

Most salmon sharks are landed in the Tohoku region, centering on Kesennuma in Miyagi Prefecture. The commercial value of this species is high because of its high-quality meat, and in addition to its use as food, salmon shark fins and skins are used for handicrafts. Landings of salmon shark in 1992-2003 were 1,400-3,900 mt per year for longline and driftnet fisheries combined, accounting for 8-18% of the total landings of pelagic sharks.

Of the other pelagic sharks (oceanic whitetip shark, silky shark, bigeye thresher, crocodile shark), the crocodile shark is never used commercially, even for its fins. According to data from 1992-2003, landings of these species were reported at 3-85 mt per year for oceanic whitetip shark, and for thresher shark, including the bigeye thresher, at 25-706 mt per year. Landings data for silky shark are not available as this species is not recorded separately, but landings of requiem sharks as a group are reported at 0-130 mt per year (Fisheries Agency/Fisheries Research Agency 1994-2005).

Regarding the three species of large sharks, i.e. whale shark, basking shark, and great white shark, a harpoon fishery targeting basking sharks existed in the 1960s, but there are no fisheries targeting these species at present.

International research

In recent years, as a reflection of the rising international concern for conservation and management of shark stocks, collection of catch data and stock assessment of sharks are being promoted by some international fisheries management organizations. Japan has been fulfilling its obligations as a major fishing nation and promoting research cooperation in the form of provision of catch data and presentation of research results, especially with regard to pelagic sharks caught incidentally by tuna fisheries.

Resource management

In Japan's longline fisheries, where most pelagic sharks are caught, effort has shown a declining trend in recent years (Fig.4). However, overall effort by all fishing nations in the Pacific has increased over the same period (Fig.5). Therefore, reduced effort by Japan is being replaced by effort exerted by other countries such that fishing effort as a whole is increasing, with a concomitant increase in fishing pressure on pelagic sharks. At present, no catch regulations aimed at managing shark populations are being implemented by international fisheries management organizations related to tuna fisheries. However, depending upon the results of stock assessment, there is a possibility that catch regulations may have to be implemented for the conservation of sharks. In response to the FAO International Plan of Action for Conservation and Management of Sharks (IPOA-Sharks), Japan developed its National Plan of Action for Conservation and Management of Sharks (NPOA-Sharks). Within this framework, a system was established to monitor the state of shark resources in Japan, and, when necessary, the Committee on Development of the National Plan of Action for the Conservation of Shark Resources recommends measures to implement conservation and management of sharks to the Fisheries Agency.

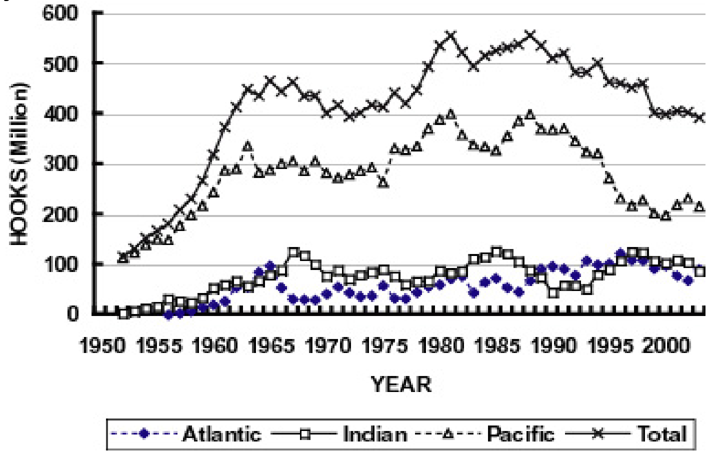


Fig. 4. Annual changes in Japan's longline fishing effort (unpublished data, National Research Institute of Far Seas Fisheries)

Fig. 5 Annual changes in longline fishing effort in the Pacific (downloaded data, Secretariat of the Pacific Community)

Present and future issues

- As the issues surrounding sharks have been identified relatively recently, more appropriate national system and organization to respond to these issues in areas such as research and administration is necessary.

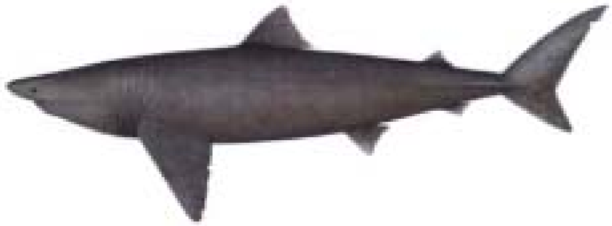
- Unlike the situation for tunas and marlins, there are no long-term time series of catch data that can be used for stock assessment.

- For many species of sharks, erroneous species identification can occur during catch recording by fishing vessels.

- As pelagic sharks are highly migratory species, cooperation between countries is indispensable in carrying out stock analysis.

- There are no fisheries targeting large sharks. However, these species sometimes stray into set nets accidentally. For this reason, there is a need to establish an arrangement to systematically collect information on incidental catch in set nets.

2. Basking Shark
(*Cetorhinus maximus*)



Fisheries and other issues relevant to this species

In Japan, this species has historically been harvested by harpoon fishery. Its liver was used in Nakiri, Mie Prefecture from the latter half of the 1960s to the 1970s, but no harvesting has taken place recently. Currently, basking sharks are caught incidentally on rare occasions in set nets along the coast of Tohoku and Hokkaido from spring to autumn, and incidents of sharks straying into set nets occur throughout the country. As harvesting rarely occurs and the species' market value is low, post-harvest disposition varies from landing to live release. Almost no official catch statistics are available.

At CITES COP11 in 2000, the United Kingdom proposed listing of the basking shark on Appendix II on the basis that it is endangered, but this proposal was rejected. Then the U.K. submitted a revised proposal for listing on Appendix III. At COP12 in 2002, the U.K. tabled a further proposal to uplist the species from Appendix III to II. This was adopted after gaining the votes of more than two thirds of the Contracting Parties.

Biological characteristics

Distribution
The basking shark is distributed from temperate to arctic regions, and is found in both coastal and offshore areas (Fig.1). This species also occurs in tropical areas on rare occasions, but this is considered to be "straying" into the area and instances of occurrence there are said to be few. In the Western Pacific, Chinese Taipei is the southern boundary (Compagno 2001). This species occurs along the Pacific coast in near-shore areas of Japan from spring to summer. In the Sea of Japan, it occurs primarily in winter and spring. In Okinawa, the southernmost part of Japan, it is observed in July. Basking sharks occur in both the Eastern and Western Pacific, but whether there are exchanges between these areas is unclear. In addition, information on basking shark occurrence on either side of the North Atlantic is not available.

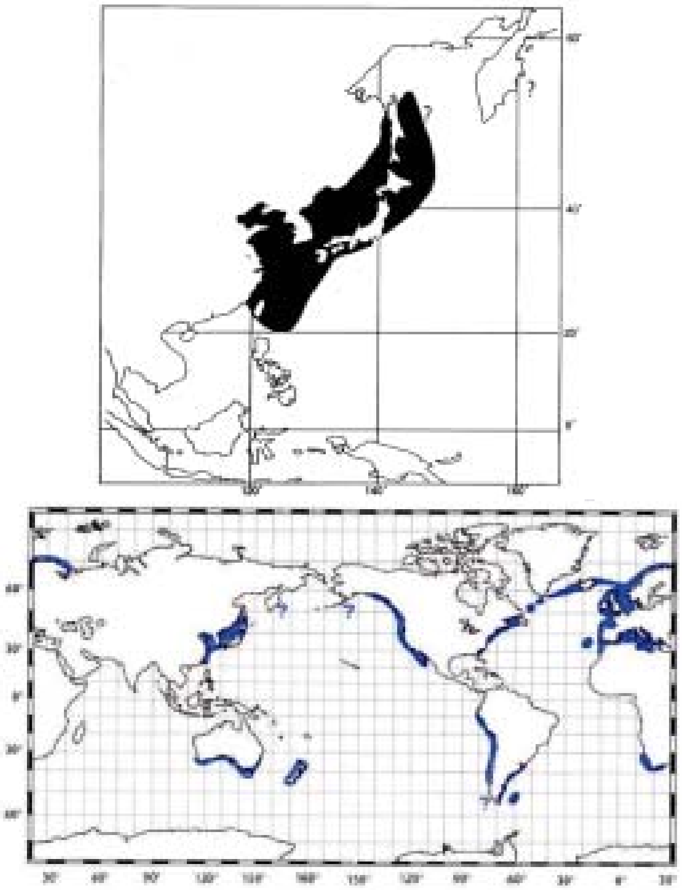


Fig. 1. Distribution of the basking shark (Uchida 1995, Last and Stevens 1994)

Spawning and migration

Although there are few records of small individuals from observations or surveys, a record from the 19th century states that the minimum length of a swimming individual was 1.65 m (Bigelow and Schroeder 1948). From this, it is estimated that the body length at the time of birth is 1.7 to 1.8 m. Based on uterine structure, i.e. an inner wall covered with ciliform tissues, and taxonomic similarities with sharks belonging to the family Lamniformes, the reproductive pattern of this species is believed to be viviparity and oophagy (Matthews 1950, Compagno 2001).

Growth and sexual maturity

The length at sexual maturity for male basking sharks is 6.4 to 7.4 m, and age of maturity is 6 to 8 years. The length at sexual maturity for females is not known, but it is estimated that the gestation period extends for 3.5 years (Parker and Stott 1965). This estimate is based on studies of vertebral centrum growth annuli from individuals in the eastern North Atlantic. Furthermore, this finding is based on the assumption that 2 growth rings represent one year, but it is possible that one growth ring represents one year, and some researchers estimate that the age of sexual maturity of males may be 12 to 16 years (Compagno 2001). Bigelow and Schroeder (1948) estimated total length at sexual maturity for males at 4.6 to 6.1 m based on changes in body form, clasper condition, and gonadal status.

Feeding habits

The basking shark is one of 4 species of large elasmobranchs which prey on plankton (the others species being the whale shark, the megamouth shark, and the manta ray). The basking shark swims with its mouth wide open, and preys on copepods; larvae of cirripedes, decapods and stomotopods; and fish eggs, using its gill rakers as filters (Compagno 2001).

Stock status

Population trends

Table 1 summarizes the number of occurrences, including catches, of basking sharks around Japan. From the latter half of the 1960s to the first half of the 1970s, annual harvesting by harpoon fishery of about 100 individuals a year took place in Nakiri, Mie Prefecture. Since that time, there have been no fisheries directly targeting basking sharks but there have been incidental catches in set nets. Such cases continue to be reported in the media several times a year, but it is difficult to quantify the frequency of occurrence from such reports.

Table 1. Occurrence records of basking sharks by year around Japan. Occurrence records were summarized from published information. Place names other than Nakiri (Mie Prefecture) are indicated by the prefectural name only. The figures in parentheses are the numbers of reported individuals.

Year	No.of occurrences	Place of occurrences(Pref.)
1940s	100	Nakiri[4] Annualy approx. 100catches
1967	100	Nakiri[1]
1968	100	Nakiri[1]
1969	100	Nakiri[1]
1970	100	Nakiri[1] Wakayama[4]
1971	101	Nakiri、Fukushima[1]
1972	100	Nakiri[1]
1973	100	Nakiri[1]、Ishikawa(1)[5]
1974	100	Nakiri[1]
1975	152	Mie、Yamaguchi、Nakiri[1]
1976	20	Nakiri[1]
1977	10	Mie、Nakiri[1]
1978	6	Nakiri[1]
1979	11	Ishikawa[1]、Mie（10）[2]
1980	2	Hyogo、Shizuoka[1]
1981	4	Okinawa[1]、Mie（３）[2]
1982	1	Nagasaki[1]
1983	1	Ishikawa[5]
1984	2	Hokkaido、Niigata[1]
1985	3	Hokkaido、Ishikawa、Shimane[1]
1986	3	Nagasaki（2）、Shizuoka[1]
1987	1	Okinawa[1]
1988	2	Ishikawa[1]
1989	1	Shizuoka[1]
1990		
1991	1	Fukuoka[1]
1992	1	Totori[1]
1993	5	Kochi、Hyogo[1]、Ishikawa[5]、Iwate(2)[6,7] Fukuoka[8]
1994	2	Kochi、Ishikawa[1]
1995	2	Iwate(2)[3]
1996	1	Miyagi[3]
1997	4	Wakayama(4)[4]
1998	1	Iwate[6]
1999	1	Iwate(2)[3,7]、Ishikawa[5]
2000	1	Ishikawa[5]
2001	1	Miyagi[3]、Ishikawa[5]
2002		
2003	1	Iwate[7]

Sources:

1) Uchida, S. (1995)
2) Yano, K.(1981)
3):Global Guardian Trust(2002)
4) Global Guardian Trust(2003)
5) Global Guardian Trust(2004)
6) National Research Institute of Far Seas Fisheries(2003)
7) National Research Institute of Far Seas Fisheries(2004)
8) Kitakyushu City Museum of Natural History http://www.kmnh.jp/check/011.html

In comparison with the period between 1960 and the 1970s when about 100 basking sharks frequented the area near Nakiri, Mie Prefecture, numbers have obviously decreased. However, it is not necessarily the case that large numbers of basking sharks were present prior to that period since there is a view that large-scale migrations occur with a frequency of 30 years.

There has been no fishery targeting basking sharks since the latter half of the 1970s and the only records available are of accidental strayings of this species into set nets throughout the country. Over this long time period, incidental catch in set nets seems to be occurring at fixed rate. Although the population size of basking sharks inhabiting the waters adjacent to Japan is not known, since the decrease in numbers in the latter half of the 1970s, no clear trend of either increase or decrease has been observed in recent years.

Trends in fishing pressures
As there is no fishery targeting this species, this discussion assumes that the number of set nets, into which straying of basking sharks is observed, represents a form of fishing pressure to this species (Fig.2). Over the past 30 years, the number of large-scale set nets increased from 800 to 900 in the 1980s, but fell again to around 800 in the 1990s. The number of small set nets reached 16,000 in the first half of the 1980s, and then fell to about 12,900 in 2000. The number of salmon set nets increased during this period from approximately 400 to 900. The total of the 3 types of set nets was about 12,000 in 1970 but reached a peak of about 18,000 in the first half of the 1980s. Subsequently, total set net operations gradually decreased to about 14,500 in 2000. It is not clear to what extent these set nets constitute fishing pressure on basking sharks. If they do exert fishing pressures, it is assumed that such pressures gradually declined from the 1980s to 1990s.

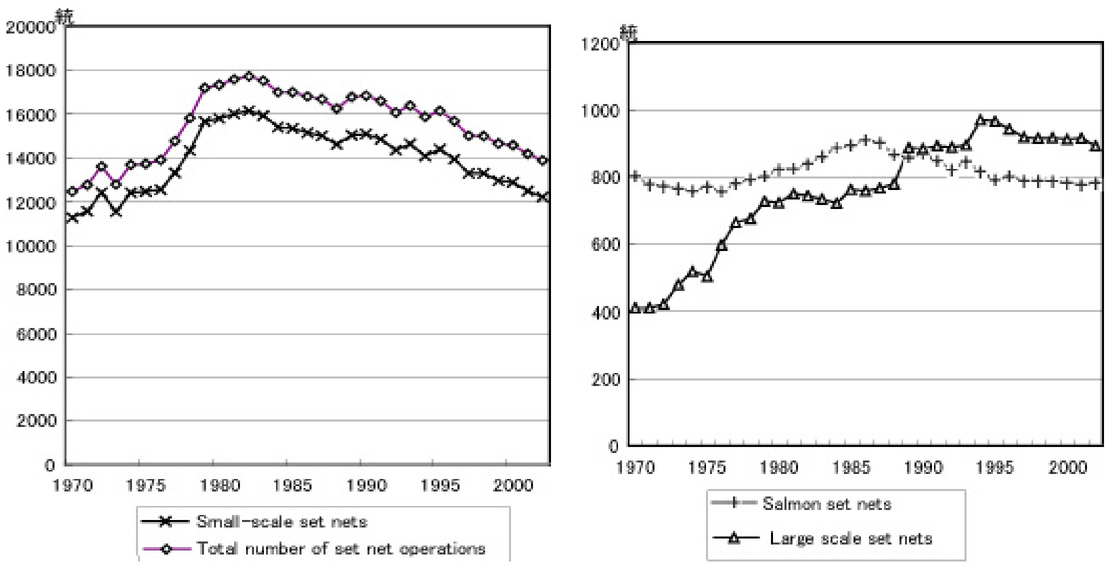


Fig. 2. Changes in the number of set net operations along the coast of Japan from 1970 to 2002 (Statistics and Information Division of the Ministry of Agriculture, Forestry and Fisheries 1972-1973, Statistics and Information Division of the Ministry of Agriculture, Forestry and Fisheries 1974-2003, Statistics Division of the Ministry of Agriculture, Forestry and Fisheries 2004)

Management measures

As no fisheries targeting this species exist in Japan, no active fishing takes place. There is no system in place in Japan to systematically collect information on this species when caught incidentally in set net fisheries. As a result, there is very little knowledge concerning the incidental catch of this species. In order to implement stock assessment and conservation measures, there is an urgent need to establish an information collection system for this species.

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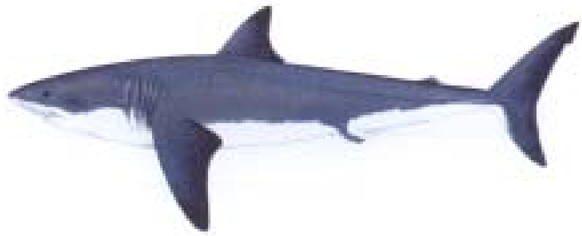
3. Great White Shark
(*Carcharodon carcharias*)



Fisheries and other issues relevant to this species

There are no directed fisheries for great white sharks in Japan. However, this species is caught incidentally in set nets and less frequently by coastal fisheries such as gillnet, bottom trawling, crab basket, and small-scale longlines (Nakaya 1994, Uchida and Toda 1996). This species is believed to be coastally distributed, and incidental catch by distant-water fisheries, such as tuna longline fisheries, is very rare.

At CITES COP11 in 2000, the United States and Australia tabled a joint proposal for listing of this species on Appendix I on the grounds that it is endangered. The proposal was rejected by means of a vote. No proposal to this effect was made at COP12 in 2002, but at COP13 in 2004, Australia and Madagascar tabled a joint proposal, and this species was included in Appendix II as a result of voting.

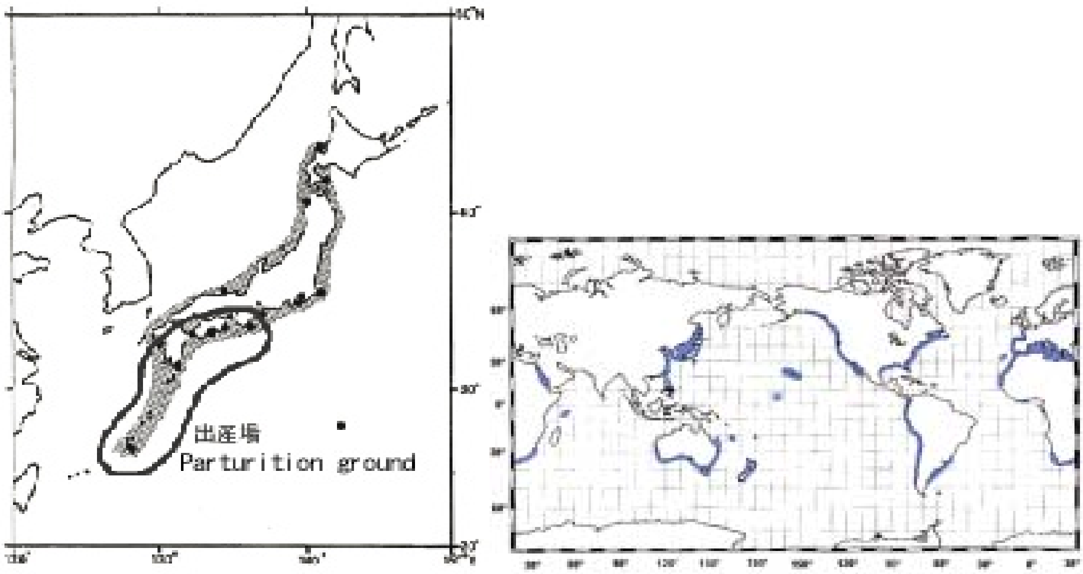


Fig. 1. Distribution of great white sharks around Japan and worldwide (Teshima 1994 partly revised, Last and Stevens 1994).

Biological characteristics

Distribution and migration

The great white is a large shark extensively distributed in coastal areas from temperate to arctic regions throughout the world (Last and Stevens 1994). The distribution of this species around Japan extends from the area off Okinawa to

Hokkaido, and it is believed to undertake southern and northern migrations in the area near the Japanese Archipelago according to seasonal changes in water temperature (Nakano and Nakaya 1987, Teshima 1994, Nakaya 1994). There is a high possibility is that they engage in seasonal migrations related to parturition, but much is unknown at present. The stock structure of this species is also not known, but it is likely that since they occur on both eastern and western edges of the Pacific they may be spatially segregated due to their preference for coastal habitats.

Parturition period and size at birth

The breeding pattern of the great white shark exhibits ovoviparity (aplacental viviparity), with embryos feeding on other ova produced by the mother (oophagy) after the yolk sac is absorbed. According to recent observations which found fragments of foetal skin and teeth in the intestines of great white shark foetuses about to be born (total length 130 to 150 cm), there is a possibility of cannibalism among foetuses in the uterus. Furthermore, it is considered that great white sharks have functional teeth immediately after birth due to development of teeth during the foetal period (Francis 1996, Uchida and Toda 1996).

The size at birth of this species is 120 to 150 cm, and the parturition period in the area north of Kyushu is considered to be April and May, and, in Okinawa, February and March (Francis 1996, Uchida and Toda 1996). The body weight corresponding to this size is from 12 to 16 kg to 26 to 32 kg (Francis 1996). The number of foetuses per uterus is 2 to 4 (Compagno 2001).

The parturition ground is believed to lie in the area between Okinawa and the Kansai Region (central Honshu) because the occurrence of pregnant sharks and swimming juveniles, believed to be neonates, is limited to this area.

Growth and sexual maturity

With regard to growth of this species, estimates have been obtained from specimens collected from the west coast of the United States and South Africa (Cailliet et al. 1985, Wintner and Cliff 1999). The growth relationships are shown below where L_t is the total length at t, and t is age. When total length is converted to precaudal length, it is 653 cm (764 TL) and 544 cm (686 TL), respectively.

$$L_t = 764(1 - e^{-0.058(t+3.53)})$$ (Cailliet et al. 1985)

$$L_t = 686(1 - e^{-0.065(t+4.4)})$$ (Wintner and Cliff 1999)

Females of this species attain sexual maturity at 4 to 5 m, and at 12 to 14 years of age, and live at least 23 years. Males mature at 3.5 to 4.1m and at 9 to 10 years of age. On the assumption that the maximum body length (total length) of this species is 7.6m, irrespective of sex, the maximum age estimated from the growth formulae is 27 years (Compagno 2001).

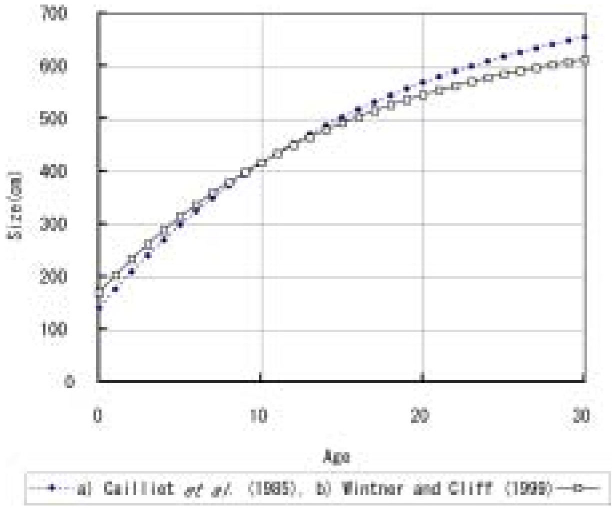


Fig. 2. Growth curve for the great white shark.

Table 1. Age and size of the great white shark calculated by two methods.

Age	a) Size (cm)	b) Size (cm)
0	141	171
1	177	203
2	210	233
3	241	262
4	270	289
5	298	314
6	324	337
7	349	359
8	373	380
9	395	399
10	415	417
11	435	434
12	454	450
13	471	465
14	488	479
15	503	492
16	518	504
17	532	515
18	545	526
19	557	536
20	569	546
21	580	554
22	590	563
23	600	570
24	609	578
25	618	585
26	626	591
27	634	597
28	641	602
29	648	608
30	655	613

a)Cailliet *et al.*(1985)、 b)Winter and Cliff(1999)

Feeding habit and predators

The great white shark is an opportunistic predator and selects prey species which are readily available in its habitat. Main prey species include teleost and cartilaginous fishes, marine mammals, seabirds, molluscs, crustaceans, marine reptiles (e.g. marine turtle species), and gastropods (Compagno 2001). One case of a killer whale (*Orcinus orca*) preying on 3-4 m great white shark has been reported in the Farallon Islands off California (Pyle et al. 1999).

Stock status

Population trend

Table 2 summarizes occurrences of great white sharks by age in the waters adjacent to Japan. Records of historical occurrences are scarce, and reports of 1 to 3 sharks a year have been made in recent years. The reason behind reports of large numbers of occurrences in 1992 (12) and 1993 (6) is likely to have been the increased media attention focused on this species as a result of a fatal attack on a diver in the Seto Inland Sea in 1992.

Trends in fishing pressures

Of the 19 reported occurrences of great white shark in 1992 and 1993, 16 were incidental catches by coastal fisheries (Nakaya 1994). Of these, 12 were caught by set net, two by gillnet and one each in the bottom trawl and crab basket fisheries. As there is no fishery targeting this species, this discussion assumes that the number of set nets, in which incidental catch occurs most frequently, represents a form of fishing pressure to this species. Over the past 30 years, the number of large-scale set nets increased from 800 to 900 in the 1980s, but fell again to around 800 in the 1990s (Fig. 3). The number of small set nets reached 16,000 in the first half of the 1980s, and then fell to about 12,900 in 2000. The number of salmon set nets increased during this period from approximately 400 to 900. The total of the 3 types of set nets was about 12,000 in 1970 but reached a peak of about 18,000 in the first half of the 1980s. Subsequently, total set net operations gradually decreased to about 14,500 in 2000. It is not clear to what extent these set nets constitute fishing pressure on great white sharks. If they do exert fishing pressures, it is assumed that such pressures gradually declined from the 1980s to 1990s.

Stock management measures

As there is no system in Japan to systematically collect information on species caught incidentally in the set-net fishery, information on incidental catch of species like great white shark is very limited. In order to implement stock assessment and conservation measures, there is an urgent need to establish a system to collect information on incidental catch of such rarely caught species.

Table 2. Occurrence records of the great white shark by year in the area around Japan. The figures in parentheses are the number of sharks sighted. Occurrence records were summarized from published information.

Year	No.of occurrences	Place of occurrences (Pref.)
1956	1	Hyogo [1]
1957		
1958	1	Kochi [1]
1959		
1960		
1961		
1962	1	Chiba [1]
1963		
1964		
1965		
1966		
1967		
1968		
1969		
1970		
1971	1	Aomori [1]
1972		
1973		
1974		
1975	1	Okinawa [2]
1976		
1977	2	Okinawa [2]
1978		
1979	2	Kochi、Okinawa [1]
1980	1	Okinawa [2]
1981	1	Okinawa [2]
1982		
1983		
1984	1	Okinawa [2]
1985	3	Hokkaido(2) [1]、Okinawa [2]
1986	1	Wakayama [2]
1987		
1988	1	Okinawa [2]
1989	3	Okinawa [2]
1990	2	Okinawa [2]
1991		
1992	12	Ehime(2)、Kagoshima(2)、Kochi(2)、Hokkaido(2)、Miyagi、Wakayama、Chiba [6]、Hyogo
1993	6	Shimane(2)、Fukuoka、Kagoshima、Oita、Chiba [6]
1994	3	Okinawa、Kochi [2]、Shizuoka [6]
1995	2	Tokyo（Izu Islands）[5]、Okinawa [7]
1996		
1997	3	Mie [4]、Wakayama（２）[8]
1998	1	Miyagi [6]
1999	1	Yamaguchi [3]
2000	2	Akita [10]、Iwate [9]
2001		
2002	2	Iwate [7]

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1) Nakano and Nakaya (1987)
2) Uchida, Toda (1996)
3) Chugoku Newspaper
4) Toba Aquarium
5) Taikichi's Sea
6)Nakaya 1994
7)Global Guardian Trust(2002)
8)Global Guardian Trust(2003)
9)National Research Institute of Far Seas Fisheries(2003)
10)Fisheries Agency, Fisheries Research Agency(2002)

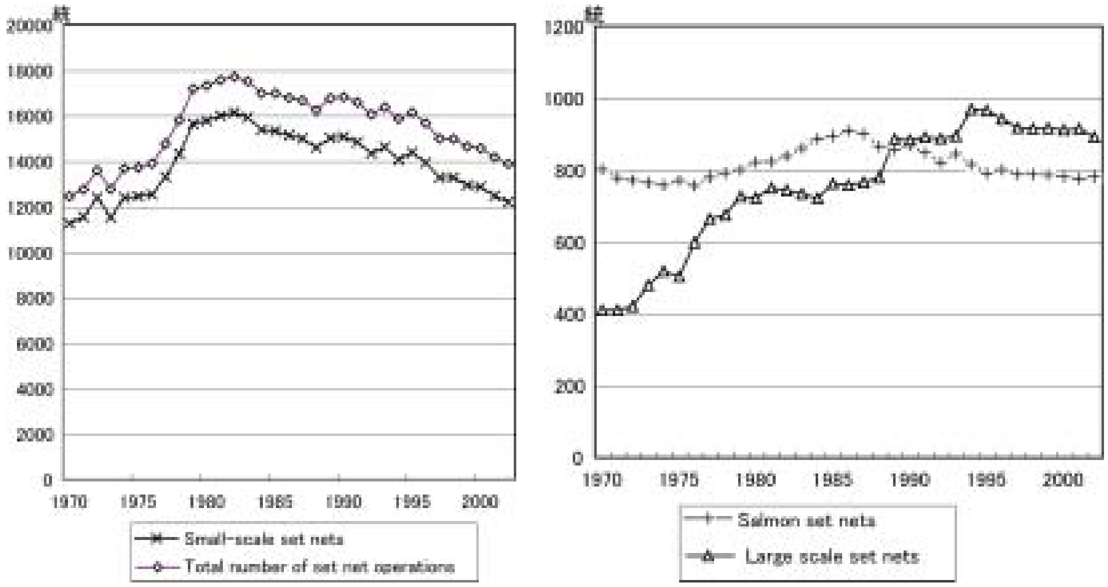

Fig. 3. Changes in the number of set net operations along the coast of Japan from 1970 to 2002 (Statistics and Information Division of the Ministry of Agriculture, Forestry and Fisheries 1972-1973, Statistics and Information Division of the Ministry of Agriculture, Forestry and Fisheries 1974-2003, Statistics Division of the Ministry of Agriculture, Forestry and Fisheries 2004)

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4. Whale Shark
(*Rhincodon typus*)

Fisheries and other issues relevant to this species

There are no directed fisheries for whale shark in Japan. A considerable number of this species is believed to be caught incidentally in set nets, but these sharks are usually either released or discarded as they have no commercial value. This species is seldom landed in the market. Incidental catch by set nets occurs primarily in the area between the main island of Okinawa and the Pacific coasts of Kyushu and Shikoku (Uchida 1995).

The IUCN (the World Conservation Union) has classified the whale shark as a vulnerable on the grounds that historical fishing effort targeting this species has resulted in reduced catches and population declines; its reproductive rate is low; and there is a possibility of future population declines due to continuing directed fisheries and incidental catch. At CITES COP11 in 2000, the United States proposed listing of whale shark in Appendix II, but the proposal was rejected. At COP12 in 2002, India, the Philippines and Madagascar tabled a joint proposal for listing this species on Appendix II. This was adopted as a result of voting.

Biological characteristics

Distribution
The whale shark is distributed in tropical and temperate zones throughout the world, and migrates through pelagic and coastal waters. This species is distributed generally in the zone between 35 degrees S and 30 degrees N centering on the equator, and occurs in higher latitudinal areas according to the movements of warm currents (Fig.1). Some examples include summer-time occurrences in the area off Hokkaido in the Western Pacific (43 degrees N) and in the area off New England in the Western Atlantic (42 degrees N). It has been determined that this species' movements are related to optimum water temperature and prey availability (Iwasaki 1970, Clark 1992), but the range over which it migrates and its preferred water depth are not well understood. In recent years, attempts have been made to clarify the migration route of whale sharks using satellite tracking, and it was determined that individuals released off Baja, California migrated to the equatorial zone of the Western Pacific after 10 months (Eckert and Stewart 2001).

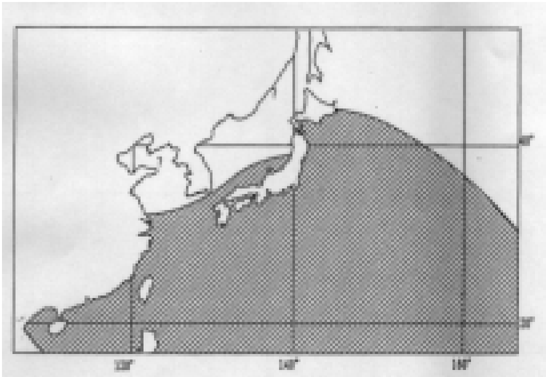
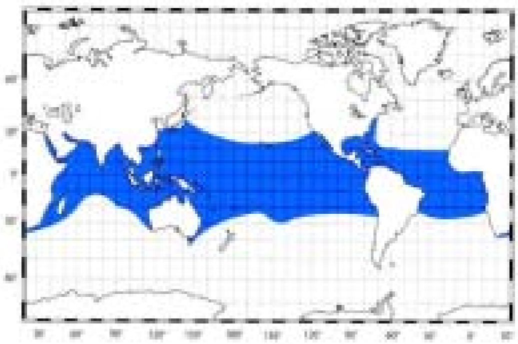

Fig. 1. Distribution of whale sharks around Japan and worldwide (Uchida 1995, Last and Stevens 1994)

Little or no knowledge is available on stock structure of whale sharks. As this species is distributed from tropical to temperate zones, it is assumed that the Atlantic stock is separate from the Pacific/Indian Ocean stock. However, it is not known whether subpopulations occur in particular geographic regions of any of these ocean basins.. As east-west movement over long range of periods has been documented in the Pacific, if there are separate stocks there may be interaction between them. The relationship between Pacific and Indian Ocean populations also remains to be clarified.

Spawning and migration

Information on breeding of whale sharks was unknown for many years. But, in 1995, a female of 11m caught in Chinese Taipei was found to be pregnant, and had a total of 300 foetuses and eggshells in both uteruses. One of these foetuses survived 143 days in an aquarium in Japan. This confirmed that the whale shark is oviparous. Small individuals of this species are between 55 and 93 cm in length, but only nine individuals of this size have been reported worldwide. Thus, the size at birth may be within this range, but this has not been verified (Joung et al. 1996).

Growth and sexual maturity

Although this species is said to be the largest fish in the world, and there are records claiming lengths of 17-18 m and 21.4 m, the actual maximum length is not clear. A value 13.7 m is often given as the maximum length for this species, but the most recent accurate measurements give its maximum length as 12.1m (Compagno 2001).

The annual growth rate of whale sharks in captivity (in an aquarium with a capacity of 1,100 tons) was recorded as 29.5 cm (total length after 5 years and 7 months of captivity, with a length at the time of delivery to the aquarium of 3.65 m) and 46 cm (after 1 year and 9 months of captivity, with a length at the time of delivery of 4.4 m). Growth rate in an aquarium with a capacity of 5,400 tons was 45.5 cm (after 4 years and 4 months of captivity, with a length at the time of delivery of 4.1 m) (Uchida 1995). There is another case showing an annual growth rate of 29.5 cm, but this rate is believed to have been low because the individual was in poor health during the latter half of the captive period. Based on this information, it is estimated that young whale sharks with total lengths of about 3-6 m can grow at least 45 cm in a year (Uchida 1995).

Feeding habit

The whale shark is one of 4 species of large elasmobranchs which prey on plankton (the others species being the basking shark, the megamouth shark, and the manta ray). The whale shark swims with its mouth wide open, and preys on sardines, anchovies, mackerels, small-size tunas, albacore tuna, and squid in addition to crustaceans such as copepods (Compagno 2001).

Stock status

Population trends

According to Uchida (1995), a total of 78 sharks were caught incidentally in set nets around the main island of Okinawa in the 16 years from 1979 to 1994. This represents an average of 4.9 sharks per year. The incidental catches occurred between March and September, but such catches are more common in the summer. A total of 25 sharks were caught incidentally along the Pacific coast of Shikoku in the 5 years between 1989 and 1993 for an average of 5 sharks per year. Incidental catches in this area occurred with the highest frequency in June and July.

Table 1 shows records of occurrence of the whale shark in waters adjacent to Japan, from the set net fishery, as compiled from published information from 1970 to 2002, and purse seine fishery operations involving sets on whale sharks. About 2 to 16 whale sharks stray into set nets every year. The number of operations involving sets on whale sharks in the purse seine fishery increased in the 1990s, exceeding 200 sets in 1996-1998. On the basis of both sources of information, it is believed that a considerable number of whale sharks migrate to the waters adjacent to Japan every year.

Table 1.Occurrence records for Whale sharks by year in Japanese waters. Columns show year, the sum of observations from the purse seine and set net fisheries, purse seine sets on whale sharks, occurrences in set net fisheries summarized from published information, and the source of the set net occurrence information

Year	(1)＋(2)	Operation involving incidental take of sharks(1)	Number of occurrences (2)	Places of occurrences (Prefecture)
1950	2		2	Oita, Miyagi[1)]
1951 ～1961				
1962	2		2	Nagasaki[1)], Aomori[4)]
1963 ～1969				
1970	1	1		
1971	31	31		
1972	15	13	2	Fukui[1)]、Wakayama[7)]
1973	12	10	2	Kagoshima、Niigata[1)]
1974	7	7		
1975	34	34		
1976	60	60		
1977	24	24		
1978	15	15		
1979	15	9	6	Okinawa (5)、Kyoto[1)]
1980	17	11	6	Okinawa (5)、Fukui[1)]
1981	10	5	5	Okinawa (5) [1)]
1982	24	19	5	Okinawa (5) [1)]
1983	27	21	6	Okinawa (5)、Shimane[1)]
1984	86	79	7	Okinawa (5)、Kyoto、Ishikawa[1)]
1985	50	42	8	Okinawa (5)、Ishikawa、Niigata、Shizuoka[1)]
1986	74	65	9	Okinawa (5)、Kyoto (2)、Fukui、Ishikawa[1)]
1987	107	102	5	Okinawa (5) [1)]
1988	49	44	5	Okinawa (5) [1)]
1989	45	34	11	Okinawa (5)、Shikoku Pacific coast (5)、Kagoshima[1)]
1990	45	35	10	Okinawa (5)、Shikoku Pacific coast (5) [1)]
1991	69	53	16	Okinawa (5)、Shikoku Pacific coast (5)、Tokushima、Wakayama (2)、Chiba、Kyoto、Saga[1)]
1992	43	33	10	Okinawa (5)、Shikoku Pacific coast (5) [1)]
1993	172	153	19	Okinawa (10) [6)]、Shikoku Pacific coast (5) [1)]、Ishikawa(4)[8)]
1994	101	92	9	Okinawa (5)、Ishikawa[1)]、Kochi (3) [5)]
1995	180	171	9	Kochi (9) [5)]
1996	218	214	4	Okinawa (4) [6)]
1997	231	219	12	Kagoshima (5) [3)]、Kochi (4) [5)]、Wakayama[7)]、Okinawa(2)[6)]
1998	231	229	2	Kochi[5)]、Okinawa[6)]
1999	174	172	2	Okinawa[4)]、Kochi[5)]
2000	72	56	16	Kagoshima (8) [2)]、Kochi (2) [5)]、Okinawa (6) [6)]
2001	11	n.a.	11	Kagoshima (5) [3)]、Oita、Mie[4)]、Okinawa (3) [6)]、Ishikawa[8)]
2002	8	n.a.	8	Kagoshima (6) [3)]、Aomori[4)]、Ishikawa[8)]

Sources:：
1) Uchida, S. (1995)
2) Anon 2001: Whale sharks migrating to the sea of Kagoshima Prefecture Sea near Sakurajima. Vol 4, No.13, 2001: 2-3.
3) Kagoshima Aquarium, Nakahata (pers. comm.)
4) Internet
5) Osaka Kaiyukan, Nishida (pers. comm.)
6) Global Guardian Trust(2002)
7) Global Guardian Trust(2003)
8) Global Guardian Trust(2004)

Fig.2 shows annual changes in the total number of purse seine operations in Japan's eastern coastal and near sea waters and southern fishing grounds (offshore of the Philippines), as obtained from logbooks of Japanese purse seine fishing vessels, and changes in the number of fishing operations involving sets on whale sharks (unpublished data, National Research Institute of Far Seas Fisheries). In the eastern offshore fishing ground of Japan, the number of sets on whale sharks remained in the range of 10 to 50 sets per year from 1970 to the 1980s, but it increased noticeably in the 1990s to 50-200 sets per year. This was due to the fact that northern purse seine vessels began at that time to target skipjack schools more heavily, which resulted in an increase in recorded whale shark occurrences. In the southern fishing ground, whale shark sets consistently numbered between 20-100 per year during the period from 1980 to the 1990s. To what extent these data represent the occurrence frequency of whale sharks is now being discussed, but, for the time being there has been no sign that this frequency is declining with time.

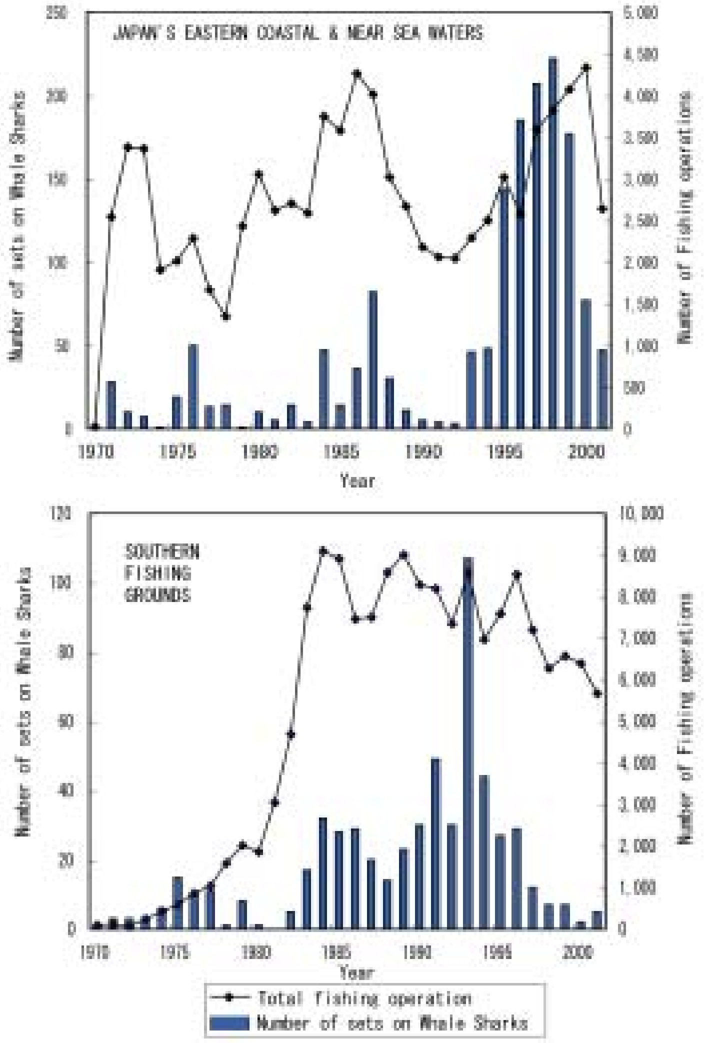

Fig. 2. Annual changes in the total number of purse seine operations in Japan's eastern coastal and near sea waters and southern fishing grounds (offshore of the Philippines), as obtained from logbooks of Japanese purse seine fishing vessels, and changes in the number of fishing operations involving sets on whale sharks.

Trends in fishing pressures

As there are no fisheries targeting whale sharks, this discussion assumes that the greatest number of incidental catches occur in set net fisheries (Fig.3). Over the past 30 years, the number of large-scale set nets increased from 800 to 900 in the 1980s, but fell again to around 800 in the 1990s. The number of small set nets reached 16,000 in the first half of the 1980s, and then fell to about 12,900 in 2000. The number of salmon set nets increased during this period from approximately 400 to 900. The total of the 3 types of set nets was about 12,000 in 1970 but reached a peak of about 18,000 in the first half of the 1980s. Subsequently, total set net operations gradually decreased to about 14,500 in 2000. It is not clear to what extent these set nets constitute fishing pressure on whale sharks. If they do exert fishing pressures, it is assumed that such pressures gradually declined from the 1980s to 1990s.

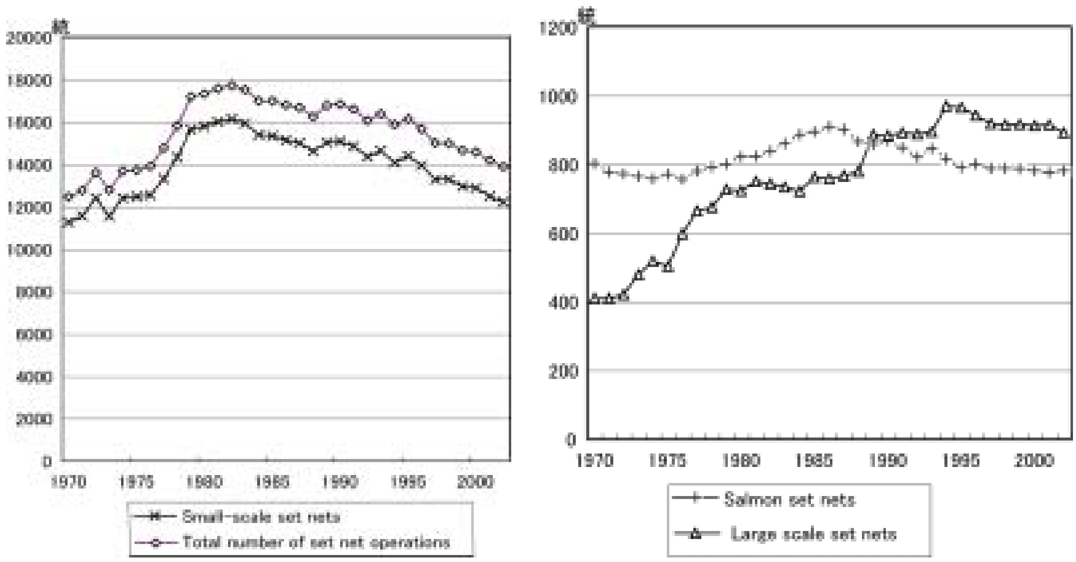

Fig. 3. Changes in the number of set net operations along the coast of Japan from 1970 to 2002
(Statistics and Information Division of the Ministry of Agriculture, Forestry and Fisheries 1972-1973, the Statistics and Information Division of the Ministry of Agriculture, Forestry and Fisheries 1974-2003, Statistics Division of the Ministry of Agriculture, Forestry and Fisheries 2004)

Management measures

As there are no fisheries targeting whale shark, no active fishing takes place. However, because commercial fisheries for whale shark exist in neighboring countries (Chinese Taipei, Philippines, etc.), there is a need for Japan to monitor the situation of these species with caution.

There is no system in place in Japan to systematically collect information on this species when caught incidentally in set net fisheries. As a result, there is very little knowledge concerning the incidental catch of this species. In order to implement stock assessment and conservation measures, there is an urgent need to establish an information collection system for this species.

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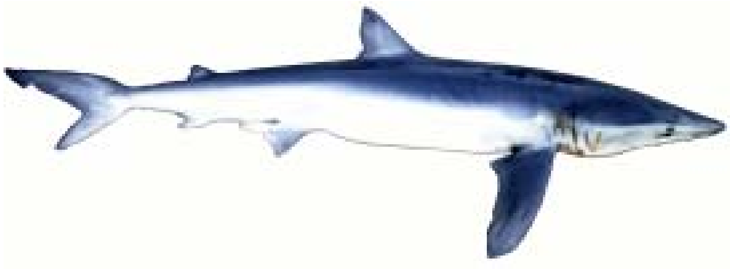
5. Blue Shark
(*Prionace glauca*)



Overview of the fishery

The blue shark occurs in both tropical and temperate zones throughout the world, and is considered to have the highest stock abundance among pelagic sharks. It is caught incidentally in large numbers by tuna longline fisheries. However, the blue shark is not a major target species for these fisheries. Except for the coastal areas and fishing grounds off Northern Japan, where the commercial value of the species is high, blue sharks caught incidentally in distant-water areas are either landed at foreign ports near the fishing ground or discarded alive or dead. Landings in Japan mainly occur at Kesennuma, and this species' meat, fins, vertebra, and skin are used for food and handicrafts. Table 1 shows the amount of sharks landed by tuna longline fisheries, based on the "Annual Report on Fisheries and Aquaculture Production Statistics" (Agriculture, Forestry and Fisheries Statistics) published by the Statistics Department of the Ministry of Agriculture, Forestry and Fisheries. According to these statistics, tuna longline fisheries since 1971 are classified into 3 categories, distant-water, near-shore and coastal. The total catch of blue shark by these fleets varied between 13,000 and 30,000 mt per year. Annual catches were declining until the latter half of the 1990s, but an increasing trend has been observed in recent years. The species composition of these catches is not known with certainty, but it is estimated that blue sharks account for about 70-80% of the total (Nakano 1996).

Landed weight by species at major fishing ports used by tuna longline fisheries was studied under the Survey Project for Bluefin Tuna around Japan (fiscal year 1992-1996) and the Survey Project for Highly Migratory Fish Species around Japan (beginning in fiscal year 1997) both sponsored by the Japan Fisheries Agency. According to the results of these surveys, landings of blue shark totaled 10,500-16,000 mt per year (average: 13,200 mt per year) for the period 1992-2003, with a slight increase observed in recent years and the percentage of blue shark as high as 69-76% of the total landings of sharks (Fig.1). Nearly 95% of blue sharks are caught by longline fisheries.

Table 1. Catches of sharks by tuna longline fisheries reported in the Agriculture, Forestry and Fisheries Statistics (mt)

Year	Distant Water	Near Shore	Coastal	Total
1971	10,782	16,698	1,833	29,313
1972	8,588	14,207	1,992	24,787
1973	9,219	13,878	2,316	25,413
1974	6,866	13,054	2,357	22,277
1975	7,898	14,389	1,325	23,612
1976	7,142	14,167	2,615	23,924
1977	6,590	16,352	2,321	25,263
1978	7,718	13,189	3,116	24,023
1979	8,211	17,025	2,832	28,068
1980	8,811	18,639	2,242	29,692
1981	8,716	13,623	2,237	24,576
1982	8,090	12,567	1,713	22,370
1983	9,496	14,025	749	24,270
1984	9,009	11,871	2,336	23,216
1985	8,042	12,341	2,524	22,907
1986	7,750	13,952	2,116	23,818
1987	8,676	11,506	2,302	22,484
1988	10,240	10,884	2,115	23,239
1989	6,565	8,211	1,863	16,639
1990	4,387	8,293	1,838	14,518
1991	5,940	10,139	1,680	17,759
1992	7,130	10,753	1,719	19,602
1993	6,960	10,882	1,812	19,654
1994	5,625	8,207	2,052	15,884
1995	2,947	8,054	1,683	12,684
1996	3,093	9,143	1,954	14,190
1997	3,258	10,844	2,128	16,230
1998	7,720	9,089	2,551	19,360
1999	8,649	9,011	2,345	20,005
2000	6,897	7,782	2,031	16,710
2001	6,947	9,907	2,633	19,487
2002	9,909	11,711	2,007	23,627

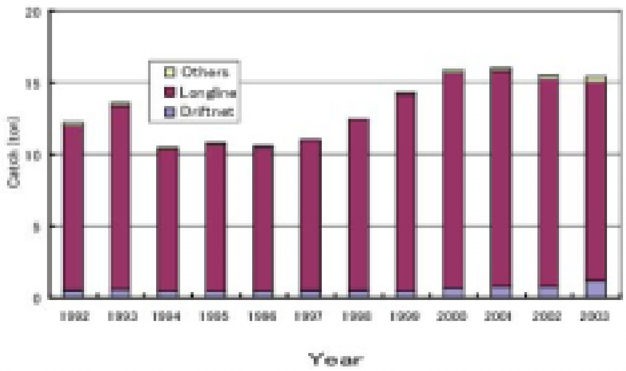


Fig. 1. Landings of blue shark at major fishing ports in Japan.

Biological characteristics

Distribution

This species is extensively distributed in coastal and pelagic areas of tropical and temperate zones in the southern and northern Pacific, the southern and northern Atlantic, and the Indian Ocean (Fig.2, Compagno 1984). Blue shark abundance in the temperate zone is particularly high, suggesting that this is its main range (Nakano 1996). Little or no information is available on the state of the stock.

Nevertheless, since the breeding periods are reversed in the southern and northern hemispheres, it is reasonable to assume separate stocks exist in the southern and northern Pacific and in the southern and northern Atlantic. This species description assumes there are five stocks: these four, plus a fifth stock in the Indian Ocean. However, there is a possibility of exchange between southern and northern populations because tagged individuals have been recaptured on the opposite side of the equator (Casey et al. 1989). Furthermore, considering the possibility of a continuous distribution in the southern hemisphere, the existence of a single stock in these waters cannot be ruled out.

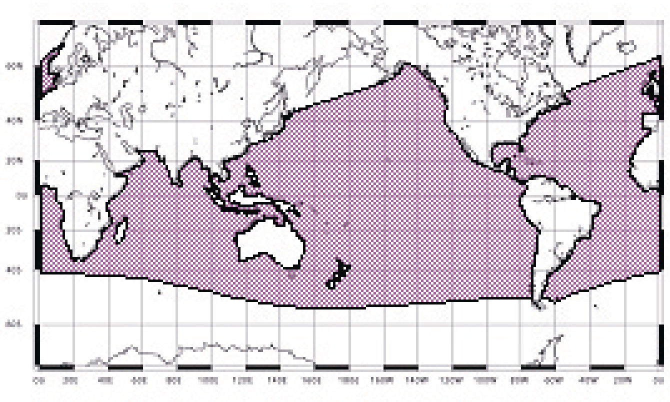


Fig. 2. Distribution of blue sharks (Compagno 1984).

Spawning and migration
The breeding pattern of this species is viviparity and yolk sac placenta, and the average number of juveniles produced per pregnancy is 25.6, with a range of 1-135 (Nakano 1994, Gubanov and Grigor'fyev 1975). The body length at birth (precaudal length) is 30-43 cm (Nakano 1994). A migration model has been proposed for the North Pacific (Nakano 1994) which suggests that this species mates in the area around 20 degrees N in early summer, and females give birth in the area north of 30 degrees N after one year of gestation. Juveniles remain in a nursery area at the subarctic boundary around 40 degrees N, and move to the temperate zone after reaching sexual maturity.

Growth and sexual maturity
Age is estimated from rings formed in the vertebrae, and based on the results of vertebral analysis, Cailliet and Bedford (1983), Tanaka (1984), and Nakano (1994) have reported growth formulae by sex for the Pacific. Differences in growth between the sexes have been observed, with males growing faster and to a larger size than females. Length at sexual maturity is 140-160 cm for both males and females in the North Pacific (Suda 1953, Nakano 1994). In the North Atlantic, it is reported that length at sexual maturity is about 165 cm for females and 160 cm for males (Pratt 1979). When these length estimates are converted to age, they represent 6 years of age for females and 5 years of age for males. Blue shark life span is estimated at 20 years or more (Compagno 1984).

The growth formulae obtained in the North Pacific are shown below:

Females, Total Length: $L_t = 241.9(1 - e^{-0.251(t-(-0.795))})$ (Cailliet and Bedford 1983)

Males, Total Length: $L_t = 295.3(1 - e^{-0.175(t-(-1.113))})$ (Cailliet and Bedford 1983)

Females, Precaudal Length: $L_t = 256.1(1 - e^{-0.116(t-(-1.306))})$ (Tanaka 1984)

Males, Precaudal Length: $L_t = 308.2(1 - e^{-0.094(t-(-0.993))})$ (Tanaka 1984)

Females, Precaudal Length: $L_t = 243.3(1 - e^{-0.144(t-(-0.849))})$ (Nakano 1994)

Males, Precaudal Length: $L_t = 289.7(1 - e^{-0.129(t-(-0.756))})$ (Nakano 1994)

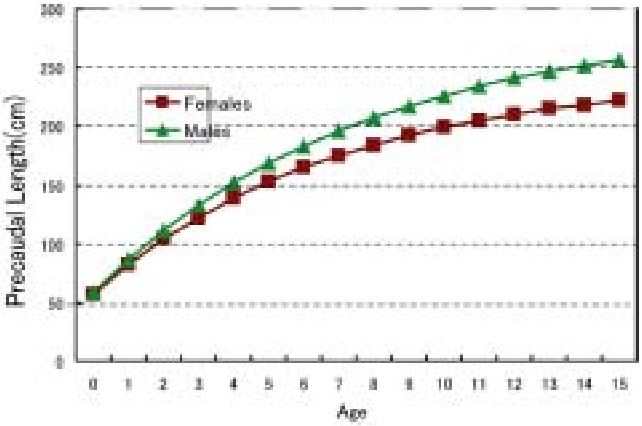


Fig. 3. Age and growth of blue sharks (Nakano 1994).

Table 2. Age and growth of blue shark based on precaudal length in cm (Nakano 1994).

Age	Females	Males
0	57	59
1	82	87
2	104	111
3	122	133
4	139	152
5	153	169
6	165	183
7	175	196
8	184	207
9	192	217
10	199	226
11	205	234
12	210	241
13	215	247
14	218	252
15	222	256

Feeding habit and predators

The main prey species of the blue shark are highly productive pelagic fishes, tunas, squid and octopus (Kawasaki et al. 1962, Taniuchi 1984, Strasburg 1958). This species consumes different prey depending on area and growth stage, but it is not known to be particularly selective in feeding, showing opportunistic feeding habits based on readily available species abundantly distributed in its habitat. Whether there are any predators on adult blue sharks is not known, but predation on juvenile sharks by larger sharks and marine mammals is possible (Nakano and Seki

2003).

Stock status

Population trends

Nakano and Honma (1996) analyzed logbooks from tuna longline fishing vessels, and showed that there is a relationship between species composition and reporting rate of incidental catches (the percentage of sets for which sharks were reported). According to their analysis, logbooks with reporting rates of 70% or greater can be used as an indicator of catch per unit effort (CPUE, expressed as the number of fish caught per 1000 hooks) for blue shark. Subsequently, data from logbooks with reporting rates of 70% or more were extracted from Japanese tuna longline fleet records for 1971-2001, and the CPUE of blue shark, standardized by means of a Generalized Linear Model (GLM), was calculated. As a result, in the North and South Pacific, standardized CPUE of blue shark showed moderate increases and decreases, but no major changes. In fact, in the North Pacific, a trend of slightly increasing CPUE has been observed in recent years (Fig.4).

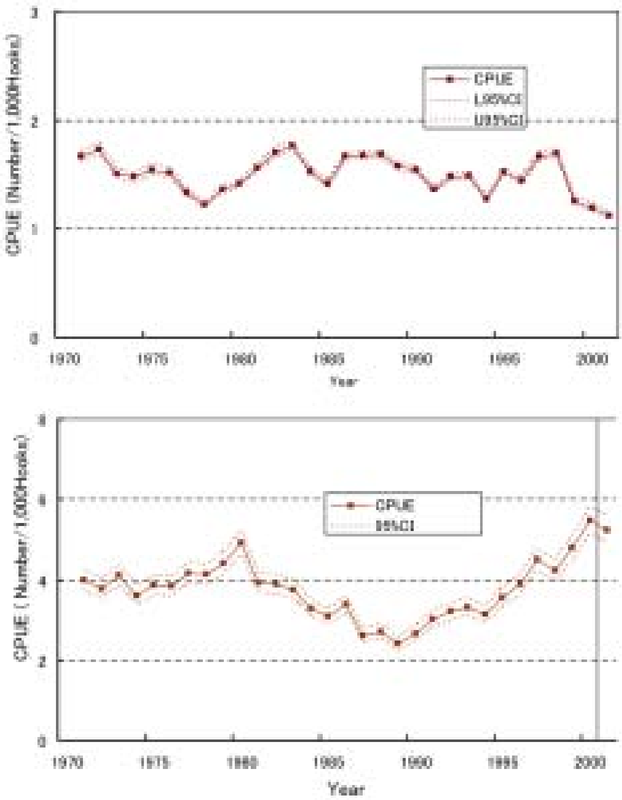


Fig. 4. Standardized CPUE of blue sharks in the North (upper chart) and South (lower chart) Pacific.

In addition to these analyses, Kleiber et al. (2001) estimated total catches of blue shark for each nation fishing in the North Pacific, and the proportion of this catch relative to maximum sustainable yield (MSY). As a result, they reported that the current catch is about one quarter to one half of the MSY estimated by the model, and that major decreases or other drastic changes in the blue shark population are not likely at the present time.

Regarding stock status in the North and South Atlantic, standardized CPUE has been calculated based on logbooks from tuna longline fishing vessels from Japan, the United States, and Chinese Taipei (ICCAT 2004, Nakano and Clarke 2004, Brooks et al. 2004, Liu et al. 2004). As shown in Fig.5, moderate changes were observed in all cases, including the North Pacific, with no significantly changing trend. (The fluctuations in the South Atlantic in 1977-1980 are considered to arise from to the low number of data points available for analysis.). Stock assessment was attempted using various models, and most results for both the North and South Atlantic showed that the current population level is greater than the population level needed to generate MSY (ICCAT 2004). Furthermore, total catches were estimated using data filtered by reporting rates from the Japanese logbooks (Matsunaga and Nakano 2004b). It was estimated that 110,000 to 330,000 (average: approximately 200,000) blue sharks representing 4,200 to 12,700 mt (average: 7,600 mt) have been harvested by Japanese longline fishing vessels each year from 1994 to 2003.

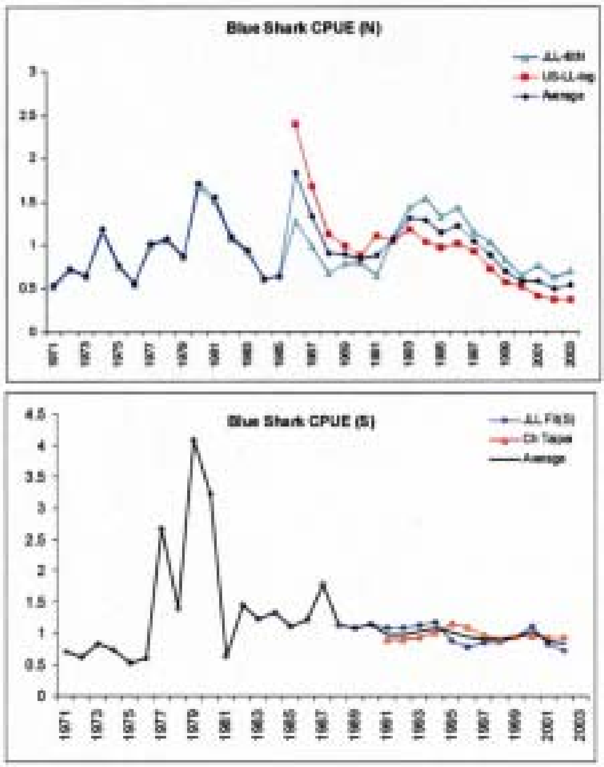


Fig. 5. Standardized CPUE of blue sharks in the Atlantic (upper: North Atlantic, lower: South Atlantic, JLL: Japan, US: the United States).

With regard to the Indian Ocean stock, annual changes in standardized CPUE were obtained from logbooks of Japanese tuna longline fishing vessels as well as shark incidental catch data collected by scientific observer surveys in the southern bluefin tuna fishing ground off South Africa and Australia (Matsunaga and Nakano 2004a). In all cases, a pattern of fluctuating CPUE was observed as in the case of other blue shark stocks (Fig.6). The reason for the differences between the patterns produced by the two data sources are believed to be due to the fact that the logbooks represent CPUE for the entire population including young fish whereas the observer data represents CPUE for mainly young fish. Summarizing the above results, no significant increase or decrease was observed in the CPUE of blue sharks in any stock for the approximately 30 year period between 1971 to 2003. Therefore, it is assumed that blue shark populations have remained stable during this period.

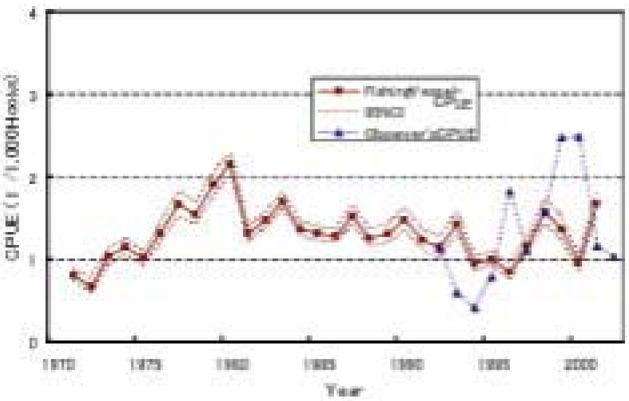


Fig. 6. Standardized CPUE of blue sharks in the Indian Ocean.

Trends in fishing effort

Fig. 7 shows the fishing effort (in number of hooks) by Japanese tuna longline vessels by ocean and for the three oceans in total (unpublished data, National Research Institute of Far Seas Fisheries). Fishing effort for Japanese vessels in total increased from 116 million hooks in 1952 to over 400 million hooks in 1962. Fishing effort remained between 400 million and 470 million hooks until 1978. Later, and until 1991, it rose to a level of 500 to 560 million hooks, but declined since 1992, falling below 400 million hooks in 1999 and 2000.

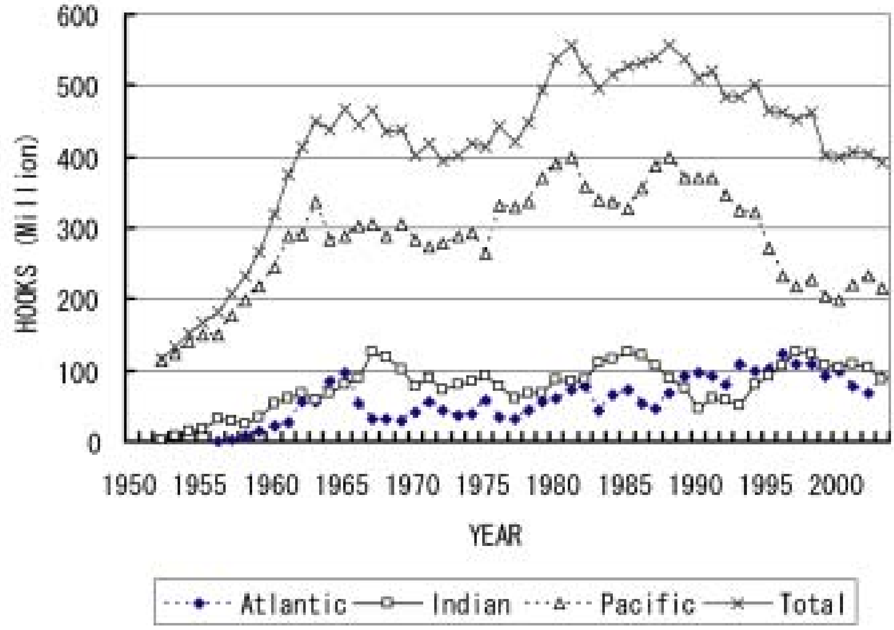


Fig. 7. Fishing effort by Japanese tuna longline fisheries by ocean and in total.

When we examine the changes in fishing effort by ocean, effort in the Pacific increased to between 110 and 300 million hooks in 1952-1962, and leveled out at around 300 million hooks by 1975. Subsequently, fishing effort increased to 320 to 400 million hooks in 1976-1994, but continuously declined for 6 years from 1995 to 2000, dropping below 200 million hooks in 2000. In the Atlantic, tuna longline operations began in 1956, and fishing effort increased to 90 million hooks by 1965, but then remained at 30 to 80 million hooks in 1966-1988. Thereafter, fishing effort increased until 1997 and stabilized at around 100 million hooks in 2000. In the Indian Ocean, fishing effort increased from 1952 to 1967, reaching 130 million hooks in 1967. From that time until 1987 fishing effort hovered around 100 million hooks (60 to 130 million hooks), and then began to decline to about 50 million hooks in the period 1990-1993, before turning upward and reaching about 100 million hooks in 2000.

Fig.8 shows the total fishing effort for tuna longline fishing vessels in the Pacific based on data from the Secretariat for the Pacific Community (SPC) aggregated for all fishing nations including Japan. Although fishing effort in the Pacific as a whole showed an increasing trend since 1995, effort by Japan substantially decreased due to the impact of vessel decommissioning programs. Overall fishing effort in the 1990s remained at a level of 600 to 700 million hooks. Effort by Japanese fishing vessels formerly accounted for more than half of the total, but at present Japan's effort comprises less than one third of the total. The increase in fishing effort is believed to be due to an increase in fishing vessels from Chinese Taipei, the Republic of Korea, and China. Furthermore, similar trends are assumed to be applicable in the Atlantic and Indian Oceans as well, indicating that as effort by Japanese fishing vessels has decreased it has been offset by the effort of fishing vessels of other countries.

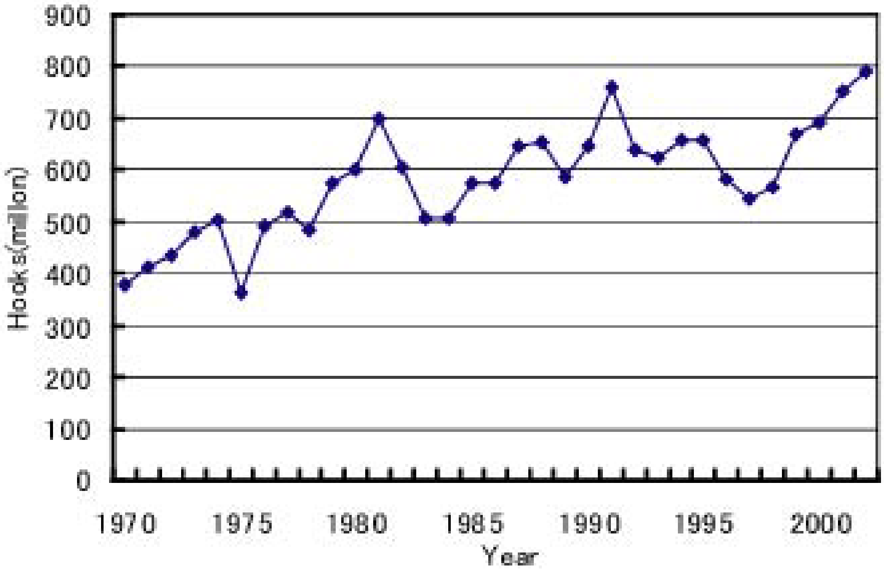


Fig. 8. Fishing effort (number of hooks) by tuna longline fisheries in the Pacific for all fishing nations including Japan (data downloaded from the SPC website).

Stock levels and trends

The stock level in the North Pacific is considered to be high based on the estimates of Kleiber et al. (2001). The status of other stocks is unknown. However, since no significant increase or decrease in CPUE has been observed during the past 30 years, it is assumed that all of the stocks remain stable.

Management measures

There are no specific recommendations for conservation and management because no conspicuous changes have been observed in stock status. Nevertheless there is a need to continue to monitor blue shark populations. Currently, the biggest problem is the absence of catch data by species for stock assessment. Recently, the Fisheries Agency revised the logbook reporting requirements for tuna longline fisheries and now requires catch recording for 6 species of sharks. However, there are cases where accurate reporting of shark catches does not occur, and it is difficult to assess the actual situation, including discard amounts by species. In order to accurately estimate shark catches by species and the quantity of discards in tuna longline fisheries, it will be necessary to promote data collection via methods which do not depend on fishermen, such as observer programs, and to develop improved means of data collection for the future.

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6. Shortfin Mako Shark
(*Isurus oxyrinchus*)

Overview of the fishery

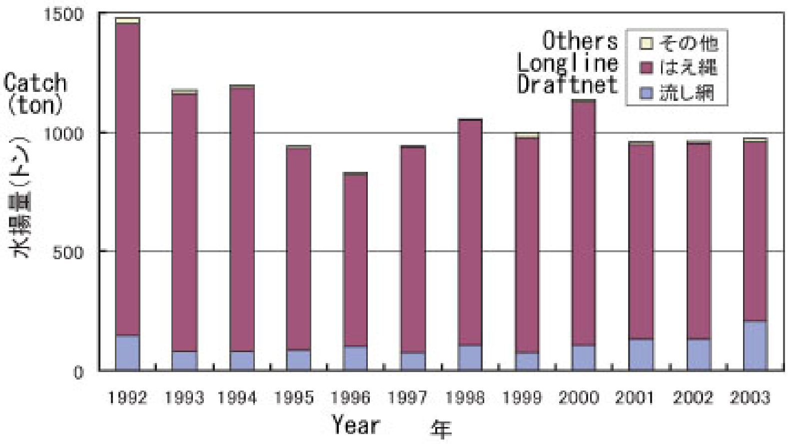

Fig. 1. Landed volume of shortfin mako shark at major fishing ports in Japan.

The shortfin mako is distributed in tropical and temperate regions throughout the world, and is commonly found in both coastal and pelagic zones. This species is caught incidentally in tuna longline fisheries and driftnet fisheries. In comparison to other sharks, it has a high commercial value and, in many cases, is landed by distant-water longline fishing vessels rather than being discarded. Therefore, unlike other species of sharks, there is believed to be no substantial difference between actual catch weights and landed weights at fishing ports. Landings mainly occur at Kesennuma in Miyagi Prefecture, and meat, fins, vertebra, and skins are used for food and handicrafts. Most of the meat is believed to be exported to western countries. Landed weight by species at major fishing ports used by tuna longline fisheries was studied under the Survey Project for Bluefin Tuna around Japan (fiscal year 1992-1996) and the Survey Project for Highly Migratory Fish Species around Japan (beginning in fiscal year 1997) both sponsored by the Japan Fisheries Agency. These surveys showed that the annual landed weight of shortfin mako sharks in Japanese fishing ports in 1992-2003 was 800 to 1,500 mt, of which landings by longline fisheries formed the majority (700 to 1,300 mt) followed by driftnet fisheries. There were no conspicuous changes in the landed weights during this period. Landings of shortfin mako sharks accounted for 5.8% of total shark landings during this period (Fig.1).

Biological characteristics

Distribution

This species is extensively distributed in coastal and pelagic areas of tropical and temperate zones throughout the world (Fig.2, Compagno 2001). Its abundance in the temperate zone is relatively high, and it is often found in the same areas as the blue shark (Nakano 1996). Almost nothing is known concerning shortfin mako stock status, but as the breeding periods are reversed in the southern and northern hemispheres, it is reasonable to assume separate stocks exist in the southern and northern Pacific and in the southern and northern Atlantic. This species description assumes there are five stocks: these four, plus a fifth stock in the Indian Ocean. However, considering the possibility of a continuous distribution in the southern hemisphere, the existence of a single stock in these waters cannot be ruled out.

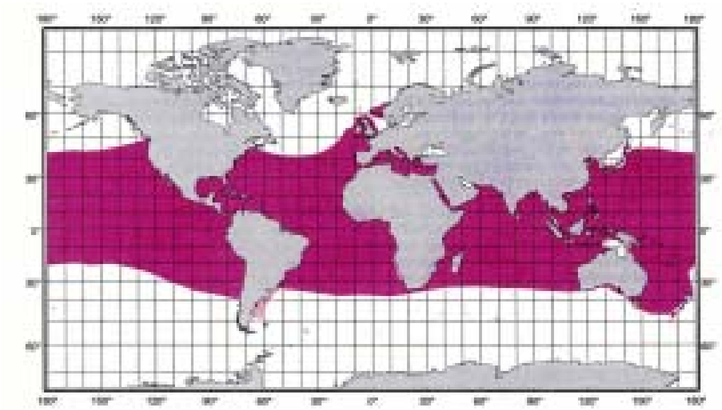

Fig. 2. Distribution of shortfin mako shark (Compagno 2001).

Spawning and migration

The breeding pattern of this species is ovoviparity (aplacental viviparity), with embryos feeding on other ova produced by the mother (oophagy) after the yolk sac is absorbed. The range in the number of juveniles produced per pregancy is 4 to 16, and the body length at the time of birth is approximately 70 cm (Stevens 1983). There is little available information on migration, but it is believed that a nursery ground for juveniles exists near the subarctic boundary of the North Pacific (Nakano 1996). Although the times and locations of mating and parturition are not well understood, the parturition period is known to be from late winter to mid-summer (Compagno 2001).

Growth and sexual maturity

Age can be estimated from rings formed in the vertebra, and results reported by Cailliet and Bedford (1983) and Senba (2003) for the Pacific, and by Pratt and Casey (1983) for the Atlantic, are summarized in the following growth formulae:

Males and Females, Total Length: $L_t = 321.0(1 - e^{-0.072(t-(-3.75))})$ (Cailliet and Bedford 1983)

Females, Precaudal Length: $L_t = 332.20(1 - e^{-0.075(t-(-3.22))})$ (Senba 2003)

Males, Precaudal Length: $L_t = 273.64(1 - e^{-0.017(t-(-2.80))})$ (Senba 2003)

Females, Fork Length: $L_t = 345.0(1 - e^{-0.203(t-(-1.00))})$ (Pratt and Casey 1983)

Males, Fork Length: $L_t = 302.20(1 - e^{-0.266(t-(-1.00))})$ (Pratt and Casey 1983)

It is reported that females attain sexual maturity at a length of about 280 cm, and males at about 195 cm (Stevens 1983). The age of sexual maturity is estimated at 7.8 years. The maximum age for this species is not clear, but it is believed to be 18 years or longer (Cailliet and Bedford 1983).

Table1. Age and precaudal length(cm) of shortfin mako shark(Senba 2003)

Age	Females	Males
0	71	71
1	90	91
2	107	110
3	123	126
4	138	141
5	152	155
6	165	167
7	177	177
8	188	187
9	199	196
10	208	204
11	217	211
12	225	217
13	233	223
14	240	228
15	247	233

Feeding habit and predators

This species mainly feeds on tunas, skipjack and squids (Kawasaki et al. 1962, Taniuchi 1984, Strasburg 1958). It consumes different prey depending on area and growth stage, but it is not known to be particularly selective in feeding, showing opportunistic feeding habits based on readily available species abundantly distributed in its habitat. Whether there are any predators on adult shortfin makos is not known, but predation on juveniles by great white sharks has been documented (Compagno 2001).

Stock status

Population trends

With regard to the North Pacific stock, incidental catch data for sharks collected during tuna longline surveys carried out by prefectural government training and research vessels and national research vessels were analyzed. Population trends were determined by standardizing the annual changes in CPUE (catch per unit effort, expressed as the number of fish caught per 1000 hooks) by excluding the impact of such factors as season, area and fishing gear, and producing a stock abundance index, by means of a generalized linear model (GLM),. As a result, with respect to the trend from 1992 to 2001, it was shown that CPUE of the shortfin mako declined until 1996, but began to recover in subsequent years (Fig.4, red dashed line).

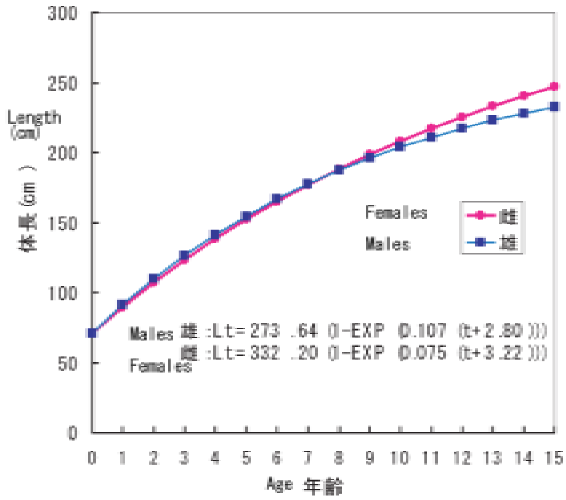

Fig. 3. Age and growth of shortfin mako shark (Senba 2003).

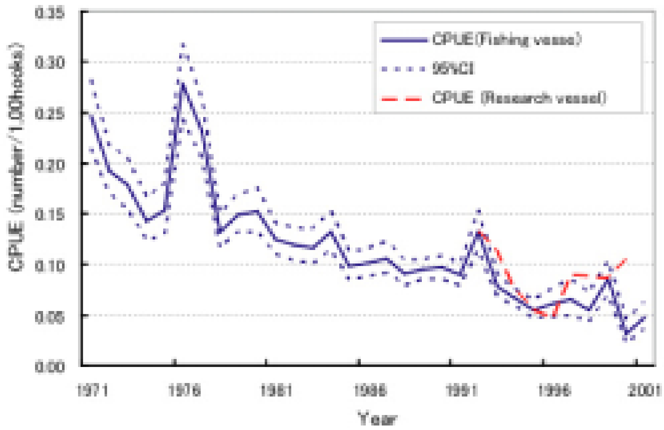

Fig. 4. Standardized CPUE of shortfin mako shark in the North Pacific.

Using a different approach, Nakano and Honma (1996) analyzed logbooks from tuna longline fishing vessels, and showed that there is a relationship between species composition and reporting rate of incidental catches (the percentage of sets for which sharks were reported). Therefore, logbooks with reporting rates of less than 40% (but greater than 0%) can provide an indicator of CPUE for shortfin mako sharks. Data from tuna longline fishing vessel logbooks in the North Pacific with reporting rates of less than 40% were extracted for 1971-2001, and standardized CPUE for shortfin mako shark was calculated. As a result, a declining trend was recognized. (Fig.4, blue solid line). However, the trends obtained from these two data sources are somewhat different. This may be explained on the basis of different operational areas, with the former operating in an area where there are mainly adult fish, and the latter catching both adult and immature fish and thus representing CPUE of the entire population (Senba 2003).

Regarding southern and northern Atlantic stocks, standardized CPUE was calculated using logbook data from Japan and United States tuna longline fishing vessels (ICCAT 2004, Senba and Takeuchi 2004, Brooks et al. 2004). As in the case of the North Pacific, gradual, long-term declines were observed for both the North and South Atlantic (Fig.5), but the magnitude of the declining trend in the South

Atlantic was small. As in the Pacific analysis, catches by Japanese longline fishing vessels in the Atlantic were estimated using data selected by logbook reporting rate (Matsunaga and Nakano 2004b). According to these calculations, it was estimated that 3,000 to 41,800 (average: 16,900 sharks) or 170 to 2,200 (average: 920) mt of shortfin mako were caught between 1994 and 2003.

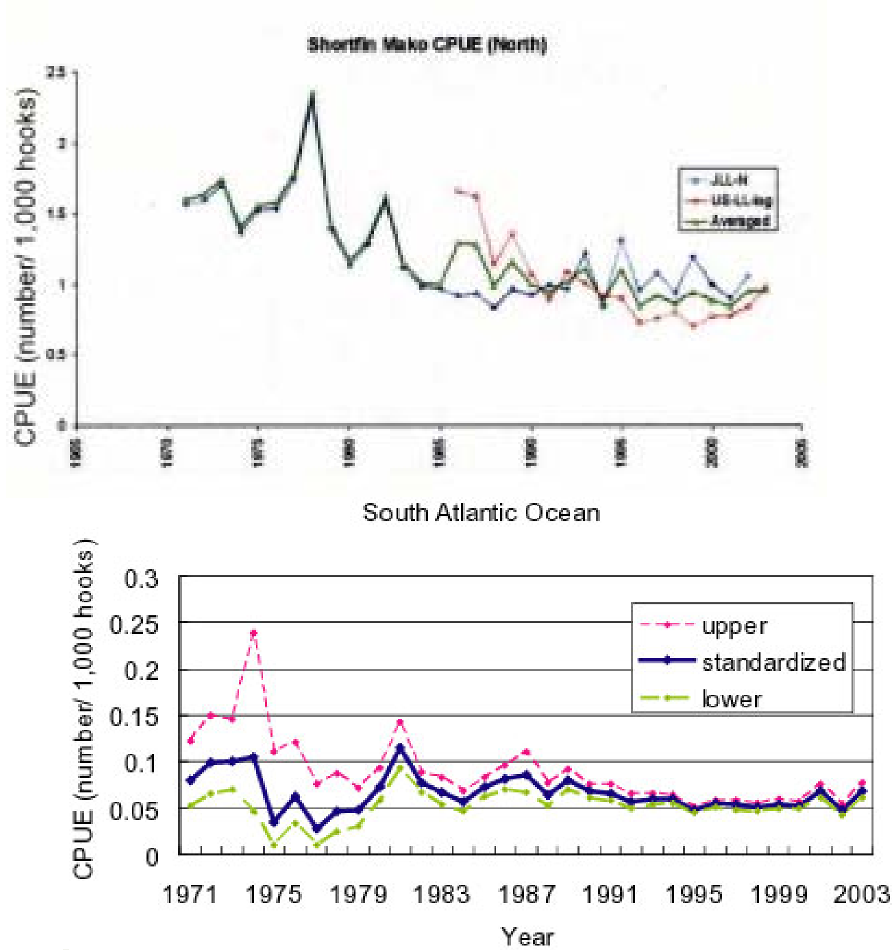

Fig. 5. Standardized CPUE of shortfin mako shark in the Atlantic (upper: North Atlantic, lower: the South Atlantic, JLL: Japan, US: the United States).

Regarding the Indian Ocean stock, annual changes in CPUE standardized by means of a GLM have been calculated using shark incidental catch data collected by observers in the areas off South Africa and Australia as well as in the southern bluefin tuna fishing ground. As shown in Fig.6, no conspicuous increase or decrease in CPUE was recognized during the 11 years from 1992 to 2002 (Matsunaga and Nakano 2004a).

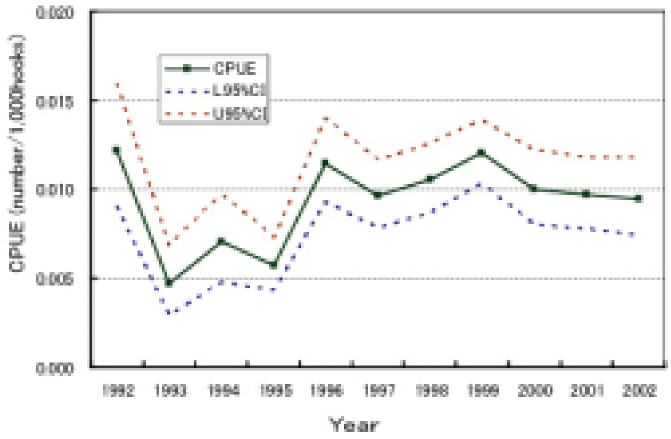

Fig. 6. Standardized CPUE of shortfin mako shark in the southern bluefin tuna fishing grounds.

To summarize the above results, no apparent increases or decreases were observed in standardized CPUE for landed weights of shortfin mako at fishing ports in Japan and in the North Pacific and southern bluefin tuna fishing grounds from 1992 to 2001. Therefore, it is assumed that the shortfin mako shark population has been stable in the two areas over the past 11 years. However, as a long-term trend, declines in CPUE were observed in the North Pacific and the North and South Atlantic over a 30 year period from 1970 to 2000, therefore it is necessary to carefully monitor the population trend.

Trends in fishing effort

Fig. 7 shows the fishing effort (in number of hooks) by Japanese tuna longline vessels by ocean and for the three oceans in total (unpublished data, National Research Institute of Far Seas Fisheries). Fishing effort for Japanese vessels in total increased from 116 million hooks in 1952 to over 400 million hooks in 1962. Fishing effort remained between 400 million and 470 million hooks until 1978. Later, and until 1991, it rose to a level of 500 to 560 million hooks, but declined since 1992, falling below 400 million hooks in 1999 and 2000.

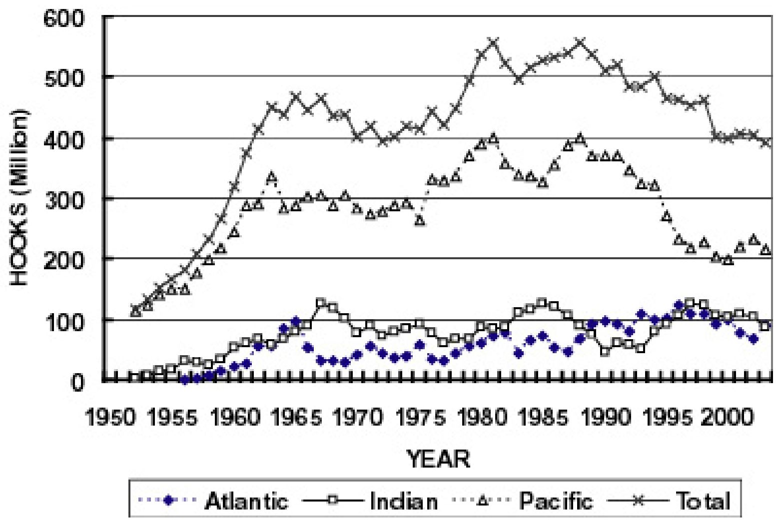

Fig. 7. Fishing effort by Japanese tuna longline fisheries by ocean and in total.

When we examine the changes in fishing effort by ocean, effort in the Pacific increased to between 110 and 300 million hooks in 1952-1962, and leveled out at around 300 million hooks by 1975. Subsequently, fishing effort increased to 320 to 400 million hooks in 1976-1994, but continuously declined for 6 years from 1995 to 2000, dropping below 200 million hooks in 2000. In the Atlantic, tuna longline operations began in 1956, and fishing effort increased to 90 million hooks by 1965, but then remained at 30 to 80 million hooks in 1966-1988. Thereafter, fishing effort increased until 1997 and stabilized at around 100 million hooks in 2000. In the Indian Ocean, fishing effort increased from 1952 to 1967, reaching 130 million hooks in 1967. From that time until 1987 fishing effort hovered around 100 million hooks (60 to 130 million hooks), and then began to decline to about 50 million hooks in the period 1990-1993, before turning upward and reaching about 100 million hooks in 2000.

Fig.8 shows the total fishing effort for tuna longline fishing vessels in the Pacific based on data from the Secretariat for the Pacific Community (SPC) aggregated for all fishing nations including Japan. Although fishing effort in the Pacific as a whole showed an increasing trend since 1995, effort by Japan substantially decreased due to the impact of vessel decommissioning programs. Overall fishing effort in the 1990s remained at a level of 600 to 700 million hooks. Effort by Japanese fishing vessels formerly accounted for more than half of the total, but at present Japan's effort comprises less than one third of the total. The increase in fishing effort is believed to be due to an increase in fishing vessels from Chinese Taipei, the Republic of Korea, and China. Furthermore, similar trends are assumed to be applicable in the Atlantic and Indian Oceans as well, indicating that as effort by Japanese fishing vessels has decreased it has been offset by the effort of fishing vessels of other countries.

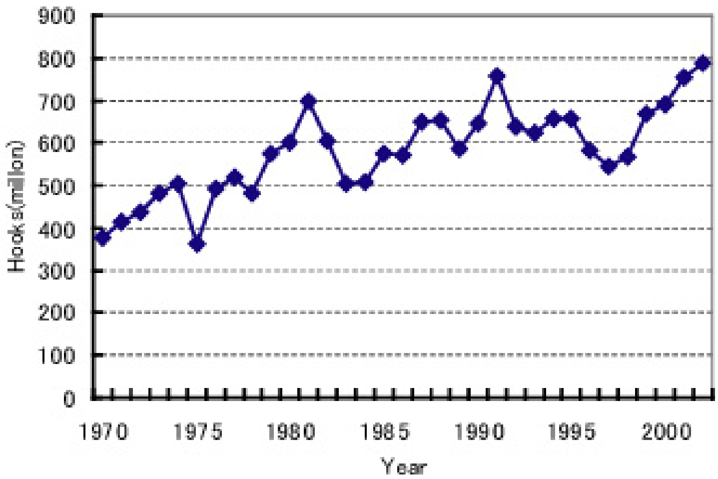

Fig. 8. Fishing effort (number of hooks) by tuna longline fisheries in the Pacific for all fishing nations including Japan (data downloaded from the SPC website)

Stock levels and trends

The stock condition is not clear for any of the stocks. The stock trend, however, is believed to be in decline because of estimated declining trends in the North Pacific and the North and South Atlantic during the past 30 years. The trend in the Indian Ocean is considered to be stable.

Management measures

Examination of an extended time series from 1970 to 2000 has shown declines in CPUE in the North Pacific and the Atlantic. Therefore, it is necessary to carefully monitor the population trend. There is a possibility that catch regulations may have to be implemented for the conservation of sharks in the future. However, the biggest problem is the absence of catch data by species for stock assessment. Recently, the Fisheries Agency revised the logbook reporting requirements for tuna longline fisheries and now requires catch recording for 6 species of sharks. However, there are cases where accurate reporting of shark catches does not occur, and it is difficult to assess the actual situation, including discard amounts by species. In order to accurately estimate the shark catches by species and the quantity of discards in tuna longline fisheries, it will be necessary to improve data collection methods in the future, including promoting fishery-independent data collection programs, such as observer programs.

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7. Spiny Dog Fish
(*Squalus acanthias*)

Overview of the fishery

The spiny dog fish is believed to have been harvested on both the Pacific and Sea of Japan sides of northern Japan since olden times. However, it was only since the the beginning of the 20th century that this species attracted the attention of fishermen as a target species. In Hokkaido, Aomori, Akita, and Ishikawa prefectures, a spiny dog fish fishery was initially carried out concurrently with bottom longline targeting of Pacific cod and halibut. In later years (1912-1926), a spiny dog fish fishery developed temporarily in response to a rise in prices of fish cake, but then declined because of sharp fall in fish cake prices. This fluctuation was repeated several times. Furthermore, during this period, a bottom gillnet fishery was introduced in Hokkaido and Aomori Prefectures. In Hokkaido, this gear was widely adopted and become a major fishery, but in Aomori Prefecture many fishing vessels reverted to bottom longline fishing after 3 or 4 years (Tanabu et al. 1958).

In the late 1920s spiny dog fish began to be harvested by engine-powered bottom trawling. However, in the period before and after World War II, bottom longlining became the mainstay operation because of a lack of materials necessary to construct trawling gear. In postwar years, this species was actively harvested by engine-powered bottom trawling following the government's policy for increasing food production. As a result, catches increased rapidly, with the average annual catch in the period 1952-1955 reaching 42,000 mt (Table 1).

In recent years, this species has mainly been harvested by offshore bottom trawling, but catches have drastically declined as compared with the period before 1955. Catches in Pacific bottom trawl fisheries off Aomori and Chiba Prefectures were around 1,000 mt in the 1970s, but declined with some fluctuation to less than 500 mt in recent years. Catches in this area are highest in the Erimo Western and Shiriyazaki Areas, both of which are fished mainly by vessels from Aomori Prefecture. In the Sea of Japan, although catches of this species are only recorded in a general shark category by bottom trawlers, spiny dog fish are believed to account for a major portion of the reported catch (Minami, personal communication, December 2003). Catches in the Sea of Japan were about 1,000 mt in the 1970s, but declined to around 100 to 200 mt in recent years. As they are reported only in a general category of sharks and rays in the logbooks of offshore bottom trawling vessels in Hokkaido, catches of spiny dog fish in this area cannot be precisely identified. However, it is estimated that the catch has totaled about 10 mt in recent years (Yabuki, personal communication, December 2003). Catches in the North Pacific, including the Erimo West Area in 2003 totaled 123 mt, and in the Sea of Japan totaled 125 mt (Fig.1). These catches in the North Pacific represented the lowest reported levels since 1971.

Table 1. Catches of spiny dog fish by area for 1952-1955 (Tanabu et al.1958, revised)

Area	1952	1953	1954	1955	Average
Grand Total	59,805	35,730	40,114	32,678	42,082
Total:Hokkaido	36,439	14,070	15,326	14,228	20,016
Tohoku area	15,574	10,286	12,045	11,276	12,295
South area	3,698	2,445	1,493	1,331	2,242
West area	5,910	1,328	1,781	1,358	2,594
Total:Pacific	23,051	14,201	16,024	11,779	16,264
North area	22,916	14,070	16,024	11,771	16,195
Central area	56	83	0	0	35
South area	79	41	0	0	30
Total: Japan Sea	8,854	7,448	8,760	6,664	7,931
North area	7,185	6,113	8,258	6,105	6,915
West area	1,669	1,331	499	559	1,014
Total:East China Sea	0	4	0	0	1
Total;Inland Sea	0	0	0	0	0

When bottom trawl catches in 2003 are partitioned into latitudinal and longitudinal 10 x 10 degree grids , the northern Tohoku Region constitutes the center of the fishing grounds on both the Pacific and the Sea of Japan sides (Fig.2). In Aomori Prefecture where the catch volume is large, there are vessels primarily targeting this species during winter.

At CITES COP13 in 2004, Germany planned to propose listing of this species on Appendix II, but as a result of prior consultations with other countries, it did not table the proposal at the meeting.

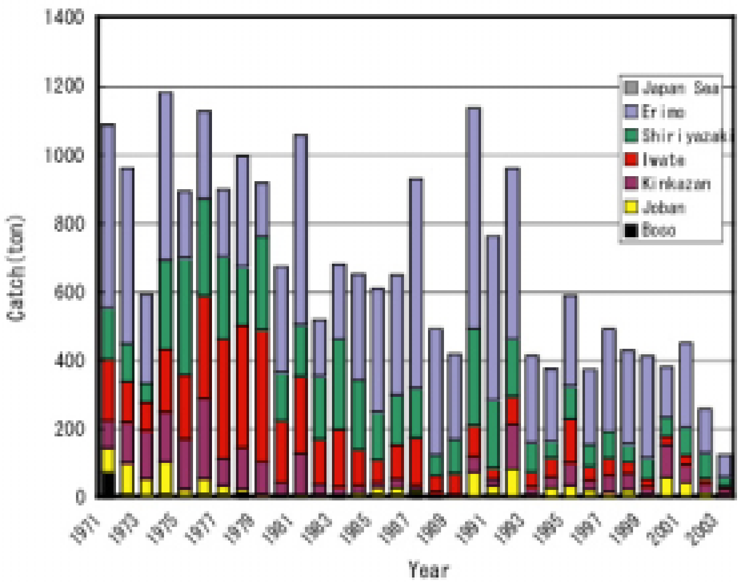

Fig. 1. Catches of spiny dog fish by area by offshore trawling.

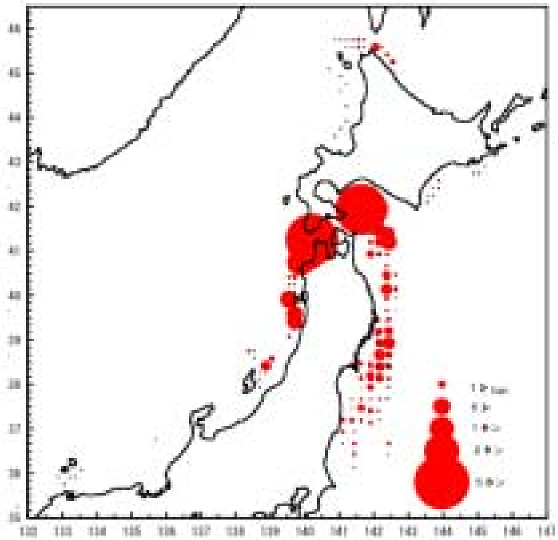

Fig. 2. Distribution of catches of spiny dog fish by offshore trawling in 2003. Catch figures are for sharks/rays in the Sea of Japan and for sharks off Hokkaido. In all cases, it is estimated that spiny dog fish comprises a major portion of the catch.

Biological characteristics

Distribution

Except for tropical and subtropical regions, this species is distributed extensively in almost all areas, including the entire North Pacific, the eastern and western parts of the North Atlantic, the Mediterranean, the area off the southern coast of Australia, the southern tip of the African continent, and the southern areas of the South American continent (Abe 1986, Fig.3). In the area around Japan, this species is distributed in large numbers off Tohoku and Hokkaido. On the Pacific side, it is found from Chiba Prefecture northward, and on the western side of Japan, to the western extent of the Sea of Japan (Yoshida 1991). On the Pacific side of the Tohoku Region, spiny dog fish are found at the water depths of 150 to 300 m.

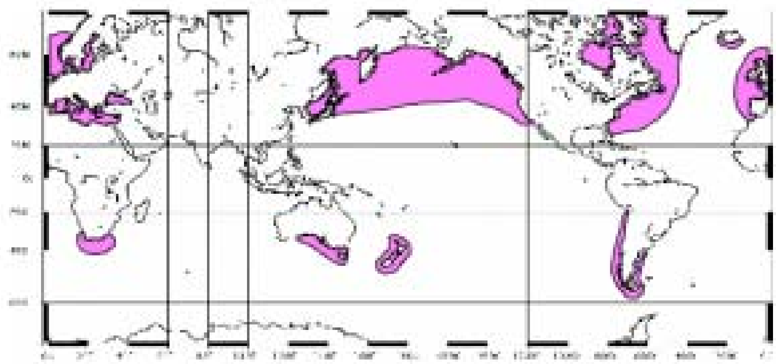

Fig. 3. Distribution of spiny dog fish.

Spawning and migration

This species is oviparous and its gestation period is long (20-22 months). It gives birth to juvenile fish of a total length of about 30 cm in February to May (Yoshida 1991). Details of migration are not known. In surveys of salmon resources conducted in the North Pacific using driftnets and longlines, this species was caught incidentally and at least 12 sharks that were tagged and released on the Pacific coast of Canada were recaptured in the Tohoku Region (Inada 1992). A spiny dog fish tagged and released near Vancouver in July in 1985 was recaptured in the area off Shimokita Peninsula, Aomori Prefecture, in September 2003. Although the details are not available, there are also several other reports of tag recoveries. From this information, it is estimated that there is considerable exchange of individuals among areas in the North Pacific.

Growth and sexual maturity

In British Columbia, Canada, males grow to a length of 90 cm in 30 years, and females to 1 m over a lifespan of 60 years. The age at sexual maturity in this species is 23 years for females (total length of about 90 cm), and 14 years for males (total length of about 70 cm) (Ketchen 1975). It is estimated that spawning takes place along the coast of northern Japan as well as in other areas, but the precise locations of spawning grounds have not been identified.

Hecate Strait		
	F	$Lt = 125.1\ (1 - e^{-0.031(t+10.6)})$
	M	$Lt = 84.7\ (1 - e^{-0.092(t+2.7)})$
Georgia Strait		
	F	$Lt = 129.1\ (1 - e^{-0.034(t+7.3)})$
	M	$Lt = 96.1\ (1 - e^{-0.068(t+5.0)})$
Washington Strait		
	F	$Lt = 152.9\ (1 - e^{-0.036(t+6.7)})$
	M	$Lt = 101.8\ (1 - e^{-0.071(t+5.2)})$

Feeding and predators

This species feeds mainly on fishes and cephalopods. Predators of this species are unknown.

Stock status

Population trends

Offshore bottom trawling in the North Pacific takes place using three fishing methods. The Japanese Danish seine fishery is carried out in Aomori Prefecture, two-boat trawling and Japanese Danish seining is conducted in Iwate Prefecture, and otter trawling occurs in Miyagi, Fukushima, Ibaraki, and Chiba Prefectures. In the Sea of Japan, two-boat trawling is carried out in Shimane Prefecture, and Japanese Danish seining is used in other prefectures. In the North Pacific area, CPUE has shown a substantial decline in all areas in recent years. CPUE in 2003 in the Erimo West Area was 26.0 kg/tow, compared to 7.4 kg/tow in the Shiriyazaki Area, and 5.4 kg/net in two-boat trawling in the Iwate Area. With respect to otter trawling, CPUE was 2.7 kg/net in the Kinkazan Area, 3.8 kg/net in the Joban Area and 4.4 kg/net in the Boso Area. All areas showed a decrease in CPUE from 2002. CPUE in the Japanese Danish seine fishery in the Sea of Japan visibly declined in recent years, from 30-50 kg/net in the 1970s to around 10 kg/net from 1990 onward. However, a year-to-year increase of 20.4 kg/net was observed between 2002 and 2003. On the whole, CPUE is low and shows a declining trend (Fig.4). Given these trends in catches and CPUE, the spiny dog fish population is considered to be at a very low level in recent years.

Trends in fishing effort

In terms of fishing effort expressed as number of bottom trawl tows per year in the North Pacific, effort in the Erimo West and Shiriyazaki Areas has remained generally stable since 1990. However, fishing effort in 2003 was 2,469 and 3,534 tows/yr, respectively, indicating that effort in both areas has declined in comparison to the previous year. In parallel, fishing effort also substantially decreased in the Japanese Danish seine fishery in the Iwate Area. This is due to conversion from Japanese Danish seine operations to two-boat trawling. In two-boat trawling in the Iwate Area, fishing effort in the first half of the 1990s was at a high level of over 3,000 tows/year, but decreased rapidly since 1998 to 1,012 tows/yr in 2003. Annual fluctuations in the Kinkazan and Joban areas are substantial, but the number of tows has generally increased in the 1990s, with a total of 5,713 and 2,266 tows, respectively, in 2003. In contrast, the number of tows in the Sea of Japan's Japanese Danish seine fishery drastically declined in recent years, falling below half the level observed in the 1970s. Further decreases were observed in 2003, when the number of tows was only 5,208 (Fig.5). Based on this information, it is considered that fishing effort for spiny dog fish since 1990 has decreased in the Sea of Japan but has remained stable in the North Pacific area.

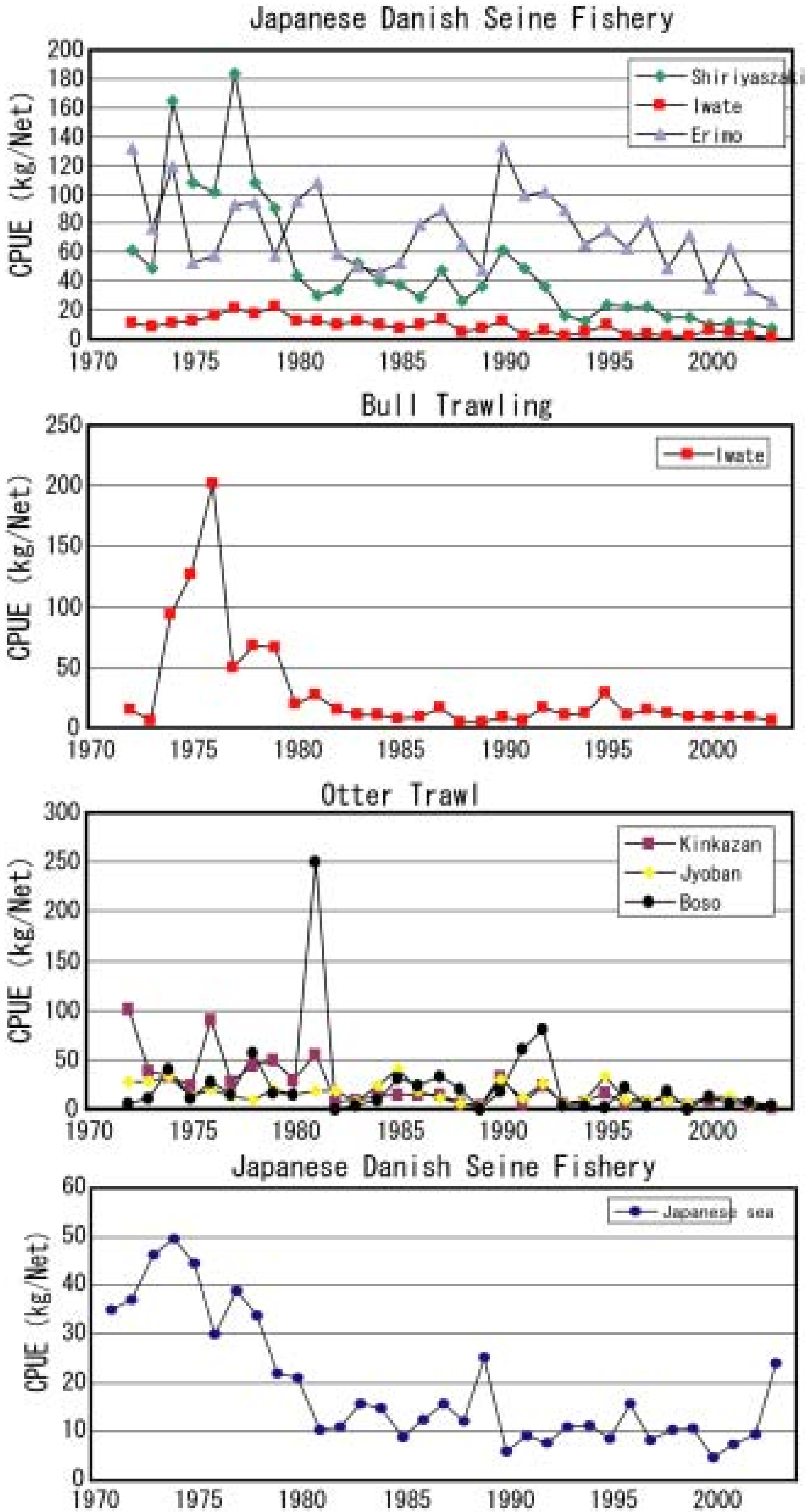

Fig. 4. CPUE of spiny dog fish by offshore trawling in the North Pacific area and the Sea of Japan (Japanese Danish seine).

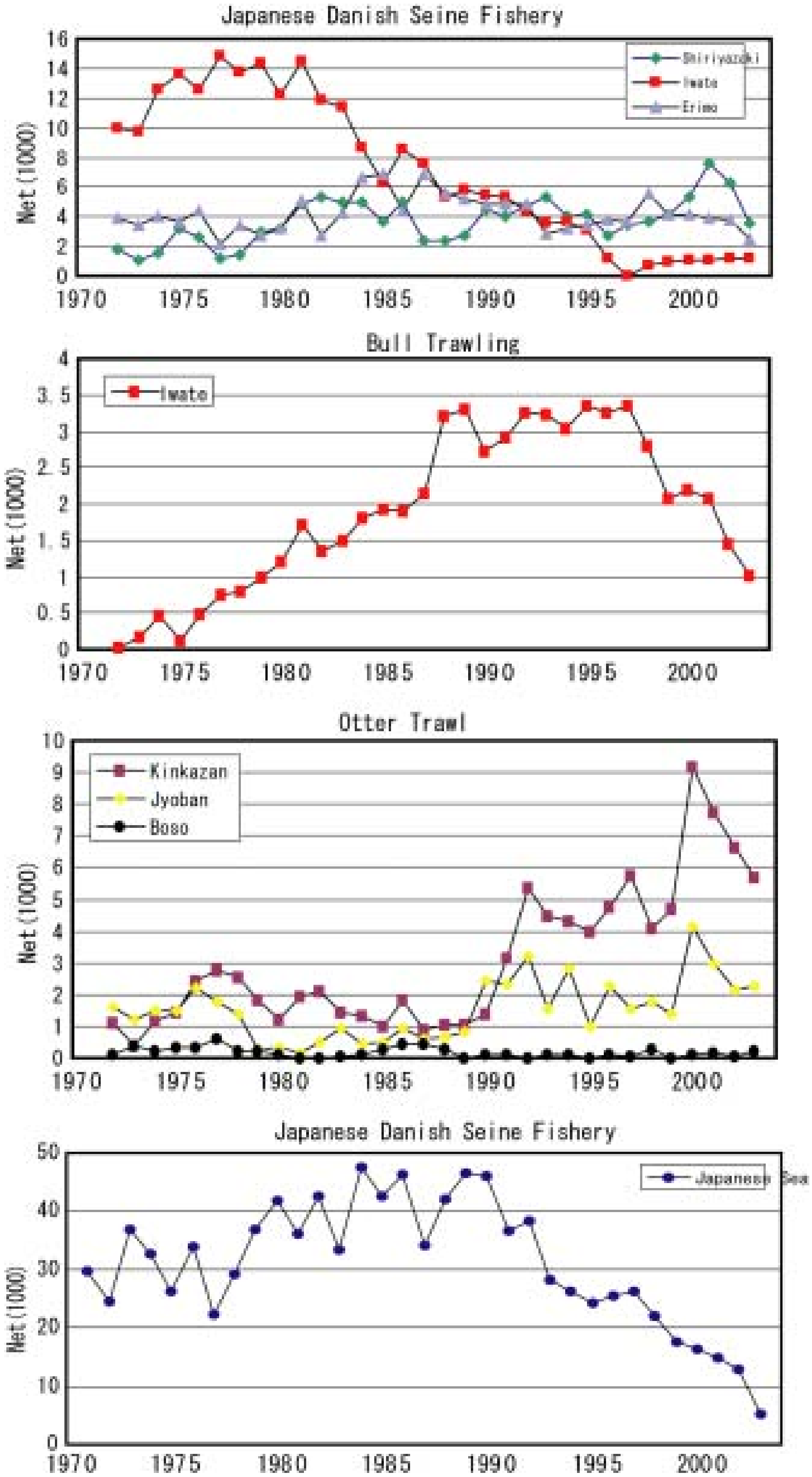

Fig. 5. The number of tows per year for spiny dog fish by offshore trawling in the North Pacific area and the Sea of Japan (Japanese Danish seine)

Stock levels and trends

Catches of spiny dog fish reached approximately 60,000 mt in 1952, but have substantially declined since then, falling below 1,000 mt in the North Pacific area and the Sea of Japan since 1993. Further declines continue. It is considered that there was a targeted fishery for this species in the 1950s, but not thereafter, and therefore differences in catches are not simply reflecting the differences in stock levels. However, it is conjectured that there do exist substantial differences in stock levels. Furthermore, bottom trawl catches have decreased since the 1970s, and CPUE in the Erimo West, Shiriyazaki and the Sea of Japan areas has also declined drastically. From this information, it is considered that the stock level of spiny dog fish is low and exhibiting a declining trend.

Management measures

Given that the life span of this species is very long, and the age at sexual maturity is 23 years for females and 14 years for males, it is will be extremely difficult for this species to recover to the stock level of the 1950s. Despite these limited prospects for recovery, it is desirable that fishing effort not be increased from the present level in order to prevent further decreases in stock size.

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8. Salmon shark (*Lamna ditropis*) and Porbeagle (*Lamna nasus*)

Salmon shark

Porbeagle

Overview of the fishery

The salmon shark is found in subarctic areas of the North Pacific in coastal to pelagic zones. This species is mainly caught incidentally by longline and driftnet fisheries, and many salmon sharks are landed in the Tohoku region of northern Honshu, especially at Kesennuma in Miyagi Prefecture. In comparison to other sharks, the quality of salmon shark meat is good and it has a relatively high commercial value given that its meat, fins and skin are used for food and handicrafts. The porbeagle, a closely-related species, is distributed in the north Atlantic and subarctic zones of the Southern Hemisphere. Japanese tuna longline fishing vessels catch this species incidentally, but the majority of landings take place in fishing ports near the fishing grounds because the value of this species does not warrant its transport back to Japan. Landed weight by species at major fishing ports used by tuna longline fisheries was studied under the Survey Project for Bluefin Tuna around Japan (fiscal year 1992-1996) and the Survey Project for Highly Migratory Fish Species around Japan (beginning in fiscal year 1997) both sponsored by the Japan Fisheries Agency., These surveys showed that annual landings of salmon shark at major fishing ports in Japan used by longline and driftnet fisheries between 1992-2003 was 1,000 to 2,900 mt, and 300 to 1,300 mt, respectively, with a total of 1,400 to 3,900 mt per year (Fig.1). An increasing trend was observed in each fishery, with the percentage of salmon sharks within the total landings of all sharks standing at 8-17%, second only to the blue shark. Many porbeagles are believed to be landed at foreign ports, but the actual situation is not well understood.

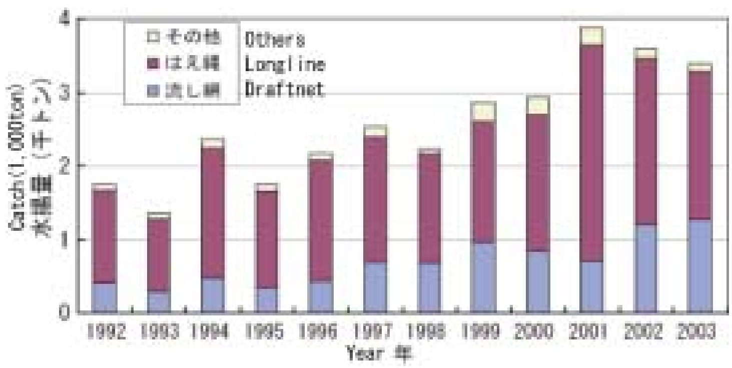

Fig. 1. Landed volume of salmon shark at major fishing ports in Japan.

Biological characteristics

Distribution

Salmon sharks are widely distributed from coastal to pelagic waters in subarctic zones of the North Pacific, and the subarctic is considered to be its main range (Nakano 1996). Porbeagles are distributed in the North Atlantic and subarctic regions of the Southern Hemisphere (Fig.2, Compagno 2001). There is a single stock of salmon shark. In the case of the porbeagle, it is likely that because the breeding periods occur at opposite times of year in the two hemispheres there exists a single stock in the north Atlantic and another continuously distributed stock in the Southern Hemisphere.

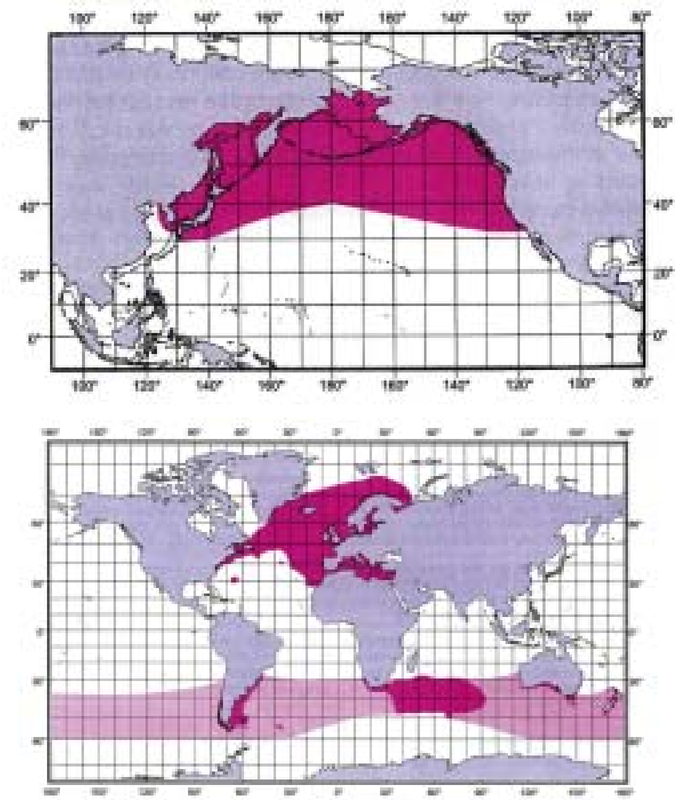

Fig. 2. Distribution of salmon shark (upper) and porbeagle (lower) (Compagno 2001).

Spawning and migration

The breeding pattern of both species is viviparity and adelphagy. It has been reported that the range of the number of juveniles produced per pregnancy and the size at birth for salmon shark are 4-5, and about 70 cm, respectively (Tanaka 1980a). For porbeagle the figures are 1-5, and 60-75 cm, respectively (Compagno 2001). Regarding migration, seasonal southern and northern movements have been suggested (Tanaka 1980a, Yatsu 1995). In the case of juvenile salmon shark, it is conjectured that nursery grounds lie along the boundary of the subarctic zone (Nakano 1996). Knowledge about mating and parturition grounds is scarce, but it is estimated that the parturition period is from March to May for salmon shark (Tanaka 1980a), and spring to summer for porbeagle (Compagno 2001).

Growth and sexual maturity

Age is estimated from rings formed in the vertebrae and based on vertebral analyses, Tanaka (1980a) reported on the growth of salmon shark and Morinobu (1996) reported on the growth of porbeagle in the Indian Ocean's southern bluefin tuna fishing ground. Size at sexual maturity for salmon shark is estimated at 180 cm for females, and 140 cm for males. The age at sexual maturity for salmon shark is estimated at 8-10 years and 5 years, for females and males respectively (Tanaka 1980a). For porbeagle, maturity is said to be reached at a length of 212 cm (fork length) for females at the age of 14 and at 175 cm for males at the age of 7 (Campana et al. 1999). Life spans are estimated at 29 years for males and over 27 years for females in the salmon shark (Compagno 2001) and at 20 years for the porbeagle (Aasen 1963).

Given below are growth formulae, in precaudal length, for the two species in the North Pacific and the Indian Ocean:.

Salmon shark, females, North Pacific: $L_t = 203.8(1 - e^{-0.136(t-(-3.946))})$ (Tanaka 1980a)

Salmon shark, males, North Pacific: $L_t = 180.3(1 - e^{-0.171(t-(-3.628))})$ (Tanaka 1980a)

Porbeagle, females, Indian Ocean: $L_t = 214.0(1 - e^{-0.082(t-(-4.43))})$ (Morinobu 1996)

Porbeagle, males, Indian Ocean: $L_t = 250.0(1 - e^{-0.066(t-(-4.64))})$ (Morinobu 1996)

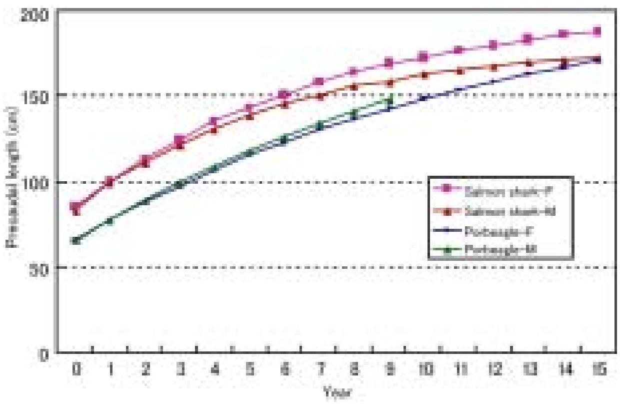

Fig. 3. Age and growth of salmon shark (2 upper lines) and porbeagle (2 lower lines) (Tanaka 1984, Morinobu 1996).

Table 1. Age and precaudal length (cm) of salmon shark and porbeagle, (Tanaka 1984, Morinobu 1996).

Age	salmon shark		porbeagle	
	Female	Male	Female	Male
0	85	83	68	68
1	100	99	81	81
2	113	111	92	91
3	124	122	102	102
4	135	131	112	111
5	143	139	119	120
6	151	146	128	129
7	158	151	133	136
8	164	156	138	144
9	169	159	146	150
10	173	163	149	
11	177	166	152	
12	180	168	156	
13	183	170	159	
14	186	171	163	
15	188	173	168	

Feeding habit and predators

Large salmon sharks found north of 48 degrees N consume salmon and squids while small individuals of this species found south of 48 degrees N consume highly productive pelagic fishes (sardines, Pacific saury, etc.) and squids (Sano 1960, Kawasaki et al. 1962, Sano 1962, Tanaka 1980b). Salmon sharks consume different prey depending on area and growth stage, but they are not known to be particularly selective in feeding, showing opportunistic feeding habits based on readily available species abundantly distributed in their habitat. Porbeagles also consume many species of highly productive pelagic fishes (Compagno 2001). It is not known whether there are any predators of either species.

Stock status

Population trends

Data on incidental catch of salmon shark was obtained from tuna longline surveys carried out by prefectural government vessels (training and research vessels) and national government survey vessels. Annual estimates of catch per unit effort (CPUE, expressed as the number of fish caught per 1000 hooks), which serves as an index of stock abundance, were obtained by removing the impact of such factors as season, area and fishing gear by means of a generalized linear model (GLM). The resulting trend for the period from 1992 to 2002 suggests that while changes in CPUE of salmon shark during this period are small, a slight trend of increasing CPUE is apparent (Fig.4).

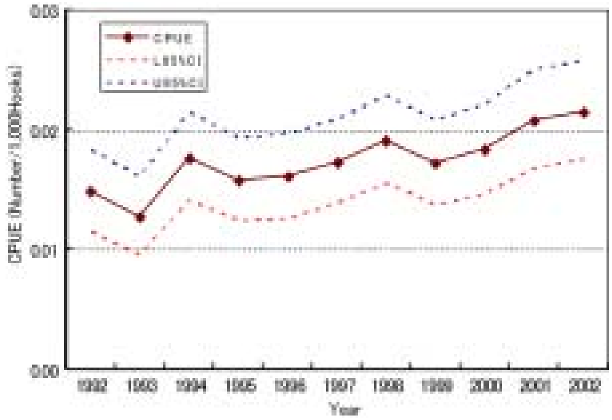

Fig. 4. Standardized CPUE of salmon shark in the North Pacific.

Standardized CPUE for porbeagle in the Southern Hemisphere has been obtained by means of a GLM using shark incidental catch data obtained through scientific observer surveys in the southern bluefin tuna fishing grounds off South Africa and off Australia (Matsunaga and Nakano 2004). The results show that CPUE repeatedly increases and decreases from 1992 to 2002, and no consistent trend is apparent (Fig.5).

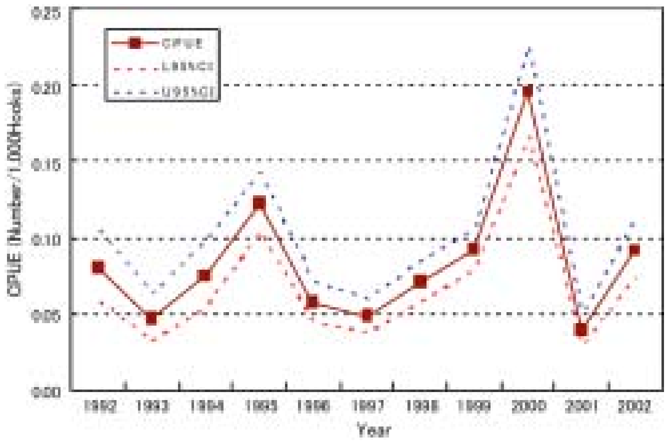

Fig. 5. Standardized CPUE of porbeagle in the southern bluefin tuna fishing ground

To summarize the above results, it was estimated that the population of salmon shark in the North Pacific remained stable or gradually increased during the studied 10 year period. No conspicuous trend of either increase or decrease was recognized in standardized CPUE, and landings at Japanese fishing ports showed a somewhat increasing trend. For porbeagle, it was estimated that the population remained stable in the Southern Hemisphere during the past 10 years since no conspicuous increase or decrease in CPUE was observed.

Trends in fishing effort

Fishing effort (in number of hooks) by Japanese tuna longline vessels by ocean and for the three oceans in total are shown below in Figure 6 (unpublished data, National Research Institute of Far Seas Fisheries). Fishing effort for Japanese vessels in total increased from 116 million hooks in 1952 to over 400 million hooks in 1962. Fishing effort remained between 400 million and 470 million hooks until 1978. Later, and until 1991, it rose to a level of 500 to 560 million hooks, but declined since 1992, falling below 400 million hooks in 1999 and 2000.

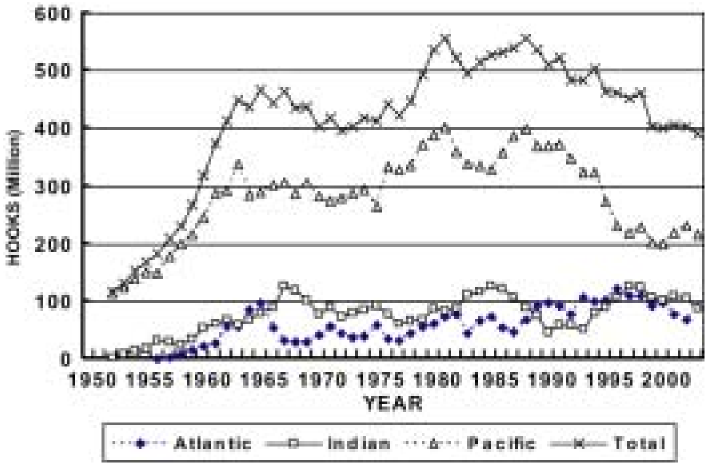

Fig. 6. Fishing effort by Japanese tuna longline fisheries by ocean and in total.

When we examine the changes in fishing effort by ocean, effort in the Pacific increased to between 110 and 300 million hooks in 1952-1962, and leveled out at around 300 million hooks by 1975. Subsequently, fishing effort increased to 320 to 400 million hooks in 1976-1994, but continuously declined for 6 years from 1995 to 2000, dropping below 200 million hooks in 2000. In the Atlantic, tuna longline operations began in 1956, and fishing effort increased to 90 million hooks by 1965, but then remained at 30 to 80 million hooks in 1966-1988. Thereafter, fishing effort increased until 1997 and stabilized at around 100 million hooks in 2000. In the Indian Ocean, fishing effort increased from 1952 to 1967, reaching 130 million hooks in 1967. From that time until 1987 fishing effort hovered around 100 million hooks (60 to 130 million hooks), and then began to decline to about 50 million hooks in the period 1990-1993, before turning upward and reaching about 100 million hooks in 2000.

Fig.8 shows the total fishing effort for tuna longline fishing vessels in the Pacific based on data from the Secretariat for the Pacific Community (SPC) aggregated for all fishing nations including Japan. Although fishing effort in the Pacific as a whole showed an increasing trend since 1995, effort by Japan substantially decreased due to the impact of vessel decommissioning programs. Overall fishing effort in the 1990s remained at a level of 600 to 700 million hooks. Effort by Japanese fishing vessels formerly accounted for more than half of the total, but at present Japan's effort comprises less than one third of the total. The increase in fishing effort is believed to be due to an increase in fishing vessels from Chinese Taipei, the Republic of Korea, and China. Furthermore, similar trends are assumed to be applicable in the Atlantic and Indian Oceans as well, indicating that as effort by Japanese fishing vessels has decreased it has been offset by the effort of fishing vessels of other countries.

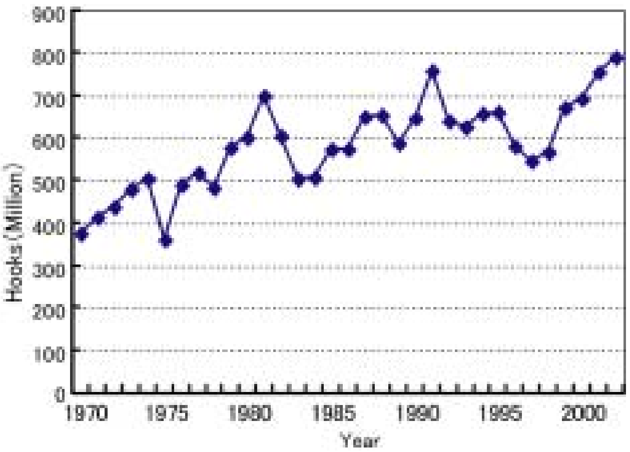

Fig. 7. Fishing effort (number of hooks) by tuna longline fisheries in the Pacific for all fishing nations including Japan (data downloaded from the SPC website)

Stock levels and trends

The stock status of these two species is not known. From the changes in CPUE and landings, stocks of these two species are assumed to have remained more or less stable.

Management measures

There are no specific recommendations for conservation and management because no conspicuous changes have been observed in stock status. Nevertheless there is a need to continue to monitor these populations. Currently, the biggest problem is the absence of catch data by species for stock assessment. Recently, the Fisheries Agency revised the logbook reporting requirements for tuna longline fisheries and now requires catch recording for 6 species of sharks. However, there are cases where accurate reporting of shark catches does not occur, and it is difficult to assess the actual situation, including discard amounts by species. In order to accurately estimate shark catches by species and the quantity of discards in tuna longline fisheries, it will be necessary to promote data collection via methods which do not depend on fishermen, such as observer programs, and to develop improved means of data collection for the future.

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9. Other Pelagic Sharks

Oceanic Whitetip Shark (*Carcharhinus longimanus*)
Silky Shark (*Carcharhinus falciformis*)
Bigeye Thresher Shark (*Alopias superciliosus*)
Crocodile Shark (*Pseudocarcharias komoharai*)

Oceanic Whitetip Shark

Bigeye Thresher Shark

Silky Shark

Crocodile Shark

Introduction

Taniuchi (1997) listed 26 species as being caught incidentally by Japanese tuna longline fisheries, and of these, 7 species (crocodile, shortfin mako, longfin mako, bigeye thresher, blue, silky, and oceanic whitetip sharks) are caught relatively frequently. Nakano (1996) reported on the catch composition of 15 species of sharks based on data from prefectural government surveys carried out in the Pacific. Six species (blue, shortfin mako, crocodile, oceanic whitetip, silky and bigeye thresher sharks) accounted for 1% or more of the catch composition. Furthermore, Matsunaga and Nakano (1996) analyzed 25 species in data derived from JAMARC and prefectural government surveys. Blue, shortfin mako and salmon sharks, which are discussed separately, and the 4 species discussed in this document (oceanic whitetip, silky, bigeye thresher, and crocodile shark) are the species most frequently caught in tuna longline fisheries.

Biological characteristics

Distribution

Distribution maps for 4 species of pelagic sharks caught incidentally in tuna longline fisheries are shown in Fig. 1 (Last and Stevens 1994). Crocodile, oceanic whitetip, silky, and bigeye thresher sharks are mainly distributed in the tropical zones of the three world oceans. According to Figure 1, the distribution of silky sharks is locally limited, and the distributions of bigeye thresher and crocodile sharks are characterized by many question marks. However, according to surveys by the Fisheries Agency and the National Research Institute of Far Seas Fisheries, these species are extensively distributed throughout the tropical zone. Little or no information exists concerning the stocks of pelagic sharks. Given their distribution and ecology, it may be reasonable to assume that there exists a single stock for each tropically-distributed species (crocodile, oceanic whitetip, silky and bigeye thresher sharks) in the Pacific, the Atlantic, and the Indian Oceans. Further analysis is needed on distribution, migration, mark-recapture and genetic characteristics of pelagic shark stocks.

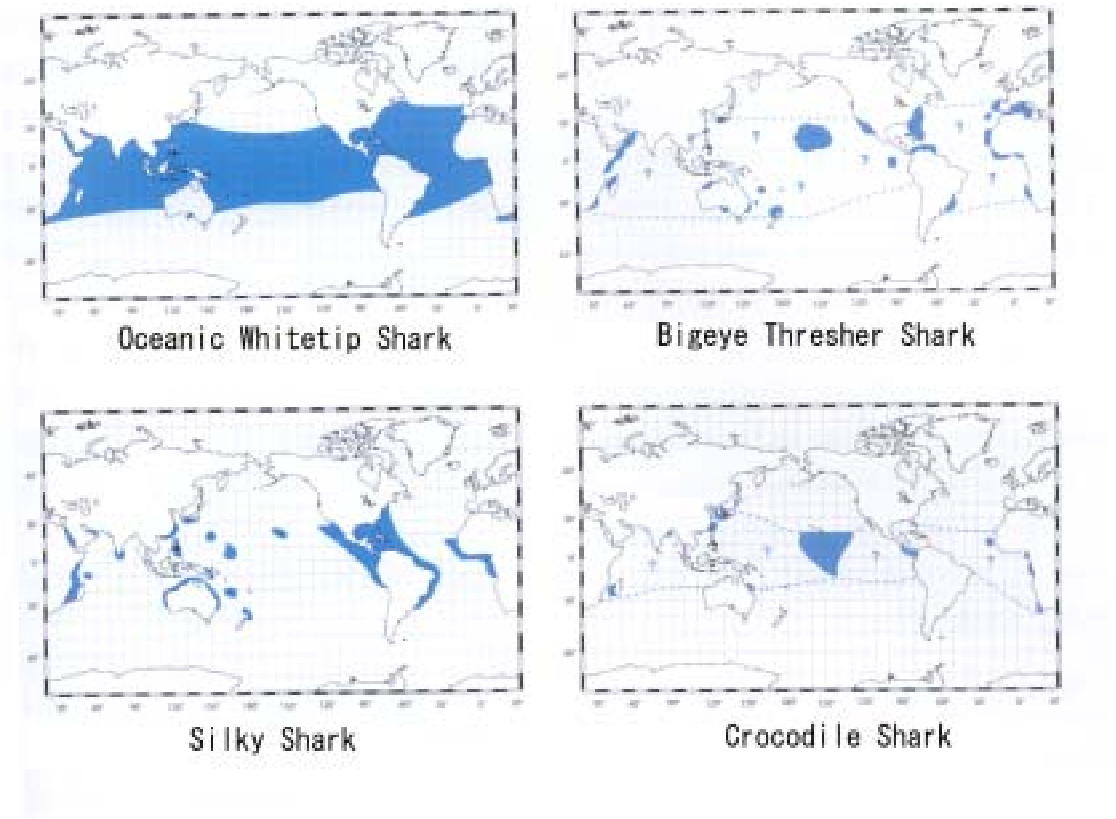

Fig. 1. Distribution of pelagic sharks (Last and Stevens 1994)

Spawning and migration

The breeding patterns exhibited by elasmobranchs (sharks and rays) are diverse, but they are broadly classified into oviparity and viviparity. Taniuchi (1988) defined breeding patterns based on the extent of maternal nutritional supply. According to this definition, viviparity is further divided into facultative viviparity and obligate viviparity; and obligate viviparity is again divided into lecithotrophy and matrotrophy. Matrotrophy is further divided into three categories: oophagy and adelphagy; placental analogues; and yolk sac placenta. An outline of the shark breeding patterns proposed by Taniuchi (1988) is shown below (Table 1).

Table 1. Breeding patterns of elasmobranch defined on the basis of maternal nutritional supply (Taniuchi 1988).

表1.栄養補給からみた板鰓類の繁殖様式(谷内1988)

1卵生 oviparity
2胎生 viviparity
  I偶発胎生 facultative viviparity
  II真正胎生 obligate viviparity
  A卵黄依存型 lecithotrophy
  B母体依存型 matrotrophy
    1)卵食性・共食い型 oophagy and adelphagy
    2)胎盤性類似物型 placental analogues
    3)胎盤型 yolk sac placenta

The breeding patterns of 4 species of pelagic sharks caught incidentally in tuna longline fisheries and discussed here are viviparity and yolk sac placenta for oceanic whitetip and silky sharks, and viviparity and oophagy and adelphagy for crocodile and bigeye thresher sharks. The average (and range in parentheses) of the number of young produced by each species is: 4 for crocodile shark (Compagno 1984), 6.2 (,1-15) for oceanic whitetip shark (Seki et al. 1998), 6.2 (1-16) for silky shark (Oshitani et al. 2003), and 2-4 for bigeye thresher shark (Compagno 1984) (Table 2). Body length at birth is: 41 cm (total length) for crocodile shark (Compagno 1984), 40.55 cm for oceanic whitetip shark (Seki et al. 1998), 48.60 cm for silky shark (Oshitani et al. 2003), and 60-140 cm (total length) for bigeye thresher shark (Compagno 1984). Where not otherwise indicated, body length represents precaudal length.

Table 2. Breeding patterns, number of juveniles born, and the body length at birth of 4 species of sharks caught by tuna longline fisheries

Species	Breeding patterns	Number of calves(average, extent)	Body length at birth (cm)
Crocodile sharks	viviparity, oophagy/adelphagy	**4**	**41**（total length）
Oceanic whitetip	sharks viviparity, yolk sac placenta	**6.2,1-15**	**40-55**（precaudal length）
Silky sharks	viviparity, yolk sac placenta	**6.2,1-16**	**48-60**（precaudal length）
Bigeye threshers	viviparity, oophagy/adelphagy	**2-4**	**60-140**（total length）

Table 3. Conversion formulae between body length measurement types for 4 species of sharks caught by tuna longline fisheries

Species	Measured position（**x-y**）	Conversion formula	Research area	Researcher
Crocodile sharks		**Unknown**		
Oceanic whitetip sharks	**PL-TL**	**TL=1.397xPL**	Pacific	**Seki *et al.*（1998）**
Silky sharks	**TL-PL**	**TL=2.08+1.32xPL**	Pacific	**Oshitani *et al.*(2003)**
	FL-PL	**FL=1.09+1.03xPL**	Pacific	**do**
	PL-TL	**TL=3.4378+1.3358xPL**	Atlantic	**Bonfil *et al.*（1993）**
	PL-FL	**FL=1.3017+1.0758xPL**	Atlantic	**do**
	FL-TL	**TL=1.8878+1.2412xFL**	Atlantic	**do**
	TL-FL	**FL=-2.6510+0.8388xTL**	Atlantic	**Kohler *et al.* (1995)**
Bigeye threshers	**PL-TL**	Female**:TL=15.3+1.81xPL**	Pacific	**Liu *et al.*（1998）**
	PL-TL	**Male:TL=15.1+1.76xPL**	Pacific	**do**
	FL-TL	Female**:TL=13.3+1.69xFL**	Pacific	**do**
	FL-TL	**Male:TL=26.3+1.56xFL**	Pacific	**do**

Table 4. Growth formulae of 4 species of sharks caught by tuna longline fisheries

Species	Growth formula	Measured position	Researched area	Researcher
Crocodile sharks	**Unkown**			
Oceanic whitetip sharks	$Lt=244.58(1-e^{-0.103(t-(-2.697))})$	precaudal length	Pacific	**Seki *et al.* (1998)**
Silky sharks	$Lt=290.5(1-e^{-0.153(t-(-2.2))})$	total length	Atlantic	**Branstetter (1987)**
	$Lt=313.1(1-e^{-0.089(t-(-3.3))})$	total length	Atlantic	**Bonfil *et al.* (1993)**
	$Lt=216.4\ (1-e^{-0.148(t-(-1.76))})$	precaudal length	Pacific	**Oshitani *et al.* (in press)**
Bigeye threshers	**Female:** $Lt=224.6(1-e^{-0.092(t-(-4.21))})$	precaudal length	Pacific	**Liu *et al.* (1998)**
	Male: $Lt=218.8(1-e^{-0.088(t-(-4.24))})$	precaudal length	Pacific	

Growth and sexual maturity

Growth formulae have been estimated for each of these 4 species of pelagic sharks caught by tuna longline, except for the crocodile shark. However, the length measurement basis for the formulae varies between precaudal, fork and total length depending on the researcher. Therefore, previously published formulae allowing conversions between various length measurements are given below (Table 3).

Seki et al. (1998) reported on the growth formula for oceanic whitetip shark in the Pacific. For silky shark, Branstetter (1987) and Bonfil et al. (1993) reported formulae for the Atlantic, and Oshitani et al. (2003) reported formulae for the Pacific. (Table 4). For bigeye thresher, Liu et al. (1998) gives the growth relationship in the Pacific. There exist no published data regarding growth in the crocodile shark.

Stock status

Population trends

Landed weight by species at major fishing ports used by tuna longline fisheries was studied under the Survey Project for Bluefin Tuna around Japan (fiscal year 1992-1996) and the Survey Project for Highly Migratory Fish Species around Japan (beginning in fiscal year 1997) both sponsored by the Japan Fisheries Agency. . According to these surveys, major species caught by tuna longline fisheries and their proportion of the total catch in 1992-2003 were: blue shark (73.1%), salmon shark (14.2%), shortfin mako shark (5.8%), thresher shark (2.6%), requiem shark (0.3%), and oceanic whitetip shark (0.3%). The major fishery landing sharks in Japan is the near-shore tuna longline fishery. Especially in Miyagi Prefecture, almost all captured sharks are landed. Therefore, it is considered that the species composition of landings somewhat accurately reflects catch composition. However, crocodile sharks with no commercial value are not landed. Another species identification problem arises because silky sharks may be recorded in either requiem shark or other shark categories.

Taniuchi (1990) analyzed the catch reports of Japanese prefectural government vessels in the Pacific and Indian Oceans, and reported that the catch rate of sharks caught in tuna longline surveys in 1973-1985 was more or less constant. Figs. 2 and

3 show the catch rates for oceanic whitetip, silky, thresher, and crocodile sharks for these vessels during the periods 1967-1970 and 1992-2002. Catch rates for oceanic whitetip shark showed a declining trend, and no conspicuous changes were observed for silky shark. The CPUE for threshers in 1992-2002 is higher than that for 1967-1970. The decline in CPUE for oceanic whitetips and the increase in CPUE for threshers is attributed to deeper setting of longlines in the later period. Approximately 200-500 individuals of crocodile shark were captured in annual surveys, and the CPUE in 1992 to 2002 showed a slight increase.

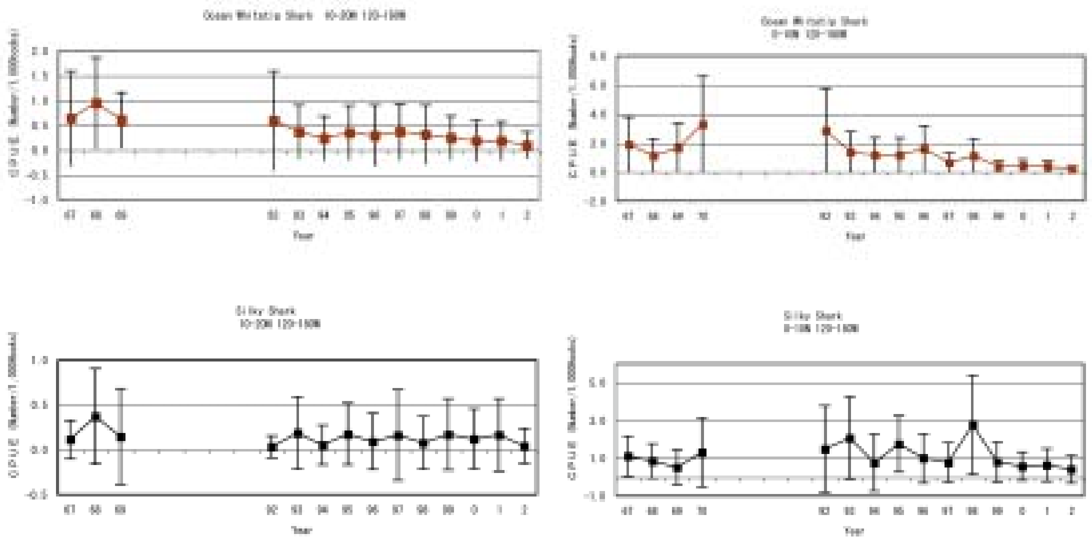

Fig. 2. CPUE and standard deviation of oceanic whitetip and silky sharks for each survey year, as observed in surveys conducted by prefectural government vessels

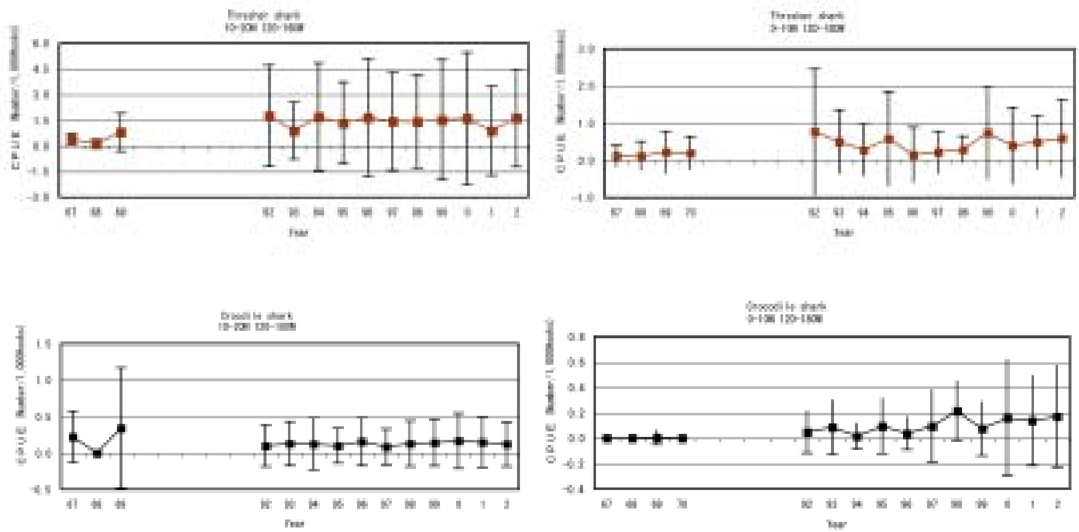

Fig. 3. CPUE and standard deviation of thresher and crocodile sharks for each survey year, as observed in surveys conducted by prefectural government vessels

Trends in fishing pressures

According to the Annual Report on Fisheries and Aquaculture Production for fiscal year 2000, the number of vessels engaged in tuna longline fisheries were: 542 distant-water tuna longline vessels (gross tonnage of 120 tons or more); 145 near-shore tuna longline vessels (gross tonnage from 20 to 120 tons); and 783 coastal tuna longline vessels (gross tonnage of less than 20 tons). The catch of tunas in 1997 was 185,000 tons.

Figure 4 shows the fishing effort (in number of hooks) by Japanese tuna longline vessels by ocean and for the three oceans in total (unpublished data, National Research Institute of Far Seas Fisheries). Fishing effort for Japanese vessels in total increased from 116 million hooks in 1952 to over 400 million hooks in 1962. Fishing effort remained between 400 million and 470 million hooks until 1978. Later, and until 1991, it rose to a level of 500 to 560 million hooks, but declined since 1992, falling below 400 million hooks in 1999 and 2000.

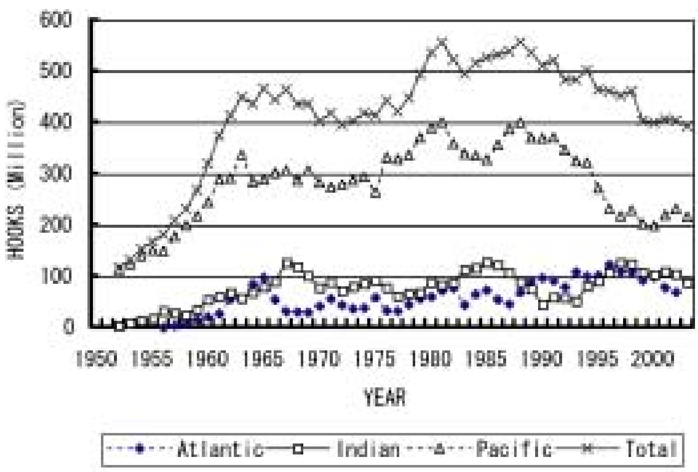

Fig. 4. Number of hooks used by Japanese tuna longline fisheries

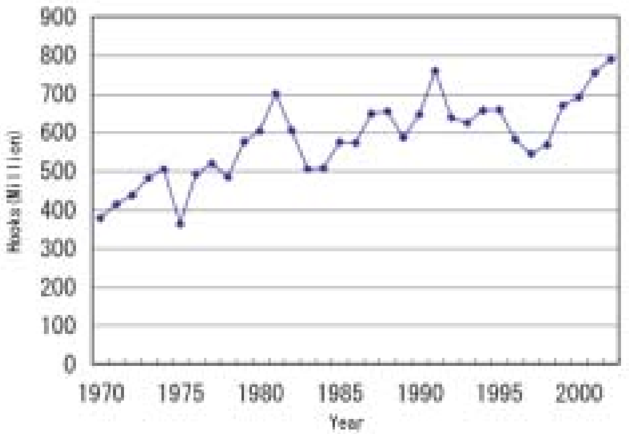

Fig. 5. Number of hooks used by tuna longline fisheries in the Pacific Ocean as a whole

When we examine the changes in fishing effort by ocean, effort in the Pacific increased to between 110 and 300 million hooks in 1952-1962, and leveled out at around 300 million hooks by 1975. Subsequently, fishing effort increased to 320 to 400 million hooks in 1976-1994, but continuously declined for 6 years from 1995 to 2000, dropping below 200 million hooks in 2000. In the Atlantic, tuna longline operations began in 1956, and fishing effort increased to 90 million hooks by 1965, but then remained at 30 to 80 million hooks in 1966-1988. Thereafter, fishing effort increased until 1997 and stabilized at around 100 million hooks in 2000. In the

Indian Ocean, fishing effort increased from 1952 to 1967, reaching 130 million hooks in 1967. From that time until 1987 fishing effort hovered around 100 million hooks (60 to 130 million hooks), and then began to decline to about 50 million hooks in the period 1990-1993, before turning upward and reaching about 100 million hooks in 2000.

Management measures

As no conspicuous changes have been observed in the stock status of oceanic whitetip, silky, or bigeye thresher sharks, there is no need for special recommendations on conservation and management. However, there is a need to continue monitoring their stock status. Since little or no data showing the stock status of crocodile sharks are available, future studies will be necessary.

The absence of species-specific catch statistics for stock assessment is the biggest problem. Recently, the Fisheries Agency revised the logbook reporting requirements for tuna longline fisheries and now requires catch recording for 6 species of sharks. However, there are cases where accurate reporting of shark catches does not occur, and it is difficult to assess the actual situation, including discard amounts by species. In order to accurately estimate the shark catches by species and the quantity of discards in tuna longline fisheries, it will be necessary to improve data collection methods in the future, including promoting fishery-independent data collection programs, such as observer programs.

Table 5. Landed volume of sharks by species at major fishing ports collected under Fisheries Agency-sponsored surveys (units in mt)

Year/Species	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Salmon shark	1,748	1,352	2,357	1,738	2,172	2,527	2,222	2,868	2,932	3,880	3,596	3,386
Shortfin mako	1,479	1,175	1,197	944	833	944	1,055	1,001	1,135	960	965	973
Longfin mako	5	4	4	6	6	6	12	4	8	8	5	4
Blue shark	12,250	13,548	10,500	10,839	10,589	10,998	12,427	14,298	15,870	16,028	15,531	15,388
Oceanic whitetip	65	77	53	83	41	39	85	66	12	13	8	4
Silky shark	0	0	0	0	0	0	0	0	0	11	0	0
Requiem shark	126	103	65	91	29	28	30	43	21	13	3	8
Hammerhead shark	38	41	23	20	33	21	16	26	34	25	33	17
Threshershark	706	553	498	537	514	485	455	473	536	369	298	281
Other sharks	1,217	129	461	644	552	724	611	861	598	972	647	286
Total	17,635	16,981	15,157	14,901	14,770	15,772	16,913	19,640	21,146	22,279	21,086	20,347

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10. Skates

1) Fisheries harvesting skates

Skate species are harvested by kasube gillnet and also caught incidentally by trawl and flounder gillnet fisheries. In Hokkaido, skates are found in large numbers in the Okhotsk Sea and along the coast of the Sea of Japan, but, along the Pacific coast, they are found only in mixed species assemblages with other Raja (Nagasawa and Torisawa 1991). According to catch statistics for 1968-2000, catches in the Soya District were high and comprise 41% of the total. There are sizable catches along the coast of the Sea of Japan and the Okhotsk Sea, such as at Shiribeshi (23%), Nemuro (13%), Rumoi (6%), and Abashiri (7%) (Table 1). By gear type, the catches of gillnet fisheries, such as the flounder gillnet fishery, comprise 73% of the total followed by the longline fishery with 11% and the trawl fishery with 11% (data for 1968-1998).(Table 2, Fig.1).

2) Species of skates subjected to harvesting

Skates discussed in this section belong to the Family Rajidae. Amaoka et al. (1995) recorded 23 species of skates in northern Japan. Of these, there are 21 species likely to be distributed in the area around Hokkaido:

Genus Dipturus:
Mottled skate, Acutenose skate, Three star skate, Common skate;

Genus Bathyraja:
Abyssal skate, File skate, Raspback skate, Challenger skate, Duskypink skate, Okhotsk skate, Duskypurple skate, Tsumura skate, Notoro skate, Lindberg skate, Whitehead skate, Fedorov skate, Aleutian skate, Golden skate, Thorn skate;

Genus Rhinoraja:
Dapple-bellied softnose skate, White-bellied softnose skate (Amaoka et al. 1995).

Of the species listed above, Mottled skates are harvested in the largest quantities, followed by Golden skates (Nagasawa and Torisawa 1991).

3) Biology of skates subjected to harvesting

Fish commonly called Kasube in Hokkaido are fishes belonging to the Family Rajidae. They are classified into the Genus Dipturus, the Genus Bathyraja, and the Genus Rhinoraja according to the shape of their soft snouts.

Fishes belonging to the Genus Dipturus have thick and robust soft snouts. The Mottled skate and the Acutenose skate are classified within this genus. Acutenose skates are often found along the Pacific coast, and they resemble the Mottled skate. They can be distinguished by their long and stick-like projecting snout, and the absence of clear spot marks on the discs.

Fishes belonging to the Genus Bathyraja have soft snouts. They include the Golden skate and the Raspback skate. Golden skates are second in abundance only to Mottled skates, occurring mainly in the Okhotsk Sea and the northern part of the Sea of Japan.

Fishes belonging to the Genus Rhinoraja have slender and soft snouts. The snout in this genus is the softest because it is not fused with the skull. The Genus Rhinoraja and the White-bellied softnose skate are included in this genus. All of them are found in deep sea areas of the Pacific (Nagasawa and Torisawa 1991).

i) Standard Japanese name, scientific name, English name, and identification issues standard Japanese name / scientific name / English name

Megane kasube / *Raja pulchra* / Mottled skate

Tengu kasube / *Raja tengu* / Acutenose skate

Dobu kasube / *Bathyraja smirnovi* / Golden skate

Sokogangiei / *Bathyraja bergi* / Raspback skate

Kuji kasube / *Rhinoraja kujiensis* / Dapple-bellied softnose skate

Onaga kasube / *Rhinoraja longicauda* / White-bellied softnose skate

Catches of the Mottled skate (regional name: Makasube) are highest, followed by the Golden skate. The regional Ainu names Kasube and Dorokasube probably mean Golden skate, however this issue may require further confirmation.

ii) Distribution

Mottled skates are found at depths of 50-100 m. This species is oviparous and its body size reaches 1m. It is distributed from Hokkaido, including the Okhotsk Sea, to the East China Sea.

Golden skates have been recorded at depths of 100-950 m. They are distributed in northern Japan, the Okhotsk Sea, the North Pacific, and the Bering Sea.

Raspback skates are found at depths of 100-250 m, and are distributed in the Pacific off northern Japan, the Sea of Japan, and the Okhotsk Sea.

Dapple-bellied softnose skates are mainly found at depths of 600-800 m, and are distributed from the Chishima Islands to the East China Sea.

White-bellied softnose skates are mainly found at depths of 300-1,000 m, and are distributed north of Choshi in the Pacific off northern Japan (Amaoka et al. 1995).

iii) Breeding pattern, number of juveniles reproduced and body length at birth

The breeding pattern of all the species belonging to the Rajidae genus is oviparity. These species bear eggs wrapped with spool-shaped eggshells, called "tako-no-makura" (pillow of octopus) or "kasube-no-tabako-ire" (tobacco pouch of kasube). Eggshells of the Mottled skate (*Raja pulcra*) are large, with short angular protrusions at the four corners. The body size at birth is 140-188 mm long and 70-95 mm wide. Spawning occurs in spring, and 1-5 juveniles are born from an egg after several months.

In the Bering Sea and the southern area off the Alaskan Peninsula, a decrease has been reported in the weight of yolk bladders along with an increase in body size and weight of juveniles for *Bathyraja aleutica* which belongs to the same family as the Golden skate (*Bathyraja smirnovi*) (Teshima and Tomonaga 1986).

iv) Age and growth

It has been reported in North Carolina that the weight of females is greater than that of males, the fin length of females is shorter than that of males, and the body width of females is slightly narrower than that of males. The relationships between body weight and total length(Tl) by sex have also been reported. The length-weight relationship are reported in the following formulae (Schwartz).

Male Log weight = -4.9320 + 2.8808 Log Tl (r = 0.9118)
Female Log weight = -5.7680 + 3.2869 Log Tl (r = 0.9565)

v) Stock Status
Very little is known about skate stocks. There is a possibility that stocks can be distinguished by the depth and bottom type over which the species are found, and by breeding patterns and egg cases. Further research may be necessary.

4) Historical catches

According to Hokkaido Statistical Annual Reports on Agriculture, Forestry and Fisheries from 1968 to 2002, and the Annual Reports on Fisheries and Aquaculture Production Statistics in 1999 and 2000, catches, which had remained at the 2,000 mt level in the latter half of the 1960s, fell to the 1,000 mt mark by the early 1970s, because of the decline in trawling catches. In parallel with the increase in gillnet catches from the mid-1970s; catches reached a peak of 5,000 mt in 1980. In this year, catches of skates in the cod gillnet fishery was at a very high level (939 mt). Later, catches by gillnet decreased, stabilizing at a level around 2,500 mt which has continued until the present time (Table 2, Fig.1).

5) Fishing effort (number of vessels operating, number of fishing days, etc.)

Regarding catches by various types of fisheries, the flounder gillnet fishery has been catching skates on relatively on a stable basis (Table 2). Although detailed data on fishing effort are not available, the number of fishery management units and number of fishing days for the flounder gillnet fishery was obtained from Hokkaido Agriculture, Forestry and Fisheries Statistics Annual Reporst. Data on the number of fishery management units from 1968 to 2002 showed that the maximum was 4,598 in 1980, the minimum was 3,018 in 2001, and the average was 3,994. Data on the annual number of fishing days from 1968 to 1987 showed an average of 270,204 days (maximum 319,284 days in 1981; minimum 214,224 days in 1971) (Table 3).

6) Changes in stock status and fishing rate

Catches of skates by the flounder gillnet fishery, both in terms of number of fishery management units and number of fishing days, continued to gradually decline after peaking in 1971, staying at a relatively low level till 2000, and then increasing in 2001 (Table 3, Fig.2). These results are considered to be a reflection of the stock status of skates to some extent, however some caveats are necessary. For example, catches of skates in the flounder gillnet fishery account for only 13% of the total catch, and the number of fishery management units and fishing days are arbitrary measures of fishing effort.

7) Recommendations on stock assessment and conservation and management

Although data on stock status by species are not available, catches of skates in the flounder gillnet fishery, both in terms of number of fishery management units and number of fishing days, gradually declined after peaking in 1971. Catches remained at stable low levels in the 1980s and the 1990s, but showed some increase in recent years. There is a need to continue monitoring changes in fishing rates.

This assessment has shown that there are statistical catch data by species that can be used for species-specific stock assessment; that catches were high in the northern part of the Sea of Japan and Okhotsk Sea according to available data; and that the fishery most suited for stock assessment is the flounder gillnet fishery. It will be necessary to compile data on catches and fishing effort by species through market surveys in these locations in the future.

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Table 1. Catch volume of Skates by administrative area in Hokkaido in 1968-2002(ton)

Year	Soya	Abashiri	Nemuro	Kushiro	Tokachi	Hidaka	Iburi	Oshima	Hiyama	Shiribeshi	Ishikari	Rumoi	Total
1968	810	162	344	3	51	112	282	41	35	450	15	163	2,468
1969	387	227	376	2	49	103	213	49	44	317	21	191	1,979
1970	483	201	349	2	70	160	199	81	64	425	62	399	2,495
1971	72	8	323	1	33	59	234	11	48	476	39	249	1,553
1972	80	24	282	3	36	54	186	7	44	308	25	80	1,129
1973	130	78	563	1	49	75	161	4	30	191	13	86	1,381
1974	172	101	173	1	43	47	129	12	14	262	7	68	1,029
1975	787	110	179	1	36	32	127	15	34	478	27	269	2,095
1976	721	91	612	2	37	14	93	23	13	423	56	251	2,336
1977	1,884	97	273	2	20	8	87	3	6	1,242	16	167	3,805
1978	1,228	52	272	3	24	5	100	6	8	248	14	136	2,096
1979	2,389	40	290	3	11	2	82	6	5	184	10	112	3,134
1980	3,419	49	439	1	8	152	133	4	8	831	3	134	5,181
1981	595	39	420	2	16	104	74	3	4	1,817	3	52	3,129
1982	1,335	143	321	2	18	116	69	3	5	1,595	31	160	3,798
1983	1,134	41	556	1	5	60	40	3	5	593	23	179	2,640
1984	1,711	61	429	3	5	59	35	15	9	604	30	307	3,268
1985	533	48	445	11	1	1	51	107	5	410	11	106	1,729
1986	905	81	275	7	1	2	31	99	9	528	2	113	2,053
1987	1,143	115	275	4	23	1	28	73	5	866	30	128	2,691
1988	1,413	179	411	4	31	1	44	68	24	515	15	185	2,890
1989	970	230	362	6	26	0	31	19	5	259	14	82	2,004
1990	1,324	182	261	195	7	0	21	71	8	472	15	64	2,620
1991	1,138	187	237	3	0	0	9	63	28	293	19	139	2,116
1992	624	384	415	1	1	1	21	90	32	389	18	122	2,098
1993	909	130	266	2	5	1	45	48	29	457	14	124	2,030
1994	845	174	205	4	6	0	20	33	51	586	12	92	2,028
1995	680	234	166	4	4	1	22	33	85	560	22	109	1,920
1996	696	247	127	7	2	0	32	64	67	635	16	124	2,017
1997	677	282	159	45	2	1	22	50	83	425	26	157	1,929
1998	985	261	204	30	1	1	24	41	123	306	14	171	2,162
1999	1,054	308	244	27	1	1	84	42	103	384	13	149	2,410
2000	1,117	501	211	131	3	0	33	64	97	552	9	121	2,840
2001	1,040	311	316	13	2	1	30	24	86	484	17	119	2,442
2002	1,016	295	247	10	1	4	31	21	118	645	27	192	2,607
average	983	162	315	15	18	34	81	37	38	549	20	151	2,403
%	41	7	13	1	1	1	3	2	2	23	1	6	100

Table2.(1) Catch volume of Skates by type of fisheries in Hokkaido 1968-2002(tons)

Year	Pelagic trawl fishery	Offshore trawl fishery	Small type trawl	net trawl subtotal	flounder gillnet	pollock gillnet	cod gillnet	Atka mackerel gillnet	king crab gillnet	other gillnet	gillnet subtotal
1968	0	698	23	721	505	5	0	4	0	250	764
1969	0	491	36	527	327	5	0	6	1	415	754
1970	0	814	30	844	450	2	0	5	1	503	961
1971	0	0	15	15	658	8	0	2	0	645	1,313
1972	0	0	4	4	427	12	0	27	4	417	887
1973	0	0	13	13	362	23	0	3	23	557	968
1974	0	57	4	61	260	2	0	18	0	384	664
1975	0	37	8	45	330	0	0	9	10	1,310	1,659
1976	0	28	4	32	376	169	0	63	58	1,231	1,897
1977	0	41	4	45	304	11	0	9	54	3,065	3,443
1978	0	4	8	12	280	2	27	11	14	1,530	1,864
1979	0	25	5	30	262	4	598	22	0	2,025	2,911
1980	0	35	6	41	379	1	939	0	0	3,363	4,682
1981	0	34	8	42	360	2	257	2	3	2,123	2,747
1982	0	531	3	534	355	14	216	1	9	2,442	3,037
1983	0	307	2	309	456	0	94	1	0	1,476	2,027
1984	0	551	8	559	381	0	97	0	5	2,080	2,563
1985	0	28	11	39	240	1	120	2	20	1,186	1,569
1986	0	239	15	254	199	5	93	18	8	1,236	1,559
1987	0	223	6	229	218	0	72	3	4	1,909	2,206
1988	0	161	6	167	230	1	22	9	0	1,934	2,196
1989	0	132	3	135	214	0	68	3	0	1,194	1,479
1990	0	364	7	371	256	2	19	4	0	1,655	1,936
1991	0	184	3	187	364	0	10	1	0	1,231	1,606
1992	0	172	7	179	345	12	12	9	0	1,022	1,400
1993	0	253	13	266	186	7	17	5	0	1,205	1,420
1994	0	328	10	338	213	5	30	9	0	1,019	1,276
1995	0	283	9	292	207	2	26	1	0	1,118	1,354
1996	0	259	17	276	203	2	28	4	0	1,154	1,391
1997	0	242	45	287	204	3	25	128	0	882	1,243
1998	0	474	38	512	258	20	52	10	0	920	1,260
1999	0	436	21	457	223	30	38	11	0	1,199	1,502
2000	546	349	19	914	232	18	39	9	0	1,280	1,578
2001	0	245	26	271	369	19	59	9	0	1,149	1,604
2002	0	366	21	387	328	7	50	4	0	1,401	1,789
average	16	240	13	265	313	11	86	12	6	1,329	1,757
%	1	10	1	11	13	0	4	1	0	55	73

Table2.(2)

Year	cod and shark longline	baitless longline	pollock longline	other longline	longline subtotal	salmon set net	other large type set net	small type set net	set net subtotal	others	Total
1968	345	49	0	492	886	40	0	53	93	4	2,468
1969	224	16	0	368	608	32	4	54	90	0	1,979
1970	148	82	1	272	503	111	6	66	183	4	2,495
1971	48	24	8	51	131	38	1	39	78	16	1,553
1972	14	22	7	118	161	33	1	40	74	3	1,129
1973	94	13	32	182	321	40	0	39	79	0	1,381
1974	65	7	4	92	168	33	1	99	133	3	1,029
1975	79	13	6	158	256	25	1	108	134	1	2,095
1976	85	9	10	146	250	43	0	112	155	2	2,336
1977	68	2	5	105	180	43	0	91	134	3	3,805
1978	0	4	5	105	114	31	1	71	103	2	2,095
1979	0	0	1	100	101	13	1	79	93	0	3,135
1980	0	0	0	284	284	28	3	143	174	0	5,181
1981	0	0	0	244	244	35	2	59	96	0	3,129
1982	0	0	0	125	125	30	10	61	101	0	3,797
1983	0	0	0	155	155	29	19	101	149	0	2,640
1984	0	0	0	17	17	30	27	72	129	0	3,268
1985	0	0	0	14	14	10	7	90	107	0	1,729
1986	0	0	0	138	138	32	18	52	102	0	2,053
1987	0	0	0	193	193	20	9	34	63	0	2,691
1988	0	0	0	440	440	32	9	46	87	0	2,890
1989	0	0	0	327	327	29	3	31	63	0	2,004
1990	0	0	0	273	273	21	2	17	40	0	2,620
1991	0	1	0	256	257	32	3	30	65	1	2,116
1992	0	0	0	421	421	55	5	38	98	0	2,098
1993	0	1	0	286	287	13	5	39	57	0	2,030
1994	0	2	0	332	334	26	2	52	80	0	2,028
1995	0	0	0	189	189	30	4	51	85	0	1,920
1996	0	1	0	242	244	29	6	69	104	2	2,017
1997	0	15	0	247	262	44	7	78	129	7	1,929
1998	0	2	0	213	215	73	6	95	174	1	2,162
1999	0	2	0	274	276	92	12	71	175	0	2,410
2000	0	4	0	159	163	59	5	120	184	1	2,840
2001	0	4	0	313	317	120	16	111	247	3	2,442
2002	0	3	0	188	191	108	10	121	239	1	2,607
average	33	8	2	215	258	42	6	69	117	2	2,403
%	1	0	0	9	11	2	0	3	5	0	100

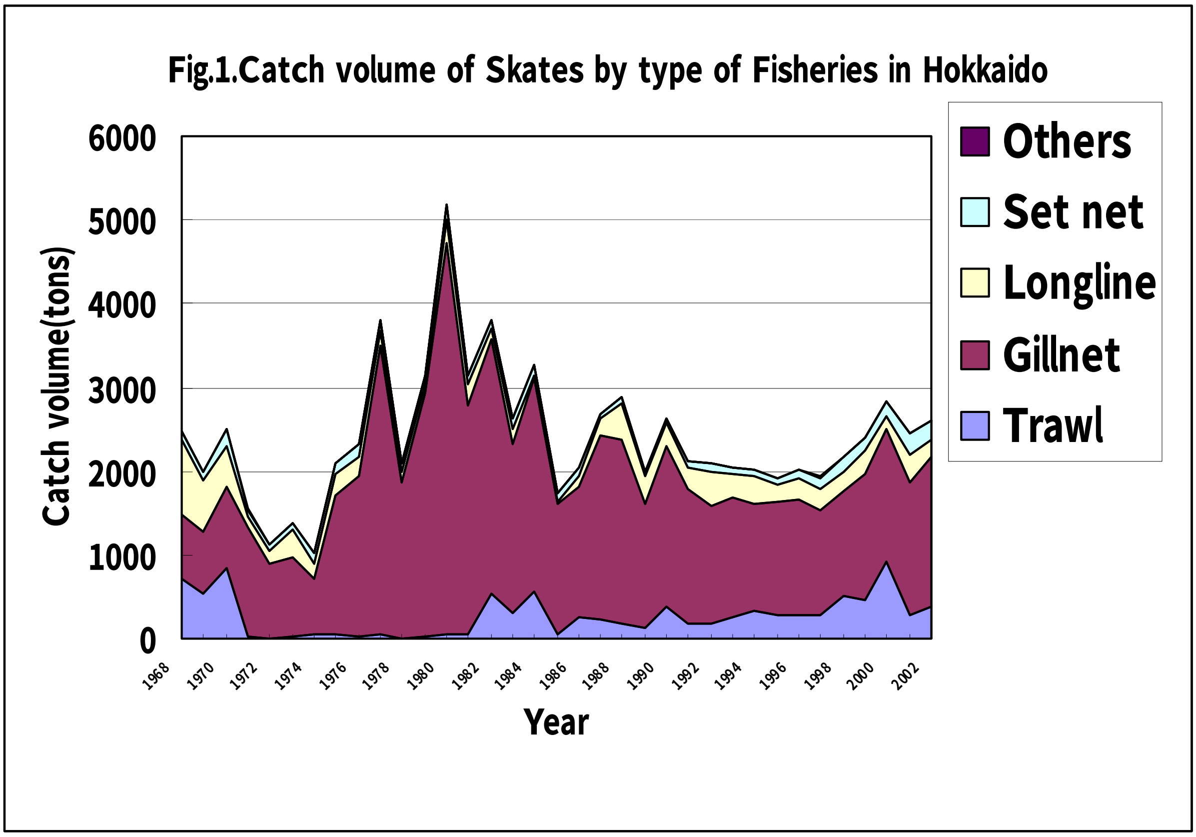
Fig.1.Catch volume of Skates by type of Fisheries in Hokkaido
Catch volume(tons)
6000
5000
4000
3000
2000
1000
0
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
Year
Others
Set net
Longline
Gillnet
Trawl

Table3. Fishing unit, fishing days, catch volume, skates catch per fishing unit and skates catch per fishing days by flounder gillnet in Hokkaido 1968-2002

Year	Fishery unit	Fishing days	Catch volume(tons)	Skates catch volume(tons)	Skate catch per fishing unit x100	Skates catch per fishing days x10000
1968	4,025	244,855	26,428	505	12.5	20.6
1969	3,711	240,882	24,695	327	8.8	13.6
1970	3,830	238,647	29,275	450	11.7	18.9
1971	3,671	214,224	30,364	658	17.9	30.7
1972	3,655	222,603	27,047	427	11.7	19.2
1973	3,643	226,332	27,220	362	9.9	16.0
1974	3,841	234,715	27,690	260	6.8	11.1
1975	3,851	235,605	31,401	330	8.6	14.0
1976	3,819	238,307	31,918	376	9.8	15.8
1977	4,341	296,156	38,762	304	7.0	10.3
1978	4,283	302,691	36,540	280	6.5	9.3
1979	4,528	309,816	33,763	262	5.8	8.5
1980	4,598	318,855	31,700	379	8.2	11.9
1981	4,594	319,284	33,897	360	7.8	11.3
1982	4,551	302,855	34,433	355	7.8	11.7
1983	4,382	263,819	28,238	456	10.4	17.3
1984	4,466	289,723	32,480	381	8.5	13.2
1985	4,524	314,558	32,334	240	5.3	7.6
1986	4,363	289,393	27,808	199	4.6	6.9
1987	4,308	300,768	27,429	218	5.1	7.2
1988	4,391		27,133	230	5.2	
1989	4,376		26,715	214	4.9	
1990	4,464		28,377	256	5.7	
1991	4,249		26,610	364	8.6	
1992	4,234		26,250	345	8.1	
1993	4,059		23,250	186	4.6	
1994	3,727		19,227	213	5.7	
1995	3,714		21,527	207	5.6	
1996	3,742		22,299	203	5.4	
1997	3,710		23,742	204	5.5	
1998	3,416		22,091	258	7.6	
1999	3,250		21,605	223	6.9	
2000	3,251		21,188	232	7.1	
2001	3,018		20,276	369	12.2	
2002	3,188		21,207	328	10.3	
average	**3,994**	**270,204**	**27,569**	**313**	**8.0**	**13.7**

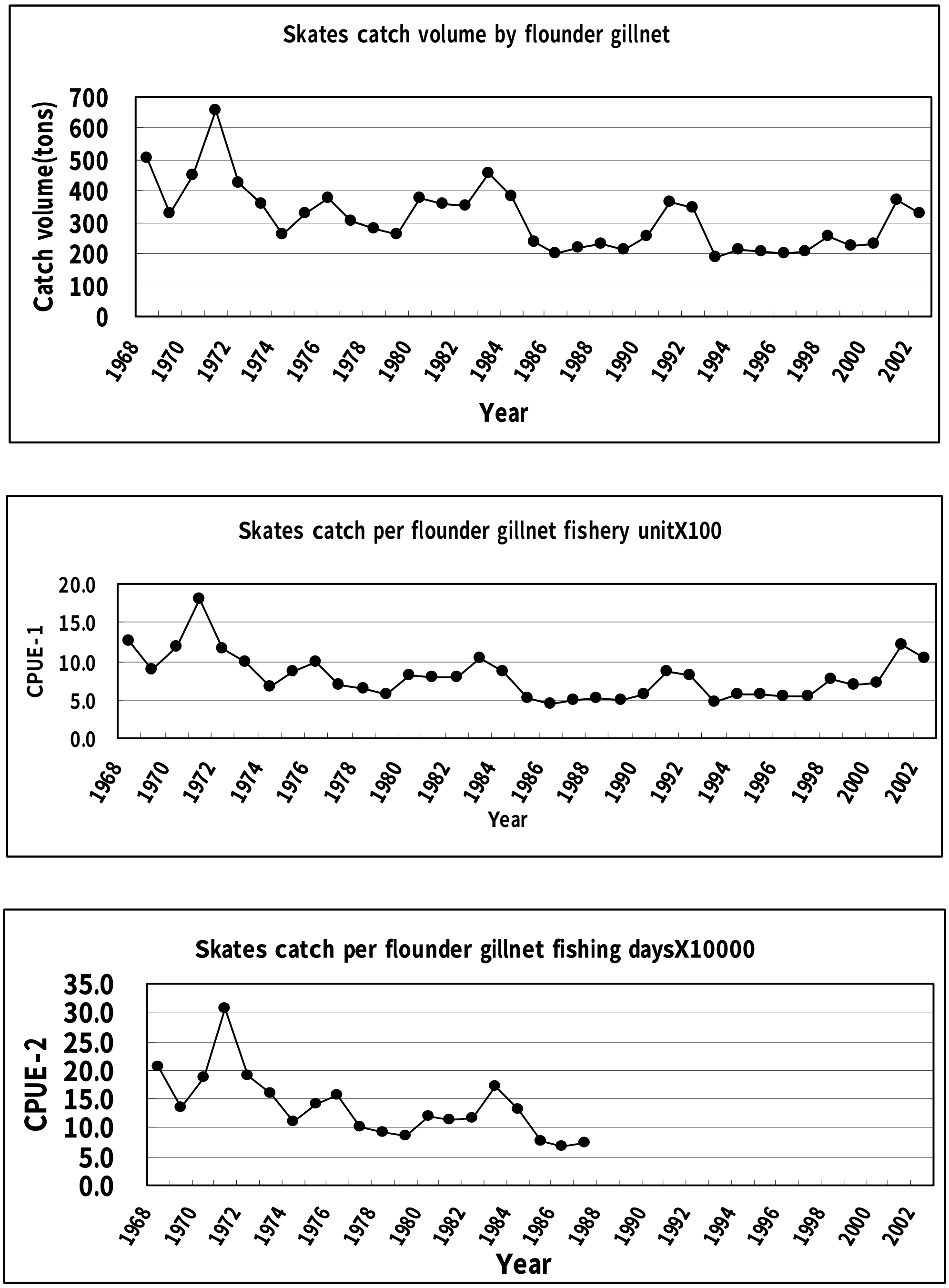

Fig.2 Skates catch volume, catch per fishery unit and catch per fishing days by flounder gillnet