Reconsideration of catch of shortfin mako (*Isurus oxyrinchus*) caught by Japanese large-mesh driftnet fishery between 1975 and 1993 in the North Pacific.[1]

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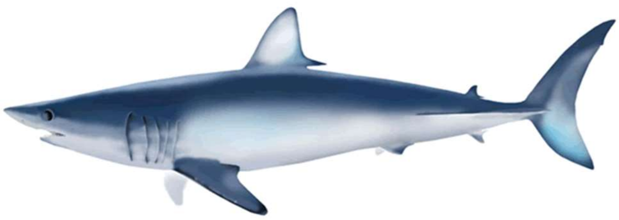

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Abstract

The catch of shortfin mako (*Isurus oxyrinchus*) caught by large-mesh driftnet fishery in the North Pacific between 1977 and 1993 at high seas was revisited due to high uncertainty in the previous estimate and recent update for the catch of blue shark by this fishery. Considering the possible underreporting of sharks and lack of species-specific reporting system of this species in the logbook data of large-mesh driftnet fishery, estimation using species compositions (three values) derived from observer data (1990-1991) on this fishery (approach 1) and survey data for pomfret (1978-1984) with similar gear modification and operation area with commercial vessel (approach 2), and a mixture of the species composition derived from approaches 1 and 2 (approach 3) were applied to the landing statistics of "sharks" in Japanese statistical yearbook. The estimated catch derived from approach 3 was chosen by considering the annual variability of the species composition and ranged from 81.5 to 606.5 ton. These estimates were smaller than those used in the previous stock assessment for this population in 2018, but the previous catch estimate of this fishery was likely to be overestimate, considering that the ratio between shortfin mako catch per blue shark catch was unreasonably higher than that derived from observer and survey data. Although work for further improvement needs to be continued, we propose to use the estimated catch in this working paper for the upcoming stock assessment of shortfin mako in the North Pacific in 2024.

Introduction

In the North Pacific, shortfin mako (*Isurus oxyrinchus*, hereafter indicated as SMA) has been caught as bycatch by various type of fishery in Japan. Domestically, landing by longline dominated (80% of total shortfin mako landed) and the ratio of catch by driftnet fishery is 17% (Semba and Kai 2023). Before the introduction of moratorium for high sea driftnet fishery in 1993, Japan had two types of driftnet fishery, consisting of large mesh driftnet and squid driftnet fishery at high seas. There was concern about the impact of these fishery on ecosystem, such as bycatch of sharks, seabirds, and marine mammals. Impact on blue shark was estimated by several studies (e.g., McKinnell and Seki 1998; Ichii et al. 2017), and the amount of bycatch was also estimated (Yatsu et al. 1993), especially for squid driftnet fishery, but the information on the impact by large mesh driftnet fishery on sharks at high seas before 1993 is relatively small. In case of Japan, logbook data between 1977 and 1993 and observer data between 1990 and 1991 were available, regarding Japanese large-mesh driftnet fishery before the moratorium.

As indicated in the report of last stock assessment of SMA (ISC Shark Working Group 2018), the catch for the early period (1975-1993) was highly uncertain because species-specific catch was not reported for major fisheries. Details on the method and material for the estimated catch by Japanese driftnet fishery is unknown, but there is possibility that the catch of blue shark used in the stock assessment of blue shark in 2009 (Kleiber et al. 2009) was converted for the use of estimation of SMA catch. As this estimate in 2009 assessment was also uncertain in terms of method and materials for the estimation and unreasonable constant value for some years, the catch of blue shark by Japanese large mesh driftnet fishery was updated in the stock assessment of blue shark in 2022 (Fujinami et al. 2021). Considering same problem in SMA, it is necessary to update the catch of shortfin mako by this fishery, at least, using the same approach. The aim of this document is to re-estimate the catch of SMA by Japanese large mesh driftnet between 1975 and 1993, based on other data sources available.

Materials and methods

Data Source

1. *Logbook data*

   Logbook data of large mesh driftnet was available between 1977 and 1993. This data includes tonnage of the vessel, date and location of operation, sea surface temperature, effort (i.e., number of tan), gear configuration (e.g., length of each tan and mesh size) and species-specific catch in number per operation. Regarding the catch of shark, only catch for blue shark and salmon shark was reported and that of SMA was unknown.

2. *Japanese statistical yearbook ("Norin tōkei")*

   Japan fishery agency complies the yearbook and opens the data to the public every year through Ministry of Agriculture, Forestry and Fisheries. The yearbook contains landing data covering wide areas in Japan and includes total amount of catches for sharks caught by different fishing gears after 1951, however, the shark species are aggregated into one category "sharks" after 1967 (Fujinami et al. 2021). We assumed that this landing was derived from the operation conducted in the North Pacific, considering that fishermen unlikely bring sharks to Japan from the South Pacific.

3. *Scientific observer data of large mesh driftnet*

   Scientific observer data on board large mesh driftnet vessel was available between 1990 and 1991. This data contains detailed information on each set; fishing date (year, month, day, time), fishing area (latitude and longitude), environmental condition (sea surface temperature and oceanic condition) at the time of driftnet deployment and retrieval, gear configurations (mesh size, number of deployed nets, length of one net) and catch in number of all species caught by the driftnet fishery (Fujinami et al. 2021).

4. *Driftnet survey data for pomfret*

   Japan Marine Fisheries Resources Research Center (JAMARC; presently the Marine Fisheries Research and Development Center of Fisheries Research Agency) conducted a large-mesh driftnet surveys targeting pomfret (Bramidae) between 1978 and 1984. A series of surveys was conducted exclusively in the North Pacific Ocean (Fig.1), mainly between May and January (some operation from February to April). The setting began in the afternoon and ended around the sunset and then retrieved 5–7 hours after the setting. Mesh sizes of 160 mm were mostly used[1], and the net depth was approximately 10 m from the sea surface (estimated from 66.5 "kake" and mesh size)[2]. The mean number of nets (i.e., number of "tan") per set was 808 and the length of the unit net was 33.0 m. This survey data consists of the details of the operations (date, location, time of setting and retrieval, number of nets, water temperature from three layer) and the catches of 24 species in numbers and weights. Regarding sharks, catch of salmon shark, blue shark, shortfin mako, thresher shark (Alopias spp.) and hammerhead sharks (Sphyrna spp.) were recorded.

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[1] Mesh size used in commercial vessel: 165~180 mm

[2] Depth of net used in commercial vessel: 8~11 m

Approach of estimation

Approach 1. Estimation by species composition from observer data and aggregated shark landing data.

Species composition (in number) calculated from all observer data (year aggregated: Material No.3) was multiplied to the landing data of sharks (aggregated: in weight) in each year (i) in Norin tokei (Material No. 2). The species composition used here (Fujinami et al. 2022) was calculated by aggregated number of shortfin mako and aggregated number of all sharks (all period).

$$Catch_i = Species\ composition\ in\ number\ (observer) \times landing\ (weight)_i$$

Approach 2. Estimation by species composition of driftnet survey data and aggregated shark landing data.

Species composition calculated from pomfret survey data (Material No.4) was multiplied to the landing data of sharks (aggregated) in each year (i) in Norin tokei (Material No. 2). In survey data, both species-specific number and weight are available, species composition in weight was calculated. As this dataset is available between 1978 and 1984 and no data was available for the period between 1975 and 1977 and between 1985 and 1993, mean value of species composition between 1978 and 1984 was applied for each year to estimate the catch of SMA.

$$Catch_i = \overline{Species\ composition\ in\ weight\ (survey\text{: } 1978 - 1984)} \times landing(weight)_i$$

For comparison, estimate based on species composition in number was also calculated.

Approach 3. Combination of Approach 1 and Approach 2

Catch of SMA was estimated by applying species composition estimated by Approach 2 (i.e., 5.0%) to the period between 1975 and 1989 and that estimated by Approach 1 (i.e., 5.9%) to the period between 1990 and 1993, considering the possible effect of annual change of operation area of this fishery on the species composition (Fig. 2).

Results

Catch estimated by Approach 1 ranged from 82 (1992) to 698 (1978) ton (Table1). The species composition applied here is 5.9% (see Table1 in Fujinami et al. 2021). Catch estimated by Approach 2 ranged from 70.9 to 606.5 (1977) ton (Table2). The species composition applied in this approach was 5.0% and mean composition estimated from catch number was also 5.0%. Thus, the effect of unit (i.e., catch number or weight) is likely to be small. Table 3 shows the estimated applying approach 1 for the landing between 1975 and 1989 and approach 2 for the landing between 1990 and 1993.

Although the catch of F12 (Japanese driftnet) used in the previous assessment might include both catch of large-mesh driftnet and squid driftnet fishery, the estimated catch by each approach was much lower than catch used in previous assessment.

Discussion

As known, Japanese large-mesh driftnet fishery changed the operation area historically; operation in the coastal area targeting for striped marlin (and swordfish) in 1970's followed by expansion of fishing area to the eastward targeting for albacore (and skipjack) in 1980's (Nakano et al. 1993). Effort distribution of logbook data indicates that fishing ground in 1990's was southward and eastward compared to the earlier period (See Fig. 1) and thus, approach 3 would be reasonable rather than approach 1 and 2. As only number-based composition was available in Approach 1 (observer data: 1990-1991), application of weight-based composition (available in survey data) would be more appropriate.

In this revision of SMA catch by Japanese large mesh driftnet fishery before 1993, estimation by statistical approach for logbook data was not conducted because of the possibility of under-reporting suggested in blue shark (Fujinami et al. 2021) and there is no information about the catch of SMA in the logbook data. Preliminary analysis that catch of SMA was raised by coverage ratio of effort between logbook data and survey data provided much smaller catch, which was partly because of error data in the compiled logbook data (e.g., effort data). Instead, another data source was used to estimate the species composition of SMA in this reconsideration. As future work (after completion of correction of logbook data), it may be worth to evaluate the effectiveness of statistical approach adopted for the estimation of blue shark's catch by squid driftnet fishery based on observer data (Fujinami et al. 2021) to increase the reliability.

The mean value of catch ratio between SMA and blue shark (SMA catch/blue shark catch) between 1975 and 1993 for "Japanese driftnet fishery" based on estimates used in previous assessment (2017 for blue shark and 2018 for SMA) was about 60% (102% after revision of blue shark catch in 2021), while that calculated from survey data and observer data was 1.9% and 6.7%, respectively. Mean ratio based on species-specific landing data after 1992 is 9.5% (Semba 2023). Although further examination is necessary, such information suggests the possibility that past catch of SMA of this fishery might be over-estimate. Generally, the biomass (and probably catch) of SMA is expected to be lower than that of blue shark from lower productivity of SMA compared to blue shark (Yokoi et al. 2017). Considering the impact of this fishery in the early period is high (ISC Shark Working Group 2018), it is necessary to discuss the best approach to estimate the impact of this fishery and continue the improvement of estimation of mortality by this fishery.

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Table1 Estimated catch of SMA by approach 1. Species composition of 5.9% was applied to landing of each year.

year	Catches of sharks in “Norin-toukei” (ton)	Estimated catches in weight (ton)	Catches (F12) used in the stock assessment
species	All sharks	Shortfin mako	Shortfin mako
1975	3,898	230	1,329
1976	7,179	424	1,329
1977	11,822	698	1,329
1978	7,222	426	1,329
1979	5,350	316	1,329
1980	3,884	229	1,329
1981	3,810	225	4,142
1982	3,817	225	4,142
1983	2,871	169	4,064
1984	3,127	185	3,810
1985	3,011	178	3,607
1986	3,349	198	3,674
1987	2,982	176	3,655
1988	2,463	145	3,595
1989	2,051	121	5,007
1990	1,787	105	2,630
1991	2,127	126	2,630
1992	2,012	119	1,639
1993	1,381	82	139

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Table 2. Estimated catch of SMA by approach 2. Species composition of 5.0 % was applied to landing of each year.

year	Catches of sharks in "Norin-toukei" (ton)	Estimated catches in weight (ton)	Catches (F12) used in the stock assessment (2018)	Ratio of shortfin mako in sharks (in weight)	Ratio of shortfin mako in sharks (in number)
species	All sharks	Shortfin mako	Shortfin mako	Shortfin mako	Shortfin mako
1975	3,898	200.0	1,329		
1976	7,179	368.3	1,329		
1977	11,822	606.5	1,329		
1978	7,222	370.5	1,329	0.01	0.01
1979	5,350	274.5	1,329	0.02	0.02
1980	3,884	199.3	1,329	0.04	0.04
1981	3,810	195.5	4,142	0.09	0.08
1982	3,817	195.8	4,142	0.04	0.03
1983	2,871	147.3	4,064	0.04	0.05
1984	3,127	160.4	3,810	0.11	0.13
1985	3,011	154.5	3,607		
1986	3,349	171.8	3,674		
1987	2,982	153.0	3,655		
1988	2,463	126.4	3,595		
1989	2,051	105.2	5,007		
1990	1,787	91.7	2,630		
1991	2,127	109.1	2,630		
1992	2,012	103.2	1,639		
1993	1,381	70.9	139		
Mean				0.051	0.050

Table 3. Estimated catch of SMA by approach 2. Species composition of 5.0 % was applied to landing between 1975 and 1989 and 5.9% was applied to landing between 1990 and 1993.

year	Catches of sharks in “Norin-toukei” (ton)	Estimated catches in weight (ton)	Catches (F12) used in the stock assessment (2018)
species	All sharks	Shortfin mako	Shortfin mako
1975	3,898	200.0	1,329
1976	7,179	368.3	1,329
1977	11,822	606.5	1,329
1978	7,222	370.5	1,329
1979	5,350	274.5	1,329
1980	3,884	199.3	1,329
1981	3,810	195.5	4,142
1982	3,817	195.8	4,142
1983	2,871	147.3	4,064
1984	3,127	160.4	3,810
1985	3,011	154.5	3,607
1986	3,349	171.8	3,674
1987	2,982	153.0	3,655
1988	2,463	126.4	3,595
1989	2,051	105.2	5,007
1990	1,787	105.4	2,630
1991	2,127	125.5	2,630
1992	2,012	118.7	1,639
1993	1,381	81.5	139
Mean			

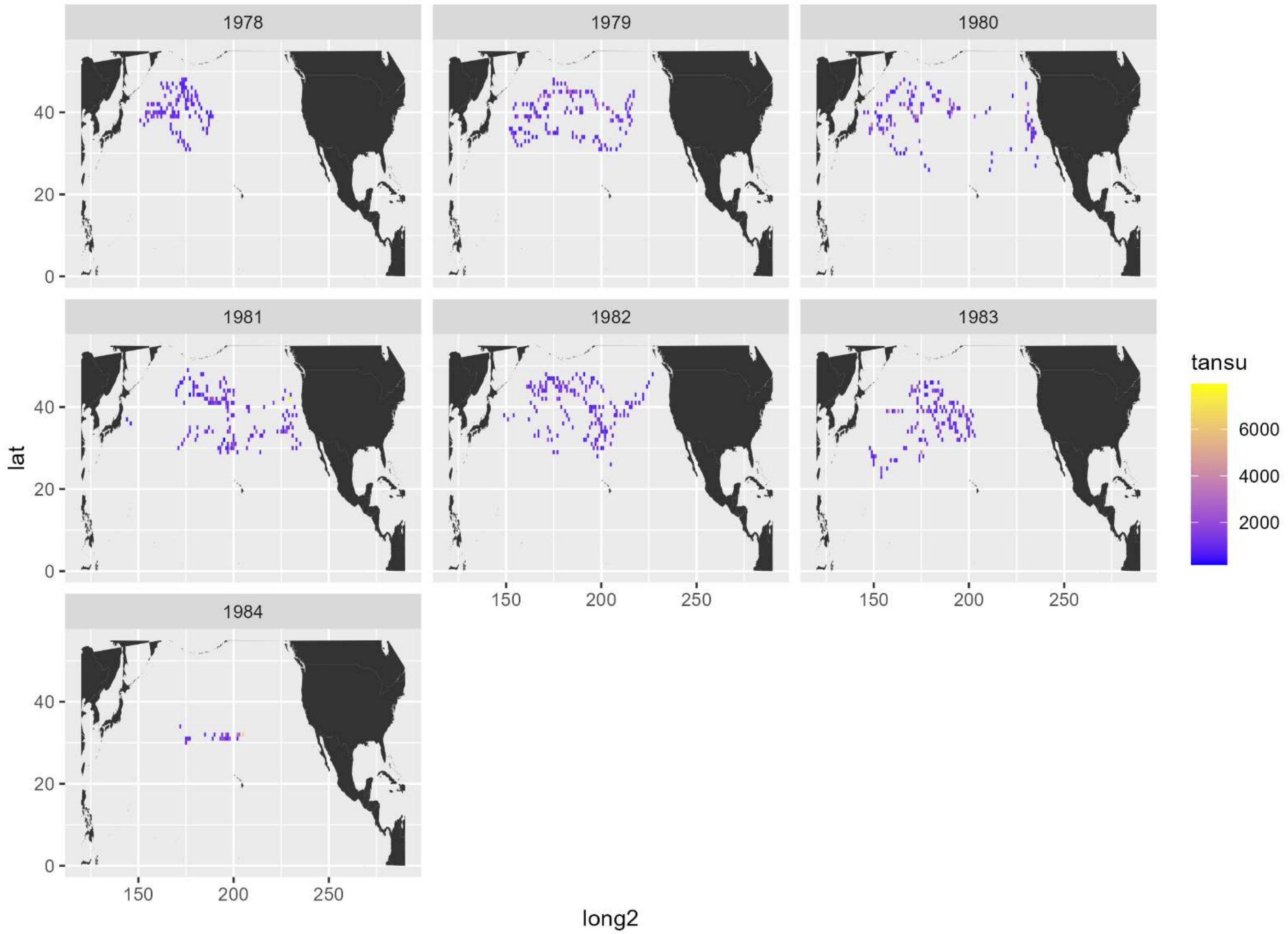

Fig.1 Annual distribution of effort of pomfret survey. Effort was calculated by applying number of tan by length of tan per set.

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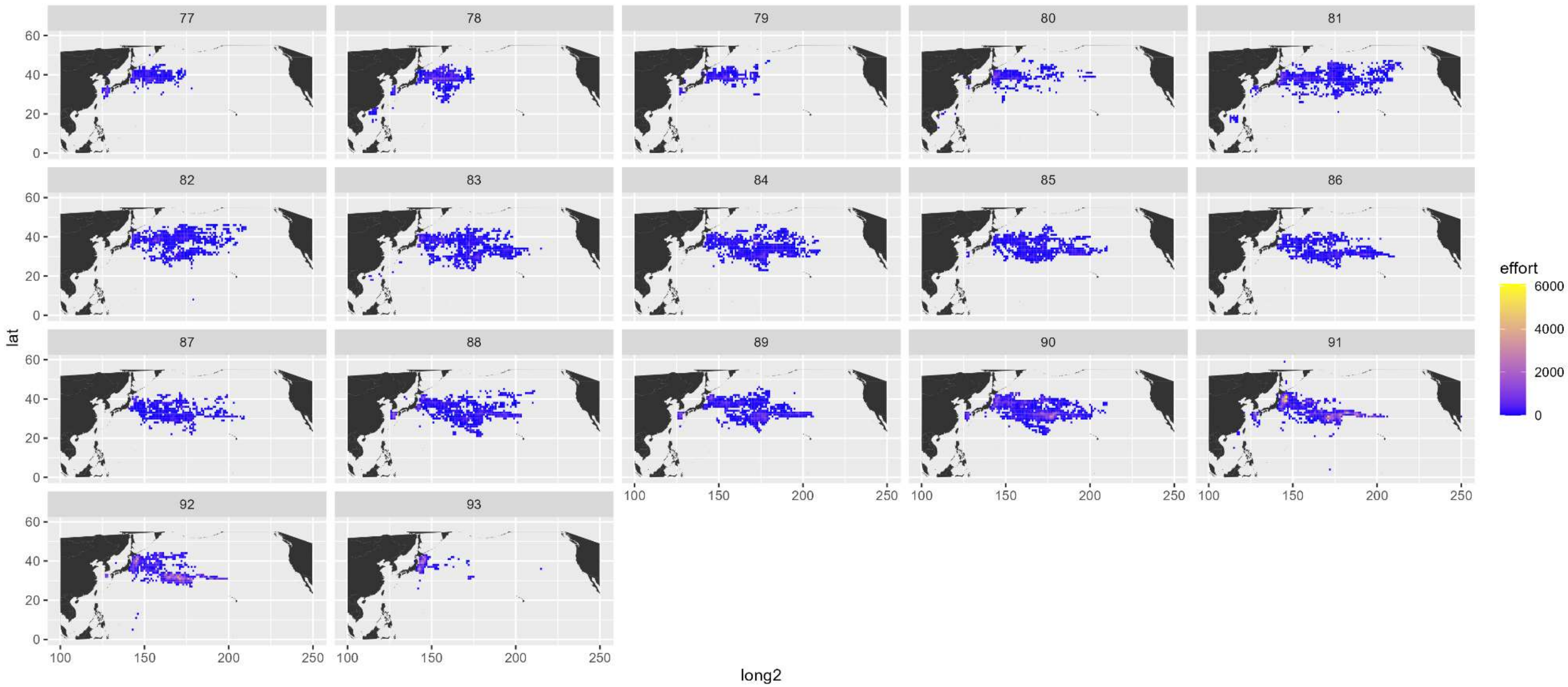

Fig.2 Annual distribution of effort of logbook data of Japanese driftnet fishery between 1975 and 1993. Effort was calculated by applying number of tan by length of tan per set