# Update of annual catches for shortfin mako caught by Japanese offshore and distant water longliner in the North Pacific Ocean from 1994 to 2022[1]

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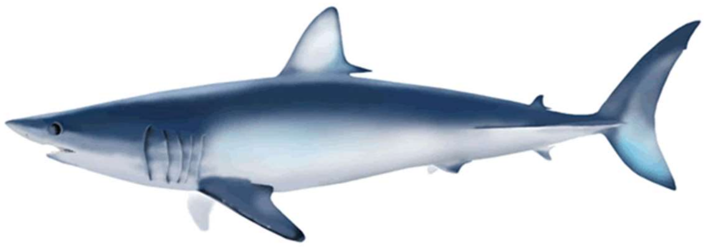

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**Abstract**

This working paper provides update of Japanese annual catches of shortfin mako, *isurus oxyrinchus*, caught by Japanese offshore and distant-water longline fishery in the North Pacific Ocean for 1994-2022. Since the landings of sharks is frequently underestimated due to the lower market value than any other teleost species such as tunas and billfishes, total annual catches of shortfin mako including retained, discard and released catches were estimated using a product of standardized annual CPUEs and the total annual fishing effort (the number of hooks) for 1994-2022. The calculation was separated by the shallow-set and deep-set longline fisheries. The annual catch number for shallow-set longline fishery was estimated using the season-year specific CPUEs for Japanese offshore and distant water shallow-set longline fishery with the fishing efforts of the shallow-set fishery, while those for deep-set longline fishery was estimated using the annual CPUEs for Japanese research and training vessels with the fishing efforts of the deep-set fishery. Further, the annual catch number was converted to annual catch weight using an average weight of shortfin mako by area and season. The results showed that the annual catch was stable between 1200 *t* and 1700 *t* until 2017, and then it had gradually decreased and reached around 500 *t* in recent years due to the continuous reduction of fishing effort, especially for the deep-set fishery.

## Introduction

Shortfin mako, *Isurus oxyrinchus*, in the North Pacific Ocean is frequently caught as bycatch by pelagic longline fisheries targeting tuna and billfish (Kai et al. 2017). Since the market value of shortfin mako is lower than any other species such as tunas and billfishes, total catches (retained, discarded, and released catches) for shortfin mako landed in Japan is frequently underestimated. Therefore, the total catch in number of shortfin mako caught by Japanese offshore and distant water longline fishery in the North Pacific Ocean were estimated by multiplying the annual abundance index by the annual fishing effort in the previous data analysis for the benchmark stock assessment in 2018 (Kai and Semba, 2017).

The objective of this document paper is to update annual catch in number and weight of shortfin mako caught by Japanese offshore and distant water longline fishery in the entire North Pacific Ocean from 1994 to 2022.

## Materials and Methods

### *Data source*

The author used 1) Japanese longline logbook data collected in the entire North Pacific

Ocean for 1994-2022, 2) standardized CPUE of shortfin mako caught by Japanese offshore and distant water longline fishery and Japanese research and training vessel fishery in the North Pacific Ocean from 1994 to 2022 (Kai, 2023a, b), 3) an average of nominal CPUE for the shallow-set and deep-set fisheries from 1994 to 2022, and 4) season and area specific mean body weight of shortfin mako in the North Pacific Ocean that was calculated using "Gyoseki" which is logbook datasets including catch number ("L5n") and catch weight ("L5w") aggregated with spatial resolutions of 5 x 5 degrees (**Table 1**). This database was updated in recent years and conversion factor from processed weight to round weight was applied to the data.

*Definition of four fleets*

The author separated the Japanese offshore and distant water longline fishery into four fleets in accordance with the previous analysis (Kai and Semba, 2017):

1) Japanese offshore "Kinkai" shallow-set longline fisheries,
2) Japanese distant water "Enyo" shallow-set longline fisheries,
3) Japanese offshore "Kinkai" deep-set longline fisheries,
4) Japanese distant water "Enyo" deep-set longline fisheries,

where offshore fleet was defined by tonnage of vessels between 20 and 120 tons, distant water fleet was defined by vessels larger than 120 tons, "shallow-set" was defined by number of hooks between floats (HBF) smaller than 6, and "deep-set" was defined by HBF larger than 5.

*Definition of quarter and areas*

The author used three months quarter (1:Jan-Mar; 2:Apr-Jun; 3:Jul-Sep; 4:Oct-Dec) and five areas:

1) west of dateline ( ≤ 180 ºE ) and ≥ 30º N;
2) west of dateline ( ≤ 180 ºE ) and < 30º N;
3) east of dateline ( > 180 ºE and ≤ 150 ºW) and ≥ 30ºN;
4) east of dateline ( > 180 ºE and ≤ 150 ºW) and < 30ºN;
5) eastern Pacific Ocean ( > 150 ºW)

*Estimation of total catch for shallow-set longline fishery*

(1) The season-year specific scaled CPUEs from the spatio-temporal model for Japanese Kinkai shallow longline fishery (Kai, 2023a) were converted to the season-year specific absolute CPUEs using the mean value of the nominal CPUEs from 1994 to 2022 (0.68 individual per 1000 hooks).

(2) Catch number by season, area and year was estimated through multiplying the season-year specific absolute CPUEs by the season-, area-, and year- specific total fishing effort (i.e., number of hooks). If landed catch number was higher than estimated catch number, landed catch number was used as estimated catch number for the specific year-season.
(3) Catch weight by season, area and year was calculated through multiplying the catch number by the average weight of shortfin mako by season and area (**Table 1**).
(4) The catch number and weight were aggregated by the season and area, and then estimated the annual catch number and weight.

*Estimation of total catch for deep-set longline fishery*
(1) The year-specific scaled CPUEs from the spatio-temporal model for JRTV (Kai, 2023b) were converted to the year-specific absolute CPUEs using the mean value of the nominal CPUEs from 1994 to 2022 (0.098 individual per 1000 hooks).
(2) Catch number by season, area and year was estimated through multiplying the year-specific absolute CPUEs by season-, area-, and year-specific total fishing effort. If landed catch number was higher than estimated catch number, landed catch number was used as estimated catch number for the specific year.
(3) Catch weight was calculated through multiplying the catch number by the average weight of shortfin mako by season and area (**Table 1**).
(4) The catch number and weight were aggregated by the season and area, and then estimated the annual catch number and weight.

## Results

The estimated annual catch weight of shortfin mako caught by Japanese offshore and distant-water longline fishery showed a stable trend between 1200 *t* and 1700 *t* until 2007, and then it had gradually decreased and reached around 500 *t* in recent years (**Table 1**, **Fig. 1**) due to the continuous reduction of fishing effort, especially for the deep-set fishery (**Table 1**, **Fig. 2**). The updated annual catches for both shallow-set and deep-set fisheries had much increased (**Figs. 3, 4**) due to the increase of the mean body weight by area and season compared to the values used in the previous data analysis in 2017 (Kai and Semba, 2017).

## Discussions

The author updated Japanese annual catches of shortfin mako caught by Japanese offshore and distant-water longline fishery in the North Pacific Ocean for 1994-2022. The annual trends in catch weight indicated that the value has been decreasing since 2016 and reached to the historical lowest levels in recent years because of the decline of catches for both shallow-set and deep-set longline fisheries (**Fig. 1**) due to the continuous reduction of fishing effort.

In the previous data analysis for the benchmark stock assessment in 2018 (ISC, 2018), the annual CPUEs standardized by generalized linear model (GLM) were used to estimate the annual catch (Kai and Semba, 2017). Meanwhile, in this study, the annual CPUEs and year-season specific CPUEs standardized by spatio-temporal generalized linear model (GLMM) were used to estimate the annual catches. One of the merits using the spatio-temporal model is the direct use of the year-season specific CPUEs which enabled us to estimate the catch number more accurately. In addition, the accuracy of updated CPUEs for shallow-set and deep-set fisheries estimated by the spatio-temporal models were much better than that for those estimated by the GLM as the spatio-temporal model can treat the fine scale of spatial and temporal effects through spatio-temporal random effects (Thorson, 2019). The author therefore believes that the accuracy of updated catches of shallow-set and deep-set fisheries were much improved. Although the annual trends of standardized CPUEs for both fleets were significantly changed by altering the model from GLM to GLMM, the differences of the CPUEs between current and previous analysis had a small effect on the estimation of the catch compared to the effect of the increase in the mean body weight by area and season. The database "Gyoseki" had already been converted from the processed weight to round weight using the conversion factors. It is certain that the estimated mean body weight of shortfin mako by area and season has large uncertainties as the shortfin mako commonly landed by gilled and gutted without head with fins or processed form "fillet". The use of annual catch number instead of annual catch weight might be reasonable as input values of stock synthesis (SS) model if the main modeler concerns the large uncertainty in the conversion from the catch number to catch weight.

**Reference**

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**Table 1.** Average rounded body weight (kg) of shortfin mako by area and quarter.

| Area | Quartor | Body weight |
|---|---|---|
| 1 | 1 | 43.3 |
| 1 | 2 | 39.9 |
| 1 | 3 | 50.6 |
| 1 | 4 | 52.2 |
| 2 | 1 | 57.1 |
| 2 | 2 | 65.2 |
| 2 | 3 | 51.8 |
| 2 | 4 | 55.0 |
| 3 | 1 | 68.6 |
| 3 | 2 | 58.4 |
| 3 | 3 | 75.7 |
| 3 | 4 | 75.4 |
| 4 | 1 | 63.7 |
| 4 | 2 | 61.4 |
| 4 | 3 | 78.3 |
| 4 | 4 | 73.8 |
| 5 | 1 | 66.6 |
| 5 | 2 | 59.7 |
| 5 | 3 | 63.1 |
| 5 | 4 | 66.8 |

**Table 2.** Annual catch (number and tons) and landed catch (number and tons) of North Pacific shortfin mako caught by Japanese shallow and deep-sets longline fishery and the number of hooks (millions) from 1994 to 2022.

| Year | Number of catch | | Number of landed catch | | Weight of catch (tons) | | Weight of landed catch (tons) | | Numer of hooks (millions) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Shallow | Deep | Shallow | Deep | Shallow | Deep | Shallow | Deep | Shallow | Deep |
| 1994 | 7,172 | 14,548 | 3,197 | 8,396 | 451 | 896 | 205 | 534 | 25.5 | 117.5 |
| 1995 | 8,438 | 17,442 | 3,669 | 12,539 | 525 | 1119 | 229 | 832 | 24.1 | 113.3 |
| 1996 | 9,401 | 10,885 | 5,429 | 6,175 | 570 | 657 | 336 | 385 | 22.1 | 96.6 |
| 1997 | 10,085 | 10,650 | 6,939 | 5,995 | 610 | 658 | 416 | 379 | 21.6 | 90.2 |
| 1998 | 10,316 | 11,044 | 7,559 | 4,559 | 632 | 674 | 454 | 288 | 22.7 | 89.3 |
| 1999 | 11,504 | 16,196 | 9,759 | 4,768 | 716 | 987 | 606 | 302 | 22.9 | 99.1 |
| 2000 | 13,941 | 11,489 | 12,585 | 3,033 | 881 | 703 | 791 | 191 | 25.3 | 89.1 |
| 2001 | 13,240 | 9,611 | 10,903 | 2,803 | 842 | 588 | 679 | 182 | 25.4 | 92.0 |
| 2002 | 11,163 | 9,373 | 9,523 | 1,855 | 689 | 578 | 587 | 114 | 23.2 | 83.1 |
| 2003 | 11,113 | 9,348 | 9,982 | 2,257 | 691 | 588 | 617 | 151 | 20.2 | 80.5 |
| 2004 | 13,147 | 7,173 | 10,690 | 1,459 | 817 | 440 | 653 | 93 | 21.2 | 69.0 |
| 2005 | 14,229 | 6,368 | 12,798 | 1,688 | 897 | 396 | 804 | 111 | 19.0 | 60.6 |
| 2006 | 14,923 | 7,962 | 13,401 | 2,208 | 964 | 500 | 869 | 143 | 18.7 | 57.2 |
| 2007 | 17,794 | 7,478 | 15,704 | 1,665 | 1125 | 460 | 992 | 101 | 21.7 | 45.4 |
| 2008 | 14,202 | 4,524 | 13,018 | 1,530 | 890 | 280 | 810 | 99 | 19.8 | 41.8 |
| 2009 | 18,095 | 2,616 | 16,308 | 634 | 1132 | 159 | 1010 | 40 | 16.7 | 31.8 |
| 2010 | 17,542 | 3,156 | 13,987 | 742 | 1103 | 191 | 862 | 48 | 16.0 | 31.6 |
| 2011 | 9,857 | 2,828 | 9,415 | 911 | 598 | 174 | 570 | 60 | 8.9 | 38.8 |
| 2012 | 12,587 | 2,522 | 11,203 | 530 | 803 | 155 | 711 | 33 | 10.5 | 32.0 |
| 2013 | 10,075 | 1,375 | 8,499 | 523 | 622 | 86 | 520 | 35 | 11.2 | 28.9 |
| 2014 | 14,561 | 2,705 | 12,604 | 575 | 882 | 165 | 746 | 39 | 10.6 | 31.2 |
| 2015 | 14,186 | 3,918 | 13,136 | 277 | 874 | 236 | 807 | 18 | 8.9 | 27.9 |
| 2016 | 17,239 | 2,328 | 16,932 | 444 | 1092 | 143 | 1075 | 30 | 8.9 | 19.4 |
| 2017 | 12,274 | 1,256 | 12,007 | 180 | 777 | 74 | 762 | 11 | 8.4 | 16.5 |
| 2018 | 13,911 | 1,375 | 13,567 | 221 | 893 | 83 | 874 | 14 | 8.5 | 17.1 |
| 2019 | 12,422 | 1,395 | 12,056 | 164 | 785 | 83 | 765 | 11 | 8.1 | 15.9 |
| 2020 | 8,278 | 963 | 7,733 | 55 | 488 | 57 | 459 | 4 | 8.4 | 14.4 |
| 2021 | 6,695 | 848 | 6,032 | 33 | 406 | 51 | 371 | 2 | 6.7 | 11.4 |
| 2022 | 8,962 | 418 | 8,326 | 12 | 589 | 23 | 557 | 1 | 5.3 | 5.8 |

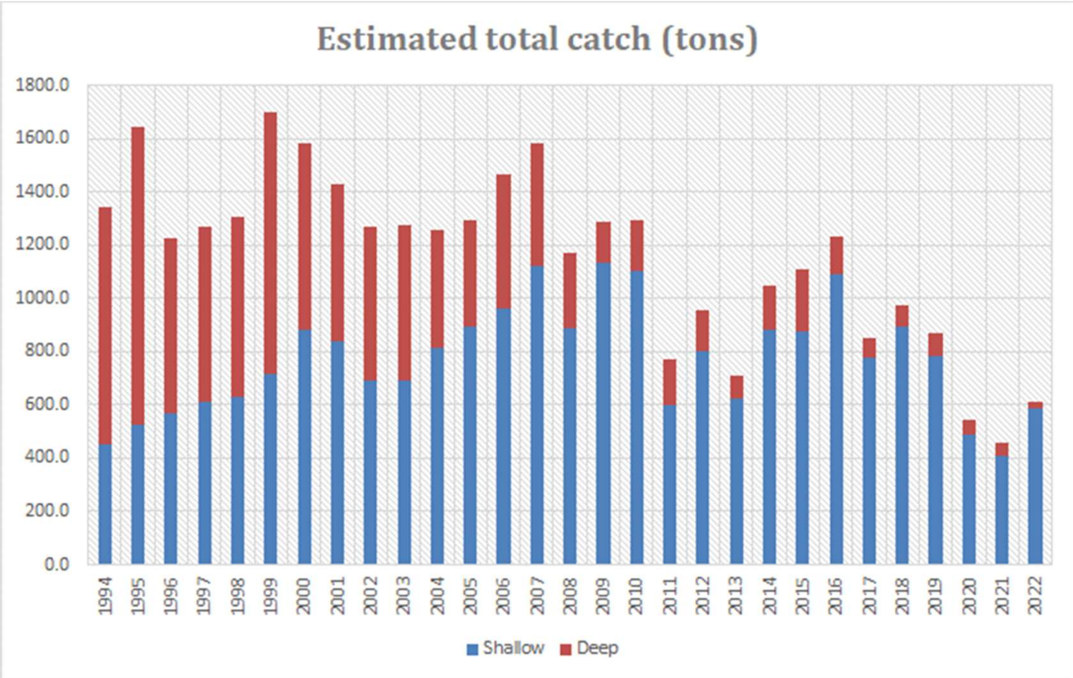


**Figure 1.** Annual change in estimated total catches (tons) for shallow and deep-set fishery from 1994 to 2022.

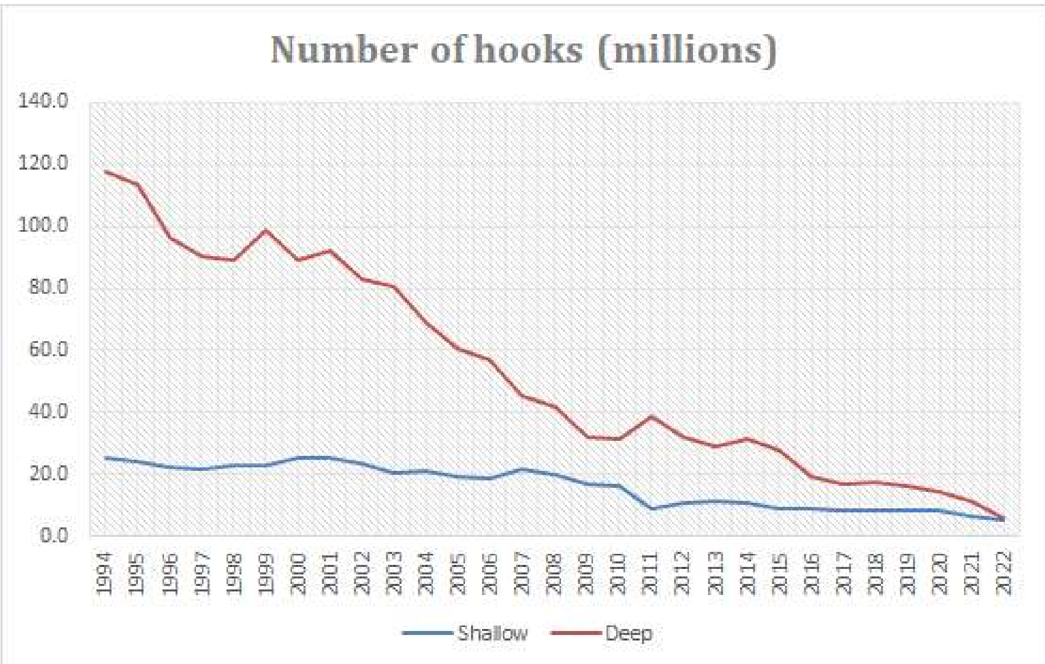


**Figure 2.** Annual change in number of hooks (millions) for shallow and deep-set fishery from 1994 to 2022.

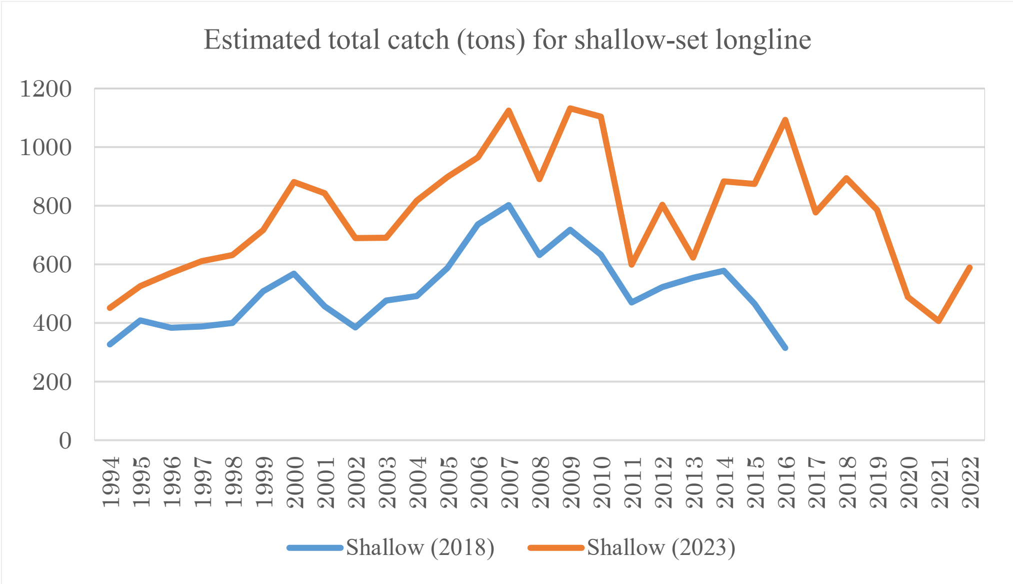


**Figure 3.** Comparisons of annual catch weight (tons) for shallow-set longline fishery from 1994 to 2022 with that used in the previous analysis in 2017.

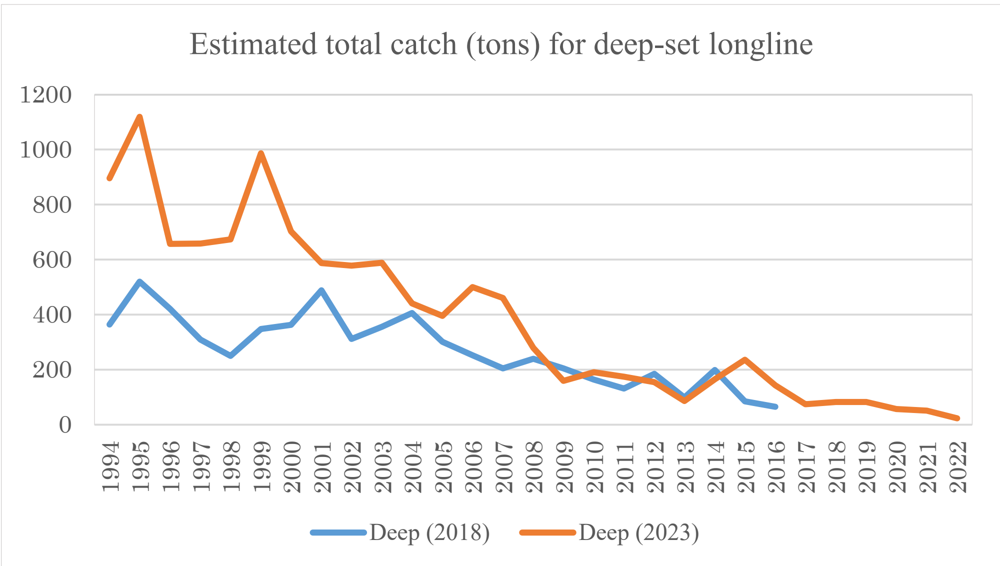


**Figure 4.** Comparisons of annual catch weight (tons) for deep-set longline fishery from 1994 to 2022 with that used in the previous analysis in 2017.