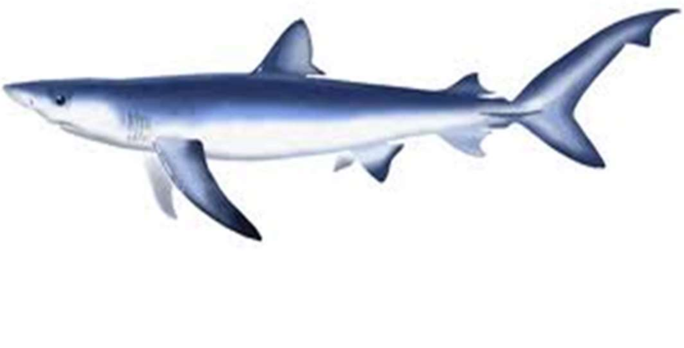
Reconstruction of catch for blue sharks caught by high seas squid driftnet fisheries of the Republic of Korea and Chinese-Taipei in the North Pacific from 1979 to 1992 [1]

Mikihiko Kai[2], Nicholas Ducharme-Barth[3], Yuki Fujinami[4], Steven L. H. Teo[5],

[2] Fisheries Resources Institute, Japan Fisheries and Education Agency,
5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan
[3] NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, Hawaii USA
[4] Fisheries Resources Institute, Japan Fisheries and Education Agency,
1551-8, Taira-machi, Nagasaki, 851-2213, Japan
[5] NOAA Fisheries, Southwest Fisheries Science Center, La Jolla, California USA

Email: kaim@affrc.go.jp



[1] Working document submitted to the ISC Shark Working Group Workshop, 19-22, 26-28 April 2022 (JST), Web-meeting. **Document not to be cited without author's permission.**

Summary

This working paper details the reconstruction of catch for blue sharks caught by high seas squid driftnet fisheries of the Republic of Korea and Chinese-Taipei in the North Pacific Ocean from 1979 to 1992. Although previous studies clearly indicated that the squid driftnet fisheries of Republic of Korea and Chinese Taipei operated in the high seas in the 1980s and the beginning of 1990s and likely caught a large number of blue sharks as bycatch, the catch data of these countries had not been used in previous stock assessments for blue sharks in the North Pacific Ocean. The main reason was the lack of useful catch statistics for blue sharks because these fleets targeted flying squid, *Ommastrephes bartrami*. In previous assessments, the blue shark catch for the Japanese squid driftnet fishery was reconstructed from logbooks and observer data but such information was unavailable from the Republic of Korea and Chinese-Taipei fisheries. To reconstruct the catch of blue sharks caught by these fleets, two approaches were applied using the records of statistics in the published paper. (1) The nominal CPUE of blue shark caught by the Japanese squid driftnet fleet was multiplied by fishing effort, but this method was only applied to the data of Republic of Korea. (2) The ratio of blue shark to squid catch from the Japanese squid driftnet fleet was applied to the total flying squid catch for both fleets to estimate blue shark catch. The estimated catch of the Republic of Korea squid driftnet fishery was calculated as the average of both methods while the estimated catch for the Chinese-Taipei squid driftnet fishery was calculated from only the second method. The squid driftnet fishery started in 1978 and was banned in 1993 (i.e., last year with positive catch was 1992) but various information from the fisheries were missing from the early and late years of the fisheries. Linear interpolation was used to fill in the blue shark catch for years with missing information. Subsequently, the total blue shark catch of all three fisheries was used in the base case model of the 2022 stock assessment. The estimated total catch of the squid driftnet fisheries sharply increased in the early 1980s before gradually increasing in the mid-1980s and peaking in 1988. After that, the catch decreased until the year of ban of high seas drift net fishery.

Introduction

Japanese high seas squid driftnet fishery commenced operations in 1978 and commonly targeted flying squid, *Ommastrephes bartrami* (Yatsu et al., 1993). A substantial number of sharks were caught by this fishery as non-target species, especially blue shark, (*Prionace glauca*) in 1980s and the beginning of 1990s (McKinnell and Seki, 1998). Blue shark (*Prionace glauca*) is widely distributed from tropical to temperate waters around the globe and is the most abundant species of oceanic pelagic shark (Nakano and Steven, 2008). Blue shark in the Pacific Ocean is thought to comprise two-stocks, roughly separated north and south along the equator (ISC, 2017). The stock assessment of blue shark in the North Pacific Ocean is conducted by the ISC SHARK working group (WG). In the previous stock assessment in 2017, the historical catches of blue shark caught by Japanese squid driftnet fishery from 1981 to 1992 were used. However, the 2017 assessment assumed a constant value (13,331 MT) for the annual catches from 1981 to 1988 because detailed information on the catches, including the calculation/estimation methods, were not available. In addition, the Japanese logbook data from 1981 to 1992 lack species-specific information on sharks. Therefore, Fujinami et al. (2021) estimated the catch of the Japanese high seas driftnet fishery using statistical models (a generalized linear model; GLM and a generalized additive model; GAM) with scientific observer data in 1990 - 1991 and logbook data from 1981 - 1992. The WG reviewed and considered the catch estimates from Fujinami et al. (2021) to be the best available estimates for the Japanese squid driftnet fishery. However, the Republic of Korea and Chinese-Taipei also had squid driftnet fisheries during the period but the blue shark catch for those fisheries had not previously been estimated.

The Republic of Korea and Chinese-Taipei commenced squid driftnet fishing in 1979 and 1980, respectively (Yatsu et al. 1993). The backgrounds of both driftnet fisheries including the catch statistics of flying squid and fishing effort were summarized in two studies (Gong et al., 1991; Yeh and Tung, 1991). These studies indicated that these squid driftnet fisheries were similar to the Japanese squid driftnet fishery and had major operations on the high seas in the 1980s and the early 1990s. This suggests that a large number of blue sharks were likely caught as bycatch by these fisheries. However, the catch data of these fisheries have not been estimated nor used in previous stock assessments of blue sharks in the North Pacific Ocean. The main goal of this working paper is to reconstruct the catch for blue sharks caught by the high seas squid driftnet fisheries of the Republic of Korea and Chinese-Taipei in the North Pacific Ocean from 1979 to 1992, and then to reconstruct the total catch by combining the reconstructed catch of all three fisheries. In addition, the uncertainty of the reconstructed catch was also estimated.

Materials and Methods

To achieve the goal, the following two approaches were applied.

(1) The estimated nominal CPUE of blue shark caught by Japanese fleet from Fujinami et al. (2021) was multiplied by the reported fishing effort of the other squid driftnet fisheries. The fishing effort of the Republic of Korea squid driftnet fishery was reported in "poks" with 1 pok being a 50 m length of net (Table 3 in Gong et al., 1993). However, the nominal CPUE of the Japanese driftnet fishery was estimated with a different definition of fishing effort ("tans"; 1 tan is 1 km length) (Fujinami et al., 2021). Therefore, the Korean fishing effort in "pok" was converted to "tan" by dividing the number of "poks" by 20. The catch of blue shark in numbers of fish was calculated by multiplying the nominal CPUE of the Japanese fishery by the reported fishing effort of the Korean fishery. On the other hand, the catch of Chinese Taipei was not reconstructed using this method because fishing effort was not reported in terms of the length of driftnets used (Yeh and Tung., 1993).

(2) The squid driftnet catch of blue shark for the Republic of Korean and Chinese Taipei was calculated by applying the ratio of blue shark to squid catch from the Japanese fleet to the reported flying squid catch for these fisheries. The Japanese blue shark to flying squid ratio for each year was calculated as the reported blue shark catch (numbers) from Fujinami et al. (2021) divided by the reported flying squid catch (metric tons) from Ito et al. (1993). Uncertainty in this ratio was developed by treating blue shark catch and flying squid catch as correlated random variables drawn from a multivariate normal distribution. The assumed mean of the distribution were the annual pairs of blue shark and flying squid catch, with an assumed standard error derived from the reported 95% confidence intervals from Ito et al. (1993). The covariance for this multivariate normal distribution was informed by the correlation in blue shark and flying squid catch time series, with an assumed CV for the correlation of 0.25. Pairs of values (N=1000) drawn from this multivariate distribution were used to create a distribution for the ratio of blue shark to flying squid catch. Each resampled ratio was then applied to the reported flying squid catch of the Republic of Korea and Chinese Taipei fisheries (Gong et al., 1991; Yeh and Tung, 1991) and combined to estimate the blue shark catches and associated uncertainty.

Subsequently, several steps were taken before the estimated catches could be used in the upcoming stock assessment. 1) The estimated catch of the Republic of Korea squid driftnet fishery was calculated as the average of both abovementioned methods. 2) The early and late years of all three fisheries had various data gaps that had to be filled before being used. Linear interpolation was used to fill in catch of early and late periods for three countries assuming 0 catch in 1977 and 1993. 3) The estimated catch of all three fisheries were summed into a single squid driftnet fishery for the assessment.

Results

The fishing effort and the estimated catch number from the 1st method, and nominal CPUE of Japanese fleet are shown in **Table 1.** The Korean fishing effort (number of poks and total length) gradually increased and peaked in 1989, but the estimated blue shark catch peaked in 1988 due to the high CPUE of the Japanese fleet in 1988.

The estimated catches and the lower and upper 95% confidence intervals from the 2nd method are summarized in **Table 2**. The median of estimated catch for the Republic of Korea fishery gradually increased from 1979, peaked in 1989 and decreased subsequently. Meanwhile, the median of estimated catch for the Chinese Taipei fishery fluctuated between 12,000 and 211,000 fish during the period and the catch number was much lower than those for other fleets. The uncertainty of the estimated catch was large due to the high estimated CV (0.21) derived from Japanese data (Table 4 in Yatsu et al., 1993).

The reconstructed catch of the squid driftnet fishery used in the upcoming stock assessment are summarized in **Table 3**. The total catch sharply increased in the beginning of 1980s, and then gradually increased and peaked at 4,313,000 individuals in 1988. After that, the catch decreased until high seas drift net fisheries were banned in 1993.

Discussions

This working paper documents the reconstruction of catch for blue sharks caught by the high seas squid driftnet fisheries of the Republic of Korea and Chinese-Taipei in the North Pacific Ocean from 1978 to 1992. Although the reconstructed annual catch includes a large uncertainty in the estimated catch, this reconstructed catch is the best available estimate of blue shark catches from this fishery. We therefore recommend using this catch time series for the stock assessment of North Pacific blue shark in 2022. We recommend that the WG continue future research into the reconstruction of blue shark catch from this important historical fishery to reduce the uncertainty in the estimated catch.

It should be noted that we attempted to use fishing effort in number of fishing days to reconstruct the blue shark catch. However, Yeh and Tung (1993) only reported the number of fishing days during 1986-1990 for Chinese-Taipei and included both small- and large- mesh driftnet fishery (Table 1 in Yeh and Tung, 1993). Further, the fishing effort of the Republic of Korea fishery was not reported in number of fishing days (Gong et al., 1993). Therefore, the catch was not reconstructed using this method.

References

Fujinami, Y., Kanaiwa, M., Kai, M. 2021. Estimation of annual catch for blue shark caught by Japanese high seas squid driftnet fishery in the North Pacific Ocean from 1981 to 1992. ISC/21/SHARKWG-2/07.

Gong, Y., Kim, Y.S., Hwang, S.J. 1993. Outline of the Korean Squid Gillnet Fishery in the North Pacific. Bulletin 53 (I)-North Pacific Commission. 45–69.

ISC. 2017. Stock assessment and future projections of blue shark in the North Pacific Ocean through 2015. ISC Plenary report and documents. Annex 13.

ISC. 2021. Report of the Shark Working Group Workshop. 9-19, November, webinar.

Ito, J., Shaw, W., and Burger, R.L., 1993. Symposium on biology, distribution and stock assessment of species caught in the High Seas driftnet fisheries in the North Pacific Ocean held by the standing committee on biology and research at Tokyo, Japan in 1991. Vancouver, Canada.

McKinnel, S., Seki, M.P. 1998. Shark bycatch in the Japanese High Seas squid driftnet fishery in the North Pacific Ocean. Fish. Res. 39, 127–138.

Nakano, H., Stevens, J. D. 2008. The biology and ecology of the blue shark, *Prionace glauca*. In: Camhi, M. D., Pikitch, E. K., Babcook, E. A., editors. Sharks of the open ocean: biology, fisheries and conservation. Oxford: Blackwell Scientific. p. 140–51.

Yatsu, A., Hiramatsu, K., Hayase, S. 1993. Outline of Japanese squid driftnet fishery with notes on the by-catch. Bulletin 53 (I)-North Pacific Commission. 5-24.

Yeh, S.Y., Tung, I.H. 1993. Review of Taiwanese Pelagic Squid Fisheries in the North Pacific. Bulletin 53 (I)-North Pacific Commission. 71–76.

Table 1. Summary of estimated catch (1000s of fish) for the Republic of Korea fleet based on the 1st method.

Year	No. of gillnets(poks): 1pok is 50m length	Converted fishing effrot (1km tan)	Nominal CPUE from Japanese data	Calculated catch number
1983	5,634,961	281,748	1.28	359
1984	12,506,039	625,302	1.33	829
1985	13,943,441	697,172	1.26	878
1986	17,587,232	879,362	1.35	1,185
1987	19,781,364	989,068	1.38	1,369
1988	24,594,370	1,229,719	1.60	1,972
1989	24,780,316	1,239,016	1.28	1,582
1990	24,590,505	1,229,525	0.91	1,120

Table 2. Summary of estimated catch (1000s of fish) for Republic of Korean and Chinese Taipei fleets based on the 2nd method.

		Median		Low (2.5th percentile)		High (97.5th percentile)	
Year	Japan	Republic of Korea	Chinese Taipei	Republic of Korea	Chinese Taipei	Republic of Korea	Chinese Taipei
1978	23						
1979	46	53		6		155	
1980	69	107	12	12	1	311	36
1981	92	160	46	18	5	466	132
1982	1,223	214	76	25	9	621	220
1983	1,669	267	105	31	12	777	304
1984	2,031	350	196	40	23	1018	568
1985	2,241	502	155	58	18	1457	449
1986	2,453	418	98	48	11	1215	286
1987	2,213	599	132	69	15	1739	382
1988	2,895	715	74	82	9	2077	216
1989	2,225	951	211	109	24	2761	611
1990	1,037	877	96	101	11	2548	279
1991	943	585	64	67	7	1699	186
1992	655	292	32	34	4	849	93

Red figure denotes the catch number estimated from the linear interpolation

Table 3. Summary of estimated catch (1000s of fish) from both methods and reconstructed catch (1000s of fish) used in the base case model.

		Method1		Method2		Average		Base case
Year	Japan	Republic of Korea	Chinese Taipei	Republic of Korea	Chinese Taipei	Republic of Korea	Chinese Taipei	Three countries
1978	23							23
1979	46	72		53		63		109
1980	69	144		107	12	125	12	207
1981	92	216		160	46	188	45	326
1982	1,223	287		214	76	251	75	1,549
1983	1,669	359		267	105	313	104	2,087
1984	2,031	829		350	196	590	195	2,815
1985	2,241	878		502	155	690	154	3,084
1986	2,453	1,185		418	98	802	98	3,353
1987	2,213	1,369		599	132	984	131	3,328
1988	2,895	1,972		715	74	1,344	74	4,313
1989	2,225	1,582		951	211	1,266	209	3,700
1990	1,037	1,120		877	96	999	96	2,131
1991	943	747		585	64	666	46	1,655
1992	655	373		292	32	333	23	1,010

Red figure denotes the catch number estimated from the linear interpolation