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Update of Japanese catches for blue shark caught by Japanese offshore and distant-water longliner in the North Pacific[1]

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Abstract

This working paper provides update of Japanese catches of blue shark (*Prionace glauca*) caught by Japanese offshore and distant-water longline fishery during 1994 and 2015 in the North Pacific. Since the landings of sharks is frequently underestimated due to the lower value than any other teleost species such as tunas and billfishes, total catches including retained and discard/released catches were estimated using a product of the yearly changes in standardized CPUEs and the fishing effort. The methods were almost similar to those used in the previous analyses. The results showed that the total catches of blue shark in the North Pacific caught by Japanese offshore and distant-water longline fishery had been decreasing since 1995 until 2015 due to the reduction in the fishing effort. The estimated catches in recent five years were varied between 11,532 and 18,692 tons.

Introduction

Blue shark in the North Pacific is occasionally targeted and frequently caught as bycatch by pelagic longline fisheries targeting tuna and billfish (Nakano 1994; Nakano and Seki 2003). Since the market value of blue shark is lower than any other species such as tunas and billfishes, total catches (retained and discarded catches) for blue shark landed in Japan is frequently underestimated. Therefore, the total catches of blue shark (*Prionace glauca*) caught by Japanese offshore and distant-water longline fishery in the North Pacific were estimated by multiplying the time series of the abundance indices by those of fishing effort (Hiraoka *et al*., 2013b; Kai *et al*., 2014).

This document paper provides updated catch estimation of Japanese offshore and distant-water longline fishery in the North Pacific from 1994 to 2015.

Materials and Methods

Data source

Set-by-set logbook data from Japanese offshore and distant water longline fishery are used to standardize CPUE and to estimate the total catches of blue shark caught from 1994 to 2015. The details of the logbook data are described in Kai *et al*. (2014).

Definition of four fleets

In consideration of the changes in the targeting species, operational areas, and effective fishing effort, Japanese offshore and distant-water longline fishery were separated into four fleets (Kai *et al*., 2014):

(i) Japanese offshore shallow-set longline fisheries (Kinkai-shallow),

(ii) Japanese offshore deep-set longline fisheries (Kinkai-deep),

(iii) Japanese distant-water shallow-set longline fisheries (Enyo-shallow),

(iv) Japanese distant-water deep-set longline fisheries (Enyo-deep),

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where categories of "Kinkai" and "Enyo" were defined by the tonnage of vessel (20-120 MT and larger than 120 MT), and categories of "shallow-set" and "deep-set" were separated by number of hooks between floats (HPF: smaller than 7 and larger than 6).

Estimation of total catch

Standardized CPUEs for four fleets were estimated using the data after filtering. Then the catches were estimated using the total number of hooks as well as the CPUEs. The procedures are as follows:

(1) Annual trends of the CPUEs for four fleets from 1994 to 2015 were standardized using the following generalized linear models (Kai *et al*., 2014):

For "Kinkai-shallow" and "Enyo-shallow" during 1994 to 2015,

E[Catch]=exp{Intercept + Y + A + Q + F + T + Y*T + Q*T}offset(Effort)

$Catch \sim \mathrm{NB}(\mu, k)$

For "Kinkai-deep" during 1994 to 2015,

E[Catch]=exp{Intercept + Y + A + Q + G +A*G}offset(Effort),

For "Enyo-deep" during 1994 to 2015,

E[Catch]=exp{Intercept + Y + A + Q + G + P}offset(Effort),

where E[Catch] is expected total number of catch for blue shark, Effort is the number of hooks (x 1000) as an offset variable, Y is year (1994-2015), A is area (1-4), Q is quarter (Jan-Mar, Apr-Jun, Jul-Sept, Oct-Dec), F is fishery (Offshore and Distant-water), T is target (10^{th} percentile ranking of swordfish CPUE), G is two types of gear sets ("Shallower-deep" (HBF < 15) and "deeper-deep" (HBF > 14)), and P is two areas of prefectures ("Hokkaido and Tohoku" and "Others"; see at the map in the Hiraoka *et al*., 2013a,b). These variables (Y, A, Q, F, T, G, and P) are defined as categorical explanatory variables. Y*T, Q*T, and A*G are interactions between Y and T, Q and T, and A and G respectively. NB stands for Negative binomial; μ is the mean; and k is the dispersion parameter.

(2) Total catch in number by fleets were estimated by multiplying each CPUE time series by the total number of hooks by fleets.

(3) Total catch in weight were calculated by multiplying the catch in number by year, season and area by the average weight of a blue shark by season and area (Table 2; Hiraoka et al. 2013a,b, Kai *et al*. 2014). The blue shark is processed using two different processing methods: dress with fins ("Kesennuma dress") and dress without fins ("dress") for the offshore and distant water fisheries, respectively. We therefore used different conversion factors:1.7 for "Kinkai" and 2.0 for "Enyo" (Semba *et al*., 2015). In summary, we corrected the weight data using two conversion factors:

(i)1.7/1.2 for Kinkai fleets

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(ii) 2.0/1.2 for Enyo fleet,

(4) Since Takahashi *et al*. (2012) suggested that the ratio of CPUE for "Enyo-deep" between research and commercial longline is 13:1, the annual total catch in weight including retained catch as well as discard/release of blue shark were raised by the value (i.e. 13 times).

Results

The estimated total catches (tons) of blue shark caught by Japanese offshore and distant-water fishery tended to decrease since 1994 until 2015 due to the reduction in the fishing effort (number of hooks x 1000) throughout the years (**Table1**, **Figure 1**). The annual trends of the total catches were quite similar between updated and previous ones. Yearly changes in updated total catches by fleets showed that the total catch of offshore ("Kinkai") shallow-set had increased since 1994 until 2001, and then it had decreased until 2011 and it maintained stable around 5,000 tons thereafter (**Table1**, **Figure 2**). Estimated total catch of distant-water deep had sharply decreased in since 1995 and it had reached to the lowest value (3023 tons) in 2009. After that, the estimated catches kept around 4000 tons except in 2010 and 2011.

Discussion

Our results suggested that the total catches of blue shark in the North Pacific caught by Japanese offshore and distant-water longline fishery had been decreasing since 1994 until 2015 due to the reduction in the fishing effort. Therefore, it is considered that the uptrends of the CPUE in recent five years for Japanese offshore and distant water sallow-set longline fishery (Kai and Shiozaki, 2016) is caused by the reduction of the fishing pressure. The abrupt increase of the catches in 2010 and 2011 for distant-water deep-set longline fishery was unexplainable due to insufficient information about the fishery. Tsunami in 2011 is unlikely to impact on the increase. We will need to explore the reasons in future work.

When we standardize the CPUEs for the Japanese longline fishery, we used the same models as those used in the previous analyses. Although, the method of the CPUE standardization for the Japanese offshore and distant-water shallow-set longline fishery was justified by Hiraoka *et al*. (2016), other methods for Japanese deep longline fishery are likely to include large uncertainties. In future work, we should validate the CPUE trends using the fishery independent data such as observer data.

Reference

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Table 1. Annual changes in estimated catch (tons), retained catch, and discarded/released catches of North Pacific blue shark caught by Japanese offshore and distant-water longline fishery and the fishing effort (number of hooks x 1000) from 1994 to 2015.

Year	Offshore shallow			Offshore deep			Distant-water shallow			Distant-water deep			Total			
	Estimated catch	Retained catch	Discarded/ Released	Estimated catch	Retained catch	Discarded/ Released	Estimated catch	Retained catch	Discarded/ Released	Estimated catch	Retained catch	Discarded/ Released	Estimated catch	Retained catch	Discarded/ Released	Fishing effort
1994	8,665	8,247	418	3,858	2,092	1,766	485	405	80	18,005	1,244	16,761	31,013	11,987	19,025	135839
1995	8,680	7,648	1,031	2,207	1,004	1,203	1,140	1,140	0	23,951	1,642	22,309	35,978	11,435	24,543	129722
1996	8,842	8,209	633	3,399	1,735	1,664	959	959	0	14,110	1,043	13,067	27,310	11,946	15,364	110993
1997	11,056	11,056	0	2,074	1,075	999	1,340	1,340	0	16,096	1,067	15,029	30,566	14,538	16,027	104756
1998	10,909	10,854	55	1,447	477	971	1,515	1,431	84	15,478	1,128	14,351	29,350	13,889	15,460	106271
1999	12,856	12,856	0	1,020	388	631	1,717	1,717	0	10,790	955	9,835	26,382	15,916	10,466	115194
2000	17,231	16,038	1,193	627	89	538	1,959	1,959	0	6,719	670	6,049	26,535	18,755	7,780	106683
2001	19,458	18,722	735	507	110	397	2,821	2,821	0	7,028	788	6,239	29,814	22,442	7,372	112073
2002	16,746	16,746	0	548	103	444	1,959	1,959	0	4,930	491	4,439	24,183	19,299	4,884	101238
2003	16,423	16,334	89	1,297	197	1,100	2,114	2,114	0	5,029	369	4,660	24,863	19,014	5,849	96343
2004	14,025	14,025	0	3,601	180	3,421	3,652	3,652	0	4,537	325	4,212	25,815	18,182	7,633	86336
2005	17,184	16,879	306	1,169	153	1,017	2,932	2,473	459	5,869	450	5,419	27,155	19,954	7,201	76204
2006	13,987	13,987	0	1,903	220	1,683	2,979	2,582	398	4,333	341	3,992	23,202	17,130	6,072	72284
2007	11,419	11,419	0	3,541	185	3,355	2,937	2,382	555	4,309	255	4,054	22,205	14,241	7,964	63367
2008	10,095	10,095	0	1,072	116	956	2,685	2,359	326	3,999	280	3,719	17,851	12,850	5,002	58252
2009	11,842	11,821	20	412	45	367	2,863	2,642	221	3,023	201	2,822	18,141	14,710	3,431	45743
2010	10,018	9,989	29	204	23	182	2,680	2,680	0	8,857	364	8,493	21,760	13,056	8,704	44662
2011	4,336	3,859	476	122	13	109	1,742	1,742	0	12,493	588	11,905	18,692	6,203	12,490	45593
2012	5,799	5,498	300	284	33	251	2,545	2,545	0	3,675	185	3,491	12,303	8,261	4,042	40722
2013	4,808	4,581	226	4,157	138	4,020	1,955	1,955	0	4,537	237	4,300	15,457	6,911	8,546	38296
2014	5,973	5,218	754	2,742	118	2,624	1,717	1,717	0	4,674	374	4,300	15,106	7,428	7,678	40001
2015	5,312	4,987	325	57	6	51	2,358	2,358	0	3,805	297	3,508	11,532	7,649	3,884	32924

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Table 2. Average body weight (kg) of blue shark by area and quarter.

Area	Quarter	Total number	Round weight	Average-weight
1	1	2112394	43494075	20.58994
2	1	18223	468158	25.6905
3	1	133384	3817282	28.61874
4	1	78979	3233284	40.93853
5	1	32714	898736	27.47252
1	2	2809934	48387126	17.22002
2	2	333508	5172216	15.50852
3	2	402235	11597037	28.8315
4	2	63589	2587959	40.69822
5	2	42046	1180960	28.08733
1	3	2717791	48350381	17.79032
2	3	151114	2705509	17.90376
3	3	65384	1921470	29.38746
4	3	8945	346577	38.74533
5	3	41259	1220596	29.58375
1	4	1806861	35086170	19.4183
2	4	50230	1156457	23.02323
3	4	17799	507601	28.51851
4	4	17860	690492	38.66137
5	4	45893	1304058	28.41518

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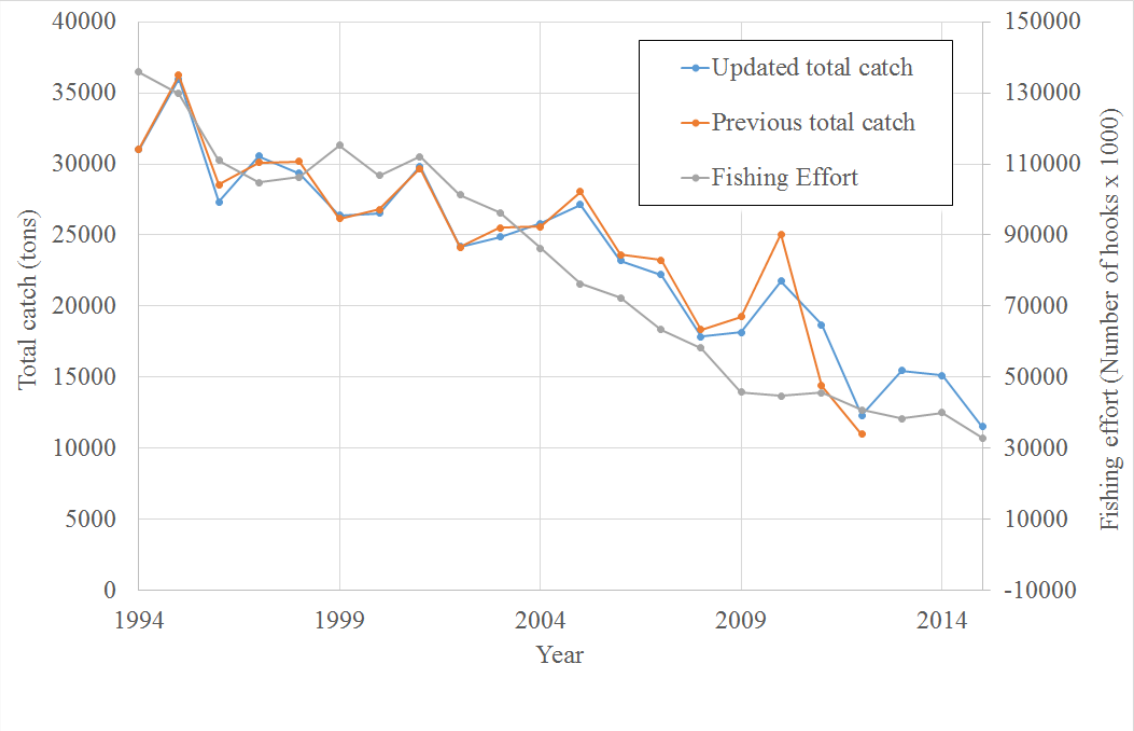

Figure 1. Yearly changes in updated total catches (tons), previous total catches (tons), and total fishing effort (number of hooks x 1000) from 1994 to 2015.

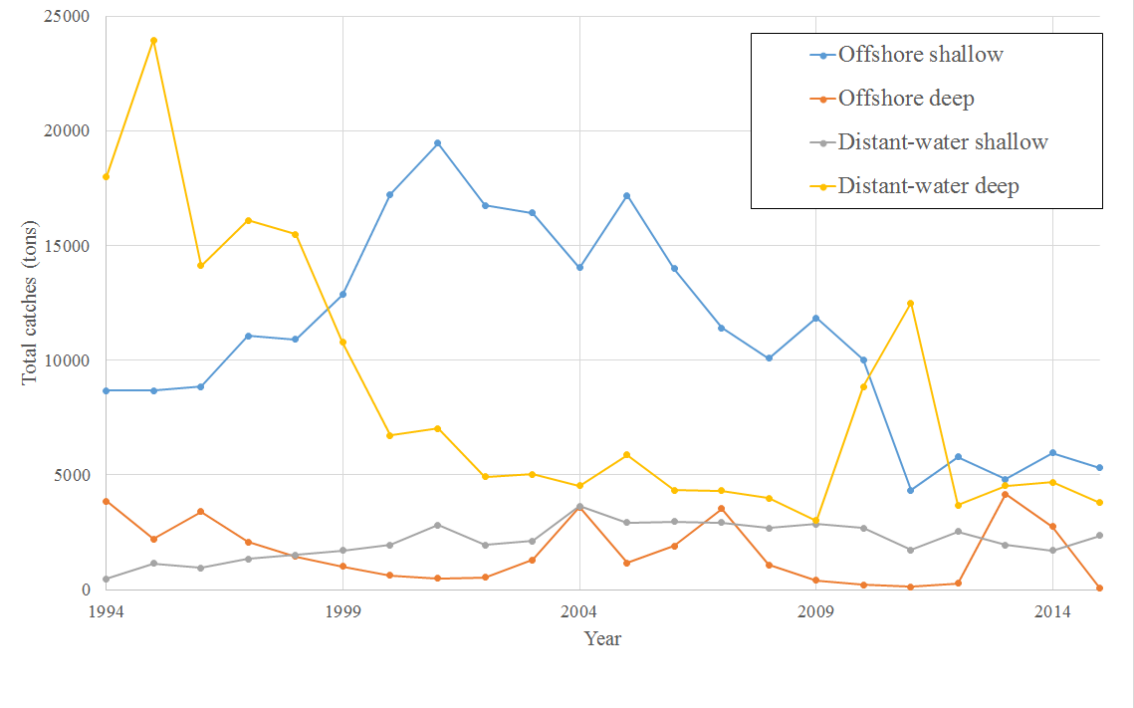

Figure 2. Yearly changes in updated total catches (tons) by four fishery types from 1994 to 2015.

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