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Overview of historical skipjack length and weight data collected by the Japanese pole-and-line fisheries and Research vessel (R/V) from 1953 to 2017

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Summary

The objective of this document is to describe the data sources of skipjack length and weight information collected by the Japanese pole-and-line commercial fisheries and research vessel (R/V) between 1953 and 2017. The data were compared with the data that the SPC holds. Although we found some discrepancies between data presented in this document and SPC holds, we could not reach any concrete conclusions the reasons. One possibility is that data in earlier period based on information collected by the R/Vs. It is important to note that new data sources are added and updated extending back to the early 1950s. This is the best available skipjack length and weight data collected mainly from the port sampling project and archived in the NRIFSF.

Introduction

Length data is an important information for estimating, for example, fish growth and selectivity of fisheries in stock assessment modeling. Age must be inferred using length-composition data and growth curve. Reliable length composition data should be used for the integrated stock assessment modeling because of less biased estimates of age that would lead to estimate of biological parameter such as growth, natural mortality and recruitment variability as well as spawning stock biomass.

The National Research Institute of Far Seas Fisheries (NRIFSF) has been collecting length and weight information of tuna and tuna-like species to conduct biological study and provide basic biological assumptions to stock assessment. There are several kinds of data source; sampling at port landed by commercial fisheries and sampling on board by research vessels (R/V) and training vessels (T/V).

The objective of this document is to describe the data sources of skipjack length and weight information collected by the Japanese pole-and-line both commercial fisheries and R/Vs between 1953 and 2017.

Data sources

There are several data sources in this document that are summarized in Table 1. Data sources are based on port sampling conducted by 1) the NRIFSF, 2) fisheries experimental stations in main skipjack unloaded ports of several prefectures (outsourcing from the NRIFSF), 3) Tohoku National Research Institute (TNFRI) which had been responsible research institute to conduct skipjack survey in earlier period (1953 – 1976) and 4) Ibaraki Fisheries Experimental Station which was not included in 2). Another platform to collect biological information is on board measurements by R/Vs and T/Vs as mentioned above.

Skipjack is the main species which 97.1% of total measurements (Table 1a) and time series of measured skipjack shown in Fig. 1 by gears. Majority of measurements were done from the JPN pole-and-line commercial fisheries. Number of measured length and weight at the same time were also summarized in Table 1b. It should be noted that the percentage of the data with length and weight lower because it takes lots of time and efforts compared to collect only length data.

Port sampling is an important and practical way to collect biological information and the large percentage of size sampling. Protocol and manual for collecting biological information has not been changed largely since the beginning of the sampling project. Measurements has been done at a timing between unloading of fish from the vessels and fish auction. Samplers randomly conduct measurement and compile by specific spatial ranges of 1x1, 5x5, 5x10 and 10x20 depending on the width of the range of fishing positions. This information is determined by the interview with skipper at unloading sites and/or logbook used for verifying reported positions afterwards. In most cases of skipjack fisheries operated in the norther area, fish is unloaded as unfrozen status. Fishing dates are on a daily basis and fishing positions on a minute basis. Main items in data is summarized in Table 2.

Total number of measured skipjack in each year shown in Table 3 separately the data archived in the SPC and newly submitted in 2019 by us. Although we found some discrepancies between data presented in this document and SPC, we could not reach any concrete conclusions to specify the reasons. One possibility is that submitted data in earlier period was based on the information collected by R/Vs. New data from 1953 to 1976 collected by the TNFRI was compiled and added.

Results and Discussion

Fig. 2 shows the location of fisheries where skipjack were caught and measured at the ports by the JPN commercial PL (**Fig. 2a**) and R/V (**Fig. 2b**). Locations in each quarter show similar spatial patterns and quarter 2 and 3 higher coverage around Japan between (30°N, 140°E) and (40°N, 145°E). Although both sampling locations shows similar spatial coverage, it should be noted that the coverage by R/V is slightly spread to north Pacific (near 180°) in quarter 2 and 3, and to central tropical Pacific in quarter 4.

The analysis of length frequency distribution by seasons showed multimodal feature in quarter 1 from the PL and R/V, and quarter 4 from the R/V with the presence of at least three modes which is equivalent to three age groups (**Fig. 3**). These modes displacement in northern area suggest that smaller and larger skipjack cohabits during this quarter, however subsequent movement patterns must be different because only unimodal distributions were evident in quarter 2 and 3. This implies that younger age group move into the fishing grounds which is also evident from the large scale tagging analysis (Kiyofuji *et al.*, 2019).

Time series of length frequency shows that consistent modes in 40 to 44cm (**Fig. 4a and 4b**). Although slight shift to larger mode was found after 2000 from the commercial PL (**Fig. 4a**), no such shift was identified from the data by R/V. One possible explanation is that the measurements frequency was increased in quarter 3 compared to other time periods (**Table 4**). However, this does not indicate larger fish in this area because the size of this fish in this season is larger than the previous season.

Skipjack lengths and weights ranged from 15 to 90 cm and from 0 to 20 kg and their relationship in this document was estimated by different data set (PL, R/V and combined) as follows;

$$W = 8.62 \times 10^{-6} \times L^{3.23} \quad \text{(only PL data)}$$
$$W = 9.21 \times 10^{-6} \times L^{3.20} \quad \text{(only R/V data)}$$
$$W = 9.76 \times 10^{-6} \times L^{3.20} \quad \text{(combined data)}$$

where W is the weight in kg and L is the fork length in cm. It shows no significant differences the length-weight relationships among data set (**Fig. 5**). The coefficients of allometry obtained in length-weight relationships compared to other studies (Pacific: Kawasaki, 1952; coast of Brazil: Soares et al., 2019; Indian Ocean: Chassot et al., 2016), length-weight relationships show slight differences amongst ocean and gear. Several life history circumstances could cause these differences. Reproduction is one possibility because growth of gonad increases during reproductive periods while somatic growth decrease. Further research is required to understand reproduction and somatic growth from energetic budget point of view (e.g. Kitagawa and Aoki, 2017).

Fish measured from JPN PL were stored in ice with sea water, indicating that body size would not be reduced or shrinked as frozen status. Further analysis is needed if the data are combined the large-scale purse seine fisheries because fish status could be different among fisheries due to fish storage methods.

In summary, it is important to note that new data are added and updated from the Japanese pole-and-line date back to the early 1950s. The size data and time series described in this document is the best available data which can be used for the stock assessment in the WCPO.

Acknowledgments

We sincerely thank P. Williams of the SPC for providing size data archived in the SPC data base which were previously submitted by Japan. We also acknowledge M. Vincent (SPC) for his enormous efforts to prepare data for the assessment and S. McKechnie of the SPC for correcting grammatical errors in the manuscript.

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Table 1. (a) Size data archived in NRIFSF (National Research Institute of Far Seas Fisheries) from 1953 to 2017 caught by the Japanese pole-and-line fisheries. (b) Number of fish with length and weight.

(a)

Organization	Period	Species	Number of measured ind. Total	SKJ
NRIFSF	2001 – 2017	SKJ and ALB	1,064,621	1,015,081 (96.0%)
Outsourcing from NRIFSF to each prefecture	2001 – 2017	SKJ, ALB, other tuna species	917,313	892,850 (97.3%)
TNFRI [1]	1953 – 1976	SKJ, ALB, other tuna species	993,435	991,772 (99.8%)
R/V and T/V	1964 – 2017	SKJ, ALB, other tuna species	160,060	125,795 (78.5%)
Ibaraki Fisheries Experimental Station	1970 – 2003	SKJ, ALB, other tuna species	844,135	838,998 (99.3%)
Total	**1953 – 2017**		**3,979,564**	**3,864,496 (97.1%)**

1: TNFRI: Tohoku National Fisheries Research Institute

(b)

Organization	Period	Number of measured ind. Total	SKJ length	SKJ length and weight
NRIFSF	2001 – 2017	1,064,621	1,015,081 (96.0%)	250,892 (23.5%)
Outsourcing from NRIFSF to each prefecture	2001 – 2017	917,313	892,850 (97.3%)	74,465 (8.1%)
TNFRI [1]	1953 – 1976	993,435	991,772 (99.8%)	0 (0.0%)
R/V and T/V	1964 – 2017	160,060	125,795 (78.5%)	90,630 (56.6%)
Ibaraki Fisheries Experimental Station	1970 – 2003	844,135	838,998 (99.3%)	88,530 (10.4%)
Total	**1953 – 2017**	**3,979,564**	**3,864,496 (97.1%)**	**504,517 (12.6%)**

Table 2. Data format.

No.	Variable	Description
1	Organization	Responsible organization
2	Date of measurement	YYYYMMDD
3	Date of catch	YYYYMMDD
4	Latitude	DDMM (DD: degree, MM: minutes)
5	Latitude code	North or South
6	Longitude	DDDMM (DDD: degree, MM: minutes)
7	Longitude code	East or West
8	spatial scale	1:10x20, 2:5x10, 3:5x5, 4:1x1
9	port	Name of port
10	species	Skipjack, Albacore and other tuna species
11	gear	PL, PS, TR, LL, GN, SN
12	vessel name	Name of landed vessel
13	FL	Fork length (mm/cm)
14	BW	Body weight in Kg
15	GW	Gonad weight in g
16	Gender	male or female

Table 3. Differences in total number of size data between NRIFSF and SPC holds.

YEAR	SAMPLES (N)						OLD DATA				NEW DATA in 2019 (R/V)				NEW DATA in 2019 (PL)			
							LATITUDE		LONGITUDE		LATITUDE		LONGITUDE		LATITUDE		LONGITUDE	
	OLD	submitted in 2004	submitted in 2019	NEW in 2019														
				Total	R/V	PL	FROM	TO	FROM	TO	FROM	TO	FROM	TO	FROM	TO	FROM	TO
1953	0	-	-	81879	0	81879									05N	40N	120E	155E
1954	0	-	-	84045	0	84045									20N	40N	115E	150E
1955	0	-	-	79965	0	79965									05N	40N	120E	155E
1956	0	-	-	54182	0	54182									05N	40N	115E	165E
1957	0	-	-	40910	0	40910									05N	40N	115E	160E
1958	0	-	-	40609	0	40609									05N	40N	125E	155E
1959	0	-	-	25128	0	25128									10N	40N	120E	150E
1960	0	-	-	16229	0	16229									10N	40N	125E	160E
1961	0	0	-	19443	0	19443									10N	40N	130E	150E
1962	0	0	-	23939	0	23939									15N	40N	130E	150E
1963	0	0	-	12412	0	12412									15N	40N	130E	155E
1964	208	208	-	22946	207	22739	30N	35N	135E	145E	30N	35N	135E	145E	10N	40N	125E	150E
1965	5	5	-	31181	5	31176	25N	25N	125E	125E	25N	25N	125E	125E	10N	40N	125E	155E
1966	28	28	-	28840	148	28692	15N	25N	120E	145E	15N	30N	120E	145E	05N	40N	125E	150E
1967	63	63	-	26329	320	26009	20N	30N	120E	130E	20N	35N	120E	140E	00N	40N	130E	160E
1968	396	396	-	30850	396	30454	20N	35N	120E	145E	20N	35N	120E	145E	00N	40N	125E	165E
1969	246	246	-	53458	246	53212	30N	35N	135E	145E	30N	35N	135E	145E	00N	40N	115E	160E
1970	3580	604	-	45452	385	45067	00N	40N	120E	150E	20N	35N	120E	145E	00N	40N	120E	160E
1971	4297	799	-	48867	682	48185	00N	35N	120E	150E	15N	35N	120E	145E	00N	40N	120E	165E
1972	4944	858	-	55574	785	54789	05N	35N	120E	165E	20N	35N	130E	145E	00N	40N	115E	170E
1973	7274	1190	-	50133	1548	48585	00N	35N	115E	150E	15N	35N	120E	150E	00N	40N	115E	160E
1974	5906	845	-	44618	70	44548	00N	40N	120E	175W	00N	25N	120E	140E	00N	40N	120E	170E
1975	8795	2089	-	23496	887	22609	00N	40N	120E	180W	05N	35N	125E	150E	00N	40N	120E	170E
1976	10151	2879	-	14166	817	13349	00N	40N	120E	175E	00N	40N	120E	170E	00N	40N	120E	170E
1977	9470	2932	-	10614	907	9707	00N	40N	120E	180W	00N	25N	120E	175W	25N	40N	135E	155E
1978	13483	4978	-	13743	1267	12476	00N	40N	120E	180W	00N	40N	120E	175E	25N	40N	135E	150E
1979	13518	6585	-	8012	1370	6642	00N	40N	120E	175E	00N	40N	120E	180	30N	40N	130E	155E
1980	17948	6636	-	11739	1855	9884	00N	40N	120E	180W	00N	35N	120E	180	15N	40N	130E	150E
1981	21991	10613	-	11410	1525	9885	00N	40N	120E	180W	00N	40N	120E	180	25N	40N	135E	150E
1982	16008	5254	-	20797	1418	19379	00N	40N	120E	175W	00N	40N	120E	165W	25N	40N	140E	160E
1983	22075	7183	-	29765	1944	27821	00N	40N	125E	180W	00N	40N	125E	180	25N	40N	140E	165E
1984	26816	10521	-	38333	2480	35853	00N	40N	115E	180W	00N	40N	120E	170W	15N	40N	135E	165E
1985	17416	7673	-	24645	2107	22538	00N	40N	120E	180W	00N	40N	125E	175W	20N	35N	140E	155E
1986	23805	11233	-	26913	2493	24420	00N	40N	125E	180W	00N	40N	125E	175W	25N	40N	135E	155E
1987	16804	7387	-	22560	1756	20804	00N	40N	125E	180W	00N	35N	125E	170W	30N	40N	140E	150E
1988	28144	23056	-	14241	1760	12481	00N	40N	125E	180W	05S	35N	125E	175W	25N	40N	130E	155E
1989	66791	25712	-	18704	1803	16901	00N	40N	125E	180W	00N	35N	125E	170W	15N	40N	130E	150E
1990	18279	13861	-	16782	1708	15074	00N	40N	125E	180W	00N	40N	125E	170W	20N	40N	135E	165E
1991	41095	22162	-	32898	2308	30590	00N	40N	120E	180W	00N	40N	125E	160W	30N	35N	140E	145E
1992	24272	18524	-	37680	2632	35048	00N	40N	125E	170E	05S	40N	125E	170E	20N	40N	135E	150E
1993	28306	25711	-	32561	3316	29245	00N	40N	125E	180W	00N	40N	125E	180	30N	40N	135E	150E
1994	61033	32640	-	33890	3305	30585	00N	40N	125E	180W	00N	40N	125E	170W	25N	40N	135E	150E
1995	85867	56162	-	49912	2448	47464	00N	40N	125E	180W	00N	40N	125E	175W	25N	40N	140E	150E
1996	53357	38911	-	49903	2327	47576	00N	40N	125E	180W	05N	40N	125E	175W	25N	35N	135E	165E
1997	68777	55964	-	73238	3425	69813	00N	40N	120E	175E	00N	40N	120E	170E	30N	35N	140E	150E
1998	97377	63034	-	56133	4196	51937	05N	40N	125E	170E	05N	40N	125E	170E	20N	40N	140E	150E
1999	67908	62981	-	42362	3230	39132	05N	40N	125E	170E	05N	40N	125E	170E	30N	40N	135E	150E
2000	87063	86510	-	67843	7120	60723	00N	40N	125E	175E	00N	40N	125E	175E	30N	40N	135E	150E
2001	141074	73235	-	114053	5353	108700	00N	40N	125E	175E	00N	40N	125E	175E	15N	40N	125E	155E
2002	117910	89603	-	102457	5916	96541	05N	40N	125E	175E	05N	40N	125E	175E	05N	40N	125E	160E
2003	162652	109993	-	102535	5964	96571	05N	40N	125E	175E	05N	40N	125E	175E	20N	40N	130E	160E
2004	125822	64543	-	80937	3291	77646	05N	40N	125E	175E	05N	40N	125E	175E	15N	40N	130E	155E
2005	103150	-	-	103605	5862	97743	15N	40N	125E	170E	05N	40N	125E	170E	15N	40N	125E	155E
2006	55809	-	-	60883	2855	58028	05N	40N	125E	155E	05N	35N	125E	150E	20N	40N	125E	155E
2007	54711	-	-	55178	4262	50916	10N	40N	125E	155E	10N	35N	125E	155E	20N	40N	125E	150E
2008	58811	-	-	58596	4321	54275	10N	40N	125E	160E	15N	35N	130E	150E	20N	40N	125E	160E
2009	70184	-	-	74070	3380	70690	10N	40N	125E	155E	10N	40N	125E	165E	15N	40N	125E	155E
2010	74282	-	-	111070	3516	107554	10N	40N	125E	155E	10N	35N	125E	155E	20N	40N	125E	155E
2011	108067	-	108067	96971	2808	94163	20N	40N	120E	140E	10N	35N	125E	170E	20N	40N	125E	155E
2012	105286	-	105286	96184	2272	93912	20N	40N	120E	140E	10N	35N	125E	150E	20N	40N	125E	155E
2013	26331	-	26331	103738	2593	101145	10N	40N	120E	180W	10N	40N	125E	165E	20N	40N	130E	155E
2014	18394	-	18394	70539	1879	68660	10N	40N	120E	140E	10N	35N	125E	155E	15N	40N	130E	155E
2015	28395	-	28395	59615	2516	57099	10N	40N	120E	160E	15N	35N	125E	160E	15N	40N	125E	155E
2016	58878	-	68960	71112	2152	68960	10N	40N	120E	140E	10N	35N	125E	160E	15N	40N	135E	155E
2017	64854	-	60932	62018	1086	60392	10N	40N	120E	140E	10N	30N	125E	150E	15N	40N	130E	155E

Table 4. Percentage of data to total number in each decades and quarter in norther area (area north of 20N)**.** Note that 0.0 and – represent value of less than 0.0 and no data, respectively.

Period	JPN commercial PL (n = 2,820,301)				JPN R/V (n = 87,316)			
	1	2	3	4	1	2	3	4
1950 – 1959	1.27	5.0	6.2	1.6	-	-	-	-
1960 – 1969	0.0	3.1	3.7	4.7	0.0	1.0	0.4	0.0
1970 – 1979	0.0	3.4	2.6	6.6	0.3	6.0	1.4	0.1
1980 – 1989	0.0	2.7	3.6	6.7	0.7	6.8	2.5	0.6
1990 – 1999	-	4.0	7.9	2.1	2.1	13.8	3.1	1.5
2000 – 2009	0.5	6.9	13.8	5.8	5.2	26.1	6.2	4.8
2010 – 2019	2.2	5.4	10.9	4.3	2.0	9.2	2.4	3.0

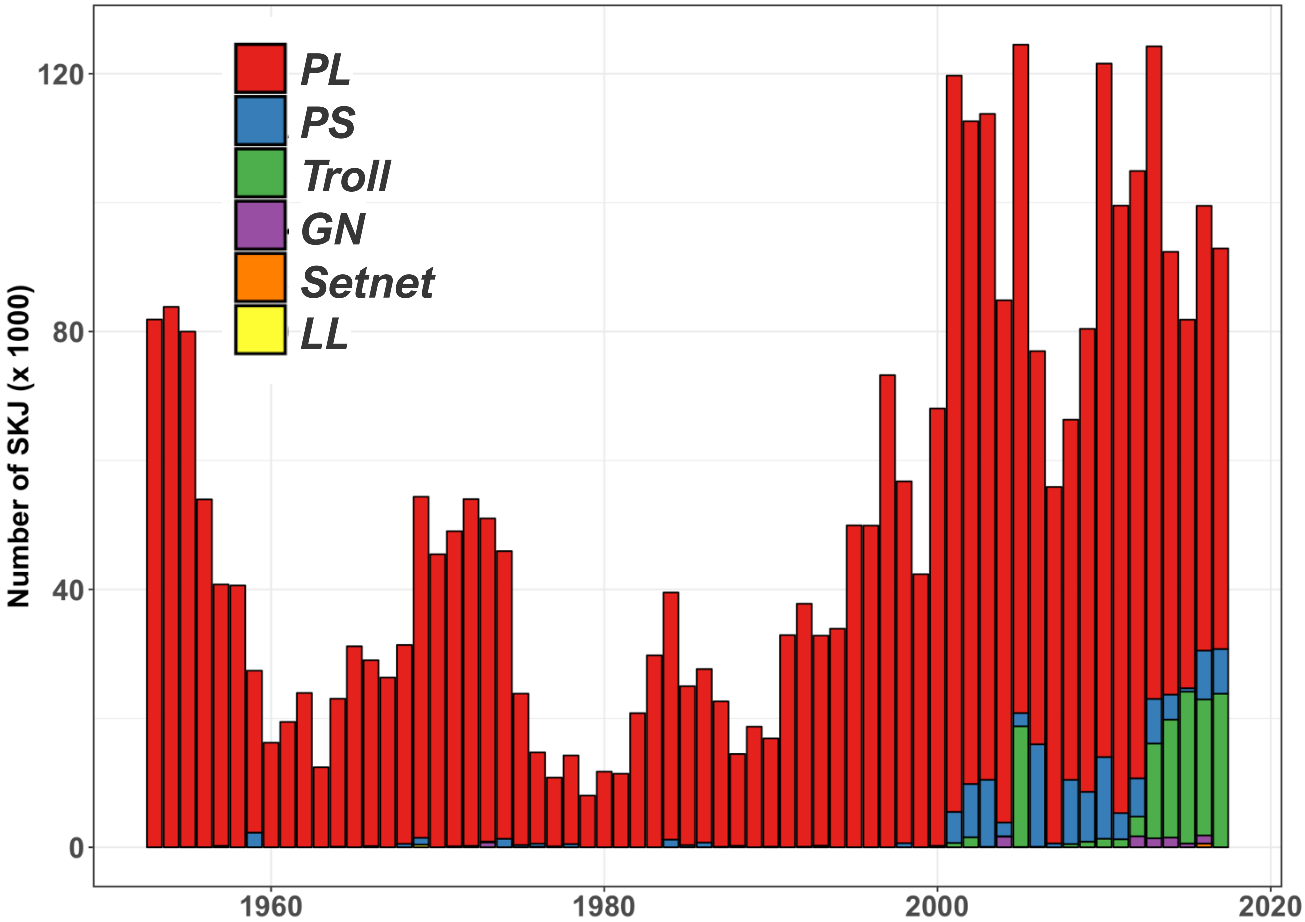
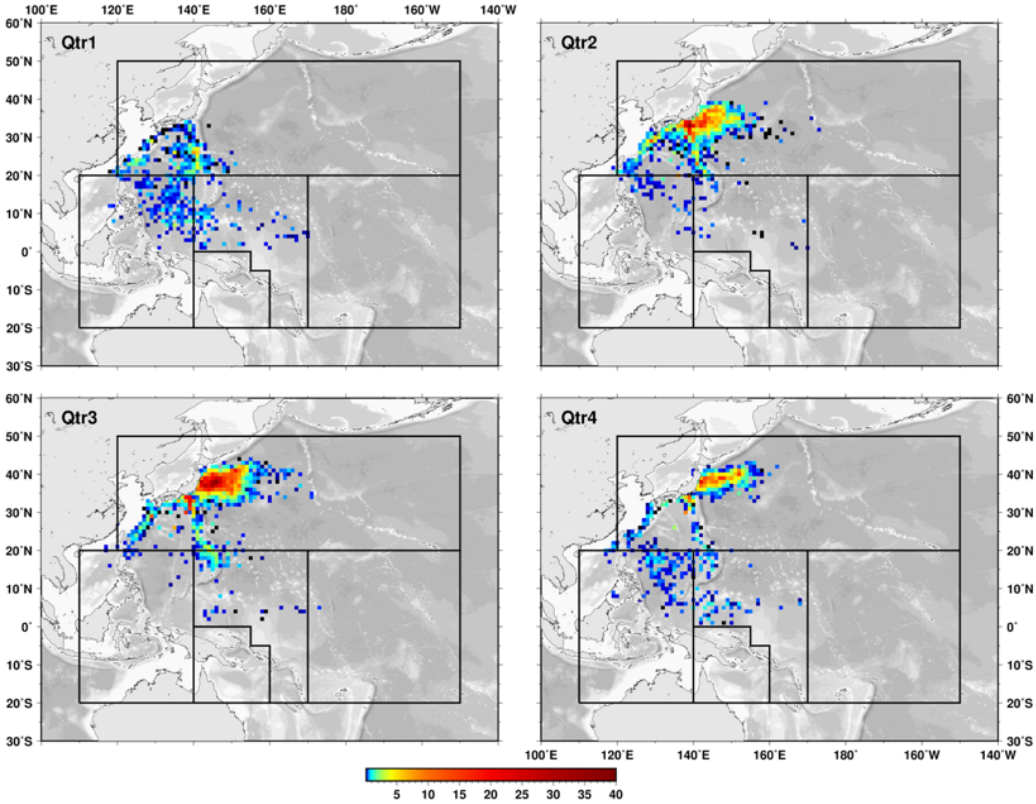


Figure 1. Number of measured skipjack tuna landed by different gears between 1953 and 2017.

(a)



(b)

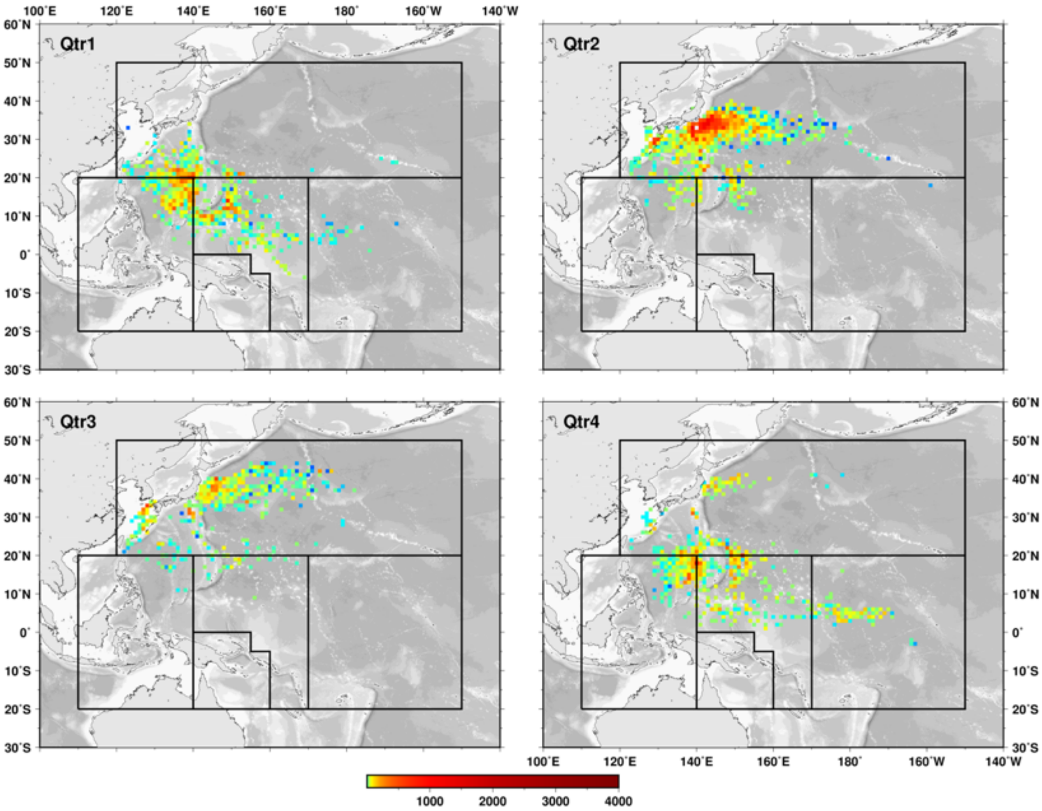
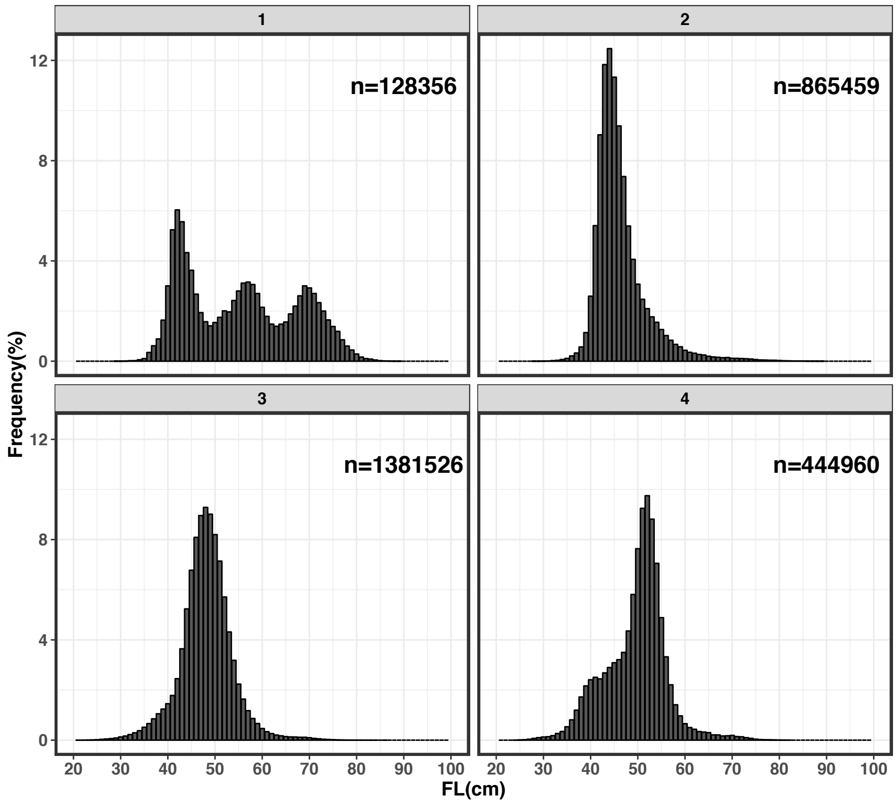


Figure 2. Number of measured skipjack in each quarter between 1953 and 2017 caught by the JPN commercial PL fisheries (a) and by the JPN R/V PL fisheries. Note that number in (a) is number x 1,000.

(a)



(b)

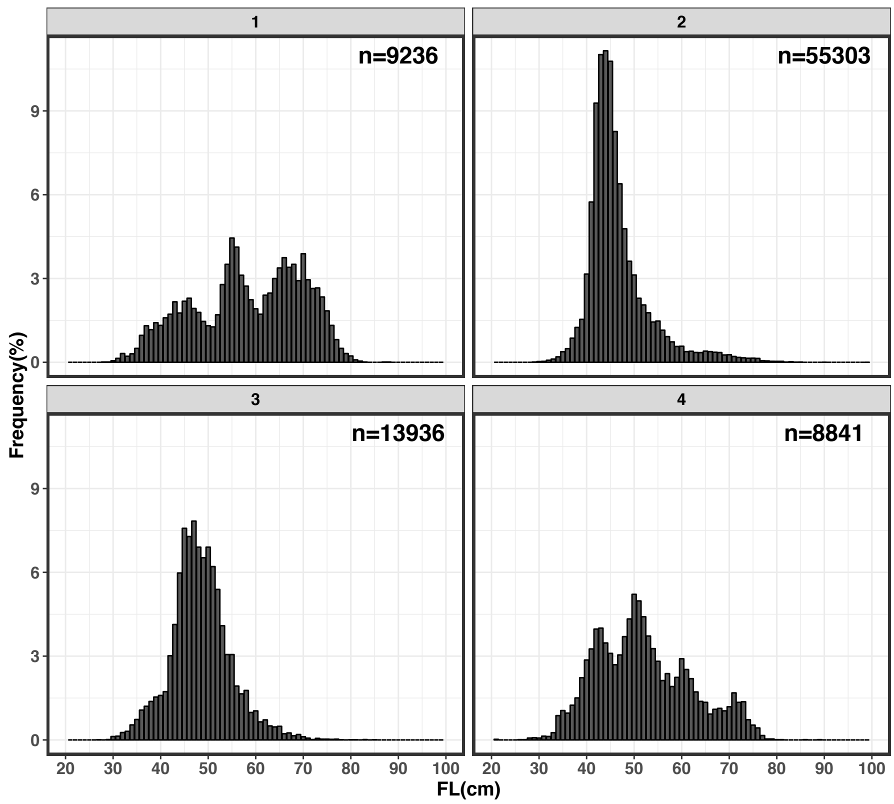


Figure 3. Quarterly length frequency in region1 (northern area) by the JPN commercial PL fisheries (a) and by the JPN R/V PL fisheries (b). Note that only fine spatial data (1 x 1) was extracted.

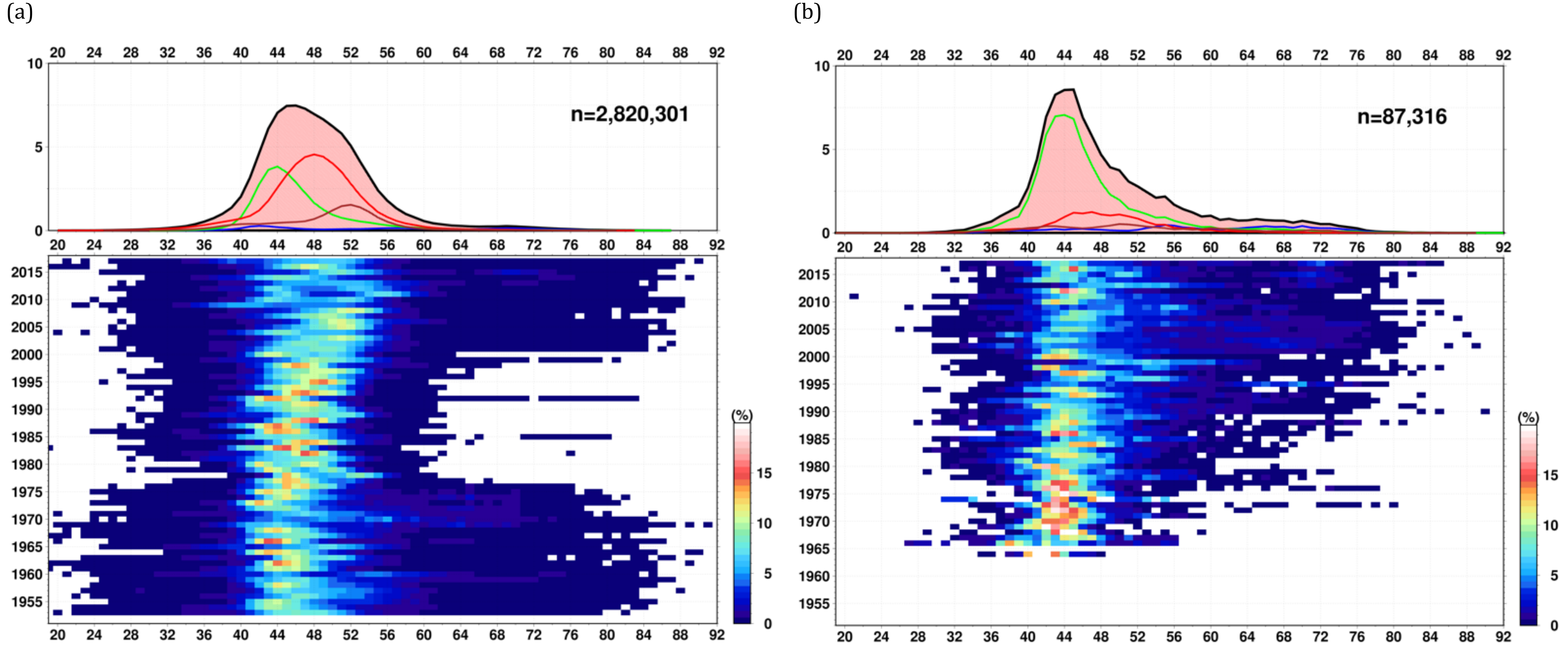


Figure 4. Histogram of measured skipjack (upper) and length-year plot of size in region 1 of 2016stock assessment area (lower). Solid blue, green, red and brown lines in upper figure show each quarter from 1^{st}, to 4^{th} when skipjack were caught. Solid black line represents overall frequency distribution. (a) Japanese commercial pole-and-line fisheries and (b) JPN pole-and-line R/V.

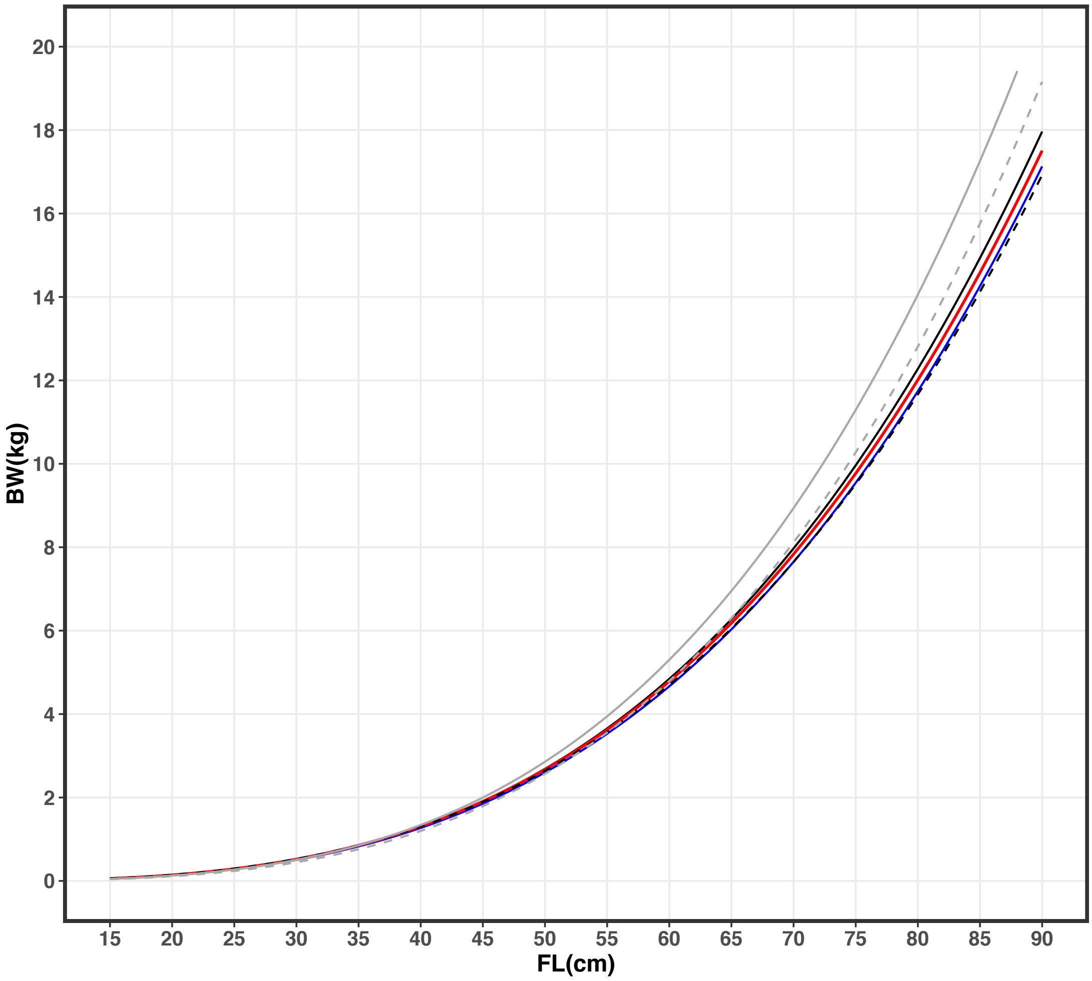


Figure 5. Skipjack length and weight relationships estimated using data collected by the Japanese commercial pole-and-line fisheries (solid black line), Japanese R/V PL (solid blue line) and combined above mentioned data (solid red line), respectively. Data were same data shown in Fig. 2 and 3 but only data with length and weight data together. Dashed black, solid and dashed gray lines represent the length-weight relationships from Kawasaki (1952), Chassot et al. (2016) in Indian Ocean from the purse seine fisheries and Soares et al. (2019) off Brazil from the pole-and-line fisheries.