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Historical biomass/number estimates and weight/number based indices of Pacific saury from Japanese fishery independent survey up to 2021

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Summary

The fishery independent survey by Japanese scientific research vessels were conducted in 2021. The historical biomass/number estimates and weight/number based indices were calculated based on the survey results. Estimated total biomass was 845 thousand metric tons, which consisted of 537 thousand and 458 thousand metric tons of age 0 and 1 fish, respectively. The estimated total biomass in 2021 was the lowest among the years except for 2020, in which the biomass estimate was missing. These values are potentially slightly underestimated, since the eastmost and a part of the second eastmost lines were not surveyed due to the unavoidable return induced by an injury of a crew. For equitable comparison, we also estimated the biomass trend only for areas survey in 2021 and trend was generally the same.

1. Introduction

Japan has carried out fishery independent surveys in June and July every year since 2003 using the sea surface trawl nets. The biomass/number estimates have been estimated by the swept area method using longitudinal survey lines stratification (Hashimoto et al., 2020), based on the survey results. In this document, we report the updated biomass/number estimates and historical weight/number based indices for each age throughout 2003–2021.

2. Materials and methods

The survey in this year were conducted by Shunyo Maru (887 tons), Hokko Maru (902 tons) and Hokuho Maru (664 tons). Shunyo Maru covered a single area (159°E–163°E), whereas Hokko Maru and Hokuho Maru were assigned to separated areas (151°E and 167°E–175°E for Hokko maru and 143°E–147°E, 155°E, and 179°E–169°W for Hokuho Maru). The fishing gear and the survey method were standardized among all research vessels (Hashimoto et al., 2020).

The total and each age's biomass and number of fish were estimated by the swept area method with longitudinal survey lines stratification (Hashimoto et al., 2020), assuming a catchability of 0.179 (Naya et al., 2010). Corresponding indices (weight/number based indices, which are

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biomass and number without being divided by the catchability), are also calculated, in which the catchability is estimated rather than fixed at 0.179. The coefficient of variance (CV) for each estimates was calculated using 1000 bootstrap data generated by a bootstrapping of the densities of the sampling stations in each stratum.

The weight- and number-based densities of each age, each sampling station, each year was calculated according to the age-length key and weight-length relationship for each year (Suyama et al. 2020). The fish smaller and larger than the 50% point (length in which age 0 and 1 are equally contained) are regarded as age 0 and 1, respectively. Only in 2021, the age-length key and weight-length relationship obtained from 2003–2020 and 2008, respectively, are tentatively used because the measurement of the 2021 samples is not finished yet.

Although the survey had been conducted up to 165°W line so far, Hokuho Maru had to quit the survey at the 40°30′N on the 169°W line in this year, because of a crew's injury. Therefore, the catch data in the unsurveyed area (north of the 40°30′N on the 169°W line and the entire 165°W line) thereafter are missing. The proportions of the past years' (other than 2011 and 2020) biomass in the unsurveyed area in this year were also calculated to estimate the extent of the potential underestimation of the biomass in 2021. The proportions were calculated by two methods. One was based on the number of the sampling stations. Since we had three sampling stations on the south part of the 169°W line in this year before the accident, the proportions of the biomass from the fourth to the last sampling points were calculated. Another was based on the sea surface temperature (SST). The proportions of the biomass in the sampling stations on the 169°W line with SST lower than that of where the survey was stopped (15.4°C) and in the whole sampling stations on the 165°W line were calculated. In addition, we also estimated the biomass trend only for areas survey in 2021 using the same method.

3. Results

Most of the fish were caught east of 170°E. In each line, age 1 fish tended to be distributed in the northern part, whereas age 0 fish were caught throughout the line (Fig. 1). The total biomass/number and the weight/number based indices in 2021 were the lowest among the years except for 2020, in which the biomass estimate was missing (Table 1–4; Fig 2). The estimated total biomass was 845 thousand metric tons, consisting of 537 and 458 metric tons of age 0 and 1 fish, respectively. Note that the sum of age 0 and age 1 fish weight does not become the total weight, because we used a tentative length-weight relationship in 2021. As a whole, the Pacific saury stock showed continuous decreasing trend since 2003 (Fig. 2). The estimated total biomass/number in 2021 were the lowest, except for the missing 2020 biomass. The proportions of the biomass in the unsurveyed area in the past years were approximately 17% in median and 30% at maximum regardless of the methods used for the calculation (Table 5). Nevertheless, the general decreasing trend and the lowest total biomass/number estimate in 2021 hold even when the biomass in the 2021 survey area were compared (Fig. 3).

Reference

Hashimoto M., Kidokoro H., Suyama S., Fuji T., Miyamoto H., Naya M., Vijai D., Ueno Y., and Kitakado T. (2020) Comparison of biomass estimates from multiple stratification approaches in a swept area method for Pacific saury *Cololabis saira* in the western North Pacific. Fisheries Science 86:445–456

Naya M, Ueno Y, Mouri T, Oshima K, Watanabe T, Fujita K, Itoh K, Iwasaki K, Matsuo Y, Itoh Y, Shimizu Y (2010) Estimation of the fishing efficiency of a mid-water trawl for Pacific saury *Cololabis saira* using a high-frequency side-scan sonar. Nippon Suisan Gakkaishi 76:658–669

Suyama S, Matusi H, Fuji T, Nakayama S, Hashimoto M, Oshima K (2020) Age-determination and age-length keys for Pacific saury, Cololabisa saira, from 2000 to 2018. NPFC-2020-SSC PS06-WP16

Table 1. Total biomass/number for 2003–2021.

Year	Total							
	Weight (thousand MT)	95%CI lower	95%CI upper	CV (%)	Number (million)	95%CI lower	95%CI upper	CV (%)
2003	5,970	3,763	8,238	20.0	60,425	40,214	80,468	17.8
2004	5,394	3,314	7,453	20.3	80,762	48,427	118,181	23.0
2005	5,061	3,126	6,985	19.4	42,027	27,558	56,664	18.2
2006	4,268	2,460	6,244	22.8	49,501	29,444	68,553	20.8
2007	3,615	2,040	5,260	23.4	55,005	29,231	85,279	26.4
2008	4,870	3,028	6,819	20.1	41,659	27,272	56,032	18.3
2009	3,641	2,061	5,873	28.3	68,222	41,782	98,363	21.7
2010	2,631	1,787	3,546	17.3	32,762	21,001	45,030	19.0
2011	3,623	2,606	4,690	15.1	38,943	24,818	54,702	19.7
2012	2,355	1,486	3,396	21.3	31,465	19,393	45,836	21.7
2013	3,654	2,042	5,416	23.1	36,205	21,697	51,779	21.3
2014	2,824	1,752	3,965	20.2	32,502	19,622	45,983	20.6
2015	2,357	1,444	3,431	21.2	32,055	19,043	47,881	22.4
2016	1,997	954	3,434	31.8	34,069	14,876	62,219	35.5
2017	987	568	1,457	23.6	16,709	8,197	26,022	28.2
2018	2,346	1,374	3,548	23.8	32,874	18,066	49,694	24.4
2019	1,646	935	2,434	24.4	29,835	17,278	43,032	22.5
2020	–	–	–	–	–	–	–	–
2021	845	402	1,352	29.9	16,720	7,098	27,857	33.2

Table 2.Biomass/number at age for 2003–2021.

Year	Age0 Weight (thousand MT)	Age0 95%CI lower	Age0 95%CI upper	Age0 CV (%)	Age1 Weight (thousand MT)	Age1 95%CI lower	Age1 95%CI upper	Age1 CV (%)
2003	1,251	715	1,899	23.7	4,718	2,839	6,833	22.6
2004	2,447	1,633	3,355	19.0	2,947	1,328	4,628	30.1
2005	328	134	530	31.8	4,732	2,838	6,671	20.5
2006	1,066	597	1,591	23.9	3,202	1,641	4,935	26.5
2007	1,421	611	2,601	36.3	2,194	1,061	3,526	29.2
2008	299	157	485	29.2	4,571	2,772	6,535	21.1
2009	2,158	1,291	3,124	22.1	1,482	385	3,562	59.2
2010	831	481	1,183	22.0	1,801	1,138	2,634	21.1
2011	984	520	1,516	25.8	2,640	1,806	3,422	15.6
2012	1,167	658	1,747	24.0	1,189	639	1,989	29.4
2013	549	251	932	31.7	3,105	1,641	4,671	25.1
2014	989	504	1,527	26.6	1,835	994	2,755	25.5
2015	1,330	656	2,137	27.3	1,028	480	1,665	30.7
2016	941	352	1,793	39.4	1,056	342	2,063	43.2
2017	478	197	794	33.0	508	243	889	32.4
2018	680	311	1,139	31.5	1,666	856	2,674	28.3
2019	686	391	1,031	23.5	960	351	1,625	36.5
2020	–	–	–	–	–	–	–	–
2021	537	207	903	34.8	458	199	770	33.4

Year	Age0 Number (million)	Age0 95%CI lower	Age0 95%CI upper	Age0 CV (%)	Age1 Number (million)	Age1 95%CI lower	Age1 95%CI upper	Age1 CV (%)
2003	24,178	13,848	34,748	22.4	36,247	22,113	51,721	22.0
2004	60,718	34,044	94,241	26.3	20,044	9,546	31,356	28.3
2005	7,372	2,988	12,218	32.4	34,656	20,589	48,858	20.8
2006	26,149	14,760	38,041	23.3	23,353	11,726	35,728	25.8
2007	37,064	14,041	66,928	36.7	17,942	8,626	29,265	29.6
2008	7,028	3,116	12,383	34.0	34,631	21,677	48,598	20.2
2009	57,599	34,114	83,420	23.0	10,623	3,041	24,740	55.4
2010	17,538	8,725	27,192	28.4	15,225	9,660	22,199	21.1
2011	18,603	8,156	32,994	34.8	20,340	14,114	26,110	15.3
2012	22,626	12,159	34,845	26.0	8,838	4,991	14,546	28.5
2013	11,297	5,521	18,711	29.7	24,907	13,318	37,503	25.2
2014	18,355	8,625	29,633	29.5	14,147	7,772	21,221	25.2
2015	23,096	11,247	37,303	27.8	8,959	4,078	14,796	31.4
2016	24,798	7,788	50,102	43.4	9,271	2,947	18,135	43.0
2017	12,105	4,267	21,248	36.7	4,605	2,146	8,034	32.9
2018	18,078	6,795	31,542	34.8	14,796	7,490	23,945	28.8
2019	20,832	9,734	32,639	28.3	9,003	3,246	15,382	37.2
2020	–	–	–	–	–	–	–	–
2021	12,898	4,435	22,657	37.9	3,822	1,679	6,374	32.7

Table 3. Age-aggregated weight/number based indices for 2003–2021.

Year	Total							
	Weight (thousand MT)	95%CI lower	95%CI upper	CV (%)	Number (million)	95%CI lower	95%CI upper	CV (%)
2003	1,069	674	1,475	20.0	10,816	7,198	14,404	17.8
2004	965	593	1,334	20.3	14,456	8,668	21,154	23.0
2005	906	560	1,250	19.4	7,523	4,933	10,143	18.2
2006	764	440	1,118	22.8	8,861	5,270	12,271	20.8
2007	647	365	942	23.4	9,846	5,232	15,265	26.4
2008	872	542	1,221	20.1	7,457	4,882	10,030	18.3
2009	652	369	1,051	28.3	12,212	7,479	17,607	21.7
2010	471	320	635	17.3	5,864	3,759	8,060	19.0
2011	649	466	840	15.1	6,971	4,442	9,792	19.7
2012	422	266	608	21.3	5,632	3,471	8,205	21.7
2013	654	366	969	23.1	6,481	3,884	9,268	21.3
2014	505	314	710	20.2	5,818	3,512	8,231	20.6
2015	422	258	614	21.2	5,738	3,409	8,571	22.4
2016	357	171	615	31.8	6,098	2,663	11,137	35.5
2017	177	102	261	23.6	2,991	1,467	4,658	28.2
2018	420	246	635	23.8	5,884	3,234	8,895	24.4
2019	295	167	436	24.4	5,340	3,093	7,703	22.5
2020	–	–	–	–	–	–	–	–
2021	151	72	242	29.9	2,993	1,271	4,986	33.2

Table 4. Weight/number based indices at age for 2003–2021.

Year	Age0				Age1			
	Weight (thousand MT)	95%CI lower	95%CI upper	CV (%)	Weight (thousand MT)	95%CI lower	95%CI upper	CV (%)
2003	224	128	340	23.7	845	508	1,223	22.6
2004	438	292	600	19.0	527	238	828	30.1
2005	59	24	95	31.8	847	508	1,194	20.5
2006	191	107	285	23.9	573	294	883	26.5
2007	254	109	466	36.3	393	190	631	29.2
2008	54	28	87	29.2	818	496	1,170	21.1
2009	386	231	559	22.1	265	69	638	59.2
2010	149	86	212	22.0	322	204	471	21.1
2011	176	93	271	25.8	473	323	613	15.6
2012	209	118	313	24.0	213	114	356	29.4
2013	98	45	167	31.7	556	294	836	25.1
2014	177	90	273	26.6	328	178	493	25.5
2015	238	117	382	27.3	184	86	298	30.7
2016	168	63	321	39.4	189	61	369	43.2
2017	86	35	142	33.0	91	43	159	32.4
2018	122	56	204	31.5	298	153	479	28.3
2019	123	70	185	23.5	172	63	291	36.5
2020	–	–	–	–	–	–	–	–
2021	96	37	162	34.8	82	36	138	33.4

Year	Age0				Age1			
	Number (million)	95%CI lower	95%CI upper	CV (%)	Number (million)	95%CI lower	95%CI upper	CV (%)
2003	4,328	2,479	6,220	22.4	6,488	3,958	9,258	22.0
2004	10,869	6,094	16,869	26.3	3,588	1,709	5,613	28.3
2005	1,320	535	2,187	32.4	6,203	3,685	8,746	20.8
2006	4,681	2,642	6,809	23.3	4,180	2,099	6,395	25.8
2007	6,634	2,513	11,980	36.7	3,212	1,544	5,238	29.6
2008	1,258	558	2,217	34.0	6,199	3,880	8,699	20.2
2009	10,310	6,106	14,932	23.0	1,902	544	4,428	55.4
2010	3,139	1,562	4,867	28.4	2,725	1,729	3,974	21.1
2011	3,330	1,460	5,906	34.8	3,641	2,526	4,674	15.3
2012	4,050	2,177	6,237	26.0	1,582	893	2,604	28.5
2013	2,022	988	3,349	29.7	4,458	2,384	6,713	25.2
2014	3,286	1,544	5,304	29.5	2,532	1,391	3,799	25.2
2015	4,134	2,013	6,677	27.8	1,604	730	2,649	31.4
2016	4,439	1,394	8,968	43.4	1,660	527	3,246	43.0
2017	2,167	764	3,803	36.7	824	384	1,438	32.9
2018	3,236	1,216	5,646	34.8	2,648	1,341	4,286	28.8
2019	3,729	1,742	5,842	28.3	1,612	581	2,753	37.2
2020	–	–	–	–	–	–	–	–
2021	2,309	794	4,056	37.9	684	300	1,141	32.7

Table 5. Historical proportions of the biomass in the unsurveyed area in 2021.

Year	method	
	based on the number of sampling station	based on the SST
2003	10.3%	10.3%
2004	19.3%	18.5%
2005	3.7%	2.4%
2006	7.8%	7.8%
2007	21.8%	21.8%
2008	8.2%	8.2%
2009	3.8%	3.8%
2010	29.8%	29.8%
2012	10.9%	10.9%
2013	24.7%	23.2%
2014	17.7%	19.1%
2015	30.1%	30.1%
2016	16.4%	16.4%
2017	10.8%	10.8%
2018	16.8%	17.0%
2019	17.1%	17.4%
minimum	3.7%	2.4%
mean	15.6%	15.5%
median	16.6%	16.7%
maximum	30.1%	30.1%

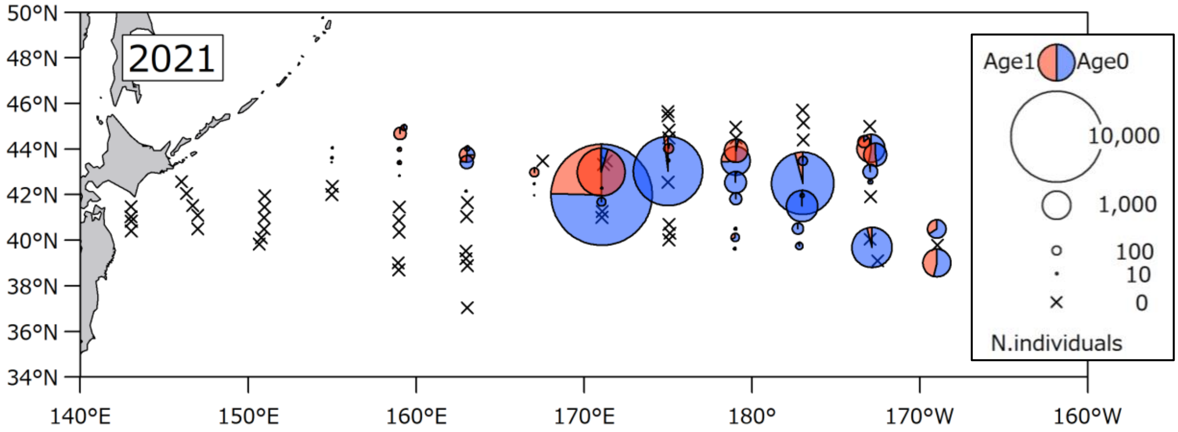


Fig. 1. Number of individuals collected at each sampling station in the 2021 survey.

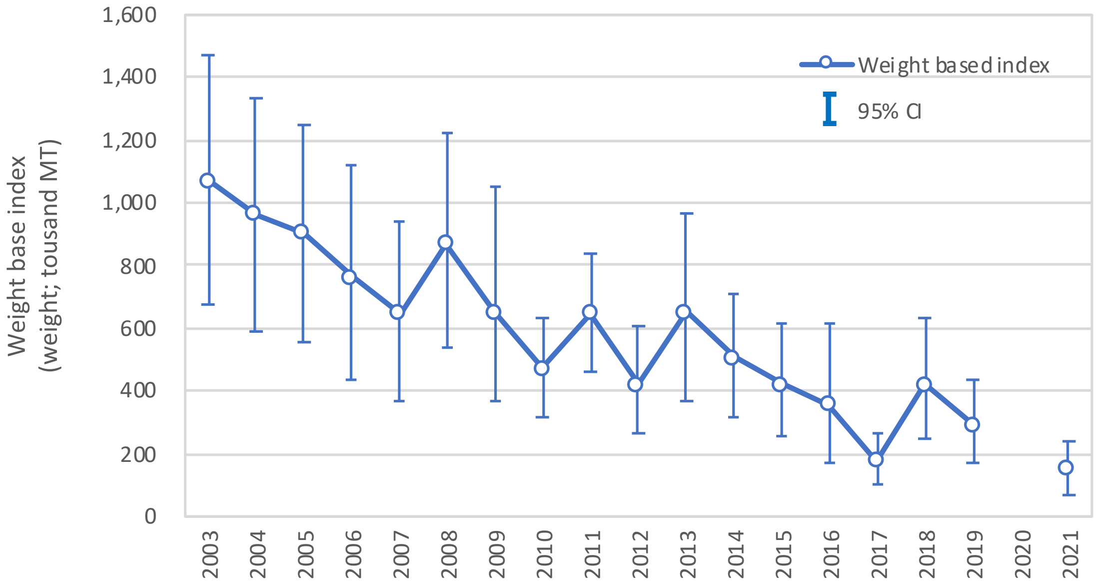


Fig. 2. Annual weight based index from 2003 to 2021. Bars indicate 95% confidence intervals.

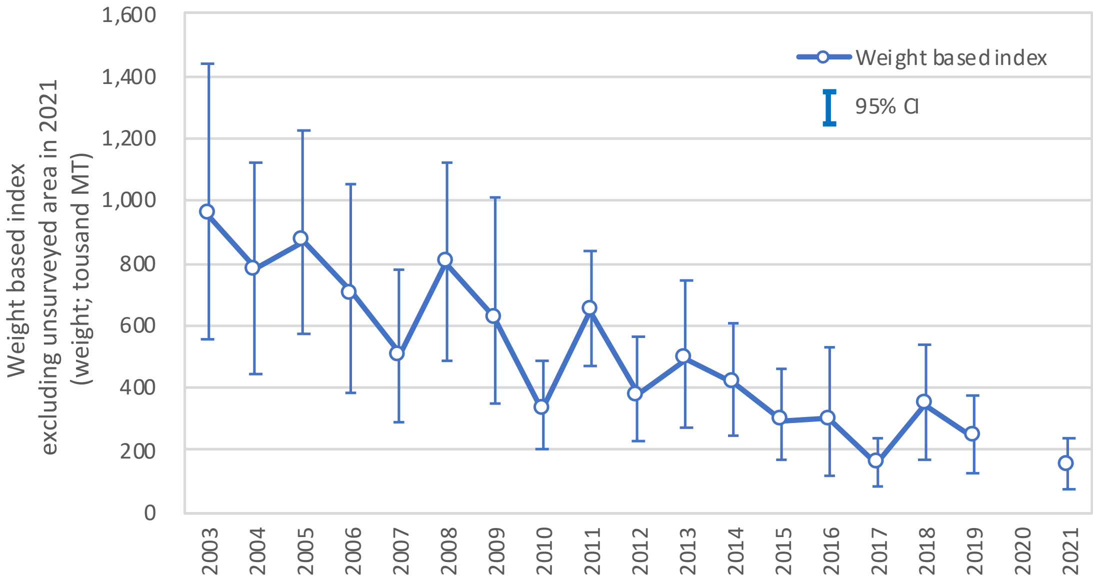
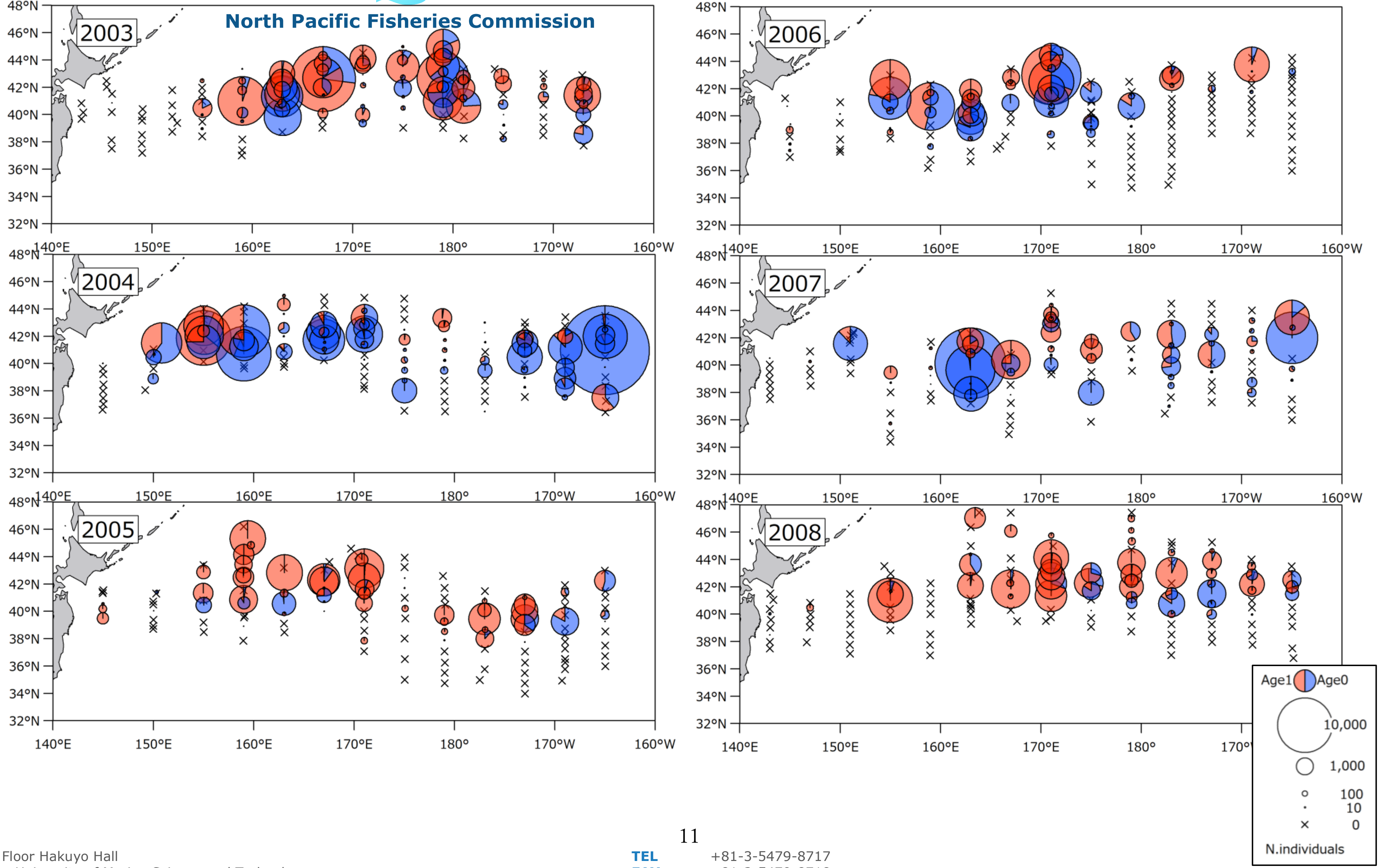


Fig. 3. The historical biomass in the 2021 survey area.



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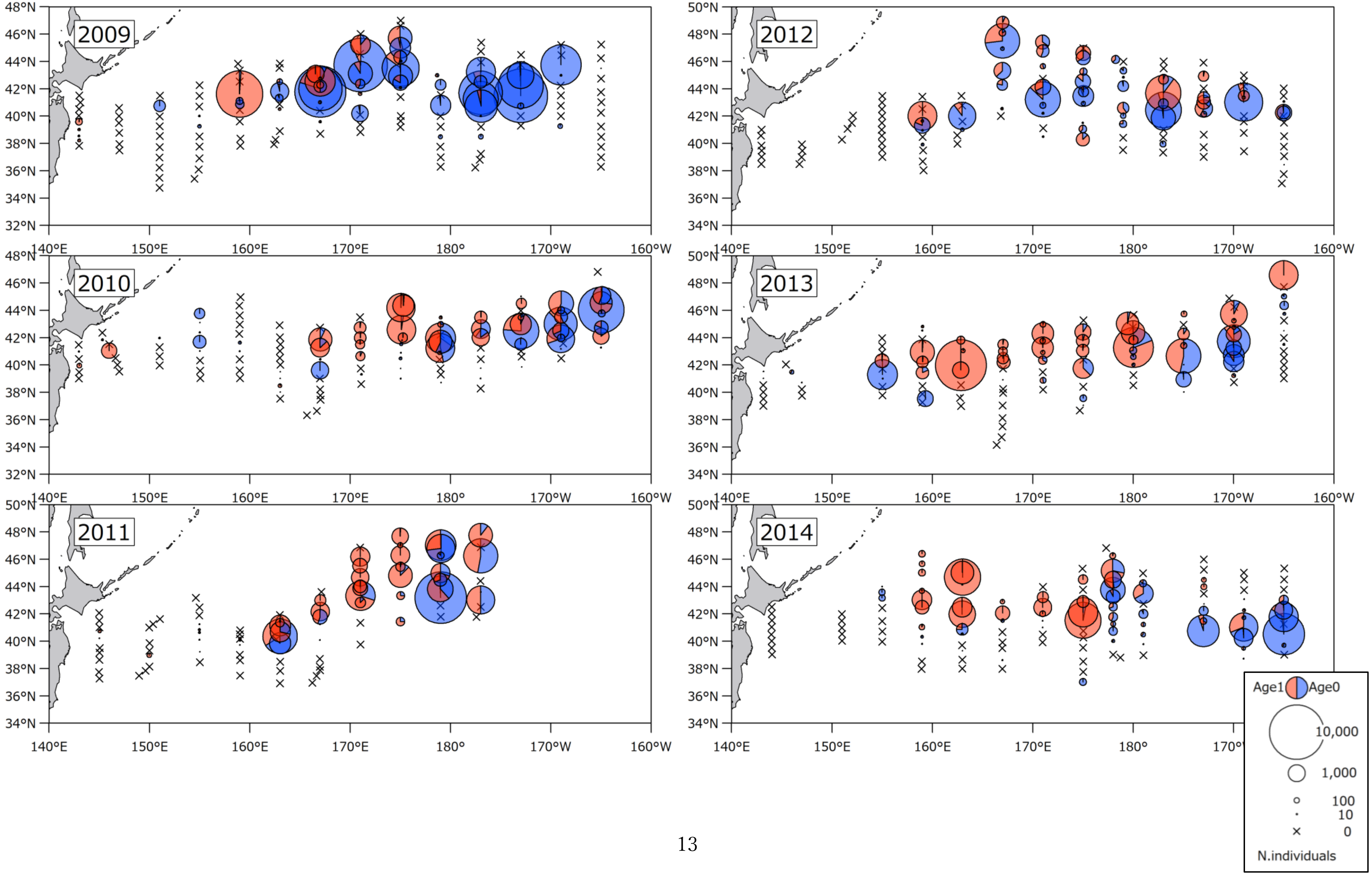
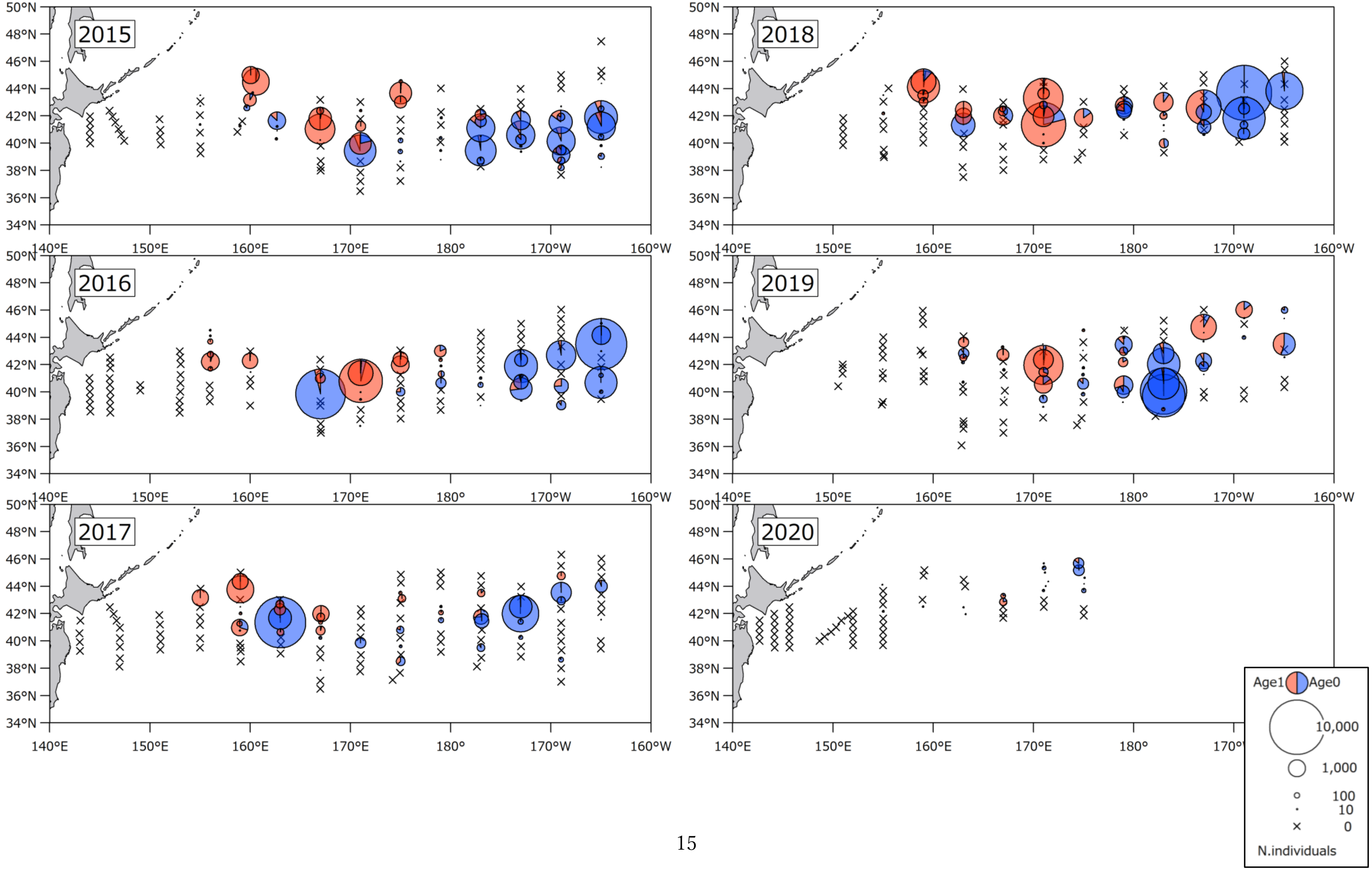
Appendix Fig.1 Number of individuals collected at each sampling station and percentage for each age.


2009
2010
2011
2012
2013
2014
48°N
46°N
44°N
42°N
40°N
38°N
36°N
34°N
32°N
50°N
140°E
150°E
160°E
170°E
180°
170°W
160°W
Age1
Age0
10,000
1,000
100
10
0
N.individuals

Appendix Fig.1 (continued) Number of individuals collected at each sampling station and percentage for each age.



2015
2018
2016
2019
2017
2020
50°N
48°N
46°N
44°N
42°N
40°N
38°N
36°N
34°N
140°E
150°E
160°E
170°E
180°
170°W
160°W
Age1
Age0
10,000
1,000
100
10
0
N.individuals

Appendix Fig.1 (continued) Number of individuals collected at each sampling station and percentage for each age.