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SUMMARY

Korean distant water tuna and tuna-like fisheries in the Pacific Ocean consist of a longline fishery and a purse seine fishery. There were 94 active longline vessels and 23 active purse seine vessels in 2021. The number of longline vessels remained below 100 since 2015, and the number of purse seine vessels remained the same as the previous year. The two Korean fisheries harvested 46,762 tons of tuna and tuna-like species in the North Pacific Ocean in 2021. The total catch of the longline fishery was 16,950 tons, a 21% increase over 2020, while the purse seine fishery harvested 29,812 tons, a 36% decrease year to year. The longline fishery mainly targeted bigeye and yellowfin tunas whose catch accounted for 55.9% and 31.8% of the total catch in 2021. The dominant species of the purse seine fishery was skipjack tuna (72.1%), followed by yellowfin tuna (26.0%) and bigeye tuna (1.9%). Pacific bluefin tuna (PBF) is harvested by some coastal and offshore fisheries in the Korean waters. The offshore large purse seine fishery operating in the waters surrounding Jeju Island—the largest domestic PBF fishery—harvested 422 tons of PBF in 2021, which accounted for 83% of the total domestic catch. In 2021, the catch of large PBF (30kg or greater) accounted for 11% of the total catch.

1. INTRODUCTION

Korean distant water tuna and tuna-like fisheries in the Pacific Ocean consist of a longline fishery and a purse seine fishery. The tuna longline fishery (herein 'longline fishery') commenced its first fishing in the Indian Ocean in 1957, explored the Pacific Ocean in 1958, and expanded to the Atlantic Ocean in 1967. The number of active vessels peaked at 220 in 1991 and has decreased thereafter.

The tuna purse seine fishery (herein 'purse seine fishery') started in 1971 with 3 purse seine vessels in the Eastern Pacific Ocean (EPO). It has developed into a fishery with helicopter-aided mass operations in 1979 for the first time. The number of active vessels peaked at 39 in 1990, sharply declined to 27-28 by the early 1990s, and maintained around 23-28 in the recent decade.

Korean distant water fisheries must operate under the *Distant Water Fisheries Development Act*, which came into effect on 4 February 2008. An electronic reporting (ER) system started its operation since 1 September 2015, and all Korean distant water fishing vessels must report their catch information in real time using this system. The catch and effort data reported via the ER system are monitored and managed by the National Institute of Fisheries Science (NIFS).

Pacific bluefin tuna (PBF) has been caught by domestic fleets in the Korean waters, mostly by offshore large purse seine fishery (herein 'offshore purse seine fishery') which targets pelagic species such as mackerels by operating in the Korean waters. A Ministerial Directive on the conservation and management of the PBF stock came into effect on 26 May 2011 with an aim of monitoring and managing the fisheries associated with PBF. The directive has been amended several times, and the latest amendment was put into force in 2020. The Ministerial Directive specifies the annual PBF catch limit by fishery and province, and further improvements have been made in the catch reporting system as well.

This document provides information on catch and effort of the Korean distant water tuna and tuna-like fisheries and on PBF catch of the Korean domestic fisheries.

2. FISHERIES

2.1 Distant Water Fisheries

2.1.1 Fleet Structure

Table 1 and Fig. 1 describe the annual number of active Korean vessels in the Pacific Ocean by fishery type and vessel size. The number of purse seine vessels peaked at 39 in 1990, declined to 28 by 1996, and maintained at 23-28 thereafter. In 2021, as was in the previous year, 23 vessels were active, of which 2 vessels were in 501-1,000 GRT, 15 vessels were in 1,001-1,500 GRT, and 6 vessels were over 1,500 GRT. The number of longline vessels was at 220 in 1991 but declined to 108 by 2008 and showed a slight increase up to 126 by 2012. The number further declined and remained below 100 since 2015 and recorded 94 in 2021. All the longline vessels are in the 201-500 GRT class except for a vessel in the 51-200 GRT.

2.1.2 Fishing Pattern

Figs. 2 and 3 illustrate the catch and effort distribution of the Pacific purse seine and longline fisheries in the last 5 years.

In general, the purse seine fishery operated in the tropical area of the Western and Central Pacific Ocean (WCPO) between 140°E-170°W throughout the year, and its fishing area often extended to the east depending on the oceanographic conditions. The fishing efforts of purse seine fleets in 2021 were relatively concentrated east of 165°E, and as was in 2020 the fishing area was longitudinally narrower compared to the previous years (Fig. 2).

The longline fishery has operated mainly in the tropical area of 160°E-120°W. In 2017, the fishing effort of longline fleets were higher in 170°E-175°W and further extended toward the EPO. However, from 2018 to 2021, the fishing effort has become more concentrated in the central tropical area (10°S-10°N, 170°E-160°W) compared to the previous years (Fig. 3).

2.1.3 Annual Catch and Effort

Annual catch and effort by Korean distant water tuna fisheries in the North Pacific Ocean are shown in Tables 2-3, and Figs. 4-5. Most longline and purse seine fisheries' catch are made south of 20°N (Figs. 2 and 3).

The fishing effort (no. of hooks) of the longline fishery was 33,325 thousand hooks in 2021, i.e., 10% and 4% increase compared to the effort in 2020 and the average effort of the recent 5 years (32,162 thousand hooks) (Table 2). The total fishing effort (no. of sets) of the purse seine fishery was 1,118 sets in 2021, i.e., 2% and 30% decrease over the effort in 2020 and the average of 5 recent years (1,607 sets), respectively (Table 3).

The total catch of the longline fishery in the North Pacific Ocean was 16,950 tons in 2021, a 21% increase compared to that in 2020 and a 17% increase compared to the average of the recent 5 years (14,510 tons), whereas, the catch of billfishes and sharks decreased compared to those in 2020 (Table 2 and Fig. 4). The total catch of the purse seine fishery was 29,812 tons, which is a significant decrease by 36% compared to that in 2020 and near a half of the 5-year average (59,180 tons). In particular, skipjack tuna catch dropped by 40% and 55% compared to that in 2020 and the 5-year average (47,854 tons) (Table 3 and Fig. 5).

As for the catch composition of the longline fishery in 2021, bigeye tuna, yellowfin tuna, blue marlin, and swordfish accounted for 55.9%, 31.8%, 5.0%, and 2.0% in total (Fig. 4). For the purse seine fishery, skipjack, yellowfin, and bigeye tunas accounted for 72.1%, 26.0 %, and 1.9% in total, respectively (Fig. 5).

2.2 PBF Catch by Coastal Fisheries

2.2.1 Fleet Structure

PBF is mainly caught by the offshore purse seine fishery targeting mackerels in the Korean waters. Due to the strategy set out by the government to control the fishing capacity of this fishery for the conservation and management of major commercial pelagic species, the number of vessels in the offshore purse seine fishery decreased from 32 vessels in 2002 to 24 vessels in 2012, and the number has been quite stable thereafter. In 2021, there were 19 vessels who operated and caught PBF, i.e., 4 vessels less than in 2019. A small portion of the PBF is caught by set net, troll, and trawl fisheries operating in the Korean waters (Table 4).

2.2.2 Fishing Pattern

In 2021, most PBF catch were made by the offshore purse seine fishery around the eastern and southern part of Jeju Island from March to April, which is a similar fishing pattern to the previous years. Also, the catch made by the set net fishery located along the coast north of 36°N in the East Sea has largely increased from 2020 (Fig. 6).

2.2.3 Annual Catch and Effort

The annual PBF catch by fishery are presented in Table 4 and Fig. 7. The total catch of PBF was the highest with 2,601 tons in 2003 and has shown a decreasing trend with annual fluctuations thereafter. In 2021, the PBF catch of the offshore purse seine fishery was 422 tons, which accounted for 83% over the total catch. The PBF catch of the set net fishery was 84 tons, which accounted for 17%, and trawl fishery caught around 0.2 tons in 2021.

Fig. 8 shows the PBF catch by size (large and small) from 2002 to 2021 and the catch composition by fishery and size in 2021. Large PBF (30kg or greater) has been caught in the Korean waters since 2008, and the catch of large PBFs in 2016 was around 469 tons, accounting for over 46% in the total catch. In 2020, the proportion of large PBFs in the PBF catch was around 68%, which is the highest record. Large PBFs were mostly caught by the offshore purse seine fishery operating around the southern waters of Jeju Island during March and April. A small quantity of large fish was caught by the trawl and set net fisheries as well. In 2021, the proportion of large PBFs dropped to 11%, which is a significant decrease compared to that in 2020.

The mean fork length of PBF caught by the offshore purse seine fishery was 88.1 cm in 2021, which is comparatively small than 101.2 cm in 2020 (Fig. 9).

3. DATA COLLECTION SYSTEM

3.1 Distant Water Fisheries

National Institute of Fisheries Science (NIFS) is responsible for the data collection and management of the Korean distant water fisheries. In accordance with data reporting and submission requirement by the RFMOs, necessary improvements have been made in data coverage, accuracy, and verification through cross-checking among relevant organizations and agencies. Since 1 September 2015, the *Distant Water Fisheries Development Act* has obliged fishers of distant water fisheries to report fishing information to NIFS in real time through the electronic reporting (ER) system. Continuous efforts are being made to review and update the system to include data reporting and collection requirements newly adopted by the tuna RFMOs.

3.2 Observer Program

A scientific observer program for the Korean distant water fisheries started in 2002. A qualified person for the application for observers is a college graduate, majored in natural science, or fisheries high school graduate with a minimum 1-year experience on board and certificate of qualification to deck officer. Observer candidates who passed the paper review (including medical check-up) and oral interview must take a three-weeks training program. The observer training program includes basic seafaring safety, operation of navigation devices, biological information on target and non-target species, and data collection and reporting methods for fishing activities. The trainees must take two tests during the training, one designed to assess the trainee's proficiency in the technical terms for fisheries and biology, and the other to assess the trainee's species identification skills. Trainees must score a minimum 70/100 points for both tests with 100 % attendance to pass the course and be assigned to an on-board duty. Korea has a total of 63 scientific observers up to date. Since 2020, there have been some difficulties in dispatching observers on board due to the circumstances surrounding the COVID-19 pandemic.

3.3 PBF Catch of Coastal Fisheries

To estimate the Korean historical PBF catch, we used the imported products information recorded by Japan in 1982-1999 and information on the export to Japanese markets provided by Korean Offshore Large Purse Seine Fisheries Cooperatives for 2000-2004. Since 2005, PBF catch information has been collected through the monthly sales check reported by Busan Cooperative Fish Market and National Federation of Fisheries Cooperative. All PBF catch information obtained through the sales check are monitored and managed by NIFS.

4. RESEARCH

4.1 PBF Close-Kin Program

NIFS has been collecting PBF tissue samples since 2016, mostly from those caught by the offshore purse seine fishery for the close-kin program (Table 5, Fig. 10). The samples were analyzed to develop genetic markers including Microsatellite (MS) markers (2018) and Single Nucleotide Polymorphism (SNP) markers (2019-2021). For the detection of candidate SNP markers, 34 PBFs for Whole Genome Sequencing and 96 PBFs for Genotyping-by-sequencing were used to conduct analyses based on the Reference (NCBI: GCA_009176245.1, 2019) (Fig. 11). In 2021, 410 tissue samples were collected, and the analysis is in progress.

4.2 PBF Eggs and Larvae Monitoring

Since 2013, NIFS has been collecting eggs and larvae of fisheries resources which occur, spawn, and/or migrate through the Korean EEZ to study their biological characteristics. Fig. 12 illustrates the PBF eggs and larval distribution in the Korean waters in 2021. Six larvae were found off the coast of Jeju Island in July (Fig. 12-B). In the East Sea, 17 eggs and 2 larvae were found off the coast of Dokdo in August (Fig. 12-C). The total length range of PBF larvae was from 3.28mm to 4.81mm.

Table 1. The number of active vessels in the Korean distant water tuna fisheries in the Pacific Ocean, 2008-2021

Year	GRT class by fishery									
	Longline					Purse seine				
	Total	0-50	51-200	201-500	500+	Total	0-500	501-1000	1001-1500	1500+
2008	108	-	-	108	-	28	-	15	12	1
2009	111	-	-	111	-	27	-	13	11	3
2010	122	-	-	122	-	28	-	13	13	3
2011	124	-	-	124	-	28	-	12	11	5
2012	126	-	-	126	-	28	-	12	11	5
2013	125	-	1	124	-	27	-	12	10	5
2014	110	-	1	112	-	28	-	10	13	5
2015	98	-	1	97	-	25	-	7	13	5
2016	96	-	1	95	-	25	-	7	14	4
2017	96	-	1	95	-	26	-	7	15	4
2018	96	-	1	95	-	26	-	6	15	5
2019	96	-	1	95	-	26	-	6	15	5
2020	99	-	1	98	-	23	-	2	15	6
2021	94	-	-	94	-	23	-	2	15	6

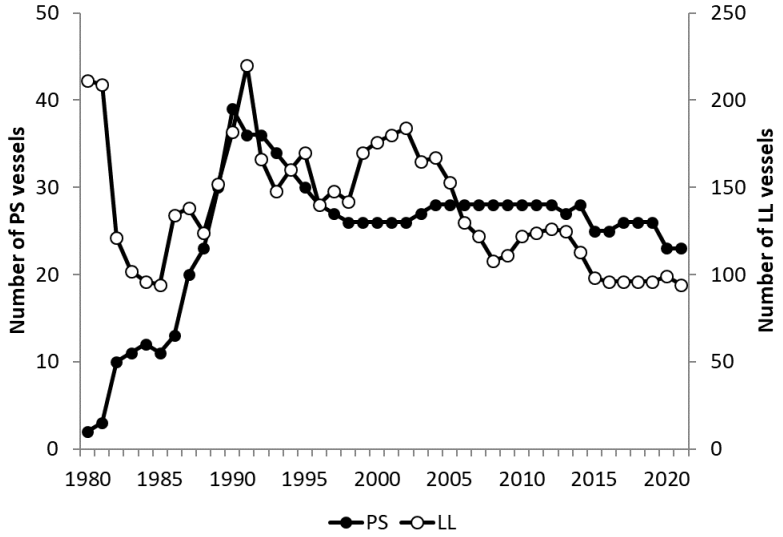

Fig. 1. Historical number of active fishing vessels of the Korean distant water tuna fisheries operated in the Pacific Ocean, 1980-2021.

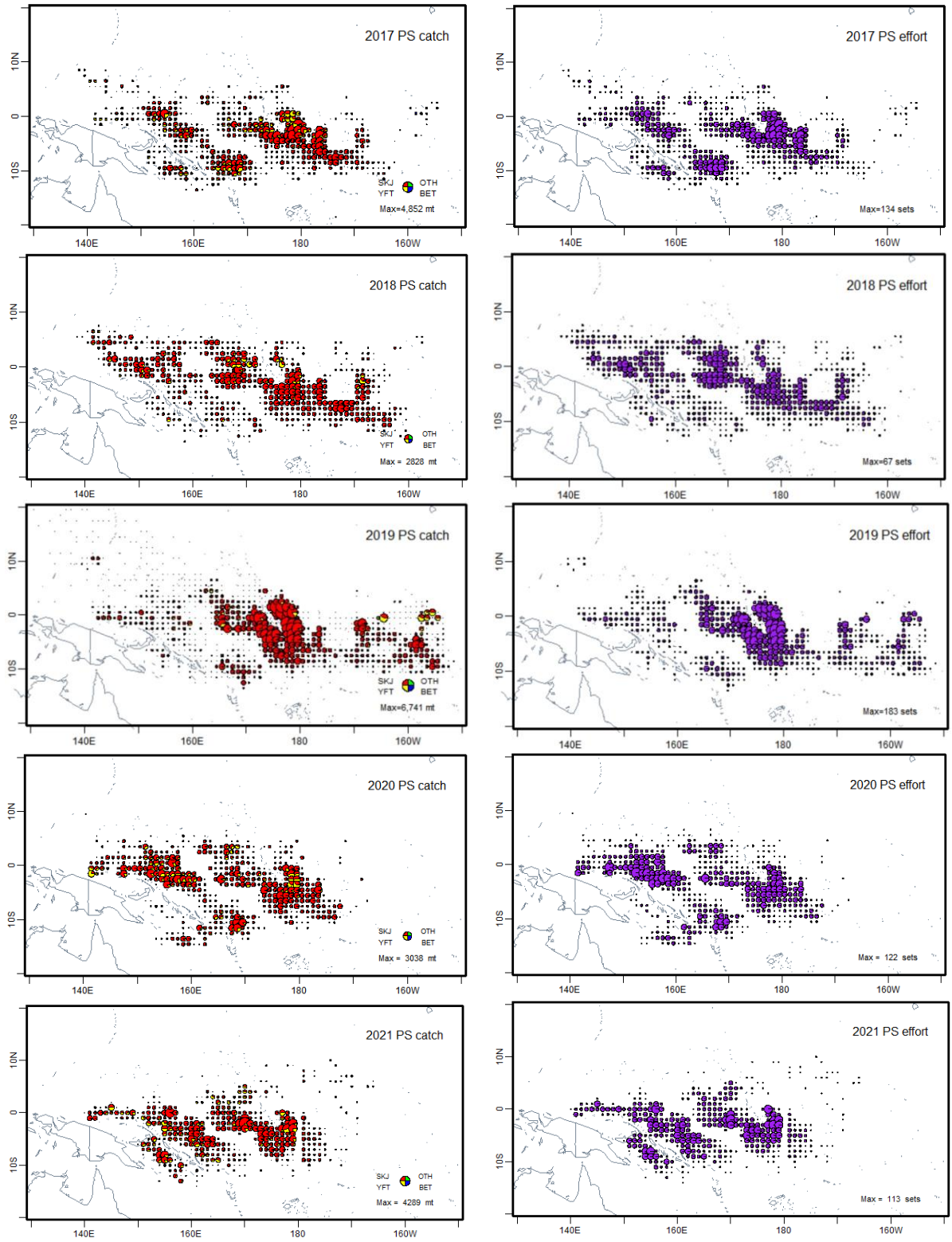

Fig. 2. Distributions of catch (left) and effort (right) of the Korean distant water tuna purse seine fishery operated in the Pacific Ocean, 2017-2021.

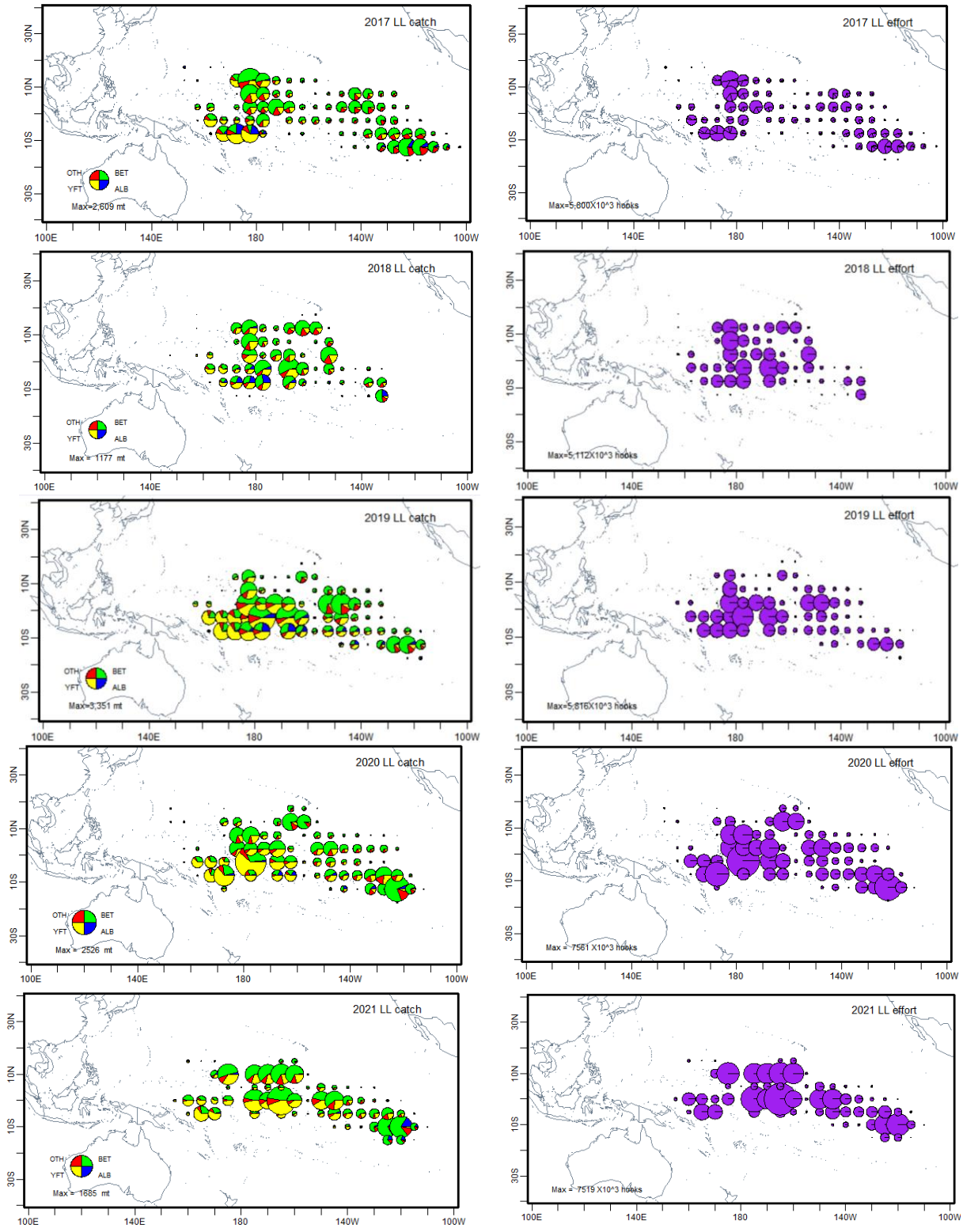

Fig. 3. Distributions of catch (left) and effort (right) of the Korean distant water tuna longline fishery operated in the Pacific Ocean, 2017-2021.

Table 2. Fishing effort (X1,000 hooks) and catch (tons) of the Korean distant water tuna longline fishery in the North Pacific Ocean, 2002-2021

Year	Hooks (X1000)	ALB	YFT	BET	SKJ	BUM	MLS	SWO	BLM	SFA	SKH	OTH	Total
2002	16,478	112	3,137	10,786	0	152	188	439	479	123	185	1,400	17,001
2003	21,431	146	4,741	9,739	6	159	206	381	819	129	95	931	17,352
2004	18,746	78	5,144	12,453	101	227	75	410	919	1	8	404	19,819
2005	14,955	420	2,958	9,257	35	304	136	404	997	0	10	820	15,340
2006	18,259	135	5,096	11,494	0	217	56	465	1,063	0	0	941	19,468
2007	15,441	137	2,175	9,606	0	121	47	453	887	0	1	291	13,718
2008	16,466	400	2,730	11,075	0	220	30	795	748	0	4	741	16,742
2009	13,286	95	2,992	10,979	0	224	23	994	654	0	13	878	16,852
2010	14,729	107	2,011	9,303	0	257	18	663	570	0	69	532	13,531
2011	16,654	78	3,146	9,047	0	684	48	962	159	1	546	941	15,614
2012	15,553	157	2,398	11,385	8	587	34	856	57	1	499	876	16,859
2013	13,780	173	1,988	6,041	22	963	65	1,071	41	2	735	204	11,306
2014	11,646	116	2,102	7,735	50	801	82	829	31	3	610	256	13,208
2015	8,022	38	1,520	6,132	41	531	44	776	82	2	250	115	9,531
2016	26,241	56	1,626	6,871	73	1,116	61	582	30	11	9	158	10,593
2017	36,780	202	3,775	10,303	147	1,453	81	583	17	13	31	262	16,867
2018	38,352	101	3,426	10,286	99	1,373	70	664	35	10	37	230	16,332
2019	29,011	65	4,106	8,758	141	981	48	468	28	8	37	149	14,789
2020	30,428	56	3,169	9,157	102	848	74	392	18	4	10	141	13,971
2021	33,325	275	5,398	9,471	209	854	82	335	11	0	2	311	16,950

ALB : Albacore tuna, YFT : Yellowfin tuna, BET : Bigeye tuna, SKJ : Skipjack tuna, BUM : Blue marlin, MLS : Striped marlin, SWO : Swordfish, BLM : Black marlin, SFA : Indo-Pacific sailfish, SKH : Sharks, OTH : Others.

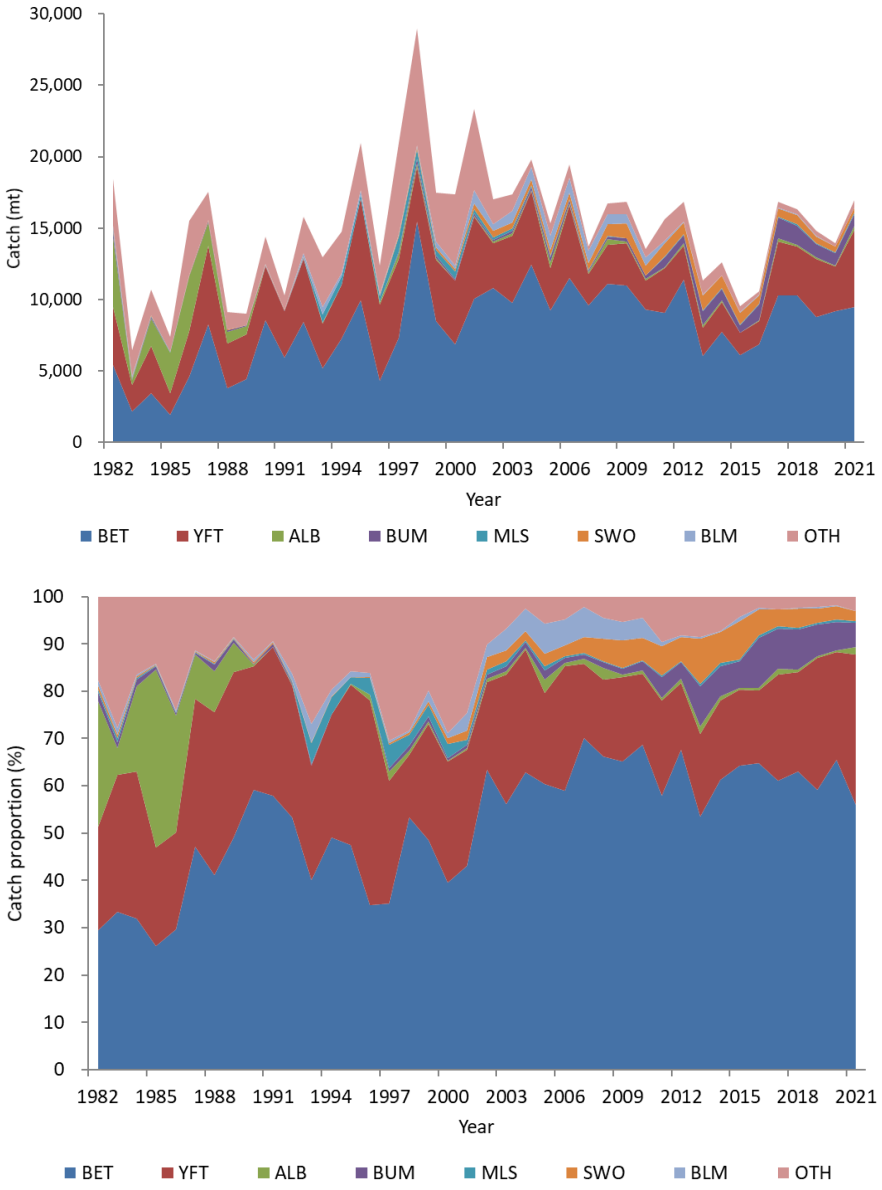

Fig. 4. Historical catches (top) and the catch proportion (bottom) by major species caught by the Korean distant water tuna longline fishery in the North Pacific Ocean, 1982-2021.

Table 3. Fishing effort (no. of sets) and catch (tons) of the Korean distant water tuna purse seine fishery in the North Pacific Ocean, 2002-2021

Year	Effort (sets)	Catch (tons)				Total
		SKJ	BET	YFT	OTH	
2002	2,537	64,897	0	16,389	0	81,286
2003	2,876	88,654	319	11,714	0	100,687
2004	1,633	43,797	48	7,426	0	51,271
2005	1,035	49,724	0	11,027	0	60,751
2006	510	67,564	13	15,394	0	82,970
2007	543	18,270	0	3,585	0	21,855
2008	490	9,233	4	7,842	0	17,079
2009	1,237	38,436	15	7,232	0	45,683
2010	727	20,751	374	4,020	0	25,145
2011	770	18,331	216	5,256	0	23,803
2012	2,402	67,448	404	19,467	1	87,320
2013	1,644	40,809	232	4,344	0	45,386
2014	1,732	40,690	265	11,343	0	52,298
2015	1,296	40,195	739	13,859	0	54,793
2016	2,379	62,849	1,025	10,088	31	73,993
2017	863	22,672	858	8,829	2	32,361
2018	2,141	59,479	1,327	12,838	1	73,645
2019	1,507	58,574	398	10,425	1	69,397
2020	1,145	35,698	847	9,959	<1	46,504
2021	1,118	21,497	573	7,742	0	29,812

SKJ : Skipjack tuna, BET : Bigeye tuna, YFT : Yellowfin tuna, OTH : Others.

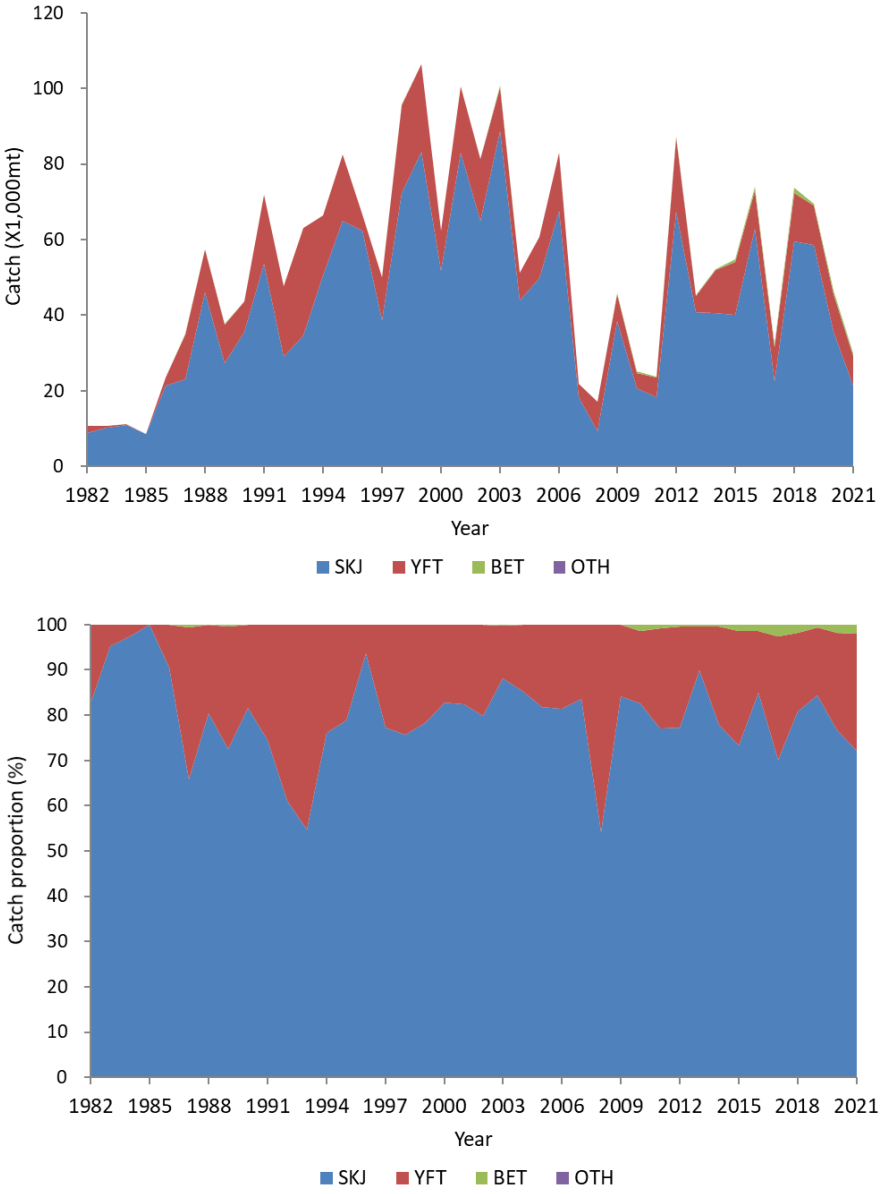

Fig. 5. Historical catches (top) and the catch proportion (bottom) by major species caught by the Korean distant water tuna purse seine fishery in the North Pacific Ocean, 1982-2021.

Table 4. Annual catch of Pacific bluefin tuna by fishery, and the number of active vessels of the offshore large purse seine fishery in the Korean waters, 2002-2021

Year	Catch (tons)				
	OLPS (no. of vessels)	Set Net	Troll	Trawl	Total
2002	932 (32)	0	0	1	933
2003	2,601 (29)	0	0	0	2,601
2004	773 (29)	0	0	0	773
2005	1,318 (29)	0	0	9	1,327
2006	1,012 (29)	0	0	3	1,015
2007	1,281 (29)	0	0	4	1,285
2008	1,866 (29)	0	0	10	1,876
2009	936 (27)	0	0	4	940
2010	1,196 (25)	0	0	16	1,212
2011	670 (25)	0	0	14	685
2012	1,421 (24)	0	1	2	1,424
2013	604 (24)	1	0	0	605
2014	1,305 (24)	6	0	0	1,311
2015	676 (24)	1	0	0	677
2016	1,024 (24)	3	0	2	1,029
2017	734 (24)	3	0	6	743
2018	523 (24)	7	0	5	535
2019	542 (23)	36	0	3	581
2020	567(18)	35	0	3	605
2021	422(19)	84	0	0.2	509*

*Regarding the total catch of 2021, catches of other fisheries (3 tons) were included.

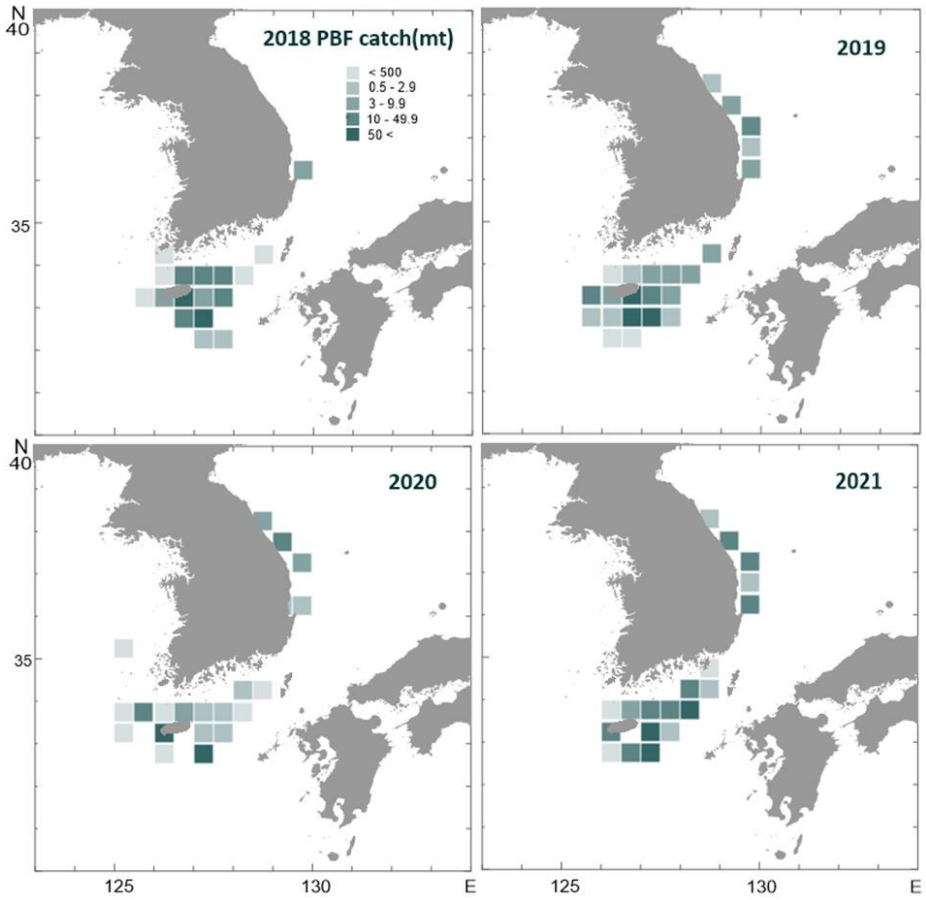

Fig. 6. Catch distribution of Pacific bluefin tuna caught by the Korean coastal and offshore fisheries, 2018-2021.

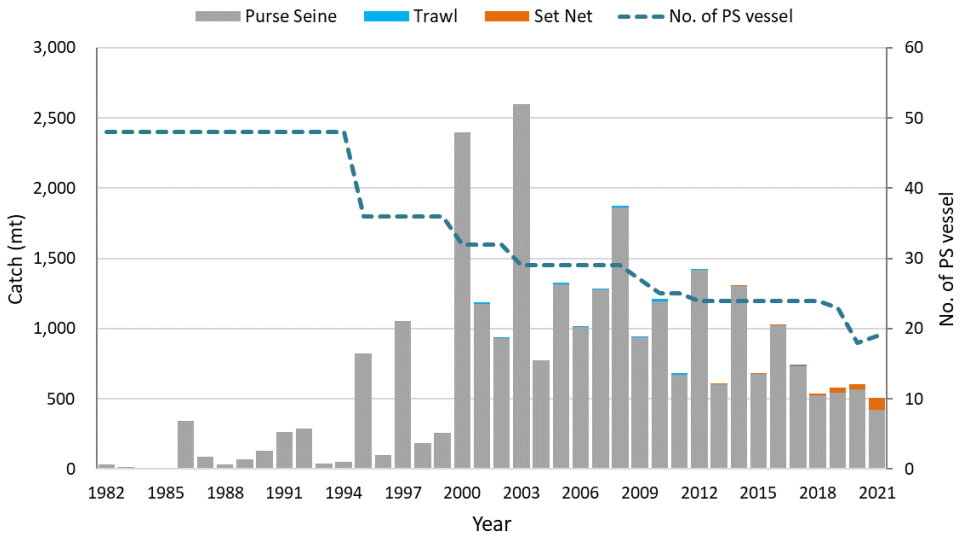

Fig. 7. Historical catch of Pacific bluefin tuna by fishery, and the number of active vessels of the offshore large purse seine fishery in the Korean waters, 1982-2021.

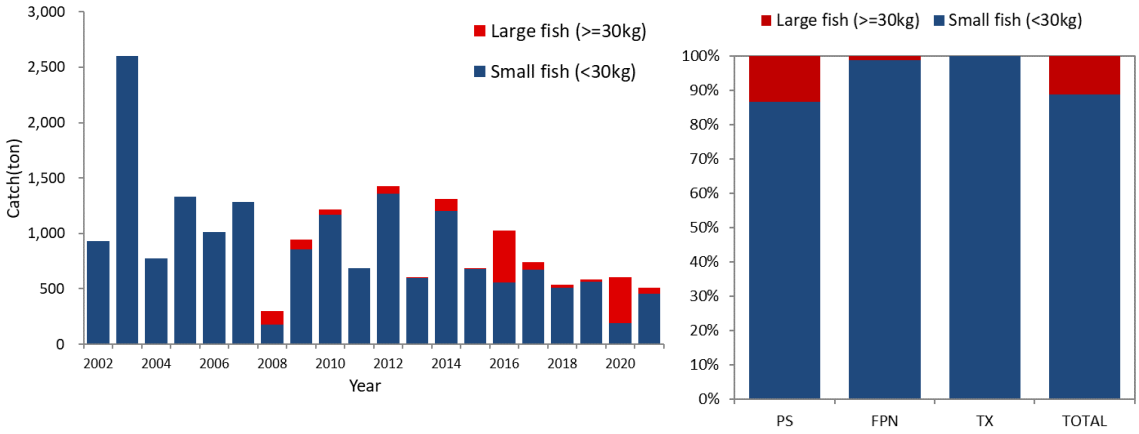

Fig. 8. Catch of Pacific bluefin tuna by size from 2002 to 2021 (left) and the catch proportion by fishery and size in 2021 (right).

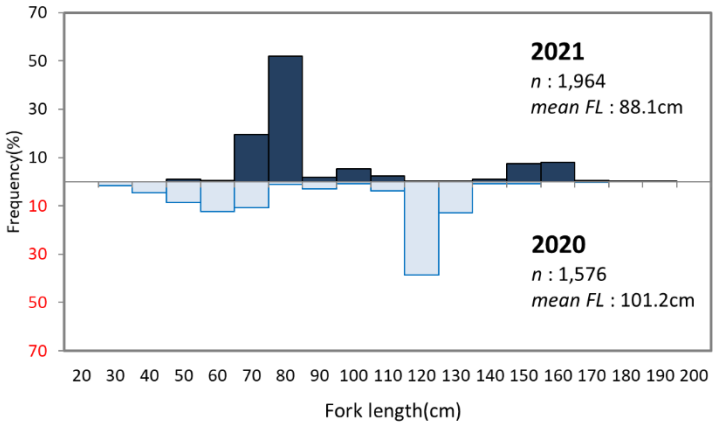

Fig. 9. Length frequency of Pacific bluefin tuna caught by the Korean offshore large purse seine fishery in 2020 and 2021.

Table 5. Summary of the number of samples and range of fork length (FL) by year for the close-kin mark-recapture

Year	Number of samples	Range of FL (cm)
2016	1,045	32.2-179.0
2017	348	35.5-89.5
2018	249	36.0-162.8
2019	313	33.9-109.6
2020	182	35.4-135.5
2021	410	52.0-123.8

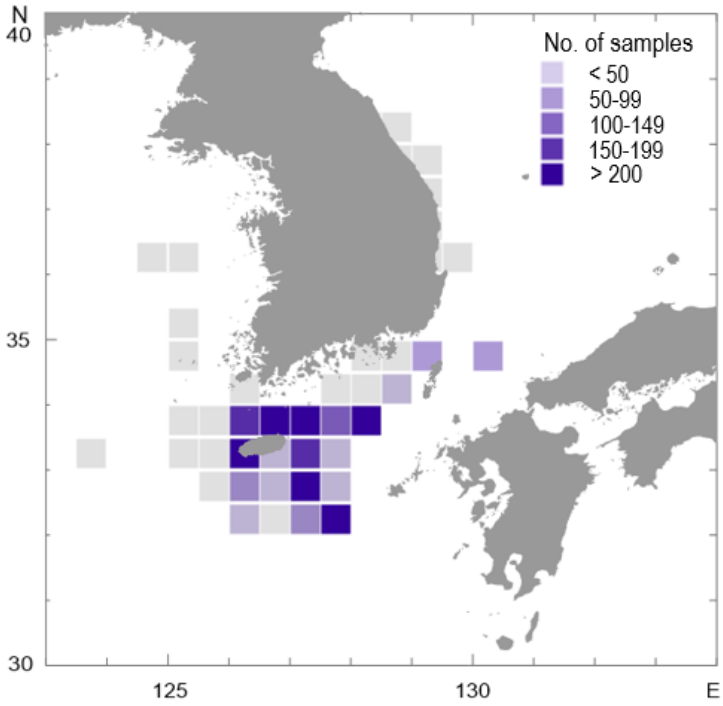

Fig. 10. Distribution of Pacific bluefin tuna sampled by the Korean coastal and offshore fisheries, 2016-2021.

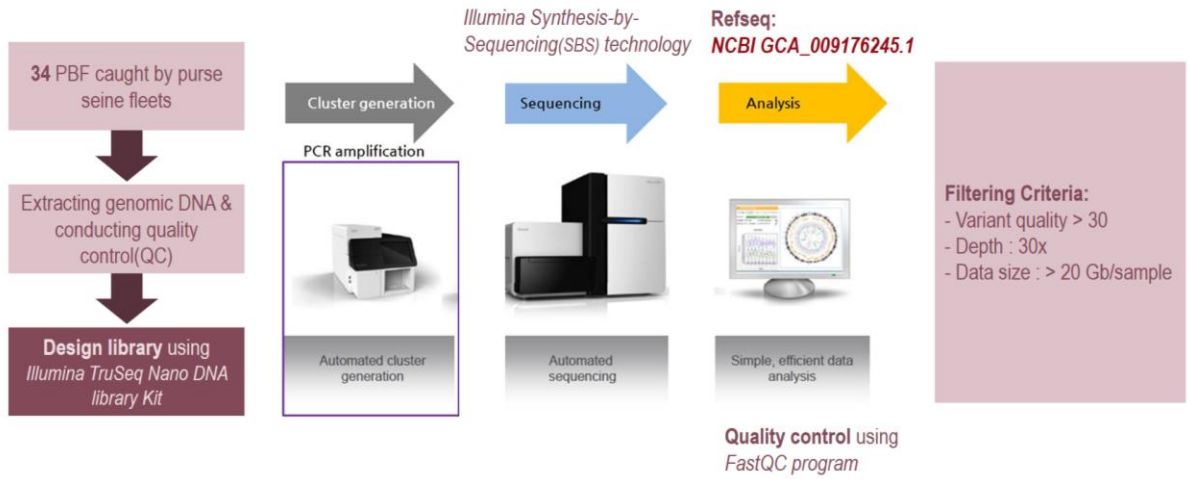

Fig. 11. Process of detecting candidate Single Nucleotide Polymorphism (SNP) markers.

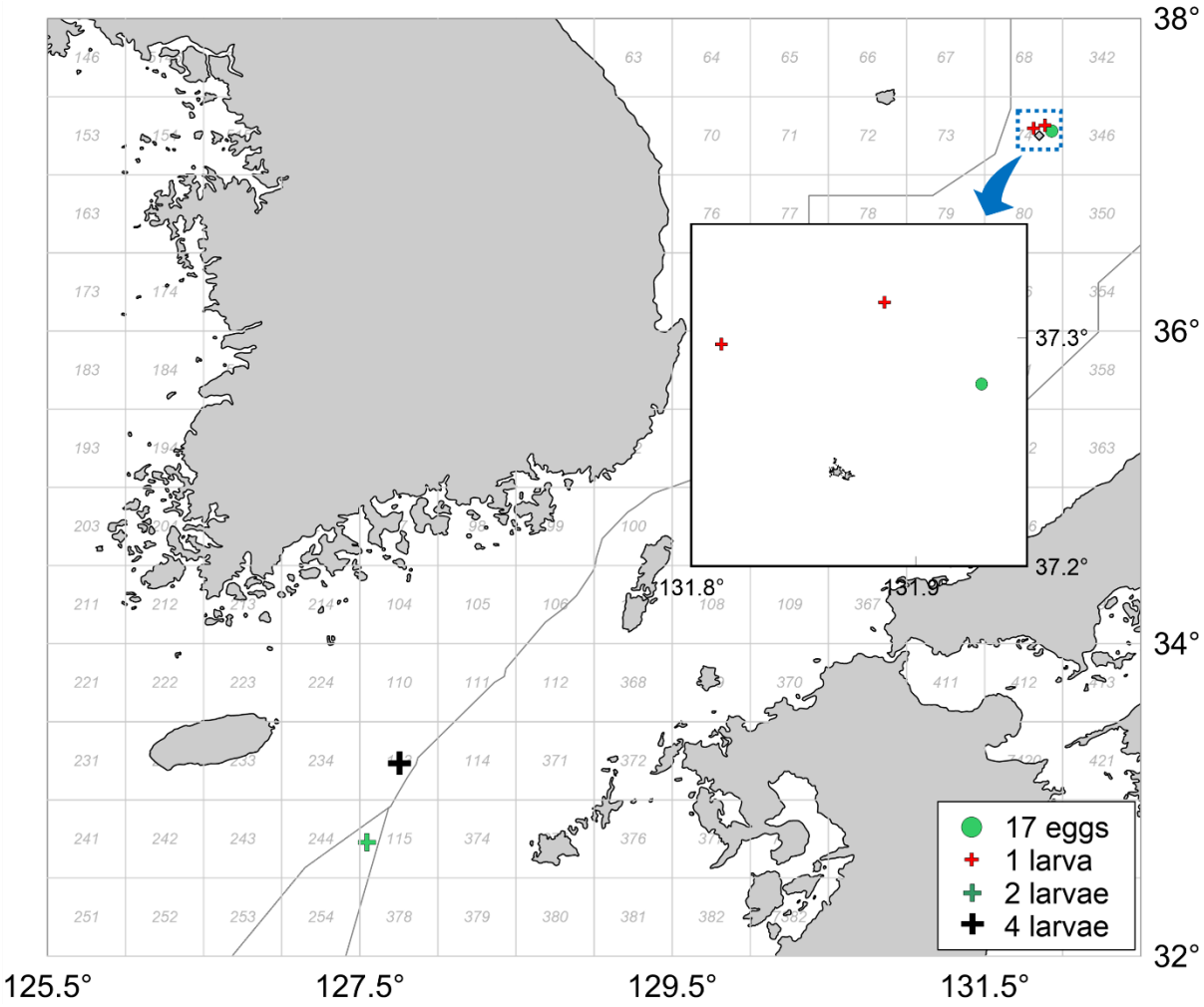

Fig. 12. A study area of PBF juvenile monitoring in the Korean waters in 2021.