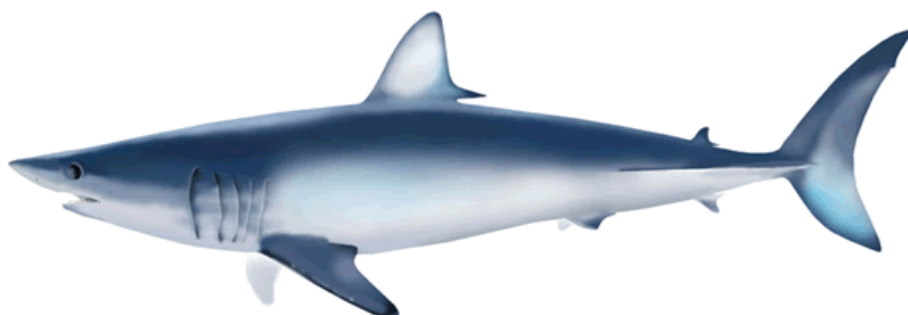


Catch, size and distribution pattern of blue sharks by Taiwanese small-scale longline fleets in the North Pacific in 2001-2015

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Abstract

This study presented the catch, size, and distribution pattern of the blue shark by Taiwanese small-scale tuna longline (STLL) fishery in the North Pacific. Catch estimated was based on the landing data from the three major fishing ports for STLL fishery. The estimated annual catch of blue sharks by Taiwanese small-scale tuna longline fisheries ranged from 6983 MT in 2013 to 14707 MT in 2011, with the mean of 11179 MT in 2001-2015. The mean size of females was 219.7 cm TL and that was 220.9 cm TL for males. Juvenile females and males were found in the equatorial waters but adults were more often found in the subtropical waters. Seasonal variations in the mean size for both sexes and the smallest mean sizes for both sexes were found in season 2. The sex ratio was significantly different from 0.5 for every season except season 4.

Introduction

There are two types of Taiwanese small-scale tuna longline (STLL) fishing vessels. The vessels less than 50 tonnages operated in the coastal and offshore waters, western North Pacific. While those vessels between 50 and 100 tonnages operate in the far sea waters in the Pacific Ocean (Fig. 1). These STLL vessels mainly target on tunas and sharks are the by-catch. Almost all sharks caught by these fleets in the North Pacific Ocean landed in Nanfanao, Chengkung and Tungkang fishing ports located at eastern and southwestern Taiwan. Nanfanao is the most important shark landing port in Taiwan, and the annual shark landings ranged from 4288 MT to 5841 MT with an average of 5004 MT from 2001 to 2015 (Table 1). Tungkang is another important shark landing port in Taiwan, and its annual shark landings ranged from 1689 MT to 3585 MT with an average of 2687 MT. Annual shark landings in Chengkung ranged from 510 MT to 954 MT from 2001 to 2015 (Table 2). According to the VMS data, the interview with the captain of longliners, and the logbook data, almost all the STLL vessels in Chengkung operated within the EEZ, however, large proportion of longliners in Nanfanao and Tungkang operated outside the EEZ.

The landing data indicated that the shark landings of these fisheries were dominated by the blue sharks of 62.2% (Fig. 2), followed by shortfin mako shark, bigeye thresher shark, scalloped hammerhead shark and pelagic thresher shark, respectively (Fig. 2). This study presents the

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catches estimate and distribution pattern of blue sharks caught by Taiwanese small-scale tuna longline fleets in the North Pacific.

Material and Method

Data sources

The daily auction records of sharks for Taiwanese STLL fleets were detailed in species at Nanfanao fish market after 1989 and Chengkung fish market after 2001. There is no species-specific auction or landing record for sharks in Tungkan fish market until 2009. A total of 12 shark species were documented in the auction records at Nanfanao and Chengkung, and the blue shark was present in the auction records since 2001, while the other 11 species included shortfin mako shark were from 1989. In this study, we only presented the shark catch and composition at Nanfanao and Chengkung in 2001-2015. Because of the lack of the observer programs for small-scale longline vessels in Taiwan before 2014, the information of dead discarded and live released or escaped were not presented in this study.

Blue shark catch

The landing of blue shark was presented in the daily auction record of Nanfanao in 2001-2015, and Chengkung in 2001-2008. The landing compositions of shark from 2001 to 2015 at Nanfanao were used to calculate the landing of blue shark at Chengkung in 2008-2015, and Tungkan in 2001-2015. According to daily auction records, all the blue shark landings at Chengkung were considered as whole fish, and 89.5% of blue shark landings at Nanfanao were frozen and processed on the sea, where the head, fins, and the internal organs of blue sharks were removed. The ratio between fresh and frozen landing of blue shark at Tungkan were assumed to equal to that at Nanfanao, because of similarity in operation distance.

For the proposal to convert frozen shark landing into total catch, 60 fresh blue sharks were sampled, processed and recorded the weight before and after processed by a local fisherman in Nanfanao. The results indicated that the processed weight is 41.08% of the whole body weight (20.11% – 56.11%, n=59). Therefore, the frozen landings were divided by 41.08% to be converted into total catch.

Size data collection

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The observer program for Taiwanese STLL fishery started from 2014. All the observers have been trained on identification of tuna and tuna like species and by-catch species such as sharks, sea birds, and sea turtles. The operation area of Taiwanese small-scale tuna longline fishing vessels in the North Pacific (2011-2015) (Fig. 1) was based on the logbook data. The blue shark specimens caught by the Taiwanese STLL vessels in the North Pacific Ocean between July 2014 and February 2016 (Fig. 2) were opportunistically collected by the on-board scientific observers. The fishing date, location, weight (in kg), and fork length (FL in cm) of the specimens were recorded, and the sex of each specimen was identified. The fork length was measured in a natural form. The equation $FL = -1.222 + 0.829 TL$ was used to convert the FL to total length (TL).

The mean sizes of specimens were compared between areas and sexes and among seasons using t-tests and analysis of variance (ANOVA) on the assumption of a normal distribution because of the large sample size. The annual variation of the mean catch-at-size was examined by ANOVA. The sex ratio was expressed as the number of females/the number of both sexes combined. Sex ratios were compared between areas and among seasons with a Chi-square test. A significance level of 0.05 was used in all statistical tests.

Results and Discussions

Blue shark catch

In total, 89.5% of the blue shark landings were frozen at Nanfanao in 2001-2015. After converting frozen blue shark landings into total catch, the annual estimated catches of blue sharks were the highest in 2005 (8645 MT) and the lowest in 2001 (3191 MT). The estimated annual catch of blue shark had an increasing trend from 4694 tons in 2001 to 8645 tons in 2005, and constantly around 7500 tons per year in 2005-2011 and decreased thereafter in Nanfanao (Fig. 3a). Under the assumption that the percentage of blue shark were the same in the Nanfanao and Tungkan, and also frozen blue shark ratio as well. The estimated blue shark catch ranged from 2607 MT to 7744 MT, with an average landing being 4759 MT at Tungkan in 2001-2015 (Fig. 3b).

A total of 66% of total large shark landings at Chengkung was occupied by blue shark,

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which ranged from 144 MT to 689 MT, with the average being 339 MT in 2001 to 2015.

Species-specific information is not available for Chengkung fish market in 2009-2013. Therefore, large shark landing and blue shark ratio (66%) were used to calculate the catch of blue shark, which was 338MT in 2009 and 183 MT in 2015 (Fig. 4). Overall, annual estimated catch of blue sharks by Taiwanese small-scale tuna longline fisheries ranged from 6983 MT in 2013 to 16081 MT in 2009, with the mean of 11566 MT in 2001-2015 (Fig. 4)(Table 3).

Size and sex variation by season

A total of 2877 blue shark specimens, including 1096 males, 1619 females, and 148 sex unknown individuals caught by the Taiwanese STLL vessels in the North Pacific Ocean were collected by the on-board scientific observers. The sizes ranged from 133 to 241 cm FL, 79-274 cm FL, and 138-179 cm FL for males, females, and sex unknown individuals, respectively. The mean size of females was 219.7 cm TL and that was 220.9 cm TL for males. No significant difference on mean length was found between sexes. Juvenile females and males were found in the equatorial waters but adults were more often found in the subtropical waters (Fig. 2). This finding was comparable to those data collected by the observers of Taiwanese LTLL fishing vessels (Liu et al. 2016) but was contradict to the migration pattern of blue shark in the North Pacific (Nakano 1994). As the observer program for Taiwanese STLL started in 2014 and the observation only limited to certain areas, more size data are needed to improve our results. The estimated mean sizes of both sexes in this study were smaller than those estimated from Taiwanese LTLL fishing vessels. Different operation depth and operation area are the two possible reasons causing this result. ANOVA revealed seasonal variations in the mean size for both sexes. The smallest mean sizes for both sexes of blue sharks was found in season 2. The sex ratios were estimated to be 0.18, 0.75, 0.69, and 0.48 for season 1-4, respectively. The sex ratio was significantly different from 0.5 for every season except season 4.

References

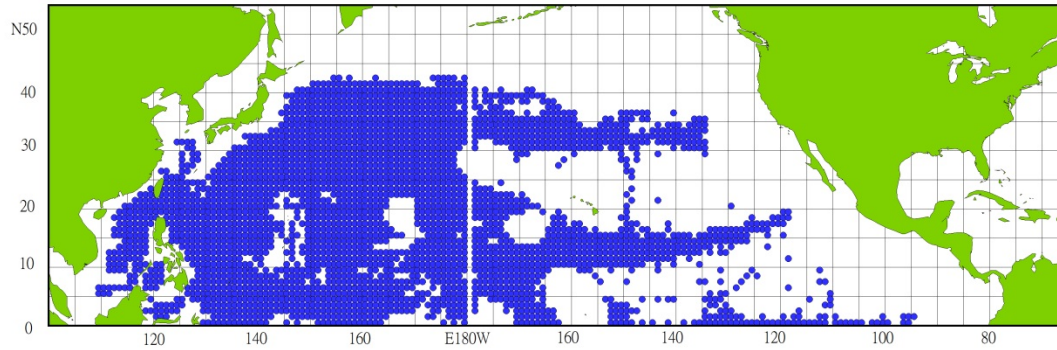
- Joung, S. J., H. H. Hsu, K. M. Liu, and T. Y. Wu. 2011. Reproductive biology of the blue shark, *Prionace glauca*, in the northwestern Pacific. ISC/11/SHARKWG-2/ working paper. 18 pp.
- Liu, K. M., K. Y. Su, and C. P. Chin. 2016. Size and spatial distribution of the blue shark, *Prionace glauca*, caught by Taiwanese large-scale longline fishery in the North Pacific

¹Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Busan, South Korea
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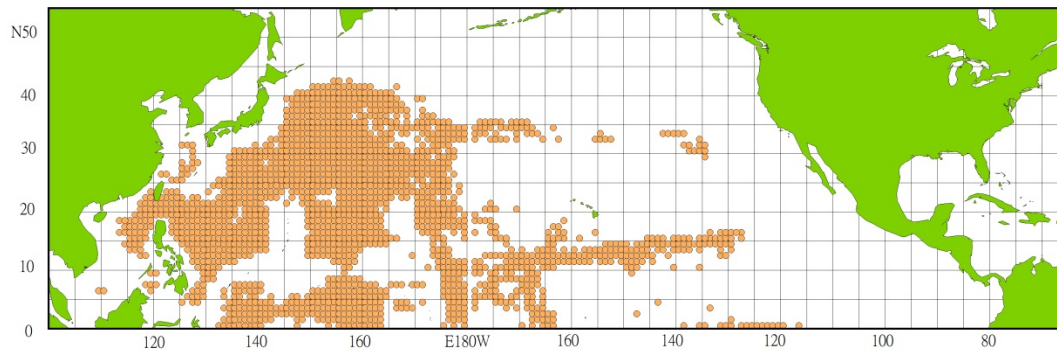
- Ocean. ISC/16/SHARKWG-1/20. 7 pp.
- Joung, S. J., K. T. Leu, K. Y. Su, H. H. Hsu, and K. M. Liu 2016. Distribution pattern and age and growth estimates of the blue shark, *Prionace glauca*, in the South Atlantic Ocean. Marine and Coastal Fisheries (In press).
- Nakano, H. 1994. Age, reproduction and migration of blue shark in the North Pacific Ocean. *Bull. Nat. Res. Inst. Far Seas Fish.* **31**: 141-256.
- Nakano, H. and M. P. Seki. 2003. Synopsis of biological data on the blue shark, *Prionace glauca* Linnaeus. *Bull. Fish. Res. Agen.* **6**: 18-55.
- Tsai, W. P., C. L. Sun, K. M. Liu, S. B. Wang, and N. C H. Lo. 2015. CPUE standardization and catch estimate of the blue shark by Taiwanese large-scale tuna longline fishery in the North Pacific Ocean. *Journal of Marine Science and Technology* 23(4), 567-574.

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(a)



(b)



(c)

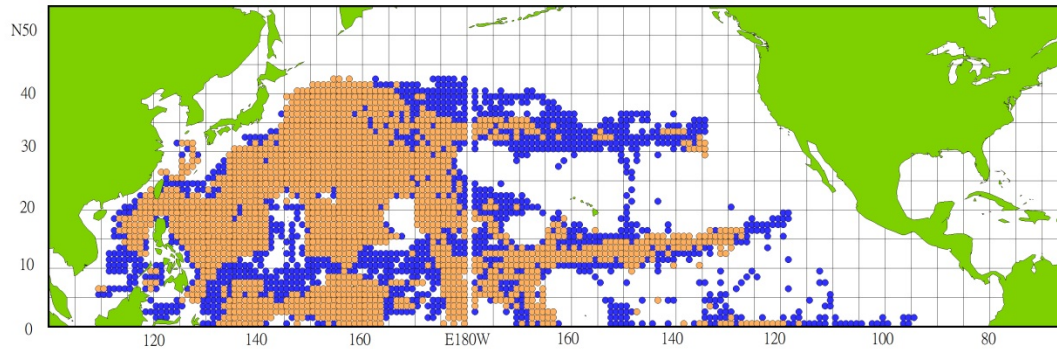


Fig. 1. The operation area of Taiwanese small-scale tuna longline fishing vessels in the North Pacific (2011-2015) from the logbook data. (a): all fishing area, (b): fishing area with blue shark catch, (c): overlapping (a) and (b).

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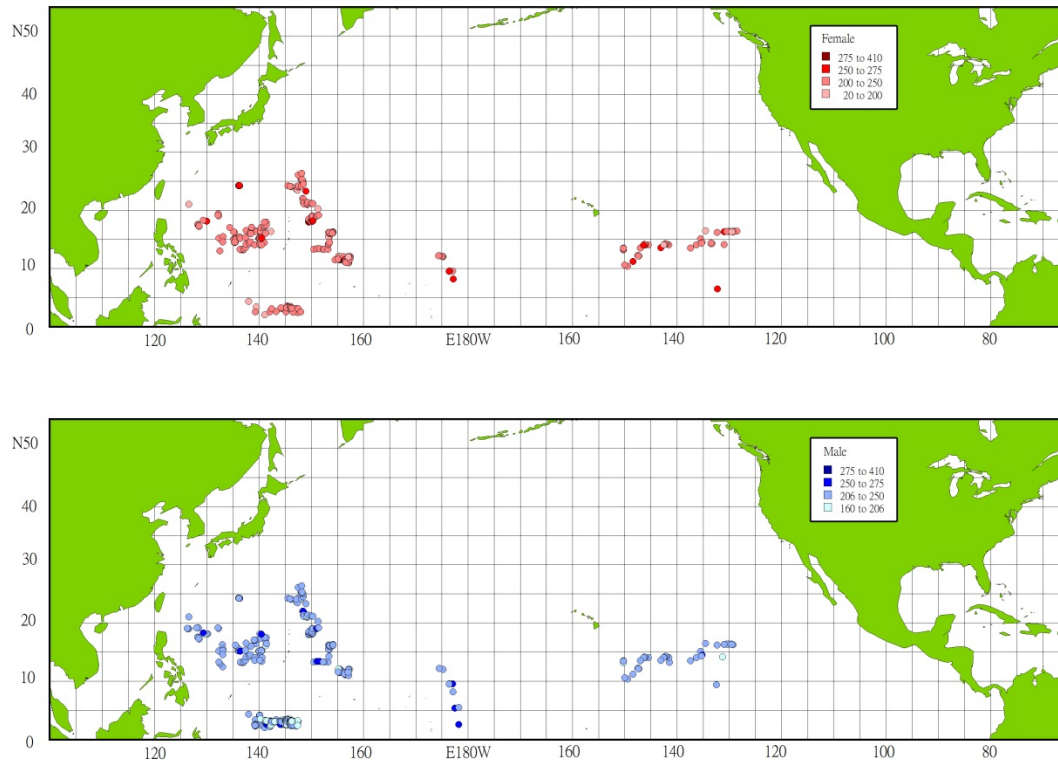


Fig. 2. Sampling location and size (TL, cm) by sex of the blue shark (*Prionace glauca*) recorded by observers on Taiwanese STLL in the North Pacific.

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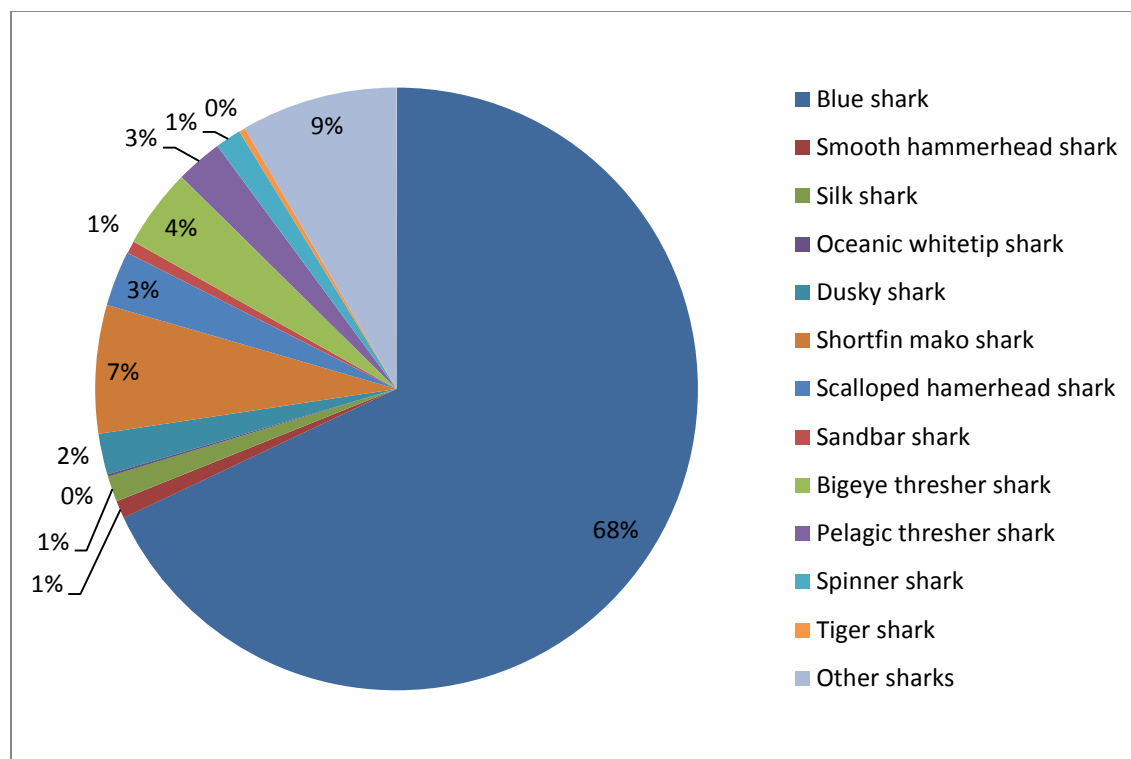
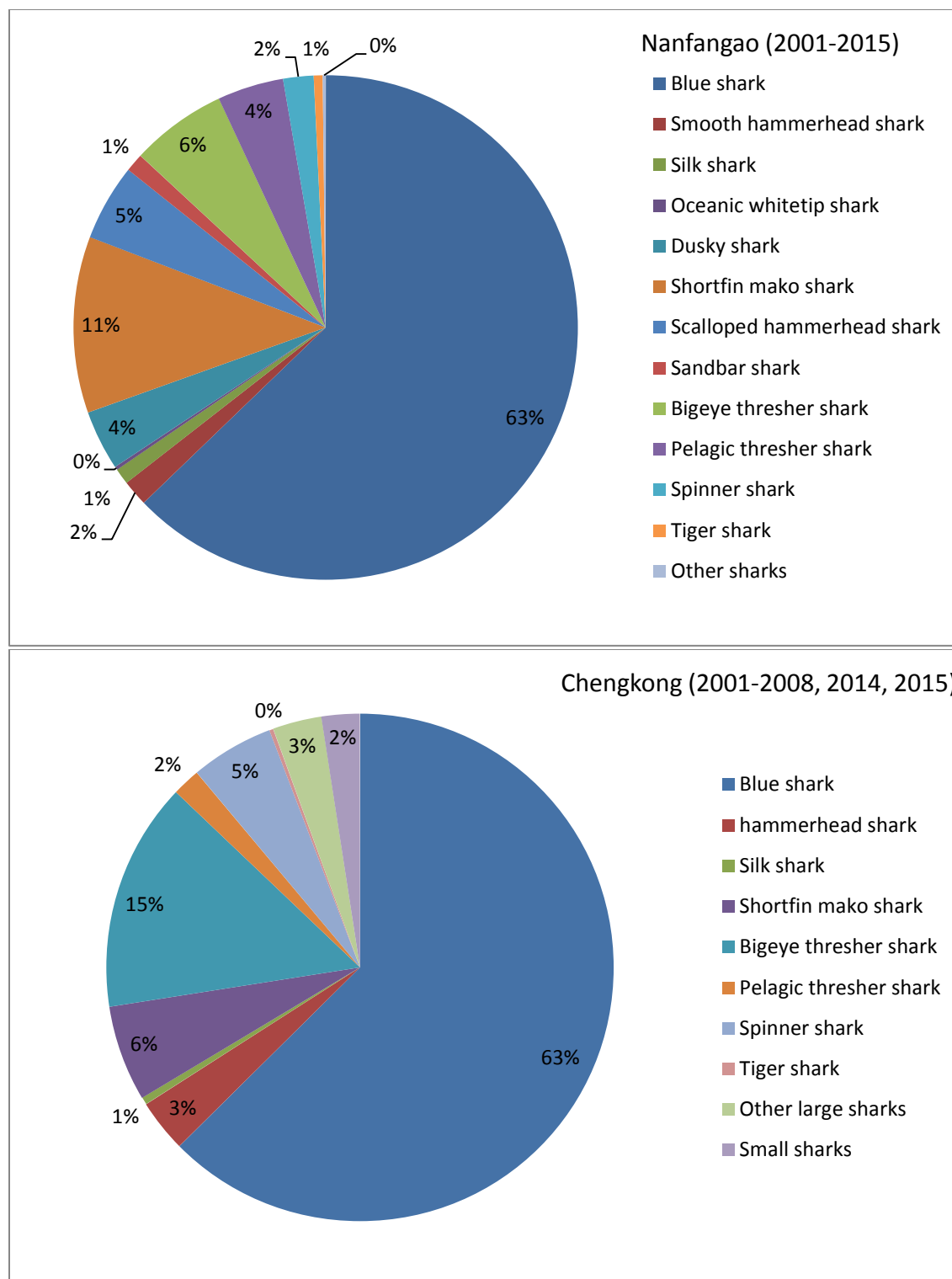


Fig. 3a. Species composition of sharks by Taiwanese STLL fishing vessels from 2001 to 2015.

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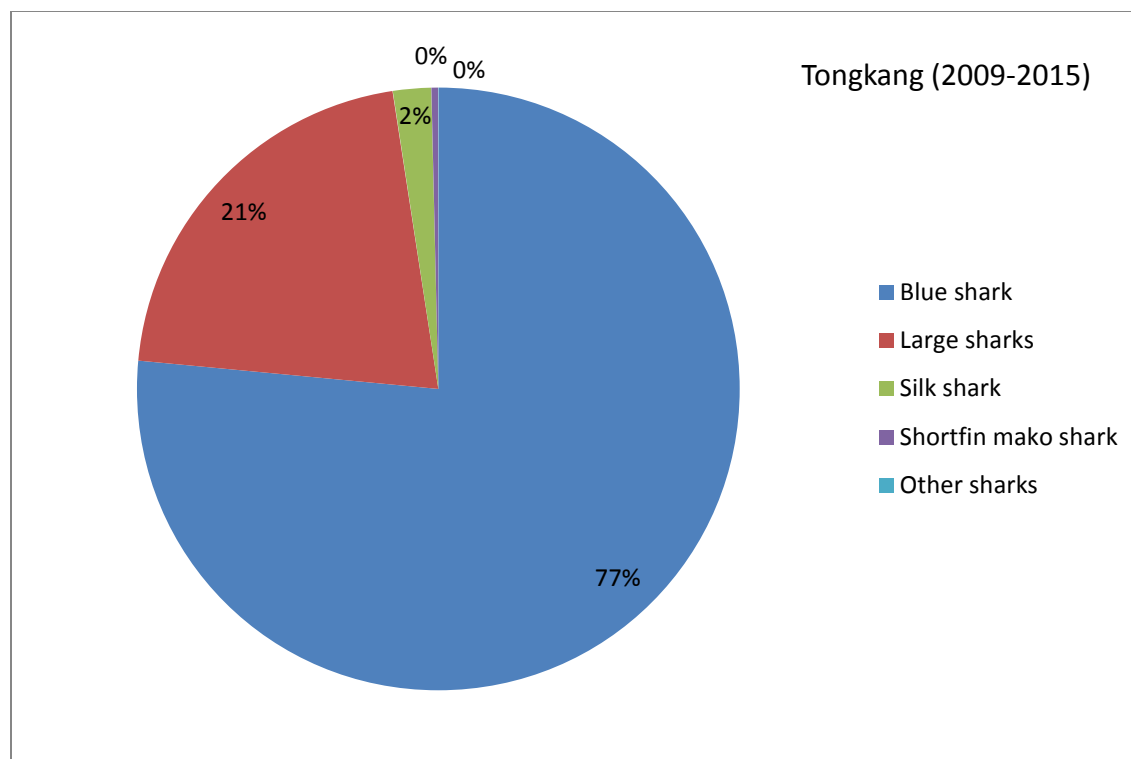


Fig. 3b. Species composition of sharks by Taiwanese STLL fishing vessels landed in different ports from 2001 to 2015.

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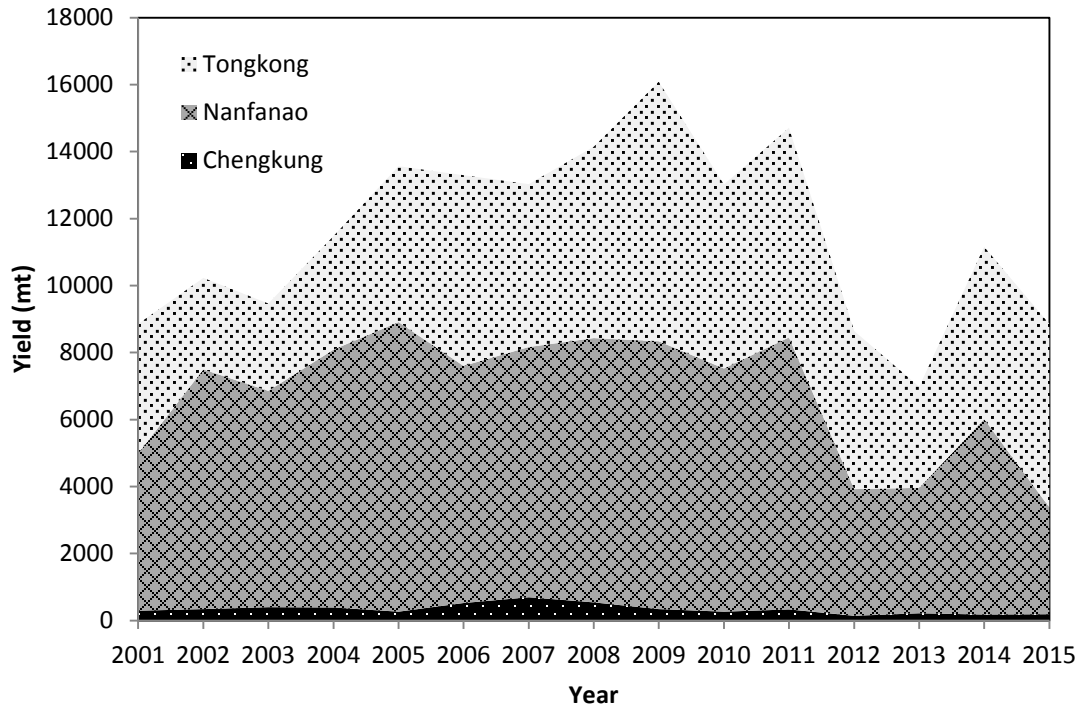


Fig. 4. Estimated blue shark catch caught by Taiwanese small-scale longline fishery from 2001 to 2015.

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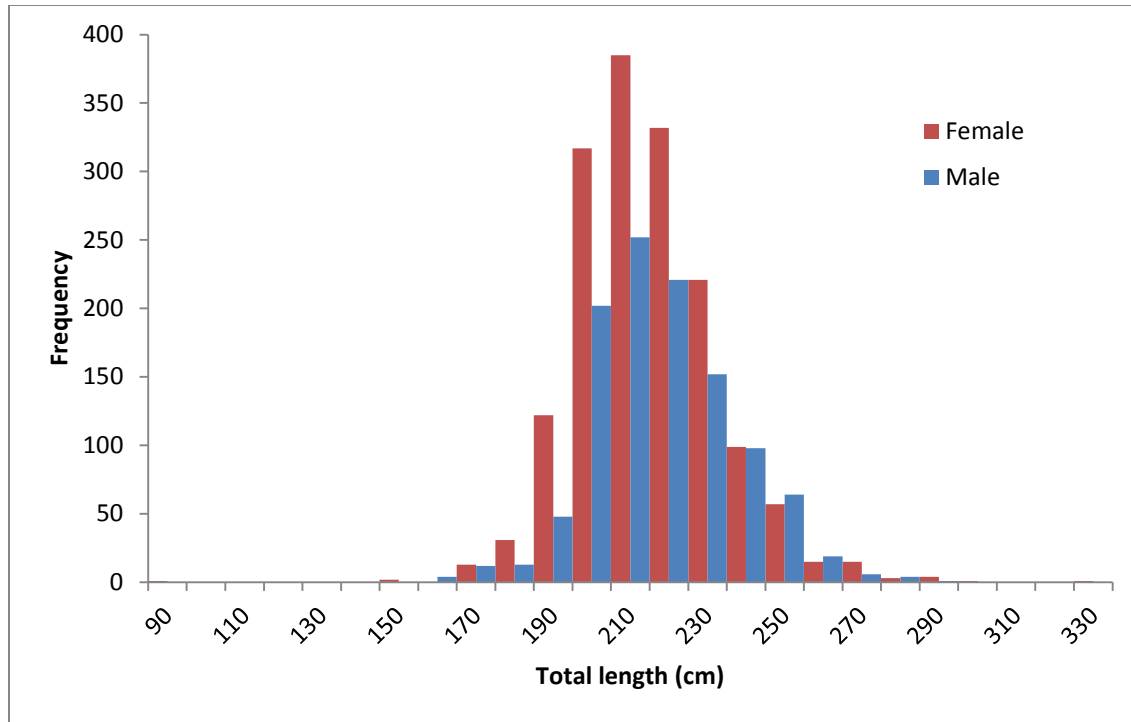


Fig. 4. Length-frequency distribution of the blue shark (*Prionace glauca*) recorded by observers on Taiwanese STLL in the North Pacific.

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Table 1. Species-specific shark landings (MT) at Nanfanao fishing port from 2001 to 2015.

Species	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Blue shark	2,049	3,124	2,756	3,268	3,794	3,016	3,658	3,560	3,320	2,988	3,431	1,599	1,635	2,510	1,404
Smooth hammerhead shark	92	96	124	79	58	64	65	57	82	57	78	53	43	72	88
Silk shark	62	137	63	61	64	51	45	54	44	40	21	14	12	10	6
Oceanic whitetip shark	46	24	23	10	8	8	7	6	6	5	2	1	—	—	—
Dusky shark	174	193	339	358	181	227	188	141	131	170	124	125	138	36	54
Shortfin mako shark	806	572	760	919	385	399	501	325	286	492	602	393	295	362	467
Scalloped hammerhead shark	246	273	385	368	213	261	194	160	255	198	167	149	152	137	126
Sandbar shark	71	98	122	87	47	57	50	32	63	33	31	22	19	20	39
Bigeye thresher shark	296	367	405	321	297	222	208	242	228	216	293	237	234	270	285
Pelagic thresher shark	319	233	188	156	166	146	168	238	173	184	204	96	208	252	115
Spinner shark	97	138	140	171	86	105	63	56	97	82	68	62	47	42	55
Tiger shark	26	41	62	43	19	23	43	39	22	13	13	13	9	5	9
Other sharks	4	3	0	0	7	16	8	22	7	8	3	20	4	23	3
Sum	4,288	5,299	5,367	5,841	5,325	4,595	5,198	4,932	4,714	4,486	5,036	2,784	2,796	3,739	2,650

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Table 2. Species-specific shark landings (MT) at Chengkung fishing port from 2001 to 2015.

Species	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Blue shark	288	336	396	392	268	520	689	540	338	260	334	144	214	179	183
hammerhead shark	23	20	27	17	17	20	22	5	15	11	20	9	13	30	23
Silk shark	4	5	9	3	6	1.1	0.16	0.1	3	2	3	1	2	—	—
Shortfin mako shark	36	40	45	36	33	45	49	14	29	23	36	16	23	30	41
Bigeye thresher shark	78	93	119	87	109	66	122	49	71	55	86	37	55	82	79
Pelagic thresher shark	10	14	14	3	11	7	11	5	7	6	11	5	7	17	16
Spinner shark	30	31	34	35	54	58	43	7	29	22	32	14	21	18	11
Tiger shark						9	3	1	1	1	1	1	1	1	1
Other large sharks	9	6	12	1	31	4	8	109	18	14	8	4	5	4	5
Small sharks	32	13	17	14	14	9	7	30	38	42	100	24	74	8	4
Sum	510	558	673	588	543	739	954	760	549	436	632	254	415	369	363

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Table 3. The blue shark catch (MT) by Taiwanese STLL fishing vessels in the North Pacific from 2001 to 2015.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Nanfanao	4,694	7,157	6,464	7,697	8,645	7,077	7,480	7,895	7,999	7,262	8,114	3,779	3,747	5,833	3,191
Tongkong	3,866	2,733	2,607	3,390	4,649	5,695	4,861	5,709	7,744	5,493	6,259	4,724	3,022	5,144	5,482
Chengkung	288	336	396	392	268	520	689	540	338	260	334	144	214	179	183
Sum	8,847	10,225	9,467	11,479	13,563	13,291	13,030	14,144	16,081	13,015	14,707	8,647	6,983	11,156	8,856

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