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Catch and abundance index of the blue shark by Taiwanese small-scale longline fishery in the North Pacific Ocean[1]

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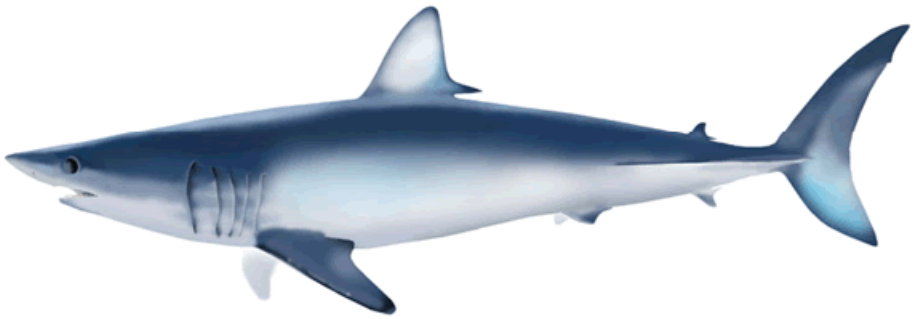

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Abstract

This study estimated the blue shark catch and abundance index of the small-scale Taiwanese longline fishery from 2001 to 2010. Almost all sharks caught by these fleets landed in Nanfanao, Chengkung and Tungkang fishing ports located at eastern and southwestern Taiwan. The landing data indicated that the shark landings of offshore fisheries were dominated by blue sharks of 62.2%, followed by shortfin mako shark, bigeye thresher shark, scalloped hammerhead shark and pelagic thresher shark, respectively. According to daily sale records, all the blue sharks landings at Chengkung were considered as whole fish, and 89.5% of blue sharks landed at Nanfanao were frozen and processed. The conversion factor between fresh and frozen landing of blue shark at Tungkang was assumed to equal to Nanfanao. The processed weight only occupied 41.08% with whole body (20.11% – 56.11%, n=59). After converting frozen landing into catch, estimated annual catch of blue sharks by Taiwanese small-scale longline fisheries ranged from 8847 mt to 16081 mt, with an average of 12314 mt in 2001-2010. Fishing efforts were the estimated from fishing days of each trip and numbers of hook per day. The fishing days of each trip of Taiwanese small-scale longline vessels in Nanfanao and Chengkung were estimated by record of vessels departure and arrival time. The standardized CPUE of blue shark ranged from 20.75 (kg/1000 hooks) to 63.57 (kg/1000 hooks) from 2001 to 2003, and increased to 40.63 (kg/1000 hooks) to 64.67 (kg/1000 hooks) from 2005-2010.

Introduction:

Almost all sharks caught by Taiwanese small-scale longline fleets 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 sharks landings ranged from 4288 mt to 5841 mt with an average of 5004 mt from 2001 to 2010 (Table 1). Tongkang 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. Annual shark landings in Chengkung ranged from 510 mt to 954 mt at Tungkang from 2001 to 2010 (Table 2). According to interview with the captain of longliners and logbooks, almost all the longline vessels in Chengkung operated within the EEZ, however, large proportion of longliners in Nanfanao and Tongkang operated outside the EEZ.

The landing data indicated that the shark landings of offshore fisheries were dominated by blue sharks of 62.2% (Fig. 1), followed by shortfin mako shark, bigeye thresher shark, scalloped hammerhead shark and pelagic thresher shark, respectively (Fig. 1). This study presents the catches and abundance indices of blue sharks caught by Taiwanese small-scale longline fleets in the North Pacific.

Material and Method

Source of data

All sharks were weighed before being auctioned and processed, so we were able to obtain accurate catches (numbers) and individual body (whole) weights (W) from sales records but sex information is not available. The daily auction record of sharks for Taiwanese domestic-based longline fleets were detailed in species at Nanfanao fish market after 1989 and Chengkung fish market from 2000 to 2008. There is no species-specific auction or landing record for sharks in Tungkang fish market. 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 2001-2010. Because

of the lack of the observer programs for small-scale longline vessels in Taiwan, the information of dead discarded and live released or escaped were not presented in this study.

The catch and effort information provided by logbook for Taiwanese small scale longline fleets were not satisfied due to the numbers of logbook were very limited. Fishing efforts were the calculated from fishing days of each trip and numbers of hook per day. The fishing days of each trip of Taiwanese small-scale longline vessels in Nanfanao and Chengkung were estimated by record of vessels departure and arrival time. The fishing days were calculated only for the trips which had blue shark catch. The numbers of hook per day were estimated by logbooks.

Blue shark catch

The landing of blue shark was presented in the daily auction record of Nanfanao in 2001-2010, and Chengkung in 2001-2008. The landing compositions of shark from 2001 to 2010 at Nanfanao were used to calculated the landing of blue shark at Chengkung in 2008-2010, and Tungkang in 2001-2010. According to daily auction records, all the blue sharks landings at Chengkung were considered as whole fish, and 89.5% of blue shark landings at Nanfanao were frozen and processed at the vessels, where the head, fins, and the organs of blue sharks were removed. The ratio between fresh and frozen landing of blue shark at Tungkang were assumed to equal to 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 fishman in Nanfanao. The results suggested that processed weight only occupied 41.08% with whole body (20.11% – 56.11%, n=59). Therefore, the frozen landings were divided by 41.08% to be converted into total catch.

CPUE standardized

A generalized linear model (Nelder and Wedderburn, 1972; Venables and Dichmont, 2001) was applied to develop a time series of relative abundance index of blue shark caught by Taiwanese small-scale longline fleet in the north Pacific.

$$Ln(CPUE) = \mu + Year + Quater + Vessel\ Size + Port + inaction + \varepsilon$$

where, *CPUE*: catch in weight of blue shark per 1000 hooks of each trip

Year: effect of year (2001-2010)

Quarter: effect of quarter (4 classes)

Vessel Size: effect of vessel size (CT0-CT4, 5 classes)

Port: effect of port (Nanfanao and Chengkung, 2 classes)

Interaction: interaction term between *Year*, *Quarter*, *Vessel Size* and *Port*

ε: error term with $N(0,\ \sigma^2)$, and was assumed as a lognormal distribution.

A step-wise regression procedure and AIC were used to determine the set of systematic factors and interactions that significantly explained the observed CPUE variability. The analyses were run with R software and glm procedures.

Results and Discussions

Blue shark catch

89.5% of total blue shark landing were frozen at Nanfanao in 2001-2010. After converting frozen blue shark landings into total catchs, the annual estimated catchs of blue sharks were the highest at 2005 in 8645 tons and the lowest at 2001 in 4694 tons. The annual estimated catchs of blue shark had an increasing trend from 4694 tons in 2001 to 8645 tons in 2005, and constantly around 7500 tons per year since 2005 in Nanfanao (Fig. 2). Under the assumption that the percentage of blue shark were the same in the Nanfanao and Tungkang, and also frozen blue shark ratio as well. The estimated annual blue shark catch ranged from 2733 mt to 7745 mt, with the average landing being 4675 mt at Tungkang in 2001-2010 (Fig. 2).

66% of total large shark landing at Chengkung was occupied by blue shark, which ranged from 268 mt to 689 mt, with the average being 428 mt in 2001 to 2008. Species-specific information is not available for Chengkung fish market in 2009-2010. Therefore, large shark landing and blue shark ratio (66%) were used to calculate the catch of blue shark, which was 338mt in 2009 and 260 mt in 2010 (Fig. 2). Overall, annual estimated catch of blue sharks by Taiwanese offshore longline fisheries ranged from 8847 mt to 16081 mt , with the average landing being 12314 mt in 2001-2010 (Fig. 2).

CPUE standardized

Table 3 indicted the sampling ratio of blue shark catch in weight used in CPUE estimation and total blue shark catch from 2001 to 2010. The records of vessels departure and arrival time were very limited from 2001 to 2004, cause coverage rate were relatively lower or even were 0 in Nanfanao and Chengkung in that period. The coverage rate ranged from 59.6% to 90.2% in Nanfanao from 2005 to 2010, and it ranges from 56.4% to 83.9% in Chengkung from 2005 to 2008 (Fig. 3).

The nominal CPUE of blue shark caught by Taiwanese small-scale longline fishery ranged from 59.46 (kg/1000 hooks) to 75.27 (kg/1000 hooks) from 2005 to 2010. The nominal CPUE of blue shark were relative lower from 2001-2003, and its maybe cause by low coverage rate in that period. The ANOVA table (table) of generalized linear model indicated that factors of year, quarter, vessel size, port, year*quarter, year*vessel size, year*port, quarter*port and vessel size *port are significant for F test ($p<0.05$). The standardized CPUE have similar trend with nominal CPUE from 2001 to 2010. The standardized CPUE of blue shark ranged from 20.75 (kg/1000 hooks) to 63.57 (kg/1000 hooks) from 2001 to 2003, and increased to 40.63 (kg/1000 hooks)to 64.67 (kg/1000 hooks) from 2005-2010 (Fig. 4).

Reference

Nelder, J. A. and Wedderburn, R. W. M. (1972). Generalized linear models. Journal of Royal Statistical Society Series A 137, 370–384.

Venables, W.N. and Dichmont, C.M. (2001). GLMs, GAMs and GLMMs: an overview of theory for applications in fisheries research. Fisheries research 70, 319-337.

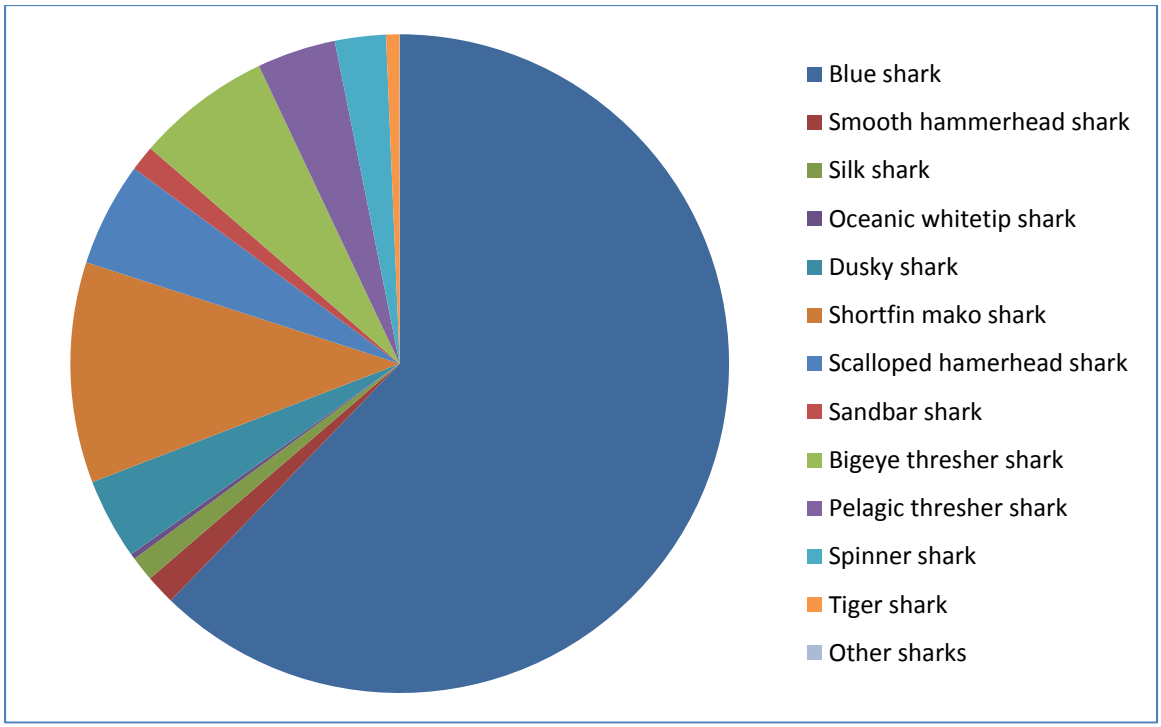

Fig. 1. Catch composition of sharks by Taiwanese offshore longline fisheries from 2001 to 2010.

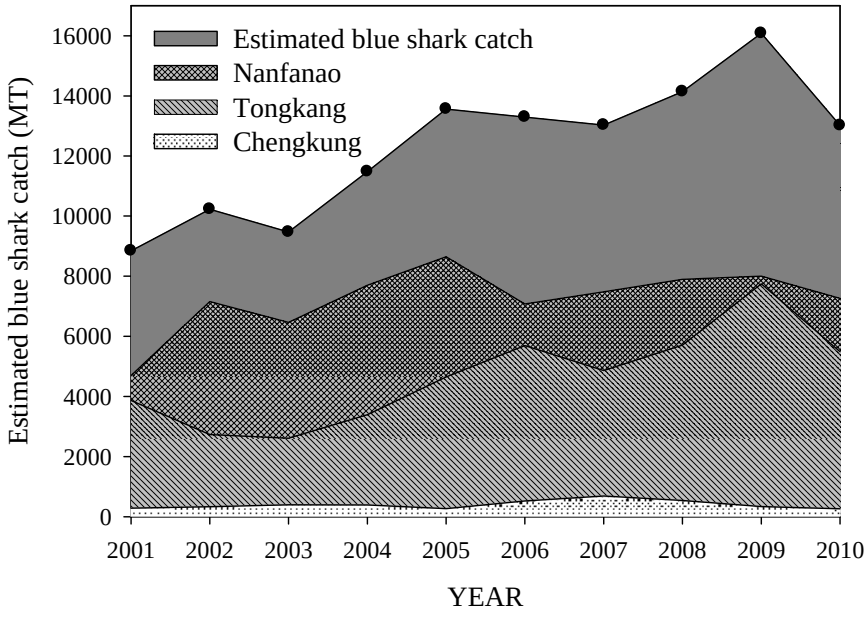

Fig. 2. Estimated blue shark catch caught by Taiwanese small-scale longline fishery from 2001 to 2010.

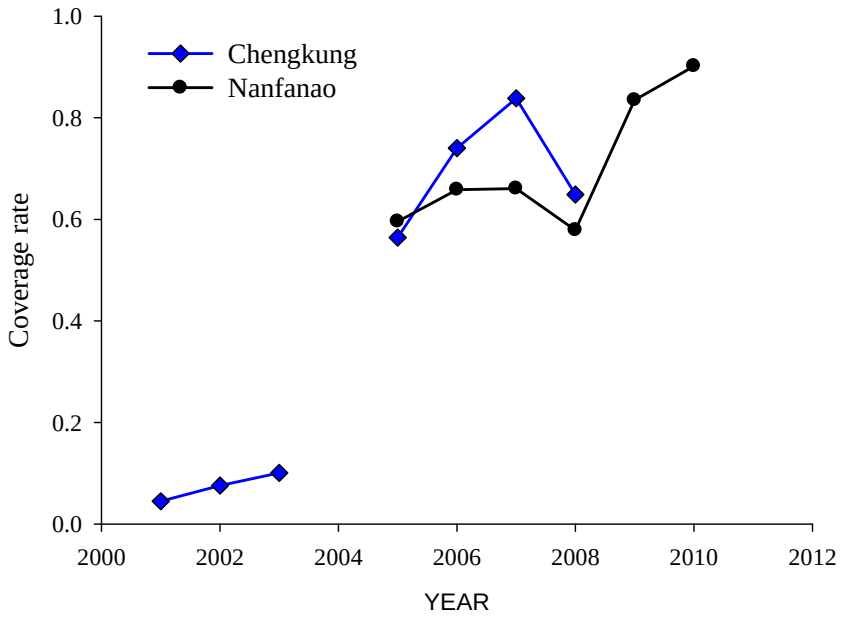

Fig. 3. Sampling ratio of blue shark catch in weight for estimating CPUE from 2001 to 2010.

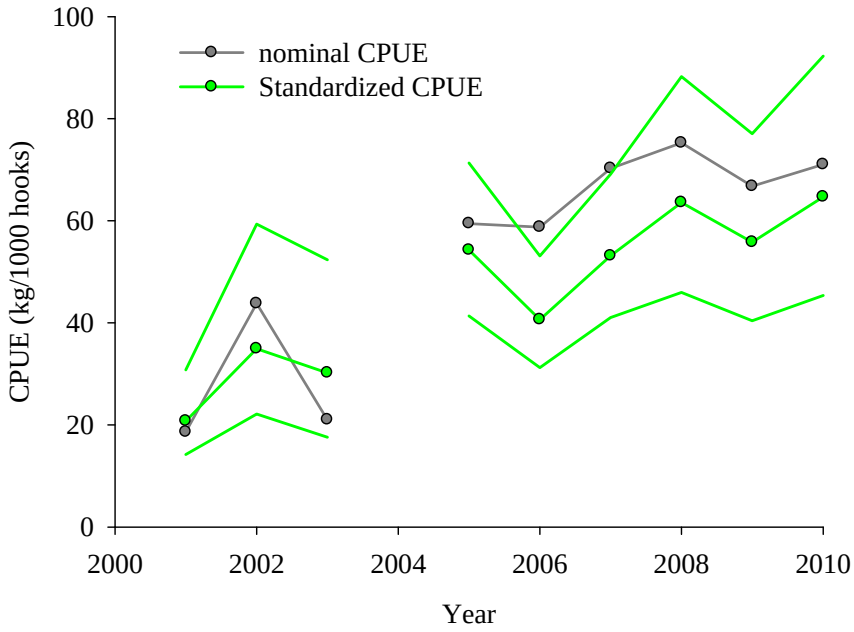

Fig. 4. The nominal and Standardized CPUE (kg/1000 hooks) of blue shark caught by Taiwanese small-scale longline fishery in the North Pacific.

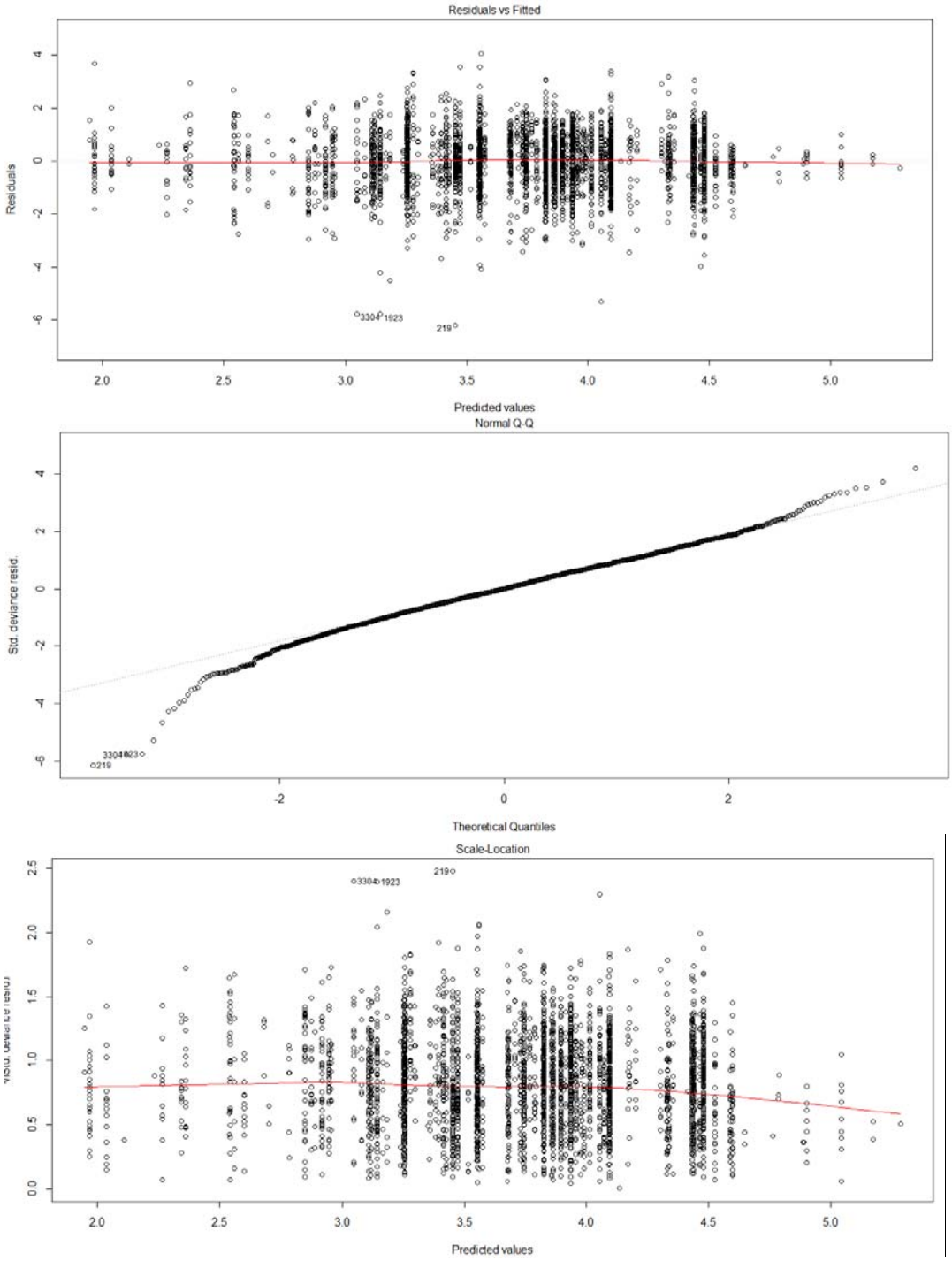

Fig. 5. The distribution of residuals and QQ plot derived from generalized linear model of standardizing CPUE of blue shark caught by Taiwanese small-scale longline fishery in the North Pacific from 2001-2010

Table 1. Species-specific shark landings (mt) at Nanfanao fishing port from 2001 to 2010.

Species	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Blue shark	2049	3124	2756	3268	3794	3016	3658	3560	3320	2988
Smooth hammerhead shark	92	96	124	79	58	64	65	57	82	57
Silk shark	62	137	63	61	64	51	45	54	44	40
Oceanic whitetip shark	46	24	23	10	8	8	7	6	6	5
Dusky shark	174	193	339	358	181	227	188	141	131	170
Shortfin mako shark	806	572	760	919	385	399	501	325	286	492
Scalloped hamerhead shark	246	273	385	368	213	261	194	160	255	198
Sandbar shark	71	98	122	87	47	57	50	32	63	33
Bigeye thresher shark	296	367	405	321	297	222	208	242	228	216
Pelagic thresher shark	319	233	188	156	166	146	168	238	173	184
Spinner shark	97	138	140	171	86	105	63	56	97	82
Tiger shark	26	41	62	43	19	23	43	39	22	13
Other sharks	4	3	0	0	7	16	8	22	7	8
Sum	4288	5299	5367	5841	5325	4595	5198	4932	4714	4486

Table 2. Species-specific shark landings (mt) at Chengkung fishing port from 2001 to 2010.

Species	2001	2002	2003	2004	2005	2006	2007	2008	2009*	2010*
Blue shark	288	336	396	392	268	520	689	540		
hammerhead shark	23	20	27	17	17	20	22	5		
Silk shark	4	5	9	3	6	1.1	0.16	0.10		
Shortfin mako shark	36	40	45	36	33	45	49	14		
Bigeye thresher shark	78	93	119	87	109	66	122	49		
Pelagic thresher shark	10	14	14	3	11	7	11	5		
Spinner shark	30	31	34	35	54	58	43	7		
Tiger shark						9	3	1		
Other large sharks	9	6	12	1	31	4	8	109	511	394
Small sharks	32	13	17	14	14	9	7	30	38	42
Sum	510	558	673	588	543	739	954	760	549	436

*: Species-specific catch information is not available

Table 3. Estimated blue shark catches (mt) by Taiwanese small-scale longline fisheries from 2001 to 2010.

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Fresh landings	661	767	681	651	900	855	2328	1466	452	274
Frozen landings	3363	3885	3609	4448	5202	5109	4397	5208	6420	5234
Total Landings	4024	4652	4290	5099	6102	5964	6725	6674	6872	5508
Converted catch	8847	10225	9467	11479	13563	13291	13030	14144	16081	13015

Note: These values are preliminary and for ISC Shark WG meeting use only.

Table 4. ANOVA table of explanatory variables in generalized linear model for blue shark CPUE (kg/1000 hooks) of Taiwanese small- scale longline fishery from 2001 to 2010.

	Df	Deviance	Resid. Df	Resid. Dev	F	Pr(>F)	
NULL			3920	4983.1			
YEAR	9	123.721	3911	4859.4	13.432	< 2.2e-16	***
QUARTER	3	117.793	3908	4741.6	38.3654	< 2.2e-16	***
CT_CLASS	4	230.321	3904	4511.3	56.2617	< 2.2e-16	***
PORT	1	41.697	3903	4469.6	40.742	1.94E-10	***
YEAR:QUARTER	21	187.685	3882	4281.9	8.7327	< 2.2e-16	***
YEAR:CT_CLASS	20	102.06	3862	4179.9	4.9862	2.17E-12	***
YEAR:PORT	3	42.597	3859	4137.3	13.874	5.37E-09	***
QUARTER:PORT	3	101.36	3856	4035.9	33.013	< 2.2e-16	***
CT_CLASS:PORT	2	91.579	3854	3944.3	44.7407	< 2.2e-16	***