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# Estimating the composition and capture status of bycatch using Chinese longline observer data in the Indian Ocean

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**Abstract:** From 2012 to 2015, five Chinese tuna longline observer trips were conducted in the Indian Ocean (N10°35'- S33°20', E40°58'- E89°54'). Bycatch and capture status from these trips were analyzed in this report. A total of 4,463 individuals among 52 bycatch species were captured from 911,718 hooks deployed, including tunas (39.4%), billfishes (12.0%), sharks (12.4%), rays (2.4%), sea turtles and seabirds (0.09%), and miscellaneous species (33.8%). The dominant bycatch species were yellowfin tuna (*Thunnus albacores*), swordfish (*Xiphias gladius*), Indo-pacific blue marlin (*Makaira mazara*), blue shark (*Prionace glauca*), pelagic stingray (*Dasyatis violacea*), longnose lancetfish (*Alepisaurus ferox*), escolar (*Lepidocybium flavobrunneum*), and opah (*Lampris guttatus*). The capture status for bycatch species, i.e. dead, hurt, alive, retained, or discarded, was also analyzed. The capture fate of dead, hurt, and alive accounted for 44.7, 12.7, and 42.6 percent of the total bycatch, respectively. The proportion of retained and discarded bycatch was 76.2% and 23.8%. Blue shark and shortfin mako were mostly retained when captured, whereas other sharks (oceanic whitetip shark, pelagic thresher, bigeye thresher, *etc*), rays and sea turtles were almost all discarded or released. This report provides important information for the understanding of bycatch composition and discards for the Chinese longline fleet in the Indian Ocean during that period.

## Introduction

Tuna longline fishery targeting tuna and tuna-like species is one of the most important components of the pelagic fisheries in the Indian Ocean (Clarke et al. 2014). The target species of Chinese longline fishery are albacore and bigeye tuna, but a variety of non-targeting species were also captured, including billfishes, sharks, rays, etc. Bycatch species are important components of marine ecosystem and play an important role in balancing the ecosystem (Sethi et al. 2014). Many non-targeting species are often discarded and their capture statuses are not understood.

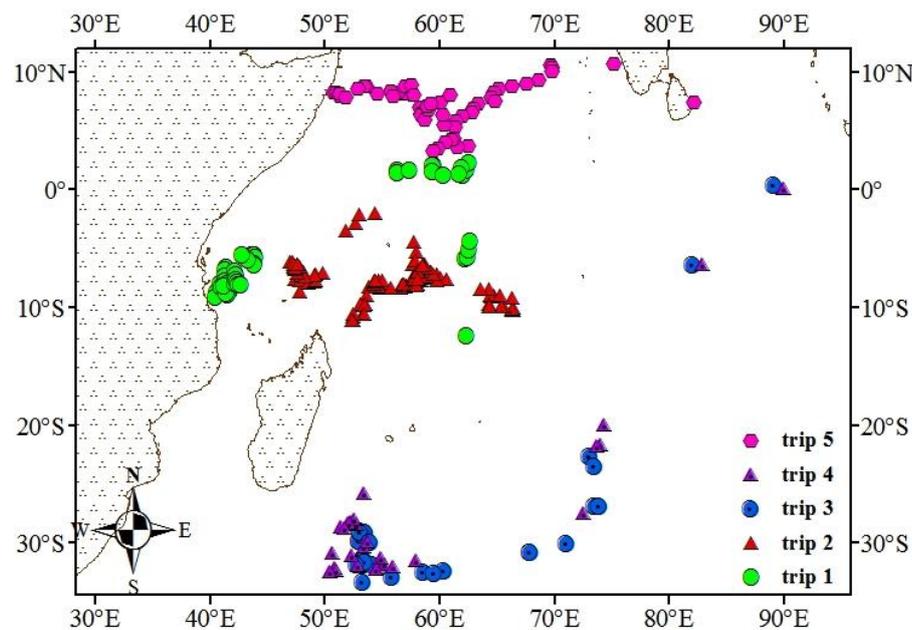
Although longline bycatch have been reported for other fishing countries (Ariyogagautama 2014; Panjarat 2015), information on bycatch species of Chinese longline fishery, especially on sharks, rays, and sea turtles, was rarely reported. The capture status (e.g. discard or retain) has not been analyzed. Using observer data, the objective of this paper is to estimate the species composition and capture status of bycatch for the Chinese tuna longline fishery in the Indian Ocean.

## Material and method

Bycatch data was collected by scientific observers from 5 trips (318 operations and 911,718 hooks deployed) in the Indian Ocean during 2012-2015 (Table 1). The data includes fishing position (N10°35'- S33°20', E40°58'- E89°54', Figure 1), date, the number of hooks, catch number by species, fork length (cm, FL) and sex, and capture status. The catch rate (CPUE) was described as number of fishes caught per 1000 hooks. We analysed the catch composition and capture status (fate), including proportion of dead, hurt, alive, retained, and discarded, for bycatch species.

**Tab.1 Summary of longline observer trips conducted in the Indian Ocean**

<b>Trips</b>	<b>Time</b>	<b>Operations /days</b>	<b>Operation area</b>	<b>Hooks</b>
<b>1</b>	2012.10.29-2013.1.22	69	N1°14'-S9°00' E40°58'-E60°33'	23-24 hooks/basket, 218520
<b>2</b>	2013.10.7-2014.2.22	129	S1°58'-S11°05' E47°02'-E66°27'	16 hooks/basket, 343024
<b>3</b>	2014.8.3-2014.9.26	33	N0°19'-S33°20' E52°49'-E89°12'	24-32 hooks/basket, 110703
<b>4</b>	2014.8.3-2014.9.26	28	N0°11'-S32°26' E50°21'-E89°54'	24-28 hooks/basket, 89183
<b>5</b>	2015.12.15-2016.2.17	54	N10°35'- N3°17' E52°55'-E69°48'	16 hooks/basket, 149565



**Fig.1 Spatial distribution of Chinese longline observer trips in the Indian Ocean**

## Results

### Bycatch species composition

Bigeye or albacore tuna was target species of the Chinese longline fishery. Thus, other species were defined as bycatch in this study. Therefore, other tuna species (e.g. yellowfin tuna) was also defined as bycatch (Table 2). The bycatch species were classified into different categories, i.e. tunas, billfishes, sharks, rays, sea turtles, seabirds and miscellaneous species. Figure 2 showed the composition of bycatch species groups (percentage of catch in number) based on trip. The tuna was the primary component group of the bycatch in trip 1 and 2, whereas the miscellaneous

species dominated in trip 3, 4, and 5, occupying 57.81%, 63.33%, and 40.07% of total bycatch, respectively.

There were a total of 4463 bycatch individuals (including an escaped blue shark) captured by the five tuna longline trips, including 1758 non-target tunas, 2705 other bycatches. The tunas accounted for about 39.4% of the total bycatch, comprising bigeye tuna (*Thunnus obesus*, 155), albacore (*Thunnus alalunga*, 94), yellowfin tuna (*Thunnus albacores*, 1481) and skipjack tuna (*Katsuwonus pelamis*, 28). Yellowfin tuna is the most abundant species in tuna bycatch, accounting for 84.2% of the total tuna bycatch.

**Tab.2 The list of tuna bycatch composition**

Trip	Target	Number of non-target tuna catch			
		Bigeye tuna	Albacore	Yellowfin tuna	Skipjack tuna
1	Bigeye tuna	0	76	779	14
2	Bigeye tuna	0	3	464	6
3	Albacore	70	0	5	2
4	Albacore	85	0	16	2
5	Bigeye tuna	0	15	217	4

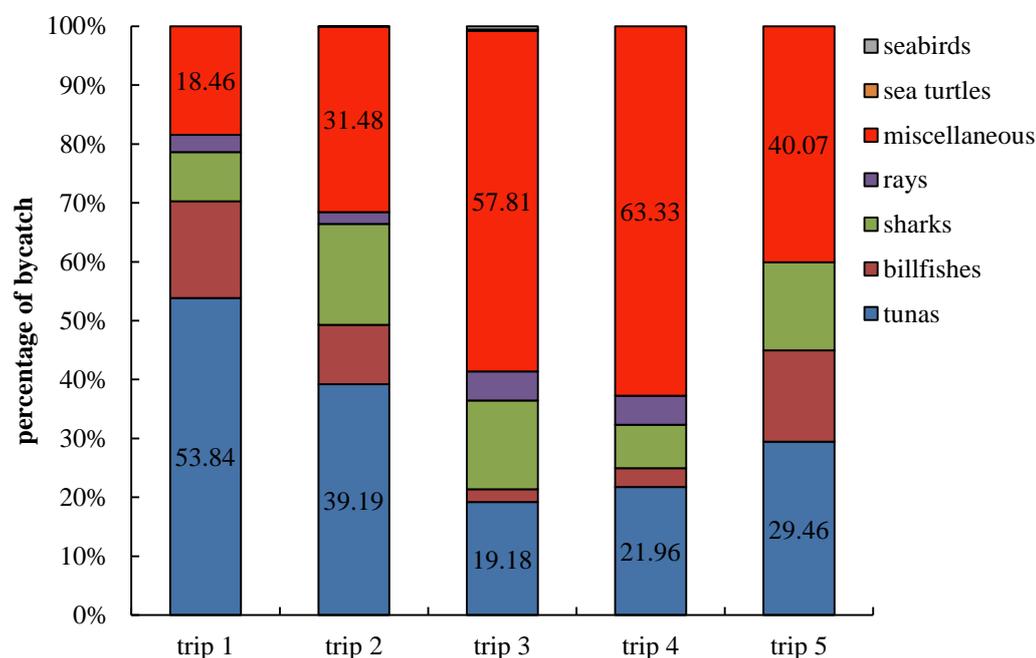


Fig.2 Proportion of catch in number of by-catch species groups caught by Chinese tuna longline observer trips in the Indian Ocean

The detailed composition of bycatch species (except for tuna bycatch) was listed in Table 3. During 2012-2015, 2705 individuals were captured (one blue shark escaped), belonging to 13 shark species (20.41%), 7 billfish species (19.74%), 1 ray species (3.99%), 2 sea turtle species

(0.07%), 2 seabirds (not identified to species, 0.07%) and 23 miscellaneous species (55.71 %).

The composition of the shark catches consists of blue shark (*Prionace glauca*) 16.38%, shortfin mako (*Isurus oxyrinchus*) 0.78%, oceanic whitetip shark (*Carcharhinus longimanus*) 0.55%, pelagic thresher (*Alopias pelagicus*) 0.52%, Longfin mako (*Isurus paucus*) 0.48%, silky shark (*Carcharhinus falciformis*) 0.41%, bigeye thresher (*Alopias superciliosus*) 0.33% and velvet dogfish (*Zameus squamulosus*) 0.30%, while other sharks accounted less than 1%. It well showed that blue shark was more frequently captured than other sharks. Mendonca (2009) also found blue shark is frequently caught in the longline and gillnet fisheries.

The billfishes included swordfish (*Xiphias gladius*), Indo-pacific blue marlin (*Makaira mazara*), striped marlin (*Tetrapturus audax*), and Indo-pacific sailfish (*Istiophorus platypterus*), with percentage of 8.5, 5.95, 3.07, and 1.40, respectively. The remaining billfishes accounted for 0.82%.

The only captured ray species was pelagic stingray (*Dasyatis violacea*), accounting for 3.99%. The composition of sea turtles included leatherback turtle (*Dermochelys coriacea*) and olive ridley turtle (*Lepidochelys olivacea*), which accounted for less than 0.1%. Miscellaneous fishes accounted for 55.71%, including longnose lancetfish (*Alepisaurus ferox*), escolar (*Lepidocybium flavobrunneum*) and opah (*Lampris guttatus*). It was noted that the percentage of miscellaneous fishes was higher than that of sharks, billfishes and rays.

We also found that the major species contributing to the longline bycatch were *Prionace glauca*, *Xiphias gladius*, *Makaira mazara*, *Dasyatis violacea*, *Alepisaurus ferox*, *Lepidocybium flavobrunneum* and *Coryphaena hippurus*.

**Tab.3 The list of bycatch species composition (tunas excluded)**

Category	English name	Scientific name	Catch	
			Number	%
<b>Sharks</b>	Blue shark	<i>Prionace glauca</i>	443	16.38%
	Shortfin mako	<i>Isurus oxyrinchus</i>	21	0.78%
	Oceanic whitetip shark	<i>Carcharhinus longimanus</i>	15	0.55%
	Pelagic thresher	<i>Alopias pelagicus</i>	14	0.52%
	Longfin mako	<i>Isurus paucus</i>	13	0.48%
	Silky shark	<i>Carcharhinus falciformis</i>	11	0.41%
	Bigeye thresher	<i>Alopias superciliosus</i>	9	0.33%
	Velvet dogfish	<i>Zameus squamulosus</i>	8	0.30%
	Blacktip shark	<i>Carcharhinus limbatus</i>	5	0.18%
	Great hammerhead	<i>Sphyrna mokarran</i>	4	0.15%
	Crocodile shark	<i>Pseudocarcharias kamoharai</i>	4	0.15%
	Kitefin shark	<i>Dalatias licha</i>	3	0.11%
	Bignose shark	<i>Carcharhinus altimus</i>	2	0.07%
	Sub total		552	20.41%
<b>Billfishes</b>	Sword fish	<i>Xiphias gladius</i>	230	8.50%
	Indo-pacific blue marlin	<i>Makaira mazara</i>	161	5.95%

	Striped marlin	<i>Tetrapturus audax</i>	83	3.07%
	Indo-pacific sailfish	<i>Istiophorus platypterus</i>	38	1.40%
	Shortbill spearfish	<i>Tetrapturus angustirostris</i>	17	0.63%
	Black marlin	<i>Makaira indica</i>	4	0.15%
	Unidentified species		1	0.04%
	Sub total		534	19.74%
<b>Rays</b>	Pelagic stingray	<i>Dasyatis violacea</i>	108	3.99%
<b>Sea turtles</b>	Leatherback turtle	<i>Dermochelys coriacea</i>	1	0.04%
	Olive ridley turtle	<i>Lepidochelys olivacea</i>	1	0.04%
<b>Seabird</b>			2	0.07%
	Longnose lancetfish	<i>Alepisaurus ferox</i>	552	20.41%
	Escolar	<i>Lepidocybium flavobrunneum</i>	310	11.46%
	Opah	<i>Lampris guttatus</i>	188	6.95%
	Dolphinfish	<i>Coryphaena hippurus</i>	103	3.81%
	Great barracuda	<i>Sphyrna barracuda</i>	77	2.85%
	Wahoo	<i>Acanthocybium solandri</i>	76	2.81%
	Sickle pomfret	<i>Taractichthys steindachneri</i>	67	2.48%
	Bigscale pomfret	<i>Taractichthys longipinnus</i>	49	1.81%
	Oilfish	<i>Ruvettus pretiosus Cocco</i>	23	0.85%
	Crestfish	<i>Lophotus capellei</i>	17	0.63%
	Slender mola	<i>Ranzania leavis</i>	9	0.33%
<b>Miscellaneous</b>	Snake mackerel	<i>Gempylus serpens</i>	9	0.33%
	Lustrous pomfret	<i>Eumegistus illustris</i>	6	0.22%
	Smooth puffer	<i>Lagocephalus laevigatus</i>	3	0.11%
	Remora remora	<i>Remora remora</i>	3	0.11%
	Atlantic pomfret	<i>Brama brama</i>	3	0.11%
	Dagger pomfret	<i>Taractes rubescens</i>	3	0.11%
	Pacific fanfish	<i>Pteraclis aesticola</i>	2	0.07%
	Rainbowrunner	<i>Elagatis bipinnulata</i>	2	0.07%
	Dealfish	<i>Desmodema polystictum</i>	2	0.07%
	Sharptail sunfish	<i>masturus lanceolatus</i>	1	0.04%
	Echeneis pediculus	<i>Remora osteochir</i>	1	0.04%
	Dolphin	<i>Delphinidae</i>	1	0.04%
	Subtotal		1507	55.71%

### Spatial distribution of bycatch species

Figure 3 showed that tunas, sharks, billfishes and miscellany were caught in almost all fishing areas, however, the rays were mainly caught in the ranges of 5°N-10°S and 25°-35°S.

Figure 4 showed the spatial distribution of tuna bycatch CPUE. The CPUEs of tuna bycatch were in the range of 0.28-0.79, and the higher CPUEs of tuna were caught in latitude of 10°N-10°S and longitude of 45°-65°E.

Figure 5 illustrated the spatial distribution of other bycatch CPUEs. The CPUE values ranged between 0.28 and 1.04. The higher CPUEs of other bycatch were in latitude of 10°N-10°S and longitude of 45°-65°E.

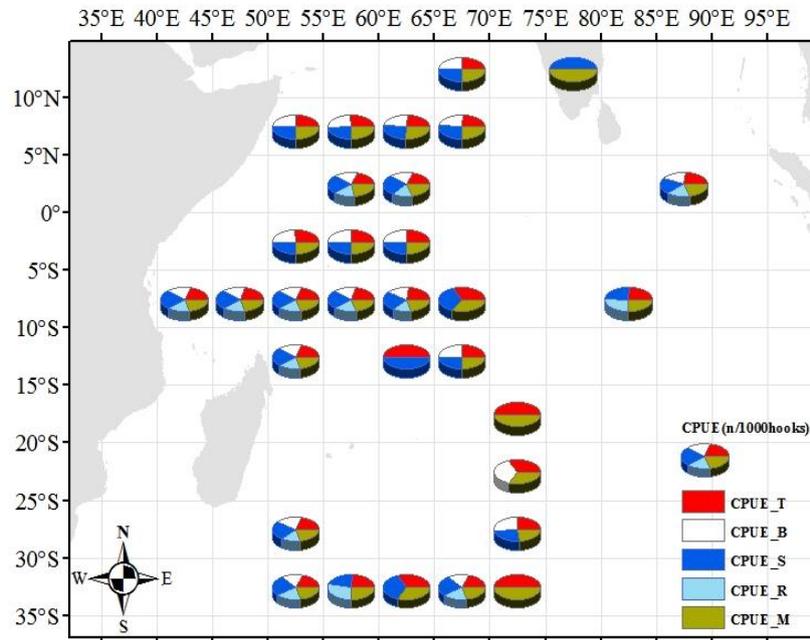


Fig.3 Spatial distribution of bycatch species CPUE (n/1000 hooks), shown in 5x5 degree grid

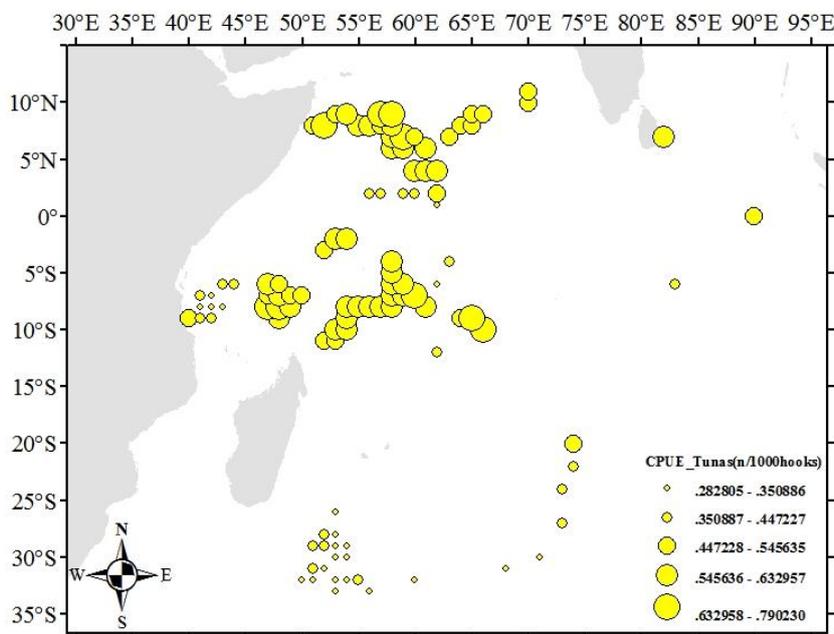


Fig.4 Spatial distribution of tuna bycatch CPUE (n/1000hooks)

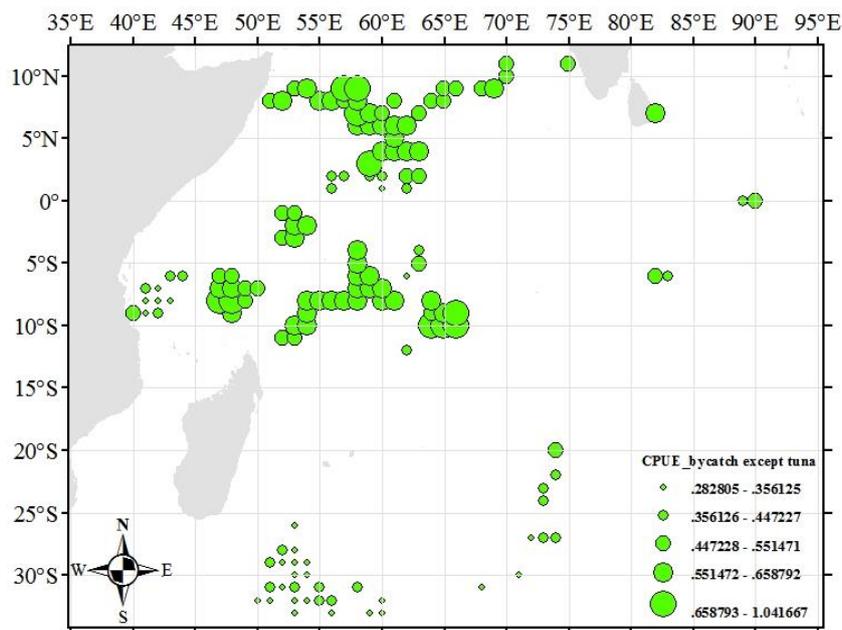


Fig.5 Spatial distribution of shark, ray, billfish and miscellaneous fish CPUE (n/1000hooks)

### Capture fate of bycatch species

The capture fate, i.e. dead, hurt, alive, retained, or discarded of bycatch species were recorded by scientific observers. Capture statuses were recorded for a total of 4458 individuals (excluding one escaped blue shark) including tuna bycatch, sharks, billfishes, rays and miscellaneous fishes (Figure 6). Because of economic value, tuna bycatch is retained whatever dead or alive. According to the record, a total of 4 sea turtles and seabirds were all caught dead and discarded. The proportion of dead, hurt (including hurt but nearly dead), and alive bycatch was 44.7% (1995), 12.7% (565), and 42.6% (1902), respectively. It was obvious that most sharks and rays were alive when caught, accounting for 77.3% of the total sharks and 83.3% of the total rays. The proportion of dead billfish was much higher than that of hurt or alive billfish (Figure 7).

When the non-target species was captured in longline fishery, it may be retained or discarded according to the economic value and management measure. The proportion of retained for all bycatch was 76.2%, and the discard proportion was 23.8%. Based on the observers' records, species with partly body retained are also recorded as "retained". The main retained species included shark, billfish and part of other bycatch species. Most of sharks, billfishes and miscellaneous fish were retained after headed, gutted, and tailed. The fate of "discarded" means discarding the uneconomic species, such as ray (only *Pelagic stingray*) (Figure 8).

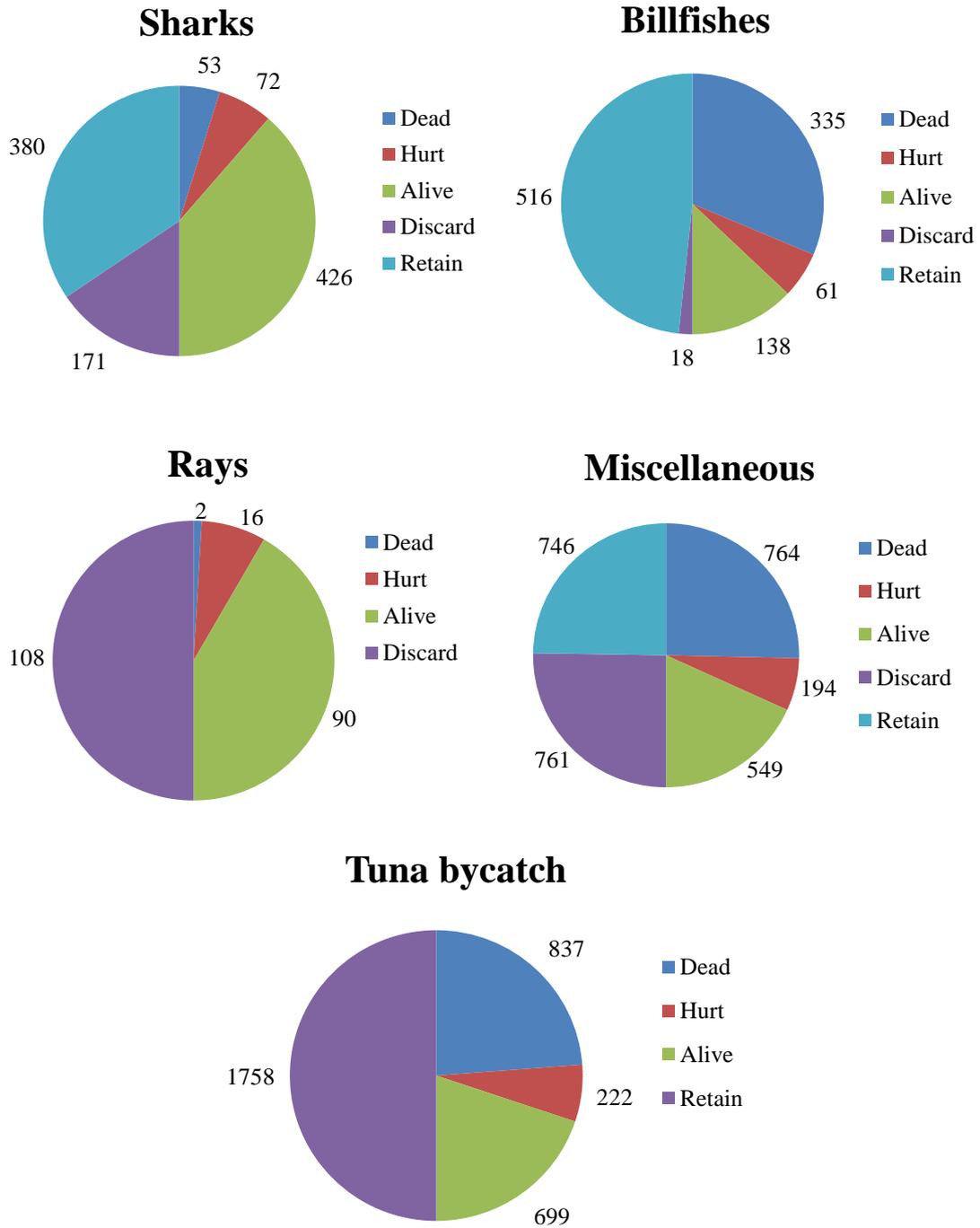


Fig. 6 The composition of capture fate of bycatches

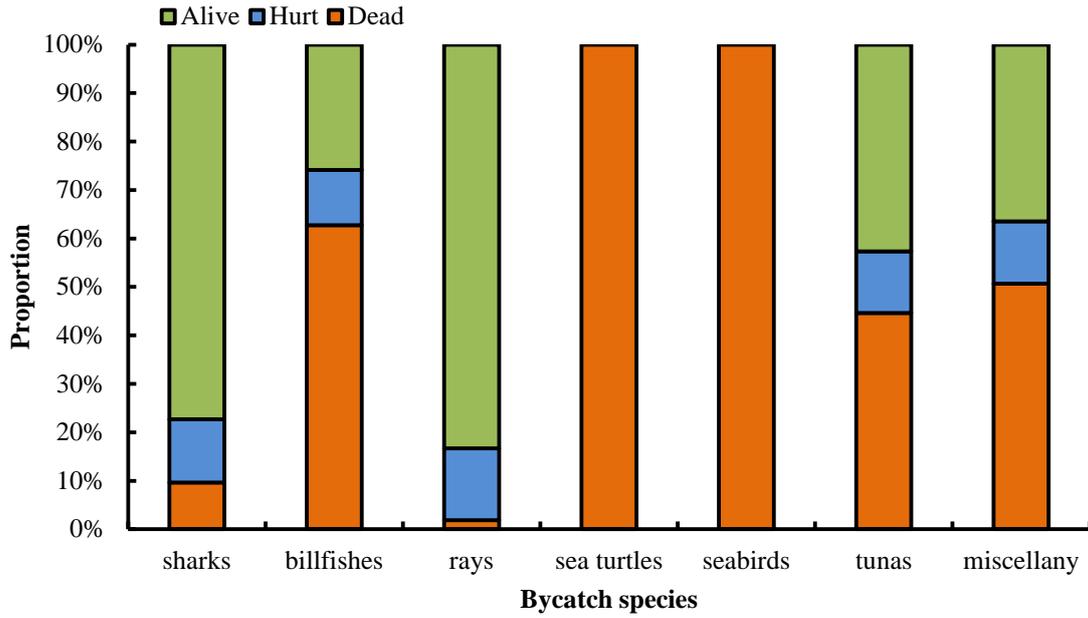


Fig.7 The proportion of alive, hurt and dead bycatches

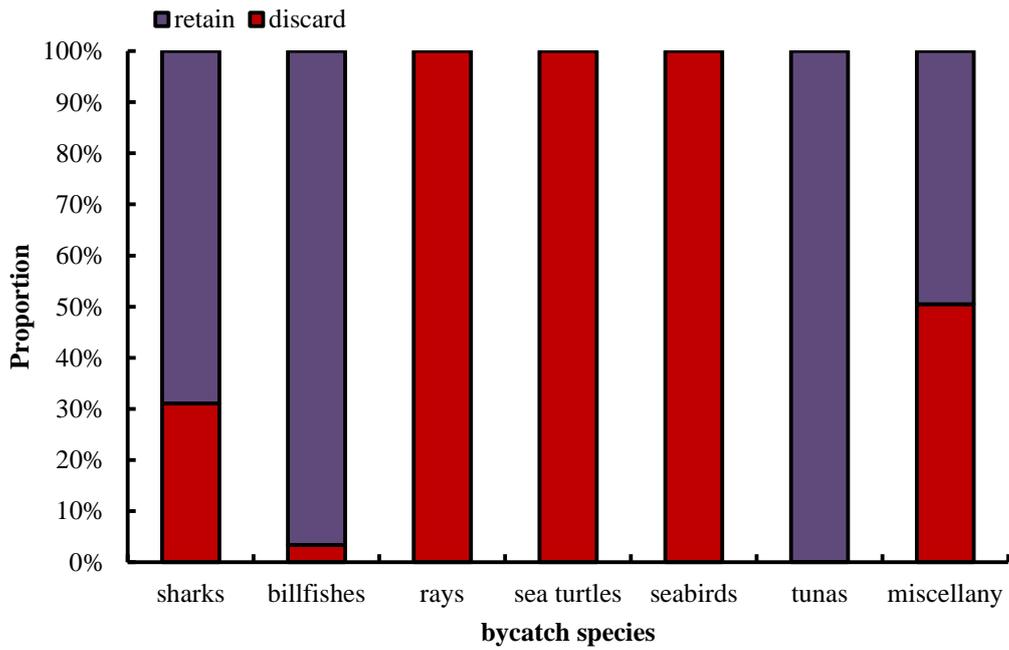


Fig.8 The proportion of retained and discarded bycatches

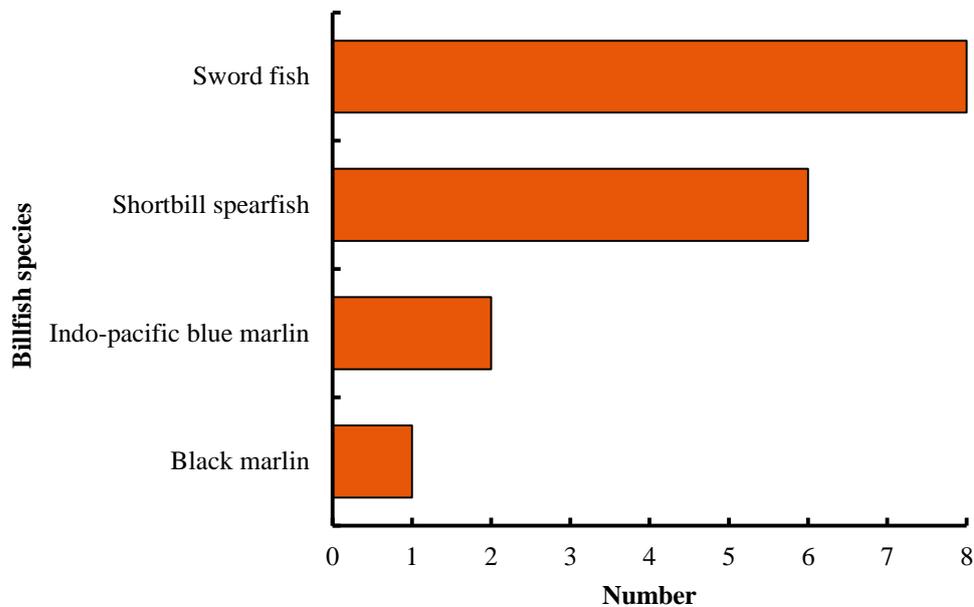
**Discard of concerned bycatch species****Sharks and billfishes**

Sharks are the primary bycatch species and most of them are retained. A total of 170 sharks were discarded in the five trips, accounted for 30.9% of the total shark catches (excluding one escaped blue shark) (table 4). The proportion of discard of shortfin mako was 19.05%, followed by blue shark 22.85%, longfin mako 23.08%, silky shark 45.45%, bignose shark 50%, oceanic whitetip shark 60%, blacktip shark 100%, pelagic thresher 100%, bigeye thresher 100%, and great hammerhead 100%. It was obvious that the majority of longfin mako, silky shark and oceanic whitetip shark from trip 1 were retained, but all discarded in following trips, especially in trip 5. Because of low economic value, kitefin shark, crocodile shark, and velvet dogfish were all discarded.

Tab. 4 Discard information of shark bycatches (N=total catch number, D=discard dead, A=discard alive, DR=discard rate) in the Chinese tuna longline fishery, 2012-2016

Species	Trip 1 (2012.10.29-2013.1.22)				Trip 2 (2013.10.7-2014.2.22)				Trip 3 (2014.8.3-2014.9.26)				Trip 4 (2014.8.3-2014.9.26)				Trip 5 (2015.12.15-2016.2.17)			
	N	D	A	DR	N	D	A	DR	N	D	A	DR	N	D	A	DR	N	D	A	DR
<b>Blue shark</b>	90	0	0	0%	173	0	0	0%	51	0	1	2.0%	29	0	1	3.4%	99	2	97	100%
<b>Shortfin mako</b>	7	0	0	0%	3	0	0	0%	3	0	1	33.3%	5	0	0	0%	3	0	3	100%
<b>Oceanic whitetip shark</b>	6	0	0	0%	8	2	6	100%	-	-	-	-	-	-	-	-	1	0	1	100%
<b>Pelagic thresher</b>	5	4	1	100%	8	2	6	100%	-	-	-	-	-	-	-	-	1	0	1	100%
<b>Bigeye thresher</b>	-	-	-	-	5	1	4	100%	-	-	-	-	-	-	-	-	4	1	3	100%
<b>Longfin mako</b>	12	0	2	16.7%	1	0	1	100%	-	-	-	-	-	-	-	-	-	-	-	-
<b>Silky shark</b>	7	0	1	14.3%	-	-	-	-	-	-	-	-	-	-	-	-	4	0	4	100%
<b>Velvet dogfish</b>	4	0	4	100%	-	-	-	-	-	-	-	-	-	-	-	-	4	0	4	100%
<b>Blacktip shark</b>	1	0	1	100%	4	1	3	100%	-	-	-	-	-	-	-	-	-	-	-	-
<b>Great hammerhead</b>	-	-	-	-	4	4	0	100%	-	-	-	-	-	-	-	-	-	-	-	-
<b>Crocodile shark</b>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0	100%
<b>Kitefin shark</b>	2	0	2	100%	-	-	-	-	1	0	1	100%	-	-	-	-	-	-	-	-
<b>Bignose shark</b>	-	-	-	-	1	0	0	0%	0	0	0	0%	1	0	1	100%	-	-	-	-
<b>Total</b>	134	4	11	11.2%	207	10	20	14.5%	55	0	3	5.5%	35	0	2	5.7%	120	7	113	100%

The total number of discarded billfish was 18, accounted for 3.37% of the total billfish catches. The discarded billfish included Indo-Pacific blue marlin (1.24%), swordfish (3.48%), shortbill spearfish (35.29%), black marlin (25%) and one unidentified billfish (100%). In general, sharks and billfishes are the main retained species in bycatch, the discarded amount was slight.



**Fig.9 The discarded number of billfishes**

#### Rays, sea turtles and seabirds

As above mentioned, there were only one ray species (*Pelagic stingray*), two sea turtle species (*Leatherback turtle*, *Olive ridley turtle*) and two unclassified seabirds captured during those trips. The discard rate of ray, sea turtle and seabird was 100%, 100% and 100%, respectively. The study showed that pelagic stingray was frequently captured.

### Acknowledgement

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