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Incidental and bycatches of sharks and turtles in the Reunion Island swordfish longline fishery in the Indian Ocean (1994-2000)

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Abstract

The Indian Ocean swordfish longline fishery based in Réunion Island started operating in 1991. Between 1994 and 2000, Ifremer[1] collected data from voluntary logbooks and regular at-sea and port sampling programmes.
5885 longline sets were examined to quantify the catches of five major shark species caught by the domestic longline fleet between 1997 and 2000: blue shark (*Prionace glauca*), Oceanic whitetip shark (*Carcharhinus longimanus),* shortfin mako (*Isurus oxyrinchus*), hammerhead sharks (scalloped hammerhead *Sphyrna lewini* and smooth hammerhead *Sphyrna zygaena* combined).
Blue shark (*Prionace glauca*) was dominant in the catch with an average of 180 t per year between 1997 and 2000; this represented between 75% and 88% of the total catch of sharks.
Mean catch rates for blue shark, oceanic whitetip shark were significantly higher for the small sized vessels (less than 16 m) operating in the immediate vicinity of the island, during the whole period (Kruskal-Wallis test, $p<0.05$). Significant decreases of the catch rates were observed for these two species from 1998 to 2000, declining from 2.2 to 1.03 blue sharks per thousand hooks and from 0.13 to 0.07 oceanic whitetip sharks per thousand hooks as the fishing effort of this boat category increased twofold over the same period.
Results using hook-timers indicated that 52 % of the blue shark and 59 % of the oceanic whitetip shark were retrieved dead and around 50% died within 6 to 8 hours after being hooked. 6,516 of the 13,325 blue sharks caught were released alive and it is estimated that after four months, 5,558 were still alive (41.5%). These results suggest that only a portion of discarded shark should be when considering species-specific management measures, as species with high survival rates may substantially reduce bycatch mortality.
The amount of size data recorded was very low for all the shark species and limits its use; nevertheless for blue shark the size ranged from 64 to 289 cm (FL), this average was 195.5 cm FL and about 40 % of specimens measured were less than the size of sexual maturity (i.e., <185 cm FL).
During 1996 and 2000, the fishery recorded 97 interactions with turtles: 51 with leatherback, 30 with hawksbill and 16 with green turtles. The catch status of the turtles (alive or dead) when the gear was retrieved varied depending on the species, but in most of the cases, they were released alive. This study underscores the need to conduct experiments to gain information about long-term survival of released bycatch species.

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Introduction

The Indian Ocean swordfish longline fishery based in Réunion Island was initiated in the early 1990s. Between 1994 and 2000, Ifremer (financed by the European Union and Reunion local Councils) has collected data from voluntary logbooks, regular at-sea campaigns and landing samplings. This data collection system was designed to provide information on catches, bycatch and incidental catches, size composition of target species, fishing effort, CPUE, predation by marine mammals on captured swordfish and biological parameters of swordfish.

These studies took part in two successive programs: the PTRII (Programme Thonier Régional II, Commission de l'Océan Indien) and the «Programme Palangre Réunion » (PPR), an Ifremer programme financed by the European Union and Reunion local Councils.

The aims of this paper are to present the most pertinent results obtained from the studies conducted during this period concerning the most commonly caught blue sharks (*Prionace glauca*), oceanic whitetip shark (*Carcharhinus longimanus)*, shortfin mako (*Isurus oxyrinchus*) and for hammerhead sharks (scalloped hammerhead *Sphyrna lewini* and smooth hammerhead *Sphyrna zygaena* combined). Catch and CPUE trends of sharks are described. A brief examination of incidental turtle catches is presented.

Description of the Fishery

Longline Fleet

The domestic longline fleet has been categorised into two classes of vessels: small / medium boat class comprising vessels less than 16 meters and a large boat class comprising vessels over 16 meters long.

The number of days at sea varies according to vessel size, capacity and weather conditions. The smallest boats stay at sea 2 to 3 days, whilst medium-sized vessels generally stay 6 to 8 days; some of the largest vessels may stay at sea for up to 30 days.

The rapid development of the domestic swordfish longline fishery has been described (Poisson *et al*, 1998 ; Poisson and René, 1999; Poisson and Taquet, 2001; Miossec and Taquet, 2004). In 1998, the fleet was composed of 20 small and 10 large vessels.

Fishing gears and methods

All the Reunion vessels use a system of drifting longline utilising a main spool. The main line is a monofilament composed of nylon 3.5 - 4 mm diameter. The monofilament main line is stored on a large hydraulic-powered reel, each storing between 20 and 80 km of main line. The lines with generally Mustad J-hooks (size 8/0 or 9/0) are 10 meters long and 2 mm in diameter. These are attached to the mainline with snaps. The depth of fishing is controlled by branch line and float line lengths, distance between buoys, number of hooks between two floats and speed of the boat during the setting. Weights may also be added to control the line depth in strong currents. In addition, a large float is used to separate the various sections composed of 60 to 100 hooks. Between 300 and 2500 hooks are utilised during each set. The buoys at the end of the longline are equipped with a strobe light and a radio retrieval system. While the longlines can be rigged in many ways, because swordfish is the target species, the longline is always set in the evening. Squid is used as bait and a light stick placed one meter above the hook. The longliners set about 6-10 hooks between floats and attach generally one light stick for every 3 branch lines. This whole operation requires three crewmen on deck for baiting the hooks and clipping buoys and branch lines on the mainline and one at the helm. The longline is set in 3 to 6 hours cruising down wind. The line is hauled after sunrise. The duration of the haul depends on the catch and sea conditions.

Data collection

Logbook system

The logbooks used were designed specifically for this study and contained information collected both during the longline setting and hauling, mainly at the beginning and ending of each of these activities. The records included date, time, location of the sets (by GPS), number of hooks deployed, total catch of swordfish, major tuna and tuna-like species as well as other fish species, by-catches (by number). For the most commonly caught sharks blue shark, oceanic whitetip shark, shortfin mako and hammerhead sharks, the number of individuals kept onboard and the number of released were recorded. The species and number of turtles caught and their condition (dead or alive) and the number of swordfish damaged by predators was recorded.

At the same time, scientists onboard recorded the condition of the animals when the gear was retrieved, collected biological data and samples mainly on swordfish which was the studied species but also on other species. They also conducted experiments deploying "hook timers" and depth recorders on the main line.

CPUE

Two CPUE's were estimated:
CPUE-t, defined by the total number of fish caught (retained onboard and released at sea), by sharks species per 1000 hooks.
CPUE-r, corresponding to number of fish retained onboard, by sharks species per 1000 hooks.

Results and discussion

Logbook coverage

Logbooks were distributed widely to all the boats along with species identification guides and on sharks and sea turtles. Disposable cameras were also provided so the identification of some specimen could be confirmed later. Fishing masters and crew demonstrated their willingness to co-operate to this program and agreed to collect information on a voluntary basis. Logbook data were cross-checked against the data recorded by scientists onboard and at port sampling data and corrections are made when necessary. This system provided basic confirmation of the information received. The close co-operation provided good results and enabled the compilation of accurate and consistent data sets during seven consecutive fishing seasons (table 1).
Nevertheless, while the catch data for the major species was considered good quality from the beginning, some identification problems on sharks persisted during the first three years after implementation, because of this, it was decided to restrict the analyses to the observed sets made from 1997 to 2000 (5885 sets).

Table 1 : Fishing operation coverage rates from 1994 to 2000 obtained with the logbook system (small boat class: vessels less than 16 meters; large boat class: vessels over 16 meters).

Small boats	1994	1995	1996	1997	1998	1999	2000
January	*91*	*52*	*100*	*21*	*54*	*28*	*39*
February	*42*	*65*	*62*	*28*	*51*	*33*	*45*
March	*100*	*72*	*70*	*26*	*54*	*44*	*34*
April	*85*	*54*	*56*	*73*	*31*	*33*	*35*
May	*44*	*85*	*44*	*56*	*27*	*31*	*24*
June	*62*	*91*	*67*	*100*	*49*	*32*	*32*
July	*77*	*78*	*56*	*73*	*66*	*33*	*30*
August	*63*	*91*	*49*	*69*	*68*	*33*	*13*
September	*76*	*76*	*36*	*50*	*33*	*35*	*22*
October	*93*	*46*	*18*	*54*	*42*	*23*	*14*
November	*45*	*100*	*18*	*44*	*64*	*28*	*10*
December	*42*	*60*	*17*	*59*	*48*	*34*	*12*
Large boats							
January	0	100	82	100	100	55	92
February	0	88	77	44	40	100	57
March	0	64	78	100	78	100	62
April	26	78	81	48	20	52	56
May	76	100	75	93	27	39	22
June	100	78	84	55	40	36	57
July	55	70	56	54	20	62	43
August	100	100	91	38	64	52	43
September	80	89	37	100	34	57	34
October	100	96	66	43	100	61	59
November	38	62	55	60	34	70	51
December	100	100	55	38	26	37	60

Fishing Effort

The effort of the fleet is represented by the yearly estimated number of hooks set by the two segments of the fleet. From 1994 to 1999 effort steadily increased before dropping in 2000. The contribution of the largest vessels to the fishing effort decreased slowly especially from 1999. Thus for the first time, in 1999, the number of hooks set by the small boats overtook the number of hooks set by the largest vessels (figure 1).

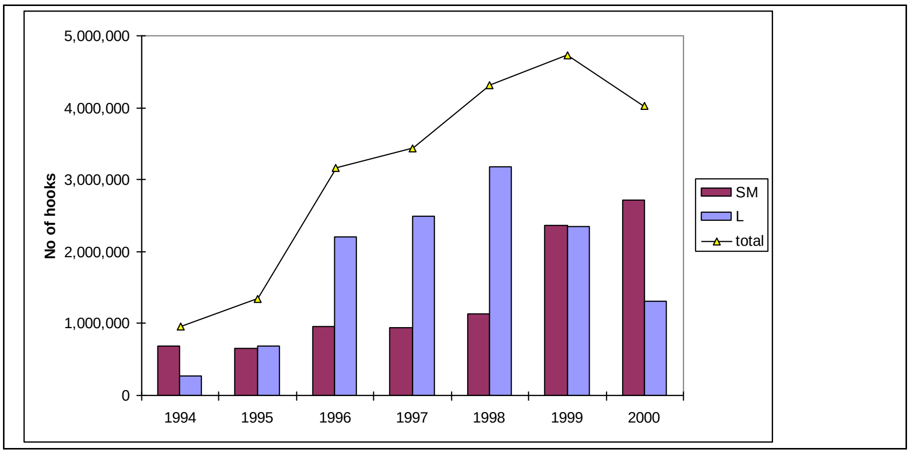


Figure 1: estimated number of hooks deployed by boat category (SM: small; L: large) between 1994 and 2000

Between October 1992 and December 2000, 9505 individual hauls of longline fishing gear were documented. The greatest amount of yearly effort was observed in 1999 (1,815 sets).

Fishing grounds

The locations of effort (number of hooks) from 1997 to 2000 (by year and boat category) are shown in Figure 2. This figure shows the spatial extension of the large boats to the Southwest in the 200 nautical mile zone, to the Mozambique Channel and to Seychelles waters in 1997 and 1998. The decline of large boats from the fleet brought notable changes, therefore catches in 1999 and in 2000 are made mainly around Reunion island between 50° E and 60° E and 20° S and 25° S. Only a few vessels ventured far from in 2000.

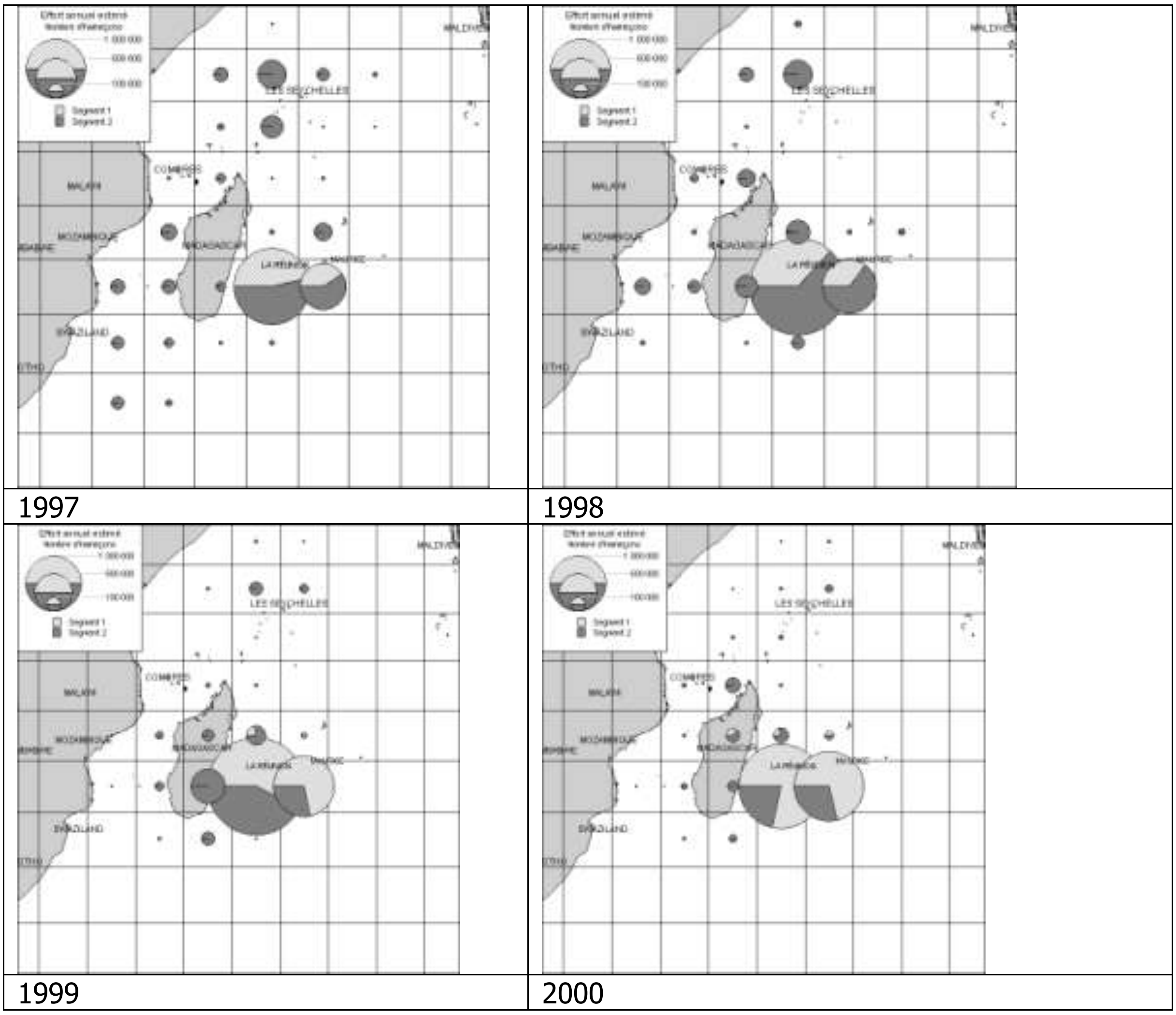


Figure 2: yearly effort distribution per boat category (no. of hooks) from 1997 to 2000. Category 1: less than 16 meters (small or medium boat class); Category 2: over 16 meters (large boat class).

Catch and discard

Catches were estimated using average weights of individuals sampled during the whole period, the following average weights were used: Blue shark (BSH); 47.5 kg, Oceanic whitetip (OCS) ; 41kg, Shortfin mako shark (SMA); 41.5 kg, hammerhead sharks (HAM); 44 kg. Tables 2 and 3 show the estimated amount of four shark species and group landed (sharks retained on board) and caught per year by the entire fleet.

Table 2: Estimated landings (in tons) of four species of sharks per boat category (SM: small; L: large) by the Reunion Island-based swordfish longline fishery in the Indian Ocean (1997-2000): BSH : Blue shark; OCS: Oceanic whitetip; SMA: Shortfin mako shark; HAM : hammerhead sharks

year	BSH			OCS			SMA			HAM			
	SM	L	Total	SM	L	Total	SM	L	Total	SM	L	Total	**Grand Total**
1997	3.8	3.8	7.6	4.7	13	17.6	4.8	9.9	14.6	1.1	0.8	1.9	**41.7**
1998	2.9	26.1	28.9	11.6	10	21.6	3	3	6	1.2	0.8	2.1	**58.6**
1999	27.7	17.1	44.8	14.7	5.2	19.8	4.6	1.7	6.3	1	0.7	1.7	**72.6**
2000	4.8	11.9	16.7	11.3	9.5	20.8	8.8	3.9	12.7	0.2	0.6	0.8	**51**
Total	*39.2*	*58.9*	***98***	*42.3*	*37.6*	***79.9***	*21.2*	*18.4*	***39.6***	*3.4*	*3*	***6.4***	**223.9**

Silky shark made up the majority of the remained shark bycatch (SKH) (Table 3) with in lesser extend thresher sharks, tiger sharks and *Carcharinus spp*. An average of 28 kg was used to estimate catches for this aggregated group.
It should be noted, that the total catch of the remained shark bycatch between 1997 and 2000 is almost equal to the catch of blue shark, oceanic whitetip shark, Shortfin mako shark and hammerhead sharks combined (Table 4).

Table 3: Estimated amount (in tons) of remained sharks bycatch (SKH) landed per category (SM: small; L: large) of the Reunion Island -based swordfish longline fishery in the Indian Ocean (1994-2000)

year	SKH		
	SM	L	Total
1997	24.4	10.7	35.1
1998	14.4	45.2	59.6
1999	29.9	47.0	76.9
2000	23.7	28.2	51.9
Total	*92.4*	*131.1*	***223.5***

Table 4: Estimated total caches (in tons) of four species of sharks caught per boat category (SM: small; L: large) of the Reunion Island-based swordfish longline fleet (1994-2000): BSH : Blue shark; OCS: Oceanic whitetip; SMA: Shortfin mako shark; HAM : hammerhead sharks

year	BSH			OCS			SMA			HAM		
	SM	L	Total	SM	L	Total	SM	L	Total	SM	L	Total
1997	72.61	46.96	119.6	7.79	15.03	22.8	4.9	10.09	15	1.1	1.38	2.5
1998	133.1	69.53	202.6	14.56	10.66	25.2	3.09	3.24	6.3	1.21	0.84	2.1
1999	163.9	74.02	238	16.37	5.74	22.1	4.81	2.1	6.9	1.37	0.85	2.2
2000	120.6	43.64	164.3	12.68	10.07	22.7	9.83	4.16	14	0.99	0.62	1.6
Total	*490.2*	*234.2*	***724.4***	*51.4*	*41.5*	***92.9***	*22.6*	*19.6*	***42.2***	*4.6*	*3.7*	***8.3***

Blue shark was dominant in the catch with an average of 180 tons per year between 1997 and 2000; this shark species represented between 75 % (in 1997) and 88% (in 1999) of the total catch of sharks.
Discarding also varied over the whole period, ranging from low discards (2.6%) for shortfin mako, to high discards for blue shark (86.5%) (Table 5).

Table 5: Estimated discarded sharks (in tons) of four species of sharks caught by the Reunion Island-based swordfish longline fleet (1994-2000) : BSH : Blue shark; OCS: Oceanic whitetip; SMA: Shortfin mako shark; HAM : hammerhead sharks

year	BSH			OCS			SMA			HAM		
	Total	discard	% discard	Total	discard	% discard	Total	discard	% discard	Total	discard	% discard
1997	120	112.0	93.6%	22.8	5.1	22.5%	15	0.2	1.3%	2.5	0.6	23.2%
1998	203	173.6	85.7%	25.2	3.6	14.4%	6.3	0.2	3.8%	2.1	0.0	1.9%
1999	238	193.2	81.2%	22.1	2.2	10.0%	6.9	0.4	5.8%	2.2	0.2	6.8%
2000	164	147.6	89.8%	22.7	2.0	8.6%	14	0.3	1.9%	1.6	0.0	1.3%
Total	***724***	***626.3***	***86.5%***	***92.9***	***12.9***	***13.9%***	***42.2***	***1.1***	***2.6%***	***8.3***	***0.8***	***9.5%***

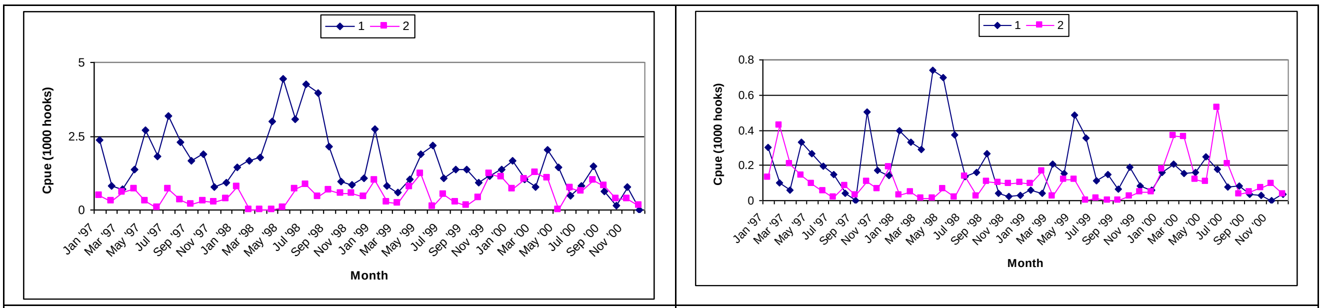
Urea stored in the blood system quickly turns to ammonia when the blue shark dies which affects the meat quality. The flesh can spoil other fish stored in the same hold.
Onboard reunion longliners, sharks when alive are generally not brought aboard the vessel but are released in the water by cutting the gangion as close to the hook as possible as several accidents were recorded with sharks biting crews during hauling.
Nevertheless when they are retrieved dead sharks are often "finned" and carcasses are discarded at sea. Besides shortfin makos are generally kept as the flesh is valuable and particularly appreciated. To a lesser extent oceanic sharks and hammerhead shark are also retained for flesh and finns (table 2).

CPUE

Results of CPUE analyses were restricted to blue shark and Oceanic whitetip shark, because of the relatively low levels of catches of shortfin mako and the hammerheads. However, an exploratory analysis of the less common species showed that the yearly average CPUE for shortfin mako varied between 0.01 to 0.03 sharks per 1000 hooks and from 0.01 to 0.005 sharks per 1000 hooks, respectively for the small (cat 1) and large (cat 2) vessels.
The yearly average CPUE-t for hammerhead sharks varied between 0.01 to 0.03 sharks per 1000 hooks and from 0.01 to 0.005 sharks per 1000 hooks, respectively for the small (cat 1) and large (cat 2) boat category.

The following charts (figure 3 to 5) show the CPUE trends, per boat category, by month from 1994 to 2000 and by month and by year combined over the whole period for blue shark, Oceanic whitetip shark and shortfin mako and for the hammerhead sharks group.

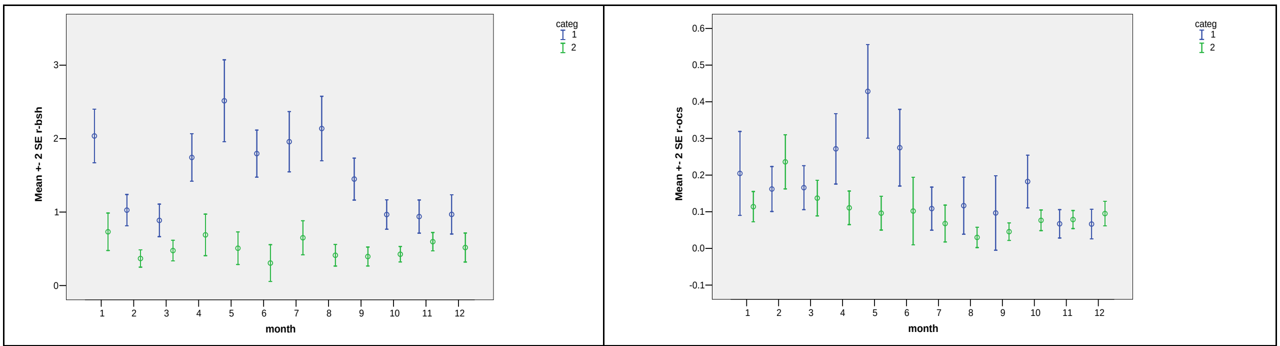
Non-parametric statistical tests (Kruskal-Wallis tests) were applied in the analysis to verify the statistical significance of the differences among the average CPUE for each boat category.



(1) (2)

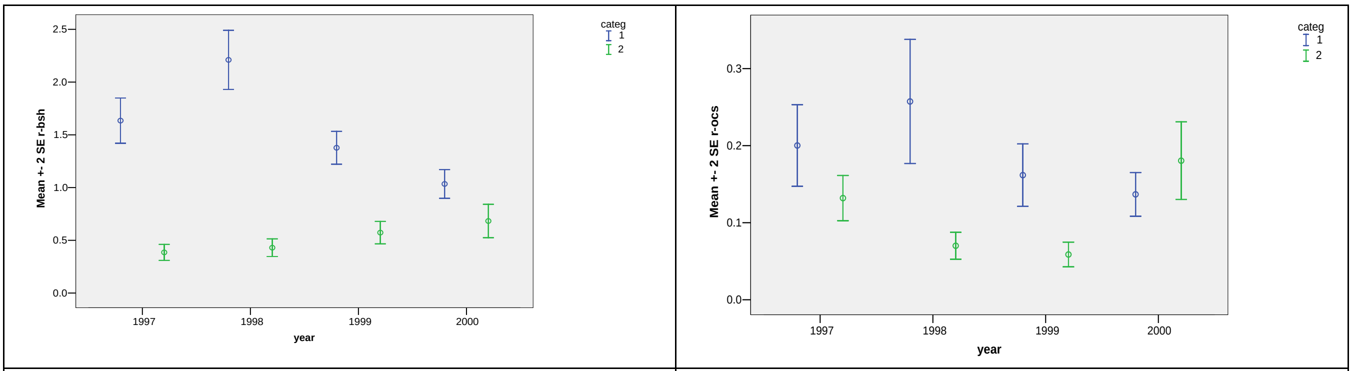
Figure 3: Average monthly CPUE-t for blue shark (1), oceanic withetip (2) per boat category (1: small; 2: large), from 1994 to 2000 for Reunion Island swordfish longline fishery

Mean CPUE(s) for Blue shark and oceanic whitetip shark were significantly higher for small sized vessels (category 1) during the whole period (Kruskal-Wallis test, $p<0.05$). The higher relative CPUE of blue sharks and oceanic whitetip sharks recorded for the small boats category could reflect the occurrence of these species in the vicinity of Reunion island and the few seamounts localised in the western part of the island, especially in May and June (fig 3 and fig 4).



(1) (2)

Figure 4: Average monthly CPUE-t for blue shark (1), oceanic withetip (2) per boat category (1: small; 2: large) , from 1994 to 2000 for Reunion Island swordfish longline fishery



(1) (2)

Figure 5: Average yearly CPUE-t for blue shark (1), oceanic withetip (2), per boat category (1: small; 2: large) from 1994 to 2000 for Reunion Island swordfish longline fishery

Blue shark

The yearly average CPUE ranged from 1.03 to 2.21 sharks per 1000 hooks and from 0.38 to 0.68 sharks per 1000 hooks, respectively for the small (cat 1) and large (cat 2) boat category (fig 5).

For the small boats category (cat 1), a significant decrease of the CPUE-t yearly mean (Kruskal-Wallis test, $p<0.05$) were obtained for the blue shark from 1998 to 2000, declining from 2.2 to 1.03 sharks per thousand hooks as the fishing effort of this boat category increased twofold over the same period.

No significant difference in the CPUE was noticed over the period (Kruskal-Wallis test, $p>0.05$) for the large size boat category.

The higher monthly catch rates occurred between April and August (fig 10).

Oceanic whitetip shark

The yearly average CPUE-t for oceanic withetip ranged from 0.14 to 0.26 sharks per 1000 hooks and from 0.06 to 0.18 sharks per 1000 hooks, respectively for the small (cat 1) and large (cat 2) boat category (fig 9).

For the large boats category (cat 2), a significant decrease of the CPUE-t yearly mean (Kruskal-Wallis test, $p<0.05$) were obtained for the oceanic whitetip sharks between 1997 to 1998, declining from 0.13 to 0.07 sharks per thousand hooks, followed by an increase. Combined per month, a peak is recorded in May (0.4 sharks/1000 hooks)

Survival time

Data from 160 longline sets equipped with hook-timers were used in analyses and resulted in condition (i.e., live or dead) information on 92 individual blue shark and 17 oceanic whitetip sharks. Results indicated that 51.1 % of the blue shark and 58.8 % of the oceanic whitetip shark were retrieved dead. Apparently, studies conducted with day sets displayed higher survival rates for blue shark 100% by Boggs (1992), 93 % by Bach et al. (1999) and 69% Diaz et al. (2005).

50% of the individuals blue and oceanic whitetip sharks died respectively within the eighth hours and within the sixth hours following their capture (fig 1). Besides, 4% of the blue shark and 14% of the oceanic whitetip shark caught were still alive after 14 hours.

For gauging post-release mortality of longline-caught blue shark, tagging studies are needed. Blue sharks appear to be very robust animals, (Moyes *et al* , 2006) showed in their study that most blue shark can survive the stresses associated with capture.

Almost every individual tagged (85%) survived more than 4 months post-release. Using this information we can assume that among the 13,325 blue sharks caught during this period (628 tons), 6,516 have been released alive and that after 4 months, 5,538 were theoretically still alive (41.5%).

These mortality data suggest that only a portion of discarded shark should be taken into account when considering species-specific management measures, as species with high survival rates may substantially reduce bycatch mortality.

Size frequency

The amount of size recorded has been very low for all these species and prevent any size trend analysis, nevertheless about 40 % of blue shark measured less than the size of sexual maturity (i.e., <185 cm FL). For this species the size ranged from 64 to 289 cm (curved FL) and the average was 195.5 cm FL (curved).

Interaction with sea turtles

During 1996 and 2000, the fishery had 51 interactions with leatherback, 30 with Hawksbill turtles and 16 with green turtles (Poisson, 2000). In some cases fishermen reported some individuals as "unidentified turtles" and 23 interactions must be taken into account for other species than leatherback turtle which is easy to identify. The catch status of the turtles (alive or dead) when the gear was retrieved varied widely depending on the species. Though, all the leatherback turtles caught were released alive but 5 green turtles and 3 hawksbill turtles were found dead at the haulback operations (Table 6). In most of the case, they were released alive. The predominant species for small sized vessels was Hawksbill turtle and leatherback turtle for the large vessels with 13 and 43 specimen caught respectively. These data have extracted from the logbooks, the average coverage for the two boat categories were 35.1% and 56.8% (Table 6).

One boat reported that in two consecutive days on the 25th and on 26th February 1997, 5 and 3 leatherback turtles were caught respectively in the vicinity of a sea surface temperature frontal structure. Due to the limited number of data, no particular investigation on the aggregation of turtles in relation with SST features was conducted.

The trends of the average turtles CPUE(s) (all species combined) were almost similar for both boat categories, after a peak of 0.02 turtles per thousand hooks for the small boats and 0.015 turtles per thousand hooks for the large one, recorded in 1997, CPUE(s) were stable in both cases between 1998 and 2000 averaging at 0.013 and 0.012 individuals caught per thousand of hooks respectively (Table 6).

Table 6: Status on the number of turtles caught by the Reunion Island swordfish longline fishery per boat category in the Indian Ocean (1994-2000), logbook coverage and CPUE (No of turtles per thousand hooks)

Species		1996	1997	1998	1999	2000	Total	%
small boats	STATUS							
Chelonia mydas	na	0	0	0	0	0	**0**	0.0
(Green turtle)	alive	0	0	0	1	1	**2**	66.7
	dead	0	0	1	0	0	**1**	33.3
	Total	***0***	***0***	***1***	***1***	***1***	***3***	
Dermochelys	na	0	0	0	0	0	**0**	0.0
coriacea	alive	0	1	4	2	1	**8**	100.0
(leatherback turtle)	dead	0	0	0	0	0	**0**	0.0
	Total	***0***	***1***	***4***	***2***	***1***	***8***	
Eretmochelys	na	0	2	0	0	0	**2**	15.4
imbricata	alive	0	7	0	2	2	**11**	84.6
(Hawksbill turtle)	dead	0	0	0	0	0	**0**	0.0
	Total	***0***	***9***	***0***	***2***	***2***	***13***	
unidentified	na	0	0	0	1	1	**2**	15.4
turtles	alive	0	0	2	4	5	**11**	84.6
	dead	0	0	0	0	0	**0**	0.0
	Total	***0***	***0***	***2***	***5***	***6***	***13***	
	Grand Total	**0**	**10**	**7**	**10**	**10**	**37**	
	hooks	367,757	459,945	541,994	770,679	708,389	2,848,764	
CPUE (no turtle/thousand hooks)		0.00E+00	2.17E-02	1.29E-02	1.30E-02	1.41E-02	1.30E-02	
Logbook coverage		38.5	48.5	47.8	32.5	26.1	35.1	
Large boats	STATUS							
Chelonia mydas	na	0	0	0	1	0	**1**	7.7
(Green turtle)	alive	0	2	2	2	2	**8**	61.5
	dead	0	0	0	4	0	**4**	30.8
	Total	***0***	***2***	***2***	***7***	***2***	***13***	
Dermochelys	na	0	2	1	0	0	**3**	7.0
coriacea	alive	4	18	3	9	6	**40**	93.0
(leatherback turtle)	dead	0	0	0	0	0	**0**	0.0
	Total	***4***	***20***	***4***	***9***	***6***	***43***	
Eretmochelys	na	0	0	1	0	0	**1**	5.9
imbricata	alive	0	4	2	7	0	**13**	76.5
(Hawksbill turtle)	dead	0	1	0	2	0	**3**	17.6
	Total	***0***	***5***	***3***	***9***	***0***	***17***	
unidentified	na	0	0	0	1	1	**2**	20.0
turtles	alive	0	2	1	0	2	**5**	50.0
	dead	0	0	3	0	0	**3**	30.0
	Total	***0***	***2***	***4***	***1***	***3***	***10***	
	Grand Total	**4**	**29**	**13**	**26**	**11**	**83**	
	hooks	2,211,624	2,492,893	3,176,169	2,349,739	1,314,169	11,544,593	
CPUE (no turtle/thousand hooks)		1.81E-03	1.56E-02	6.30E-03	1.53E-02	1.60E-02	1.04E-02	
Logbook coverage		66.5	60.9	43.4	62.2	55.6	56.8	
Total fleet		**4**	**39**	**20**	**36**	**21**	**120**	

Conclusion

Thanks to fishermen co-operation, the logbook system program provided a great number of observations spread out over several fishing seasons. Collection of data on the major species was the priority from the beginning of the programme in 1993, data collection on predation and incidental catches of turtles was introduced gradually. Because of possible misreported information on sharks, a part of data for sharks was not considered. However, the quality of the data on bycatch after 1997 is considered good quality.
In this study, the greatest percentage of bycatch was composed of sharks and mainly blue shark. These results provide a clearer perspective of the magnitude of shark bycatch, species commonly caught in the pelagic longline fishery. The sharks observed in this study are highly migratory, they are obviously subject to fishing mortality from other tuna longline fisheries in the Indian ocean. Of concern is the indication that CPUE of blue shark for the boats operating close to the island has declined from 1998 to 2000 concomitant with a steadily increase of the number of hooks deployed by this boat category. It is difficult to draw conclusion with this limited temporal series but these data could serve as a baseline for future shark surveys. Whether a relatively high percentage of blue shark and turtles are discarded alive, it is difficult to evaluate the real positive impact on the stock as far as the post survival rates after release for each species has not been considered.

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