Survival rate of silky sharks (*Carcharhinus falciformis*) caught incidentally onboard French tropical purse seiners

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Abstract

Currently, French purse seiners in the Indian Ocean release all sharks and rays that are caught in order to reduce the fishery induced mortality of elasmobranchs. Through participation in two commercial fishing trips, we first recorded the number of sharks (primarily silky sharks, *Carcharhinus falciformis*) that were alive or dead, once they had been sorted by the crew on the upper and lower decks. More sharks were observed in the lower deck (73%) than in the upper deck. The silky sharks observed on the upper deck were significantly larger than the ones found in the lower deck. The immediate mortality (sharks that were dead at the time of observation) rates appeared to be linked with the location of the individual, as more sharks were found dead on the lower deck than the upper deck. The immediate mortality rates also increased with the set size (tonnage). In total, 20 silky sharks (125.3 ± 33.8 cm total length) were tagged with MiniPATs (Wildlife Computers, Redmond, WA, USA) to study their survival after release. Six tags clearly showed mortality directly after release, while data from three tags suggested delayed mortality after 2.5, 14 and 15 days. Nine tags showed that the sharks survived. Two tags failed to report data and one was incorrectly initiated. Following these findings a 'best practices' manual for fishers will be prepared to increase rates of survival of sharks caught by purse seine vessels. However, other methods prior to the sharks being brought onboard must also be investigated.

Introduction

When setting around FADs, in addition to the catch of target species (tropical tuna), purse seiners incidentally capture some bycatch species. In the Indian Ocean, the bycatch/tuna catch ratio is estimated to be 4.7% (Amandè et al. 2008), including discards of small sized tunas, other bony fish and elasmobranchs. The main shark species incidentally caught by purse seiners around FADs is the silky shark (*Carcharhinus falciformis*). It is well known that sharks have life history straits that make them vulnerable to overfishing. As such, even if the percentage of catch from purse seine fishery is relatively small as compared to the catch of adults by longliners (Gilman 2011), it is important to find methods to reduce any fishery induced mortality of these sharks.
The current practice onboard European purse seiners is to release sharks and rays that are caught. Before investigating methods (e.g. best practices) that could be used by the crews to reduce the fishery induced mortality of these animals, it is important to document the numbers of sharks that survive after being released. Through combined efforts of two projects (the EU

funded MADE project, www.made-project.eu and the project Contrat Avenir from the French fleet organization ORTHONGEL), we investigated the numbers of sharks that are incidentally captured and of these, the proportion of dead versus alive. In addition, of the alive sharks, we assessed the proportion of those that survive after being released by the crew, by equipping sharks with pop-up archival tags (miniPATs, WildLife Computers). From the total of sharks caught, we then calculated the percentage of sharks that survive incidental capture.

Materials and methods

Observations and tagging were conducted through participation of scientists to two regular fishing cruises of French purse seiners. During the first cruise of 21 days (16 March to 5 April 2011, Mozambique Channel), of the 111 silky sharks that were caught in 15 sets (for a total of 503 t of tunas), 109 sharks were sampled (2 silky sharks were discarded by crew inadvertently), ranging from 67 to 166 cm (total length). During the second cruise of 31 days (10 May to 9 June 2011, mainly North of Mauritius), one mako shark (*Isurus oxyrhincus*) was caught in a set on a free-swimming school and 24 silky sharks were caught in 4 sets on FADs, ranging from 50 to 235 cm.

Once caught, fish are firstly landed on the upper deck from the bunt with the brailer and then sent to the lower deck via the hopper. “Unwanted fish” are manually sorted at both locations. In order to collect the relevant information during the fishing operation, one scientist standed on the upper deck close to the hopper while another one stayed in the lower deck next to the conveyor belt to localise and to remove the sharks. All the sharks were pulled out and put aside to be measured with a tape measure (total length and fork length) and sexed. Scientists noted the condition of the shark at the moment of their appearance.

To investigate the survival of released sharks, mini PATsWildlife Computer (Redmond, WA, USA) were programmed to popup after a fixed period of 100 days and to transfer the data set to Argos satellite. All the tags were rigged prior to deployment. They were fitted with a guillotine which activates when the tag reaches a depth of 1,800 meters avoiding its destruction. The tags were affixed to sharks by inserting a nylon anchor (Wilton type) into the dorsal muscle underneath the pterygiophores of the dorsal fin. Two different anchor sizes were used according to the size of the individual. Sharks with a length (TL) ranging from 85 to 150 cm, the 36 mm anchors were chosen while for the bigger sharks the 46 mm anchors were used. The dart was attached to the miniPAT with a stainless steel wire. This wire was protected by a shrinking tube. The tag was maintained parallel to the body with a loop spaghetti tag (keeper strap) inserted almost at the rear of the dorsal fin preventing the tag to hurt the animal when swimming. By examining the vertical profile from the miniPAT tags, a mortality was defined when a tagged shark continuously descended beyond 1800 meters, causing the tag to automatically release.

Results

Estimates of immediate mortality rates

Immediate mortality rate related to the location

The immediate mortality rate was linked with the location where the individuals were observed. More sharks were found dead in the lower deck (73%) than in the upper deck (33%). Overall, adding sharks for which the location was unknown, 38% of the sharks caught were alive. More sharks were observed in the lower deck (73%) than in the upper deck (Tables 1 and 2).

Table 1 : Number of alive and dead silky sharks and immediat mortality rate for the individuals sorted in the upper and lower decks.

Status	Location			
	Unknown	Lower deck	Upper deck	Total
Dead	12	62	10	84
Alive	8	23	20	51
Total	20	85	30	135
% Immediat Mortality	60%	73%	33%	62%

Table 2 : Date, tonnage, number of silky sharks dead and alive, mean length (Total length) for each set in two major locations; upper and lower deck and immediat mortality rate per set. (For 20 individuals the location has not been documented).

Date	Set	Tonnage	Location	TL (Mean)	Dead	Alive	Total	% Immediat Mortality
21/3/11	**1**	60	Lower deck	87.3	11		**11**	100 %
24/3/11	**1**	4	Lower deck	91.7	9		**10**	
			Upper deck	80.0		1		90%
25/3/11	**1**	65	Lower deck	88.6	4		**6**	
			Upper deck	98.0	1	1		83%
26/3/11	**1**	3	Lower deck	89.0	1		**2**	
			Upper deck	84.0		1		50%
26/3/11	**2**	15	unk	118.3	6	2	**10**	
			Upper deck	137.0		2		60%
27/3/11	**1**	80	Lower deck	127.0	1		**2**	0%
			Upper deck	108.0	1			
27/3/11	**2**	5	Lower deck	92.1	3	4	**7**	43%
28/3/11	**2**	12	Lower deck	86.0		1	**14**	
			unk	85.1	6	6		
			Upper deck	140.0		1		43%
29/3/11	**1**	6	Lower deck	98.0		2	**3**	
			Upper deck	75.0		1		0%
30/3/11	**1**	55	Lower deck	85.9	12		**15**	
			Upper deck	94.0	3			0%
31/3/11	**1**	21	Lower deck	87.5	2		**5**	
			Upper deck	87.8	2	1		80%
31/3/11	**2**	10	Lower deck	94.0	2	2	**4**	50%
1/4/11	**1**	42	Lower deck	95.0	3	2	**7**	
			Upper deck	80.0	1	1		57%
1/4/11	**2**	6	Lower deck	83.3		3	**5**	
			Upper deck	92.5		2		0%
2/4/11	**1**	125	Lower deck	98.2	3	1	**8**	
			Upper deck	137.3	2	2		62,5%
24/5/11	**1**	6	Lower deck	72.0		3	**3**	0%
25/5/11	**1**	6	Lower deck	95.8	9	5	**18**	
			Upper deck	90.3		4		50%
25/5/11	**2**	0	Upper deck	150.0		2	**2**	0%
27/5/11	**1**	0	Upper deck	235.0		1	**1**	0%
			unknown	95			**20**	
			lower deck	90.9			**83**	
			upper deck	108.4			**30***	

–*29 individuals measured, 2 sharks found in the fish wells but not sampled were added for the calculation

Immediate mortality rate as a function of the set size

The set sizes (tonnage) were stratified into three classes (Null/Small tonnage: <10 t; Medium tonnage: between 10 and 50 t; Large tonnage > 50 t). The estimations of the immediate mortality rates appeared to increase with the set size (tonnage) (Fig.1).

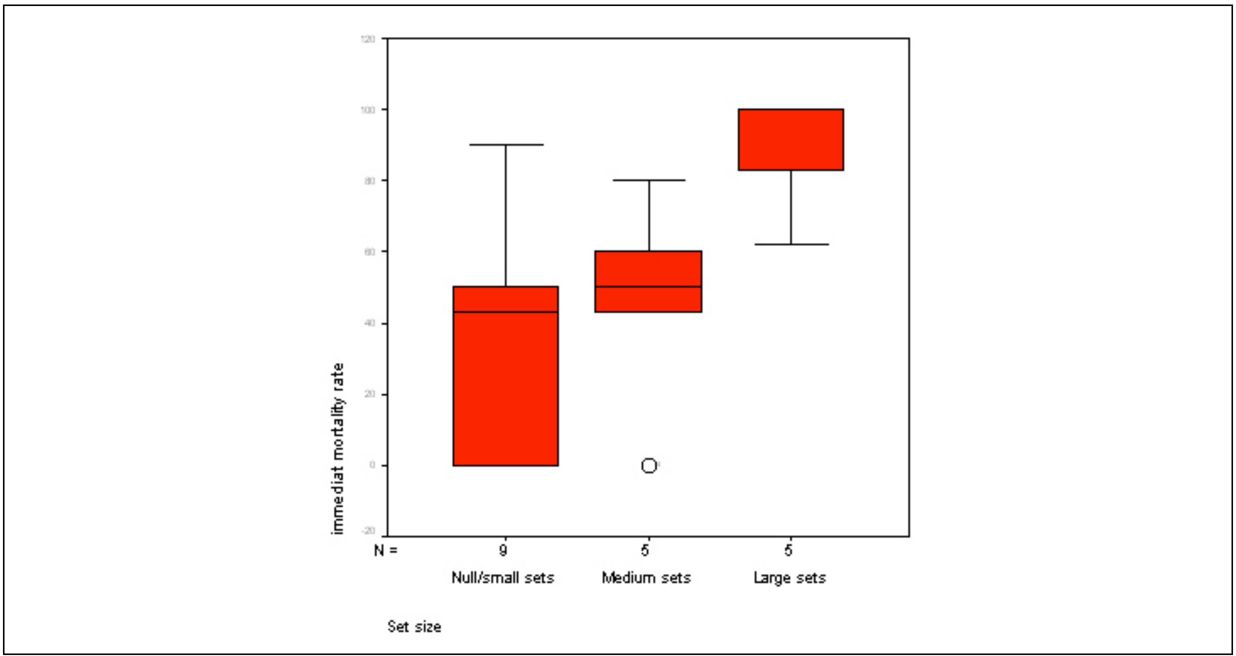

Figure 1 : Average immediate survival rates as a function of set sizes (Null/Small tonnage: <10 t; Medium tonnage: between 10 and 50 t; Large tonnage > 50 t).

Immediate mortality rate relative to shark size and set size

A total of 135 silky sharks were incidentally caught during both fishing trips but only 132 length measurements could be done, ranging from 50 to 235 cm (total length) (Fig. 2).

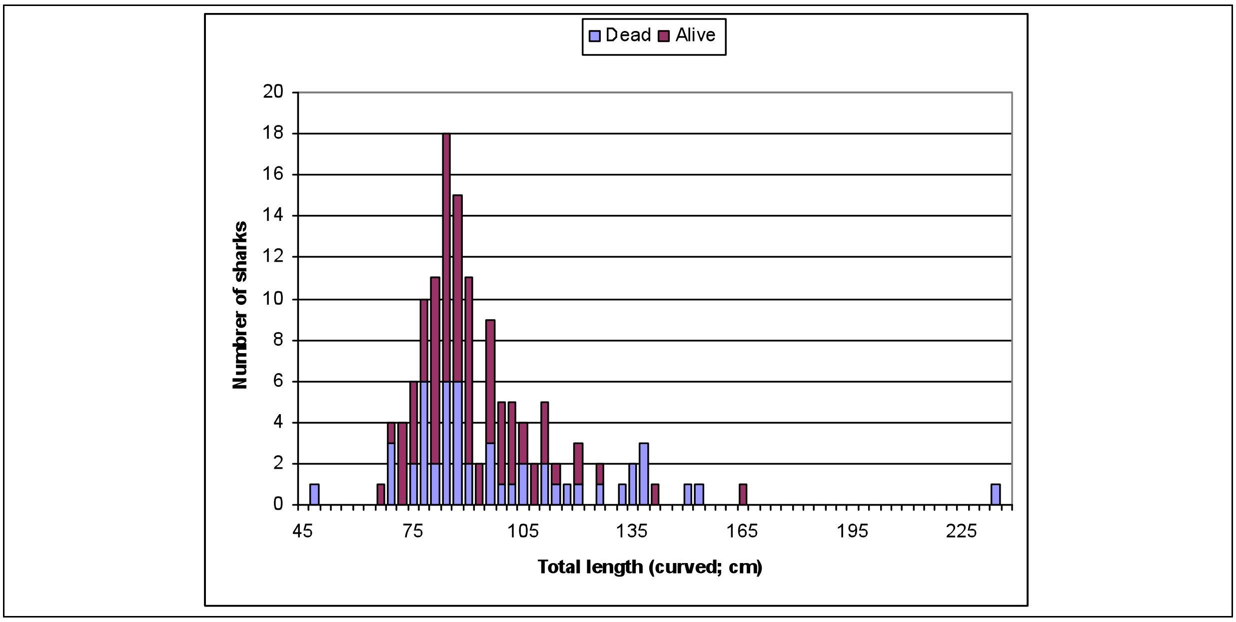

Figure 2 : Size frequency distribution (3-cm classes) of the sharks sampled alive and dead during the study (n=132).

The silky sharks observed on the upper deck were significantly larger than the ones found in the lower deck (t-test, p<0.01); 108.4 cm (SD=37.7) *versus* 90.9 cm (SD=14).

The silky sharks observed alive were significantly larger than the ones found dead (t-test, p=0.032): 100.8 cm (SD=30.8) *versus* 92.0 cm (SD=15.7).
The sharks sizes were stratified into three classes (Small:<=85 cm (TL); Medium: between 86 and 110 cm; Large:>110 cm). The estimations of the immediate mortality rates for each class size appeared to increase with the set size (tonnage) (Table 3). These data suggest that the immediate mortality rate is lower for small or medium sets than for larger ones, but is still high (with the potential exception of large sharks, but the dataset is too small to draw any conclusion).

Table 3: Percentage of individuals in various size classes that were found dead according to different set sizes

	Immediate mortality rates: % (numbers)		
	Null and small sets (<= 10 tons)	Medium sets (>10 tons & <= 50 tons)	Large sets (> 50 tons)
Large sharks (> 110 cm TL)	22% (2)	25% (2)	71% (5)
Medium sharks (> 85 cm and <=110 cm TL)	61% (11)	57% (12)	100% (18)
Small sharks (<= 85 cm TL)	39% (9)	73% (8)	88% (15)

Estimates of post release survival rates

In total, 20 silky sharks (125.3 ± 33.8 cm total length) were tagged with MiniPATs (Wildlife Computers, Redmond, WA, USA) to study their survival after release. Six silky sharks and the mako shark died immediately after release. The time depth profile from a miniPAT attached on these individuals shows that the animal sank down to 1800 meters. At this depth the guillotine was activated and the tag released. Three sharks showed delayed mortality after 2.5 days (Fig. 3), 14 and 15 days (Fig. 6) and 9 tags showed that sharks survived.

Figure 3 : Typical temperature (upper graph) and depth (middle graph) and dawn dusk ((lower graph) profiles from a miniPAT on a silky shark which died 2.5 days after release.

Of the 3 tags deployed in this study, two did not report their data to the satellite while one reported partial and incorrect data due to misuse of the tag before deployment.

Discussion

Large sets result in the highest mortality across all size classes of sharks. However, this seems to be most apparent for the largest size class (although the dataset on large sharks is too small for any conclusion), as the mortality of small and medium sharks is always high irrespective of the set size. The primary factor affecting immediate mortality appears to be the location of the individuals, not the size of sharks. Larger sharks are easily identified on the upper deck and can be released quickly, while smaller sharks typically go unoticed and end up in the lower deck.
The tagging allowed to assess the survival of releases sharks. The delayed mortalities after 14 and 15 days can be questionable as this was a long time after tagging, and it is difficult to determine if these mortalities were due to the fishing event. In total, we estimated that 38% of the sharks caught were alive and our tagging experiment shows that 50% of the released sharks survived. This leads to the conclusion that approximately 19% of all sharks caught could survive the fishing operation.

These results help determine the priorities to significantly reduce fishery induced mortalities of sharks in the future:

- find methods to release sharks prior to setting, or prior to hauling, as many sharks observed on the deck were dead
- facilitate the release of sharks from the upper deck (as sharks in the lower deck have very low chance of survival), and provide a guide for best practices (i) to avoid injuries to the crew when handling sharks and (ii) to optimize the survival of sharks.

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