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Comparison of bycatch species captured during daytime and nightime: preliminarily results of longline experiments carried out in Seychelles waters

Caroline Gamblin[1,2], Bach Pascal[3], Vincent Lucas[1]

[1]SFA Box 449 Victoria, Mahe, Seychelles
[2]SCAC Ambassade de France aux Seychelles La Ciotat Building BP478, Mahe, Seychelles
[3]IRD UR 109 Station Ifremer BP60 97420 Le Port-Ile de la Reunion

Abstract

Bycatch and mitigation measures are a keystone issue to assure a sustainable use of marine resources. Many studies focus on gear configuration and not on fishing strategy when fish habitat is a major question in term of gear selectivity. The objective of this study is to compare bycatch that occurred during night sets and day sets.

For that purpose, 69 fishing experiments using an instrumented longline (hook timer, temperature depth recorder) were carried out in Seychelles waters from December 2004 to May 2006 on board small scale research longliner. Two types of sets were done: some during night (setting at dusk and hauling at dawn) with shallow basket to principally target swordfish and some during day (inverse cycle of night set) with shallow and deep basket to target tuna. Each time, bycatch species were identified (species, basket and hook number) and the depth of capture calculated.

Results show difference between the two strategies in terms of species composition, quantity, and depth of catch. Day sets induce more bycatch than night sets.

Introduction

Bycatch is actually one of the most discussed issues in terms of sustainable and responsible use of marine resources (Dobrzynski et al., 2003; Kelleher, 2005; Hall and Manprize, 2005). In this context, longline fishing is often considered as a non-selective gear in terms of both species and size (Bjordal and Løkkeborg, 1996; Marin et al., 1998; Kelleher, 2005). Pelagic longline targets mainly swordfish and tuna species but also catches other bycatch species that may or may not be marketable. Thus, the longline bycatch issue does not concerns only emblematic species like sea turtles, sea birds and sharks (Hall et al., 2000) but also other species like sailfish, marlins, pomfrets and lancetfish. Studies dealing with mitigation measures to limit discard focus principally on gear configuration (hooks design for example (Read, 2007)) and scarcely on fishing practices by themselves (soak time, depth and time of capture) (Valdermarsen and Suuronen, 2003; Werner et al., 2006). Furthermore experiments in pelagic areas are expensive and time consuming (Lewison et al., 2004; Hall and Mainprize, 2005; Kelleher, 2005) so data are scarce. However some studies considered the depth of capture or time of setting (Beverly et al., 2004). Bach et al., in press, looked at the effect of bait types on the hooking response and species selectivity of longline gear.

Generally, longliners that target swordfish deploy their hooks close to the surface (25 to 100m) (Ward and Elscott, 2000) at dusk and retrieve them at dawn. The opposite cycle is used to target tuna (setting a few hours before dawn and hauling at the beginning of the afternoon) and the line is generally set deeper (Ward & Hindmarsh in prep).

This study is a preliminary analysis of data collected during monitored longline fishing experiments carried out in Seychelles. Our objective is to compare bycatch which occurred during night sets and daytime sets. Results are compared in terms of species and number. The depth of capture of each bycatch species is also estimated. Special emphasis is placed on sharks and commercial non-targeted species.

Materials and Methods

Data analysed in this study were collected as part of the CAPPES project (Gamblin et al., 2006). The prospected fishing area is commonly exploited by small scale Seychellois longliners targeting swordfish, the principal species landed by the domestic longline fishermen (Lucas et al., 2006) and more recently tuna (mainly yellowfin (*Thunnus albacares*) and bigeye (*Thunnus obesus*)).

Description of the monitored longline

11 trips that contain 69 sets were conducted in the Seychelles waters around the Plateau of Mahe (Figure 1) from December 2004 to May 2006 using an instrumented monofilament longline. Trips were realised with small scale longliners (the R/V L'Amitie of the Seychelles Fishing Authority (SFA) and two professional boats (M/V Pisces and Albacore)) with an average of 400 hooks per set. Given the limit size and storage capacity of the fishing vessels used (23m max length) trips did not exceed 10 days and took place in a 150 miles radius around Mahe Island (Wendling and Lucas, 2003).

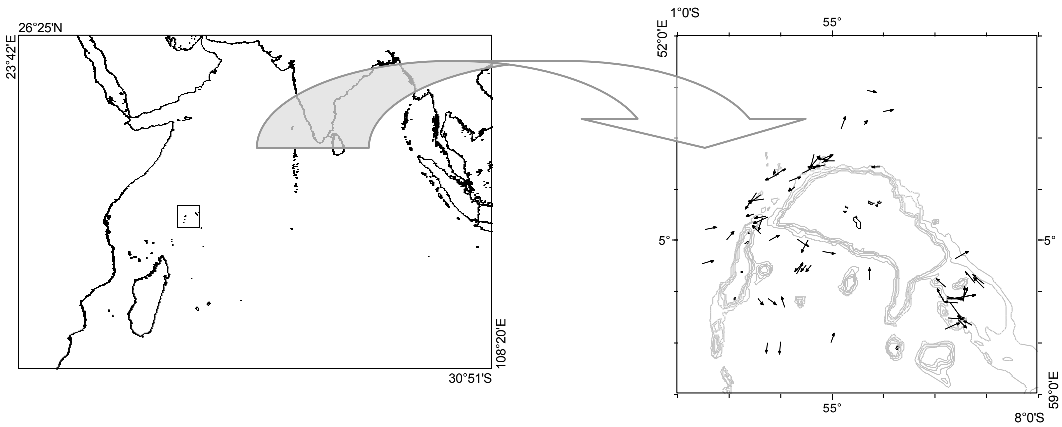


Figure 1: Spatial distribution of the 69 sets conducted during the CAPPES Project

To monitor the behaviour of the line and then to know the depth of the line and the time and temperature of capture, two main instruments were deployed. Most branchlines were equipped with a hook timer (model produced by Lindgren Pitman Ltd) placed above the hook (Somerton et al., 1988; Boggs, 1992). It gives the time elapsed in minutes between the attack of the bait and its recovery on board. Temperature-Depth-Recorders (TDR, model Minilog12-TX from Vemco) were used to assess the depth attained by the line and the corresponding temperature. They were placed in the middle of the basket, which generally corresponds to the point that will reach the maximum depth (Mizuno et al. 1997).

Fishing strategy and experimental design

A line shooter was mainly used to control the sinking rate (shape) of the line and in the case of day setting, to be able to reach deeper layers. Otherwise the line was set taut, as it is traditionally done by the local fishermen to target swordfish in the surface layer during the night.

Table 1 summarizes the main characteristics of the two types of set. Considering day set, setting begins on average two hours before sunrise and hauling starts at the beginning of the afternoon. The line was generally constituted of two parts: one with shallow baskets and one with deep baskets. On average 15 hooks were deployed per basket (minimum 8 and maximum 30). Night setting begins around 8pm and hauling early morning. Only shallow basket was build with an average of 9 hooks per basket.

The effort deployed during the two types of sets can be considered as similar.

Table 1: Characteristics of the sets done during the project (DB= distance between floats, LLBF=mainline length between floats)

	Day set	Night Set
Set start time	4:49	20:24
Set duration	2:06	2:21
Soaking time	6:05	8:29
Hauling start time	13:02	7:57
Hauling duration	3:51	3:39
Number total of hooks	14657	14792
Shooter speed	7.14	6.81
Vessel speed	6.57	6.26
DB	800	553
LLBF	923	852
Average number of hooks/basket	14	9

Each species caught was identified and measured. Time of capture was calculated when hook timers were present. Bycatch was composed mainly of lancetfish (*Alepisaurus ferox*) and we considered that they are underestimated considering that the crew did not always inform the scientist on board when each time one was on the line.

<u>Discard rate</u>

An overall discard rate was calculated for all the trips and then considered for daytime and nighttime set. This rate refers to the weight of discards and is the summed discard as a percentage of summed landing plus summed discards.

$$discardrate(\%) = \frac{summeddiscard * 100}{summeddiscard + summedlanding} \quad (1)$$

<u>Nominal catch rate (CPUE: number of fish per 1000 hooks)</u>

Nominal catch rates (fish per 1000 hooks) were calculated for each bycatch species, then comparing daytime sets and nighttime sets. The different species of sharks are considered in details.

<u>Determination of the depth of capture</u>

The depth of capture of each species was estimated using the TDR data (when they were available) or using the catenary geometry formula (Yoshihara, 1951, 1954; Suzuki et al., 1977):

$$D_j = LF + LB + (LLBF/2) * (1 + \cot^2 \varphi)^2 - (1 - (2j/N))^2 + \cot^2 \varphi^{1/2} \quad (2)$$

where D_j is the depth of the j^{th} hook, LF the length of the floatline, LB the length of the branchline, LLBF the length of the mainline between two consecutive floats (basket), N the number of hooks per basket + 1, j the j^{th} hook from the mainline, φ the angle between the horizontal and the tangential line of the mainline.

In this case the shape of the line is estimated using the sagging rate (SR) defined as the ratio between the horizontal distance between floats (DBF) and LLBF. Yoshirara (1954) proposed a formula to calculate SR:

$$SR = DBF / LLBF = (\cot \varphi) * \ln (\tan(45^o + \varphi / 20)) \quad (3)$$

Regarding TDR data, the maximum depth of a basket not equipped with a TDR was estimated as the average of the value obtained with the TDRs attached on basket before and after.

Results

<u>Discard rate</u>

For all the trips the discard rate was 33,0%. The discard rate for daytime sets was 50,8% and it decreases to 20,8% for nighttime sets.

<u>Species composition</u>

Thirteen bycatch species were caught in all (Table 2A), of which only three were marketable: sailfish (*Istiophorus platypterus*), skipjack (*Katsuwonus pelamis*) and marlin (blue marlin (*Makaira mazara*) and black marlin (*Makaira indica*). Dolphinfish (*Coryphaena hippurus*) unlike in Pacific is not considered as a marketable species in Seychelles. The majority of the species (marketable or non marketable) were caught during day sets (75% of the total). Some species were found mainly during nightime sets like skipjack (*Katsuwonus pelamis*), oilfish (*Ruvettus pretiosus*) and ocean sunfish (*Mola mola*) and some preferentially during dayset like oarfish (*Regalecus glesne*) or pomfret (*Brama* sp.). During daytime sets the lancetfish wss the main bycatch species caught and during nighttime the main species was sharks. 13 species of sharks (Table 2 B) were captured with two main species: blue shark (*Prionace glauca)* and silky sharks (*Carcharrhinus falciformis*).

Table 2 :Composition of bycatch and of sharks caught during the project

Scientific Name	Other Name	Total	Day	Night
Istiophorus platypterus	Sailfish	132	108	24
Katsuwonus pelamis	Skipjack	28	1	27
Makaira sp.	Marlin	15	4	11
Acanthocybium solandri	Wahoo	16	12	4
Alepisaurus ferox	Lancetfish	333	325	8
Brama sp.	Pomfret	10	8	2
Coryphaena hippurus	Dolphinfish	70	50	20
Dasyatis violacea	Blue stingray	27	19	8
Regalecus glesne	Oarfish	3	3	
Mola mola	Ocean sunfish	3		3
Ruvettus pretiosus	Oilfish	15	1	14
Sphyraena barracuda	Great Barracuda	26	23	3
	Shark	106	34	72
	Total	784	588	196
	Marketable bycatch	175	113	62
	Non marketable	609	475	134

A

Scientific Name	Other Name	Total	Day	Night
Prionace glauca	Blue shark	31	8	23
Carcharhinus melanopterus	Blacktip reef shark	1	1	
Alopias superciliosus	Bigeye thresher shark	2		2
Alopias vulpine	Common thresher shark			1
Carcharhinus falciformis	Silky shark	54	19	35
Sphyrna mokarran	Great hammerhead	1		1
Carcharhinus limbatus	Blacktip shark	1		1
Isurus paucus	Longfin mako	1	1	
Isurus oxyrinchus	Shortfin mako	2	1	1
Carcharhinus longimanus	Oceanic whitetip	9	3	6
Alopias pelagicus	Pelagic thresher	1	1	
Sphyrna lewini	Scalloped hammerhead	1		1
Galeocerdo cuvier	Tiger shark	2		2
	Total	106	34	73

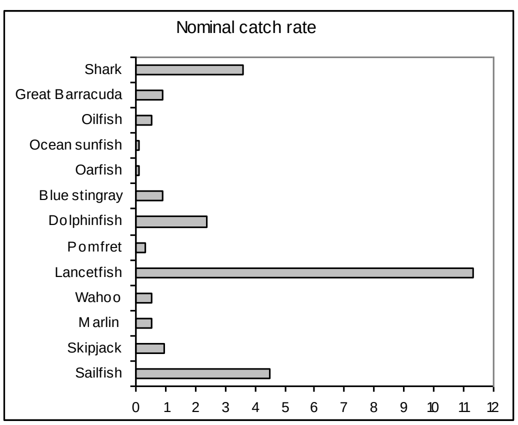
B

For the nominal catch (fish per 1000 hooks), values range from less than one (ocean sunfish, oarfish, pomfret…) to almost twelve for lancetfish (Table 3 A). The nominal catch for sailfish and sharks were around 4 fishes per 1000 hooks. Considering daytime and nighttime sets (Table 3 B), the range of values during daytime is wider than for nighttime with a nominal catch of 22 for lancetfish during daytime. Sharks nominal catch was the most important at night with 8 fish per 1000 hooks.

Considering the different species of sharks (Table 3 C), the majority of species have a nominal catch inferior to one fish per 1000 hooks except the blue sharks with 2 fish per 1000 hooks and the silky sharks with almost 4.

Table 3: Overall Nominal catch rate (fish per 1000 hooks), during day and night sets and considering all the species of sharks caught

A



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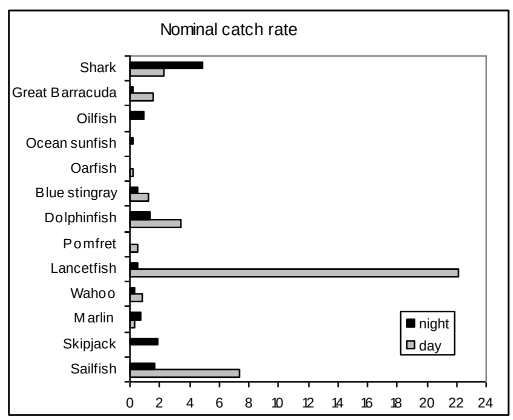

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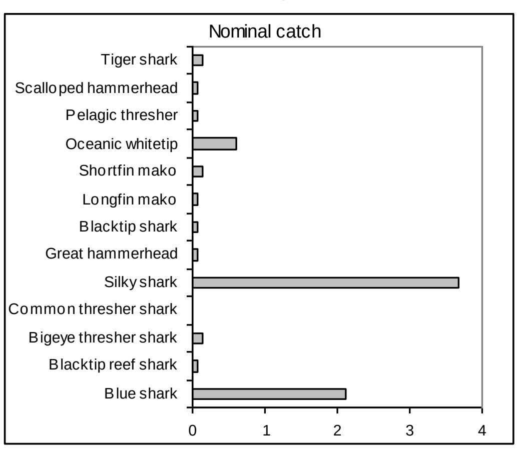


Depth of capture

For each bycatch species the depth of capture was determined. Species were represented in three groups: i. marketable species ii. sharks and iii. discard species.

- Marketable species (Figure 2)

All the marketable species were caught in the 150 m layer during both day and night sets. Marlins were never caught below 100m.

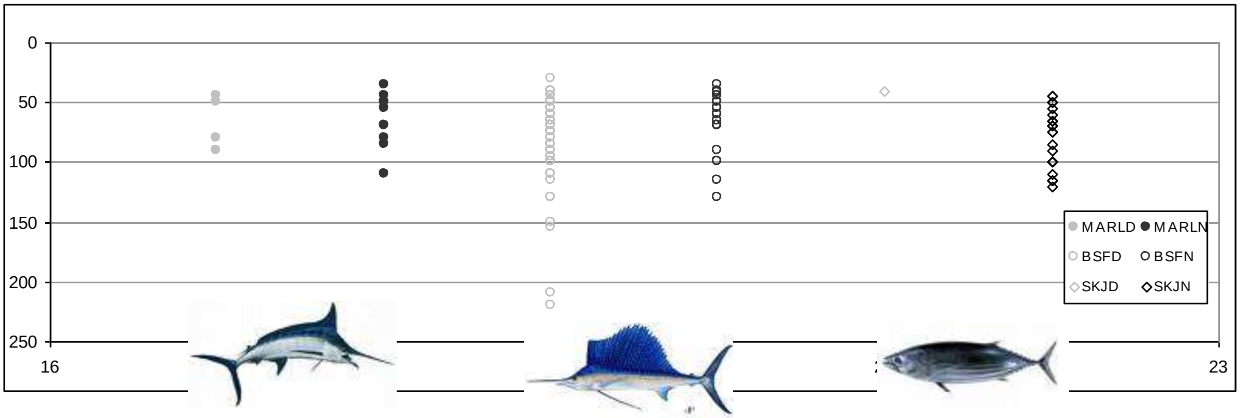
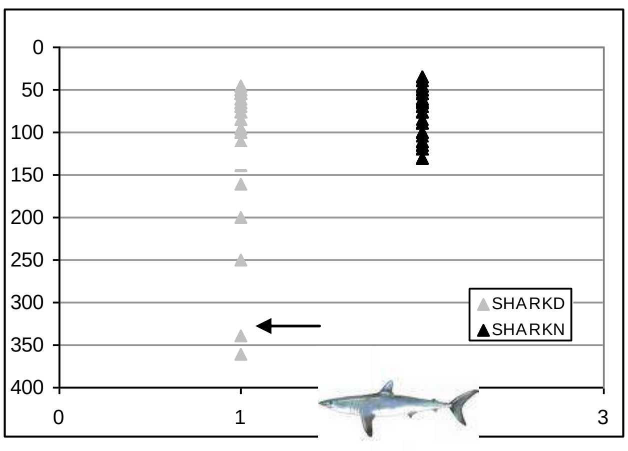


Figure 2: Vertical distribution of the three marketable but non targeted species: marlins, sailfish and skipjack

- Sharks (Figure 3)

Most of the sharks were caught below 150 m depth during night as well as during the day. However sharks caught in deeper layer were exclusively observed during daytime. The black arrow represents a blue shark caught at a depth of 340 m and at a temperature of 10^{o}C.

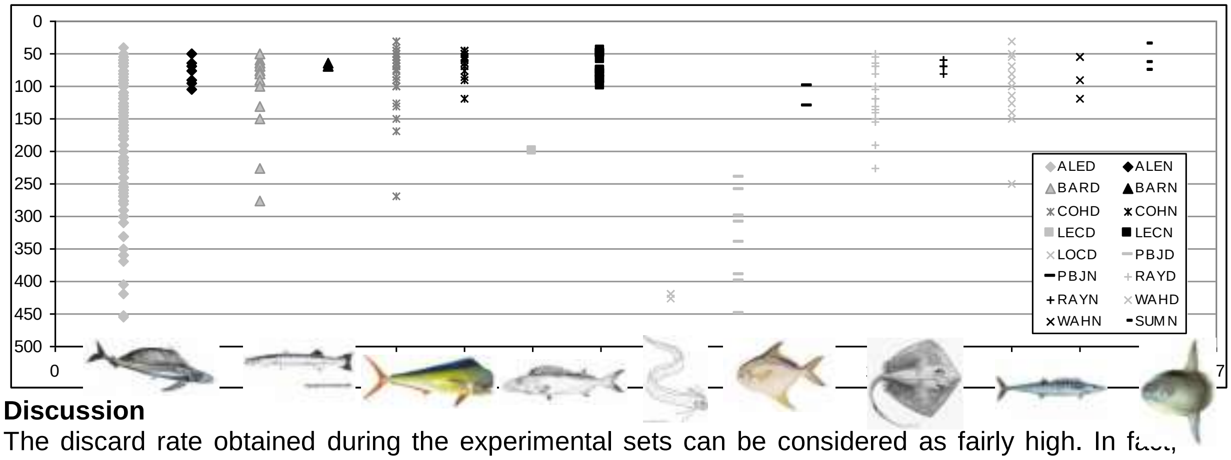
Figure 3: Vertical distribution of sharks



- Other non marketable species (Figure 4)

During night sets all species were caught at a depth less than 150m. During day sets, the maximum of the bycatch was found in the 200m layer. However, some species were only found in deep layers like the oarfish (*Regalecus glesne*) and the pomfret (*Brama spp.)*. The lancetfish (*Alepisaurus ferox*) was recorded mainly during daytime and at depths ranging from 50m to 500m.

Figure 4: Vertical habitat of the discard species



Discussion

The discard rate obtained during the experimental sets can be considered as fairly high. In fact, according to Kelleher (2005), the mean discard rate in the longline fishery is 28,5% with a standard range of 0 to 40%. Furthermore, on one hand large scale vessels are considered to catch greater number of bycatch and commonly have a discard rate of 30 to 40 percent. On the other hand, smaller locally base longline vessels are supposed to have a lower rate of about 15% (SPC). Our high result can be explained by the fact that it has been obtained during scientific operations where all the bycatch are reported. Furthermore, dolphinfish is scarcely considered as in Seychelles like a discard.

The species composition bycatch is in accordance with what is commonly found in the longline fishery. Because the majority of the hooks are in the upper mixed layer, there may be interactions with sensitive surface species like sharks (Baum et al., 2003) and turtles but also with marlin sailfish or dolphinfish that are scarcely considered by scientist and so not well documented. For the swordfish fishery (night shallow sets), sharks are the principal discards (majority *Carcharhimus falciformis* (Silky shark) and *Prionace glauca* (Blue shark) (Kiyota et al., 2003; Kelleher, 2005). Nominal catch rate of these species is very high in comparison with what is found in the Pacific (1.6 for the blue shark and 0.8 for the silky shark respectively) according to Williams (1997). It raises the worrying issue of the impact of longline on the sustainability of these sharks populations and the absolute necessity of the implementation of the plan of action (Lucas and Gamblin, 2006). For the daytime sets lancetfish is the major discard. The nominal catch of sailfish and dolphinfish were relatively high too. Because these species are generally landed few consideration is given to them. Nevertheless the impact of fishing activities on these large pelagic species should not be underestimated considering that most abundant predators, such as sharks, tuna and billfish suffered a declines of abundance (Baum et al., 2003; Myers and Worm, 2003) and that ecosystem models are not able today to accurately predict the consequences of variations in predator abundance (Ward and Myers, 2005)

The composition of pelagic species in longline catches are significantly influenced by the fishing depth (Løkkeborg and Bjordal, 1992). Hence the depth at which species are captured is fundamental to understanding the impacts of longline fisheries on target and bycatch species (Bigelow et al., 2006). In the project, considering both day and night sets and all species combined, maximum of capture occurred in the 200m layer. The greater the fishing depth the smaller is the proportion of bycatch species. Some experiments have been carried out to introduce deeper baskets and avoid the conflict and interaction with other surface fisheries and to reduce bycatch of surface bycatch species (Beverly et al., 2004). However there is no proof that this technique really reduces bycatch and furthermore it is not evident that it assures cost effective yield for the targeted species. Actually maximum yield for all commercial species combined often occurs in the upper 100m of the water column even for deep depth day sets (Chavance, 2005). Thus avoid bycatch by targeting deeper layers may not be commercially viable.

To conclude, daytime set with some baskets targeting deeper layers seems not to be an effective solution to reduce both bycatch and discard. On the contrary in these experimental fishing trips it involves higher catches in terms of both number of species and quantity.

Further longlining experiments are clearly needed in a bycatch mitigation studies as bycatch, is considered nowadays as a major adverse impact of fishery (Kaiser and de Groot, 2000), and is a keystone issue of new perspectives in fisheries management (Sainsbury and Sumaila, 2001; Sissenwine and Mace, 2003; Parson, 2005).

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