Fate of the fish caught on longline gears and potential mitigation measures

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Abstract:

This document summarises some major results obtained during experiments conducted in collaboration with the Reunion Island (France) (20°-22°N and 53°-57°N) fishing industry. These studies may aid fishermen in modifying fishing operations and selecting a fishing strategy to increase economic benefits and also to reduce the impact on bycatch mortality. Firstly, we investigated the behaviour of the fishes when caught on the longline gear and the survivorship of fish hooked, using longline gears instrumented with hook time recorders (HT) and temperature depth recorders (TDR). We showed that the percentages of fish recovered alive at hauling varied among species. The percentages of fish recovered alive up to 8 h after capture provides a rough idea of the resistance of each species to the capture process; these rates were recorded for the blue shark (Prionace glauca), the oceanic whitetip shark (Carcharhinus longimanus) and for the bigeye tuna (Thunnus obesus) and were respectively 29%, 23 % and 27% while this rate was lower for the swordfish (8%). Moreover, we demonstrated that shortening the soaking time during the fishing operation could be beneficial in many ways for fishermen. A second study on the reproduction dynamic of the swordfish in the vicinity of Reunion Island showed that the Big Old Fat Fecund Female Fish (BOFFFF) hypothesis could effectively apply to this species. Consequently, the removal of the larger, older individuals could be detrimental for the stock and the current results may be used, in the future, to support new policies preserving population age structure. One management method available to conserve older fish would be to institute slot size limits for retention (minimum and maximum size) but this potential measure to be successful need the individuals to survive their release back to the water. The last study aimed at investigating the possibility of developing a method to reduce the stress of the fishes caught with hooks. Prototypes of "sleeping hook" were developed and tested, using rod and reel, around moored fish aggregating devices (FAD's). During the fishing experiments a total of 162 fish comprising 3 main species were caught including: yellowfin tuna (Thunnus albacares), skipjack tuna (Katsuwonus pelamis) and dolphinfish (Coryphaena hippurus). Analyses of blood chemistry stress indicators revealed the "sleeping hook" method to be successful in reducing the fish stress. Additional research should be conducted to evaluate the feasibility of reducing the soaking period in the current fishing strategy. However, the "sleeping hook" could contribute to the development of alternative fishing technology enabling also to reduce the side effect of protracted soaking times e.g. by reducing post hooking mortality and increasing the post release survivorship of species of conservation concern and unwanted sized target species.

Introduction

In the last decade, the bycatch and its management have become an important issue in the global fisheries management and the search for solutions to bycatch problems has intensified. There has been a growing evidence of the negative impact on commercial longline fisheries of catching unwanted species of conservation concern (Bonfil, 1994; Buencuerpo, et al., 1998; Campana, et al., 2005; Francis, et al., 2001; Lewison and Crowder, 2007; Petersen, et al., 2009; Pinedo and Polacheck, 2004).
This document presents briefly the major results obtained during experiments conducted in collaboration with the Reunion Island (France) (20°-22°N and 53°-57°N) fishing industry (PPR[1] project) while studying behaviour of fish hooked on longline, the reproduction dynamics of swordfish (*Xiphias gladius*) and the stress response of large pelagic fish resulting from the hooking capture process. These studies may aid fishermen in modifying fishing operations and selecting a fishing strategy to increase economic benefits and also to reduce the impact on bycatch mortality. These results led me to formulate general recommendations regarding future research directions.

Objectives of the studies

Behaviour and survivorship of the fish hooked on longline gears

The first study aimed at investigating the effect of operational factors on the catch rates, estimating fish capture time and monitoring the behaviour of the fish caught. To collect the accurate data, portions of the commercial longlines were instrumented with hook timers (HT) and time-depth recorders (TDR) attached in the middle position between two consecutive floats. (Poisson, et al., Manuscript submitted for publication-a).

Reproductive traits of the swordfish

The objectives of the study were to identify the reproductive traits of the swordfish of the southwest Indian Ocean stock and propose management and conservation measures to ensure long-term sustainable yield (Poisson and Fauvel, 2009a; b).

Stress response of large pelagic to the hooking capture process

The last study aimed at investigating the possibility of developing a method to reduce the stress of the fishes caught on hooks. Prototypes of "sleeping hooks" were designed and tested during fishing trips around FADs anchored on the west coast of Reunion Island (Poisson, et al., Manuscript submitted for publication-b).

Results

Soaking time and mortality

Hook timers provided information concerning the capture process. The number of commercial species caught (swordfish and tunas: *Thunnus albacares*, *Thunnus obesus*, *Thunnus alalunga*) declined with time (Fig. 1A). There was an opposite trend for the six bycatch species, blue

[1] The "Programme Palangre Réunion" (PPR) project was an IFREMER programme financed by the European Union (FEDER), Conseil Régional and Conseil Général de La Réunion.

marlin (*Makaira mazara*) and dolphin fish (*Coryphaena hippurus*) that were usually caught after the longline had soaked for 8 hrs or longer (Fig. 1B). Pelagic stingrays (*Dasyatis violacea*), in particular, were caught upon longline retrieval. We found that 60% to 80% of swordfish were caught after the initial fourth and the sixth hours of the fishing operation.

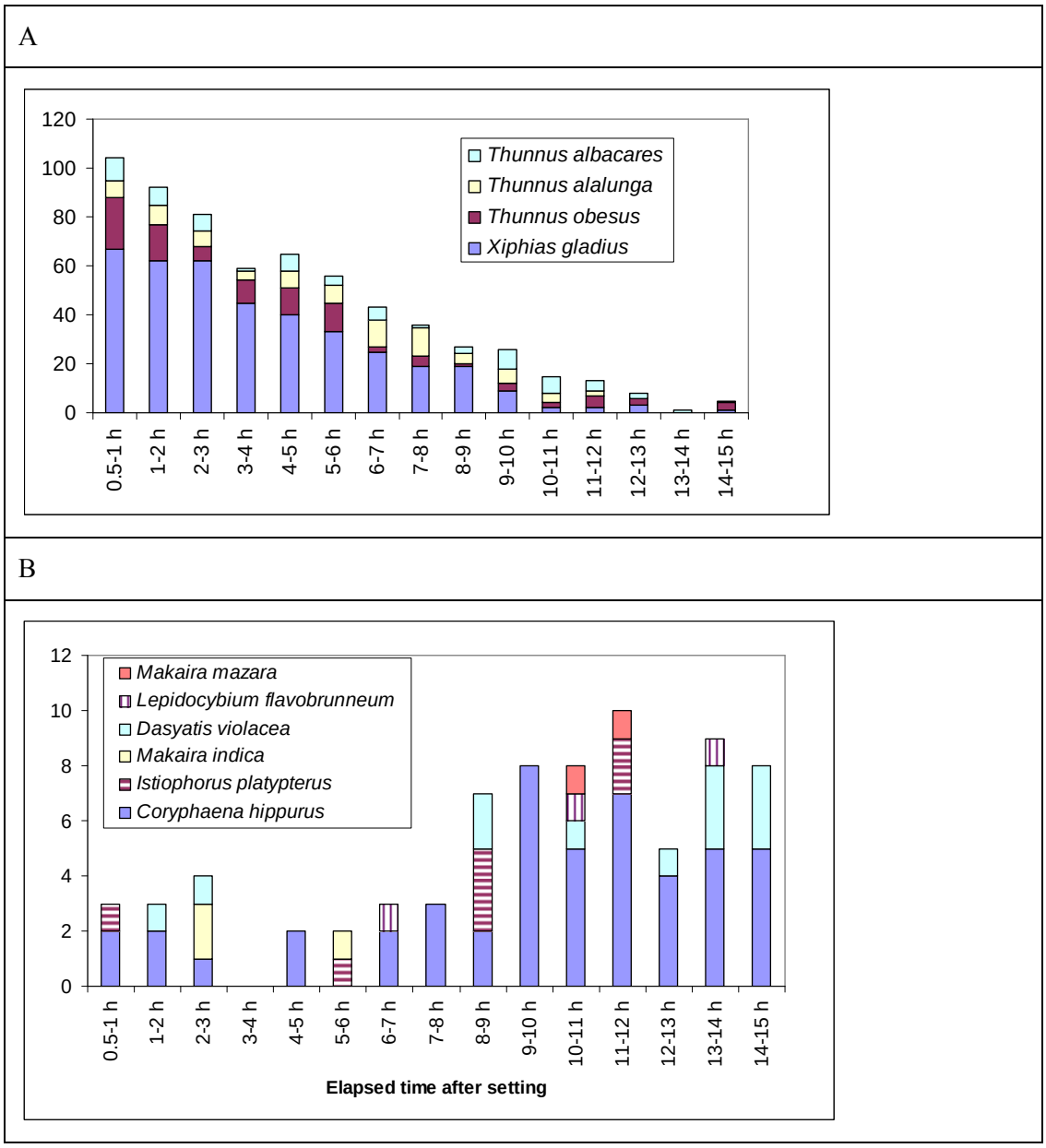

Figure 1: Hook-timer data for 12 species and three broader species groups caught on instrumented longlines off Reunion Island (20°-22°N and 53°-57°E). Height of each bar represents the sum of frequencies for the main commercial species (A) and for billfish and other bycatch (B).

The percentages of fish alive when the longline was retrieved to the vessel varied widely among species. Survival was high for the species such as dolphinfish and marlins which strike the line mainly during the last phase of the fishing operation. Nevertheless, over 40% of the main elasmobranch species (blue shark, oceanic whitetip shark and pelagic stingray) as well as the sailfish were alive upon retrieval. The percentage of 20% for swordfish could be considered low, moreover we did not found any relationship between the length of the individuals and the maximum survival time after hooking. The percentages of fish recovered

alive up to 8 h after capture provides a rough idea of the resistance of each species to the capture process. The higher rates were recorded for the blue shark, the oceanic whitetip shark and for the bigeye tuna were respectively 29%, 23 % and 27% while this rate was lower for the swordfish (8%) (Table 1).

Table 1: Number of fish caught per species (N), number of fish alive at hauling (n), range of size per species (Lower jaw fork length- LJFL for swordfish and fork length-FL for other species in cm), survival time maximum per species, percentages of individuals alive at hauling and after 8 hours of the hooking.

Common name	Species	N	n	Length(cm)	Survival time max (hours)	Alive at hauling(%)	Alive after 8 hours(%)
Swordfish	*Xiphias gladius*	389	76	93-242	14	19.5	8.4
Bigeye tuna	*Thunnus obesus*	86	42	65-160	14	48.8	26.7
Albacore tuna	*Thunnus alalunga*	79	3	105-113	8	3.8	1.2
Yellowfin tuna	*Thunnus albacares*	66	23	99-150	14	34.8	13.6
Dolphinfish	*Coryphaena hippurus*	48	32	83-120	14	66.7	8.3
Oceanic whitetip	*Carcharhinus longimanus*	17	7	120-151	14	41.1	23.5
Blue shark	*Prionace glauca*	92	45	150-240	14	48.9	29.3
Sailfish	*Istiophorus platyterus*	7	3	?-163	4	42.8	-
Black marlin	*Makaira indica*	3	3	238-240	2	100	-
Blue marlin	*Makaira mazara*	2	0	-	-	0	-
Pelagic stingray	*Dasyatis violacea*	12	5	-	2	41.2	-

Maternal effect (swordfish) into consideration

Our results outlined the important role of the older/larger in the reproductive capacity of the population and as a consequence, the swordfish population could be negatively affected if the new hypotheses on maternal effects would apply to the species (according to the Big Old Fat Fecund Female Fish (BOFFFF) hypothesis (Berkeley, et al., 2004; Conover and Munch, 2002)). Consequently, the removal of the larger, older individuals could be detrimental for the stock and the current results may be used, in the future, to support new policies preserving population age structure. There are three main management methods available to conserve older fish in an exploited population:

- Reduce the rate of exploitation significantly,
- Implement marine reserves in which fishing is prohibited and older fish can survive and spawn.
- Institute slot size limits in which there is both a minimum and maximum size for retention (this potential measure to be successful the fishes must be released unharmed after capture to survive their released back to the water);

In general, no-take marine reserves are a hard sell to fishermen and regulations on gear modifications may be more easily accepted by the fishing industry than reductions in fishing effort.

Development of the" sleeping hook"

During the fishing experiments, a total of 162 fish comprising 3 main species were caught including: yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*), and dolphinfish (*Coryphaena hippurus*). Analyses of blood chemistry stress indicators from the

fish were conducted to assess the fish stress relative to struggling behaviour and exposure to air. Our results revealed the "sleeping hook" method to be successful in reducing the fish stress. The levels of cortisol and glucose for yellowfin tuna, and the levels of cortisol and lactate for dolphin fish were significantly lower in sedated fish in comparison with the fish caught without sedation on regular hooks.

Discussion and future research needs

Improving gear selectivity (i.e., reducing threatened species, unwanted size fish, depredation and loss at sea) is considered a high priority in pelagic longline fisheries because of its ecological and economic benefits (Brill, et al., 2009; Gilman, et al., 2008; Mandelman, et al., 2008). These results led to the consideration of several issues:

-We suggested that shortening the soaking time during the fishing operation should be beneficial as it could reduce at the same time (1) the catches of minor commercial species,(2) the depredation rates (3) the fish losses at sea, (4) the hooking and post release mortality and improve the quality of the flesh of the target species.

- Live release of by-caught sharks (Moyes, et al., 2006) and billfish (Kerstetter and Graves, 2006; 2008) is by far the best management measure to reduce longline fishing mortality of these species up to now but it is still insufficient to minimize fishing mortality and the post release survivorship should be assessed carefully.

- A series of options for protecting juvenile swordfish were already considered in some areas (Cramer, 1996; 1997; 2003). Scientists should take into account now the crucial biological characteristic of the female swordfish and take into consideration potential mitigation measures to protect the older/larger individuals.

- The concept of the "sleeping hook" represents an important basis for planning future fish stress-related experiments, shows promise for reducing post hooking mortality of bycatch species, and has the potential to increase retention and reduce damage to target species caught in longline and other fishing operations using hooks. There are now challenges of developing this device on a large scale at a reasonable price that will be easy to implement longliners and other commercial fishing operations. However, we believe that the approach can yield important perspectives possibly leading to the development of alternative fishing technology enabling new management mechanisms that may be more easily accepted by the fishing industry than reductions in fishing effort.

- The last study raised also the issue of "fish welfare[2]", concept already widely studied and promoted in aquaculture (Borski and Hodson, 2003; Ferrante, et al., 2008). Fish farmers use routinely anaesthetic to minimise stress when they handle the fish. Stress of reared fish is well documented (Iversen and Eliassen, 2009; Orban, et al., 2008). A device like the 'sleeping hook' could possibly become necessary if in the future, commercial fisheries are required to consider sentience or animal welfare as discussed in a recent report of experts (Anon, 2009).

Before their implementation, mitigation measures must be tested in close collaboration with the fishing industry and their effect on target species and other species of economical value must be evaluated.

2 Institutional Animal Care and Use Committees ; http://www.iacuc.org/

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