Received: 5 September, 2012

Summary of results on the development of methods to reduce the mortality of silky sharks by purse seiners

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Abstract

A review of the research conducted under the ISSF Bycatch project and the EU funded MADE project for the development of methods to reduce the FAD purse seine fishery-induced mortality of silky sharks is presented. The review comprises non entangling FADs, behavior of silky sharks, attraction of sharks away from FADs, double FAD experiments, attraction of sharks outside the net, and survival of sharks released alive.

Introduction

The main shark species incidentally caught by purse seiners around FADs is the silky shark (*Carcharhinus falciformis*). It is well known that most sharks have life history traits that make them vulnerable to overfishing (Baum et al., 2005, Dulvy et al., 2008). As such, even if the purse seine catch of silky shark is relatively small as compared to the catch levels in longline fisheries (Gilman, 2011), it is important to find methods to reduce any fishery induced mortality of these sharks.

Technical methods to reduce the fishery-induced mortality of any species could be used at four points in the fishing process: before arriving at the FAD, before setting the net, release from the net, and when fish are on the deck.

Here, recent results from two projects that joined forces to find methods to reduce the mortality of silky sharks by purse seiners: the EU funded MADE project and the Bycatch project funded by the International Seafood Sustainability Foundation (ISSF) are reported. This will specifically include the 11-day cruise onboard the MV Dugong (Silhouette Cruise) chartered by ISSF in June 2011 (scientific team: John Filmalter, Fabien Forget, Gregory Berke, and Rhett Bennett) and the recent 39-day cruise onboard the French Purse Seiner Torre Giulia (CFTO), chartered by ISSF in the Western Indian Ocean in April-May 2012 (scientific team: Patrice Dewals, John Filmalter, Fabien Forget).

Before arriving at the FAD

Sharks can get entangled in the netting hanging under the FAD. Franco et al. (2009) identified some criteria for non entangling FADs and proposed various possible designs. Among the proposed designs, it was suggested that if purse seine nets were to be used, they should be rolled and tied into tight sausage-like bundles, a design that has been adopted by French purse seiners in the IO. However, while this design significantly reduces the probability of sharks getting entangled, it does not completely eliminate the risk of entanglement, as some knots can fail causing part of the net to open, as observed on a few FADs by scuba divers during the cruises. While rolling nets to form "sausages" is a good practice to be promoted in a transition period (to be determined), the ideal design of non entangling FADs should not be made of nets and should use non meshed materials (e.g. ropes). ISSF will soon release guidelines for non entangling FADs.

Before setting the net

Natural behavior of sharks and tuna

Sharks and tuna were tagged with acoustic tags and their presence around drifting floating objects were monitored using acoustic receivers. One objective is to observe if there are some periods of the day when tunas are associated with floating objects while sharks are not. Preliminary data analysis show that the temporal patterns of association with floating objects of silky sharks and tunas (skipjack, yellowfin and bigeye tunas) are very similar. It therefore seems unlikely that adjusting fishing time could be a good method to avoid catching sharks.

Double FADs

The objective is to investigate the potential for species (or, possibly, size classes) to naturally segregate when the various species (or sizes) are confronted by the choice of two adjacent aggregating devices: some species might choose only one of the two FADs (with not all species going to the same FAD), whereas some might split between the two FADs.

Prior to the start of the 39-day cruise (Torre Giulia) chartered by ISSF in 2012, five double FADs were deployed. Three of them were visited during the cruise and the full protocol could only be conducted twice. In the summary of results presented below, we consider that a species occupy both FADs when relatively similar abundance is observed on each FAD. A species is considered to select a FAD when most individuals (> 60%) were observed at one FAD.

Experiment 1: Only one species (*Aluterus monoceros*) occupied both FADs, while all other species selected the same FAD: *Elagatis bipinnulata*, *Kyphosus vaigiensis*, *Decapterus macarellus, Abudefduf vaigiensis, Platax teira, Thunnus albacares, Acanthocybium solandri, Shypraena barracuda, Coryphaena hippurus, Seriola riviolana, Canthidermis maculatus, Caranx sexfaciatus*. No silky shark (*Carcharhinus falciformis*) was observed during this first experiment.

Experiment 2:

- 4 species occupied both FADs in more or less equal numbers (*Shypraena barracuda, Acanthocybium solandri, Kyphosus vaigiensis, Lobotes surinamensis*)
- 3 species selected FAD 'A': *Decapterus macarellus, Aluterus monoceros, Thunnus albacares*
- 8 species selected FAD 'B': *Elagatis bipinnulata, Canthidermis maculatus, Seriola riviolana, Coryphaena hippurus, Carcharhinus falciformis, Abudefduf vaigiensis, Urapsis helvola, Aluterus scripta*

As for all UVCs, estimates of tuna (*T. albacares*) abundance are only approximate. A few species showed different behavior between the 2 experiments:

- *Aluterus monoceros* split between the 2 FADs in the first experiment (total abundance 12) while they selected one FAD in the 2nd one (total abundance 3).
- *Shypraena barracuda* selected one FAD in the first experiment (total abundance 2) while they split between the 2 FADs in the second experiment (total abundance 10).
- *Acanthocybium solandri* selected one FAD (total abundance 3) and split in the 2nd experiment (total abundance 3)
- *Kyphosus vaigiensis* selected one FAD in the 1st experiment (total abundance 153) and split in the 2nd experiment (total abundance 80)

These preliminary experiments tend to show that most species seem to select one FAD, and that it is not always the same FAD that gathers all species. For silky sharks in particular, further experiments are recommended.

Attraction of sharks away from FADs

Shark attraction experiments were conducted on 5 different FADs during a 11-day cruise (MV Dugong) chartered by ISSF in June 2011 off the Seychelles. The scientific protocol consisted of (i) assessing the numbers of sharks around the FAD at the start of the experiment (snorkeling), (ii) using a small tender to drift slowly away from the FAD with a bag full of fish chum (bait), (iii) assessing the number of sharks attracted and maximum distance of attraction using underwater GoPro cameras and a handheld GPS. Each experiment was terminated when either the tender reached a distance of 500 m from the FAD or when no more sharks were observed for several minutes.

FAD	Number of sharks at start	Number of sharks attracted	Maximum distance (m)
1	9	3	500
2	2	1	120
3	3	2	80
4	2	1	80
5	2	2	250

Table 1: Details of the 5 experiments to attract sharks away from FADs

This pilot study provided key information (Table 1):

- sharks can be attracted hundreds of meters away from FADs by simply towing a bag of bait away from the FAD
- reactions of sharks varied greatly between the experiments ranging from almost no reaction to attraction up to 500 m. It appears that many factors could be responsible for the success of the attraction: if the FAD was fished a few days before (probably affecting the natural behavior of sharks), the size of the multispecies fish aggregation, feeding motivation, etc. The small dataset does not allow conclusions to be drawn on the respective effects of each parameter.

Release from the net

Following results from the experiment consisting in attracting sharks away from the FADs, showing that sharks are sensitive to two stimuli (the bait and the FAD), it was suggested to combine these two stimuli when sharks are encircled by the purse seine net, to attract them outside the net. Trials were conducted during the Torre Giulia cruise chartered by ISSF in April-May 2012. Table 3 details the observations recorded during each attraction experiment.

Table 3. Detailed observations during the attraction experiments

Trial number	date	Drift attached to FAD inside the net	Slow towing of the FAD inside net	Towing FAD out of the net
1	12/04/12	Set on a log. 3 drifts done inside the net. No chum was used. Some sharks, rainbow runners, triggerfish and decapterus were observed with the sea viewer camera, but estimating numbers was difficult due to	One shark, some rainbow runners and triggerfish were observed to follow the log	The log was then rapidly towed out of the net at the stern once the rings were up and the purse closed. It was not possible to tow the FAD slowly as the speed was necessary to control the movement of the large log. The fish could not

		rough sea conditions causing instability		follow the log
2	03/04/12	Set on the same log as trial 1. Chum was used. A small school of rainbow runners and a shark were observed.	The rainbow runners and the shark followed the log	The log had to be towed rapidly to maintain control. The bow thruster was used to create tension ensuring the corks would sink, there was a strong lateral current at the point where the log was towed through. Observations under the log once out the net showed that only some small rainbow runners had managed to remain with the log as it passed through the gap and current
3	18/04/12	Set on a raft. No chum used. Decapterus and small rainbow runners were observed following the FAD	Decapterus and small rainbow runners were observed following the FAD	FAD removed from net by the bow. Small rainbow runners and decapterus following the FAD out of the net
4	28/04/12	Set on an old raft. Chum was used. A few sharks, a large school of triggerfish and rainbow runners were observed.	Sea was calm so we were able to move very slowly. The aggregation followed the FAD with the chum.	Only a third of the aggregation (triggerfish and rainbow runners) escaped. The sharks did not follow. The other part of the bycatch remained in the net.
5	30/04/12	Set on large fiberglass box. Chum was used. Large school of rainbow runner, triggerfish, sharks and other smaller bycatch species were observed during the 2 drifts with the sea viewer.	The bycatch aggregation, except the sharks, followed the FAD	The FAD was towed out over the cork line. No possibility to escape.
6	03/05/12	Set on a raft. Observation done by divers. Bycatch aggregation (triggerfish, decapterus, dorado, wahoo, rainbow runners and sharks) followed the FAD.	The bycatch aggregation, except the sharks, followed the FAD	The FAD was towed out over the cork line and maintained on the other side of the cork line. The bycatch aggregation stayed close to the net but only for a few minutes.
7	06/05/12	Set on a raft. Observation done by divers.Triggerfish, large school of rainbow runners and decapterus. Sharks were seen at the	Most of the bycatch aggregation followed the FAD, no shark followed.	The FAD was towed out over the cork line. No possibility to escape.

		beginning but were not closely associated to the FAD the entire time.		

Conclusions:

- Passive drifts were more efficient to attract sharks than when the FAD was actively towed (even slowly)
- Fish are scared by the side thrusters or the hull and very few escaped through the gap at the bow

Recommendations:

- To make a window in the middle of the net (the part of the net that is further away from the vessel) and pass the FAD through this window. The window could be 15 m deep. The window could be 15m wide, but then, it would require some active towing of the FAD. The window could also be wider (e.g. 50m), and/or several windows could be used, to favour passive drifts of FADs.

In June 2012, experiments on another escape panel were conducted in the Western Pacific Ocean during another cruise chartered by ISSF onboard the Cape Finisterre (TriMarine). Diving inside the net allowed the scientists to observe a particular area in the net where sharks naturally aggregate. An escape panel was designed and tested during the cruise, see Itano et al. (2012).

When fish are on the deck

Poisson et al. (2011) presented results on the mortality rate of sharks caught by purse seiners and estimated the total survival rate when sharks are released alive.
During the ISSF cruise onboard the Torre Giulia, a total of 18 sets were made, 16 on floating objects and 2 on free schools, with the following results (see Filmalter et al. 2012):

- Numbers of sharks observed dead on the deck: 64 (56 kept onboard + 8 discarded).
- Numbers of sharks released alive: 22 (12 tagged with a miniPAT + 10 tagged with a spaghetti tag)
- Survival of the 12 sharks tagged with a miniPAT: 4 sharks died immediately or less than a week after release.
- Survival of the 10 sharks tagged with a spaghetti tag: 3 were observed sinking immediately after release and were considered dead. The status of the 7 others is not known.

As the status of 7 sharks released alive with spaghetti tags is uncertain, the final mortality rate is comprised between 82% (71 dead sharks) and 91% (78 dead sharks).

A guide for best practices for handling sharks and rays onboard burse seiners has been done (Poisson et al. 2012).

Conclusions

Combining results from Poisson et al. (2011) and Filmalter et al. (2012), it appears that on average, the fishery-induced mortality of silky sharks by purse seiners could be reduced by 10-20% if crews adopt the best practice of releasing all sharks observed alive onboard. This result, however, highlights the need to develop a method to avoid bringing sharks on the deck, as the brailing operation appears to likely be the main factor responsible for the mortality of sharks. The observations made during the ISSF cruise onboard the Torre Giulia led to the suggestion of testing an escape panel through which the FAD would be towed outside the net, slowly, to bring sharks (and other bycatch) outside the net. It is noteworthy that in the Western Pacific Ocean, Itano et al. (2012) tried an escape panel at a different location after observations of the behavior of sharks in the net (Muir et al. 2012). Though not completely successful (i.e. sharks were in front of the panel but did not escape due to lack of motivation), such an escape panel appears to be very promising and further tests should be conducted to determine the stimuli that could motivate sharks to pass through the escape panel. It is very likely that a significant reduction of the fishery-induced mortality of silky sharks by purse seiners could be acheived through a combination of good practices, e.g. releasing sharks through an escape panel in the net and releasing sharks alive from the deck if some are still caught, along with time-area closures as suggested by Amandè et al. (2011).

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