Global comparison of post release survival of silky sharks caught by tropical tuna purse seine vessels

J. Filmalter, M. Hutchinson, F. Poisson, W. Eddy, R. Brill, D. Bernal, D. Itano, J. Muir, A.-L. Vernet, K. Holland, L. Dagorn

Introduction

ISSF, in collaboration with other bycatch mitigation projects, such as the EU MADE project and the ORTHONGEL bycatch project, has undertaken tagging experiments to quantify the fishery impact on silky sharks (*Carcharhinus falciformis*) incidentally captured in the global tropical tuna purse seine fishery. Silky sharks commonly associate with floating objects in the open ocean environment. This phenomenon has been observed throughout the species' cosmopolitan distribution range. Several other pelagic and coastal species also display this behaviour, but its prevalence in three tropical tuna species (skipjack, *Katsuwonus pelamis*, yellowfin, *Thunnus albacares*, and bigeye *T. obesus,* tunas) has led to the commercial exploitation of this behaviour. Industrial purse seine vessels, targeting tropical tunas, deploy and maintain vast arrays of drifting fish aggregating devices (FADs) to augment their catches. These FADs are left to drift freely for months at a time while the aggregated biomass develops. FADs are then revisited and the purse seine net deployed around them, thus capturing the aggregation. As a result of this practice, silky sharks, the majority of which are early juveniles, which also form part of these aggregations, are regularly captured as well. Considering the poor or unknown status of its populations in different oceans (Justel-Rubio and Restrepo, 2015), reducing the fishery-induced mortality of this species is a management priority. The retention of incidentally captured silky sharks is prohibited by some tuna regional fisheries management organisations (RFMOs) such as ICCAT and WCPFC, while their live release is encouraged by others (IOTC and IATTC).

Recently, three independent studies were conducted, in the Indian, Eastern Pacific and Western and Central Pacific Oceans respectively, to investigate the post-release survival rates of silky sharks caught during tuna purse seine operations on FADs. Quantifying the fishery impact on captured silky sharks was an early priority identified by the ISSF bycatch project. Establishing this baseline would allow the identification of the stage of the fishing process where practical mitigation methods would optimise survival and minimise risk for the sharks. This report serves to summarise and compare these results and provide a global overview of post release survival rates of silky sharks in the tuna purse seine fishery using FADs.

Suggested citation:

Filmalter, J., M. Hutchinson, F. Poisson, W. Eddy, R. Brill, D. Bernal, D. Itano, J. Muir, A.-L. Vernet, K. Holland, and L. Dagorn. 2015. Global comparison of post release survival of silky sharks caught by tropical tuna purse seine vessels. ISSF Technical Report 2015-10. International Seafood Sustainability Foundation, Washington, D.C., USA.

Study Summaries

Indian Ocean

Poisson *et al*. (2014a) conducted three cruises on board French-flagged commercial purse seine vessels in the western Indian Ocean between 2011 and 2012. All three of these vessels followed similar pursing and brailing techniques, with the catch being landed into a large metal hopper on the upper deck where it was partially sorted by the crew before it passed to the lower deck for storage. The study examined the fate of 202 of the 221 sharks caught during these cruises, the remaining 19 individuals were either discarded by the crew (n = 18) or caught in sets not made on FADs (n = 1). Captured sharks were classified into two categories according to the manner in which they were landed onboard; 1) entangled in purse seine net during hauling or 2) brailed with the catch. These two categories constituted 5% and 95% of the sharks respectively.

Comparisons of at vessel mortality showed that 18% of the entangled sharks were dead on arrival while 79% of the brailed sharks were dead. The state of brailed sharks appeared to be linked to their location when first observed. Forty percent of sharks on the upper deck were dead while 73% were dead when found on the lower deck.

Of the sharks that showed signs of life, a subsample of 31 individuals (5 entangled, 26 brailed) were tagged with pop-up satellite tags (PSATs, miniPAT, Wildlife Computers, Redmond, WA, USA). These tags were programmed to release from the animal after 100 days, or immediately following a decent beyond 1800m. Alternatively, if the swimming depth did not change for a period of 48-72 hours, the tag would be automatically released. The depth data recorded and transmitted from these tags were used to determine the fate of the sharks following their release. Four tags failed to report (from 1 entangled and 3 brailed sharks) leaving a sample of 27 tags for analysis. All entangled sharks survived after release. Eleven of the 23 brailed sharks (48%) died, seven immediately after release and four between 2.5 and 35 days later.

Considering all sharks assessed during this experiment, 82% of those that were entangled survived while 15% of the sharks that were brailed survived. Overall this led to a total survival rate of 19%. The authors concluded that following the best practices for handling sharks on deck (Poisson *et al.* 2014b) was critical for maximising post release survival.

Western and Central Pacific Ocean

Hutchinson *et al.* (2015) conducted an investigation into the post-release survival of silky sharks caught during purse seine operations in the western and central Pacific Oceans. This work was carried out during an ISSF chartered cruise onboard a U.S. flagged purse seine vessel in May and June 2012. This vessel also used a metal hopper on the upper deck into which the catch was brailed. Here a

large portion of the unwanted species were manually removed and released overboard.

A total of 295 silky sharks were captured in 31 fishing sets. This study investigated the post release survival of a subset of sharks from five different stages of the fishing process. These stages were; 1) pre-set, 2) encircled, 3) entangled, 4) 1st brail, 5) later brails. Three types of PSAT tags were used in this study: MiniPATs, sPATs (Wildlife Computers, Redmond, USA) and X-Tags (Microwave Telemetry). sPATS differed from miniPATs and X-Tags in that they did not transmit archived data but rather provided summary data from the 30 day deployment through which the fate of the shark could be inferred. MiniPATs and X-tags were programmed to release between 100 and 360 days after deployment. Sharks were considered to have survived if the vertical data transmitted by the tag showed no signs of mortality, i.e. the tag did not go beyond 1680 m, within 10 days of release.

Blood chemistry was analysed from 87 individuals, 17 of which were tagged with satellite tags to establish biochemical stress indices that correlate with mortality for this species. Lactate concentrations in the blood were measured in the field using a portable automated blood chemical analyser.

A total of 165 sharks (56%) were classified as dead when observed onboard while 20 (7%) had unknown fates. The remaining 110 individuals (37%) showed variable signs of life when released and were assigned a representative score, from 4 to 1 based on their observed behaviour following release. A score of 4 assigned to sharks showing excellent condition with no sign of trauma, while a score of 1 applied when the shark was able to right itself and made efforts to swim away.

Twenty-eight sharks were tagged with satellite tags (15 SPATs, 11 miniPATs and 2 X-Tags). No data were obtained from the two X-Tags. Of the remaining 26 tags, 23 (three pre-set, two encircled, 11 entangled, four 1st brail, three later brails) provided sufficient data to determine the fate of the shark. The other three tags prematurely released from the sharks within 10 days of tagging and were thus excluded from the experiment. Fifteen (65%) of these tags indicated the sharks survived, while eight reported mortality within 10 days of release. A significant relationship was found between blood lactate concentration and post-release mortality in these individuals and regression analysis showed that lactate concentration was a good predictor of survival probability.

By fitting the lactate concentrations from non-tagged sharks using a maximum likelihood approach to the established logistic survival curve function the survival probability of silky sharks released at various stages of the fishing process were obtained. Accordingly, all sharks caught prior to setting and those released before the net prior to sacking up showed 100% survival. Sharks that were entangled in the net also showed a high survival rate of 68.7%. Sharks recovered from the first brail had a 16.7% survival rate, while those from later brails had a 6.7% survival rate. When combined together these figures resulted

in an overall survival rate of 15.8% of all sharks caught during the normal purse seine operation.

Eastern Pacific Ocean

Between 2011 and 2012, (Eddy *et al.*, In press) investigated the post-release survival of pelagic sharks from tuna purse seine vessels in the equatorial eastern Pacific Ocean. The study was conducted during two ISSF cruises on Ecuadorian flagged commercial tuna purse seine vessels. A total of 53 silky sharks, six scalloped hammerhead sharks, *Sphyrna lewini*, and 1 mako shark, *Isurus oxyrinchus,* were caught during 23 fishing sets. Sharks were assigned a score between 1 and 5 to reflect their condition (1 = excellent, 5 = moribund) when they reached the vessel. Neither of these vessels used a hopper on the upper deck, with the catch passing directly from the brailer to the lower deck where sharks were separated and returned to the upper deck.

Sharks larger than 85 cm (fork length, FL) and an at-vessel condition of 4 or better were fitted with PSATs (MiniPATs) to assess post release survival. Sixteen sharks (13 silky sharks and three scalloped hammerhead sharks) were tagged. Of these 16 sharks, four were entangled in the purse seine during hauling and 12 were removed from the brailer with the tuna. PSATs were programmed to release 30 to 45 days after deployment. Additionally, sharks with condition states of four or higher but that were smaller than 85 cm FL were tagged with plastic dart tags (PDTs). Blood samples were taken from live sharks that arrived on deck and were not designated for PSAT tagging, to measure plasma lactate concentrations and pH. Additional blood chemistry characteristics (concentrations of calcium, chloride, sodium and potassium) were measured using a handheld blood gas analyser.

At-vessel mortality was found to be 58% for silky sharks and zero for scalloped hammerheads. At-vessel, post-release, and total mortality rates were found to be related to the size of the tuna catch with larger catches resulting in higher mortality rates. Two measures of survival were calculated which differed according to the assumptions made regarding the fate of untagged sharks. First, assuming all sharks released without PSATs survived: Total survival rate for; all sharks = 23.3%; silky sharks = 20.7% and; scalloped hammerhead sharks = 50%. Second, total survival rates were calculated after applying the survival rates to those with an unknown fate based upon their at-vessel physical condition. This led to a total survival rate for; all sharks of 10%; silky shark of 8.5% and; for scalloped hammerheads of 25%.

Global overview

The outcomes of the three independent studies conducted to assess the fishery impact on incidentally captured silky sharks associated with drifting FADs are all very similar. At-vessel mortality ranged from 56 to 69% (mean = 61%) while total survival ranged from 8.5 to 19% (mean = 14.4%) (Table 1). Following these results obtained from five different fishing vessels in three regions of the world,

it appears that any difference that may exist between the fishing operations has limited effect on the survival rate of captured silky sharks.

Table 1 Summary of silky shark survival studies from tuna purse seine vessels in three regions

Study	Region	No. Sets	No. Silky sharks caught	At-vessel mortality rate	No. Tagged	Total survival rate
Poisson *et al*. 2014	IO	48	221	69%	31	19%
Hutchinson *et al*. 2015	WCPO	31	295	56%	28	15.8%
Eddy *et al*. In press	EPO	23	53	58%	13	8.5%
Total		102	569	$\bar{x}$ =61%	72	$\bar{x}$ =14.4%

The major factors contributing to the incidental mortality of silky sharks are related to the process of sacking up the catch along side the vessel and brailing the catch onto the vessel. It is noteworthy that the vessels in the first two studies used a hopper on the upper deck to sort the catch before it moved to the lower deck, while in the study of Eddy et al. no hopper was used and the total survival rate was the lowest. While the differences in total survival are not very large, small improvements could represent significant numbers of sharks, considering the global extent of these fishing practices. Clearly mitigation measures aimed at optimising the survival rate of FAD associated silky sharks will likely focus on avoiding their encirclement entirely, or alternatively, on different methods for sacking up, landing and handling the catch. Poisson *et al.* (2014b) described the recommended practices for handling sharks and other large bycatch species onboard purse seine vessels. These guidelines provide useful information that can maximised the survival probability for non-target species that are released following capture in the tuna purse seine fishery. The practices recommended in this document have been communicated to fishers through an on-going series of skippers workshops hosted by the ISSF at major ports from which purse seine vessels operate, around the world (Murua *et al.* 2014). These workshops have provided the opportunity to not only disseminate information on best handling practices, but also to integrate insights and ideas from a vast number of skippers and spread this information throughout the global fishery.

References

Eddy, W.C., Brill, R.W. and Bernal, D. Rates of at-vessel mortality and post-release survival of pelagic sharks captured with tuna purse seines around drifting fish aggregating devices (FADs) in the Equatorial Eastern Pacific Ocean. *In Press*. Fisheries Research.

Hutchinson, M., Itano, D., Muir, J. and Holland, K.N. (2015) Post-release survival of juvenile silky sharks captured in a tropical tuna purse seine fishery. *Marine Ecology Progress Series* **521**, 143–154.

Justel-Rubio, A. and V. Restrepo. 2015. Preliminary study of the relative fishery impacts on non-tuna species caught in tuna fisheries. ISSF Technical Report 2015-02. International Seafood Sustainability Foundation, Washington, D.C., USA.

Murua, J., Moreno, G., Hall, M.A., Itano, D.G., Dagorn, L. and Restrepo, V. (2014) ISSF Skipper Workshops: Collaboaration between scientists and fishing industry to mitigate bycatch in tuna FAD fisheries. 50 pp.

Poisson, F., Filmalter, J.D., Vernet, A.-L. and Dagorn, L. (2014a) Mortality rate of silky sharks (Carcharhinus falciformis) caught in the tropical tuna purse seine fishery in the Indian Ocean. *Canadian Journal of Fisheries and Aquatic Sciences* **71**, 795–798.

Poisson, F., Séret, B., Vernet, A.-L., Goujon, M. and Dagorn, L. (2014b) Collaborative research: Development of a manual on elasmobranch handling and release best practices in tropical tuna purse-seine fisheries. *Marine Policy* **44**, 312–320.