Progress report on the post release mortality of the oceanic white tip shark (POREMO project) discarded by EU purse seine and pelagic longline fisheries

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ABSTRACT

In this progress report we present the context of the project POREMO funded by EU France in the frame of the development appropriate IOTC conservation measures and to mitigate this species bycatch in major European tuna fisheries in the Indian Ocean. The POREMO project aims to quantify the post release mortality of the oceanic white tip shark by-caught by the EU tuna purse seine and pelagic longline fisheries in order to assess the retention ban measure taken as conservation and management measure (CMM) for this species as specified in the IOTC resolution 13/06. The material purchased for these purposes and the present situation of electronic tag deployments are presented.

KEYWORDS

Post release mortality | Oceanic white tip shark | Tuna purse seine fishery | Pelagic longline fishery | Electronic tag | Indian Ocean | Conservation measures

1. Context

Appropriate mitigation measures in fisheries must be set up to preserve protected, endangered and threatened (PET) species to maintain both biodiversity and ecosystem sustainability. Many of PET species are more susceptible to overfishing than other species because their life history traits are mostly characterized by few offsprings, low population growth rate, a slow growing, a first age at maturity late and a high longevity. These traits characterize almost all shark species. In the IOTC area of competence many pelagic shark species are either targeted or caught as bycatch by several gears (purse seine, pelagic longline, drifting gillnet, handline and pole and line), (IOTC-IOShYP01, 2014). Shark caught as unwanted bycatch for many industrial fleets are discarded dead or alive. With the implementation of a regional observer program (IOTC Resolution 11/04 on a Regional Observer Scheme) more data are available to assess the status of shark at release. The release of shark alive has been considered as a relevant conservation measure for threatened and endangered shark species. Such considerations led to the adoption of two IOTC resolutions: the IOTC resolution 12/09 "on the conservation of thresher sharks (Family Alopiidae) caught in association with fisheries in the IOTC area of competence" and the IOTC resolution 13/06 "on a scientific and management framework on the conservation of shark species caught in association with IOTC managed fisheries". This last resolution in its paragraph 3 specifies "CPCs shall prohibit, as an interim pilot measure, all fishing vessels flying their flag and on the IOTC Record of Authorized Vessels, or authorized to fish for tuna or tuna-like species managed by the IOTC on the high seas to retain onboard, tranship, land or store any part or whole carcass of oceanic whitetip sharks with the exception of paragraph 7 (dedicated for scientific purposes). The provisions of this measure do not apply to artisanal fisheries operating exclusively in their respective Exclusive Economic Zone (EEZ) for the purpose of local consumption". While this ban retention has been considered as insufficient for the recovering of shark population (Tolotti et al., 2015), above all its effectiveness has not been assessed in the Indian Ocean and we need to deeper explore the survivorship rate of released sharks.

In the frame of the EU Data Collection MultiAnnual Program (EU DCMAP) project, in 2017 EU France allocated to IRD a budget of 100.000 € dedicated for a pilot study focused on shark post release mortality (PRM) of sharks bycaught by EU fleets operating in the Atlantic and Indian oceans. The Observatory of exploited tropical pelagic ecosystems (Ob7) of IRD which is overseeing the DCMAP for tropical fisheries for France had taken the decision to focus this pilot study in the Indian Ocean related to the current shark conservation issues in the IOTC area of competence. As recent advances on PRM have been obtained for whale shark (Escalle et al., 2014) and silky shark (Poisson et al., 2014), it was decided to focus this research on the oceanic whitetip shark (OCS, *Carcharhinus longimanus*), a species commonly occurring as bycatch in EU purse seine (PS) and pelagic longline (LL) fisheries. The study covers purse seine fleets of Spain and France and pelagic longline fleets for Portugal and France. During an *ad hoc* discussion held during the 13th WPEB in San Sebastian (Spain), it was agreed that this study coordinated by IRD will be an excellent contribution to the IOTC PRM work plan even acknowledging that some industrial PS and LL fleets releasing OCS as bycatch will not be covered in this PRM study for OCS.

2. State of the art

The mortality of fishes subject to discard is the sum of 1) the at-vessel mortality (AVM) corresponding to the proportion of fishes dead at hauling or on the deck before being released at sea and 2) the post release mortality (PRM) corresponding to the proportion of fish released alive but not able to survive in the short term due to injuries during the catching, hauling or discarding processes (Davis, 2002; Poisson et al., 2014). It is often allowed that sharks show high capacity to recover following injury even though injury types have not been systematically collected (Chin et al., 2015).

Several tagging technics (conventional tags, acoustic tags, electronic tags) have been carried out to explore the post-release mortality of sharks on field during both experimental and commercial fishing operations (see Ellis et al., 2017 for a review). Due to the limits of conventional and acoustic tagging to quantify the exact degree of discard survival, recent studies consider expensive but efficient electronic tags (mainly pop-up satellite archival tags), (Moyes et al., 2006; Campana et al., 2009; Musyl et al., 2011; Capietto et al., 2014; Poisson et al., 2014; Escalle et al., 2016).

However due to the cost of PSAT, experiments prioritized the release of individuals prone to survive in order to collect important additional data aiming to analyze individual behaviors and the ecology of species. Recently, new electronic tag design (sPAT) cheaper than pop-up archival tags and dedicated to survivorship studies have been developed in order to better encompass the different status of individuals at release.

Meta-analysis published recently (Godin et al., 2012; Ellis et al., 2017) produced a synthesis of results for at vessel mortality (AVM) and post release mortality (PRM) from studies published from 2009 to 2015 for several species regarding different fisheries.

For longline fisheries, shark AVM and PRM mortalities are highly variable between species (Gilman et al., 2008; Godin et al., 2012; Ellis et al., 2017), (Tables 1 and 2). The time spent hooked is an important factor to consider as soak time can be potentially long. Both AVM and PRM vary with a range of biological attributes (species, size, sex and mode of gill ventilation) as well as the range of factors associated with capture (e.g. gear type, soak time, catch mass and composition, handling practices and the degree of exposure to air and any associated change in ambient temperature). In general, demersal species with buccal-pump ventilation have a higher survival than obligate ram gills ventilators. Several studies have indicated that females may have a higher survival than males. Certain taxa (including hammerhead sharks *Sphyrna spp.* and thresher sharks *Alopias spp.*) are particularly prone to higher rates of mortality when caught.

On board tuna purse seiners some experiments have been carried out to assess the post release mortality of silky shark and whale shark. During three fishing cruises of purse seiner in the Indian Ocean 31 silky sharks (*Carcharhinus falciformis*) considered as alive were tagged with satellite tags to investigate their PRM (Poisson et al., 2014). The majority of individuals (95%) were brought on board using the brailer. Combining the proportion of sharks dead (AVM = 72%) and the mortality rate of those released (PRM = 48%), the overall mortality rate of brailed individuals was 85%. Few individuals (5%) were not brailed as they were entangled and landed during the hauling process. The survival rate of these meshed individuals reached 82%. However the combination of these two categories led to an overall survival rate of 19%. During a chartered cruise on board a tuna purse seine vessel conducting typical fishing operations the post-release survival and rates of interaction with fishing gear of incidentally captured silky sharks (*Carcharhinus falciformis*) were investigated using a combination of satellite linked pop-up tags and blood chemistry analysis (Hutchinson et al., 2015). To identify trends in survival probability and the point in the fishing interaction when sharks sustain the injuries that lead to mortality, sharks were sampled during every stage of the fishing procedure. The total survival rate of silky sharks captured in purse seine gear was found to be less than 16%, a result similar to the one obtained by Poisson et al. (2014). In 2014, Escalle et al. (2016) deployed pop-up satellite tag on six large whale sharks (total length > 8 m) released after being encircled in the purse seine in the eastern tropical Atlantic Ocean. Results show that whale sharks can survive at least 21 days (maximum duration registered was 71 days) after their release from the net and suggest that large whale sharks would exhibit low post release mortality.

For gillnet fisheries very limited information on AVM and PRM are available (IOTC-IOShYP01, 2014) although it is considered that mortality of elasmobranchs for this gear is high. For example, even with short soak times of about one hour, high AVM rates have been registered for *Carcharhinus limbatus* (58%) and *Sphyrna tiburo* (62%) (Hueter et al., 2006).

3. POREMO material

Following discussions during the *ad hoc* meeting of IOTC scientists organized within the framework of the 13th WPEB in San Sebastián, Spain, it was accepted that two providers, Wildlife Computers (Redmond, WA, USA) and Microwave Telemetry (Columbia, MD, USA), was producing reliable material well shaped for purposes of the study. A similar decision was reached during the International Expert Workshop on shark post-release mortality tagging studies (Common Oceans, 2017). Finally, as recommended by expert during the workshop, the IOTC group decided to select Wildlife Computers as unique supplier for the tagging material.

Moreover, it was decided to combine two types of tags for the study:

- survival PAT (sPAT) designed to evaluate short-term post release mortality (set to release 60 days after the deployment) aimed to be deployed on oceanic white tip individuals either tired and sluggish on the deck or exhausted on deck,
- miniPAT (full functioning pop-up archival tag) which will be deployed on individuals in excellent or good conditions in order to collect movements and habitat utilization of oceanic white tip sharks information which are deficient in the Indian Ocean basin. Tags were programmed to pop-off 180 days after their deployment.

In December 2107, the POREMO Project purchased 35 electronic tags (20 sPAT and 15 miniPAT). Those tags have been deployed on several fleets from EU and Seychelles following the scheme presented in the table 3.

4. Tag deployment

So far three electronic tags were deployed, 2 sPAT by AZTI on Spanish purse seiners and 1 miniPAT by IPMA on a Portuguese longliner. The metadata describing these deployments are presented in the table 4.

More deployment might be realized during the last quarter of this year by observers on board i) French purse seiners and longliners and ii) Spanish purse seiners. It is expected that all tags be deployed by the end of the first quarter 2019.

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Table 1. Summary of studies examining sharks at-vessel mortality (AVM) for pelagic longline fisheries. Data in parentheses corresponds to the number of individuals observed.

Shark species	AVM	Targeted species	Reference
Prionace glauca	4.5% (513)	Swordfish/ Albacore	(Megalofonou et al., 2005)
	0% (21)	Tuna	(Boggs, 1992)
	13.5% (7838)	Tuna	(Francis et al., 2001)
	12.2% (434)	Swordfish	(Francis et al., 2001)
	51.1% (92)	Swordfish	(Poisson et al., 2010)
	14.3% (30168)	Swordfish	(Coelho et al., 2012)
Isurus oxyrinchus	16.1% (31)	Swordfish/ Albacore	(Megalofonou et al., 2005)
	28.4 % (299)	Tuna	(Francis et al., 2001)
	35% (80)	Swordfish	(Beerkircher et al., 2002)
	35.6% (1414)	Swordfish	(Coelho et al., 2012)
Isurus paucus	30.7% (168)	Swordfish	(Coelho et al., 2012)
Lamna nasus	39.2 % (2370)	Tuna	(Francis et al., 2001)
Alopias vulpinus	6.3% (16)	Swordfish/ Albacore	(Megalofonou et al., 2005)
Alopias superciliosus	0 (1)	Swordfish/ Albacore	(Megalofonou et al., 2005)
	53.7% (82)	Swordfish	(Beerkircher et al., 2002)
	50.6% (1061)	Swordfish	(Coelho et al., 2012)
Alopias spp.	40% (6)	Tuna	(Boggs, 1992)
Carcharhinus plumbeus	0 (2)	Swordfish/ Albacore	(Megalofonou et al., 2005)
	26.8% (112)	Swordfish	(Beerkircher et al., 2002)
	36% (8583)	Shark	(Morgan and Burgess, 2007)
Carcharhinus longimanus	15% (26)	Tuna	(Boggs, 1992)
	27.5 % (131)	Swordfish	(Beerkircher et al., 2002)
	58.9% (17)	Swordfish	(Poisson et al., 2010)
	34.3% (281)	Swordfish	(Coelho et al., 2012)
Carcharhinus falciformis	66.3% (1446)	Swordfish	(Beerkircher et al., 2002)
	55.8% (310)	Swordfish	(Coelho et al., 2012)
Carcharhinus limbatus	88% (1982)	Shark	(Morgan and Burgess, 2007)
Carcharhinus obscurus	48.7% (679)	Swordfish	(Beerkircher et al., 2002)
	81% (662)	Shark	(Morgan and Burgess, 2007)
Carcharhinus signatus	80.8% (572)	Swordfish	(Beerkircher et al., 2002)
Galeocerdo cuvier	8.5% (2466)	Shark	(Morgan and Burgess, 2007)
	2.9% (36)	Swordfish	(Coelho et al., 2012)
Sphyrna lewini	61% (199)	Swordfish	(Beerkircher et al., 2002)
	91.4% (455)	Shark	(Morgan and Burgess, 2007)
	57.1% (21)	Swordfish	(Coelho et al., 2012)

Sphyrna mokarran	93.8% (178)	Shark	(Morgan and Burgess, 2007)
Sphyrna zygaena	71% (372)	Swordfish	(Coelho et al., 2012)
Pteroplatytrygon violacea	12% (8)	Tuna	(Boggs, 1992)
	1%	Swordfish	(Coelho et al., 2012)
Mantas and devil rays	1.4% (145)	Swordfish	(Coelho et al., 2012)
Myliobatidae	0% (19)	Swordfish	(Coelho et al., 2012)

Table 2. Summary of studies examining post-release mortality (PRM) of sharks for pelagic longline fisheries. Data in parentheses corresponds to the number of individuals observed.

Shark species	PRM	Targeted species	Reference
Prionace glauca	Healthy - 0% (10) Injured – 33% (27)	Swordfish & Tunas	(Campana et al., 2016)
Lamna nasus	Healthy – 10% (29) Injured – 75% (4)	Swordfish & Tunas	(Campana et al., 2016)
Isurus oxyrinchus	Healthy - 30% (23) Injured – 33% (3)	Swordfish & Tunas	(Campana et al., 2016)
Carcharhinus obscurus	Healthy – 11.1% (18) Injured – 66.6% (3)	Sharks	(Marshall et al., 2015)
Carcharhinus plumbeus	Healthy – 20% (10)	Sharks	(Marshall et al., 2015)

Table 3. Electronic tags sharing between EU partners and Seychelles of the POREMO project.

Country	Gear	Partner	sPAT	minPAT	Total
EU.FRA	PS	IRD	9	3	12
EU.REU	LL	CAP RUN	2	7	9
EU.SPA	PS	AZTI	9	0	9
EU.PRT	LL	IPMA	0	1	1
SEY	LL	IRD	0	4	4
		Total	12	15	35

Table 4. Metadata of electronic tag deployments realized in the frame of the POREMO project.

Date	Local Time	Lat. (°)	Long. (°)	Length (cm)	Sex	Gear	Country	Status	Tag PTT N°
15/05/2018	15:15	32.75 S	34.87 E	FL = 195 est.	F	LL	POR	Vigourous	miniPAT 49012
08/08/2018	16:27	5.18 S	62.18 E	FL = 145 est.	F	PS	SPA	Good condition	sPAT 46265
09/08/2018	16:47	5.30 S	61.05	FL = 130 est.	F	PS	SPA	Good condition	sPAT 46276