

## SATELLITE TAGGING OF SHORTFIN MAKO FOR HABITAT USE AND POST-RELEASE SURVIVAL: PROGRESS REPORT FOR SRDCP

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### SUMMARY

*This paper provides an update of two projects developed within the ICCAT Shark Research and Data Collection Program (SRDCP) using satellite telemetry, specifically a study on habitat use and another on post-release survival. Currently, all phase 1 (2015-2016) tags (23 tags: 9 miniPATs and 14 sPAT) have been deployed by observers on Portuguese, Uruguayan and US vessels in the temperate NE, temperate NW and SW Atlantic. A total of 668 tracking days have been recorded. In terms of post-release survivorship, data from 19 tags/specimens is available. From those, 6 specimens died (31.6%) while the remaining 13 (68.4%) survived the first 30 days after tagging. All planned project milestones and deliverables have been achieved and delivered in due time. For the 2nd phase of the project (2016-2017) 12 miniPATs were acquired and will be deployed during 2017 in various regions of the Atlantic, including temperate, tropical and equatorial waters.*

### RÉSUMÉ

*Le présent document fournit une mise à jour de deux projets menés dans le cadre du Programme de recherche et de collecte de données sur les requins (SRDCP) de l'ICCAT, utilisant la télémétrie par satellite, en particulier une étude sur l'utilisation de l'habitat et une autre sur la survie suivant la remise à l'eau. Actuellement, toutes les marques de la phase 1 (2015-2016) (23 marques : 9 miniPAT et 14 sPAT) ont été apposées par des observateurs déployés à bord de navires portugais, uruguayens et américains dans les eaux tempérées du Nord-Est, les eaux tempérées du Nord-Ouest et du Sud-Ouest de l'Atlantique. Au total, 668 jours de suivi ont été enregistrés. En termes de survie après la remise à l'eau, les données provenant de 19 marques/spécimens sont disponibles. Sur celles-ci, six spécimens sont morts (31,6 %) tandis que les 13 restants (68,4 %) ont survécu les 30 premiers jours après le marquage. Toutes les étapes principales du projet ont été réalisées et les documents requis ont été présentés dans les délais fixés. Pour la deuxième phase du projet (2016-2017), 12 miniPAT ont été acquises et seront déployées au cours de 2017 dans diverses régions de l'Atlantique, y compris les eaux tempérées, tropicales et équatoriales.*

### RESUMEN

*Este documento presenta una actualización de dos proyectos desarrollados en el marco del Programa de recopilación de datos e investigación sobre tiburones (SRDCP), utilizando telemetría vía satélite, específicamente un estudio sobre utilización del hábitat y otro sobre supervivencia posterior a la liberación. Actualmente, todas las marcas (23 marcas: 9 miniPAT y 14 sPAT) de la fase 1 (2015-2016) han sido colocadas por los observadores embarcados en buques estadounidenses, uruguayos y portugueses, en el Atlántico nordeste templado, noroeste templado y suroeste. Hasta la fecha se ha registrado un total de 668 días de rastreo. En términos de supervivencia tras la liberación, se dispone de datos de 19 marcas/ejemplares. De estos, seis ejemplares murieron (31,6%), mientras que los 13 restantes (68,4%) sobrevivieron los primeros 30 días tras su marcado. Todas las metas y documentos previstos del proyecto se han completado y entregado en el plazo previsto. Para la segunda fase del proyecto (2016-2017) se adquirieron 12 miniPATs que se colocarán durante 2017 en diferentes regiones del Atlántico, lo que incluye aguas ecuatoriales, tropicales y templadas.*

### KEYWORDS

*Habitat use; Post-release survival; Sharks research program; Satellite tagging; Shortfin mako.*

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## Introduction

In 2013 the ICCAT Shark Species Group developed the general guidelines of the Shark Research and Data Collection Program (SRDCP), aimed at the development and coordination of science and science-related activities needed to support provision of sound scientific advice for the conservation and management of sharks in the Atlantic. During the 2014 inter-sessional meeting, the Sharks Working Group updated the SRDCP, which was framed within the 2015-2020 SCRS Strategic Plan. The initial 2-year implementation of this Research Program focuses on biological aspects, ecology and fisheries of shortfin mako shark that are relevant to the upcoming stock assessment of this important species.

Quantifying habitat use and migration patterns is important for management of fish populations and conservation planning. The knowledge of the movement patterns (i.e., use of space and activity patterns) is essential in understanding the behavior of a species as well as defining essential habitats. The need to understand whether fish are migrating between regions that can be undergoing different types and levels of fishing activity is also very important. Another important aspect is related with quantifying mortality. However, and even though those issues are of great importance, there is still limited information on the stock structure and post-release mortality of most pelagic elasmobranchs at an ocean wide level. Using incorrect assumptions about the stock structure, movements and mortality can lead to biased conclusions about the level of fishing that is sustainable. Therefore, information about these processes should be incorporated into stock assessments.

Given the wide range of information that can be gathered with satellite telemetry studies, within the ICCAT SRDCP, two specific studies using satellite telemetry were developed, specifically: 1) a study that uses satellite telemetry to gather and provide information on stock boundaries, movement patterns and habitat use of shortfin mako in the Atlantic; and 2) a study that uses satellite telemetry to determine post-release mortality of discarded specimens. The objectives of this working document are to provide an update of the current development status of both projects, and the plans for the next stage of this project.

## Progress on the project execution

### *General progress*

The first tags acquisition process (miniPATs for habitat use and sPATs for post-release survival) was completed during October-November 2015 by the ICCAT Secretariat, and the tags were then distributed to the participating Institutes in late 2015. In this first project phase, a total of 9 miniPATs and 14 sPATs were acquired (funds from 2015). Additionally, in late 2016, 12 additional miniPATs were acquired with the funds from 2016 for deployment during 2017, during the 2nd phase of the project. As one of the original miniPAT tags (2015) failed due to a depth sensor problem, the tag manufacturer provided one additional replacement tag. As such, for the 2nd phase of the project a total of 13 miniPATs are available for deployment in 2017. **Table 1** describes the numbers of tags acquired during the two project phases and their allocation for deployment as well as the current deployment status.

The list of milestones and deliverables originally developed and their current development status is provided in **Table 2** (habitat use) and **Table 3** (post-release survival). Given that the Atlantic SMA stock assessment has been postponed from 2016 to 2017, the expected completion dates of the deliverables has been updated to reflect this, giving more time for the deployment of the tags and additional work. Some additional deliverables were also added so that the SCRS and the Sharks-WG are regularly updated on the project execution status.

### *Habitat use studies*

Currently, all tags from the phase 1 (2015-2016) of the project (9 miniPATs and 14 sPAT, in a total of 668 tracking days) have been deployed from observers from Portuguese, US and Uruguayan vessels, in the temperate Northeast, temperate Northwest and Southwest Atlantic, respectively (**Figure 1**). Additional tags have also been deployed by national programs and project that are cooperating with the ICCAT/SRDCP initiative (**Figure 2** and **Table 4**). Considering all other participating projects, a total of 38 tags (1,566 tracking days) have been deployed to date.

In terms of movements, at this stage only preliminary analysis has been carried out as there are still tags from phase 2 of the project (2017) to be deployed. As such, and for information purposes, only preliminary tracks are shown in this update (**Figure 3**). However, even with this preliminary analysis, it is interesting to note that the

specimens tagged in the temperate NE Atlantic (tagged in December and January) moved to southern areas, while specimens tagged in the tropical NE region close to the Cabo Verde archipelago (tagged between August and October) moved easterly to areas closer to the African continent. There were also 3 tags deployed in equatorial waters (December and February) and of those one specimen was fished/recaptured off Walvis Bay, Namibia. The specimens tagged in the SW Atlantic off Uruguay tended to stay in the same general area (**Figure 3**). Finally, for the specimens tagged in the temperate northwest Atlantic there were general southern movements (**Figure 3**).

### *Post-release mortality studies*

In terms of post-release survivorship, also only preliminary analysis is shown from the phase 1 of the project, and considering both the miniPATs and sPATs with data that can be used for analyzing the post-release mortality. At this stage, from the 19 tags with such information, 6 specimens died (31.6%) while the remaining 13 (68.4%) survived at least the first 30 days after tagging (**Table 5**).

### **Contribution of SMA satellite telemetry data from other projects**

As initially planned, the participating scientists and Institutes in this study have also other ongoing projects and initiatives that also include the deployment of satellite telemetry tags in SMA (see details in **Table 4**, **Figure 1** and **Figure 2**). Most of those additional tags from these other projects have already been deployed, or are planned to be deployed during 2017.

- **Project LL-Sharks:** 10 tags have been deployed on SMA specimens by Portuguese fishing vessels in the tropical NE and equatorial regions within the scope of Project LL-Sharks (*Mitigação das capturas de tubarões na pescaria de palangre de superfície*; Ref: 31-03-05-FEP-44; funded by PROMAR).
- **Project MAKO-WIDE:** Within project MAKO-WIDE - *A wide scale inter-hemispheric and interdisciplinary study aiming the conservation of the shortfin mako shark in the Atlantic Ocean*; Ref: FAPESP/19740/2014; funded by FCT-Portugal and FAPESP-São Paulo, Brazil), we are in the process of acquiring 16 additional miniPAT tags, of which 10 will be deployed by Portuguese vessels in the NE tropical and temperate Atlantic and 6 will be deployed by Brazilian vessels in the SW Atlantic.
- **Project SAFEWATERS SC-07:** This project (*The provision of advice on the conservation of pelagic sharks associated to fishing activity under EU Sustainable Fisheries Partnership Agreements in the Atlantic Ocean*, under the Framework Contract MARE/2012/21, funded by the European Commission) has recently deployed 5 miniPATs for deployment in SMA in the EEZ of Cabo Verde (tropical NE Atlantic).
- **NOAA (US-PRT-URY) collaboration project:** Within this collaboration project that involves scientists from NOAA (US), DINARA (Uruguay) and IPMA (Portugal), 9 miniPATs have been acquired by NOAA and are in the process of being deployed in the NW Atlantic. Additionally, one previous tag also from NOAA was deployed in 2014 by Uruguay in the SW Atlantic.

### **Project future steps**

The main plan for the next phase of the project is to continue the tag deployment during 2017 in the several regions of the Atlantic (see planning for phase 2 tags in **Table 1**). The main deliverables and outcomes expected for these projects are SCRS papers. Specifically, an update is now presented in this paper and, according to the deliverable schedule (**Tables 2 and 3**), we plan to provide more detailed analysis and results on both projects during the SMA ICCAT stock assessment meeting in June 2017. Submission of the final results to peer-review journals are also envisioned pending agreement of all participants in the study.

## Acknowledgments

This study was carried out as part of a cooperative work conducted by the ICCAT Shark species group integrated in the ICCAT Shark Research and Data Collection Program (SRDCP). The authors are grateful to all fishery observers and longline skippers from the Nations involved in this study. Tags from additional sources have been contributed and deployed with several national Projects, specifically: Project "LL-Sharks: Mitigação das capturas de tubarões na pescaria de palangre de superfície (Ref: 31-03-05-FEP-44, funded by PROMAR)", Project "MAKO-WIDE - "A wide scale inter-hemispheric and inter-disciplinary study aiming the conservation of the shortfin mako shark in the Atlantic Ocean (Ref: FAPESP/19740/2014)", funded by FCT (Portuguese Foundation for Science and Technology) and FAPESP (São Paulo Research Foundation, Brazil), and Project SAFEWATERS SC7 (The provision of advice on the conservation of pelagic sharks associated to fishing activity under EU Sustainable Fisheries Partnership Agreements in the Atlantic Ocean) under the Framework Contract MARE/2012/21, funded by the European Commission. Additional satellite tags were acquired by NOAA in US-Uruguay and US-Portugal-Uruguay collaboration initiatives. Rui Coelho is supported by an Investigador-FCT contract from the Portuguese Foundation for Science and Technology (FCT) supported by the EU European Social Fund and the Programa Operacional Potencial Humano (Ref: IF/00253/2014).

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**Table 1.** List with the distribution of miniPATs and sPATs by the participating Institutes, for the 2 project phases. Current deployment status and additional notes are also provided.

<b>Project Phase</b>	<b>Institute</b>	<b>Tag types and quantities</b>	<b>Tagging areas</b>	<b>Status of deployment</b>
<u>Phase 1</u> (2015-2016)	IPMA (Portugal)	6 miniPATs + 4 sPATs	Temperate NE	All tags deployed (see summary results)
	NOAA (US)	5 sPATs	Temperate NW	All tags deployed (see summary results)
	DINARA (Uruguay)	3 miniPATs + 5 sPATs	SW Atlantic	All tags deployed (see summary results)
<u>Phase 2</u> (2016-2017)	IPMA (Portugal)	3 miniPATs	Tropical NE, Equatorial (E)	Planned to start deployment in Spring 2017
	NOAA (US)	3 miniPATs	Temperate NW	Planned to start deployment in March 2017
	DINARA (Uruguay)	4 miniPATs	SW Atlantic	Planned to start deployment in March 2017
	UFRPE (Brasil)	3 miniPATs	Equatorial (W)	Planned to start deployment in June 2017

**Table 2.** List of milestones and deliverables with the respective expected completion dates and execution status for the shortfin mako satellite tagging project for habitat utilization studies. Note that some deliverables were added (not originally planned) due to the postponement of the shortfin mako Atlantic stock assessment to 2017.

Item	Type <sup>1</sup>	Name	Description	Expected date	Originally planned <sup>2</sup>	Status
1	M	miniPSAT acquisition	Acquisition of PSAT tags by the ICCAT Secretariat	Nov-15	Yes	Completed
2	M	miniPSAT programming	PSATs programmed and distributed to the participating Institutes	Dec-15	Yes	Completed
3	D	SCRS paper	A SCRS paper describing and updating the project status, to be presented to the 2016 ICCAT Sharks-WG	18-Apr-16 (2016 WG-Sharks meeting)	Additional	Completed
4	M	miniPSAT deployments (stage 1 tags)	PSAT deployments on SMA	31-Mar-17	Yes	Completed (1st stage tags deployed from Dec-2015 to Dec-2016)
5	M	miniPSAT deployments (stage 2 tags)	PSAT deployments on SMA	2017	Planned at project stage 2	Ongoing (2nd stage tags expected to be deployed in 2017)
6	D	SCRS paper	A SCRS paper describing and updating the project status, to be presented to the 2017 SMA data preparatory meeting	SMA data preparatory meeting (28-Mar-17)	Additional	Completed (this work)
7	D	SCRS paper	Preparation of an ICCAT/SCRS technical document	SMA stock assessment meeting (12-Jun-17)	Yes	Ongoing

<sup>1</sup> M=milestone; D=deliverable

<sup>2</sup> Some deliverables/milestones were not planned in the original project proposal. However, due to the postponement of the SMA stock assessment to 2017 those were added to provide progress reports to the Sharks WG.

**Table 3.** List of milestones and deliverables with the respective expected completion dates and execution status for the shortfin mako satellite tagging project for post-release mortality. Note that some deliverables were added (not originally planned) due to the postponement of the shortfin mako Atlantic stock assessment to 2017.

Item	Type <sup>1</sup>	Name	Description	Expected date	Originally planned <sup>2</sup>	Status
1	M	sPSAT acquisition	Acquisition of PSAT tags by the ICCAT Secretariat	Nov-15	Yes	Completed
2	D	SCRS paper	A SCRS paper describing and updating the project status, to be presented to the 2016 ICCAT Sharks-WG	18-Apr-16 (2016 WG-Sharks meeting)	Additional	Completed
3	M	sPSAT deployments	PSAT deployments on SMA	31-Mar-17	Yes	Completed (sPATS deployed between Dec-2015 and Dec-2016)
4	D	SCRS paper	A SCRS paper describing and updating the project status, to be presented to the 2017 SMA data preparatory meeting	SMA data preparatory meeting (28-Mar-17)	Additional	Completed (this work)
5	D	SCRS paper	Preparation of an ICCAT/SCRS technical document	SMA stock assessment meeting (12-Jun-17)	Yes	Ongoing

<sup>1</sup> M=milestone; D=deliverable

<sup>2</sup> Some deliverables/milestones were not planned in the original project proposal. However, due to the postponement of the SMA stock assessment to 2017 those were added to provide progress reports to the Sharks WG.

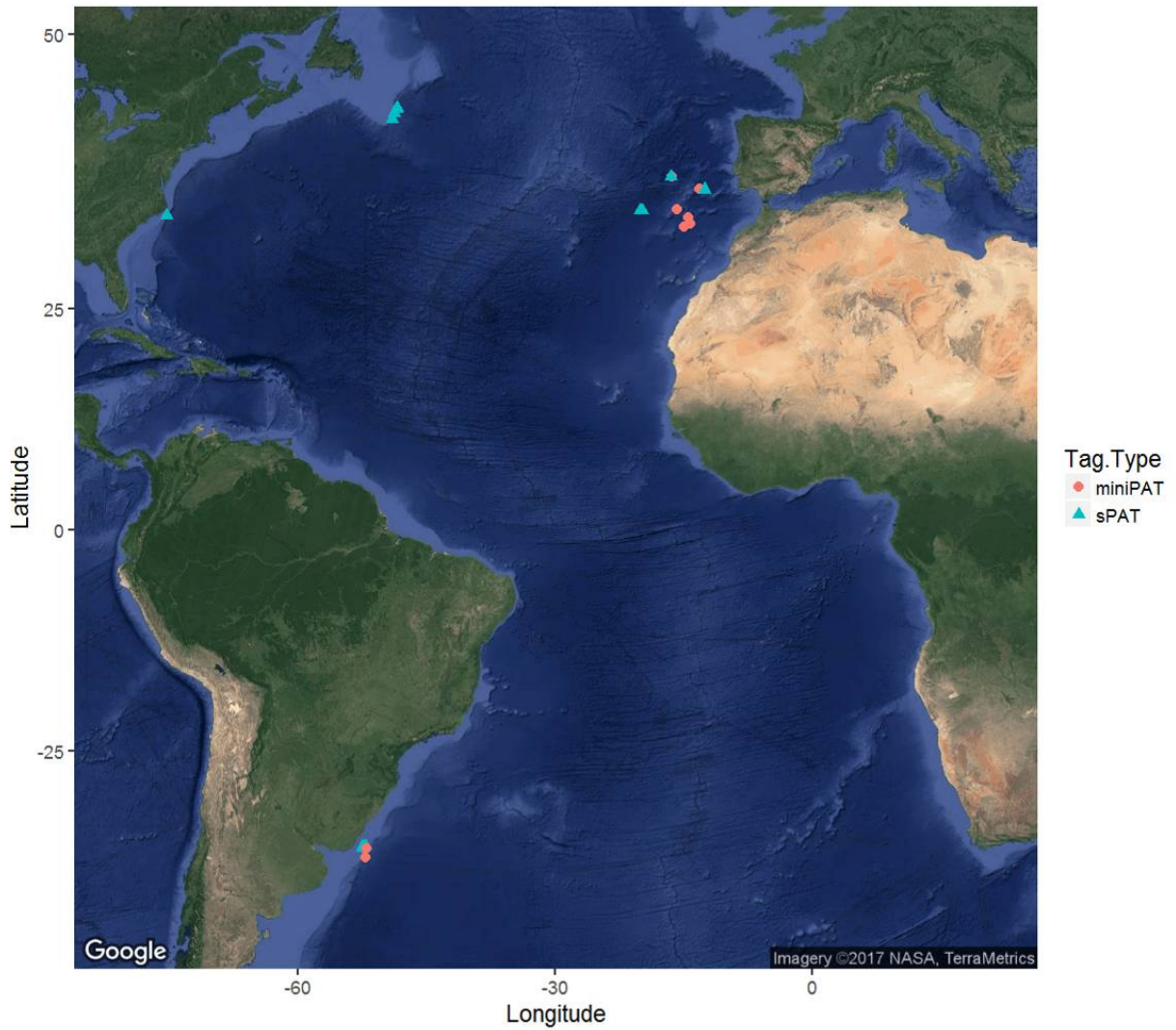
**Table 4.** Details of the tag characteristics and SMA specimens tagged to the present date. The table shows information from the tags acquired and deployed directly with the ICCAT/SRDCP project (miniPATs and sPATs), as well as other tags deployed by participating national scientists and institutes with additional funds from other sources and projects, and that will also contribute for the final analysis.

Project	Tag ID	Tag model	Size (FL)	Sex	Date	Planned (months)	Pop-up date	Tracking days	Tag/ deployment fate
ICCAT SRDCP	157339	miniPAT	128	F	21-Dec-15	4	20-Apr-16	121	OK
	157342	miniPAT	112	F	24-Jan-16	4	30-Mar-16	66	Premature release
	157341	miniPAT	124	M	9-Apr-16	4	7-Aug-16	120	OK
	157343	miniPAT	157	M	12-Apr-16	4	29-Apr-16	17	Mortality
	157344	miniPAT	107	M	12-Apr-16	4	14-Apr-16	2	Mortality
	157340	miniPAT	129	F	17-Apr-16	4	19-Apr-16	2	Mortality
	157345	miniPAT	139	M	27-Jun-16	4	2-Jul-16	5	Premature release
	157346	miniPAT	194	M	12-Dec-16	4	-	-	Tag failed
	157347	miniPAT	176	M	17-Dec-16	4	7-Jan-17	21	Sensor error
	157366	sPAT	145	M	17-Dec-15	1	16-Jan-16	30	OK
	157367	sPAT	104	M	30-Jan-16	1	29-Feb-16	30	OK
	157371	sPAT	173	M	19-Apr-16	1	20-Apr-16	1	Mortality
	157378	sPAT	170	M	19-Apr-16	1	20-Apr-16	1	Mortality
	157369	sPAT	190	U	28-Apr-16	1	27-May-16	29	OK
	157373	sPAT	180	M	06-Sep-16	1	06-Oct-16	30	OK
	157375	sPAT	215	U	06-Sep-16	1	06-Oct-16	30	OK
	157370	sPAT	180	M	12-Sep-16	1	12-Oct-16	30	OK
	157377	sPAT	240	M	17-Sep-16	1	30-Sep-16	13	Mortality
	157365	sPAT	190	F	18-Dec-16	1	17-Jan-17	30	OK
	157368	sPAT	214	F	18-Dec-16	1	17-Jan-17	30	OK
157376	sPAT	190	M	18-Dec-16	1	17-Jan-17	30	OK	
157374	sPAT	142	F	19-Dec-16	1	-	-	Tag failed	
157372	sPAT	195	F	19-Dec-16	1	18-Jan-17	30	OK	
LL-Sharks (EU.PRT)	136367	MTI Standard	160	M	10-Aug-15	2	-	-	Tag failed
	136368	MTI Standard	150	-	19-Aug-15	2	9-Sep-15	21	Premature release
	136369	MTI Standard	150	M	24-Oct-15	2	24-Dec-15	61	OK
	136370	MTI Standard	160	F	26-Oct-15	2	26-Dec-15	61	OK
	136371	MTI Standard	160	M	27-Oct-15	2	27-Dec-15	61	OK
	136372	MTI Standard	170	M	27-Oct-15	4	27-Feb-16	123	OK
	136373	MTI Standard	170	F	28-Oct-15	4	14-Dec-15	47	Premature release
	136374	MTI Standard	180	F	23-Dec-15	4	23-Apr-16	122	OK
	136376	MTI Standard	185	F	29-Dec-15	4	10-Mar-16	72	Fished
	136375	MTI Standard	180	F	7-Feb-16	4	-	-	Tag failed
Safewaters SC07 (EU)	160177	miniPAT	200	F	02-Aug-16	4	1-Dec-16	121	OK
	160178	miniPAT	150	F	24-Sep-16	4	4-Oct-16	10	Mortality
	160179	miniPAT	175	F	06-Sep-16	4	9-Sep-16	3	Mortality
	160180	miniPAT	180	F	20-Sep-16	4	19-Jan-17	121	OK
	160181	miniPAT	155	F	19-Sep-16	4	22-Sep-16	3	Mortality
NOAA (US- Uruguay) collaboration		MK10 PAT	200	M	14-Oct-14		7-Jan-15	72	

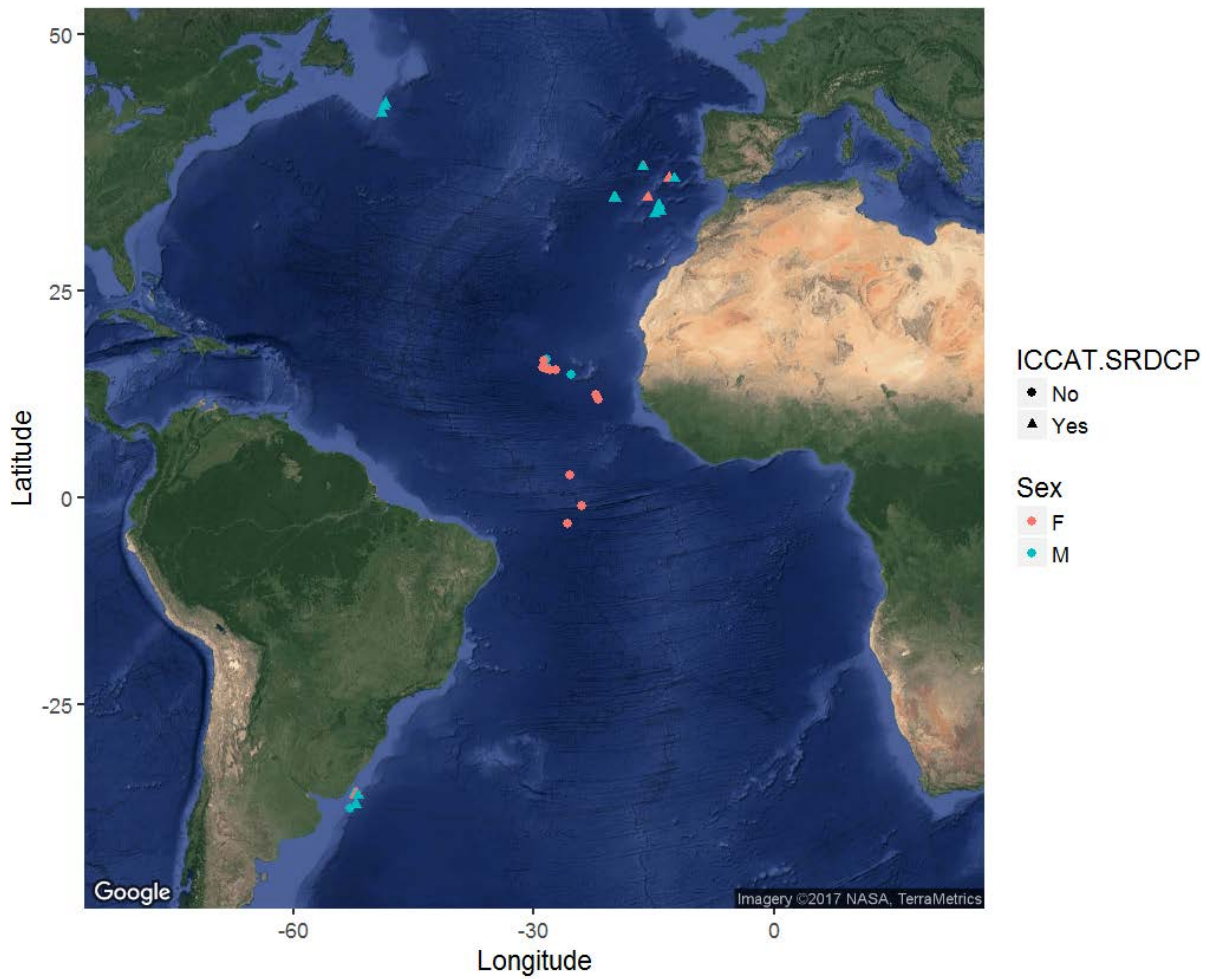


**Table 5.** Details of the miniPATs and sPATs deployed and with data reported that can be used to infer on post-release mortality. Fish condition (injuries) is used according to the ICCAT codes for tagging studies: P = Perfect (no visual damage); M = Moderate (superficial damage); S = Severe (could affect survival); U = Unknow.

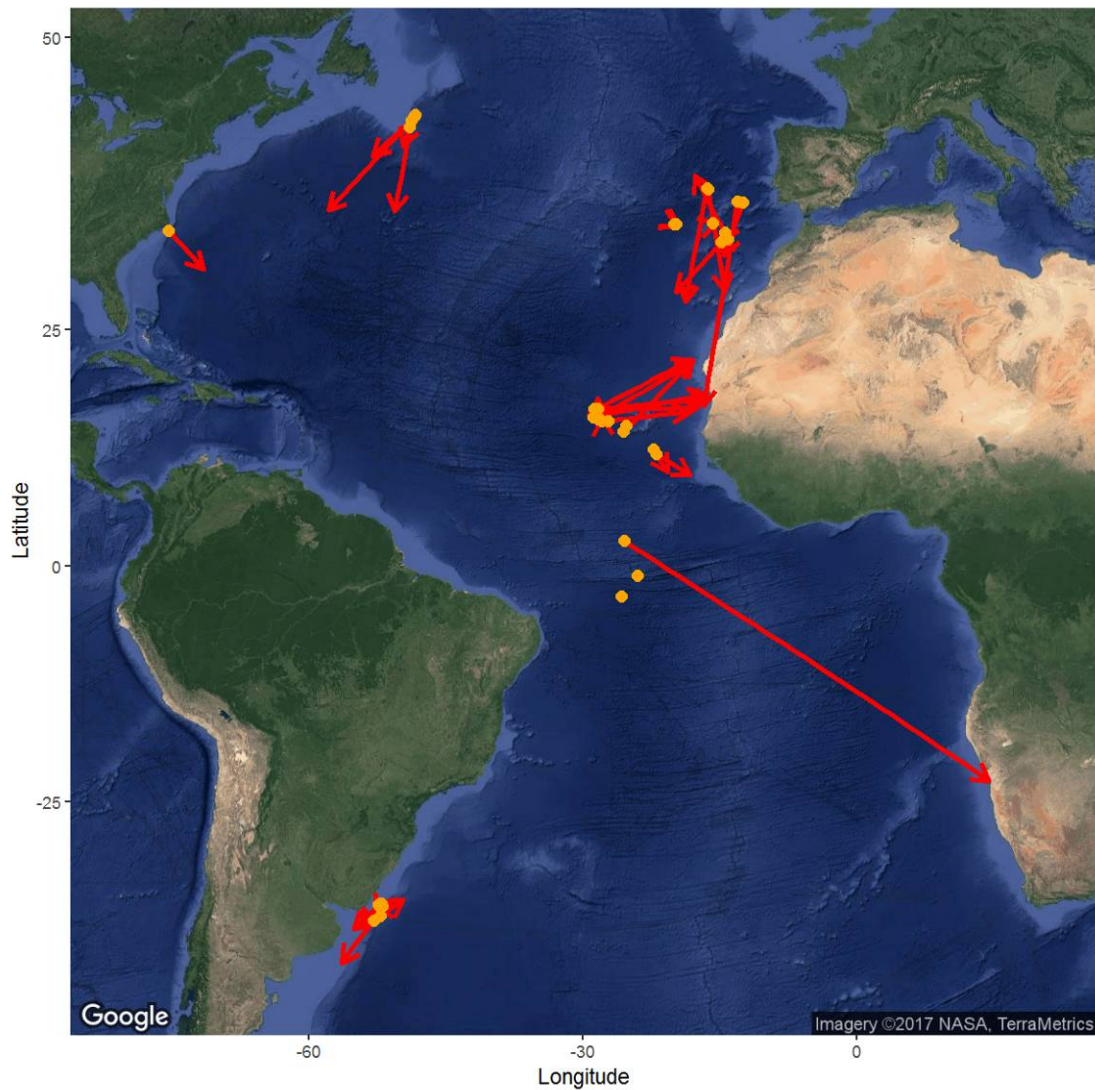
Tag ID	Tag model	Size (FL, cm)	Sex	Date	Fish condition (injuries)								Fate
					Global	head	mouth	eyes	skin	fins	body	gill slits	
157339	miniPAT	128	F	21-Dec-15	P	P	P	P	P	P	P	P	Survival
157340	miniPAT	129	F	17-Apr-16	P	P	P	P	P	P	P	P	Mortality
157341	miniPAT	124	M	09-Apr-16	P	P	P	P	P	P	P	P	Survival
157342	miniPAT	112	F	24-Jan-16	P	P	P	P	P	P	P	P	Survival
157343	miniPAT	157	M	12-Apr-16	P	P	P	P	P	P	P	P	Mortality
157344	miniPAT	107	M	12-Apr-16	P	P	P	P	P	P	P	P	Mortality
157365	sPAT	190	F	18-Dec-16	M	M	M	P	P	P	M	S	Survival
157366	sPAT	145	M	17-Dec-15	M	P	M	P	P	P	P	M	Survival
157367	sPAT	104	M	30-Jan-16	S	P	M	P	P	P	P	S	Survival
157368	sPAT	214	F	18-Dec-16	M	P	P	P	M	P	M	M	Survival
157369	sPAT	190	U	28-Apr-16	P	P	P	P	P	P	P	P	Survival
157370	sPAT	180	M	12-Sep-16	P	P	P	P	P	P	P	P	Survival
157371	sPAT	173	M	19-Apr-16	M	P	M	P	P	P	M	P	Mortality
157372	sPAT	195	F	19-Dec-16	M	P	M	P	P	P	M	P	Survival
157373	sPAT	180	M	06-Sep-16	P	P	P	P	P	P	P	P	Survival
157375	sPAT	215	U	06-Sep-16	P	P	P	P	P	P	P	P	Survival
157376	sPAT	190	M	18-Dec-16	M	P	M	P	P	P	P	S	Survival
157377	sPAT	240	M	17-Sep-16	P	P	P	P	P	P	P	P	Mortality
157378	sPAT	170	M	19-Apr-16	S	P	M	P	P	P	P	S	Mortality



**Figure 1.** Map with the location of the SMA satellite tag deployments (miniPATs and sPATs) for shortfin mako (*Isurus oxyrinchus*) carried out in 2015-1016 within the ICCAT/SRDPC Project (see **Table 4** for details).



**Figure 2.** Map with the location of the SMA satellite tag deployments for both male and female shortfin mako sharks (*Isurus oxyrinchus*). The map shows information from the tags acquired and deployed directly with the ICCAT/SRDPC project, as well as other tags deployed by participating national scientists and institutes with additional funds from other sources and projects that will also contribute for the final analysis (see **Table 4** for details).



**Figure 3.** Map with the SMA satellite tag tracks (preliminary strait line tracks). Orange dots represent tagging locations and the arrows represent the strait line tracks for the pop-up locations. The map shows information from the tags acquired and deployed directly with the ICCAT/SRDGP project, as well as other tags deployed by participating national scientists and institutes with additional funds from other sources and projects that will also contribute for the final analysis (see **Table 4** for details).