

UPDATE ON THE PORTUGUESE PELAGIC SHARKS RESEARCH PROGRAM IN THE ATLANTIC OCEAN, INCLUDING SAMPLES AND DATA UP TO 2015

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SUMMARY

Portuguese longliners targeting swordfish and operating in the Atlantic Ocean regularly capture elasmobranchs as bycatch. Of those, the blue shark (Prionace glauca) and the shortfin mako shark (Isurus oxyrinchus) constitute the two main shark species captured, even though several other species are also occasionally captured. IPMA, the Portuguese Institute for the Ocean and Atmosphere, is responsible for the National Data Collection Program, deploying fishery observers on longline vessels to collect fisheries data and samples. Therefore, IPMA has currently the means and opportunity to collect a wide variety of biological samples that are of ultimate importance to the work of the SCRS, particularly the sharks working group. In this document we present the current Portuguese pelagic shark research program for the Atlantic Ocean, and provide details regarding the collection of shark samples for the near future as per ICCAT Recommendation 13-10.

RÉSUMÉ

Les palangriers portugais ciblant l'espadon et opérant dans l'océan Atlantique capturent régulièrement des élamobranques comme prises accessoires. Parmi ceux-ci, le requin peau bleue (Prionace glauca) et le requin-taupe bleu (Isurus oxyrinchus) constituent les deux principales espèces de requins capturées, même si plusieurs autres espèces sont aussi occasionnellement capturées. IPMA, l'Institut portugais de l'océan et de l'atmosphère, est responsable du Programme national de collecte des données et déploie des observateurs des pêcheries sur les palangriers afin de recueillir des données sur les pêcheries et prélever des échantillons. Par conséquent, IPMA a actuellement les moyens et la possibilité de prélever une gamme variée d'échantillons biologiques qui sont d'une extrême importance pour les travaux du SCRS, notamment le groupe d'espèces sur les requins. Ce document présente le programme de recherche actuel portugais sur les requins pélagiques couvrant l'océan Atlantique et fournit des informations détaillées sur la collecte d'échantillons de requins pour l'avenir proche conformément à la Rec. 13-10 de l'ICCAT.

RESUMEN

Los palangreros portugueses que dirigen su actividad al pez espada y que operan en el océano Atlántico suelen capturar regularmente peces elasmobranchios como captura fortuita. De ellos, la tintorera (Prionace glauca) y el marrajo dientuso (Isurus oxyrinchus) son las dos principales especies de tiburones capturadas, aunque ocasionalmente se capturan también otras especies. El IPMA, el Instituto portugués del océano y la atmósfera, es el responsable del Programa nacional de recopilación de datos y asigna observadores en los palangreros para recopilar datos y muestras de las pesquerías. Por ello, el IPMA cuenta actualmente con la oportunidad y los medios para recoger una amplia variedad de muestras biológicas que son de gran importancia para el trabajo del SCRS, especialmente para el Grupo de especies de tiburones. En este documento, se presenta el actual programa portugués de investigación sobre tiburones pelágicos en el Atlántico, y se presentan detalles sobre la recopilación de muestras de tiburones para el futuro cercano de acuerdo con la Recomendación 13-10 de ICCAT.

KEYWORDS

Data collection, Genetics, Life history, Pelagic sharks, Research program, Sampling, Tagging

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1. Introduction

A great variety of sharks species are found within the ICCAT Convention area, from coastal to oceanic species. Among these, several pelagic shark species are currently present in the ICCAT databases and are currently impacted by commercial and recreational fisheries. However, there is still limited information about their life cycles, biological parameters, movement patterns and habitat utilization, and in the general impact of tuna fisheries in their populations in the ICCAT Convention area. Therefore, the current knowledge on ICCAT fisheries capturing sharks is causing concerns on their conservation status and management, due to the gaps in the available catch, effort and discards data. Thus, as recognized by the Sharks Working Group, poor shark fisheries data quality (and quantity) and biological knowledge gaps are limiting factors affecting the provision of the scientific advice to the Commission. Moreover, the efficiency of some recent management regulations implemented is still to be assessed.

Therefore, in the early 2000's EU-Portugal started a data collection and research program for its pelagic longline fishery, which has the pelagic sharks as a major component. The main objectives of this program are integrated with life history, population dynamics, tagging studies, genetic studies and gear technology studies, taking into consideration the results from the ERA conducted by the SCRS Sharks Working Group (WG). The main purpose is to contribute with data that can be used for the work of the SCRS Sharks Working Group, both when conducting stock assessments or other analysis on pelagic sharks.

In 2014, the EU.PRT Research program was presented to the ICCAT Sharks WG (Santos and Coelho, 2014) in order to fulfill the data and sample collection reporting requirements by the SCRS. Updated tables with the collected vertebrae and genetic tissues sample sizes, as well as the expected collection for the future, were presented. Additionally, the current projects lead by IPMA (EU.PRT) in terms of gear technology and tagging were also listed. In 2015, an update of this research program was presented (Coelho and Santos, 2015), with the new samples and data collected in the period.

What follows is a brief description of the research actions being carried out and plans for the near future regarding pelagic sharks caught on the Portuguese longline fishery. Following ICCAT Recommendation 13-10 (Recommendation on biological sampling of prohibited shark species by scientific observers), detailed information is provided regarding the request for sampling three of those currently prohibited species.

2. Objectives

The general aim of the pelagic shark component of this research program is to promote advances in the current knowledge on these species caught by the Portuguese longline fishery within the swordfish longline fishery in the Atlantic Ocean.

The specific objectives cover a wide range of issues, including biological, ecological and gear technology (mitigation) aspects. These studies will run in parallel with similar studies in the Indian Ocean, and often within the scope of the SCRS Sharks Working Group cooperative research initiatives involving research Institutes from other ICCAT Contracting Parties.

2.1 Life history and population dynamics of major shark species

Specific objectives of this task are to estimate population parameters in terms of:

1. Age and growth;
2. Reproduction

Ageing the sharks and modelling the growth of the populations is being accomplished by processing hard-structures of the specimens, specifically vertebrae. 10 to 15 samples per sex and 10 cm size classes are being collected for each shark species. To accomplish this, a section of 8-10 vertebrae is removed from selected specimen, frozen on-board the fishing vessels and then transported frozen to the IPMA laboratory (located in Olhão, Algarve, southern Portugal). Once in the laboratory, the vertebrae are processed using age and growth protocols for elasmobranchs (see for example Cailliet, 1990). Within this task we expect to be able to model growth (e.g. using von Bertalanffy growth models), and estimate parameters that can then be used in stock assessment models.

For the reproduction component of the study the data is recorded by on-board fishery observers. Specifically, data on the maturity stages, fecundity, seasonality and sex-ratio of the embryos is recorded and used for the analysis. This data is relevant for understanding not only the spatial-temporal dynamics of the populations, but it also allows the estimation of some parameters that can be used in population dynamics models, such as Leslie matrices that can use age/stage specific fecundities.

2.2 Tagging studies

The tagging component has three main objectives:

1. Determine migration patterns in the main areas of operation of the Portuguese pelagic longline fleet, assessing possible critical habitats such as mating and nursery areas;
2. Study habitat preferences in terms of depth and temperature;
3. Determine survivorship of sharks discarded alive.

ARGOS compatible Popup Archival Transmitting tags (PAT) from various projects and sources are being deployed on selected shark species. These tags are particularly suitable to track large-scale movements and behavior of large marine species, and are usually programmed to remain attached to the sharks for periods of 30 to 120 days.

The obtained information is providing insights on migratory patterns and habitat utilization of those species in the Atlantic Ocean, as well as on the existence of possible critical habitat areas, such as mating and nursery areas. Other main objective of this task is to determine the survivorship of sharks once released from the commercial fishing vessels. In fact, the question on what happens to the sharks once discarded still remains unanswered for most species and the fact that a specimen is discarded alive does not necessarily mean that it will survive the trauma of the fishing process. Therefore, calculating those long-term survival rates is extremely important not only to assess the efficiency of such management measures, but also to be used within the assessment models.

2.3. Genetic studies

The genetic component of this research project has four main objectives:

1. Identify the quantity and geographical distribution of mitochondrial DNA haplotypes of various shark species in the Atlantic Ocean;
2. Develop microsatellite *loci* using next generation sequencing techniques;
3. Establish a phylogenetic relationship between the different populations and;
4. Provide guidance on the geographical boundaries of the different populations/stocks for purposes of fisheries management and conservation initiatives.

For the population analysis based on mitochondrial DNA sequences and microsatellite markers, muscle and/or fin clips are being collected from selected species caught during the fishing operations and stored in 95% ethanol. The samples are sent to research partners (e.g. Laboratory of Biology and Fish Genetics in the Federal University of São Paulo, Brazil - UNIFESP, or National Research Institute of Far Seas Fisheries, Japan - NRIFSF), where our collaborative research partners are responsible for processing the samples and analyzing the data.

The information gathered from this component of the study is extremely important for inferring the genetic diversity within the species across the Atlantic Ocean and can provide insights on the structure of the populations. This is very important as the establishment of biological meaningful fishing stocks is essential for a correct management of the fisheries.

2.4. Gear technology studies

The gear technology study, a specific project carried out by IPMA (LL-Shark, funded by Promar) aimed to investigate mitigation measures for shark bycatch, specifically assessing the impact of the use of wire traces on the Portuguese pelagic longline swordfish fishery. This was done by comparing the catch rates of target and

bycatch species and at-haulback (on vessel) shark mortality, from traditional monofilament traces to those obtained with wire traces and using different bait type (squid vs. mackerel). The preliminary results of this project have been presented to ICCAT (Santos *et al.*, 2014a) and IOTC (Santos *et al.*, 2014b). The final results will soon be available in the peer-review literature.

3. Sample collection

Taking into consideration the results of the Ecological Risk Assessment recently conducted by the Sharks Working Group of the SCRS (Cortés *et al.*, 2010, 2012), priority was given to the species ranked on the top 10. Therefore, and because sample collection is limited to those fishing trips where a scientific observer is present on-board, the program was expected to run for at least 5 consecutive years.

The samples for estimating the life history parameters and genetics are being collected within the scope of the “*European Data Collection Framework - DCF*”, ongoing at IPMA in Portugal. Within this program we are currently capable of maintaining fishery observers’ on-board commercial longliners for trips of 20-90 days, covering a wide geographical area in the Atlantic Ocean, particularly on the Northern Hemisphere. Preliminary catch data gathered in the initial years of the program resulted in the catch of 15 shark species. The most frequently species caught consisted of blue shark (*Prionace glauca*, BSH) and shortfin mako (*Isurus oxyrinchus*, SMA). Other species accidentally caught included bigeye thresher (*Alopias superciliosus*, BTH), oceanic whitetip (*Carcharhinus longimanus*, OCS), smooth hammerhead (*Sphyrna zygaena*, SPZ), silky shark (*C. falciformis*, FAL), and crocodile shark (*Pseudocarcharias kamoharai*, PSK). At a much lower level were also caught longfin mako (*I. paucus*, LMA), porbeagle (*Lamna nasus*, POR) and tiger shark (*Galeocerdo cuvier*, TIG).

The details of the samples already available at IPMA, and the prediction of the needs in the future are shown in **Table 1** (North Atlantic) and **Table 2** (South Atlantic). These needs will be evaluated and revised on an annual basis depending on the success of sampling in each year.

A map of the collected samples is provided in **Figure 1**, and species-specific length-frequency distribution plots are presented in **Figures 2 to 7**. All analysis and plots were created in R (R Core Team, 2015), using libraries ggplot2 (Wickham, 2009) and ggmap (Kahle and Wickham, 2013).

Funding for biological sampling using the missions from the fishery observers is already guaranteed until 2020 through the DCF program. Further, funding is also available from several additional projects to tag 20 blue sharks and 15 shortfin makos starting in the 1st semester of 2016 with both PSAT and SPOT tags.

It should be noted that since the listing of several pelagic shark species in the CITES appendices, IPMA has stopped collecting samples of both vertebrae and genetic tissue on those species, specifically for oceanic whitetip shark and hammerheads. IPMA is trying to solve the issue of the permits so that sampling on those species can be resumed.

4. Reporting

As in previous years (see Santos and Coelho, 2014; and Coelho and Santos, 2015) EU-Portugal commits to report to the SCRS on an annual basis on the activities carried out during the previous year and to present the main results achieved within the scope of this research program, as per ICCAT Recommendation 13-10.

Acknowledgments

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the conservation of pelagic sharks associated to fishing activity under EU Sustainable Fisheries Partnership Agreements in the Atlantic Ocean (Framework Contract MARE/2012/21, funded by DG-MARE - European Commission)" and the "ICCAT-SRDCP - ICCAT Shark Research and Data Collection Program (funded by ICCAT)". Rui Coelho is supported by an Investigador-FCT contract from the Portuguese Foundation for Science and Technology (FCT, *Fundação para a Ciência e Tecnologia*) supported by the EU European Social Fund and the Programa Operacional Potencial Humano (Ref: IF/00253/2014).

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Table 1. Detailed number of samples currently collected and expected to still be collected within the course of the project for the North Atlantic (North of 5°N). Last updated in March 2016.

Species	Prohibited to retain in ICCAT	Listed in CITES	Vertebrae		Genetic tissue	
			Collected	To collect	Collected	To collect
BSH	No	No	1120	*	300	200
SMA	No	No	110	390	80	420
LMA	No	No	85	415	80	420
OCS**	Yes	Yes	190	310	100	400
SPZ**	Yes	Yes	150	350	80	420
FAL	Yes	No	25	475	20	480

Table 2. Detailed number of samples currently collected and expected to still be collected within the course of the project for the South Atlantic (South of 5°N). Last updated in March 2016.

Species	Prohibited to retain in ICCAT	Listed in CITES	Vertebrae		Genetic tissue	
			Collected	To collect	Collected	To collect
BSH	No	No	260	740	100	400
SMA	No	No	120	380	115	385
LMA	No	No	80	420	50	450
OCS**	Yes	Yes	150	350	100	400
SPZ**	Yes	Yes	185	315	80	420
FAL	Yes	No	25	475	20	480

Notes on tables:

* Only collecting particular size classes (extremes of the size range).

** Species not sampled in 2015. Since the listing of several pelagic shark species in the CITES appendices, IPMA has stopped collecting samples of both vertebrae and genetic tissue on those species. IPMA is trying to solve the issue of the CITES permits so that sampling on those species can be resumed.

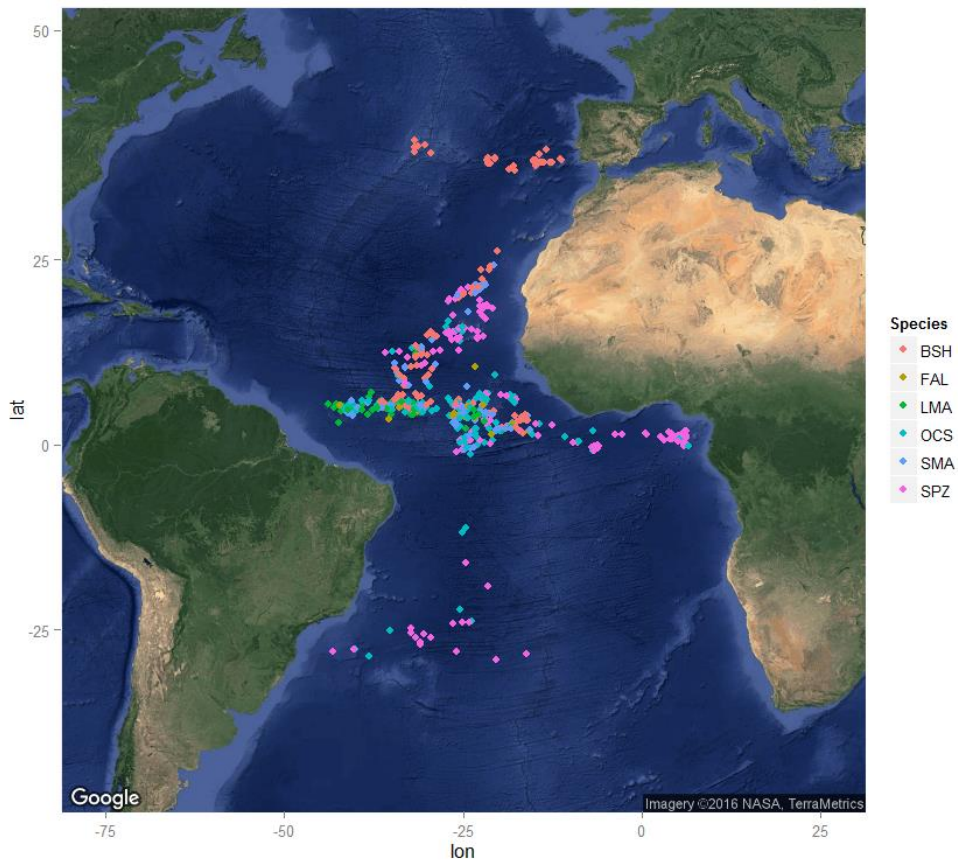


Figure 1. Distribution map with the location of the species-specific vertebra samples collected during the course of the project in the Atlantic Ocean, for age and growth studies.

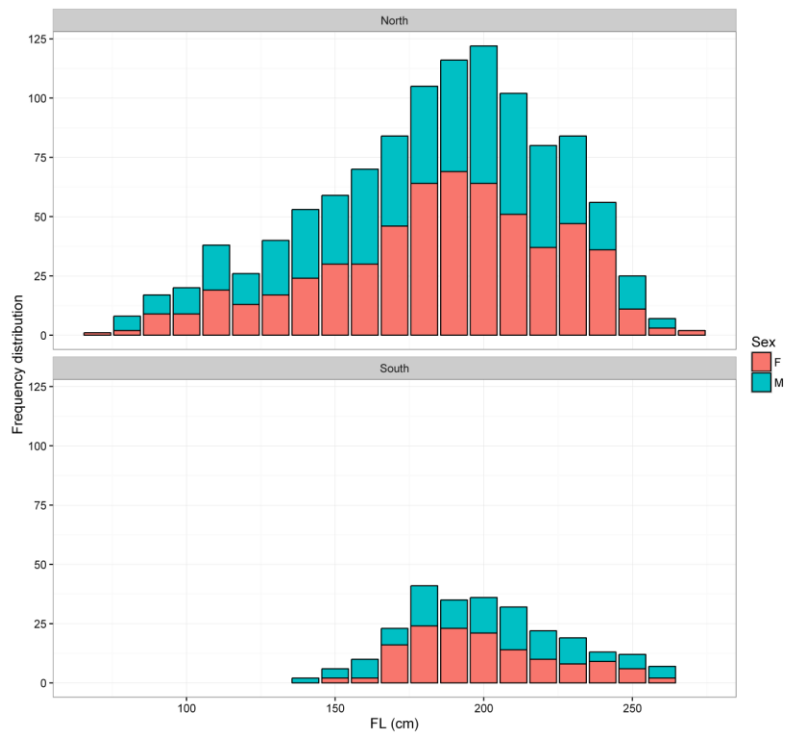


Figure 2. Size (fork length, in cm) frequency distribution of male and female blue shark (*Prionace glauca*) collected during the course of the project in the North and South Atlantic (separated at the 5°N).

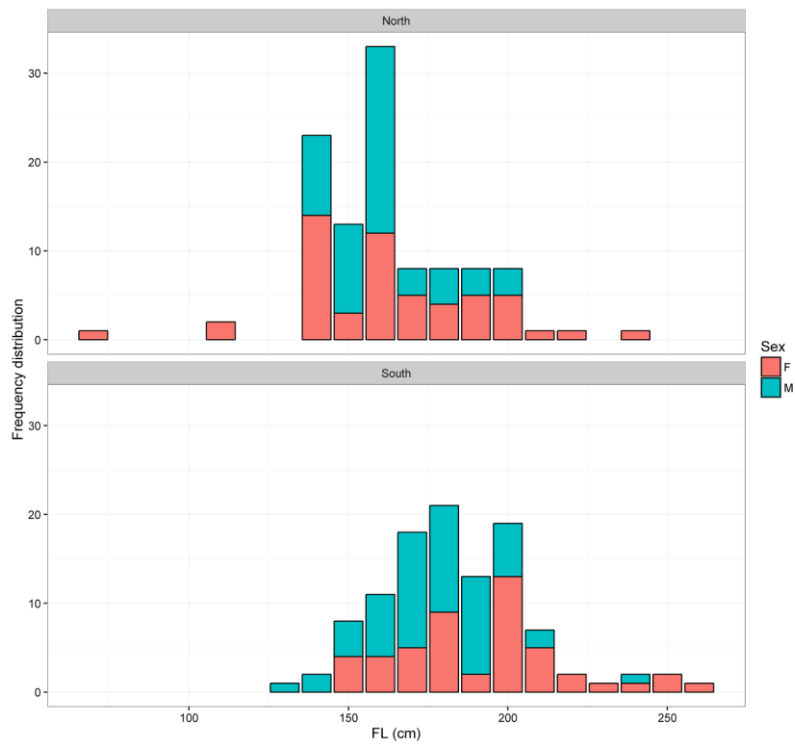


Figure 3. Size (fork length, in cm) frequency distribution of male and female shortfin mako (*Isurus oxyrinchus*) collected during the course of the project in the North and South Atlantic (separated at the 5°N).

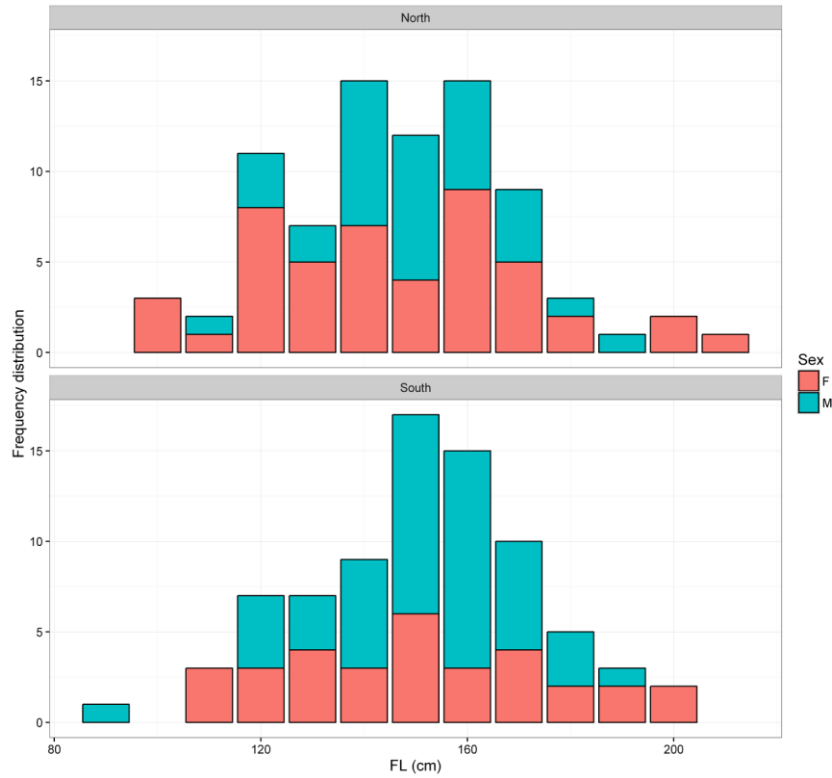


Figure 4. Size (fork length, in cm) frequency distribution of male and female longfin mako (*Isurus paucus*) collected during the course of the project in the North and South Atlantic (separated at the 5°N).

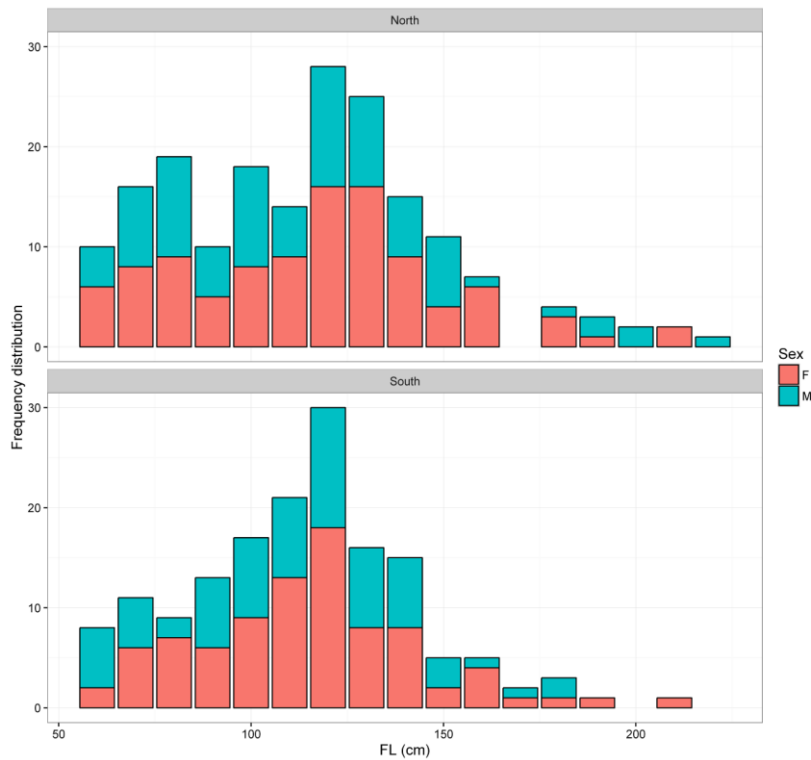


Figure 5. Size (fork length, in cm) frequency distribution of male and female oceanic whitetip shark (*Carcharhinus longimanus*) collected during the course of the project in the North and South Atlantic (separated at the 5°N).

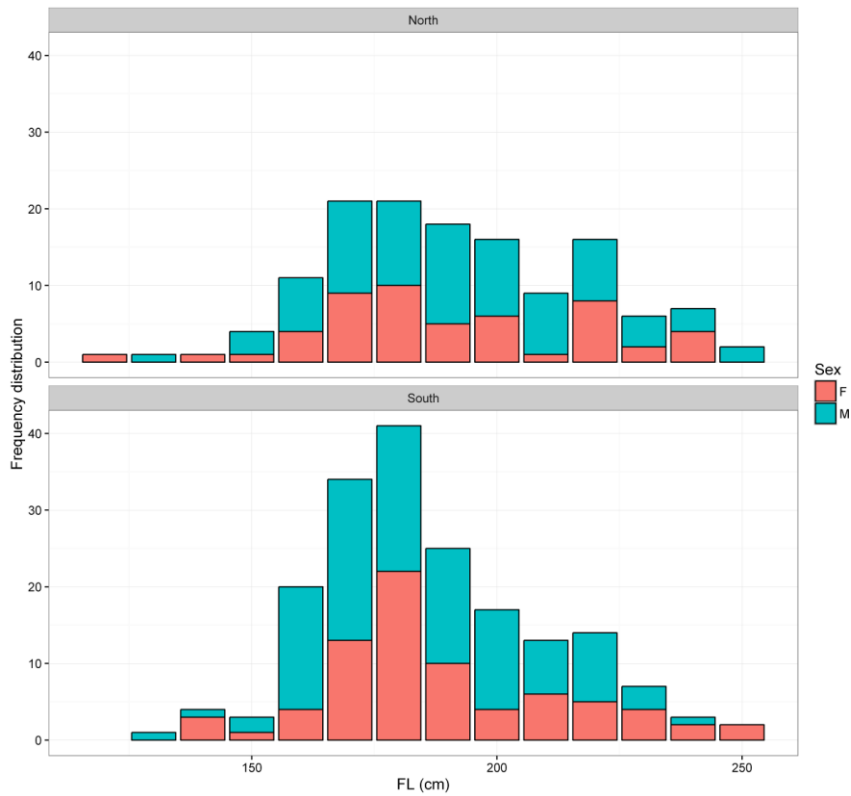


Figure 6. Size (fork length, in cm) frequency distribution of male and female smooth hammerhead (*Sphyrna zygaena*) collected during the course of the project in the North and South Atlantic (separated at the 5°N).

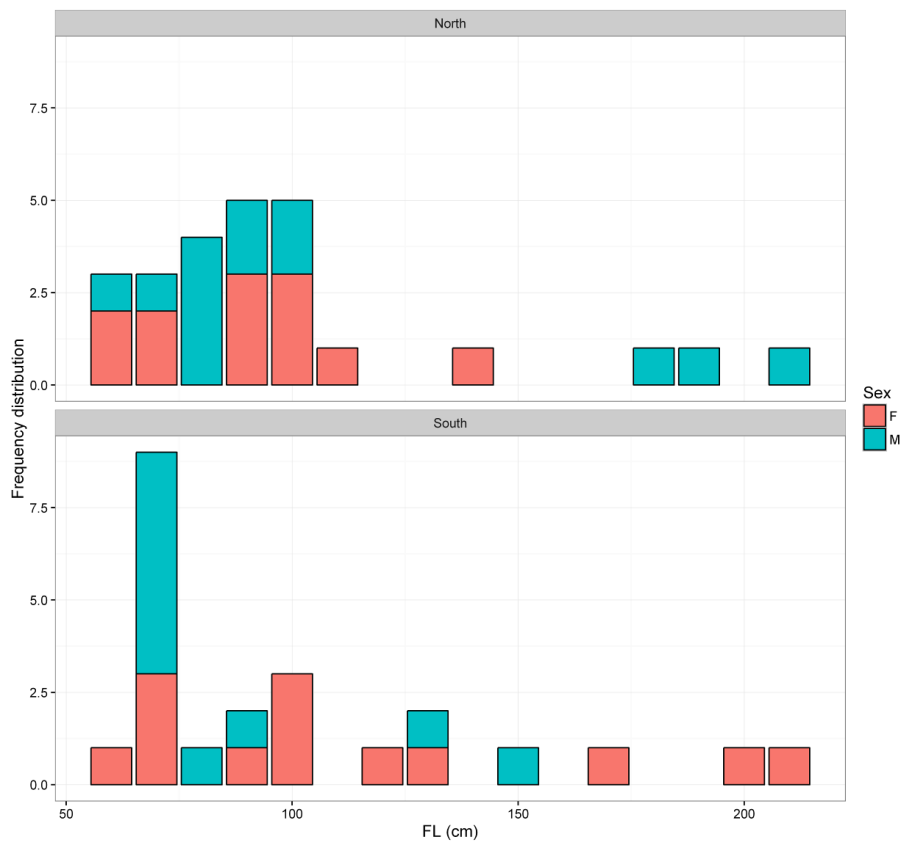


Figure 7. Size (fork length, in cm) frequency distribution of male and female silky shark (*Carcharhinus falciformis*) collected during the course of the project in the North and South Atlantic (separated at the 5°N).