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

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*SUMMARY*

*Portuguese longliners targeting swordfish and operating in the Indian 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 Working Party on Ecosystems and Bycatch. In this document we present the current Portuguese pelagic shark research program for the Indian Ocean, and provide details regarding the collection of shark samples for the near future, specially for BTH and OCS as per IOTC Resolution 12/09 and 13/06, respectively.*

*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 IOTC Convention area, from coastal to oceanic species. Among these, several pelagic shark species are currently present in the IOTC 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. Therefore, the current knowledge on IOTC 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 Working Party on Ecosystems and Bycatch (WPEB), poor shark fisheries data quality (and quantity) and biological knowledge gaps are limiting factors affecting the provision of scientific advice. Moreover, the efficiency of some recent management regulations implemented is still to be assessed.

Therefore, starting in 2011 EU-Portugal started a data collection and research program for its pelagic longline fishery in the Indian Ocean, 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. The main purpose is to contribute with data that can be used for the work of the WPEB, both when conducting stock assessments or other analysis on pelagic sharks.

In 2011, the first report of the Portuguese research program was presented to the WPEB (Santos & Coelho, 2011), and since then several works have been presented taking advantage and using those data and samples, including works on catches, distribution and standardized catch rates (e.g, Coelho et al., 2012, 2013, 2014, 2015), at-haulback mortality (e.g., Coelho et al., 2011) and gear technology including effects of hook type, trace materials and baits (e.g., Santos et al., 2012, 2014a).

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 IOTC Resolution 12/09 (Resolution on the conservation of thresher sharks (family Alopiidae) caught in association with fisheries in the IOTC area of competence) and IOTC Resolution 13/06 (Resolution on a scientific and management framework on the Conservation of sharks species caught in association with IOTC managed fisheries) detailed information is provided regarding the request for sampling those species currently prohibited to retain.

## 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 Indian 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 Atlantic 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.

Satellite 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 can provide insights on migratory patterns and habitat utilization of those species, 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.

The cost for satellite tagging studies is high, so the implementation will depend on the availability of funding. So far it has not yet been possible to deploy any satellite tags in pelagic sharks in the Indian Ocean within the Portuguese pelagic shark research program. However, the presence of the fleet and the fishery observer coverage (noting that the fishery observers present already have substantial experience deploying satellite tags from the Atlantic) is a good opportunity to start deploying those tags.

### *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 Indian 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 96% 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 Indian 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 IOTC (Santos *et al*., 2014a) and ICCAT (Santos *et al*., 2014b). The final results will soon be available in the peer-review literature.

**3. Sample collection**

Priority on the species has been given to the species most captured by the fleet and also teh ones that are the focus of the IOTC/WPEB. 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*, through the Portuguese *Programa Nacional de Amostragem Biológica - PNAB*", ongoing at IPMA in Portugal. Within this program we are currently capable of maintaining fishery observers' on-board commercial longliners for trips of 60-120 days, covering mainly the South and Southwest Indian Ocean. 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 there were also some captures of 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**. These needs will be evaluated and revised on an annual basis depending on the success of sampling in each year. Funding for biological sampling using the missions from the fishery observers is already guaranteed until 2020 through the DCF program.

A map of the collected samples is provided in **Figure 1**, and species-specific length-frequency distribution plots are presented in **Figures 2 to 8**. All analysis and plots were created in R (R Core Team, 2016), using libraries ggplot2 (Wickham, 2009) and ggmap (Kahle and Wickham, 2013).

It should be noted that since the listing of several pelagic shark species in CITES (*Convention on International Trade in Endangered Species of Wild Fauna and Flora*), IPMA has stopped collecting samples of both vertebrae and genetic tissue on those CITEs listed species, specifically for oceanic whitetip shark and hammerheads. IPMA is trying to solve the issue of the sampling permits, so that biological sampling on those species can be resumed.

**4. Reporting**

As in previous years, EU-Portugal commits to report periodically to the IOTC/WPEB on an annual basis, and as needed, on the activities carried out during the previous year and to present the main results achieved within the scope of this research program.

**5. Acknowledgments**

Sampling and data collection from the Portuguese fishery are mainly obtained and funded by PNAB - *Programa Nacional de Amostragem Biologica*, within the scope of the *EU Data Collection Framework* (DCF). Additional samples and data come from specific research projects, such as Project "*LL-Sharks: Mitigação das capturas de tubarões na pescaria de palangre de superfície* (Ref: 31-03-05-FEP-44, funded by PROMAR)";. 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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**Tables**

**Table 1.** Detailed number of samples currently collected and expected to still be collected within the course of the project for the Indian Ocean. Last updated in July 2016.

| Species | Prohibited to retain in IOTC | Listed in CITES | Vertebrae | | Genetic tissue | |
|---|---|---|---|---|---|---|
| | | | Collected | To collect | Collected | To collect |
| BSH* | No | No | 740 | 260 | 790 | 200 |
| SMA | No | No | 310 | 190 | 360 | 140 |
| LMA | No | No | 10 | 490 | 10 | 490 |
| OCS** | Yes | Yes | 10 | 490 | 10 | 490 |
| SPZ** | No | Yes | 30 | 470 | 50 | 450 |
| FAL | No | No | 40 | 460 | 40 | 460 |
| BTH | Yes | No | 50 | 450 | 60 | 440 |

Notes on tables:

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

**: Species not sampled since 2014. 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 biological sampling on those species can be resumed.

**Figures**

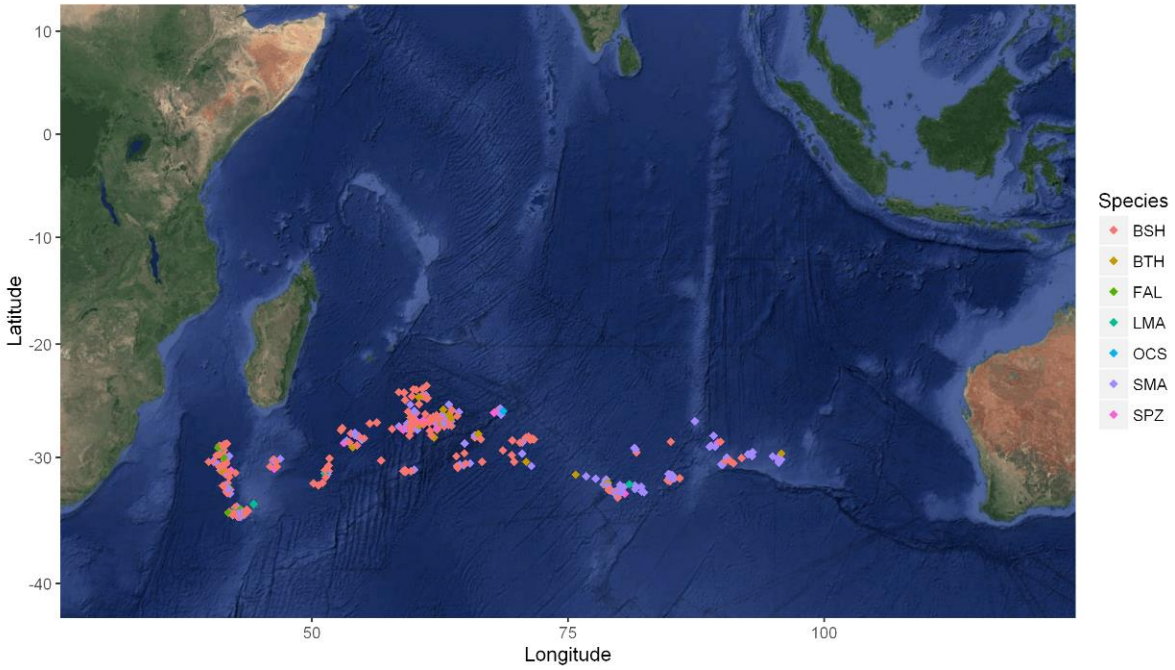


**Figure 1**: Distribution map with the location of the species-specific vertebra samples collected during the course of the project in the Indian Ocean, for age and growth studies.

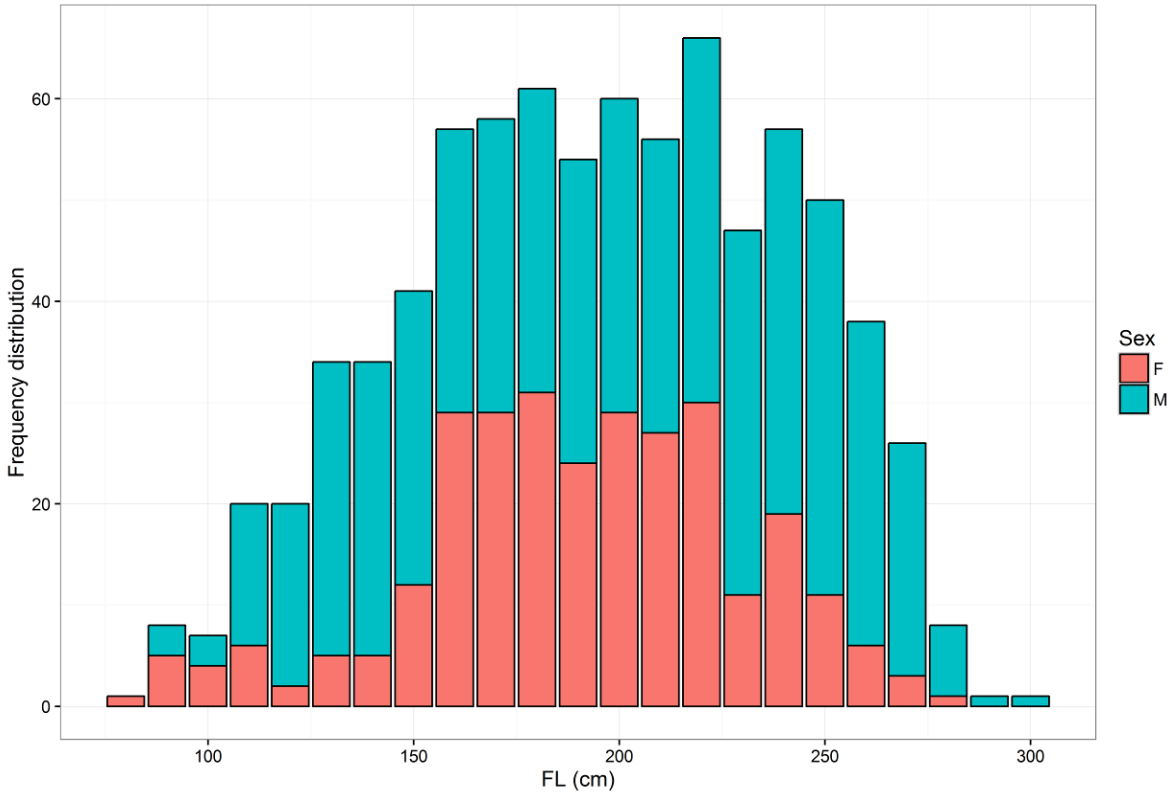


**Figure 2**. Size (fork length, in cm) frequency distribution of male and female blue shark (*Prionace glauca*) collected during the course of the project in the Indian Ocean.

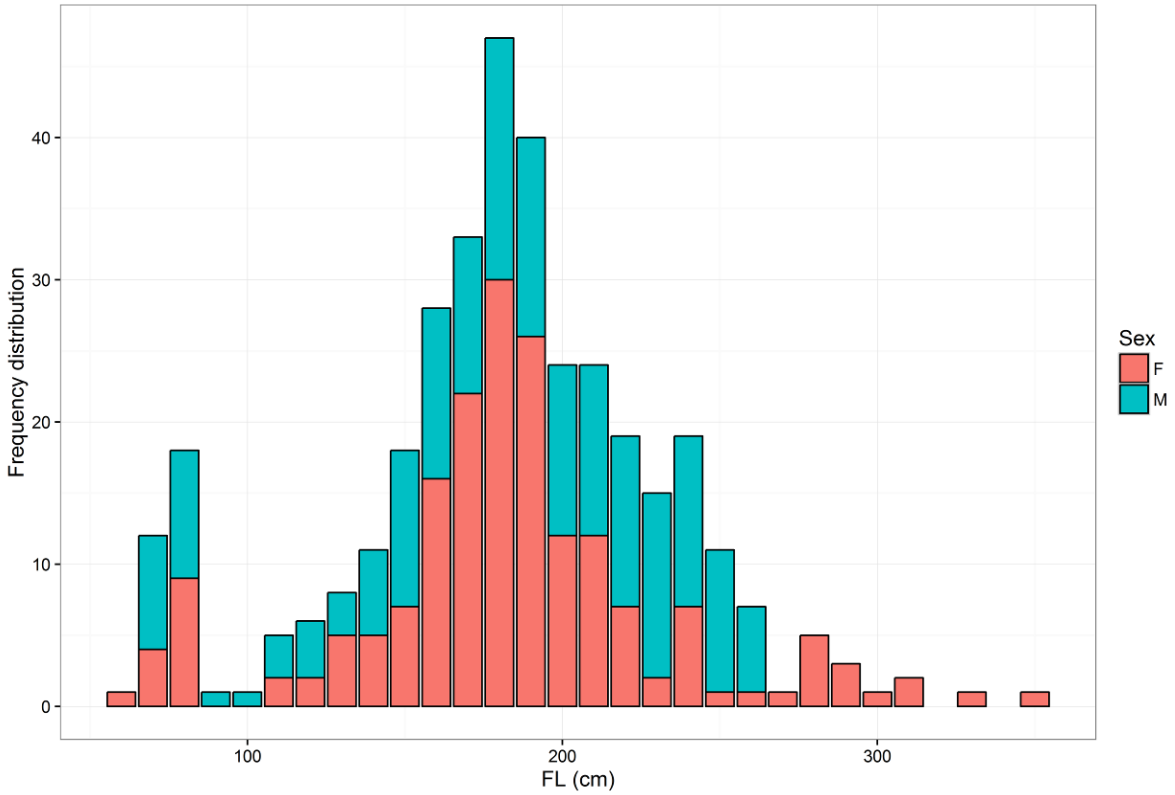


**Figure 3**. Size (fork length, in cm) frequency distribution of male and female shortfin mako (*Isurus oxyrinchus*) collected during the course of the project in the Indian Ocean.

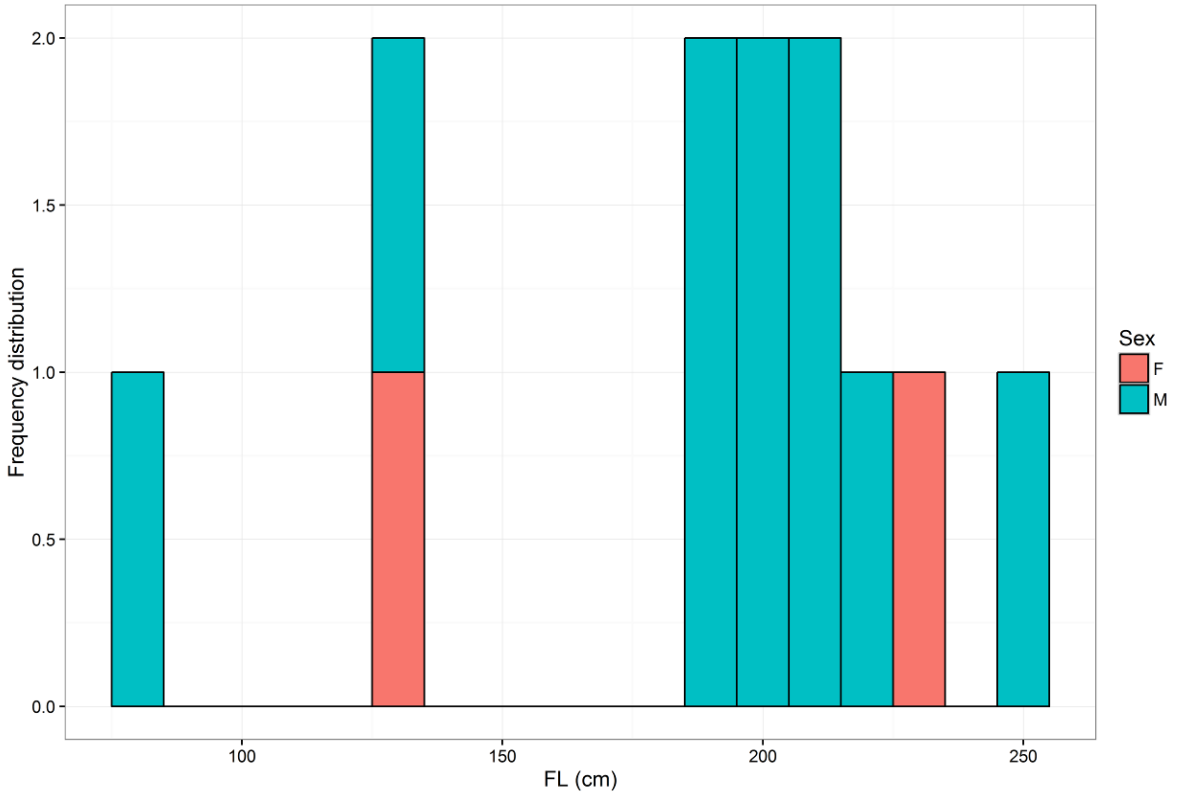


**Figure 4**. Size (fork length, in cm) frequency distribution of male and female longfin mako (*Isurus paucus*) collected during the course of the project in the Indian Ocean.

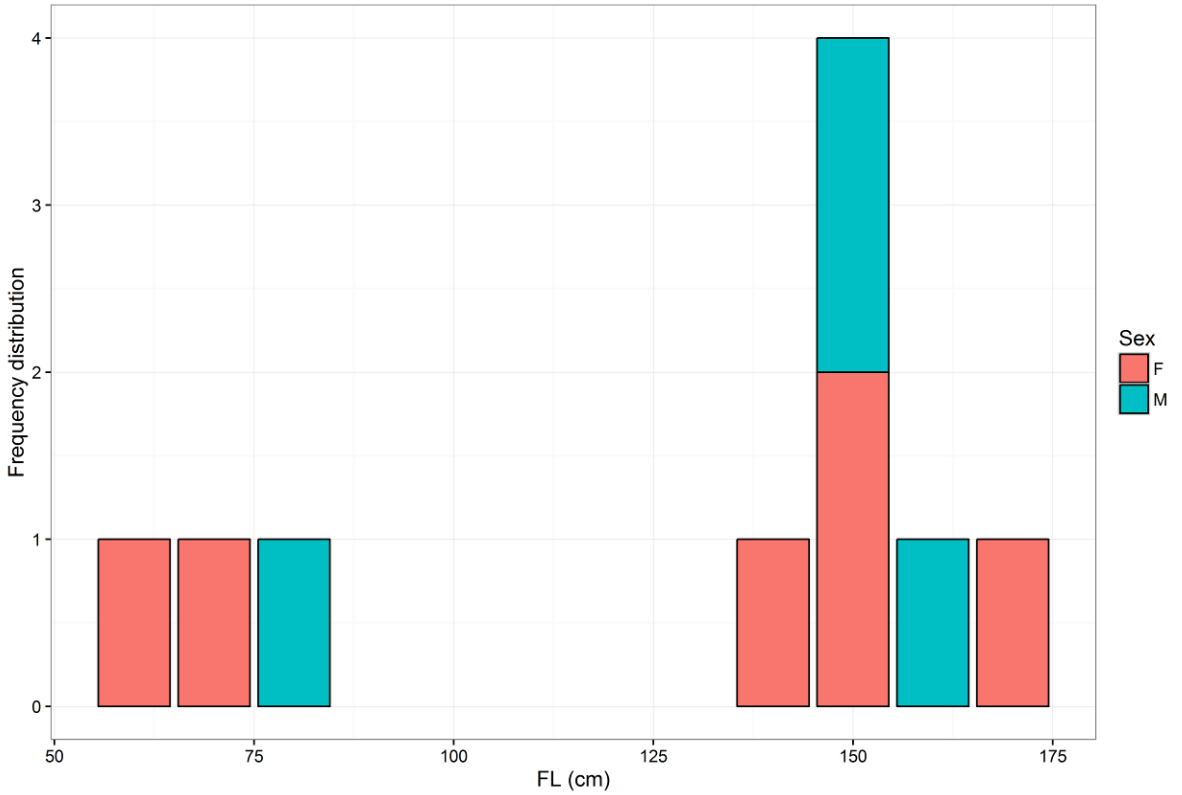


**Figure 5**. Size (fork length, in cm) frequency distribution of male and female oceanic whitetip shark (*Carcharhinus longimanus*) collected during the course of the project in the Indian Ocean.

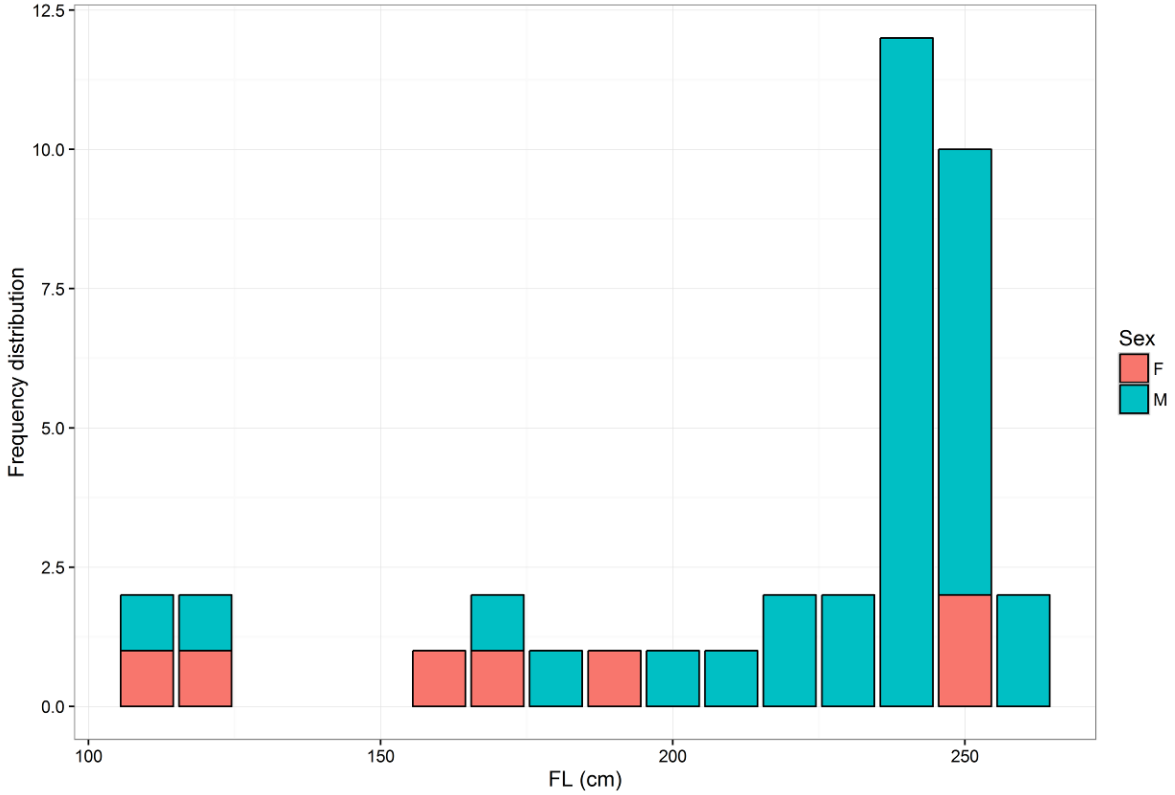


**Figure 6**. Size (fork length, in cm) frequency distribution of male and female smooth hammerhead (*Sphyrna zygaena*) collected during the course of the project in the Indian Ocean.

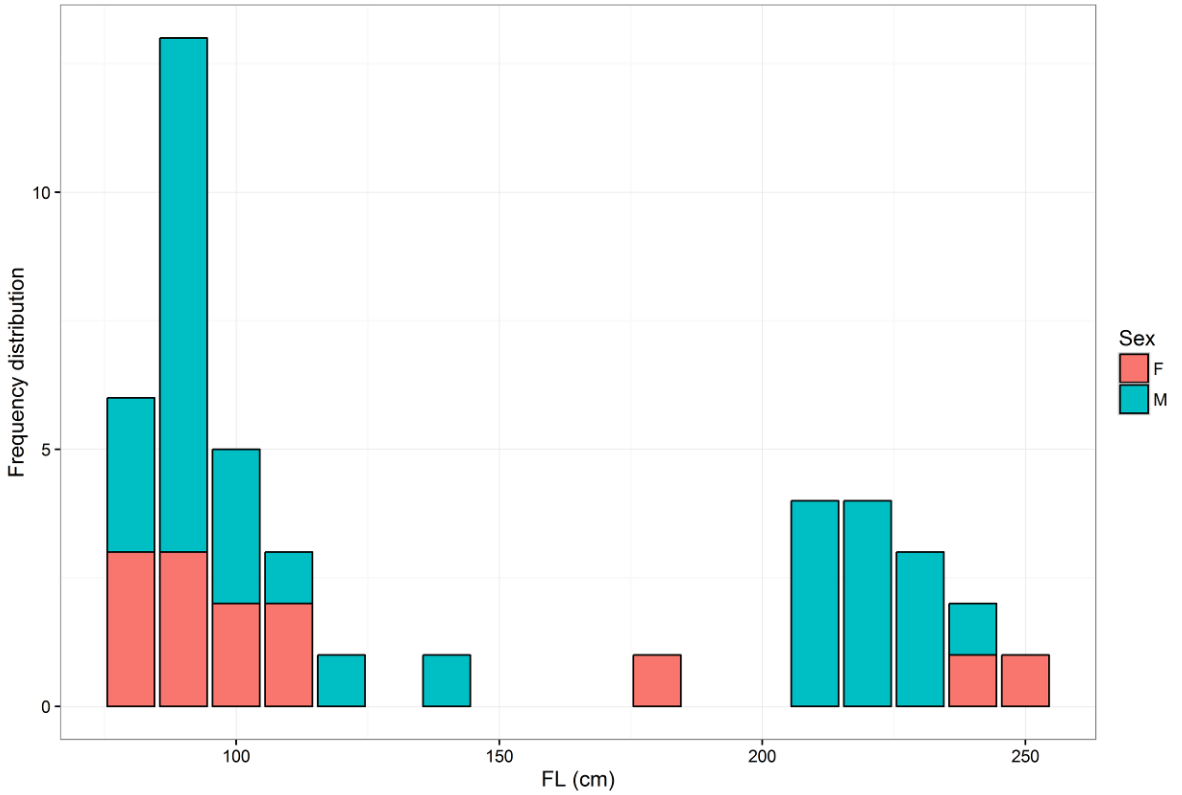


**Figure 7**. Size (fork length, in cm) frequency distribution of male and female silky shark (*Carcharhinus falciformis*) collected during the course of the project in the Indian Ocean.

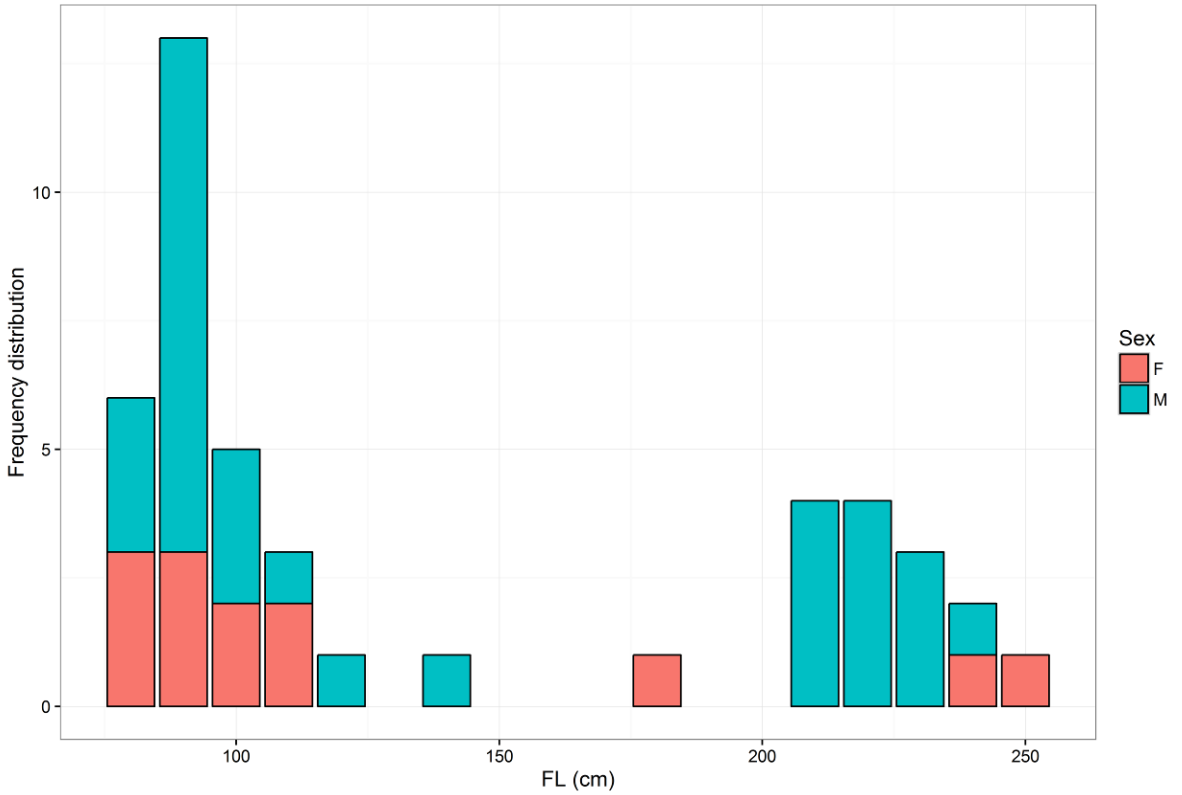


**Figure 8**. Size (fork length, in cm) frequency distribution of male and female bigeye thresher (*Alopias superciliosus*) collected during the course of the project in the Indian Ocean.