

SHARK RESEARCH AND DATA COLLECTION PROGRAM: PROGRESS ON THE AGE AND GROWTH OF THE SHORTFIN MAKO IN THE ATLANTIC OCEAN

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SUMMARY

This paper presents an update of the age and growth study within the ICCAT Shark Research and Data Collection Program (SRDCP), including the current development status and plans for the 2nd phase of the project. There are currently 469 vertebrae samples (205 females, 257 males and 7 specimens with unidentified sex) collected and processed from both the North and Southern hemispheres. The sample distribution is much more complete in the north, while in the south at this stage there are only samples from the equatorial region. The size range of the samples varies from 52 cm to 366 cm FL. The next steps of this projects is proposing a workshop on age reading and growth in order to prepare a reference set of vertebrae that can be used as a guideline for the readings of the remaining sample, and also discuss aspects of age validation and band deposition periodicity. The final results will be presented to the SCRS sharks working group in 2017, in order to contribute to the 2017 shortfin mako stock assessment.

RÉSUMÉ

Le présent document fournit une mise à jour de l'étude sur l'âge et la croissance réalisée dans le cadre du Programme de recherche et de collecte de données sur les requins (SRDCP) de l'ICCAT, incluant l'état actuel d'avancement et les plans prévus pour la deuxième phase du projet. Actuellement, 469 échantillons de vertèbres (205 femelles, 257 mâles et 7 spécimens dont le sexe n'a pas été identifié), provenant des hémisphères Nord et Sud, ont été collectés et traités. La distribution des échantillons est beaucoup plus complète dans le cas du Nord, alors que pour le Sud, pour l'instant, on ne compte que quelques échantillons de la région équatoriale. La gamme de tailles des échantillons oscille entre 52 et 366 cm de longueur à la fourche (FL). Les prochaines étapes de ces projets consisteront à proposer de tenir un atelier sur la lecture de l'âge et la croissance afin de préparer un ensemble de référence de vertèbres qui peuvent également servir de directives pour les lectures des échantillons restants et également se pencher sur les aspects de la validation de l'âge et la périodicité du dépôt des bandes. Les résultats finaux seront présentés au groupe d'espèces sur les requins en 2017, afin de contribuer à l'évaluation du stock de requin-taupe bleu de 2017.

RESUMEN

Este documento presenta una actualización del estudio de crecimiento y edad en el marco del Programa de recopilación de datos e investigación sobre tiburones (SRDCP) de ICCAT, lo que incluye el estado de desarrollo actual y los planes para la segunda fase del proyecto. Actualmente se dispone de 469 muestras de vértebras (205 hembras, 257 machos y 7 ejemplares sin sexo identificado) recogidas y procesadas procedentes de ambos hemisferios del Atlántico. La distribución de las muestras es mucho más completa en el norte, mientras que en el sur en esta fase solo hay muestras de la región ecuatorial. La gama de tallas de las muestras oscila entre 52 cm y 366 cm FL. Los próximos pasos de estos proyectos son proponer unas jornadas de trabajo sobre lectura de la edad y crecimiento para preparar un conjunto de

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referencia de vértebras que puedan utilizarse como orientación para las lecturas del resto de la muestra, y también debatir los aspectos de la validación de la edad y la periodicidad de la deposición de bandas. Los resultados finales se presentarán al Grupo de especies de tiburones del SCRS en 2017, para contribuir a la evaluación de stock de marrajo dientuso de 2017.

KEYWORDS

Age and growth, Isurus oxyrinchus, Life history parameters, Shortfin mako

Background

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 two 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.

Understanding the age structure and growth dynamics of a population is crucial for the application of biologically realistic stock assessment models and, ultimately, for effective conservation and management. Information on age and growth is often used to estimate natural mortality or total mortality, which are important components of stock assessment models, and in the calculation of population and demographic parameters such as population growth rates and generation times. Successful fisheries management thus requires precise and accurate age information to make informed decisions, and inaccurate age estimates can lead to serious errors in stock assessments and possibly to overexploitation (Campana, 2001).

Despite their importance, published age and growth studies of sharks are still scarce and only a few have provided validation of the ageing method used. Specifically for the shortfin mako (SMA, *Isurus oxyrinchus*), there are still uncertainties in the age and growth parameters. Some previous studies assumed that vertebral band deposition could be either 1 or 2 bands per year, both in the Atlantic and Pacific oceans (e.g. Bishop *et al.*, 2006; Doño *et al.*, 2015; Semba *et al.*, 2009). Some recent studies in the Atlantic have validated a 1 band per year periodicity based on bomb radiocarbon (Campana *et al.*, 2002; Ardizzone *et al.*, 2006) and oxytetracycline tagging (Natanson *et al.*, 2006), while in the Pacific a 2 band per year pattern was validated for juvenile specimens based on oxytetracycline tagging (Wells *et al.*, 2013). As such, the question of age validation for the shortfin mako shark still remains uncertain, but it seems possible that this species shifts from depositing 2 bands per year to 1 band per year after reaching maturity. Further, most of the previous studies carried out in the Atlantic have focused relatively small areas when the geographical range of the species is considered. As such, there is the need to carry out a new and large scale Atlantic wide study that covers a wide Atlantic area and can take into consideration different hypothesis in terms of band deposition patterns for this species.

Therefore, within the ICCAT SRDCP, a specific study for the age and growth of the shortfin mako in the Atlantic was developed. The purpose of the study is to conduct an Atlantic wide age and growth study for the shortfin mako shark that can contribute to the 2017 ICCAT SMA stock assessment. The main deliverable and outcome expected for this project is one SCRS paper to be presented during the 2017 SMA stock assessment meeting with the final results. Submission to a peer-review journal is also envisioned pending agreement between all participants in the study.

The objectives of this paper are to present the current development status of this project and the plans for the next stages during the 2nd year of the project.

Project execution - progress

The list of milestones and deliverables originally developed in the project proposal and their current development status is provided in **Table 1**. Additionally, 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 collection of samples and completion of the analysis.

Milestone 1 has been completed on due time. The initial compilation of vertebrae (Milestone 2) was also completed on due time, and has been updated regularly as more samples are collected and processed. For example, update tables have been provided to the SCRS in its September 2015 meeting. Currently 469 samples (205 females, 257 males and 7 specimens with unidentified sex) have been collected and processed from both the North and Southern hemispheres (see **Table 2** and **Figure 1**). The size range of the samples varies from 52 cm to 366 cm FL (Fork Length) (**Figure 2**). Milestone 3 is currently ongoing and an online repository has been created in the ICCAT servers to upload the digital images of the processed vertebrae (e.g. see figure provided in **Figure 3**). This process is expected to be fully completed by the end of 2016, in order to give as much time as possible to collect further samples during the 2016 sea campaigns.

Efforts are being made to organize a workshop on age reading and growth in Narragansett Laboratory, NOAA Fisheries Northeast Fisheries Science Center (USA), where scientists from the different participating laboratories will work together to build a reference set of vertebrae that can be used as a guideline for the readings of the remaining sample. This workshop will aid in the completion of Milestone 4. The expected date of delivery of milestones 3 to 6 have been moved one year as the ICCAT SMA Stock assessment has been altered to 2017 (see **Table 1**).

Project execution - future steps

The main plan for the next phase of the project is to carry out a "*Workshop on shortfin mako age reading and growth*", planned to be held in the Narragansett Laboratory, NOAA Northeast Fisheries Science Center, Rhode Island (U.S.), in early June 2016 (tentative dates are 2-3 June 2016). The expected participants include tentatively 2 scientists from IPMA (Portugal), one scientist from DINARA (Uruguay) and 3 scientists from NOAA Fisheries Service (U.S.). Additional funds may be obtained for other participants from other institutes that can also contribute to the study. The workshop will have an expected duration of 2 working days. The main objective is to create a reference set of vertebrae for age reading that will then be used by the different national laboratories as a reference set to individual readings and age estimates. Thereafter, age estimates (Milestone 5), growth modeling (Milestone 6) and the final SCRS paper (Deliverable 7) will be prepared according to the proposed schedule in **Table 1**. The budget required to complete this project during the 2nd year of project are shown in **Table 3**.

Acknowledgments

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Table 1. List of milestones and deliverables with the respective expected completion dates, for the shortfin mako age and growth study. The differences in the original and currently expected delivery dates are related with the fact that the shortfin mako Atlantic stock assessment has been postponed to 2017. This will provide more time for the collection of samples, age estimations and data analysis.

<i>Item</i>	<i>Type¹</i>	<i>Name</i>	<i>Description</i>	<i>Expected date (original proposal)</i>	<i>Expected date (revised proposal)</i>	<i>Status</i>
1	M	Project leader initial contact	E-mail to national scientists calling for participation in the project with SMA samples	31-Mar-15	31-Mar-15	Completed on 31-Mar-2015
2	M	Compilation of information on vertebrae	Summary table with SMA vertebrae currently available	5-May-15	5-May-15	Completed on 5-May-2015 ²
3 ³	D	SCRS paper	A SCRS paper describing the project status is prepared and presented to the ICCAT Sharks-WG	Originally not planned	18-Apr-16 (WG-Sharks meeting)	Completed on 18-Apr-2016
4	M	Vertebrae processing	Vertebrae are processed and digital images are uploaded to an ICCAT online repository	31-Dec-15	30-Dec-16	Ongoing
5	M	Age estimates	Ages are estimated by at least 1 scientist from each participating laboratory	31-Apr-16	31-Apr-17	To start during the age reading workshop
6	M	Data analysis	Growth models are finished	31-Jun-16	31-Jun-17 ⁴	Not started yet
7	D	SCRS paper	A final SCRS paper is prepared and presented to the ICCAT Sharks-WG	2016 ICCAT SMA stock assessment meeting	2017 ICCAT SMA stock assessment meeting	Not started yet

¹ M=milestone; D=deliverable

² This refers to the initial compilation of vertebrae already in the national laboratories in different processing stages. Summary tables will be periodically updated as more samples are collected and processed during the project.

³ This deliverable was not originally planned. However, due to the postponement of the SMA stock assessment to 2017, a progress reports is provided in 2016 as a SCRS paper to the Sharks Working Group.

⁴ The date provided is tentative, and can be altered depending on the schedule for the SMA stock assessment session in 2017

Table 2. Summary table with the compilation of SMA vertebrae currently available for the age and growth study by ICCAT geographical area, sex and size class (10 cm fork length classes). The samples shown in this table are from EU-Portugal (IPMA) and the US (NOAA-NMFS). The table shown was last updated in March 2016, and will be periodically updated during the course of the project as more samples are collected and become available.

<i>Size class (10 cm FL)</i>	<i>ICCAT_AT-NE</i>			<i>ICCAT_AT-NW</i>			<i>ICCAT_AT-SE</i>		<i>ICCAT_AT-SW</i>		<i>Total</i>
	<i>F</i>	<i>M</i>	<i>Unk</i>	<i>F</i>	<i>M</i>	<i>Unk</i>	<i>F</i>	<i>M</i>	<i>F</i>	<i>M</i>	
50				1	2		3	7			13
60				4	2						6
70	1			3	5	1					10
80				4	6						10
90				1	5						6
100				1	2	1					4
110	2										2
120				4	6						10
130				7	8			1			16
140	13	9	1	3	5			1			32
150	3	10		8	8	1	3	4	1		38
160	12	21		7	14		2	4	2	3	65
170	5	3		8	12		3	8	2	5	46
180	4	4		9	20		6	8	3	4	58
190	3	3		12	6		2	2		8	36
200	3	3		11	13		10	1	2	5	48
210	1			5	4		4		1	2	17
220				3	5				1		9
230				2	8		1				11
240	1			1	1		1			1	5
250				1	4		1		1		7
260				1	1		1				3
270				2	1						3
280					1						1
290				4							4
300				2							2
330				1							1
360				1							1
NA				1	1	3					5
Total	48	53	1	107	140	6	37	36	13	28	469

Table 3. Proposed budget for the 2nd year of project (2016-2017).

Item	Estimated cost (€)
Age reading and growth workshop. Planned to be held at the NOAA Northeast Fisheries Science Center, Narragansett Laboratory. Tentative dates: 2-3 June 2016.	10,000
Various consumables for processing vertebrae samples, including bleach, sectioning blades, glue, microscope slides, citoseal, dyes, scalpels, scissors, jars, gloves, tracing paper for labels, etc.	3,000
Transport of samples from vessels or landing ports to laboratories, and between laboratories, if needed.	1,000
TOTAL	14,000

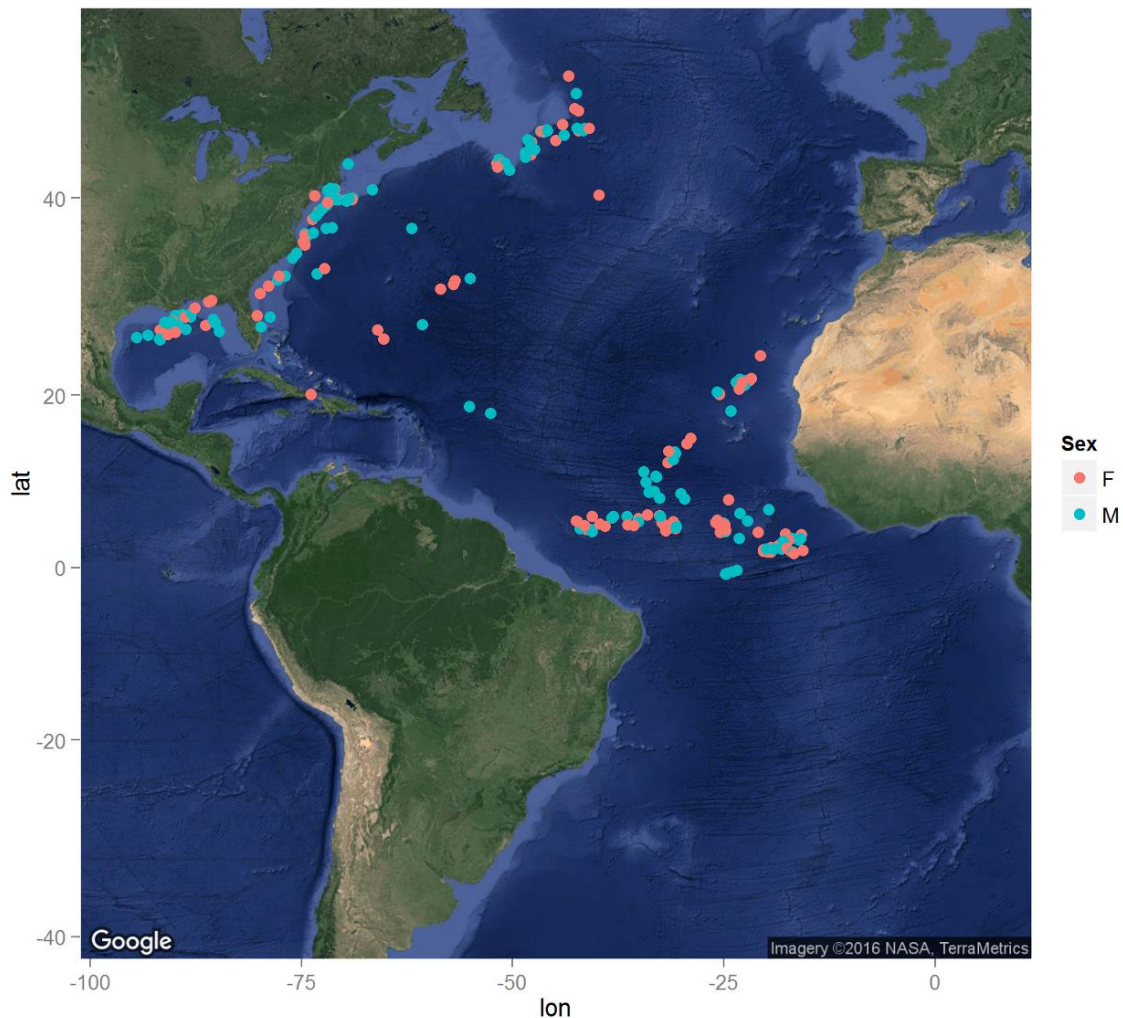


Figure 1. Map with the location of the SMA vertebrae samples currently available for the age and growth study. The samples shown in this map are from EU-Portugal (IPMA) and the US (NOAA-NMFS). The map was last updated in March 2016, and will be periodically updated during the course of the project as more samples are collected and become available.

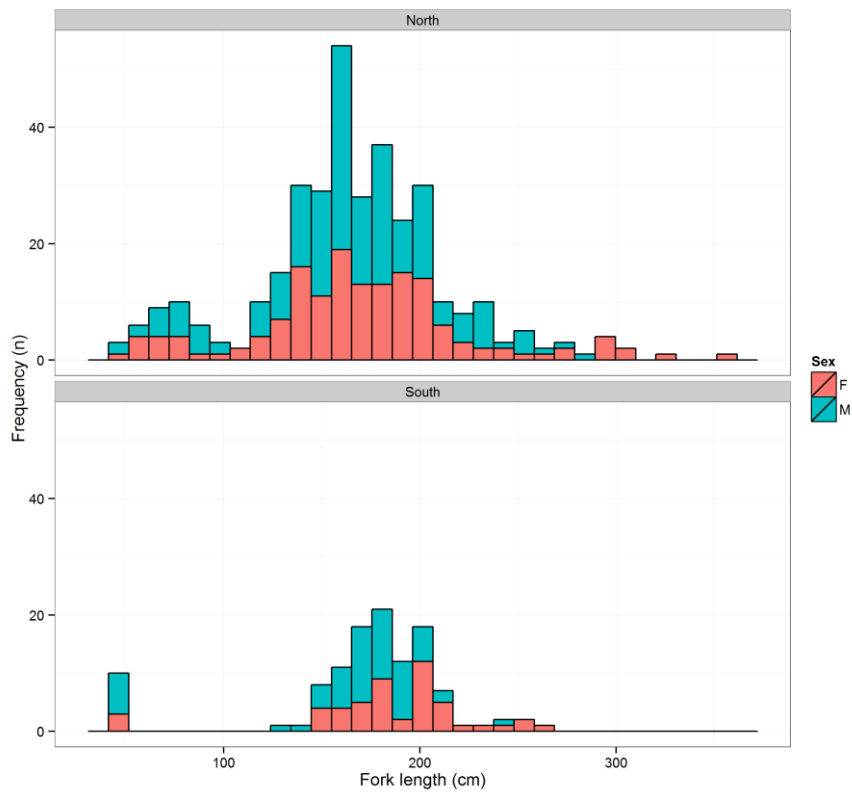


Figure 2. Size (fork length, in cm) frequency distribution of male ($n = 257$) and female ($n = 205$) SMA samples currently available for the age and growth study, for the north and south Atlantic (separated at the 5°N). The samples shown in this figure are from EU-Portugal (IPMA) and the US (NOAA-NMFS). The map was last updated in March 2016, and will be periodically updated during the course of the project as more samples are collected and become available.

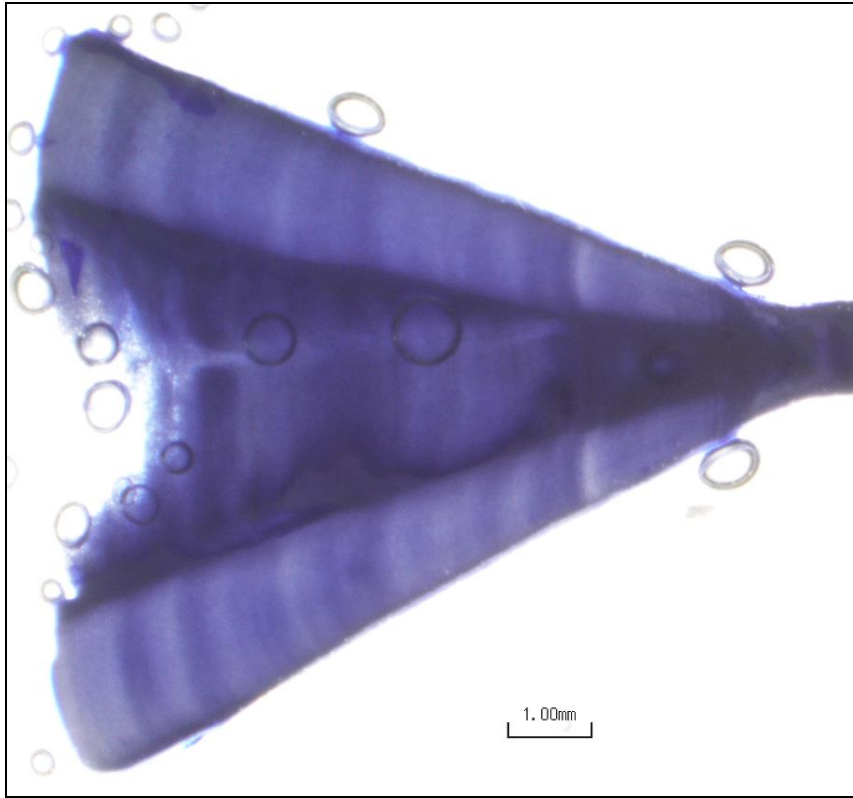


Figure 3. Example of a microphotograph of a vertebral section of shortfin mako (*Isurus oxyrinchus*) from a female specimen with 167 cm fork length, stained with crystal violet.