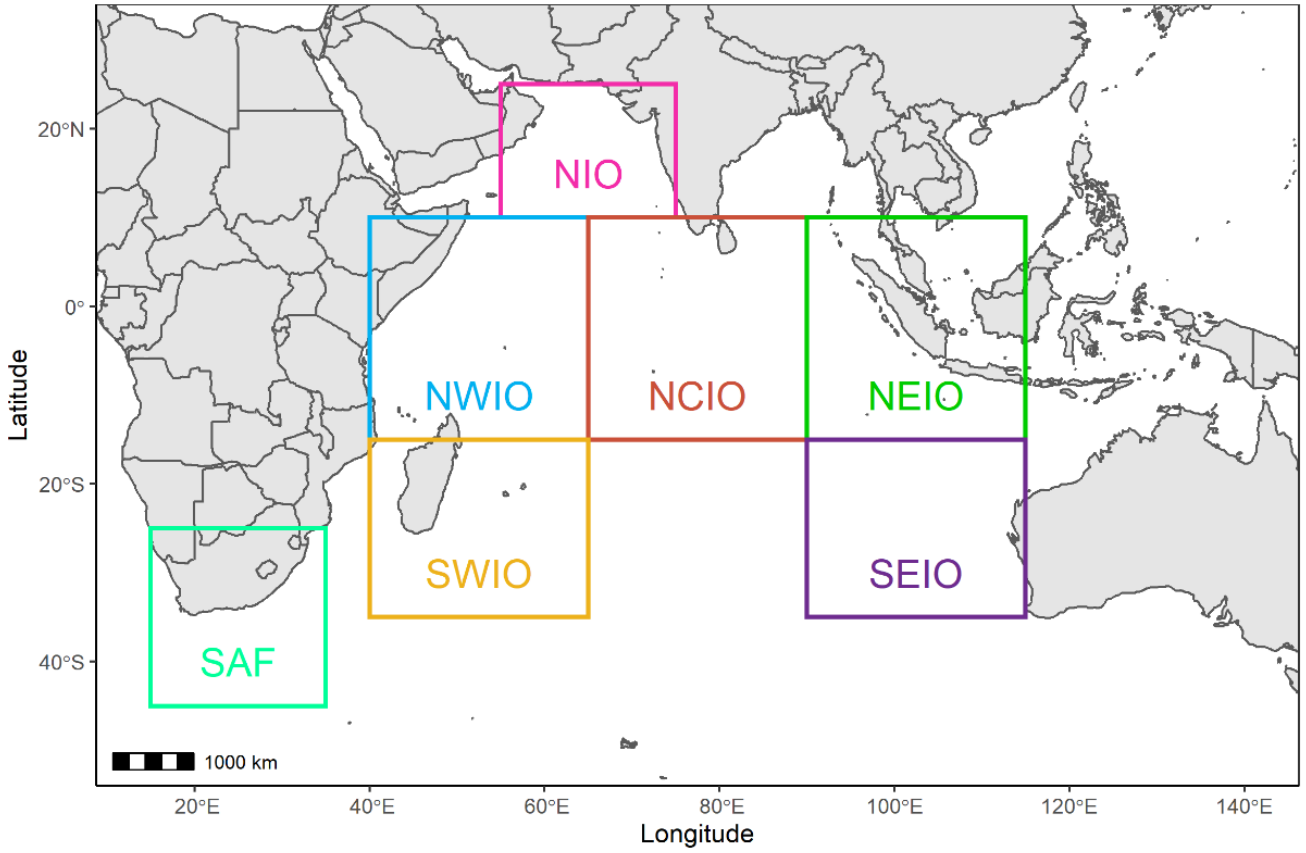
GERUNDIO

Development and Implementation of a sampling scheme to support the collection of biological samples and conduct analysis on these samples to provide improved estimates of age, growth and reproduction of tropical tunas, swordfish, and blue sharks for the Indian Ocean Tuna Commission (IOTC-2021-SC24-INF11)

GERUNDIO

Growth ag**E** **R**ecr**U**itment i**NDI**an **O**cean

GERUNDIO **G**rowth ag**E** **R**ecr**U**itment i**NDI**an **O**cean



AZTI MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE
www.azti.es
CSIRO
IRD Institut de Recherche pour le Développement FRANCE
forestry, fisheries & the environment
Department: Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA
INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION
SEYCHELLES FISHING AUTHORITY
WWF
MALDIVES MARINE RESEARCH INSTITUTE
KEMENTERIAN KELAUTAN DAN PERIKANAN

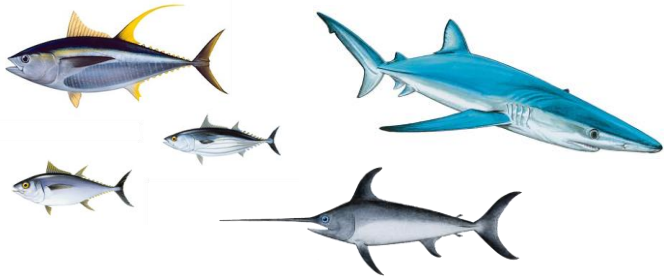
The Consortium

- Access samples througout the Indian Ocean
- Recent strategic research in method development and sampling.

BACKGROUND

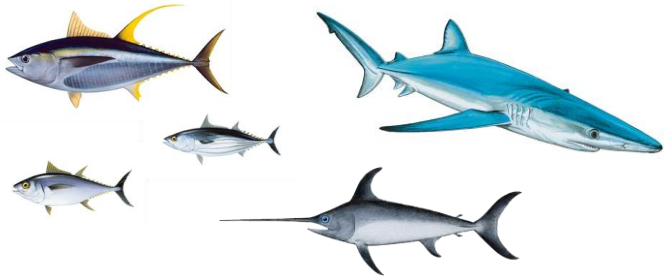
- The lack of knowledge of biological processes can reduce the reliability and confidence in stock assessments and undermine the sustainable management of fish and fisheries.

BACKGROUND



- The lack of knowledge of biological processes can reduce the reliability and confidence in stock assessments and undermine the sustainable management of fish and fisheries.
- Skipjack, yellowfin, bigeye, swordfish and blue shark are key species that inhabit tropical and subtropical waters of the world’s oceans.
- Accurate information on processes such as age, growth and reproduction are seldom available for these species in the Indian Ocean.
- Therefore, the impacts of fishing on these species are difficult to assess quantitatively.

OBJECTIVES

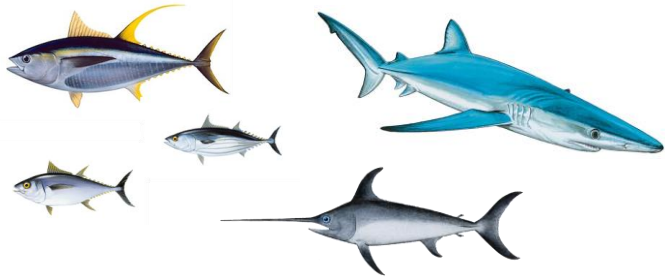


AGE, GROWTH & REPRODUCTION

GENERAL OBJECTIVE

To develop and implement a sampling scheme to support the collection of biological samples and conduct analysis on these samples to facilitate the estimation of age, growth and reproduction of tropical tunas, swordfish, and blue sharks.

OBJECTIVES



AGE, GROWTH & REPRODUCTION

GENERAL OBJECTIVE

To develop and implement a sampling scheme to support the collection of biological samples and conduct analysis on these samples to facilitate the estimation of age, growth and reproduction of tropical tunas, swordfish, and blue sharks.

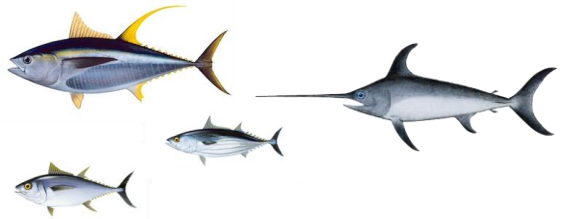
FOR IMPROVING STOCK ASSESSMENTS

AGE
Estimates of age.

GROWTH
Estimates of updated growth curves.

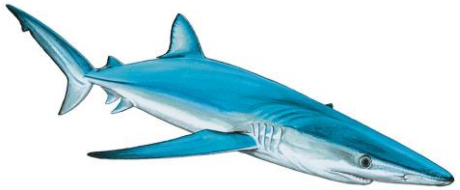
REPRODUCTION
fecundity, age at maturity, sex ratios, spawning season, and spawning fraction

METHODS



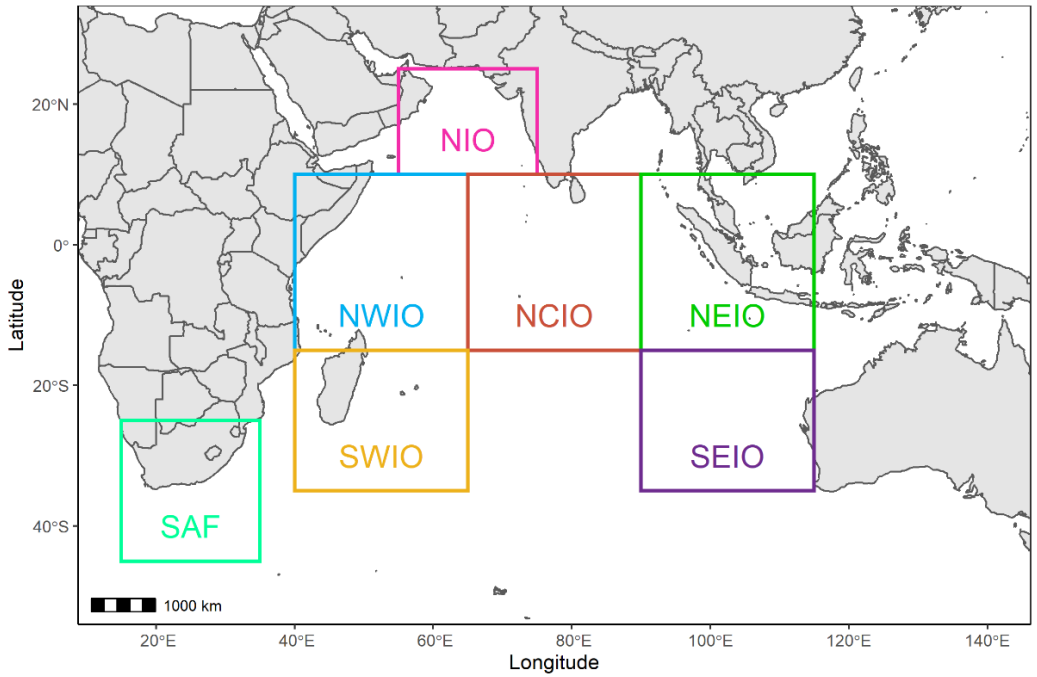
	Plan	Collect	Estimate	Analyse	Collect	Estimate
PLANNING	for obtaining samples across IO	Otoliths/body parts and data through FOP or other	Age and growth from otolith readings	Otoliths-OTC from IO-RTTP for age validation	Gonads & other material through FOP or other	Fecundity, age-mat, sex-ratio, sp-season-fraction
METHODOLOGY	Use Standard sampling techniques	Extract Otoliths, gonads and others	Prepare Otolith samples	Apply Analytical techniques to estimate age and growth	Prepare Gonad samples	Apply Histological techniques

METHODS



	Plan	Collect	Estimate	Analyse	Collect	Estimate
PLANNING	for obtaining samples across IO	**Vertebrae** and data through FOP or other	**Age from reading vertebrae**	Otoliths-OTC from IO-RTTP for age validation	**Visual assessment of maturity**	Fecundity, age-mat, sex-ratio, sp-season-fraction
METHODOLOGY	Use	Extract	Prepare	Apply	Prepare	Apply
	Standard sampling techniques	**Vertebrae**	**Vertebrae** samples	Analytical techniques to estimate age and growth	Gonad samples	Histological techniques

RESULTS (Collection of samples)



Optimal sampling plan

- Design of a biological sampling plan identifying key gaps from previous projects (catalogue of otoliths/vertebrae and gonad samples and data).
- Across species, areas, seasons and sizes.
- Simulation of minimum sampling needs.

RESULTS (Collection of samples)

Table 6. Sampling plan proposed for each regional partner accomplished by each IOTC area and displayed for each of the five studied species (numbers refers to sample size achievable quarterly).

		Species									
		SKJ			YFT		BET		SWO		BSH
Partner	**IOTC-AREAS**	**Oto**	**Spi**	**Gon**	**Oto**	**Gon**	**Oto**	**Gon**	**Oto**	**Gon**	**Ver**
CSIRO(*)	NEIO	30	40	100	115	100	115	100	100	90	100
CSIRO	SEIO				80	80	100	100	100	90	
MMRI	NCIO	40	40	100	110	100					
WWF-Pakistan	NIO	50	40	100	110	100					
AZTI/IRD/SFA	NWIO	40	30	100	90	100	90		90	90	
IRD (CITEB)	SWIO				60	60	60	60	120		
	TOTAL	**160**	**150**	**400**	**565**	**540**	**365**	**260**	**410**	**270**	**200**

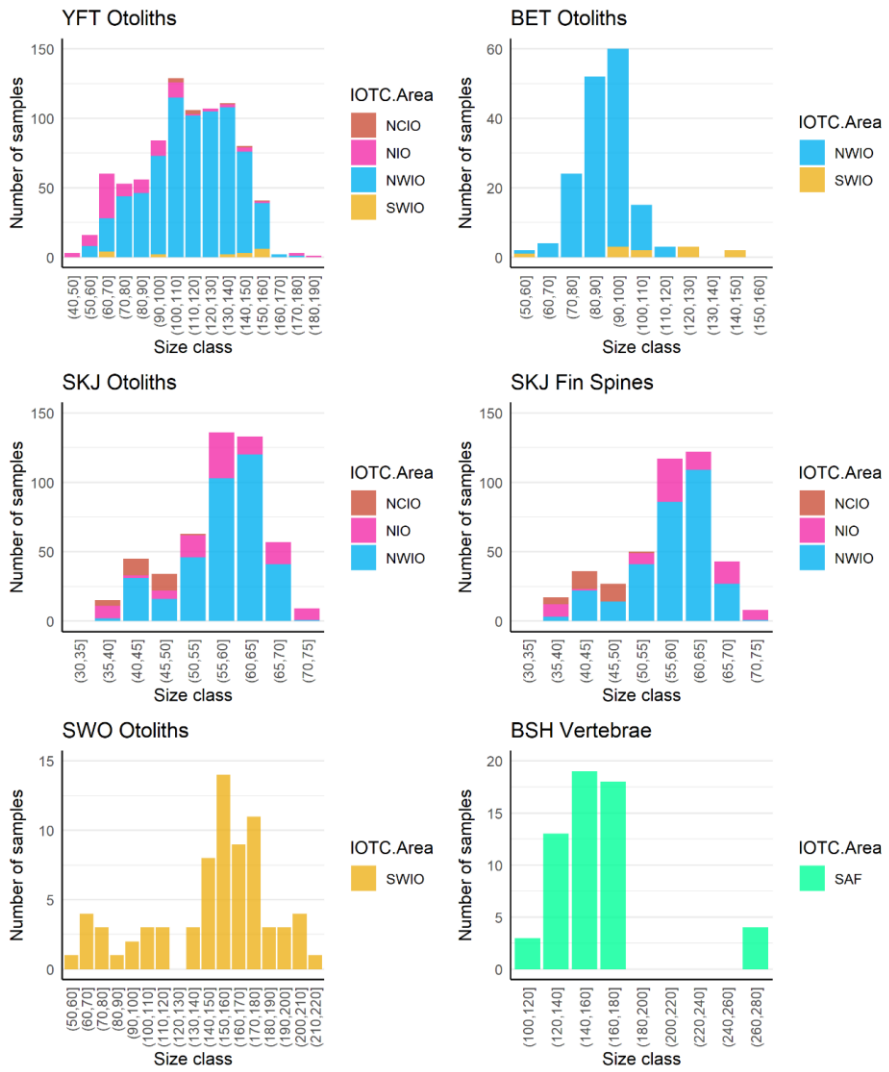
Optimal sampling plan

- Design of a biological sampling plan identifying key gaps from previous projects (catalogue of otoliths/vertebrae and gonad samples and data).
- Across species, areas, seasons and sizes.
- Simulation of minimum sampling needs.

Proposed sampling (time and budget)

- 3,320 samples in total.

RESULTS (Collection of samples)



Optimal sampling plan

- Design of a biological sampling plan identifying key gaps from previous projects (catalogue of otoliths/vertebrae and gonad samples and data).
- Across species, areas, seasons and sizes.
- Simulation of minimum sampling needs.

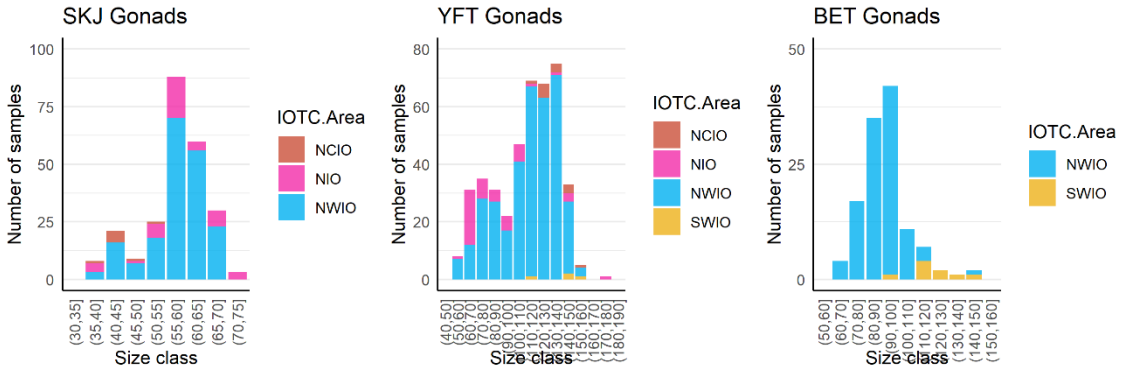
Proposed sampling (time and budget)

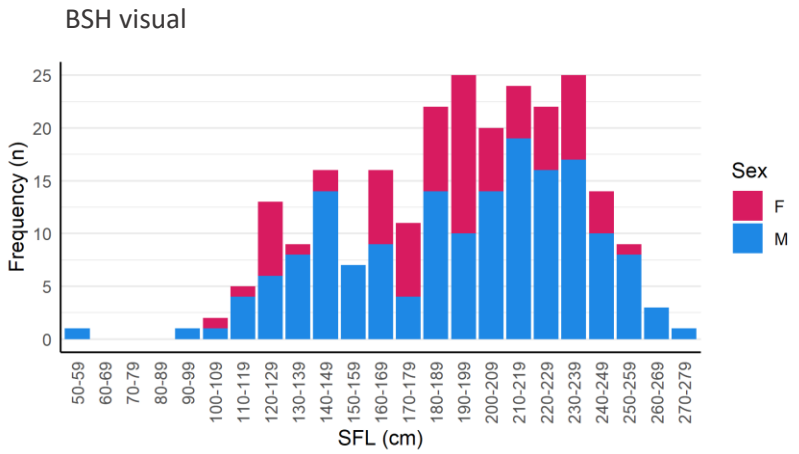
- 3,320 samples in total.

Sampling achieved

- 3,214 samples in total.
- Most sampling from NWIO.

RESULTS (Collection of samples)





Optimal sampling plan

- Design of a biological sampling plan identifying key gaps from previous projects (catalogue of otoliths/vertebrae and gonad samples and data).
- Across species, areas, seasons and sizes.
- Simulation of minimum sampling needs.

Proposed sampling (time and budget)

- 3,320 samples in total.

Sampling achieved

- 3,214 samples in total.
- Most sampling from NWIO.
- Gonads for SWO not collected, BSH (from SA) visual maturity classification.

RESULTS (Collection of samples)

Samples processed in GERUNDIO (only new samples).

	SKJ	YFT	BET	SWO	BSH	Total
Spines	120	0	0	0	0	120
Otoliths	165	280	108	136	0	689
Vertebrae	0	0	0	0	262	262
Sexed	635	1,145	162	0	41	1,942
Histology	84	202	5	0	0	301

Optimal sampling plan

- Design of a biological sampling plan identifying key gaps from previous projects (catalogue of otoliths/vertebrae and gonad samples and data).
- Across species, areas, seasons and sizes.
- Simulation of minimum sampling needs.

Proposed sampling (time and budget)

- 3,320 samples in total.

Sampling achieved

- 3,214 samples in total.
- Most sampling from NWIO.
- Gonads for SWO not collected, BSH (from SA) visual maturity classification.
- 1,071 hardparts analyzed, 1,942 fish sexed and 301 gonad histology.

RESULTS (Estimates of age and growth)

Documents for the WPEB, WPB, WPTT and SC (10)

- *Preliminary age and growth of blue shark (Prionace glauca) in the southwest Indian Ocean* (Farley, J., Robertson, S., Norman, S., Parker, D., Eveson, P., Luque, P.L., Krusic-Golub, K., Fraile, I., Zudaire, I., Artetxe, I., Murua, H., Marsac, F., and G. Merino). IOTC-2021-WPEB17(AS)-12.
- *Preliminary age and growth of swordfish (Xiphias gladius) in the western Indian Ocean* (Farley, J., Krusic-Golub, K., Clear, N., Romanov, E., Eveson, Luque, P.L., Marsac, F., Artetxe, I., Fraile, I., Zudaire, I., Murua, H. and G. Merino). IOTC-2021-WPB19-21.
- *Estimating the age and growth of bigeye tuna (Thunnus obesus) in the Indian Ocean from counts of daily and annual increments in otoliths* (Farley, J., Krusic-Golub, Eveson, P., Clear, N., Luque, P.L., Artetxe-Arrate I., Fraile, I., Zudaire, I., Vidot, A., Govinden, R., Ebrahim, A., Romanov, E. Chassot, E., Bodin, N., Parker, D., Murua, H., Marsac, F. and G. Merino). IOTC-2021-WTT23-018_Rev1.
- *Estimating the age and growth of yellowfin tuna (Thunnus albacares) in the Indian Ocean from counts of daily and annual increments in otoliths* (Farley, J., Krusic-Golub, Eveson, P., Luque, P.L., Clear, N., Fraile, I., Artetxe I., Zudaire, I., Vidot, A., Govinden, R., Ebrahim, A., Ahusan, M., Romanov, E. Shahid, U., Chassot, E., Bodin, N., Parker, D., Murua, H., Marsac, F. and G. Merino). IOTC-2021-WTT23-05_Rev1.
- *A comparison of direct age estimates from otolith and fin spine sections of skipjack tuna (Katsuwonus pelamis) in the Indian Ocean.* (Luque, L.P, Artetxe-Arrate, I, Farley, J., Krusic-Golub, K., Eveson, P., Fraile, I., Clear, N., Zudaire, I., Ahusan, M., Razzaque, S.A., Aisha, H., Vidot, A., Fily, T., Ebrahim, I., Govinden, R., Chassot, E., Bodin, N., Onandia, I., Krug, I., Murua, H., Marsac,F. and G. Merino1) IOTC-2021-SC24-INF02.

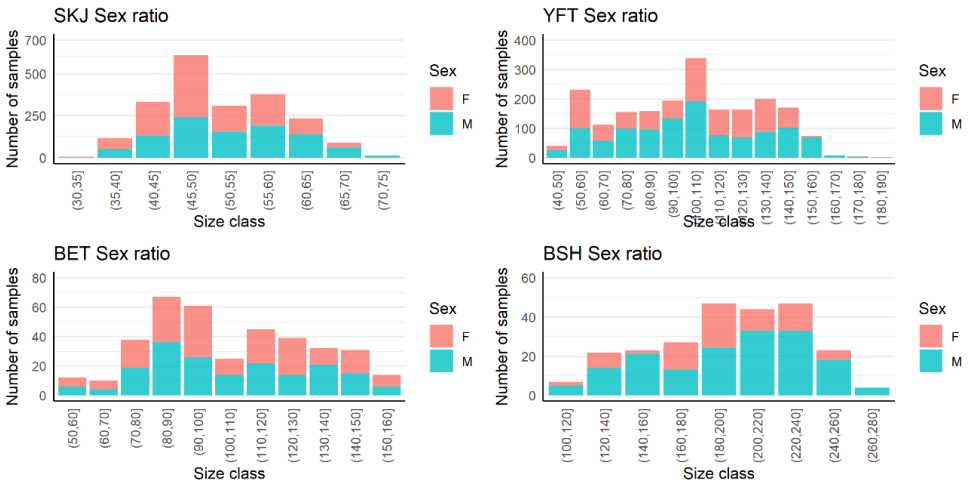
RESULTS (Estimates of reproductive parameters)

Documents for the WPEB, WPB, WPTT and SC (10)

- *Reproductive biology of the Blue shark (Prionace glauca) in the western Indian Ocean* (Murua, H., Artetxe-Arrate, I., Farley, J., Norman, S., Luque, P.L., Parker, D., Marsac, F., Zudaire, I., Fraile, I. and G. Merino). IOTC-2021-WPEB17(AS)-11.
- *A review of the reproductive biology of the swordfish (Xiphias gladius) in the Indian Ocean* (Murua, H., I., Farley, Zudaire, Luque, P.L., I., Artetxe-Arrate, Romanov, E., Marsac, Fraile, I. and G. Merino). IOTC-2021-WPB19-20.
- *Preliminary estimates of fecundity, age at maturity, sex ratio, spawning season, and spawning fraction for Indian Ocean yellowfin tuna* (Zudaire, I., Artetxe-Arrate, I., Farley, J., Murua, H., Deniz, D., Vidot, A., Razzaque, S.A., Ahusan, M., Romanov, E., Eveson, P., Clear, N., Luque, P.L., Fraile, I., Bodin, N., Chassot, E., Govinden, R., Ebrahim, A., Shahid, U., Marsac, F. and G. Merino). IOTC-2021-WPTT23-09_Rev1.
- *Preliminary estimates of fecundity, age at maturity, sex ratio, spawning season, and spawning fraction for Indian Ocean bigeye tuna* (Zudaire, I., Artetxe-Arrate, I., Farley, J., Murua, M., Deniz, D., Vidot, A., Razzaque, S.A., Ahusan, M., Romanov, E., Eveson, P., Clear, N., Luque, P.L., Fraile, I., Bodin, N., Chassot, E., Govinden, R., Ebrahim, A., Shahid, U., Marsac, F. and G. Merino). IOTC-2021-SC24-INF01.
- *Preliminary estimates of fecundity, age at maturity, sex ratio, spawning season, and spawning fraction for Indian Ocean skipjack tuna* (Zudaire, I., Artetxe-Arrate, I., Farley, J., Murua, H., Deniz, D., Vidot, A., Razzaque, S.A., Ahusan, M., Romanov, E., Eveson, P., Clear, N., Luque, P.L., Fraile, I., Bodin, N., Chassot, E., Govinden, R., Ebrahim, A., Shahid, U., Marsac, F. and G. Merino). IOTC-2021-SC24-INF02.

RESULTS (Indian Ocean biological data inventory)

- Database with data from biological surveys carried out in the IO.
- Available data and tissue samples from previous projects compiled with the new information.
- Samples identified and stored for future use.
- *Data catalogue*: 6,930 samples (3,566 otoliths, 958 spines and 3,001 gonads from 2006 to 2021) and sex ratio information for 2,097 skipjack, 2,016 yellowfin, 398 bigeye and 247 blue sharks.



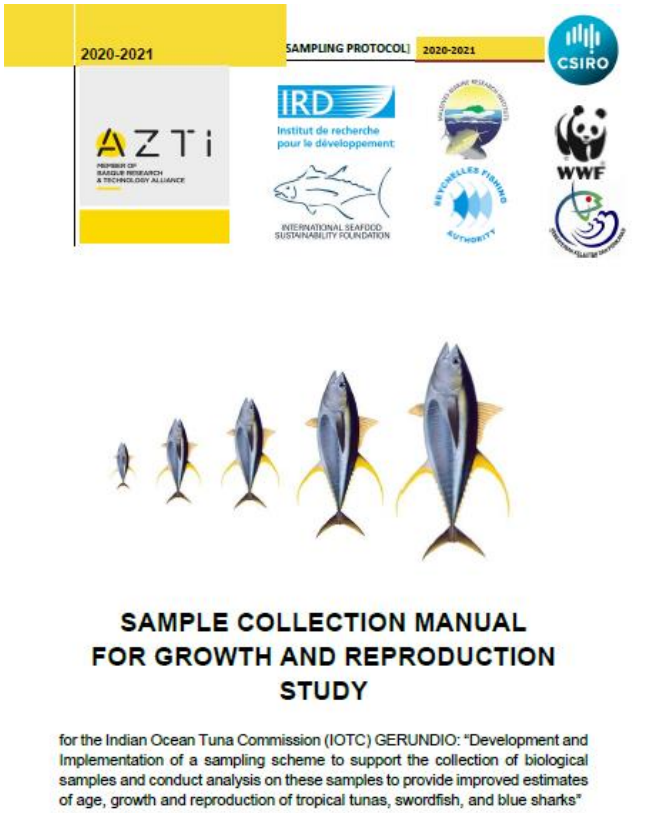
	Species	NCIO	NEIO	NIO	NWIO	SEIO	SWIO	SAF	Unknown	Total
Gonads	SKJ	57		45	674		219		8	1003
	YFT	46		48	636		83			813
	BET	2			174		9			185
	Total	105		93	1484		311		8	**2001**

	Species	NCIO	NEIO	NIO	NWIO	SEIO	SWIO	SAF	Total
Spines-SKJ,YFT,BET Vertebrae-BSH	SKJ	141		89	380		2		612
	YFT	1			49				50
	BET				30				30
	BSH							266	266
	Total	142		89	459		2	266	**958**

	Species	NCIO	NEIO	NIO	NWIO	SEIO	SWIO	SAF	Unknown	Total
Otoliths	BET	85	125		401	26	63		21	721
	SKJ	143	58	107	601	16	10			935
	YFT	99	183	99	1,158	6	132	23	76	1,776
	SWO					61	73			134
	Total	327	366	206	2,160	109	278	**23**	**97**	**3,566**

RESULTS (workshop and manual)

- A workshop on tuna reproduction was held on 16-17 July 2021.
- Online and was attended by 17 researchers from 7 Institutions (AZTI, CSIRO, IRD. SFA, MMRI, WWF-Pakistan)
- The objective was to standardize gonad analyses, from sampling and gonad collection, through samples processing and histological preparation, to histological reading and results interpretation.
- Video recording.
- Allowed sharing methods to estimate biological parameters
- A sample collection manual was prepared to homogenize sampling.



LIMITATIONS AND RECOMMENDATIONS

- ***COVID:*** Reduced opportunities to collect and ship new samples by key project partners and collaborators.
- ***Gear coverage:*** Lack of partners that monitor some fisheries (e.g., longline, gillnets, handlines) that catch medium-large size fish. For some of the target species, it was not possible to obtain samples from the complete sizes range.
- ***Sampling period:*** Project from 1st of October 2020 to 30th of November 2021. Sampling did not start until early 2021 and most of the samples were collected in the first part of 2021. Despite attempts, it was not possible for the sampling to cover each of the four seasons. Not able to evaluate inter- and intra-annual variability in the biological parameters, as planned.
- ***Species availability:*** Few samples of bigeye and swordfish. Access is difficult (no samples collected from longlines except blue shark).

LIMITATIONS AND RECOMMENDATIONS

- ***COVID:*** Reduced opportunities to collect and ship new samples by key project partners and collaborators.
- ***Gear coverage:*** Lack of partners that monitor some fisheries (e.g., longline, gillnets, handlines) that catch medium-large size fish. For some of the target species, it was not possible to obtain samples from the complete sizes range.
- ***Sampling period:*** Project from 1st of October 2020 to 30th of November 2021. Sampling did not start until early 2021 and most of the samples were collected in the first part of 2021. Despite attempts, it was not possible for the sampling to cover each of the four seasons. Not able to evaluate inter- and intra-annual variability in the biological parameters, as planned.
- ***Species availability:*** Few samples of bigeye and swordfish. Access is difficult (no samples collected from longlines except blue shark).

General Recommendations

- ❖ Overall, an ongoing sampling program should include a wider temporal and geographical coverage, with a focus on the east and central parts of the Indian Ocean and across seasons in multiple years. Concerned CPCs should engage more in sampling activities.
- ❖ Additional efforts should be placed to include longline fleets (and other gears) to increase species availability and the size-representation.

LIMITATIONS AND RECOMMENDATIONS

Specific Recommendations	Yellowfin	Bigeye	Skipjack	Swordifsh	Blue shark
Ongoing sampling of all size classes across all regions	Yes	Yes	Yes	Yes	Yes
Specific regions identified as requiring focussed sampling	North, east, and southwest IO	East IO	East and southwest IO	All regions. Including >200 cm LJFL from the western IO. Very important to record sex for all fish	All regions excluding South Africa.
Further analysis of hardparts for longevity and growth estimation	All regions but particularly samples from the east and north regions.	All regions but particularly samples from the east IO. Recommend this work is completed before the 2022 stock assessment, if possible.	All regions but particularly E and SW. Compare ages from ots. and spines from same fish. Re-read hardparts by additional readers. Determine accuracy of daily age estimates in very small fish.	All region, particularly fish >200 cm LJFL with known sex.	All regions excluding South Africa. Exchange vertebrae sections (or images) among reading laboratories and an ageing workshop to standardize approaches.
Continue analysis of OTC marked and non-marked ot. from IOTTP	Yes	Yes	Yes	NA	NA
Bomb radiocarbon (^{14}C) age validation	Currently underway	Consider. Particularly if YFT ^{14}C validation is successful.	Not suitable due to low maximum age.	Consider. Particularly if YFT ^{14}C validation is successful.	Consider. Very preliminary work undertaken (Romanov etal. 2012)
Marginal increment analysis of otoliths/spines (age validation)	May be possible with higher sample sizes	May be possible with higher sample sizes	May be possible with higher sample sizes	May be possible with higher sample sizes	May be possible with higher sample sizes
Further analysis of gonads for reproductive parameters	Improve size coverage (longline), fish>100cm. Improve geographical and temporal coverage (interannual variability)	Improve size coverage (longline), fish>100cm. Improve geographical and temporal coverage (interannual variability)	Improve size coverage (longline), fish>45cm. Improve geographical and temporal coverage (interannual variability)	Exploring the use of the Poisson et al. (2009) length-based maturity ogives by sex, converted to age-based ogives using Farley et al. (2016) growth curves by sex for use in stock assessments. Improve geographical/temporal coverage (interannual variability)	Improve geographical and temporal coverage (interannual variability) Validate macroscopic staging and estimate maturity ogive.

LIMITATIONS AND RECOMMENDATIONS

Harmonization of a data-base and storage of samples

- Common database initiated and would need to be maintained.
- A plan to build a sample database that can be accessed by all scientists in the Indian Ocean should be developed.
- Storage of old and new samples in one or more sample banks.

GERUNDIO

Development and Implementation of a sampling scheme to support the collection of biological samples and conduct analysis on these samples to provide improved estimates of age, growth and reproduction of tropical tunas, swordfish, and blue sharks for the Indian Ocean Tuna Commission (IOTC-2021-SC24-INF11)

Thanks for the great work to all participants

iotc ctoi

European Commission

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

AZTI MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE www.azti.es

CSIRO

IRD Institut de Recherche pour le Développement FRANCE

forestry, fisheries & the environment
Department: Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION

SEYCHELLES FISHING AUTHORITY

WWF

MALDIVES MARINE RESEARCH INSTITUTE

KEMENTERIAN KELAUTAN DAN PERIKANAN