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STAFF ACTIVITIES AND RESEARCH PLAN

This document is an update of Document IATTC-98-02a, which summarized the IATTC scientific staff's work plans for 2019-2023 and its current and planned research activities under the Strategic Science Plan. Projects proposed but pending funding are listed in Document IATTC-100-02b.

CONTENTS

INTRODUCTION

This document presents the staff's research and work plans, as well as brief summaries of the 66 research projects that are currently under way, or planned for the near future and funded under the 5-year Strategic Science Plan (2019-2023). The summaries include, for each project, background information, a work plan, and a progress report, as well as details of its relevance and purpose, external collaborators, duration, and deliverables; also, for existing projects, an update on activities since the previous year's report (the 'reporting period'; March 2021- March 2022- in this report).

The staff's research activities are no longer structured in accordance with the Commission's four research programs[1], as they were prior to 2018. Instead, they are classified into the seven main areas of research, called *Themes*, of the Strategic Science Plan (SSP; IATTC-93-06a). In addition to better accommodating a strategic planning approach, this new structure is intended to foster stronger collaboration among the

[1] Stock Assessment; Biology and Ecosystem; Data Collection and Database; Bycatch and International Dolphin Conservation Program (IDCP)

different programs (recommendation 17 of the 2016 IATTC Performance Review), with researchers from different programs contributing to activities under a common *Theme*. The seven *Themes,* the strategic pillars of the SSP, are the following:

Data collection for scientific support of management
Life history studies for scientific support of management
Sustainable fisheries
Ecological impacts of fishing: assessment and mitigation
Interactions among the environment, ecosystem, and fisheries
Knowledge transfer and capacity building
Scientific excellence

Each *Theme* is divided into strategic *Goals*, and the principal tasks that will be carried out to achieve a particular goal within the SSP's five-year window are called *Targets* (IATTC-93-06a). The specific activities that the staff will carry out in order to fulfil those tasks are called *Projects*, which are in some cases grouped into *Work Plans* aimed at achieving a broad objective not limited to a particular *Theme* or *Goal*.

The general *Themes*, and the more specific *Goals*, reflect the staff's principal activities in carrying out the responsibilities it is assigned by the Commission, and form an integral part of the five-year SSP. The more focused *Targets*, and the concrete *Projects*, are generally of shorter duration, and operate on a biennial cycle. Whether any *Projects* are undertaken under a particular *Goal* or *Target* in any given period will depend on the staff's research priorities, the human, logistic, and financial resources available, and any specific instructions from the Commission.

A measure of the staff's activities is the presentation of its research and the resulting publications. Presentations and publications from 2019-2020 are listed in Section F.

Since the previous report to the Commission in 2021, the following projects have been completed; details in Section G. Details of previous research projects completed under the SSP can be found on the IATTC website here.

C.4.b	Long-term sampling program for shark catches of artisanal fisheries in Central America: Phase 1
D.2.a	Pilot study of electronic monitoring (EM) of the activities and catches of purse-seine vessels
E.1.a	Evaluate potential improvement of growth model for bigeye in the EPO based on presumed annuli counts from otoliths of large fish
E.2.b.	Workshop to evaluate differences in bigeye tuna age estimation methods and resulting growth models utilized in current stock assessments by the IATTC and WCPFC
H.1.a-1:	Improve the bigeye tuna stock assessment (Phase 1)
H.1.b-1:	Improve the yellowfin tuna stock assessment (Phase 1)
I.3.a	Evaluate potential reference points for dorado in the EPO
M.2.a	Evaluate the post-release survival of silky sharks captured by longline fishing vessels in the equatorial EPO, using best handling practices
O.1.c	A review of methods to determine prey consumption rates, gastric evacuation and daily ration of pelagic fishes: a precursor to experimental estimation for key predators in the EPO
R.1.a.	Workshop on training, communication and evaluation of management strategies for tuna fisheries in the EPO
R.1.b.	Development, communication and evaluation of management strategies (MSE) for tropical tuna fisheries in the EPO involving managers, scientists and other

	stakeholders.
T.1.a.	External review of bigeye tuna assessment
T.1.b.	External review of yellowfin tuna assessment
X.1.a	Workshop to advance spatial stock assessments of bigeye tuna in the Pacific Ocean

Proposals for projects pending funding are listed in Document IATTC-100-02b.

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H.4.a: Conduct routine stock assessments of tropical tunas	
H.6.a: Participate in assessments of shared species by the International Scientific Committee (ISC)	
H.7.a: Pacific-wide exploratory assessment for bigeye tuna	
H.7.b: South Pacific swordfish assessment	
H.7.c: Participate in south Pacific albacore assessment	
H.8.b: Second trial dolphin survey	
H.8.c: Cow-calf separation	
I.1.a: Conduct a Management Strategy Evaluation (MSE) for tropical tunas in the EPO	
J.1.a (new): Temporal trends and variability in the spatial distribution of tropical tuna purse-seine fishing	
J.2.a: Quantify the relationship between vessel operational characteristics and fishing mortality	
J.2.b (new): Identifying operational characteristics associated with mobulid bycatch in the eastern Pacific Ocean	
J.3.a: Developing alternative buoy-derived tuna biomass indexes	
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L.1.a: Develop habitat models for bycatch species caught in the EPO to support ecological risk assessments (ERAs)	
L.2.b (new): Vulnerability assessment of shark bycatch in EPO tuna fisheries using the EASI-Fish approach	
L.2.c (new): Assessing the efficacy of potential management options for highly vulnerable shark species in the EPO	
L.2.d (new): Pacific-wide vulnerability assessment of pelagic shark species caught as bycatch in tuna fisheries	
L.2.e (new): Vulnerability assessment and efficacy of potential conservation measures for the east Pacific leatherback turtle stock	
M.1.b: Test sorting grids	
M.1.c: Acoustic discrimination to avoid purse seine catches of undersized yellowfin tuna	
M.1.d: Developing and testing bycatch release devices in tuna purse seiners	
M.2.b: Evaluate best handling practices for maximizing post-release survival of silky sharks in longline fisheries, and identification of silky shark pupping areas for bycatch mitigation	
M.2.c: Manta and devil ray post-release survival, movement ecology, and genetic population structure	
M.3.b: Spatial and temporal closures and the tradeoff between bycatch and target catches	
M.5.a: Develop and test non-entangling and biodegradable FADs	
M.5.b: Reducing losses, and fostering recovery, of FADs in the purse-seine fishery in the EPO	
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N.2.a. Develop models of the effects of climate change on pre-recruit life stages of tropical tunas	
N.2.b: Supporting climate-ready and sustainable fisheries: using satellite data to conserve and manage life in the ocean and support sustainable fisheries under climate change	
O.2.a: Develop and implement analytical tools for understanding the trophic ecology of apex predators	
O.2.b: An updated ecosystem model of the tropical EPO for providing standardized ecological	

ASSESSMENTS OF TUNAS AND OTHER SPECIES CARRIED OUT BY THE IATTC STAFF

The staff's main responsibility is to analyze and assess the status of the stocks of tunas and tuna-like species in the EPO and provide scientific advice to the Commission to aid in its management decisions regarding these stocks. It prepares regular assessments of the principal species of tropical tunas (bigeye, yellowfin, and skipjack), and more occasional evaluations of other species, such as south EPO swordfish, silky shark and dorado, at the Commission's request. The staff also collaborates with the International Scientific Committee (ISC) for Tuna and Tuna-Like Species in assessments of North Pacific bluefin and North Pacific albacore tunas, and some billfish and shark species, and with other organizations, such as the SPC and WCPFC, for south Pacific albacore and Pacific-wide bigeye tuna assessment. It also conducts dolphin assessments for the AIDCP.

Three types of stock assessments are carried out: 1) **benchmark assessments** (previously called "full" assessments), in which all the major assumptions are reviewed and improved; 2) **updated assessments**, in which new or updated data are analyzed, using the current assumptions; and 3) **exploratory assessments**, in which new assumptions are investigated, but are not used in the assessment on which the staff bases its management advice. In years in which exploratory assessments are conducted, management is based on the latest benchmark assessment and indicators.

Stock assessment work during 2019-2020 focused primarily on delivering benchmark assessments of bigeye and yellowfin tunas in 2020, when Resolution C-17-02 expired, and was extended for 2021 (C-20-06), and new management measures for tropical tunas will be needed for 2022-2024. The staff's workplan to improve the stock assessments for tropical tunas, which included external reviews of the assessments for bigeye and yellowfin, has now been successfully completed. New benchmark assessments are available for bigeye and yellowfin (SAC-11-06, SAC-11-07), both used for management advice in the context of a new risk analysis approach (SAC-11 INF-F, SAC-11-08). Stock status indicators are also available for the three tropical tuna species (SAC-11-05). During the following 3 years (May 2021- May 2024), during which the 5-year cycle of the Strategic Science Plan (2018-2023) will be completed, the staff will continue to improve the bigeye and yellowfin benchmark assessments, as well as the risk analysis approach. Interim and benchmark assessment for skipjack will be available in 2022 and 2023, respectively, and new benchmark assessments for bigeye and yellowfin, and an improved risk analysis will be available in 2024. The report of the skipjack benchmark assessment, including the analysis of the tagging data, and progress reports on the yellowfin and bigeye tuna assessment and risk analysis work will be presented at the SAC in 2023.

In 2021, the staff has scheduled a benchmark assessment for South Pacific albacore following recent requests by Members. IATTC and SPC scientists are planning to work collaboratively on this joint assessment considering that SPC has also scheduled the same assessment for 2021. In 2021 the staff started continued to work on the south EPO swordfish assessment by following the 1st technical workshop in south EPO swordfish, expecting to complete the assessment in 2021. SPC is also conducting an assessment for southwest Pacific swordfish in 2021. The ISC Billfish working group is conducting an assessment for swordfish in the north PO. Coordination and discussions have been taken place among IATTC staff, SPC and ISC regarding several aspects of the assessments. (e.g. stock structure definitions). Similar to the previous dorado assessment by the staff, the south EPO swordfish assessment is being conducted in close collaborations with scientists from Members and Cooperative non-Members (e.g. Chile) interested on this fishery. Results will be presented in 2022.

In 2022, an exploratory Pacific wide bigeye assessment will be conducted, also in collaboration with SPC. Although this work and collaboration was already initiated in 2020, the assessment is planned to be presented in 2022 (not 2021, as previously scheduled), so that the staff can finish the South Pacific albacore and south EPO swordfish collaborative work in 2021.

Species	SSP ref.	Last assessed	2019	2020	2021	2022	2023	2024
IATTC								
Yellowfin tuna	H.4.a	2020	Indicators/ Update[2]/ Exploratory/ Review	Benchmark	Indicators	Indicators	Indicators, Exploratory assessment	Benchmark
Skipjack tuna	H.4.a	2004/2020 Indicators	Indicators	Indicators	Indicators, Review assessment methods	Interim assessment, indicators, Initial results of tagging analysis	Benchmark assessment, tagging analysis, Indicators	Indicators
Bigeye tuna (EPO)	H.4.a	2020	Indicators/ Exploratory/ Review	Benchmark	Indicators	Indicators	Indicators Exploratory assessment	Benchmark
Bigeye tuna (Pacific wide)	H.7.a	2016				Exploratory assessment		
Striped marlin	H.7	2010						
Swordfish (south EPO)	H.7.b	2011				Benchmark		
Sailfish	H.7	2013						
Black marlin		Never						
Silky shark	H.7	2018 (EPO indicators/ Pacific-wide benchmark)	Indicators	Indicators	Indicators	Indicators	Indicators EASI-Fish vulnerability assessment	Indicators
Dorado	I.3.a	2016	Candidate RP and HCR					

[2] The yellowfin update assessment was not originally planned for 2019, but was conducted for completeness

Species	SSP ref.	Last assessed	2019	2020	2021	2022	2023	2024
COLLABORATIONS								
Pacific bluefin tuna	H.6.a	2016 benchmark/ 2018 update	Projections	Benchmark	Projections	Update	Projections	Benchmark
North Pacific albacore tuna	H.6.a	2020		Benchmark			Benchmark	
South Pacific albacore tuna	H.7.c				Benchmark			
Blue marlin	H.7	2013 benchmark/ 2016 update			Benchmark			
North Blue shark	H.6.a	2017						
South Blue shark								
Shortfin mako shark	H.6.a	2018						
Swordfish (north Pacific)	H.7	2014				Benchmark		

WORK PLANS

Work Plans combine research activities from different parts of the SSP in order to achieve certain broad scientific objectives that span more than one *Theme* or *Goal*. The following summary work plans list the specific *Targets* and *Projects* that are included, the time frame for carrying each one out, and their status.

WORK PLANS TO IMPROVE STOCK ASSESSMENTS OF TROPICAL TUNAS

Assessing the status of the tropical tuna stocks is the scientific staff's main responsibility. The staff constantly seeks to improve both its conventional stock assessments and its stock status indicators. In 2018 and 2019, the staff identified some issues in the bigeye and yellowfin assessments, respectively, that needed to be addressed. These and other issues were addressed in the staff's 2019-2021 workplan for tropical tunas. The workplan included external reviews of the assessments for bigeye and yellowfin, and has now been successfully completed. New benchmark assessments are available for bigeye and yellowfin (SAC-11-06, SAC-11-07). These assessments represent a fundamental change from the staff's previous 'best assessment' approach: they are the basis for a 'risk analysis', in which a variety of reference models are used to represent plausible alternative assumptions about the biology of the fish, the productivity of the stocks, and/or the operation of the fisheries, thus effectively incorporating assessment uncertainty into the management advice as it is formulated.

The new assessment framework offers the following advantages: 1) it explicitly incorporates the results of all reference models (*model uncertainty*) and the precision of each model's parameter estimates (*parameter uncertainty*) when computing the quantities for management interest; 2) it allows a probabilistic evaluation of whether the target and limit reference points specified in the IATTC harvest control rule for tropical tunas (C-16-02) have been exceeded; 3) it can be integrated into the Management Strategy Evaluation (MSE) framework under development at IATTC as a basis for developing operating models.

This new approach to formulating management advice for tropical tunas includes the following elements:

Two **benchmark stock assessment reports**, for bigeye (SAC-11-06) and yellowfin (SAC-11-07), presenting the results from all reference models for each species (model fits, diagnostics, derived quantities and estimated parameters that define stock status);
A **risk analysis** (SAC-11-08) specific for tropical tunas, using the methods described in SAC-11 INF-F, which assesses current stock status and quantifies the probability (risk) of exceeding target and limit reference points specified in the IATTC harvest control rule, as well as the expected consequences of alternative management measures in terms of closure days;
Interim skipjack assessment (SAC-13) and a **benchmark assessment**, which will be included in the risk analysis framework.
Stock status indicators (SAC-12-05) for all three tropical tuna species (yellowfin, bigeye, and skipjack); and;
The **recommendations** by the staff for the conservation of tropical tunas, based on the above (SAC-12-16).

There are still some remaining issues with the bigeye, yellowfin, and skipjack assessments. In particular, the bigeye assessment has two groups of results divided into pessimistic models that estimate low biomass and optimistic models that estimate high biomass and the stock structure for all species is uncertain. Information for skipjack from the recently collected tagging data and associated analysis will be included into the assessment.

New workplans have been developed for each of the three species as outlined below to address these issues for the three species and to allow improvements before the next benchmark assessments in 2023 for skipjack and 2024 for bigeye and yellowfin.

WORK PLAN TO DEVELOP A STOCK ASSESSMENT FOR SKIPJACK TUNA

Up until this year (2022), there was no stock assessment for skipjack tuna in the EPO and management advice was based on assumptions about the productivity and susceptibility of skipjack relative to bigeye tuna and the assessed status of bigeye. Management advice for skipjack is greatly improved now that an assessment is available. In Addition, tagging data for skipjack is available from recent tagging cruises and this data can be

used to develop estimates of abundance and fishing mortality (SAC-12-06, SAC-13 Inf-X), which then can be used in conjunction with Yield-Per-Recruit (YPR) and spawner-per-recruit (SPR) analysis or in a full stock assessment to provide management advice. The IATTC staff has developed a workplan to implement the research needed to develop the tagging analysis and stock assessment. Recent information on reproductive biology (Schaefer and Fuller 2019), growth (SAC-13 Inf-J), and a review of stock structure (Schaefer 2008) is available, but information on natural mortality is borrowed form an old tagging study in the WCPO. It is possible that natural mortality could be estimated from the tagging analysis. An index of abundance based on echosounder FADS has been developed (FAD-xx-xx) and was used in the stock assessment. Relationships between spatial distribution of skipjack and the environment are also being developed (Project J.2.a) and may be used in the tagging analysis. The updated risk analysis will be applied to skipjack tuna if appropriate.

Main expected workplan deliverables

2021 Review of assessment methods (SAC-12)
2022 Interim stock assessment and preliminary results of the tagging analysis (SAC-13)
2023 Benchmark assessment (SAC-14)

TABLE 1.1.a. Timeline for skipjack tuna workplan 2021-2024

2021	
Fall: Initiate development of the tagging analysis	Project H.3.a
2022	
Jan-Feb workshop on improving metrics and their scoring for the IATTC risk analysis	Unfunded project H.1.g
Conduct growth analysis	Project H.3.c
Tagging cruise	
May: Present interim assessment and preliminary results of the tagging analysis at SAC	
Summer: Initiate development of the YPR analysis/stock assessment	Project H.3.b
Summer/Fall: External review of tagging analysis	
2023	
May: Present benchmark Assessment at SAC	

TABLE 1.1.b. Projects included in the skipjack tuna work plan, 2021-2024. **Green**: completed; **blue**: funded; **red**: unfunded; **pink**: partially funded (funded components completed, other components pending) **orange**: IATTC staff and/or collaborators. Text ~~struck through~~ indicates completed or terminated projects.

SSP ref.	Target/Project	Timeframe & status			
		2021	2022	2023	2024
1.	**ASSESSMENT RESEARCH**				
H.3.a	Analysis of recent skipjack tagging data				
H.3.b	Skipjack YPR/Stock assessment		*		
H.3.c	Estimate skipjack growth rates from recent tagging data				
J.2.a	Quantify the relationship between vessel operational characteristics and fishing mortality				
H.1.g	Workshop on improving metrics and their scoring for the IATTC risk analysis		**		
T.1.c	External review of skipjack tagging analysis				
2.	**NEW DATA SOURCES**				
E.4.a	IATTC Regional Tuna Tagging Program (RTTP) - EPO				
3.	**INDICES OF ABUNDANCE**				
J.3.a	Developing alternative buoy-derived tuna biomass indexes				
4.	**LIFE HISTORY DATA**				
E.5.a	Evaluate the Pacific-wide population structure of bigeye and skipjack tunas, using genetic analyses				

*Interim assessment conducted in 2022, benchmark in 2023

** The first workshop on diagnostics for the risk analysis was conducted in Jan-Feb 2022, a second workshop will be held on using these diagnostics and other metrics and how to score them.

WORK PLAN TO IMPROVE THE STOCK ASSESSMENT FOR YELLOWFIN TUNA

An external review for the yellowfin tuna stock assessment took place in December 2019. The staff completed a benchmark assessment for yellowfin tuna in 2020. The assessment was composed by 48 models weighted using a risk analysis approach and combined to provide management advice. A new purse-seine spatiotemporal model was used to produce the main index of abundance. The models represented several hypotheses about the stock. However, one of the main overarching hypotheses, stock structure, was not possible to address extensively. There are several hypotheses that need to be investigated, including the possibility of a southern population best represented by a longline-based index of abundance. The staff plans to address stock structure hypotheses soon and to investigate the ability to estimate abundance and abundance trends in the assessment. The staff developed new natural mortality models that are now incorporated into the Stock Synthesis platform. The staff is actively tagging yellowfin tuna, although with lower emphasis than skipjack, within the regional tuna tagging program, and had recently submitted a manuscript on the previous tagging data. The new information and technical capabilities will allow the staff to explore different life-history hypotheses for yellowfin tuna in the EPO.

Main expected work plan deliverables

2021: CAPAM natural mortality workshop (Workshop report); Risk assessment methodology (Workshop report)

2022: Advance the understanding of the longline data of different fleets and potential indices of abundance (Workshop report); Spatiotemporal models (Workshop report);

2023: Explore alternative hypotheses of stock structure and life-history for YFT in exploratory stock assessment models (SAC 14 document); External review (Workshop report); Best practices in stock assessment (presentation)

2024: Benchmark stock assessment model (SAC 15 document)

TABLE 1.2.a. Timeline for yellowfin tuna work plan, 2021-2024

2021	
CAPAM natural mortality workshop	
Longline work (pending data availability)	H.1.e (ext)
2022	
Workshop on improving metrics and their scoring for the IATTC risk analysis	H.1.g (unfunded)
Longline work (pending data availability)	H.1.e. (ext)
Spatiotemporal models	H.1.f
Preliminary spatial models	H.1.b phase 2
2023	
External review	T.1.b phase 2
Exploratory models	H.1.b phase 2
2024	
Benchmark yellowfin assessment	

TABLE 1.2.b. Projects included in the yellowfin tuna work plan, 2021-2024. **Green**: completed; **blue**: funded; **red**: unfunded; **pink**: partially funded (funded components completed, other components pending); **orange**: IATTC staff and/or collaborators. Text ~~struck through~~ indicates completed or terminated projects.

SSP ref.	Target/Project	Timeframe & status			
		2021	2022	2023	2024
MONITORING STOCK STATUS AND MANAGEMENT ADVICE					
H.4.a	Conduct routine stock assessments of tropical tunas and indicators				
J.2.a	Quantification of the relationship between vessel operational characteristics and fishing mortality				
	ASSESSMENT RESEARCH				
H.1.b	Improve the yellowfin tuna stock assessment phase 2: Explore alternative hypotheses of stock structure and life-history for YFT in exploratory stock assessment models				
X.1.c	CAPAM workshop on natural mortality				
H.1.g	Workshop on improving metrics and their scoring for the IATTC risk analysis				
T.1.b	External review of yellowfin tuna assessment				
	LIFE HISTORY DATA				
E.2.a	Investigate spatiotemporal variability in the age, growth, maturity, and fecundity of yellowfin tuna in the EPO				
E.3.a	Investigate geographic variation in the movements, behavior, and habitat utilization of yellowfin tuna in the EPO				
	INDICES OF ABUNDANCE				
H.1.e	Advance the understanding of the longline data of different fleets and potential indices of abundance				
H.1.f	Workshop on improving spatio-temporal methods for tuna CPUE and length composition standardization				
	NEW DATA SOURCES				
J.3.a	Developing alternative buoy-derived tuna biomass indexes				
E.4.a	Multi-year tuna tagging study				

WORK PLAN TO IMPROVE THE STOCK ASSESSMENT FOR BIGEYE TUNA

An external review for the bigeye tuna stock assessment took place in March 2019. The staff completed a benchmark assessment for bigeye tuna in 2020. Different from the previous assessment approach that relies on one base-case model, the new benchmark assessment includes 44 reference models which are weighted using a risk analysis approach to provide management advice. The reference models for bigeye tuna are developed based on key hypotheses to explain the recruitment shift, fit to longline composition data, and the steepness of the stock-recruit relationship. The risk analysis for bigeye tuna shows that the weighted management quantities are bimodal. The optimistic group of models suggest that fishing mortality is well above the target reference level while the pessimistic group of models suggest that fishing mortality has greatly exceeded the target reference level. The staff has developed new natural mortality models that are now incorporated into the Stock Synthesis platform. The staff will continue to improve the assessment model and work on resolving the bimodal pattern. In particular, the staff will build an exploratory Pacific-wide assessment model for bigeye (Project H.7.a) to investigate whether the recruitment shift found in the EPO bigeye stock is caused by ignoring the movement between WCPO and EPO. Also, the staff will keep improving longline indices of abundance for bigeye tuna (H.1.e), which is, however, dependent on the availability of the high-resolution longline catch and effort data from the main longline CPCs.

Main expected work plan deliverables

2021: CAPAM natural mortality workshop (Workshop report)
2022: Workshop on improving the risk analysis for the tropical tunas in the EPO (Workshop report)
Advance the understanding of the longline data of different fleets and potential indices of abundance (Workshop report)
Spatiotemporal models (Workshop report)
2023: Preliminary assessment models for bigeye tuna in the EPO (SAC 14 document)
Risk assessment methodology (Workshop report)
2024: Benchmark stock assessment model (SAC 15 document)
Best practices in stock assessment (presentation)

TABLE 1.3.a. Timeline for bigeye tuna work plan, 2021-2024

2021	
CAPAM natural mortality workshop	
2022	
Longline work (depends on data submission)	H.1.e. (ext)
Workshop on improving the risk analysis for the tropical tunas in the EPO	H.1.a (unfunded)
2023	
Preliminary assessment models	
External review	T.1.a phase 2
2024	
Benchmark stock assessment	

TABLE 1.3.b. Projects included in the bigeye tuna work plan, 2021-2024. **Green**: completed; **blue**: funded; **red**: unfunded; **pink**: partially funded (funded components completed, other components pending); **orange**: IATTC staff and/or collaborators. Text ~~struck through~~ indicates completed

SSP ref.	Target/Project	Timeframe & status			
		2021	2022	2023	2024
MONITORING STOCK STATUS AND MANAGEMENT ADVICE					
H.4.a	Conduct routine stock assessments of tropical tunas and indicators				
J.2.a	Quantification of the relationship between vessel operational characteristics and fishing mortality				
	ASSESSMENT RESEARCH				
H.1.b	Improve the bigeye tuna stock assessment				
H.1.g	Workshop on improving the risk analysis for the tropical tunas in the EPO				
T.1.a	External review of bigeye tuna stock assessment				
X.1.c	CAPAM workshop on natural mortality				
	INDICES OF ABUDANCE				
H.1.e	Advance the understanding of the longline data of different fleets and potential indices of abundance				
H.1.f	Workshop on improving spatiotemporal methods for CPUE and length composition standardization				
J.3.a	Developing alternative buoy-derived tuna biomass indices				

WORK PLAN FOR MANAGEMENT STRATEGY EVALUATIONS (MSE)

The process of developing MSEs, a major objective of the IATTC and other organizations, consists of two parts. One is highly technical, and is carried out by scientific experts, but the other, which involves defining objectives, performance metrics, and candidate management strategies, requires input and participation of managers and other stakeholders. Those two parts should evolve in synergy. Stakeholder participation throughout the MSE process is central to its success and will be facilitated by an understanding of the MSE process and its components, and by strengthening communication among scientists, managers, and other stakeholders. The proposed work plan combines support for the staff in the technical development of MSE for tropical tunas and a series of workshops for training and enhancing dialogue and communication among all interested parties regarding the MSE process for tropical tunas. The stakeholder dialogue component will focus on the three tropical species (BET, YFT, SKJ). The initial technical MSE work will continue to focus on bigeye tuna, and will move to the other species towards the end of current workplan. The rationale to focus the initial technical work on BET is based on it being the species that has historically needed the strictest management, the recent work to improve BET modeling toward building BET operating models, the lack of assessment models (or operating models) for SKJ and the need for additional work on the YFT modeling to be able to incorporate relevant hypotheses for assessment and operating models. The work includes additional improvements to the bigeye stock assessment model, which will be used as a basis for the operating model used in the MSE. The current MSE workplan for tropical tunas extends to 2024 and is funded from 2021 to 2023 by the European Union, funding for 2024 and beyond has not been secured yet. The IATTC staff is also collaborating with other organizations, such as the ISC, in Pacific-wide MSEs for albacore and Pacific bluefin tunas.

Main expected deliverables (see individual project reports for details):

2018: Improved bigeye assessment for use as spatial operating model (OM)
Workshop on training, communication, and evaluation of management strategies for tuna fisheries in the EPO

2019: SAC-10: Report improvements to bigeye model for its use as OM; alternative reference points and harvest control rules (HCRs) for dorado.
Introductory harvest strategies workshops for the EPO Tuna Industry
Workshop for scientists-managers to elicit objectives, performance metrics

2020: Work on alternative ways to incorporate uncertainty in parameters and model structure during the MSE modeling phase, including incorporating results from the risk analysis

2021: Workshop to discuss alternative HCRs and refine strategy elements from previous Workshops
SAC-12 and Annual Meeting: Report on revised MSE plan and outcomes of workshops
Technical development of MSE components and framework, testing.

2022: Workshop to show MSE preliminary results, gather feedback, plan additional evaluation work
SAC-13 and Annual Meeting: Report on revised MSE plan
Technical implementation of MSE, evaluation work.

2023: Workshop to show MSE updated results, gather feedback, plan additional evaluation work.
SAC-14 and Annual Meeting: Report on revised MSE plan
Technical implementation of revised MSE, evaluation

2024: Workshop to discuss MSE results, plan for other tropical tunas
SAC-15 and Annual Meeting: Report and presentation of MSE results and plan for other tropical tunas.
Presentation of revised MSE results incorporating stakeholder input to IATTC Annual Meeting.

GREEN: COMPLETED; BLUE: FUNDED; RED: UNFUNDED, Text ~~struck through~~ indicates completed or terminated projects

SSP ref.	Target/Project	2018		2019		2020		2021		2022		2023		2024	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2
	1. SUSTAINABLE FISHERIES														
	Goal I: Test harvest strategies using Management Strategy Evaluation (MSE)														
I.1.	Conduct a comprehensive MSE for bigeye tuna and plan MSEs for the other tropical tuna species														
I.1.a	1. Stakeholder and technical MSE workshops														
	Technical meetings to agree on overall/revised MSE Plan by IATTC staff and collaborators														
	Stakeholder workshops on training and communication on MSE development and results														
	2. Technical development of MSE, HCR, MP, outputs														
	~~a. Improve the bigeye assessment for use as spatial OM~~														
	~~b. Run preliminary simulations with spatial OM~~														
	a. Run preliminary MSE based on initial input from managers and stakeholders														
	b. Run final MSE based on revised input from managers and stakeholders														
	c. Present evaluated HCR/MP to Commission, plan work for other tropical tunas														
I.2.	Collaborate with ISC in Pacific-wide MSEs for albacore and Pacific bluefin tunas (*dependent on ISC scheduling) — ALB								*	*	*	*	*		
	PBF								*	*	*	*	*		
I.3	Initiate MSE work to evaluate indicator-based harvest strategies for prioritized species and species of specific interest														
	Identify and correct the purse-seine fleet catch for bias caused by the COVID-19 pandemic in 2020-2021														
I.3.a	~~Evaluate potential reference points for dorado in the EPO~~														
	2. KNOWLEDGE TRANSFER AND CAPACITY BUILDING														
	Goal R: Improve communication of scientific advice~~Evaluate potential reference points for dorado in the EPO~~														
R.1.	Improve communication of the staff's scientific work to CPCs														
~~R.1.a~~	~~Workshop on training, communication and evaluation of management strategies for tuna fisheries in the EPO~~**Goal R:** Improve communication of scientific advice														
	~~Other MSE workshops for scientists-managers (to be planned)~~Improve communication of the staff's scientific work to CPCs														
~~R.1.b~~	~~Technical development, communication and evaluation of MSEs for tropical tuna fisheries in the EPO involving managers, scientists and other stakeholders~~														
R.2	~~a.~~ Participate in global initiatives for the communication of science: t-RFMO MSE working group~~Other MSE workshops for scientists-managers (to be planned)~~														
~~R.1.b~~	**3. SCIENTIFIC EXCELLENCE**~~Technical development, communication and evaluation of MSEs for tropical tuna fisheries in the EPO involving managers, scientists and other stakeholders~~														

SSP ref.	Target/Project	2018		2019		2020		2021		2022		2023		2024	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2
	Participate in global initiatives for the communication of science: t-RFMO MSE working group														
	3. SCIENTIFIC EXCELLENCE														
	Goal T: Implement external reviews of the staff's research														
~~T.1.~~	~~External review of bigeye assessment~~			-											
T.2.	Publications in journals														

WORK PLAN FOR THE FAD FISHERY: IMPROVE DATA COLLECTION AND MANAGEMENT, AND MITIGATE ECOLOGICAL IMPACTS

The expansion of FAD fisheries worldwide poses several challenges for tuna RFMOs. First, with the expansion has come the need for improved data collection to provide better management advice on an ever-evolving fishery. Currently, much of the detailed data on the EPO FAD fishery is collected by observers aboard Class-6 vessels. However, new resolutions and technological advances offer the possibility of collecting additional detailed data on FAD-related activities, including information provided by fishing crews on FAD form 9/2018v2 (Resolution C-19-01), raw buoy data to be provided to the IATTC staff under Resolution C-21-04 , and the use of electronic monitoring and other technologies (e.g. smartphone apps employing AI, rapid genomic tests for improved species identification) to supplement data collected by on-board observers. Second, because the FAD fishery has different impacts on the ecosystem, in terms of marine pollution, impacts on sensitive habitats, bycatches of non-target species, and catches of juveniles of target species, than other components of the purse-seine fishery, there is an urgent need to develop and test conservation and management measures that will contribute to mitigate these effects, such as gear modifications, definitions of best handling and release of sensitive species, guidelines for new FAD designs, quantification and remediation of stranding events, and assessment of different types of spatial and temporal closures on target and non-target species, among others.

The IATTC staff is currently working on numerous projects related to the FAD fishery, and has submitted proposals for funding to help fill remaining data and knowledge gaps; these are shown in the work plan below.

Main expected deliverables (see individual project reports for details):
2018: Reports summarizing current data gaps and potential improvements
2018-2022: Training workshops to expand and improve data collection
2020-2022: Pilot study on remote and electronic identification of FADs
Data-driven recommendations for the implementation of electronic monitoring in the purse-seine fleet
Quantitative evaluation of the relationship between the FAD fishery and fishing mortality
2021-2022 and beyond: Guidelines for state-of-the-art data-collection procedures for the purse-seine fishery; improved data quality and reporting procedures; better understanding of impacts of FADs on target and non-target sensitive species, as well as habitats and ecosystem; more ecologically-friendly FAD designs, and guidelines for their implementation and use; assessment of the effectiveness of different type of spatial and temporal closures on target and non-target sensitive species; a better understanding of climate change impacts on the FAD fishery

Green: completed; **blue**: funded; **red**: unfunded

SSP ref.	Target/Project	Timeframe & status					
		2018	2019	2020	2021	2022	2023
DATA							
Goal B: Identify and prioritize opportunities to improve data quality and expand data types and coverage							
B.1.a	Improving smart species identification tools						
B.2.	Expand on-board data collection to small purse seiners: train observers and fishing crews						
Goal C: Facilitate the improvement of data quality, coverage, and reporting by CPC data collection programs							
C.1.	Purse-seine fleet: Improve data reporting and content (Resolutions C-19-01 and C-21-04; SAC and WG-FADs recommendations)						
Goal D: Investigate the use of new technologies to improve data quality							
D.1.a	Exploring technologies for remote identification of FADs						
D.2.a	Pilot study of electronic monitoring of the activities and catches of purse-seine vessels						
Goal Q: Provide training opportunities for scientists and technicians of CPCs							
Q.3	Workshops for vessel crews, industry, and national authorities on requirements of C-19-01 and C-21-04 (WG-FADs Recommendation endorsed by SAC)						
CONSERVATION AND MANAGEMENT							
Goal J: Improve our understanding of the effects of the operational characteristics of the fishery on fishing mortality, stock assessments, and management advice							
J.1.a	Temporal trends and variability in the spatial distribution of tropical tuna purse-seine fishing						
J.2.a	Quantification of the relationship between vessel operational characteristics and fishing mortality						
J.2.b	Identifying operational characteristics associated with mobulid bycatch in the eastern Pacific Ocean						
J.3.a	Pilot study on developing alternative buoy-derived tuna biomass indices						
Goal M: Mitigate the ecological impacts of tuna fisheries							
M.1.a	Evaluate the effect of the depth of non-entangling FADs on catches of tunas and bycatches of other species in the purse-seine fishery						
M.1.b	Test sorting grids (with emphasis on reducing catches of juvenile bigeye)						
M.3.a	Estimate bycatch and discard rates at FADs, by species, and identify “hot spots”						
M.5.a	Develop and test non-entangling and biodegradable FADs						
M.5.b	Reducing losses, and fostering recovery, of FADs in the purse-seine fishery in the EPO						
M.1.d	Developing and testing bycatch release devices in tuna purse-seiners						
N.1.c	Developing dynamic species distributions models to inform conservation and management of non-target species and communities						
M.2.c	Manta and devil ray post-release survival, movement ecology, and genetic population structure						
O.2.c	Temporal network analysis of bycatch communities caught in purse-seine fisheries						
N.2.b	Supporting climate-ready and sustainable fisheries						
M.3.b	Spatial and temporal closures and the tradeoff between bycatch and target catches						
M.5.c	Definition of guidelines to reduce the impact of lost and abandoned FADs on marine turtles						

WORK PLAN TO IMPROVE DATA COLLECTION AND STOCK ASSESSMENTS FOR SHARKS

Paragraph 1 of Resolution C-16-05 on the management of shark species requires that "*the IATTC scientific staff shall develop a workplan…, for completing full stock assessments for the silky shark … and hammerhead sharks …*"

As the staff has noted previously, improving shark fishery data collection in the EPO is essential if conventional stock assessments and/or other indicators of stock status are to be developed for sharks. An attempt to assess the status of the silky shark in the EPO using conventional stock assessment models was severely handicapped by major uncertainties in the fishery data, and stock assessment work on hammerhead sharks is currently not possible due to the scarcity of data for this taxon. Without reliable catch and composition data and indices of abundance for all fisheries catching sharks in the EPO, any further attempts at such assessments are problematic. In this regard, the lack of funding for Project C.4.b (see IATTC-93-06c) is also problematic.

The staff developed a work plan to improve data collection and stock assessments for sharks, focused on all EPO fisheries that interact with silky and hammerhead sharks, and obtained funds from FAO-GEF to improve data collection for the coastal longline and gillnet fisheries, which have the greatest deficiencies and are estimated to take a large fraction of the shark catches. The staff is developing an experimental design for a long-term shark fishery sampling program in the EPO, for presentation to the SAC and the Commission in 2020 and hopes to deliver some form of stock assessments of silky and hammerhead sharks by the end of the SSP time frame in 2023. The type of assessment applied to each species will depend on the data available. In addition, the work plan involves bycatch mitigation activities aimed at reducing fishing mortality of sharks.

Main expected deliverables (see individual project reports for details)**:**
2019: Proposal for long-term sampling program for shark catches by artisanal fisheries in Central America
2023: Assessments of silky and hammerhead sharks in the EPO

Green: completed; **blue**: funded; **red**: unfunded

SSP ref.	Target/Project	Timeframe & status					
		2018	2019	2020	2021	2022	2023
	DATA						
Goal B: Conduct a review of current IATTC/AIDCP data collection programs, identify and prioritize opportunities to improve data quality and expand data types and coverage							
B.1.a	Improving smart species identification tools						
B.2.	Expand on-board data collection to small purse seiners						
B.3.a	Individual Vessel Limit pilot study						
Goal C: Facilitate the improvement of data quality, coverage, and reporting by CPC data collection programs							
C.1.a	Catch bias estimation						
C.4	Artisanal fisheries (coastal developing CPCs)						
C.4.a	Improving data collection for Central American shark fisheries: develop sampling protocols for catch and effort estimation (FAO-GEF ABNJ project)						
	Identify all unloading sites and obtain order-of-magnitude estimates of total catch and effort						
	Design and test sampling protocols for species and size composition sampling						
C.4.b	Long-term sampling program for shark catches of artisanal fisheries in Central America						

SSP ref.	Target/Project	Timeframe & status					
		2018	2019	2020	2021	2022	2023
Goal D: Investigate the use of new technologies to improve data quality							
D.2.a	Pilot study of electronic monitoring of the activities and catches of purse-seine vessels						
	LIFE HISTORY DATA						
F.2.a	Investigate the movements, behavior, and habitat utilization of silky sharks in the EPO						
	MONITORING POPULATION STATUS AND MANAGEMENT ADVICE						
Goal H: Improve and implement stock assessments, based on the best available science							
H.5	Undertake the research necessary to develop and conduct data-limited assessments for prioritized species (Assessments of silky and hammerhead sharks in the EPO)						
H.5.a	Revise trend estimation methods for purse-seine silky shark indices for the EPO						
Goal L: Evaluate the ecological impacts of tuna fisheries							
J.2.b	Identifying operational characteristics associated with mobulid bycatch in the eastern Pacific Ocean						
L.1.a	Develop habitat models for bycatch species caught in the EPO to support ecological risk assessments (ERAs)						
L.1.b	Develop a flexible spatially-explicit ERA approach for quantifying the cumulative impact of tuna fisheries on data-limited bycatch species in the EPO						
L.2.a	Develop and update Productivity-Susceptibility Analyses (PSAs) of tuna fisheries in the EPO						
L.2.b	Vulnerability assessment of shark bycatch in EPO tuna fisheries using the EASI-Fish approach						
L.2.c	Assessing the efficacy of potential management options for highly vulnerable shark species in the EPO						
Goal N: Improve our understanding of the interactions among environmental drivers, climate, and fisheries							
N.1.a	Analyze EPO bycatch data to assess the influence of environmental drivers on catches and vulnerability						
	BYCATCH MITIGATION						
Goal M: Mitigate the ecological impacts of tuna fisheries							
M.1.a	Evaluate the effect of the depth of non-entangling FADs on catches of tunas and bycatches of other species in the purse-seine fishery						
M.1.d	Developing and testing bycatch release devices in tuna purse-seiners						
~~M.2.a~~	~~Evaluate the post-release survival of silky sharks captured by longline fishing vessels in the equatorial EPO, using best handling practices~~						
M.2.b	Evaluate best handling practices for maximizing post-release survival of silky sharks in longline fisheries, and identification of silky shark pupping areas for bycatch mitigation						
M.2.c	Manta and devil ray post-release survival, movement ecology, and genetic population structure						
M.3.a	Estimate bycatch and discard rates at FADs, by species, and identify “hot spots”						

CURRENT AND PLANNED PROJECTS, BY THEME

DATA COLLECTION FOR SCIENTIFIC SUPPORT OF MANAGEMENT

PROJECT A.1.a: Database and Observer Data Collection Program Regular Activities	
THEME: Data collection **GOAL:** A. Database maintenance, preservation, and access **TARGET:** A.1. Routine tasks **EXECUTION**: Bycatch and IDCP Program	
Objectives	Continue observer data collection program regular activities required by the Antigua Convention and the AIDCP
Background	The AIDCP requires that all trips by Class-6 purse-seine vessels (carrying capacity > 363 t) in the EPO carry an observer aboard; the IATTC observer program covers 50% of trips. Observer records are the primary source of data on the purse-seine fishery. The Antigua Convention and various IATTC resolutions require that observers collect information on the tuna purse-seine fishery. The Bycatch-IDCP program is instrumental in training observers from national programs and under agreements with other organizations.
Relevance for management	Observer data are a key element for stock assessments and recommendations by the IATTC scientific staff
Duration	Continuous
Workplan and status	Continue to process new data. Seek opportunities to improve data collection and processing.
External collaborators	Coordination with national and regional observer programs is essential and required.
Deliverables	IATTC staff processed data from 497observed trips initiated during 2021. No alignment of dolphin safety panel in purse-seine net, 2021

PROJECT A.1.a: Routine activities of the Bycatch and IDCP Program
Reports/publications/presentations Presentations for the AIDCP seminar were updated with new resolution requirements relevant to operators, and made available to the national programs.

PROJECT A.3.a. Conversion of all remaining Visual Basic 6 (VB6) computer programs to Visual Basic Net (VB.net).	
THEME: Data collection **GOAL:** A. Database maintenance, preservation, and access **TARGET:** A.3. Standardize and automate data submissions **EXECUTION**: Data Collection and Database Program	
Objectives	Re-write in VB.net all Visual Basic (VB) version 6 computer programs still in use by the IATTC and supported national observer programs. Work with national programs to install and test in the local environments, and train national program staff.
Background	IATTC staff developed customized data entry and editing programs using VB. Microsoft has terminated support for VB6, so the development environment no longer runs on current Microsoft operating systems. The code must be re-written in a supported programming language.
Relevance for management	At some point the compiled VB6 programs will cease to work, and data required for stock management would not be available.
Duration	2 more years – planned completion in 2021
Work plan and status	Late 2014: project initiated. March 2020: conversion 75% complete. April-December: Continue conversion, prioritizing the most important computer programs.
External collaborators	Existing staff are completing the project, rather than hiring outside programmers.
Deliverables	Completion of conversion of all VB6 computer programs. Replacement of all VB6 computer programs in IATTC and national programs with VB.net programs. Provide technical support to national programs during transition.

PROJECT A.3.b: Develop databases of biological and fisheries parameters to support Ecological Risk Assessment and ecosystem models	
THEME: Data collection **GOAL:** A. Database maintenance, preservation, and access **TARGET:** A.3. Standardize and automate data submissions **EXECUTION**: Data Collection and Database Program, Biology and Ecosystem and Bycatch Program	
Objectives	Develop a comprehensive database of best-available biological and fisheries data to provide key parameters for Ecological Risk Assessment (ERA) and ecosystem models
Background	The Antigua Convention requires the IATTC to ensure the sustainability of target, associated, and dependent species affected by EPO tuna fisheries, and the ecosystem to which they belong. ERA and ecosystem models, used by IATTC staff to assess the ecological impacts of tuna fisheries in the EPO, require information on biological, physiological and trophodynamic characteristics of thousands of species in the EPO ecosystem. A database with the most up-to-date information for impacted species is required to expedite the initial parameterization, or updating, of future models.
Relevance for management	The database will contain data needed for ERAs and ecosystem models, used to identify and prioritize data collection, mitigation, and/or management measures for vulnerable species. The databases could be shared with scientists of CPCs.
Duration	2018–2023
Workplan and status	Biological and ecological literature searches for species that have been documented to interact with EPO tuna fisheries Identify fishery-related susceptibility parameters for bycatch species Update length-weight relationships and average weight by species to facilitate various staff activities and reporting (*e.g.*, Fishery Status Report).
External collaborators	Scientists from CPCs interested in contributing to and/or using the databases
Deliverables	Comprehensive life history and susceptibility database with fishery-specific information that can be shared with IATTC CPCs for those wishing to develop ERAs for a particular region and/or fishery.

PROJECT A.3.b: Develop databases of biological and fisheries parameters to support Ecological Risk Assessment and ecosystem models

Updated: May 2022

Progress summary for the reporting period

A preliminary life-history database has been developed for all species reported to have interacted with industrial purse-seine, and longline fisheries as well as the predominant small-scale coastal longline and gillnet fisheries.

Values for fisheries-related susceptibility parameters have been obtained for about 50 of the 110 bycatch species that interact with EPO tuna fisheries.

A similar initiative has been developed by the SPC and discussions are underway to develop a Pacific-wide life-history database.

New task: update length-weight relationships and average weight of bycatch species to improve various staff activities and reporting (*e.g.*, Fishery Status Report).

Challenges and key lessons learnt

The main challenge is sourcing datasets for rare/infrequently caught bycatch species with sufficient sample sizes across a wide size spectrum

Reports/publications/presentations

Five manuscripts that use these life-history and susceptibility data have been prepared for submission to scientific journals or IATTC presentations:

Griffiths, S.P. and Lezama-Ochoa, N. 2021. A 40-year chronology of spinetail devil ray (*Mobula mobular*) vulnerability to eastern Pacific tuna fisheries and options for future conservation and management. *Aquatic Conservation: Marine and Freshwater Ecosystems* 31.

Griffiths, S.P., Kesner-Reyes, K., Garilao, C., Duffy, L.M., Román, M.H., 2018. Development of a flexible ecological risk assessment (ERA) approach for quantifying the cumulative impacts of fisheries on bycatch species in the eastern Pacific Ocean. *9th Meeting of the Scientific Advisory Committee of the IATTC, 14-18 May 2018, La Jolla, California, USA. Document SAC-09-12*.

Griffiths, S.P., Lezama-Ochoa, N., Román, M.H., 2019. Moving towards quantitative ecological risk assessment for data-limited tuna fishery bycatch: application of "EASI-Fish" to the spinetail devil ray (*Mobula mobular*) in the eastern Pacific Ocean. *9th Meeting of the IATTC Working Group on Bycatch, 11 May 2019, San Diego, California, USA. Document BYC-09-01*.

Griffiths, S.P., Kesner-Reyes, K., Garilao, C., Duffy, L.M., Román, M.H., 2019. Ecological Assessment of the Sustainable Impacts of Fisheries (EASI-Fish): a flexible vulnerability assessment approach to quantify the cumulative impacts of fishing in data-limited settings. *Marine Ecology Progress Series* 625, 89-113.

Griffiths, S.P., Wallace, B., Swimmer, Y., Alfaro-Shigueto, J., Mangel, J.C., Oliveros-Ramos, R., 2020. Vulnerability status and efficacy of potential conservation measures for the east Pacific leatherback turtle (*Dermochelys coriacea*) stock using the EASI-Fish approach. *10th Meeting of the IATTC Working Group on Bycatch, 10 September 2020, La Jolla, California, USA. Document BYC-10-01*.

Comments:

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PROJECT B.1.a: Improving smart species identification tools	
THEME: Data collection **GOAL:** B. Review IATTC/AIDCP data collection programs **TARGET:** B.1. Improve data collected by the purse-seine On-Board Observer Program **EXECUTION**: Data Collection and Database Program, Ecosystem and Bycatch Program	
Objectives	Develop smart tools for accurately identifying prioritized species
Background	Researchers of Michigan State University, Texas A&M University, and St. Anselm College have been funded by the National Science Foundation to develop smart tools for identifying species in diverse fisheries contexts. Tools under development consist of: i) a smartphone application that employs artificial intelligence (AI) to perform species identification using user-supplied photos or video, and ii) genomic tests to perform genetic species identification in the field. Together, these tools could make rapid and highly accurate species identification possible without the need for specialized training or equipment. Due to a variety of reasons, accurate species identification in the field (i.e., landing sites) or by observers or cameras on-board (e.g., purse-seines, longlines) is not always possible. Therefore, tools that improve species identification of prioritized species in a rapid and accurate manner are desirable.
Relevance for management	Improved species identification during data collection programs will increase data quality provision to enhance stock assessments and other biological and ecological studies for prioritized species performed by the IATTC staff, reducing uncertainty in the scientific-advice and decision making. A trained AI model could increase the effectiveness of algorithms to review records collected by Electronic Monitoring (EM) equipment in a rapid and accurate manner, and help implement EM-programs in the region.
Duration	24 months
Workplan and status	Year 1: Sampling and collection of tissue, photo and video collection of prioritized species by technicians in the field and on-board observers or EM-cameras to improve genetic analysis and the training of the AI model, respectively. Year 2: Beta testing of smartphone application and rapid genetic tests. These activities will require the collaboration of national authorities and fishing industry.
External collaborators	Michigan State University, Texas A&M University, and St. Anselm College, fishing industry, CPCs
Deliverables	Improved smartphone application that employs an AI model to perform species identification using user-supplied photo or video. Improved genomic tests to perform genetic species identification in the field. Improved AI algorithm to review EM data in a rapid and accurate manner. Dissemination material (e.g., reports, presentations) for the Bycatch Working Group, the SAC, the Tuna Conference, and other meetings of interest.

PROJECT B.3.a: Individual Vessel Limit (IVL) pilot study	
THEME: ?? **GOAL: B. ??** **TARGET:** B.3. Purse-seine **EXECUTION**: Stock Assessment Program	
Objectives	Develop sampling designs for estimating well-level and trip-level catch composition to be used in the IVL enhanced port-sampling program in 2023-2024.
Background	At the 98th Meeting of the IATTC, the Commission established an IVL program for bigeye tuna catches (Resolution C-21-04), which is to include a special port-sampling program ("IVL enhanced port-sampling program") for trips considered to have caught a significant amount of bigeye tuna. To implement the IVL enhanced port-sampling program, the sampling protocol of this program needs to be tailored to estimation of well-level and trip-level catch composition. The sampling protocol of the current IATTC port-sampling program is not appropriate for this task because it was designed for estimation of fleet-level catch composition and was based on results of studies conducted prior to the expansion of the fishery on fish-aggregating devices in the 1990s. Given this, as outlined in SAC-13 INF-E, an IVL pilot study is planned for the second half of 2022 to: 1) collect extensive well sampling data for a simulation study to test sampling designs for well-level and trip-level catch composition estimation; and, 2) field-test the best sampling designs from (1) to identify and mitigate any logistical issues in advance of the initiation of the IVL enhance port-sampling program in 2023.
Relevance for management	Development of sampling designs for estimation of catch composition for individual vessel trips is essential to the success of the IVL enhanced port-sampling program and to the IVL Program, more generally.
Duration	6 months, July – December 2022
Work plan and status	July – October 2022: collect extensive well sampling data and conduct a simulation study to test sampling designs. November – December 2022: Field-test sampling designs developed in the simulation study, to identify and mitigate any logistical issues.
External collaborators	Government of Ecuador (4 samplers to be provided in-kind)
Deliverables	Reports for the SAC and the Commission; publications in peer-reviewed journals.

PROJECT C.1.a: Purse-seine catch composition bias estimation	
THEME: Data collection **GOAL:** C. Improve quality and expand coverage of data-collection programs **TARGET:** C.1. Purse-seine **EXECUTION**: Stock Assessment Program	
Objectives	Explore and develop robust statistical models to investigate and correct the possible bias in tuna catch composition, resulting from data loss during the COVID-19 pandemic of 2020-2021.
Background	The COVID-19 pandemic hindered collection of port-sampling data in 2020-2021. Some of the ports most affected were where bigeye tuna (BET) catch is unloaded. Port-sampling data are used to estimate the tropical tuna catch composition of the purse-seine fleet, and thus, there is concern that the Best Scientific Estimates of catch may be biased, particularly for bigeye tuna. Spatio-temporal (CAR) models to estimate port-sampling species proportions from observer (logbook) data with overall good performance were developed for 2020-2021 (SAC-13-05). Simulation results suggest the CAR model performance is robust to the type of systematic data loss that occurred in 2020. However, simulation studies need to be conducted to evaluate the robustness of the CAR model 2021 estimates. Because the stock assessment models have a quarterly time step and the fisheries definitions differ from the areas used in the CAR modeling, it will also be important to develop fine-scale spatio-temporal models (e.g., 5°- month or 5°- quarter).
Relevance for management	Revised catch estimates for the purse-seine fishery will be essential for the benchmark assessments in 2023 and 2024.
Duration	1.5 years
Work plan and status	2022: Further investigate spatio-temporal modeling options to correct possible bias in tuna catch composition estimates for all three purse-seine set types. 2023: Produce revised catch composition estimates for the purse-seine fishery for 2020-2021.
External collaborators	None
Deliverables	Reports for the SAC and the Commission; publications in peer-reviewed journals.

PROJECT C.2.b: Pilot study of electronic monitoring (EM) of the activities and catches of longline vessels	
THEME: Data collection **GOAL:** C. Improve quality and expand coverage of data-collection programs **TARGET:** C.2. Longline fleet **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	Establish what data EM is capable of collecting aboard longline vessels greater than 20 meters length with as much precision as the observer as for target and non-target catch data by size and species, discards, transshipments, and the potential augmentation of data for science purposes
Background	Tuna CPUE modelling requires high resolution spatial-temporal size composition data to estimate relative abundance indices. Current observed EPO fishing effort coverage of 5% by longline fishing vessels greater than 20 meters length, established by Resolution C-19-08 has been considered low by the IATTC staff and the IATTC Working Group on Bycatch. Instead, it's been suggested to be raised to 20%. Logistical, financial and space constrains have caused the observer placement onboard longline vessels to be difficult. Shortage of human observer coverage could be achieved by electronic monitoring systems (EMS). Trials on EM for longline fishing vessels have been fully developed in other regions of the Pacific Ocean, except in the EPO.
Relevance for management	Improved indices of relative abundance for tuna stocks will improve tuna stock assessments and therefore advise to management. Size-based stock status indicators for species not monitored with assessments will improve management decisions for those species.
Duration	26-28 months
Work plan and status	[M 1-2] Solicit bids from EM companies for equipment, installation and data archiving services. [M 3-5] Identify vessels willing to participate in the study. Purchase EM equipment. [M 6-16] Trips with simultaneous collection of EM and observer data aboard longline vessels. [M 17-21] Processing of EM data. [M 22-26] Statistical comparisons. If next activity not implemented, submit report. [M 27-28] If implemented, develop a sampling design for a pilot study using EM aboard longline vessels, and submit report.
External collaborators	Fishing industry, technology companies
Deliverables	Reports for the SAC and the Commission, with recommendation of minimum data fields that can be reliably collected by EM.

PROJECT C.2.b: Pilot study of electronic monitoring (EM) of the activities and catches of longline vessels

Updated: May 2022

Progress summary for the reporting period

Tasks achieved:

2021: August-October:

The participation of three longline vessels in the project it's been confirmed: Two Chinese-Taipei flag vessels (*Yi Rong No.168 and Huang Fu*), and one Ecuadorian flag vessel (*Altar 10*). and corresponding MOUs signed.

EM equipment was purchased and installed on the three vessels.

EM records and observer data started being collected aboard the three vessels.

The IATTC staff continues in conversations with the Instituto Costarricense de Pesca y Acuicultura, INCOPESCA (Costa Rica) for the participation of a fourth longline vessel.

Tasks pending:

June 2022: Start processing of EM data.

February 2023: Start statistical comparisons between EM and observer data and writing the report.

April 2023: Development of a sampling design for a pilot study using the data collected by EM aboard participating longline vessels. Report the results of this analysis.

Progress summary for the reporting period:

August-October 2021: Vessel companies agreed on the participation of the longline vessels in the project, and formalized this cooperation through Memorandums of Understanding (MOUs) between the IATTC and the vessel companies. EM equipment was installed on the vessels.

November 2021: EM and observer data collection started aboard longline vessels.

Challenges and key lessons learnt

Vessel owners' cooperation is key for the success of the project, an in particular for data collection using both EM equipment and observers.

Being able to cover all the elements of the longline fleet in terms of fishing operativity, fishing strategies and vessels' infrastructure is also key to obtain a meaningful representation of longline vessels and their operability.

Cameras' malfunction occurred during one trip. Problem could be temporarily solved by programming commands sent remotely by the EM provider.

Reports/publications/presentations

May 2023: Progress report will be presented at SAC-14.

2021-2024: A number of presentations are expected to inform the series of EM workshops that the staff is organizing.

Comments: -

PROJECT D.1.a: Exploring technologies for remote identification of FADs	
THEME: Data collection **GOAL:** Investigate the use of new technologies to improve data quality **TARGET:** Evaluate the functionality of electronic data collection and reporting systems **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	Evaluate the suitability of different technologies to remotely and electronically identify FADs
Background	FADs may cause significant impacts species and ecosystems. Assessing impacts require efficient collection methods for high-quality data, including correct tracking and monitoring of individual FADs throughout their lifetime. Currently, FADs are identified using satellite-buoy identifiers, and appropriately obtaining buoys' alphanumeric serial numbers has traditionally been difficult for observers, and not possible with current EMS capabilities. However, this information is key to merge and connect different IATTC databases. EMS can generate certain data on FADs (e.g. deployments, removals) but only those types of data that can be collected with cameras. An electronic system to automatically detect and identify FADs would improve the value and utility of all types of data, but particularly of data collected by EMS. Several technologies for remote identification of objects are currently on the market. These technologies should be tested under controlled conditions to better understand their advantages and disadvantages.
Relevance for management	Technologies to remotely identify FADs would improve data collection and analyses and the development of comprehensive management recommendations for target and non-target species in the EPO
Duration	12 months, starting in March 2022 (delayed one year due to COVID-19)
Work plan and status	[M 1-3] Preliminary assessment of candidate technologies and providers; purchase equipment. [M 4-9] Test technologies under controlled conditions in the Achotines lab, Panama, gradually increasing distance between the FAD and the device used for detection and the potential severity of environmental conditions: tanks, coast, bay and open sea. [M 10-12] Report writing.
External collaborators	Satlink and Digital Observer Services (DOS)
Deliverables	May 2023: reports for the FAD working group and SAC meetings with the summary of pros and cons of all the technologies considered, with specific proposals on preferred technologies for remote FAD identification and a future action plan.

LIFE-HISTORY STUDIES FOR SCIENTIFIC SUPPORT OF MANAGEMENT

PROJECT E.2.a: Investigate spatiotemporal variability in the age, growth, maturity, and fecundity of yellowfin tuna in the EPO	
THEME: Life-history studies for scientific support of management **GOAL:** E. Life history, behavior, and stock structure of tropical tunas **TARGET:** E.2. Reproductive biology of tropical tunas **EXECUTION**: Biology Program	
Objectives	Estimate age, growth, maturity, and fecundity of yellowfin from four distinct areas of the eastern Pacific for use in spatially-structured stock assessment models
Background	Current estimates of age, growth, maturity, and fecundity of yellowfin are based on otolith and ovarian tissue samples collected over 30 years ago. During 2009-2016 observers collected otolith and ovarian tissues samples at sea throughout the EPO Tagging and morphometrics data indicate there are multiple stocks of yellowfin in the EPO, probably with different life history characteristics Heavily-exploited fish stocks often show trends towards earlier maturation
Relevance for management	Spatially-structured stock assessments based on geographically-explicit life history parameters will provide a more accurate basis for the staff's management advice
Duration	5 years; initiated in 2017
Work plan and status	2017-2022: Preparation and reading of otolith samples for age estimates 2018-2021: Preparation and reading of ovarian tissue samples for maturity and fecundity estimates 2019-2023: Analyses of age and growth and reproductive biology data, and preparation of manuscripts
External collaborators	
Deliverables	Updated, geographically-explicit life-history parameters for use in spatially-structured stock assessments Manuscripts for publication in scientific journals

PROJECT E.2.a: Investigate spatiotemporal variability in the age, growth, maturity, and fecundity of yellowfin tuna in the EPO
Updated: May 2022
Progress summary for the reporting period Daily increment counts for 246 otoliths have been completed, 128 from the central offshore region and 118 from the central nearshore region. A general additive model was used to investigate whether differences in growth exists between those two regions. Microscopic slides of ovarian tissues from 1,756 fish from the four distinct areas have been evaluated and histological classifications of reproductive status completed. Fecundity estimates from 146 female yellowfin tuna have been completed.
Challenges and key lessons learnt
Reports/publications/presentations Fuller, D. and K. Schaefer. Abstract *in* Proceedings of the 69th annual tuna conference, 21-24 May 2018, Lake Arrowhead, USA Fuller, D. and K. Schaefer. Abstract *in* Report of the workshop on age and growth of bigeye and yellowfin tunas in the Pacific Ocean, 23-25 January 2019, La Jolla, USA Schaefer, K. M., and Fuller, D. W. 2022. Spatiotemporal variability in the reproductive biology of yellowfin tuna (*Thunnus albacares*) in the eastern Pacific Ocean. *Fisheries Research*, *248*, 106225.
Comments: Access to the SWFSC due to the COVID-19 pandemic has slowed progress on preparation and reading of otoliths.

PROJECT E.3.a. Investigate geographic variation in the movements, behavior, and habitat utilization of yellowfin tuna in the EPO	
THEME: Life-history studies for scientific support of management **GOAL:** E. Life history, behavior, and stock structure of tropical tunas **TARGET:** E.3. Analyze historical tagging data to improve spatially-structured tropical tuna assessments **EXECUTION**: Biology Program	
Objectives	Evaluate geographic variation in movements, behavior, and habitat utilization of yellowfin tuna via analyses of existing archival tag data sets from several discrete areas of the EPO
Background	Yellowfin exhibit restricted movements; tagged fish are normally recovered within about 1000 nm of point of release Future stock assessments of yellowfin should be spatially structured, because there are probably at least three stocks in the EPO Understanding movements, dispersion, and mixing between stocks, as well as behavior and habitat utilization, is essential for understanding population dynamics, estimating exploitation rates within stocks, and preventing localized depletions
Relevance for management	Spatially-structured stock assessments based on geographically-explicit life history parameters will provide a more accurate basis for the staff's management advice
Duration	2020-2021
Work plan and status	Several existing archival tag data sets from discrete areas of the EPO will be analyzed and compared to describe geographic variation in movements, behavior, and habitat utilization Historical conventional tag data sets for yellowfin from the EPO will also be included in the evaluations of movements and dispersion
External collaborators	
Deliverables	Manuscript for publication in a scientific journal

PROJECT E.3.a: Investigate geographic variation in the movements, behavior, and habitat utilization of yellowfin tuna in the EPO
Updated: March 2021
Progress summary for the reporting period • A manuscript has been completed.
Reports/publications/presentations Schaefer, K.M. and Fuller, D.W., 2022. Horizontal movements, utilization distributions, and mixing rates of yellowfin tuna (*Thunnus albacares*) tagged and released with archival tags in six discrete areas of the eastern and central Pacific Ocean. Fisheries Oceanography, 31(1), pp.84-107.

PROJECT E.4.a: IATTC Regional Tuna Tagging Program (RTTP) - EPO	
THEME: Life-history studies for scientific support of management **GOAL:** E. Life history, behavior, and stock structure of tropical tunas **TARGET:** E.4. Initiate a multi-year tagging program for tropical tunas **EXECUTION**: Biology Program	
Objectives	Obtain data that will contribute to, and reduce uncertainty in, EPO tuna stock assessments, particularly for skipjack tuna; Obtain information on the rates of movement, dispersion, and mixing of skipjack, yellowfin, and bigeye tunas in the EPO, and between this region and other adjacent regions of the Pacific basin; and Obtain estimates of sex-specific growth, mortality, abundance, selectivity, and exploitation rates for those species of tuna in the EPO
	This project is described in detail in Appendix 2 of Document CAF-05-04, prepared for the meeting of the Committee on Administration and Finance in July 2017
Duration	5 years (2019-2023)

PROJECT E.4.a: IATTC Regional Tuna Tagging Program (RTTP) - EPO
Updated: March 2021
Progress summary for the reporting period The initial Phase 1 85-day tagging cruise (6 March to 30 May 2019), aboard a chartered live-bait pole-and-line vessel operating off Central America and northern South America, was unsuccessful. No concentrations of skipjack, bigeye, or yellowfin tunas were found in unassociated or associated schools within the areas for which permits were obtained. A total of only 1,455 tunas were tagged: 220 skipjack (43 with archival tags (ATs)), 189 bigeye (46 with ATs), and 1,046 yellowfin (242 with ATs). The first Phase 2 89-day tagging cruise (1 February to 30 April 2020), aboard a chartered live-bait pole-and-line vessel operating off Central America and northern South America, including around the Galapagos Islands, was successful. A total of only 6,328 tunas were tagged: 6039 skipjack (185 with archival tags (ATs)), 274 yellowfin (9 with ATs), 8 bigeye (0 with ATs), and 7 fish not identified at the time of release. Cruise 3 (80d), executed under phase 2 of the RTTP, departed in early March of 2022.
Work Plan and Status • Phase 2 of the IATTC RTTP - EPO will consist of two tagging cruises conducted during 2020 and 2022 of approximately 90 days each. • A pole-and-line live-bait tuna fishing vessel was chartered to conduct a tuna tagging cruise during the period of February through April of 2020. • Permits obtained from the Government of Ecuador and the Galapagos National Park, as well as the Government of Panama, and the Government of Mexico and the Revillagigedo Islands National Park for catching bait and fishing/tagging tunas during the 2020 tagging cruise period. • The 2020 cruise plan included going directly from the vessel's homeport of San Diego to the Galapagos Islands to begin fishing/tagging operations, focusing on SKJ. • The 2022 cruise plan is modified from 2020 as it was deemed catching bait within the Galapagos National Park wasn't possible in sufficient quantities to justify returning.
Reports/publications/presentations Presentation at the May 2020 IATTC SAC Meeting
Comments:
PROJECT E.5.a: Evaluate the Pacific-wide population structure of bigeye and skipjack tunas, using genetic analyses
THEME: Life-history studies for scientific support of management **GOAL:** E. Life history, behavior, and stock structure of tropical tunas

TARGET: E.5. Genetic studies on stock structure **EXECUTION**: Biology Program	
Objectives	Determine whether bigeye and skipjack tuna from discrete areas of the Pacific Ocean show significant genetic heterogeneity
Background	Genetic studies can be used to evaluate and validate the results of tagging experiments Modern genetic analyses can be used to assess genetic heterogeneity between tropical tuna stocks Data from tagging experiments and genetic studies can inform spatially-structured stock assessments
Relevance for management	Spatially-structured stock assessments based on geographically-explicit life history parameters will provide a more accurate basis for the staff's management advice
Duration	5 years (2017-2021)
Work plan and status	2017-2019: Tissue samples from the Pacific and other oceans processed at CSIRO using genotyping and sequencing techniques 2018-2021: Analyses of genetic data at CSIRO with software specifically designed for uncovering and evaluating genetic heterogeneity in population structure 2021: Manuscript in preparation on assessment of skipjack population structure from samples from Indian Ocean, western and eastern Pacific. 2021: Manuscript in preparation on assessment of bigeye population structure from samples from western, central, and eastern Pacific
External collaborators	CSIRO, Hobart, Australia
Deliverables	Relevant information on population structure of bigeye and skipjack tunas in the Pacific for informing future stock assessments Manuscripts for publication in scientific journals

PROJECT E.5.a: Evaluate the Pacific-wide population structure of bigeye and skipjack tunas, using genetic analyses
Updated: March 2021
Progress summary for the reporting period • CSIRO processed additional tissue samples from the Pacific Ocean • CSIRO conducted updated analyses of genetic data sets, including additional tissue samples Interpretation of results is being finalized
Challenges and key lessons learnt • Collections, processing, and analyses of suitable numbers of tissue samples for assessing population structure of tunas takes considerable time and effort. • Preparations of manuscripts describing population structure of bigeye and skipjack tunas takes considerably longer than anticipated
Reports/publications/presentations: • Manuscripts in preparation on Pacific-wide population structure of bigeye and skipjack tuna
Comments: -

PROJECT E.5.b: Investigate the spawning ecology of captive yellowfin tuna, using genetic analyses	
THEME: Life-history studies for scientific support of management **GOAL:** E. Life history, behavior, and stock structure of tropical tunas **TARGET:** E.5. Genetic studies on stock structure **EXECUTION**: Biology Program	
Objectives	Assess the spawning ecology of captive yellowfin tuna at the Achotines Laboratory, by estimating the number of females that contribute to single spawning events, and their spawning periodicity and frequency
Background	Determining spawning patterns and maternal lines of inheritance using genetic techniques contributes to understanding of the stock structure of tropical tunas Captive spawning populations are useful for identifying genetic markers for female spawning patterns and matching parental markers to those found in progeny During 2011-2014, spawning female yellowfin at the Achotines Laboratory were sampled to develop mitochondrial DNA markers, and these markers are being analyzed in the eggs and larvae to estimate spawning periodicity and frequency of females
Relevance for management	Better understanding of reproductive processes contributes to understanding of recruitment and population structure of yellowfin, essential for stock assessment
Duration	12 months (June 2018-June 2019)
Work plan and status	June-December 2018: Complete laboratory analysis of genetic markers from spawning adults, eggs and larvae sampled in 2014 January 2019-December 2021: Preparation of final study results and submission of manuscript
External collaborators	Kindai University, Japan
Deliverables	SAC-09-14 Review of research at the Achotines Laboratory SAC-10-18 Review of research at the Achotines Laboratory Publication of results in a scientific journal

PROJECT E.5.b: Investigate the spawning ecology of captive yellowfin tuna, using genetic analyses
Updated: March 2022
Progress summary for the reporting period Laboratory analysis of genetic markers from spawning adults, eggs and larvae sampled in 2014 completed. Analysis of DNA markers to estimate spawning periodicity and frequency of females during 2011-2014 completed; Results for 2011-2013 presented at 69th Tuna Conference.
Challenges and key lessons learnt The genetic analyses for this study are time-consuming and require specialized analytical equipment, available to the group only at Kindai University. This delayed completion of the analysis.
Reports/publications/presentations Results of genetic analysis presented at the 69th Tuna Conference, May 2018, the 71st Tuna Conference, May 2021, the World Aquaculture Society Annual Meeting, March 2019, and the 43rd Larval Fish Conference, May 2019 SAC-12-15 Review of research at the Achotines Laboratory A manuscript was completed and submitted to a scientific journal in March 2022
Comments: The genetic study was completed in 2020. An ancillary activity will be the preliminary testing of a kit designed to identify male sex markers from the skin mucus of fish.

PROJECT F.2.a: Investigate the movements, behavior, and habitat utilization of silky sharks in the EPO	
THEME: Life-history studies for scientific support of management **GOAL:** F. Life-history studies for species at risk **TARGET:** F.2. Life history of sharks **EXECUTION**: Biology and Ecosystem Program	
Objectives	Evaluate movements, behavior, and habitat utilization of silky sharks in the equatorial and tropical EPO from in-depth analyses of existing data obtained from archival tags
Background	Understanding population structure and movements is essential for stock assessments, particularly for sharks The information available about movements, behavior, and habitat utilization of silky sharks in the EPO is limited Understanding behavior and habitat utilization is important for effective conservation measures and for ecological risk assessment analyses
Relevance for management	Improve management advice on silky sharks based on spatially-structured stock assessments; habitat utilization information is useful for mitigation and spatial management
Duration	24 months (2020-2021)
Work plan and status	The archival tag data for silky sharks collected for previous IATTC projects funded through the EU will be analyzed in depth and compared for describing geographic variation in movements, behavior and habitat utilization in a manuscript to be submitted to a scientific journal. A manuscript describing Silky Shark movements released in two discrete areas of the EPO is in preparation and will be submitted during the 2nd quarter of 2022.
External collaborators	INCOPESCA Costa Rica; WWF Ecuador; and INAPESCA Mexico
Deliverables	Manuscript for publication in a scientific journal

PROJECT F.2.a: Investigate the movements, behavior, and habitat utilization of silky sharks in the EPO
Updated: March 2021
Progress summary for the reporting period This project started in 2020

PROJECT F3.a: Feasibility study to develop a sampling program for updating morphometric relationships and collecting biological samples for priority species in EPO tuna fisheries: Phase 1	
THEME: Life-history studies for scientific support of management **GOAL:** F. Obtain key life history information for assessment and mitigation of ecological impacts on prioritized species **TARGET:** F.3. Conduct life-history studies of prioritized species **EXECUTION**: Biology and Ecosystem and Bycatch Program	
Objectives	To obtain morphometric relationships for priority species (e.g., tunas, billfishes, elasmobranchs, other large fishes) and to opportunistically collect biological samples
Background	Length-weight (L-W) relationships can vary markedly in space and time and can greatly influence stock and risk assessment models outcomes. L-W relationships for tunas are outdated (e.g., yellowfin: 1986, bigeye: 1966 and skipjack: 1959) or inadequate for many priority species (see SAC-13-11, SAC-09-12). Catch estimations are also affected by imprecise and/or outdated L-W relationships used to convert catch in numbers to weights and vice versa. Basic life history data for assessment models are absent or inadequate for most bycatch species Size composition of fish and fishing grounds differ significantly between longline (LL) and purse-seine (PS) fisheries (e.g. see IATTC-98-01); this study would initially focus on a subset of longline and PS vessels to develop sampling protocols. Simultaneously, discussions between IATTC and CPCs on improving data provision (see SAC-12-09, SAC-12-16) would occur for possible expansion to other vessels and areas in coordination with the other data collection programs in the EPO (e.g. SAC-13-12).
Relevance for management	Evidence of structure in EPO stocks of tuna species has been shown from extensive tagging studies, meristic and morphometric analyses, and genetic work, and future assessment will be executed accounting for putative stock structure. Changes in catch estimations can initiate a response in management rendering improvements to conversion factors an essential component for providing better catch estimations. Collection of morphometric and biological samples (e.g. otoliths, tissues, stomachs), will provide information to refine key life history information and to develop improved models for tunas and other prioritized species, thereby advancing scientific advice for decision making.
Duration	24 months
Work plan and status	Jun-Dec 2022: Internal staff discussions to identify target species and tasks, review and identify sampling opportunities across EPO fisheries. Reach out to CPCs and relevant stakeholders to identify collaborative sampling opportunities. As needed, collaborate with the industry to gain support, develop sampling design, data forms and databases, purchase equipment, initiate/refine protocols for LL, revise and complete protocol for PS vessels, develop a storage protocol for IATTC regional offices and imports/exports following strict international protocols, engage in conversations during workshops to improve data collection processes and identify other potential fisheries observers' program where sampling will be executed. Develop a research proposal for implementing a feasibility study in the EPO for prioritized species (Phase 2).
External collaborators	Fishing industry and CPCs, CITES offices in corresponding countries
Deliverables	Report to SAC-14 in 2023, including a potential research proposal

PROJECT G.1.a: Studies of pre-recruit survival and growth of yellowfin tuna, including expanding studies of early-juvenile life stages	
THEME: Life-history studies for scientific support of management **GOAL:** G. Investigate early life-history of tunas **TARGET:** G.1. Investigation of the factors affecting pre-recruit survival of yellowfin **EXECUTION**: Biology Program	
Objectives	Investigate the effects of key biological and physical factors on the survival and growth of pre-recruit life stages of yellowfin, with a new emphasis on studies of early-juvenile life stages
Background	Research on the early life history of yellowfin is designed to develop a more complete understanding of pre-recruit mortality and the influence of key environmental and biological factors on mortality Ongoing research has examined the effects of physical (turbulence, light, water temperature, dissolved oxygen) and biological (food concentration) factors on growth and survival of larval stages of yellowfin Recent rearing success now allows experimental studies of the growth and survival dynamics of early-juvenile yellowfin (1-6 months of age), a life stage rarely studied worldwide
Relevance for management	The ability to estimate the effects of key biological and physical factors on survival and growth of pre-recruit (0-6 months) life stages of yellowfin provides potentially key information on recruitment processes in yellowfin
Duration	3 years
Work plan and status	January 2018-December 2022: Continued experimental studies of pre-recruit life stages at the Achotines Laboratory with a focus on early-juvenile life stages
External collaborators	Kindai University
Deliverables	Presentations for SAC-09, SAC-10, SAC-11 and SAC-12 Publication of results in one or more scientific journals

PROJECT G.1.a: Studies of pre-recruit survival and growth of yellowfin tuna, including expanding studies of early-juvenile life stages
Updated: March 2022
Progress summary for the reporting period Analysis of survival and growth patterns of larval and early-juvenile yellowfin continued through 2019, were delayed due to COVID-19 during 2020-2021 and will be renewed in 2022. Current analyses focus on the early-juvenile (1-6 months) stages of yellowfin, which have been reared in land-based tanks and a sea cage since 2015. A retrospective analysis of early-juvenile growth patterns in captivity over the past 24 years is ongoing.
Challenges and key lessons learnt -
Reports/publications/presentations Presentations: SAC-09 (May 2018), SAC-10 (May 2019), SAC-11 (May 2020) and SAC-12 (May 2021) 69th Tuna Conference (May 2018), the 70th Tuna Conference (May 2019) and the 71st Tuna Conference (May 2021) 42nd Larval Fish Conference (June 2018) and 43rd Larval Fish Conference (May 2019) Two publications on this topic are being developed SAC-12-15 Review of research at the Achotines Laboratory
Comments: The juvenile studies continue to be supported by the regular IATTC budget with periodic collaboration with Kindai University. Continuing studies of early-juvenile growth were delayed in 2020-2021 due to travel restrictions related to COVID-19, but will be conducted during 2022.

PROJECT G.2.a: Develop comparative models of pre-recruit survival and reproductive patterns of Pacific tunas	
THEME: Life-history studies for scientific support of management **GOAL:** G. Investigate early life-history of tunas **TARGET:** G.2. Comparative studies of early life histories of yellowfin and Pacific bluefin **EXECUTION**: Biology Program	
Objectives	Investigate important comparative aspects of the reproductive biology, genetics and early life histories of yellowfin and Pacific bluefin tuna
Background	Pre-recruit life stages of tunas are potentially key to understanding variations in abundance and reproductive patterns of tuna populations Ongoing since 2011, this project has investigated the comparative growth, nutrition and survival of larval yellowfin and Pacific bluefin tuna Experimental results are being used to comparatively model mortality processes occurring during the pre-recruit life stages of both species
Relevance for management	Comparative models of pre-recruit mortality processes are promising for assessing recruitment patterns of both species
Duration	30 months
Work plan and status	June 2018-June 2020: Continue experimental studies of comparative larval growth and finalize data analyses June-December 2021: Complete manuscript and submit to scientific journal
External collaborators	Kindai University, Fisheries Laboratory University of Texas
Deliverables	Presentations for SAC-09, SAC-10 and SAC-11 Publication of results in a scientific journal

PROJECT G.2.a: Develop comparative models of pre-recruit survival and reproductive patterns of Pacific tunas

Updated: March 2022

Progress summary for the reporting period

Comparative experimental studies of pre-recruit life stages of yellowfin and Pacific bluefin continued during 2018 and 2019. Experimental investigations of the growth and feeding patterns of Pacific bluefin larvae were carried out at the Aquaculture Institute of Kindai University in July 2018 and July 2019. Further studies were delayed in 2020-2021 due to travel restrictions of COVID-19, but experiments will be continued during 2022.

A comparative analysis of the larval traits (survival, growth, starvation rates) of yellowfin and Pacific bluefin is being developed to gain insights into differences in spawning patterns and nursery habitats of the two species in the Pacific Ocean.

Experimental results are being incorporated into models of the pre-recruit mortality processes for both species.

A new study was initiated in mid-2019 in collaboration with Dr. Lee Fuiman of the University of Texas to investigate the relationship between diet and daily ration of captive spawning yellowfin and the fatty acid composition of their eggs. Sampling was completed in mid-2021 and samples are being analyzed at University of Texas.

Challenges and key lessons learnt:

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Reports/publications/presentations

Presentations:

SAC-09 (May 2018), SAC-10 (May 2019), SAC-11 (May 2020) and SAC-12 (May 2021)

69th Tuna Conference (May 2018) and 70th Tuna Conference (May 2019)

42nd Larval Fish Conference (June 2018) and 43rd Larval Fish Conference (May 2019).

World Aquaculture Conference (February 2020)

SAC-12-1 5 Review of research at the Achotines Laboratory

Two publications on this topic are being developed

Comments:

Regular program funds are supporting the ongoing studies with Kindai University and the fatty acid study of yellowfin eggs conducted in collaboration with University of Texas. Experimental sampling in 2020-2021 has been delayed due to travel restrictions related to COVID-19, but experimental work will be re-initiated in 2022.

PROJECT G.3.a: Develop a larval growth index to forecast yellowfin recruitment	
THEME: Life-history studies for scientific support of management **GOAL:** G. Investigate early life-history of tunas **TARGET:** G.3. Tools to forecast recruitment **EXECUTION**: Biology Program	
Objectives	To develop a larval or early-juvenile growth index for yellowfin tuna in the Panama Bight which might prove useful as an index of recruitment strength of yellowfin in the EPO
Background	Growth rate variability in the larval and juvenile stages of pelagic marine fishes is substantial, and has strong potential to influence mortality patterns during pre-recruit life stages Previous research by the Early Life History group has identified some local correspondence in the Panama Bight between high growth rates/density-dependence in growth of yellowfin larvae and recruitment estimates for yellowfin Quarterly or seasonal nightlight surveys of early-juveniles in the Panama Bight are recommended at the Achotines Laboratory, with aging analysis conducted for growth rate estimation and comparison to quarterly recruitment estimates for yellowfin
Relevance for management	The development of a larval or early-juvenile growth index is promising as a forecasting tool for assessing yellowfin recruitment patterns
Duration	4 years
Work plan and status	June 2022-December 2022: Conduct quarterly or seasonal nightlight surveys of yellowfin at the Achotines Laboratory January 2022-June 2023: Conduct otolith aging analysis on field-caught fish Analyze and compare growth data and recruitment estimates for yellowfin, and complete manuscript and submit to scientific journal
External collaborators	
Deliverables	Presentations for SAC-09, SAC-10, SAC-11 and SAC-12 Publication of results in a scientific journal

PROJECT G.3.a: Develop a larval growth index to forecast yellowfin recruitment
Updated: March 2022
Progress summary for the reporting period Analysis of *in situ* growth of yellowfin larvae and early-juveniles in relation to ocean temperature, availability of forage, larval density and availability of potential predators in nursery grounds in the Panama Bight, determined from past at-sea surveys at the Achotines Laboratory, is continuing during 2022.
Challenges and key lessons learnt Funding has not yet been secured for the at-sea surveys and subsequent analyses necessary for the completion of the growth index analysis, but expansion of analysis of past *in situ* growth sampling is continuing in 2022.
Reports/publications/presentations Presentations: SAC-09 (May 2018) 42nd Larval Fish Conference (June 2018) and 43rd Larval Fish Conference (May 2019) SAC-12-15 Review of research at the Achotines Laboratory
Comments: -

SUSTAINABLE FISHERIES

PROJECT H.1.a phase 2: Improve the bigeye tuna stock assessment: reduce the bimodal pattern in bigeye tuna assessment results	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.1. Improve routine tropical tuna assessments **EXECUTION**: Stock Assessment Program	
Objectives	Improve the bigeye tuna stock assessment by reducing the bimodal pattern in assessment results
Background	A benchmark assessment was conducted in 2020 with 48 reference models representing several hierarchical hypotheses for the stock. A risk analysis approach was used to weight those 48 reference models to get probabilistic distribution profiles for key management quantities. The main issue with the assessment results is that the probabilistic distribution profiles for both depletion and fishing mortality are bimodal.
Relevance for management	The stock assessment is used to provide management advice for tropical tunas The duration of recommended seasonal closures is based on risk analyses of bigeye and yellowfin that use the assessment results Improvements in the bigeye assessment will make the staff's management advice more accurate and precise
Duration	2021-2024
Work plan and status	2021: Re-evaluate the natural mortality assumptions 2022: CAPAM workshops on improving the risk analysis approach 2022: Workshops to finalize improvements to the longline CPUE and length-composition standardizations (Projects H.1.e – ext and H.1.f) 2023: Re-evaluate model assumptions and present an exploratory assessment 2024: Benchmark assessment
External collaborators	
Deliverables	Reports to SAC in 2022, 2023 and 2024

PROJECT H.1.b phase 2: Improve the yellowfin tuna stock assessment: Explore alternative hypotheses of stock structure and life-history for YFT in exploratory stock assessment models	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.1. Improve routine tropical tuna assessments **EXECUTION**: Stock Assessment Program	
Objectives	Improve the yellowfin tuna stock assessment by exploring alternative hypotheses of stock structure and life-history
Background	A benchmark assessment was conducted in 2020 with 48 models representing several hypotheses for the stock. The main overarching hypotheses, stock structure, was not possible to address extensively
Relevance for management	The stock assessment is used to provide management advice The duration of recommended seasonal closures is based on risk analyses of bigeye and yellowfin that use the assessment results Improvements in the yellowfin assessment will make the staff's management advice more accurate and precise
Duration	2021-2024
Work plan and status	2021: Re-evaluate the natural mortality assumptions 2022-23: Explore different hypotheses on stock structure 2022: Workshops to finalize improvements to the longline CPUE and length-composition data (Projects H.1.e – ext and H.1.f) 2023: Re-evaluate the model assumptions and implement exploratory models 2024: Benchmark assessment
External collaborators	
Deliverables	Report(s) to SAC in 2022, 2023 and 2024

PROJECT H.1.d(ext): Improve indices of abundance and length composition based on longline data	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.1. Improve routine tropical tuna assessments **EXECUTION**: Stock Assessment Program	
Objectives	Improve the yellowfin and bigeye indices of relative abundance from longline data Determine methods to identify targeting in longline fisheries Develop spatio-temporal models for creating indices of relative abundance from longline data Develop appropriate longline length-composition data for the index of abundance and for the catch Continue the ongoing collaborative work
Background	Indices of relative abundance derived from longline CPUE data are the most important piece of information in the bigeye and yellowfin stock assessments Only the Japanese data are currently used to create these indices The characteristics, tactics, and spatial distribution of the fishery have changed over time The same length-composition data are used for the index and for the catch, but these could differ Collaborative research and a workshop in 2019 have substantially progressed the

	work towards achieving the objectives. New methods, such as spatio-temporal modelling, have been developed and are used in the creation of the indices Additional research is needed to address changes in target species and factors that may change catchability so better indices of abundance by size class can be estimated Access to operational-level data for longer time periods is essential for advancing the research. Several CPCs have granted such access to the staff under bilateral MoUs renewable. The staff is recommending changes in the data submission to facilitate the research on longline data Research conducted to resolve issues in using the longline CPUE and composition data needs to be presented and discussed with scientists of the relevant CPCs	
Relevance for management	The indices have a direct impact on the stock assessment, and any improvements in the indices will directly improve the management advice for bigeye and yellowfin	
Duration	Winter 2022	
Work plan and status	2020-2022: work with CPC scientists to progress longline research Winter 2022: workshop preparation. Spring/Summer 2022: one-week workshop to discuss the results of the research conducted to resolve issues in using the longline CPUE data, write workplan to finish the work. Summer/Fall 2022: write workshop report, manuscript on longline indices of abundance Fall 2022:	
External collaborators	CPCs involved in the longline fishery, mainly China, Japan, Korea, Chinese Taipei Invited speakers	
Deliverables	Workshop report Indices of relative abundance Length compositions Project report to SAC-14, 2023	
Budget (US$)	Workshop and research expenses and invited participant travel costs	50,000

PROJECT H.1.d(ext): Improve indices of abundance and length composition based on longline data	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.1. Improve routine tropical tuna assessments **EXECUTION**: Stock Assessment Program	
Objectives	Improve the yellowfin and bigeye indices of relative abundance from longline data Determine methods to identify targeting in longline fisheries Develop spatio-temporal models for creating indices of relative abundance from longline data Develop appropriate longline length-composition data for the index of abundance and for the catch Continue the ongoing collaborative work
Background	Indices of relative abundance derived from longline CPUE data are the most important piece of information in the bigeye and yellowfin stock assessments Only the Japanese data are currently used to create these indices The characteristics, tactics, and spatial distribution of the fishery have changed over time The same length-composition data are used for the index and for the catch, but these could differ Collaborative research and a workshop in 2019 have substantially progressed the work towards achieving the objectives. New methods, such as spatio-temporal modelling, have been developed and are used in the creation of the indices Additional research is needed to address changes in target species and factors that may change catchability so better indices of abundance by size class can be estimated Access to operational-level data for longer time periods is essential for advancing the research. Several CPCs have granted such access to the staff under bilateral MoUs renewable. The staff is recommending changes in the data submission to facilitate the research on longline data Research conducted to resolve issues in using the longline CPUE and composition data needs to be presented and discussed with scientists of the relevant CPCs
Relevance for management	The indices have a direct impact on the stock assessment, and any improvements in the indices will directly improve the management advice for bigeye and yellowfin
Duration	Winter 2022
Work plan and status	2020-2022: work with CPC scientists to progress longline research Winter 2022: workshop preparation. Spring/Summer 2022: one-week workshop to discuss the results of the research conducted to resolve issues in using the longline CPUE data, write workplan to finish the work. Summer/Fall 2022: write workshop report, manuscript on longline indices of abundance Fall 2022:
External collaborators	CPCs involved in the longline fishery, mainly China, Japan, Korea, Chinese Taipei Invited speakers

Deliverables	Workshop report Indices of relative abundance Length compositions Project report to SAC-14, 2023	
Budget (US$)	Workshop and research expenses and invited participant travel costs	50,000

PROJECT H.1.f: Improving the methodology of the risk analysis	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.1. Improve routine tropical tuna assessments **EXECUTION**: Stock Assessment Program	
Objectives	Improve the risk analysis methodology by defining more objective, transparent, and automated diagnostic-based metrics for weighting fishery stock assessment model ensembles.
Background	There is uncertainty about the main assumptions in the tropical tuna assessments Risk analysis was developed and applied to yellowfin and bigeye tuna The risk analysis was based on several different diagnostics, but there evaluation for determining weighing scores was subjective and based on expert opinion A more objective and automated approach to determining scores from diagnostic and other metrics is needed
Relevance for management	Risk analysis has been used to provide management advice for bigeye and yellowfin tuna and is proposed to use for skipjack tuna.
Duration	3 years, starting 2021
Work plan and status	Jan-Feb 2022: Workshop on diagnostics Fall 2022: Workshop on objective and automatic weighting of metrics 2023: Automate weighing of metrics 2024: Apply the risk analysis to the three tropical species
External collaborators	Scientists from CPCs and other organizations participate in the workshops
Deliverables	Software to automate calculating metrics and conducting risk analysis SAC documents

PROJECT H.1.f: Improving the methodology of the risk analysis
Updated: May 2022
Progress summary for the reporting period Jan/Feb 2022: Workshop conducted on diagnostics
Challenges and key lessons learnt The COVID pandemic forced the workshop to be virtual, however it was very successful and due to the virtual format there were around 200 participants, which is about twice the number usually participating The chat feature of the virtual meeting encouraged more people to participating in discussions than usually would participate Demands on staff for other activities has prevented the completion of the report
Reports/publications/presentations
Comments: -

PROJECT H.3.a: Analysis of recent skipjack tagging data		
THEME: Sustainable fisheries **GOAL:** H. Improve and implement stock assessments, based on the best available science **TARGET:** H.3. Develop a benchmark stock assessment for skipjack tuna (conditional on implementation of tagging program **EXECUTION**: Stock Assessment Program		
Objectives	Estimate abundance and fishing mortality rate of skipjack tuna from recent tagging data while accounting for mixing rates	
Background	Currently, no assessment is available for skipjack tuna in the EPO Tagging data has been collected in several recent tagging cruises Practicalities of tagging skipjack limit the spatial distribution of tag releases The short-lived nature of skipjack tuna necessitate the modelling of mixing rates Spatio-temporal models of abundance are combined with advection-diffusion of tags to model the tagging data and estimate absolute abundance and fishing mortality	
Relevance for management	Provides estimates of abundance and fishing mortality that can be used in stock assessments or compared with proxy reference points	
Duration	2021-2024	
Work plan and status	Contract analyst Develop model Apply model to updated data Present methods and results at SAC Publish paper	
External collaborators	To be determined	
Deliverables	Report presented at SAC 2024 Published paper	
Budget (US$)	From EU tagging project funding	$150,000

PROJECT H.3.a: Analysis of recent skipjack tagging data
Updated: May 2022
Progress summary for the reporting period Initial analysis of tagging data conducted
Challenges and key lessons learnt
Reports/publications/presentations SAC-13-08
Comments: -

PROJECT H.3.b: Skipjack Stock assessment		
THEME: Sustainable fisheries **GOAL: H**. Improve and implement stock assessments, based on the best available science **TARGET:** H.3. Develop a benchmark stock assessment for skipjack tuna (conditional on implementation of tagging program **EXECUTION**: Stock Assessment Program		
Objectives	To develop as stock assessment, including the use of tagging data, to provide stock status and management advice	
Background	Currently, no assessment is available for skipjack tuna in the EPO The PSA rationale is no longer appropriate for skipjack tuna due to the implementation of the IVLs for bigeye tuna A stock assessment is needed for skipjack tuna to provide management advice Analysis of tagging data can provide estimates of biomass and fishing mortality	
Relevance for management	Provides management advice for skipjack tuna	
Duration	2022-2023	
Work plan and status	Develop model Apply model to updated data Present methods and results at SAC	
External collaborators	DTU	
Deliverables	Report presented at SAC 2023	
Budget (US$)	IATTC staff	

PROJECT H.3.b: Skipjack Stock assessment
Updated: May 2022
Progress summary for the reporting period Interim assessment completed
Challenges and key lessons learnt Other demands on staff limited the amount of time that could be spend on the stock assessment Staff time and projects need to be prioritized
Reports/publications/presentations SAC-13-07
Comments: -

PROJECT H.3.c: Estimate skipjack growth rates from recent tagging data		
THEME: Sustainable fisheries **GOAL:** H. Improve and implement stock assessments, based on the best available science **TARGET:** H.3. Develop a benchmark stock assessment for skipjack tuna (conditional on implementation of tagging program **EXECUTION**: Stock Assessment Program		
Objectives	To estimate growth from data collected in the recent tagging cruses	
Background	Estimates of growth are needed for YPR analysis and stock assessments Otolith data is unreliable for estimating growth of skipjack tuna Data is available from several recent tagging cruises Tag growth increment data can be used to estimate length-specific growth rates	
Relevance for management	The estimates of growth will be used in YPR and/or stock assessment models to provide management advice	
Duration	2023-2024	
Work plan and status	Develop model Apply model to updated data Present methods and results at SAC Publish paper	
External collaborators	None	
Deliverables	Report presented at SAC 2024 Published paper	
Budget (US$)	IATTC Staff	

PROJECT H.3.c: Estimate skipjack growth rates from recent tagging data
Updated: May 2022
Progress summary for the reporting period Growth analysis conducted
Challenges and key lessons learnt No tagging data is available for large skipjack No aging data is available
Reports/publications/presentations SAC-13 INF-J
Comments: -The absolute age and asymptotic length could not be estimated from the tagging data

PROJECT H.4.a: Conduct routine stock assessments of tropical tunas	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.4. IATTC tropical tuna assessments **EXECUTION**: Stock Assessment Program	
Objectives	Update the assessments of bigeye, yellowfin, and skipjack tunas
Background	Assessments or indicators of bigeye, yellowfin, and skipjack are conducted every year Bigeye and yellowfin assessments use the Stock Synthesis modeling platform Skipjack assessment is based on stock status indicators Assessments or indicators are updated annually, using the most recent data Major improvements to the assessments (methods and assumptions) are implemented periodically
Relevance for management	The staff's management advice for tunas is based on its stock assessments The duration of the seasonal closures recommended by the staff for bigeye and yellowfin are based on the fishing mortality estimated in the assessments
Duration	Every year (March-May)
Work plan and status	15 March: data for previous year available; assessments initiated Three weeks before SAC meeting: Assessment reports posted on IATTC website Mid-May: Present assessments at SAC meeting
External collaborators	
Deliverables	Stock assessment reports for the SAC and the IATTC; presentations at SAC and IATTC meetings

PROJECT H.4.a: Conduct routine stock assessments of tropical tunas
Updated: April 2021
Progress summary for the reporting period Benchmark assessment conducted for bigeye 2020 Benchmark assessment conducted for yellowfin 2020 Indicators constructed for the three species 2021
Challenges and key lessons learnt The results of the bigeye and yellowfin assessments were considered unreliable, and they were improved for the 2020 benchmark assessments (Projects H.1.a and H.1.b). There is uncertainty about the stock structure of yellowfin tuna The risk analysis for bigeye tuna shows a bimodal pattern
Reports/publications/presentations SAC-11-05 Bigeye, yellowfin, and skipjack tuna: indicators of stock status SAC-11-06 Bigeye tuna: benchmark assessment SAC-11-07 Yellowfin tuna: benchmark assessment SAC-12-06 Assessment methods for skipjack in the EPO: a proposal relying on recent data from the IATTC regional tuna tagging program (2019-2022) SAC-12-05 Stock status indicators (SSIs) for tropical tunas in the eastern Pacific Ocean
Comments:

PROJECT H.6.a: Participate in assessments of shared species by the International Scientific Committee (ISC)	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.6. ISC stock assessments **EXECUTION**: Stock Assessment Program	
Objectives	Staff participation in development and improvement of assessments for North Pacific-wide species of interest to the IATTC, especially Pacific bluefin and albacore tunas, but also billfishes and sharks Understand the assessment results, and communicate them to the Commission
Background	The ISC and its various working groups assess stocks in the north Pacific that are covered by both the IATTC and WCPFC The IATTC staff provides data and advice for the assessments Assessments are periodic, and the stocks assessed differ each year.
Relevance for management	The IATTC uses the results of the ISC assessments to provide management advice
Duration	Ongoing; ISC meets annually, usually in July
Workplan and status	See ISC website for details (http://isc.fra.go.jp/)
External collaborators	ISC
Deliverables	Report to SAC meetings

PROJECT H.6.a: Participate in assessments of shared species by the International Scientific Committee (ISC)
Updated: April 2021
Progress summary for the reporting period February 2020: submitted a working paper for the Billfish working group March 2020: Attended the virtual Pacific bluefin working group workshop. New benchmark assessment developed. August/September 2020 and December 2020: Attended the virtual Albacore working group workshops about the progress on Management Strategy Evaluation February 2021: Started a Basecamp North Pacific Albacore MSE – ISC albacore working group discussions for managers and other stakeholder March 2021: Attended the 5th North Pacific Albacore MSE Workshop;, the objectives were: (i) help managers and stakeholders understand MSE results, (ii) get feedback to ALBWG on the presentation of MSE results. March 2021: Made a presentation to the Billfish working group on the "1th technical workshop on S EPO swordfish, Stock structure of swordfish in the Pacific Ocean" April 2021: Participated in the north Pacific bluefin working group meeting
Challenges and key lessons learnt -
Reports/publications/presentations See working group reports on the ISC website
Comments: -

PROJECT H.7.a: Pacific-wide exploratory assessment for bigeye tuna	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.7. Other assessments **EXECUTION**: Stock Assessment Program	
Objectives	Conduct an exploratory assessment for bigeye tuna in the Pacific Ocean
Background	The assessment for bigeye tuna in the EPO shows a regime shift in recruitment. Both conventional and archival tagging data suggest that juvenile bigeye tend to move from the WCPO to the EPO. Bigeye tuna in the EPO and WCPO have notably different growth curves. The exploratory Pacific-wide assessment for bigeye tuna can help test the hypothesis that the regime shift in the recruitment of EPO bigeye tuna is caused by ignoring the immigration of bigeye tuna from the WCPO.
Relevance for management	Improvements in the stock assessment will improve the management advice
Duration	2021-2022
Workplan and status	Obtain data for bigeye tuna in the WCPO Build a single-area assessment model for bigeye tuna in the WCPO using Stock Synthesis Build a two-area Pacific-wide assessment model for bigeye tuna with assumed movement rates between WCPO and EPO Conduct the exploratory assessment and evaluate the sensitivity of the stock status of EPO bigeye to the assumed movement rates Report to SAC-13 in 2022
External collaborators	Scientists from the Pacific Community (SPC)
Deliverables	Report to SAC-13 in 2022

PROJECT H.7.a: Pacific-wide exploratory assessment for bigeye tuna
Updated: May 2021
Progress summary for the reporting period July 2020: Obtained the data needed to build a single-area assessment model for bigeye tuna in the WCPO using Stock Synthesis August 2020: Built a single-area assessment model for bigeye tuna in the WCPO using Stock Synthesis November 2020: Built a two-area Pacific-wide assessment model for bigeye tuna with assumed movement rates between WCPO and EPO
Challenges and key lessons learnt Fitting selectivity curves to length compositions are more difficult in the Pacific-wide model where the population consists of two groups of bigeye tuna with notably different growth curves. Results are sensitive to the assumed movement rates between the WCPO and EPO while the values for Pacific bigeye, especially those for adult, are unknown.
Reports/publications/presentations -
Comments: -

PROJECT H.7.b: South Pacific swordfish assessment	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.7. Other assessments **EXECUTION**: Stock Assessment Program	
Objectives	Conduct an assessment for South Pacific swordfish
Background	The South Pacific swordfish stock has not been assessed since 2011. The longline fishery has recently increased targeting of swordfish An updated assessment is needed to provide management advice
Relevance for management	The stock assessment is needed to provide management advice
Duration	2019-2022
Workplan and status	Organize a workshop to review the knowledge and start the collaborations Obtain data Report progress to SAC-12 in 2021 Pending on data submission by main fishing fleets: Host a second workshop to discuss the data and other model inputs Conduct assessment Host a third workshop to discussion of modelling results Report to SAC-13 in 2022
External collaborators	Scientists from Chile, European Union, Peru, Japan, Korea, Chinese Taipei, China and the Pacific Community (SPC)
Deliverables	Report to SAC-12 in 2021 Report to SAC-13 in 2022

PROJECT H.7.b: South Pacific swordfish assessment
Updated: May 2021
Progress summary for the reporting period Progress on this project to date is incidental to research on other topics (CAPAM workshop on spatio-temporal models; workshop on longline indices of abundance . February 2019: Exploratory work for the workshop included analyses that used the data for swordfish. Contacts in key areas of expertise have been established to start collaborative work Ongoing since August 2020 Collaboration with Chile regarding the workshop organization and data sharing December 2021: The 1st Technical Workshop on Swordfish in the South EPO was organized and took place virtually on XXX December 2021: An MOU was signed with Korea to use their operational-level catch and effort data February 2021: Collaborative work was undertaken with Japan to construct indices of abundance Ongoing since January 2021: communication with Spain and Ecuador regarding data sharing March 2021: Presentation at the ISC Billfish working group meeting on the discussions that took place during the 1st Technical Workshop on Swordfish March 2021: Participation on the 2021 SPC Pre-Assessment workshop, when discussion about the S WCPO swordfish assessment took place
Challenges and key lessons learnt Access to operational longline data is essential for conducting the assessment and has been delayed in some cases, and not possible in others, this had the delayed the work and an adjustment of the workplan is needed Collaboration with CPCs is needed to complete the assessment A successful workshop was possible due to a mix of recorded presentations and short live discussions

In 2021 all stocks of swordfish will be assessed, the discussions in several fora for a about those assessments have shown a synergic effect and it is likely that all assessments will benefit from continuing the dialog among the modelers New workshops to foster the collaboration among CPCs and other scientists should have a positive impact on the quality of the assessment
Reports/publications/presentations -Report of the 1st Technical Workshop on swordfish in the S EPO -SAC-12-07 South EPO swordfish assessment: progress report
Comments: -

PROJECT H.7.c: Participate in south Pacific albacore assessment	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.7. Other assessments **EXECUTION**: Stock Assessment Program	
Objectives	Staff participation in development and improvement of the south Pacific albacore assessment Understand the assessment results, and communicate them to the Commission
Background	The assessment is for albacore in the south Pacific that are covered by both the IATTC and WCPFC The IATTC staff provides data and advice for the assessment
Relevance for management	The IATTC uses the results of the assessment to provide management advice
Duration	Ongoing; SPC to deliver assessment results in the 2021 SC
Workplan and status	See SPC website for details
External collaborators	SPC
Deliverables	Report to SAC meetings

PROJECT H.7.c: Participate in south Pacific albacore assessment
Updated: May 2022
Progress summary for the reporting period January 2021: Attend the SPC stock assessment meetings for south Pacific albacore March 2021: Made a presentation in the SPC pre-assessment workshop (PAW) on the fishery stratification for albacore in the southern EPO August 2021: Presented the assessment results in SPC's 17th regular session of the scientific committee May 2022: Present the assessment results in SAC-13
Challenges and key lessons learnt Movement scenario is the largest axis of uncertainty in the south Pacific albacore assessment The south Pacific albacore stock is healthy and the recent fishing mortality was much lower than the fishing mortality corresponding to MSY Spawning biomass decreased fast in recent years due likely to high longline catch The stock should be monitored in the future through for example stock status indicators and conduct another benchmark assessment in 3 or 4 years
Reports/publications/presentations The stock assessment report can be found at https://meetings.wcpfc.int/node/12551
Comments: -

PROJECT H.8.b: Second trial dolphin survey in the eastern tropical Pacific Ocean (ETP)	
THEME: Sustainable Fisheries **GOAL:** H. Improve and implement stock assessments, based on the best available science **TARGET:** H.8. Assess status of dolphin stocks in the eastern tropical Pacific **EXECUTION**: ???	
Objectives	Fully field-test the drone protocol to be used in a main dolphin survey, as outlined by Oedekoven et al. (2021)
Background	Population dynamics modelling has been the preferred approach for evaluating the stock status of ETP dolphins, and those models have relied on estimates of abundance from fishery-independent surveys that were conducted by the National Marine Fisheries Service (NMFS). As a result of a hiatus in the NMFS surveys since 2006, there are currently no reliable indicators with which to monitor the status of ETP dolphin populations. This lack of information poses obvious problems for management. For example, the Antigua Convention of the Inter-American Tropical Tuna Commission (IATTC) requires that the status of all species potentially impacted by the tuna fisheries in the eastern Pacific Ocean be monitored. In addition, abundance estimates are needed to ensure that incidental dolphin mortalities are both sustainable and insignificant because the stock mortality limits are based on estimates of abundance. These needs provide impetus for a new ship-based line-transect survey to obtain new estimates of absolute abundance so that population trends can be updated. In preparation for a new dolphin survey, trial survey was conducted in November 2019 (Oedekoven et al. 2021) to field-test the ship and drone survey protocols that would be used in the new survey. During this trial survey it was not possible to fully test the drone protocol because the drone camera systems and data acquisition systems, and drone personnel, provided to the project were not according to the specified protocol, and thus a second trial survey is necessary.
Relevance for management	Improve the management of dolphin stocks in the ETP.
Duration	November 2022 – May 2024
Work plan and status	November 2022 – March 2023: preparation of a detailed trial survey work plan and budget. April 2023 – October 2023: preparation for second trial survey. November 2023: conduct second trial survey. December 2023 – May 2024: data analysis, prepare report.
External collaborators	University of St Andrews (and contractors hired by the University of St Andrews) Pacific Alliance for Sustainable Tuna Government of Mexico
Deliverables	Presentation at SAC-14 (May 2023) on trial survey plan; report on the results presented at SAC-15 (May 2024).
Comments	In as much as funding for this project has not yet been secured, the timeline shown above is preliminary.

PROJECT H.8.c: Cow-calf separation study	
THEME: Sustainable Fisheries **GOAL:** H. Improve and implement stock assessments, based on the best available science **TARGET:** H.8. ??? **EXECUTION**: ???	
Objectives	Evaluate whether permanent separation of dolphin mothers and their calves occurs during purse-seine fishing operations on dolphin-associated tuna.
Background	With the drastic decrease in dolphin mortality due to entanglement in tuna purse-seine nets during the 1990s, more attention was paid to other possible sources of mortality. Some studies have shown that in the 1980s and 1990s there were cases of orphaned nursing calves due to maternal mortality. Based on analysis of biological samples collected by fisheries observers, it has also been suggested that mothers and calves may be separated during chases leading to purse-seine sets. However, it remains an open question whether current fishing operations lead to permanent separation of cows and calves. The objective of this study is to resolve this question by determining, through direct observation, whether dolphin mothers and calves are indeed separated during chase and/or backdown.
Relevance for management	Improve the management of dolphin stocks in the ETP.
Duration	1 year
Work plan and status	May 2022: obtain commitment from one or more purse-seiners to participate in the study. June – August 2022: hold workshop on development of a detailed field protocol; consultation with drone team on project details; hire graduate students and an observer to assist with project. September – November 2022: preparation for study. December 2022 – January 2023: Conduct field study. January – May 2023: data analysis; report preparation.
External collaborators	Michael Scott; Workshop participants: Drs. Karin Forney and Eric Archer (NMFS); Drs. Lisa Balance and John Durban (Oregon State University). Drone company; several graduate students, one or more purse-seine vessels. Pacific Alliance for Sustainable Tuna
Deliverables	Presentation of results at SAC-14 (May 2023).
Comments	In as much as full funding for this project has not yet been secured, the timeline shown above is preliminary.

PROJECT I.1.a: Conduct a Management Strategy Evaluation (MSE) for tropical tunas in the EPO	
THEME: Sustainable fisheries **GOAL:** I. Test harvest strategies using management strategy evaluation (MSE) **TARGET:** I.1. Conduct a comprehensive MSE for bigeye tuna and plan MSEs for the other tropical tuna species, including the multi-species fishery for tropical tunas **EXECUTION**: Stock Assessment Program	
Objectives	Continue technical development of MSE for tropical tunas. Provide training and enhance dialogue / communication among scientists, industry, managers and other stakeholders regarding the MSE process for tropical tunas through the facilitation of a series of workshops. Elicit alternative candidate reference points, harvest control rules, performance metrics from stakeholders to be tested in addition to the interim ones.
Background	The Performance Review of the IATTC, the proposed Strategic Science Plan, and the SAC all recommended improving knowledge sharing, human-institutional capacity building and communication of scientific advice. MSE is a major objective at IATTC and other organizations. Part of the MSE process is highly technical and done by scientists. Another part (defining objectives, performance metrics, candidate management strategies), requires input and participation of managers and other stakeholders. These parts evolve in synergy. Stakeholder participation throughout the MSE process is central to its success and will be facilitated by understanding the MSE process, its components and by strengthening communication among scientists, managers and other stakeholders. Initial introductory workshops on MSE in 2015, 2018, restricted to Latin-American developing countries. Further MSE training workshops for the tuna Industry were held in 2019. The first IATTC MSE Workshop was held in 2019. .
Relevance for management	Key elements of IATTC's current management strategy, such as its control rule and reference points, along with alternatives, are currently being evaluated via MSE. The technical support will allow for better model development and directly influence the relevance of the MSE results. Workshops will improve scientists, managers and other stakeholder communication and important input for the technical work. Results will facilitate adopting a permanent tropical tuna HCR as per Res. C-16-02
Duration	MSE Workplan and funds to conduct work have been extended to 2023.
Work plan and status	Continue technical development of MSE and support of IATTC Staff. Development/tailoring of MSE Workshop materials and online resources to EPO tropical tuna fisheries including presentations and hands-on working sessions. Conduct annual Workshops with managers, industry and other stakeholders to improve understanding of the MSE process, elicit objectives, performance metrics, alternative control rules, and risk, as well as to show initial results/gather feedback
Collaborators	Work carried out by external contractor and IATTC staff.
Deliverables	Reporting to SAC of MSE development, progress, and results. Series of Workshops, Workshop reports and associated training and online materials.

PROJECT I.1.a: Conduct a Management Strategy Evaluation (MSE) for tropical tunas in the EPO

Updated: April 2021

Progress summary for the reporting period

1st IATTC MSE Workshop conducted (Dec 2019), 2nd WS postponed due to pandemic to May 2021.
Introductory MSE Workshops for the EPO Tuna Industry (Funded by WWF, FAO/ABNJ) in Ecuador, Panama, Mexico, USA and Colombia (June to September 2019).
Work on alternative ways to incorporate uncertainty in parameters and model structure during the MSE modeling phase were discussed, including incorporating results from the risk analysis.
Work on educational and communication materials for upcoming workshops.

Challenges and key lessons learnt

Pandemic altered the timeline of the 2nd WS, consideration of additional online sessions during 2021

Reports/publications/presentations (selected)

Presentations:

March 2019: Independent review of bigeye assessment
December 2019: 1st. IATTC MSE Workshop Presentations

Publications:

WSBET-02-02 Stock structure for bigeye tuna in the eastern Pacific Ocean
WSBET-02-05 Growth used in the eastern Pacific Ocean bigeye tuna assessment
WSBET-02-07 Natural mortality used in the eastern Pacific Ocean bigeye tuna assessment

Valero, J. L. 2019. Conversion of BET 2017 base case assessment from Stock Synthesis version 3.23b to 3.3. 2nd Bigeye Assessment Review. La Jolla, California (USA), 11-15 March 2019.

Valero, J. L., Maunder, M., Xu, H., Minte-Vera, C. V., Lennert-Cody, C., Aires-da-Silva, A. 2019. Investigating potential causes of misspecification-induced regime shift in recruitment in the EPO bigeye tuna (*Thunnus obesus*) assessment. 2nd BET Assessment Review. La Jolla, California (USA), 11-15 March 2019.

Valero, J. L., Maunder, M., Xu, H., Minte-Vera, C. V., Lennert-Cody, C., Aires-da-Silva, A. 2019. Spatial stock assessment model options for bigeye tuna (*Thunnus obesus*) in the EPO and beyond. 2nd Bigeye Assessment Review. La Jolla, California (USA), 11-15 March 2019.

Valero, J. L. and Aires-da-Silva, A. 2020. 1st Workshop On Management Strategy Evaluation (MSE) For Tropical Tunas: Overview, Objectives and Performance Metrics. IATTC. Meeting Report.

Maunder, M., Minte-Vera, C., Lennert-Cody, C., Valero, J.L., Aires-da-Silva, A., Xu, H.. 2020. Risk analysis for yellowfin tuna: models and their weights. IATTC, 11th Scient. Adv. Com. Meeting.

Aires-da-Silva, A., Maunder, M. N., Valero, J. L., Xu, H., Minte-Vera, C., Lenner-Cody, C. 2020. Risk analysis for management of the tropical tuna fishery in the eastern Pacific Ocean. IATTC, SAC-11.

Xu, H., Maunder, M., Minte-Vera, C., Valero, J. L., Lennert-Cody, C. 2020. Benchmark stock assessment of bigeye tuna in the eastern Pacific Ocean for 2019. Inter-Amer. Trop. Tuna Comm., 11th Scient. Adv. Com. Meeting. Minte-Vera, C., Maunder, M., Xu, H., Valero, J.L., Lennert-Cody, C. 2020. Benchmark stock assessment of yellowfin tuna in the eastern Pacific Ocean for 2019. IATTC, 11th Scient. Adv. Com. Meeting.

Maunder, M., Xu, H., Lennert-Cody, C., Valero, J.L., Aires-da-Silva, A., Minte-Vera, C. 2020. Implementing Reference Point-based fishery harvest control rules within a probabilistic framework that considers multiple hypotheses. IATTC, 11th Scient. Adv. Com. Meeting.

PROJECT J.1.a: Temporal trends and variability in the spatial distribution of tropical tuna purse-seine fishing	
THEME: Sustainable fisheries **GOAL:** J. Relationship between purse-seine fishing strategies and fishing mortality **TARGET:** J.1. Identify and monitor changes in technology and fishing strategies **EXECUTION**: Ecosystem and Bycatch Program and Stock Assessment Program	
Objectives	Evaluate the reliability of the data obtained on identification of FADs. Develope spatial-temporal indices and statistics of tropical tuna purse-seine fishery distribution in the EPO. Understand the dynamics of the purse-seine fishing operations and fishing behavior in the eastern Pacific Ocean.
Background	Catch per unit effort (CPUE) standardization and model-based stock assessments are the standard for assessing the abundance and stock status of exploited species. However, these approaches are complex and it can be difficult to identify all covariates for estimating stock size while controlling for changes in fishing efficiency. If these approaches are not properly implemented, they can lead to hyperstability, wherein CPUE values remain constant despite stock decline. Therefore, it is useful to complement more sophisticated stock assessment models with simpler approaches based on catch and effort data to maximize the probability of detecting overexploitation and hyperstability as early as possible. Time series of spatial indices of fisheries can help identify temporal patterns with a focus on long-term trends that might be indicative of declining stock status for both tuna and bycatch species or hyperstability.
Relevance for management	This project will contribute to advance our understanding of tropical tuna purse-seine fisheries spatial-temporal dynamics and their relationship to both target and non-target species catch and propose, as needed, conservation and management measures for the IATTC fisheries, as necessary. This project is also expected to receive feedback and support of well-established working groups in other t-RFMOs, such as the tropical tuna, FAD or Bycatch and Ecosystem working groups of IOTC and ICCAT.
Duration	12 months
Work plan and status	Develop a series of annual spatial indices for the catch of the three major species of tropical tunas and the most important bycatch species, as a function of ocean and fishing mode. Examine the time series of these indices to identify trends and/or unique events with a particular eye towards any long-term trends that might be indicative of declining stock status and hyperstability. Analyses will be conducted adapting the methodologies developed for the Atlantic and Indian Oceans and described in SCRS/2021/148.
External collaborators	Institut de Recherche pour le Développement (IRD), Instituto Español de Oceanografía (IEO), Secretariat of the Pacific Community (SPC)
Deliverables	A report for the SAC, Bycatch Working Group and the FAD Working Group in 2023, as well as peer-reviewed publications

PROJECT J.2.a: Quantify the relationship between vessel operational characteristics and fishing mortality	
THEME: Sustainable fisheries **GOAL:** J. Relationship between purse-seine fishing strategies and fishing mortality **TARGET:** J.2. Relationship between vessel operational characteristics and fishing mortality **EXECUTION**: Stock Assessment Program	
Objectives	Evaluate the reliability of the data obtained on identification of FADs. Investigate methods to determine purse-seine set type from various sources of data (i.e. Observers, vessel logbooks, canneries, etc.). Evaluate the relationship between catch and number of FAD deployments. Investigate more precise measures of fishing capacity that take into consideration days fished, set type, and vessel characteristics. Investigate the relationship between fishing mortality and fleet capacity. Evaluate alternative management measures such as closed areas, individual vessel limits, and gear restrictions.
Background	The constantly increasing capacity of the purse-seine fleet in the EPO requires more stringent management measures. Several management measures have been investigated as an alternative to increasing the seasonal closure. However, the measure of fishing capacity used to determine the days of closure is somewhat simplistic, and a more precise measure of capacity, and the relationship between capacity and fishing mortality, needs to be investigated. Also, the relationship between the number of FADs deployed and catches needs to be better understood. Although the staff has conducted some initial analyses, further studies need to be carried out to provide alternative management measures.
Relevance for management	The results of the project will enable the staff to refine current measures and develop alternative recommendations for managing tropical tunas in the EPO, and provide the Commission with additional tools when developing management measures.
Duration	24 months
Work plan and status	2018 – Initial analyses of the data that will lead to new insights 2019 – Further analyses to improve the staff's management advice 2020 – Apply the lessons learnt from the project and provide recommendations on both alternative management measures and additional data collection.
External collaborators	
Deliverables	Multiple reports for the meetings of the SAC and the Commission, including recommendations on tuna conservation and possibly on improvements to data collection. Software will be created that can be used to update the analyses with new data and/or alternative assumptions and new methods.

PROJECT J.2.a: Quantify the relationship between vessel operational characteristics and fishing mortality

Updated: May 2022

Progress summary for the reporting period

Task 1 (*Evaluate the reliability of the data obtained on identification of FADs*): an extensive review of FAD data reporting under Resolutions C-16-01 and C-17-02 led to:

i. modifications of Resolution C-16-01 to require only vessels without an observers onboard to fill FAD form 9/2018;
ii. multiple agreements to provide high-resolution buoy data, including biomass, in a voluntary basis for a pilot project (J.3.a, FAD-05-INF-E);
iii. continuous update of a database on buoys reported under Resolution C-17-02 and the creation of a preliminary database on buoys with biomass information; and
iv. a new pilot project on remotely and electronically identifying FADs (Project D.1.a).

Task 2 (*Investigate methods to determine purse-seine set type*): following promising tests of a preliminary set type classification algorithm, a new version is being developed, incorporating additional information to reduce the error rates.

Task 3 (*Evaluate the relationship between catch and number of FAD deployments*): see Lennert-Cody et al. 2018, SAC-10-INF-K, FAD-04-01, FAD-05-INF-A, FAD-05-INF-C, FAD-06-01, IATTC-98-INF-J. Further analysis may be required once FAD tracking data are available for the entire fleet.

Task 4, 5 (*Investigate more precise measures of fishing capacity/the relationship between fishing mortality and fleet capacity*): the staff expects to incorporate the results of its preliminary research in in-depth analyses during year 3-4 of the project. In addition, a collaboration pilot project on developing alternative abundance indices using echo-sounder buoy data is underway (J.3.a) (see FAD-05 presentation and FAD-05-INF-E, FAD-06-03). Preliminary indices were, or will be, presented in 2021 and 2022 FAD WG and SAC meetings. Similarly, the relationship between bigeye fishing mortality estimated by the benchmark stock assessment models and the number of OBJ sets have been investigated (FAD-05-INF-D).

Task 6 (*Evaluate alternative management measures*): the staff is pursuing various alternatives, including a multi-species dynamic management approach and reducing the number of active buoys allowed per vessel (see FAD-04-01, SAC-11-INF-M, SAC-12-08 and IATTC-98-INF-J).

Challenges and key lessons learnt

Current limits on the number of active buoys per vessel may be too high to be effective.

The dynamic management approach looks promising for developing alternative conservation and management measures for juvenile bigeye and yellowfin in a multi-species fisheries context, as well as for sensitive bycatch species and groups.

Despite the new forms and training workshops, FAD data reporting is still imperfect. Training of managers, fishers and observers should continue.

High-resolution buoy data, which will be available for the staff in 2022 (see Res. C-21-04), are needed to link IATTC databases (*i.e.* observers, FAD logbooks, buoy data). A single reporting format for all CPCs is desirable and thus, the staff prepared format templates and letters to effectively receive this data directly from buoy manufacturers.

High-resolution buoy data, including biomass, is key to develop fisheries-independent abundance indices and test alternative hypothesis for fishing mortality.

Because active FADs, not FAD deployments, are subject to limits, analyses using this data were performed in FAD-04-01, FAD-05-INF-A, FAD-05-INF-C, FAD-06-01 and considered in SAC-11-INF-M, SAC-12-08 and IATTC-98-INF-J but may need to be repeated with high-resolution FAD tracking data in the future.

The relationship between bigeye fishing mortality and the number of OBJ sets is positive for all but one area in the EPO, including the predominant offshore equatorial OBJ fishing area where the majority of bigeye catch occurs (FAD-05-INF-D).

Reports/publications/presentations
Presentations:
September 2019: American Fisheries Society 2019 annual conference
Reports:
FAD-04-01 Active FAD limits
FAD-05 INF-A Floating object fishery indicators: a 2019 report
FAD-05-INF-C Floating object fishery indicators: a 2020 report
FAD-05-INF-D Relationship between floating-object effort and fishing mortality
FAD-05-INF-E Tropical tuna biomass indicators from echosounder buoys in the EPO
FAD-06-01- Floating object fishery indicators: a 2021 report
SAC-11-INF-M FAD management measures
SAC-12-08 FAD management options
IATTC-98-INF-J - Active FAD limits for the purse seine fishery: staff's considerations

Comments:
Because the lead researcher of the project is now permanent staff, additional research will be conducted for some of the tasks in 2020-2023

PROJECT J.2.b: Identifying operational characteristics associated with mobulid bycatch in the eastern Pacific Ocean	
THEME: Sustainable fisheries **GOAL:** J. Relationship between purse-seine fishing strategies and fishing mortality **TARGET:** J.2. Relationship between vessel operational characteristics and fishing mortality **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	Understand the nature of mobulid bycatch in the purse seine fishery, and in particular, the effect of different operational characteristics on mobulid bycatch rates. Build on and inform ongoing research to host workshops with purse seine skippers and crew to identify feasible onboard gear, handling and release modifications to reduce mobulid mortality. Tailor bycatch mitigation options for variability in vessel and gear type, as well as the operational details of the vessel.
Background	Manta and devil rays (i.e. mobulids) range overlaps with that of the world's tuna fleets, leading to the potential for interactions with fisheries. Recent interest in mobulid conservation has focused on reducing post-release mortality. However, the operational characteristics of vessels that might determine bycatch rates for mobulids are not well understood yet. Understanding operational characteristics that are related to variability in mobulids bycatch rates will help target specific segments of the fleet for bycatch mitigation and improve discussions with stakeholders and fishers.
Relevance for management	The results of this work will help prioritize vessels with relatively high bycatch and help to identify vessels with feasible mitigation options to reduce mobulid mortality. Similarly, the results of the project will enable the staff to better understand the effect of operational characteristics of purse seiners and mobulids bycatch and propose both additional experiments and conservation and management measures for mobulids in the EPO, as necessary.
Duration	12 months
Work plan and status	2022 – analyze observer data and build models for sets with reported bycatch of mobulids as well as for sets without mobulids as a function of several operational characteristics. The analysis will focus on areas and months previously identified as bycatch "hotspots" (Lezama-Ochoa et al. 2019). The potential effect of environmental variables (e.g. SST, temperature at depth, MLD, chlorophyll) on catch rates will also be tested, and, if possible, modelled to obtain a clearer signal between vessels operational characteristics and the bycatch rates. 2023 – production of dissemination materials and reports for the SAC and the Bycatch Working group
External collaborators	University of California Santa Cruz
Deliverables	A report for the Bycatch Working Group and the SAC in 2023 Dissemination material for skippers' workshops and the tuna conference 2023

PROJECT J.3.a: Developing alternative buoy-derived tuna biomass indexes	
THEME: Sustainable fisheries **GOAL:** J. Relationship between purse-seine fishing strategies and fishing mortality **TARGET:** J.3. Study the impact of FAD operations on fishing mortality to improve management advice **EXECUTION**: Bycatch Mitigation and Gear Technology Group and Stock Assessment Program	
Objectives	Determine the feasibility of echo-sounder buoy data to be used for developing alternative abundance indices for tropical tuna. Develop preliminary catch-independent abundance indices for tropical tunas. Evaluate the usefulness of these indices to inform and complement traditional stock assessment and other projects of interest for the Commission (e.g. MSE, habitat models). Explore the future availability of echo-sounder buoy data in the region for scientific purposes. Develop strategies and plans to improve the robustness of results and help interpretation. Recommend new feasible technological developments to buoy manufacturers.
Background	Fishing efficiency of the tropical tuna purse seines are rapidly evolving due to technology and effort creep and obtaining reliable CPUE is challenging task. New technologies also provide new opportunities for science. Echo-sounder buoys have the potential to daily sample thousands of FADs in a systematic and non-invasive manner. This information could be used to develop alternative abundance indices for tunas using catch-independent data. Other t-RFMOs (e.g. ICCAT) have explored the use of buoy derived abundance indices in their recent stock assessments. Those indices were developed by AZTI. The good relationship with AZTI, OPAGAC and Cape Fisheries granted access to historical satellite-linked echosounder buoy data used by the fleet in the Pacific Ocean.
Relevance for management	This project will advance our understanding of tropical tuna species population dynamics and stock status. Project activities will support several objectives for increasing the sustainability of exploited resources described in the SSP as well as will advance on the use of new technologies and data sources to improve decision-making.
Duration	12 months, extended to 36 due to COVID-19
Work plan and status	2020 – data extraction and preparation. Run standard procedures and methodologies to obtain preliminary indices. Start discussing and exploring new approaches and uses of the data. 2021 – an AZTI researcher will visit the IATTC headquarters and preliminary indices will be updated. Preparation of dissemination materials and recommendations.
External collaborators	AZTI Foundation, OPAGAC, Cape Fisheries, ISSF
Deliverables	A series of alternative abundance indices for the three species of tropical tuna using catch-independent information. Dissemination material, including documents and presentations for the Scientific Advisory Committee and the workshop on developing alternative abundance indices for tropical tuna that ISSF is organizing, likely, in 2021.
PROJECT J.3.a: Developing alternative buoy-derived tuna biomass indexes	
Updated: May 2022	

Progress summary for the reporting period

Several online meetings have been conducted with collaborators in 2020-2022.
The feasibility of echo-sounder buoy data to be used for developing alternative abundance indices for tropical tuna has been determined.
A series of preliminary catch-independent abundance indices for tropical tunas have been produced.
A list with ideas, strategies and plans to improve the robustness of results and help interpretation has been produced, and the team will work on them in the future.
The buoy derived abundance index for skipjack has been used in the interim assessment conducted in 2022.

Challenges and key lessons learnt

Several additional tasks have been identified to improve the model output. A list of the ideas to be explored in 2021-2023 are described in FAD-05-INF-E and FAD-06-03.
Access to high-resolution buoy data, including biomass information, is key to advance the scientific advice but has also been identified as problematic and confidential by some fleet owners. The staff does not require real time data and guarantees that all the IATTC confidentiality and privacy rules are followed, if access to historic data is granted. The present project, where data has been provided by OPAGAC and Cape Fisheries in a voluntary basis, is a good example of success.
The buoy derived abundance index can be useful to improve skipjack assessment.

Reports/publications/presentations

Presentations:

FAD-05-Pres

Reports:

FAD-05-INF-E Tropical tuna biomass indicators from echosounder buoys in the EPO
FAD-06-03 Tropical tuna biomass indicators from echosounder buoys in the EPO
SAC-13-07 Interim skipjack assessment

Other products

A series of preliminary buoy-derived abundance indices for tropical tuna species for internal discussion and use in the skipjack interim assessment in 2022

Comments:

Because of the pandemic, the research stay of the main-researcher in La Jolla will be postponed to 2023.
A workshop on echo-sounder buoy data is expected to be organized by ISSF in 2022/2023, where this project will also be presented and discussed.

PROJECT K.1.a: POSEIDON project progress report	
THEME: Sustainable fisheries GOAL: K. Improve our understanding the socio-economic aspects of sustainable tropical tuna fisheries TARGET: K.1. Collaborate in socio-economic studies by other organizations EXECUTION: Stock Assessment Program	
Objectives	Build and evaluate an agent-based, adaptive fishing fleet model as an analytic tool to support management
Background	POSEIDON is a coupled human-ecological model that combines an agent-based, adaptive fishing fleet model with existing fishery models or simple biological data, to simulate vessel behavior and fishery outcomes based on policies, market influences, and environmental factors. POSEIDON provides a powerful platform for policy evaluation and decision support, with a strong focus on the spatial and human dimensions of fisheries management. POSEIDON was originally developed by a multidisciplinary team from the University of Oxford, Ocean Conservancy, George Mason University, the University of California, Santa Barbara, and Arizona State University, as part of an effort to advance innovation in fisheries management. The model has been calibrated and validated to the U.S. West Coast groundfish fishery. It is now being adapted to explore MSC certification for Indonesia's deep-water snapper fishery (in partnership with The Nature Conservancy, Indonesia).
Relevance for management	The model will be used to explore timely research questions, including FAD management, understanding the spatial dynamics of the fishery, as well as some of the social and economic issues which effect management.
Duration	3 years (end year 2024)
Work plan and status	A researcher will be based at the IATTC's office in La Jolla, and will be charged with 1) scoping model application and designing a use cases that are supportive of IATTC policy evaluation processes, 2) understanding and accessing relevant datasets from IATTC, and 3) conducting statistical analyses of data to support model development. This researcher will work closely with the modeling team based at the University of Oxford and Ocean Conservancy to drive model design, calibration and validation of the tool and its outputs, as well as evaluation of model results.
External collaborators	University of Oxford, Ocean Conservancy
Deliverables	A computer algorithm with which to run simulations to explore management options. A project report and publications in peer-reviewed journals.

PROJECT K.1.a: POSEIDON project progress report
Updated: March 2022
Progress summary for the reporting period Following the developing of an initial version of the POSEIDON operating model, the POSEIDON team developed a joint research plan in 2021 to continue developing the simulation tool in support of IATTC priorities. Following that plan, the POSEIDON model was expanded to include several feature expansions and updates, as follows. To represent a complete picture of the purse seine fishery, the POSEIDON team revised the fleet behavioral model to incorporate dolphin-setting vessels and improving the realism of unassociated sets in the simulation. They also augmented the model with an age-structured population dynamics model for Yellowfin, Bigeye and Skipjack tuna. In consultation with key international FAD researchers, changes were implemented to improve FAD aggregation dynamics. Further, an additional module was added to the model to represent value chain dynamics, such that the model can support evaluation of economic impacts of changes in the fishery. Finally, a joint diagnostics plan was developed to outline the standards that the tool must meet to match the IATTC's standard of accuracy and scientific rigor. The team is in the process of fitting (calibrating) the revised model to data from the fishery and implementing the diagnostic plan.
Challenges and key lessons learnt • • •
Reports/publications/presentations
Comments:

ECOLOGICAL IMPACTS OF FISHERIES: ASSESSMENT AND MITIGATION

PROJECT L.1.a: Develop habitat models for bycatch species caught in the EPO to support ecological risk assessments (ERAs)	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** L. Evaluating ecological impacts **TARGET:** L.1. Develop analytical tools to identify and prioritize species at risk for data collection, research and management **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	To use presence-only catch data to develop habitat models for key bycatch species caught in EPO tuna fisheries to facilitate mapping of their geographic range. To make distribution maps available in a format suitable for use as base maps for ecological risk assessment models (e.g., PSA, EASI-Fish)
Background	Many bycatch species caught in EPO tuna fisheries lack sufficient biological and catch data to undertake traditional stock assessment to determine their vulnerability to fishing. Data-limited Ecological Risk Assessment (ERA) methods are now increasingly used to determine the most vulnerable species to fishing, which have a strong reliance on estimating impacts using the overlap of fishing effort with a species' distribution. Given the success of using the EASI-Fish approach for assessing the vulnerability of data-poor bycatch species in the EPO (e.g. sharks, devil rays, leatherback turtles), further development of SDMs for other species is required.
Relevance for management	Developing habitat models for bycatch species will improve the fishing mortality estimates using ERAs, from which their status can be determined and guide managers.
Duration	24 months
Work plan and status	Jun-Dec 18: model development Jan-Feb 19: apply habitat model to bycatch species to be included in ERAs Mar-April 19: Finalize habitat maps for bycatch species May 19: present final model and assessment results at SAC-10. Jun 21-Sept 22: use Pacific-wide datasets to explore the use of a range of alternative SDMs in isolation or as ensembles for shark species caught in EPO pelagic fisheries
External collaborators	CPCs, SPC
Deliverables	Presentations at SAC-10, SAC-13 and at WCPFC, if required. Procedure, if successful, to be used annually within ERA models to assess the vulnerability of bycatch species in the EPO.

PROJECT L.1.a: Develop habitat models for bycatch species caught in the EPO to support ecological risk assessments (ERAs)

Updated: May 2022

Progress summary for the reporting period

Initial models were developed using Integrated Nested Laplace Approximation (INLA) and Generalized Additive Models (GAMs) for one species of mobulid, and the leatherback turtle, which formed the basis of EASI-Fish assessments for these species.

Subsequent explorations of SDMs were undertaken in 2021-2022 for 32 shark species caught in the EPO, in collaboration with SPC staff.

Challenges and key lessons learnt

Even highly sophisticated models in data-rich settings can predict habitat poorly, depending on the environmental data used for the prediction.

It is likely that many more presence points occur within the EEZ of coastal nations in the EPO, however, obtaining high resolution data from domestic fisheries is a major challenge.

Reports/publications/presentations

Five manuscripts that use the habitat models have been published in scientific journals or given as IATTC presentations:

Griffiths, S.P., Lezama-Ochoa, N., 2021. A 40-year chronology of spinetail devil ray (*Mobula mobular*) vulnerability to eastern Pacific tuna fisheries and options for future conservation and management. *Aquatic Conservation: Marine and Freshwater Ecosystems* 31, 2910–2925.Griffiths, S.P., Lezama-Ochoa, N., Román, M.H., 2019. Moving towards quantitative ecological risk assessment for data-limited tuna fishery bycatch: application of "EASI-Fish" to the spinetail devil ray (*Mobula mobular*) in the eastern Pacific Ocean. *9th Meeting of the IATTC Working Group on Bycatch, 11 May 2019, San Diego, California, USA. Document BYC-09-01*.

Griffiths, S.P., Kesner-Reyes, K., Garilao, C., Duffy, L.M., Román, M.H., 2019. Ecological Assessment of the Sustainable Impacts of Fisheries (EASI-Fish): a flexible vulnerability assessment approach to quantify the cumulative impacts of fishing in data-limited settings. *Marine Ecology Progress Series* 625, 89-113.

Griffiths, S.P., Wallace, B., Swimmer, Y., Alfaro-Shigueto, J., Mangel, J.C., Oliveros-Ramos, R., 2020. Vulnerability status and efficacy of potential conservation measures for the east Pacific leatherback turtle (*Dermochelys coriacea*) stock using the EASI-Fish approach. *10th Meeting of the IATTC Working Group on Bycatch, 10 September 2020, La Jolla, California, USA. Document BYC-10-01*.

Griffiths, S.P., Fuller, L.M., Potts, J., Nicol, S., 2022. Vulnerability assessment of sharks caught in eastern Pacific Ocean pelagic fisheries using the EASI-Fish approach. *13th Meeting of the Scientific Advisory Committee of the IATTC, 16-20 May 2022, La Jolla, California, USA. Document SAC-13-11, 80.*

Comments:

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PROJECT L.2.b: Vulnerability assessment of elasmobranch bycatch in EPO tuna fisheries using the EASI-Fish approach	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** L. Evaluating ecological impacts **TARGET:** L.2. Develop analytical tools to identify and prioritize species at risk for data collection, research and management **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	To use the EASI-Fish ERA approach to assess the vulnerability status of elasmobranch species caught as bycatch in EPO fisheries To identify vulnerable species using traditional biological reference points
Background	IATTC is committed, through the Antigua Convention, to ensure the long-term sustainability of all non-target species impacted by EPO tuna fisheries. Elasmobranchs have been identified in previous qualitative ERAs to be among the most vulnerable species to tuna fishery impacts in the EPO. However, these species lack sufficient biological and catch data for stock assessment, so data-limited approaches are required to assess vulnerability. In 2019, the IATTC developed EASI-Fish (Ecological Assessment for the Sustainable Impacts of Fisheries) to quantitatively assess vulnerability using traditional biological reference points used in fisheries stock assessment (e.g. F_{MSY}, $SPR_{20\%}$).
Relevance for management	The EASI-Fish assessment will transparently identify vulnerable elasmobranch species in the EPO (and across the Pacific where applicable). Vulnerable species can then be subjected to further assessment where managers can be advised on the efficacy of potential conservation and management measures that may be implemented to reduce vulnerability to sustainable levels.
Duration	12 months
Work plan and status	**Nov 2021-Jan 2022:** in collaboration with SPC, develop Pacific-wide species distribution models for 32 species of sharks. Sep-Apr 22: complete EASI-Fish assessment and identify vulnerable species May 22: present assessment results at SAC-13.
External collaborators	CPCs, SPC.
Deliverables	Paper and oral presentation at SAC-13 (SAC-13-11) Scientific journal publication

PROJECT L.2.b: Vulnerability assessment of elasmobranch bycatch in EPO tuna fisheries using the EASI-Fish approach
Updated: May 2022
Progress summary for the reporting period July-Sept 2021: Collated available effort and shark interaction data for 8 fisheries in the EPO from IATTC databases and publicly available publications Sept 2021-Mar 2022: Collated available biological information for 32 shark bycatch species with supporting references and entered into the IATTC ecosystems database. Nov 2021-Jan 2022: Developed species distribution models for 32 shark bycatch species using Maxent. Jan-Feb 2022: Improved SDMs for 32 species by beginning a collaboration with SPC, who assisted in developing SDMs using an ensemble approach from 4 SDM algorithms using all data from the Pacific Ocean. Feb-April 2022: Completed testing, diagnostics checks, and produced final results of EASI-Fish models for 32 shark species. March-Apr 2022: Write final report for SAC 13 (Document SAC-13-11).
Challenges and key lessons learnt Very little catch, biological and ecological information exists for most shark bycatch species resulting in the use of several approaches to estimate required model parameters The IATTC database contains a large number of records where taxa are identified only to high taxonomic levels, potentially missing important presence locations that are critical for the development of SDMs, especially for rarer species. Presence predictions can vary greatly depending on 1) the SDM approach used, and 2) the method used to determine probability of presence threshold values. Further research on aspects of SDMs required in this new research area. The EASI-Fish assessment identified 20 shark species as “most-vulnerable”.
Reports/publications/presentations Griffiths, S.P., Fuller, L., Potts, J., Nicol, S., 2022. Vulnerability assessment of sharks caught in eastern Pacific Ocean tuna fisheries using the EASI-Fish approach. 13th Meeting of the Scientific Advisory Committee of the IATTC, 15-20 May 2022, La Jolla, California, USA. Document SAC-13-11.
Comments: -

PROJECT L.2.c: Assessing the efficacy of potential management options on highly vulnerable shark species in the EPO	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** L. Evaluating ecological impacts **TARGET:** L.2. Develop analytical tools to identify and prioritize species at risk for data collection, research and management **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	To use the EASI-Fish ERA approach to assess the efficacy of potential conservation and management measures for reducing fishing impacts on shark species identified in project L.2.b as being highly vulnerable in the EPO
Background	IATTC is committed, through the Antigua Convention, to ensure the long-term sustainability of all non-target species impacted by EPO tuna fisheries. IATTC Project L.2.b used the EASI-Fish (Ecological Assessment for the Sustainable Impacts of Fisheries) approach to identify the most vulnerable elasmobranch species caught as bycatch in EPO tuna fisheries. EASI-Fish has been used by the IATTC as an alternative approach to traditional population models to assess the efficacy of management measures on data-limited bycatch species including the critically endangered leatherback turtle and the spinetail devil ray. The staff has been tasked to conduct conventional stock assessments for priority shark species, but the quality of the available fishery data remains prohibitive for this purpose (see section 4 on shark workplan). As an interim data-limited alternative to conventional stock assessments, EASI-Fish will be used to assess shark species identified as being highly vulnerable.
Relevance for management	EASI-Fish assessments can transparently identify vulnerable elasmobranch species in the EPO. However, vulnerability may be reduced differently for each species. Therefore, by undertaking separate EASI-Fish assessments for each vulnerable species, management measures that may be most efficient and cost-effective may be identified for each species, and for all species in concert. This will ultimately simplify the development of fewer management measures (if required) and minimize the losses of target species catch as a result.
Duration	12 months
Work plan and status	Jun-Dec 22: develop species-specific EASI-Fish assessments for the most vulnerable species identified and pose potential management strategies to reduce vulnerability Jan-Apr 23: Finalize EASI-Fish assessments May 23: present final species-specific EASI-Fish assessment results at SAC-14.
External collaborators	CPCs, SPC.
Deliverables	Paper and oral presentation at SAC-14 Scientific journal publication

PROJECT L.2.c: Assessing the efficacy of potential management options on highly vulnerable shark species in the EPO
Updated: May 2022
Progress summary for the reporting period Apr 2022: Initial EASI-Fish assessment completed for 32 shark species caught in EPO tuna fisheries (Document SAC-13-13) Apr-May 2022: 20 species identified from EASI-Fish as "most vulnerable" and require further consideration and/or more detailed assessment. May 2022: SAC to determine which (and how many) species are the highest priority to include in this project.
Challenges and key lessons learnt
Reports/publications/presentations
Comments: -

PROJECT L.2.d: Pacific-wide vulnerability assessment of pelagic shark species caught as bycatch in tuna fisheries	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** L. Evaluating ecological impacts **TARGET:** L.2. Develop analytical tools to identify and prioritize species at risk for data collection, research and management **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	In collaboration with SPC, use the EASI-Fish ERA approach to undertake a Pacific-wide vulnerability assessment of shark species caught as bycatch in tuna fisheries managed by the IATTC and WCPFC To identify the most vulnerable species using traditional biological reference points
Background	In 2021, SPC developed species distribution models for all shark bycatch species caught in WCPFC tuna fisheries with the intent to undertake a vulnerability assessment using the EASI-Fish approach. Many of the species examined by SPC have a Pacific-wide distribution and therefore cross the jurisdictional boundary between the IATTC and WCPFC. In 2022, SPC will conduct the first shark assessment using EASI-Fish. Therefore, in order to better model the true extent of fishery impacts on cross jurisdictional stocks, the SPC and IATTC staff will collaborate in the assessment.
Relevance for management	EASI-Fish assessments can transparently identify vulnerable species by using well established biological reference points, thus minimizing the chances of incurring false positives that may require improper and costly management actions to be taken. Many ERAs have previously been undertaken on individual fisheries or jurisdictions, thus underestimating true fishery impacts on shared stocks. By undertaking a Pacific-wide EASI-Fish assessment for shared stocks both the IATTC and WCPFC will better understand the true extent of fishery impacts on assessed stocks, and be able to identify species of high vulnerability in order to subject to further assessment or management as required.
Duration	12 months
Work plan and status	Sep 2021-June 2022: complete Pacific-wide EASI-Fish assessment in collaboration with SPC and identify vulnerable species. Aug 2022: present assessment results at WCPFC SC in 2022. May 2023: present assessment results at SAC-14 in 2023, if required.
External collaborators	SPC
Deliverables	Paper and oral presentation at SAC-14 and WCPFC SC, if required. A scientific journal publication.

PROJECT L.2.d: Pacific-wide vulnerability assessment of pelagic shark species caught as bycatch in tuna fisheries
Updated: May 2022
Progress summary for the reporting period July-Sept 2021: Collated available effort and shark interaction data for 8 fisheries in the EPO from IATTC databases, 5 fisheries in the WCPO from SPC databases, and publicly available publications Sept 2021-Mar 2022: Collated available biological information for ~50 shark bycatch species shared with the WCPO area from IATTC and SPC databases. Jan-Feb 2022: SPC developed SDMs for ~50 species using an ensemble approach from 4 SDM algorithms using all data from the Pacific Ocean. June 2022: Species to be selected for assessment in EASI-Fish with consultation with IATTC and WCPFC stakeholders.
Challenges and key lessons learnt
Reports/publications/presentations
Comments: -

PROJECT L.2.e: Vulnerability assessment and efficacy of potential conservation measures for the east Pacific leatherback turtle stock	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** L. Evaluating ecological impacts **TARGET:** L.2. Develop analytical tools to identify and prioritize species at risk for data collection, research and management **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	To use the EASI-Fish ERA approach to assess vulnerability status and the efficacy of conservation and management measures prescribed under IATTC Resolution C-19-04 for reducing fishing impacts on the East Pacific stock of leatherback turtle (*Dermochelys coriacea*).
Background	IATTC is committed, through the Antigua Convention, to ensure the long-term sustainability of all non-target species impacted by EPO tuna fisheries. On 1 January 2021 a revised resolution on sea turtles (C-19-04) entered into force that requires EPO tuna fisheries to implement various measures designed to reduce the bycatch of sea turtles, in particular the use of circle hooks and finfish baits in shallow longline sets. EASI-Fish has been used by the IATTC as an alternative approach to traditional population models to assess the efficacy of management measures on data-limited bycatch species, including the critically endangered spinetail devil ray. In collaboration with the Inter-American Convention on the Protection and Conservation of Sea Turtles (IAC) and EPO stakeholders, the staff developed a preliminary EASI-Fish assessment for 2018. The project was extended to improve on this model through the development of a dedicated species distribution model and an update of the fishing effort by coastal artisanal fisheries.
Relevance for management	EASI-Fish can rapidly and cost-effectively quantify the cumulative impacts of multiple data-limited fisheries on species under proposed management measures—either individually or in combinations—under IATTC Resolution C-19-04 to determine their potential efficacy of reducing the vulnerability of the EP leatherback turtle stock to becoming unsustainable in the long-term. This will ultimately simplify the choice of management measures required to meet conservation and fisheries objectives.
Duration	12 months
Work plan and status	Jun-Sept 21: Collaborate with stakeholders to collate available fishing effort and leatherback presence data in the EPO. Sept 21-Jan 22: Develop a new approach to use presence and absence records to produce a dedicated species distribution model (SDM) for the East Pacific leatherback turtle stock. Jan 22-Apr 22: Populate EASI-Fish model with biological and fisheries data and run 70 hypothetical scenarios May 22: Present final EASI-Fish assessment results and the special distribution model to the Bycatch Working Group (BYC-11).
External collaborators	IAC, CPCs
Deliverables	Papers and oral presentations for BYC-11 Scientific journal publications

PROJECT L.2.e: Vulnerability assessment and efficacy of potential conservation measures for the east Pacific leatherback turtle stock
Updated: May 2022
Progress summary for the reporting period Jun-Sept 21: Collaborated with IAC, CPCs and stakeholders to collate available fishing effort and leatherback occurrence data in the EPO. Sept 21-Jan 22: Developed a new machine-learning approach to use presence and absence records and a series of environmental variables to produce a dedicated species distribution model (SDM) for the East Pacific leatherback turtle stock. Jan 22-Apr 22: Populated EASI-Fish model with biological and fisheries data and ran 70 hypothetical scenarios Apr 22: Prepared EASI-Fish assessment and SDM results to present at BYC-11.
Challenges and key lessons learnt The machine learning algorithm used to generate the SDM and predictions for the EP leatherback turtle is capable of depicting hotspots of species habitat suitability and describe the species environmental preferences. The estimated fishing mortality, and hence vulnerability status, is strongly influenced by predictions from an SDM and also the threshold value used to define cells where the species is predicted to be present. Although the new SDM was greatly improved, further exploration of how to best determine threshold values is desirable. The complex life history of leatherback turtles presented new technical challenges for the EASI-Fish model that is constructed using a single annual timestep. Further model development is required to better represent spatial heterogeneity in fishing impacts and the potential impacts of spatial closures. For example, different size classes of animals are present in different regions during the breeding season, so a 2-stage model is desirable to characterize this aspect. International highly collaborative projects can be successful to develop studies on data-limited species that require a significant amount of data and explore and assess the potential effect of different conservation and management measures, both individually or collectively.
Reports/publications/presentations BYC-11-01 – A machine learning SDM for the EP leatherback turtle BYC-11-02 – An EASI-Fish assessment of the EP leatherback turtle and effectiveness of measures in Res. C-19-04
Comments: -

PROJECT M.1.a: Evaluate the effect of the depth of non-entangling FADs on catches of tunas and bycatches of other species in the purse-seine fishery	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** M. Mitigating ecological impacts **TARGET:** M.1. Investigate gear technology to reduce bycatch and bycatch mortality **EXECUTION**: Life-history and Behavior	
Objectives	Evaluate the performance of shallow non-entangling versus normal depth FADs in the EPO purse-seine fishery, with an emphasis on the tuna and non-tuna species catch composition; seeking a practical solution to reduce fishing mortality on small undesirable sizes of bigeye
Background	The fishing mortality of small bigeye caught in sets on FADs should be reduced, to increase the maximum sustainable yield from the bigeye fisheries in the EPO Bigeye tuna associated with FADs in the EPO exhibit deeper depth distributions than skipjack or yellowfin tunas The presence of bigeye in the EPO purse seine catch was reported to be more likely with deeper floating objects
Relevance for management	A potential solution for reducing fishing mortality on small undesirable sizes of bigeye and/or reducing fishing mortality on bycatch species associated with FADs, including sharks and turtles
Duration	2015-2018
Work plan and status	2015-2017: ISSF arranged for experiments to be undertaken at sea in collaboration with NIRSA, a seafood company located in Posorja, Ecuador, with a fleet of 11 purse-seine tuna vessels. The first experiment began in June-July 2015 with deployments of 50 shallow and 50 normal depth FADs and concluded on 31 October 2016. The second experiment began in March-May 2017 with deployments of 100 shallow and 100 normal depth FADs and concluded on 31 December 2017. 2018: The catch data collected by observers aboard NIRSA vessels from sets on the experimental FADs from the two experiments is being examined to confirm FAD types 2018: A statistical evaluation of the performance of the shallow non-entangling versus normal depth FADs, including the tuna and non-tuna species catch compositions, will be conducted
External collaborators	ISSF, NIRSA
Deliverables	Relevant information on performance of shallow non-entangling FADs versus normal FADs based on field experiments Full resolution FAD data was provided to the data team working on the POSEIDON model project Manuscript for peer review and publication in a scientific journal

PROJECT M.1.a: Evaluate the effect of the depth of non-entangling FADs on catches of tunas and bycatches of other species in the purse-seine fishery

Updated: June 2019

Progress summary for the reporting period

Analyses of the catch-per-set data for tunas and non-tuna species, coupled with corresponding effort and environmental data, were completed.

Manuscript in final stages of preparation for submission to a peer-reviewed scientific journal in 2019'.
Analyses complete and manuscript accepted for publication.

Challenges and key lessons learnt

There is no significant difference in the catch by tuna species, or the catch of total tunas between shallow (5m depth) non-entangling dFADs and a traditional dFAD design (40m depth) in the EPO.

Drift speeds between shallow (5m depth) non-entangling dFADs and a traditional dFAD design (40m depth) were not significantly different.

Satellite buoy echo-sounder data was compared to total tuna catch to evaluate whether echo-sounder biomass estimates were accurate. Results from the evaluation of 67 sets indicated that there is no correlation between biomass reported under the buoy and what the vessel captured. Eighty-five percent of the buoy estimates over estimated biomass by a considerable margin.

Reports/publications/presentations

Schaefer, K.M., Fuller, D.W. and Chaloupka, M., 2021. Performance evaluation of a shallow prototype versus a standard depth traditional design drifting fish-aggregating device in the equatorial eastern Pacific tuna purse-seine fishery. *Fisheries Research*, *233*, p.105763.

Comments:

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PROJECT M.1.b: Test sorting grids	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** M. Mitigating ecological impacts **TARGET:** M.1. Investigate gear technology to reduce bycatch and bycatch mortality **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	Reduce bycatches of small fishes (tunas and others) in purse-seine sets.
Background	Small individuals of any species (target or non-target) of no market value should be released to reduce the impacts of fishing operations and improve the sustainability of the fishery. Many seiners have sorting grids, different types of panels to allow the escape of fish of a size determined by the dimensions of the grid used, but their use has not been well documented because captains can lift them out of the water, and they do so not to lose any potential catches. Previous experiments have quantified unwanted species passing through the grid. It is necessary to test their survival after escaping, since they may have been injured while going through the grid. Experiments to verify survival should follow the tests of the grid to release unwanted individuals.
Relevance for management	Reduce the impacts of fishing and improve the sustainability of the fishery
Work plan and status	Convene a workshop with fishing captains and gear experts to decide on the standard design for all tests, using previous experience from the region. Build the design in 2 seiners, with a commitment to cooperate by leaving the grid fully underwater in all sets. Monitor with a camera the utilization of the grid in all sets. Deploy a speedboat with a researcher to film escape through the grid. This initial pilot program will attempt to measure the quantity and characteristics of escaped fish, not their survival Evaluate the significance of the releases, assuming survival. If significant, design a project to measure survival in a floating pen. Discuss with captains ways to improve their operation if needed.
Duration	18 months
External collaborators	
Deliverables	May 2019: progress report for SAC-10

PROJECT M.1.b: Test sorting grids
Updated: May 2019
Progress summary for the reporting period See WSSG-01 Meeting Report

PROJECT M.1.c. Acoustic discrimination to avoid purse seine catches of undersized yellowfin tuna	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** M. Mitigating ecological impacts **TARGET:** M.1. Investigate gear technology to reduce bycatch and bycatch mortality **EXECUTION**: Biology Program	
Objectives	Reduce bycatches of small yellowfin in purse-seine sets.
Background	The International Seafood Sustainability Foundation (ISSF) has been supporting investigations of acoustic methods for discrimination among tuna species caught in purse-seine sets Acoustic technologies could provide the ability to discriminate and avoid undersized yellowfin tuna by the purse-seine fishery to reduce the impacts of fishing operations and improve the sustainability of the fishery. To discriminate yellowfin from skipjack and bigeye, it is necessary to know the acoustic properties of yellowfin, in particular, the target strength (TS) and TS-fish length relationship. Acoustic studies will be conducted on juvenile yellowfin (1-yr-old) held in a previously deployed sea cage at the Achotines Laboratory The fundamental acoustic information obtained for yellowfin will then be compared to information previously obtained for skipjack and bigeye, hopefully enabling fishers to discriminate species before fishing
Relevance for management	Reduce the impacts of fishing and improve the sustainability of the fishery
Work plan and status	Early 2020 purchase materials used to anchor and deploy sea cage January-April 2022 install sea cage and collect juvenile yellowfin in waters adjacent to the Achotines Laboratory June 2021-April 2022 staging of ISSF acoustic equipment at Achotines Laboratory May-June 2022 conduct acoustic trial Late 2022 draft report of study results completed by ISSF researchers Late 2022 workshop organized to present the results and discuss them with scientists and buoy manufacturers
Duration	36 months
External collaborators	International Seafood Sustainability Foundation (ISSF) researchers Drs. Gala Moreno and Guillermo Boyra
Deliverables	● Study report developed by ISSF researchers and workshop organized by ISSF ● Publication of results by ISSF researchers in peer-reviewed journal

PROJECT M.1.d. Developing and testing bycatch release devices in tuna purse seiners	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** M. Mitigating ecological impacts **TARGET:** M.1. Investigate gear technology to reduce bycatch and bycatch mortality **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	Develop and test bycatch release devices in tuna purse seiners to improve post release survival, handling and release of sensitive key bycatch species, with particular emphasis on sharks
Background	Bycatch of Endangered, Threatened and Protected (ETP) species, especially elasmobranchs, are a concern in tropical tuna purse seine fisheries While the IATTC has resolutions promoting the application of best bycatch handling and releasing practices (e.g., for mobulids, sharks, turtles), there is a lack of clear guidelines for the fleet, and current release methods are quite rudimentary, often involving manual handling or basic self-made tools As part of fisheries improvement projects, several fishing organizations have implemented voluntary programs to improve bycatch handling and releasing practices. Associating and collaborating with experienced research institutions and fishing organizations would help explore, discuss and progress towards a reduction of bycatch mortality through the promotion of new tools that facilitate best handling and releasing practices
Relevance for management	Contributes to increase crew safety and survival of key sensitive bycatch species accidentally caught in tuna purse seiners
Work plan and status	Coordinate the testing of a number of novel technological devices to release bycatch species in large tuna purse seiners These specific devices will be designed to achieve more efficient releases (e.g. faster, less handling stress, safer for the crew) The benefits of these devices will be assessed in terms of species survival using satellite tags and other biological indicators (e.g. lactate levels, vitality indicators, etc.) Collect device utilization data through IATTC observers and scientific cruises with embarkment of AZTI/IATTC/ISSF scientists Use results of the project to inform conversations during skippers' workshops Promote the utilization of the most efficient devices and methods in the region and, as appropriate, help shape recommendations
Duration	24 months
External collaborators	AZTI Foundation, the International Seafood Sustainability Foundation (ISSF) and OPAGAC
Deliverables	A report showing results from novel alternative bycatch release devices tested at sea in large tuna purse seiners Dissemination material, including documents and presentations for the IATTC Bycatch Working Group, the SAC and the tuna conference.

PROJECT M.1.d. Developing and testing bycatch release devices in tuna purse seiners
Updated: May 2022
Progress summary for the reporting period Jun-Sept 21: Discuss, decide, and build specific tools for large purse-seine vessels. Sept 21-Jan 22: Develop data collection forms and protocols as well as discuss and agree the sampling design. Jan 22-Apr 22: Finalize dedicated data collection forms and instructions and coordinate logistics for the first scientific cruise with a researcher from AZTI and an IATTC observer. Apr 22: The first scientific cruise had to be postponed at the last minute due to issues related to COVID-19. Two scientific cruises are expected in 2022.
Challenges and key lessons learnt Some technological devices seem promising to improve both fishing crews' safety and sharks post-release survival. New cutting-edge promising technologies (i.e., suction discs) are currently being explored as a potential technology to be used in purse seiners.
Reports/publications/presentations A presentation at the BYC-10 meeting.
Comments: -

PROJECT M.2.b: Evaluate best handling practices for maximizing post-release survival of silky sharks in longline fisheries, and identification of silky shark pupping areas for bycatch mitigation	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** M. Mitigating ecological impacts **TARGET:** M.2. Develop best practices for release of bycatch species **EXECUTION**: Life-history and Behavior Group	
Objectives	Estimate post-release survival of silky sharks captured by Mexican longline vessels in the eastern tropical Pacific, utilizing a best handling practice, and define boundaries encompassing the probable distribution silky shark pupping areas in the EPO
Background	Apparent severe decline in the population of silky sharks in the EPO, based on trends in standardized catch-per-unit-of-effort indices Domestic longline fleets from Latin America conduct multi-species fisheries including retaining silky sharks Defining the probable distribution of silky shark pupping areas would be useful for better understanding population structure and for consideration of conservation measures including spatiotemporal closures
Relevance for management	Resolution C-16-06 on conservation measures for silky sharks stipulates to improve handling practices for live sharks to maximize post-release survival, and identification of pupping areas of the silky shark
Duration	2018-2020
Work plan and status	2018-2019: 69 silky sharks will be tagged with archival tags on Mexican longline vessels, using best handling practices 2019-2020: The data obtained will be analyzed for post-release survival and movements during 2019 and 2020. 2019-2020: Exploratory analyses of silky shark size at capture data, compiled from various fisheries in the EPO, will be conducted to determine the areas and times where silky shark pupping most likely occurs
External collaborators	INAPESCA, Mexico
Deliverables	Silky shark post-release survival rate captured by Mexican longline vessels, using best handling practices Probable distribution of silky shark pupping areas

PROJECT M.2.b: Evaluate best handling practices for maximizing post-release survival of silky sharks in longline fisheries, and identification of silky shark pupping areas for bycatch mitigation
Updated: February 2022
Progress summary for the reporting period 57 silky sharks were tagged with archival tags on Mexican longline vessels, using best handling practices The satellite data sets obtained have been compiled A table of metadata has been compiled, including release and pop-up dates and locations for all tags reporting to date, along with the fate of each shark.
Challenges and key lessons learnt:
Reports/publications/presentations Schaefer, K., Fuller, D., Castillo-Geniz, J.L., Godinez-Padilla, C.J., Dreyfus, M. and Aires-da-Silva, A., 2021. Post-release survival of silky sharks (*Carcharhinus falciformis*) following capture by Mexican flag longline fishing vessels in the northeastern Pacific Ocean. Fisheries Research, 234, p.105779.
Comments:

PROJECT M.2.c: Manta and devil ray post-release survival, movement ecology, and genetic population structure	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** M. Mitigating ecological impacts **TARGET:** M.2. Develop best practices for release of bycatch species **EXECUTION**: Bycatch Mitigation and Gear Technology Group	
Objectives	Quantify baseline capture and survival probabilities of mobulid species and identify best practices for handling and release Identify vertical and horizontal habitat use of the species to improve selectivity Quantify the accuracy of onboard observer species identification Characterize population genetic structure and effective population size across the Eastern Pacific for four mobulid species.
Background	Manta and devil ray populations are impacted globally by targeted fisheries and bycatch, including purse seine fisheries operating in the EPO The IATTC forbids retention of mobulid rays and requires release without the use of gaffs, hooks, or damage to the body or gills. Fishing crews have begun employing a variety of handling and release methods, from release by hand to the use of cargo nets. To date, there is no quantitative data to estimate the effect of these methods on the survivorship of the species
Relevance for management	Contribute to a cleaner fishing, reducing interaction and post-release mortality of sensitive bycatch species, and providing guidelines for best handling and release practices
Duration	2021-2023
Work plan and status	Train selected observers to deploy satellite tags and collect tissue samples Develop specific complementary data collection forms and protocols for data collection and tagging Analyze satellite tags to investigate animals' post release survival, ecology, and horizontal and vertical behavior Analyze tissue samples using Restricted Site Associated Sequencing (RAD-Seq) techniques to infer population structure and size from genetic information, as well as assess the accuracy of onboard observer species identifications Conduct skippers' workshops to discuss potential improvements and help shape best handling and release practices Develop bycatch mitigation and management measures based on scientific evidence
External collaborators	The Manta Trust, The Monterey Bay Aquarium, The Conservation Action Lab at University of California Santa Cruz
Deliverables	A peer-reviewed publication on the post-release survivorship of manta and devil rays released alive from tuna purse seine vessels Empirically derived guidelines for the best handling and releasing practices Peer-reviewed publications on the horizontal and vertical distribution of mobulid rays, and their environmental preferences A peer-reviewed publication on the population genetic structure of four mobulid species A peer-reviewed publication on the accuracy of species identification and the effort to improve species identification forms and training for observers Dissemination material for the Bycatch Working Group
PROJECT M.2.c: Manta and devil ray post-release survival, movement ecology, and genetic population structure	
Updated: May 2022	

Progress summary for the reporting period

2021: Develop data collection forms and protocols as well as discuss and agree the sampling design.
2021-2022: distribute tagging kits to IATTC and TUNACONS observers for opportunistic tagging. Collect tissue samples at sea, on land, and from collaborators.
At least 31 tags were deployed on mobulids to date: 16 *M. mobular*, 8 *M. Thurstoni*, 5 *M. tarapacana*, 2 *M. birostris*.
398 usable tissue samples were collected and analyzed up to date, belonging to 4 species. About 350 more samples will be potentially analyzed in 2022.

Challenges and key lessons learnt

Preliminary tagging analyses suggest species-specific post-release mortality: 50% for *M. birostris*, 60% for *M. Tarapacana*, 8% for *M. mobular* and 80% for *M. thurstoni*.
Preliminary genetic analyses suggest weak but significant population structure for all the species with good data – *M. birostris, M. thurstoni*, and *M. munkiana*. Strong evidence of connectivity exists, but local selection may also be occurring.
For *M. thurstoni* and *M. munkiana*, very low diversity and high inbreeding has been detected, suggesting potential genetic bottleneck or depletion.
There is clear distinction between Indian Ocean/W Pacific and eastern Pacific Oceans, suggesting EPO should likely be managed distinctly. Additionally, there are significant differences from northern and southern EPO, though this varies slightly by species. For some, subregions-subpopulations (north-south) may exist within the ETP.
Other regional mobulid mitigation initiatives exist, and active collaboration is being undertaken at the moment (i.e., mobulid bycatch mitigation tools in purse-seiners operating in both WCPO-EPO).

Reports/publications/presentations

A presentation at the BYC-10 meeting.
Several presentations for the skippers' workshops in 2020, 2021 and 2022.
A peer-reviewed publication.
Cronin et al. 2022, Harnessing Stakeholder Knowledge for the Collaborative Development of Mobulid Bycatch Mitigation Strategies in Tuna Fisheries, ICES Journal of Marine Science.
Other peer-reviewed publications are either in preparation or under review.

Comments:

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PROJECT M.3.b: Spatial and temporal closures and the tradeoff between bycatch and target catches	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** M. Mitigating ecological impacts **TARGET:** M.3. Conduct spatiotemporal analyses to identify areas of high bycatch/catch ratios **EXECUTION**: Bycatch Mitigation and Gear Technology Group	
Objectives	Explore the effectiveness of different types of spatial and temporal closures in reducing bycatch with the lowest losses in target catch
Background	A major impediment to ensuring fisheries sustainability is the impact of fishing practices on non–targeted species, particularly bycatch of marine megafauna Many bycatch mitigation measures have been developed to reduce the impact on bycatch species. However, most of the measures have been designed to reduce bycatch of only one species or group of species Spatial and temporal closures are another common management measure to reduce bycatch, although they have not been explored in detail in the region A major concern about the efficacy of spatial and temporal closures is the potential for fishing effort to be redistributed rather than reduced. As a result, it creates a tradeoff between reduced fishing mortality inside protected areas or seasons, and a potential increase in surrounding waters or open seasons However, the effectiveness of permanent or dynamic area closures at reducing multispecies bycatch is still an open question fur tuna purse seine fisheries in the EPO
Relevance for management	Reducing bycatch while maintaining target species catch would make the purse seine fishery more selective and cleaner. In addition, managers will be provided with the necessary information to start the conversation on different types of spatial and temporal closures that could be applied in the region, if needed
Duration	2020-2021
Work plan and status	Sep-Dec 2020: Data preparation and exploration; decide weights for key bycatch species and groups Jan-Mar 2021: Run analysis and models Apr-Jun 2021: Discussion of results and preparation of a manuscript for a peer-reviewed journal
External collaborators	University of Washington, School of Aquatic and Fishery Sciences
Deliverables	A manuscript for a peer-review journal Dissemination material for the Bycatch Working Group, likely in 2022

PROJECT M.3.b: Spatial and temporal closures and the tradeoff between bycatch and target catches
Updated: May 2022
Progress summary for the reporting period Jan-Sept 21: Run regional analyses for the purse seine observer data, by set type. Sept 21-Jan 22: Discuss results and write scientific manuscript.
Challenges and key lessons learnt Static spatial and temporal closures seem less effective to reduce bycatch than dynamic closures, particularly for highly mobile species. The degree of bycatch reduction achievable for a certain quantity of target catch is related to the correlation in space and time between target and bycatch species. If the correlation is high, it is harder to find an area to reduce bycatch without sacrificing catch of target species. The use of dynamic ocean management might be difficult to implement and enforce on many occasions. Nevertheless, dynamic approaches will be increasingly valuable in a constantly changing environment and underscore the need for more responsive and flexible regulatory mechanisms.
Reports/publications/presentations A peer review publication and a presentation for BYC-11 *Pons, M., J. T. Watson, D. Ovando, S. Andraka, S. Brodie, A. Domingo, M. Fitchett, R. Forselledo, M. Hall, E. L. Hazen, J. E. Jannot, M. Herrera, S. Jiménez, D. M. Kaplan, S. Kerwath, J. Lopez, J. McVeigh, L. Pacheco, L. Rendon, K. Richerson, R. Sant 'Ana, R. Sharma, J. A. Smith, K. Somers and R. Hilborn (2022). "Trade-offs between bycatch and target catches in static versus dynamic fishery closures." Proceedings of the National Academy of Sciences 119(4): e2114508119.*
Comments: -

PROJECT M.5.a: Develop and test non-entangling and biodegradable FADs	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** M. Mitigating ecological impacts **TARGET:** M.5. Develop best practices to mitigate anthropogenic impacts on EPO habitats **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	Construction of non-entangling FADs from biodegradable materials, not only to decrease mortality of non-target species by net-webbing entanglement, but also minimize contributions to ocean debris and pollution by commercial tuna fishing.
Background	Non-target species are also found in association with FADs, and in some instances, may become entangled in the FADs and perish. Some FAD components that are lost at sea or not retrieved, particularly those including plastics or other materials that are not readily degradable may last many years in the environment as pollutants, and threatening vulnerable ecosystems. There is an increasing interest in identifying non-entangling and biodegradable components that could be used in FAD construction, while still providing similar function in terms of tuna aggregation.
Relevance for management	Ecological impacts on vulnerable ecosystems may be considered an important factor for FAD fishery management purposes. Results may be used by the Commission members in the development of best fishing practices and management measures
Duration	29 months
Work plan and status	August 2015 – April 2017: Purchase of FAD and mooring materials. FAD deployment at test site. FAD monitoring. April – December 2017: Ongoing research on alternative non-entangling and biodegradable materials to extend the durability of the FADs. January 2018: Project report
External collaborators	
Deliverables	May 2016. *Ad hoc* working group on FADs. La Jolla, USA. May 2017. 68th Tuna Conference. Lake Arrowhead, USA. October 2017. ECOFAD meeting. Manta, Ecuador. March 2018. Project final report (Phase 1)

PROJECT M.5.a: Develop and test non-entangling and biodegradable FADs

Updated: May 2022

Progress summary for the reporting period

February–December 2018: Research on alternative non-entangling and biodegradable materials to extend the durability of the FADs.
December 2018: Agreement with vessel companies concerning methodology and allocation of FAD prototypes to vessels through Memorandums of Understanding.
April 2019: Agreement with companies regarding purchase and allocation of materials.
August 2019: Deployment and data collection of non-entangling devices (NEDs) and control pairs (traditional FADs). Observers record condition of NEDs and catches. Database on interactions with NEDs created.
June 2020: reporting of satellite buoy data attached to experimental objects starts.
January 2022: 718 NEDs have been embarked on board the participant vessels. 713 NEDs have been deployed, with 56 sets made.
January-June 2022: resume NED deployment for the last batch of experimental objects.

Challenges and key lessons learnt

Reaching agreement with vessel captains on using a limited number of standard FAD prototypes.
Simplifying the materials to purchase.
The flotation of NEDs made of natural materials was satisfactory during the period observed.
NED design using canvas and ropes made with abaca fiber showed 'very good' to 'good' condition after, at least, 2-3 months at sea. Improvements on condition were achieved by smearing this fiber with natural rubber or animal lard. 20% of FADs on board TUNACONS's vessel fleets are now using this design in a voluntary basis.
The use of the first selected cotton seems to be inappropriate. Modifications have been made to accommodate fleet's concerns. Modified prototypes are being currently tested. On-land trials to improve cotton condition are currently in development.
Preliminary analyses of tuna catches between close NEDs and FADs showed similar values. NED had an average catch per set of 34 mt and were, in 55% of the cases, greater or equal than nearby traditional FADs' catch per set.
COVID-19 pandemic caused delays on NED construction. Meetings with fleet managers and stakeholders have been held to adapt to this situation. Works have been already resumed.

Reports/publications/presentations

Several presentations made at skippers' workshops in the region
Online technical meetings with researchers involved in similar projects in the Atlantic and Indian Oceans, and ISSF staff.
SAC-09: progress report.
A project overview and preliminary results presented during 2020-2021 skippers' workshops (Manta-Ecuador).
SAC-11: progress report and presentation (SAC-11-11).
Presentation of preliminary results during 2021-2022 skippers' workshops (Manta-Ecuador).
FAD-06: progress report and staff's recommendations (FAD-06-02).

Comments:

Project was suspended during March-July 2018, thus missing the fishing season off Peru. In 2020-2021, 81 NEDs were deployed off Peru and in 2019-2021, 457 NEDs were deployed west of Galapagos. A project extension proposal was approved in October 2019 for a total of 38 months. Matters related to COVID-19 pandemic and the need for new suppliers and materials led to an additional project extension proposal, approved in March 2021, for a total of 52 months.

PROJECT M.5.b: Reducing losses, and fostering recovery of FADs in the purse-seine fishery in the EPO	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** M. Mitigating ecological impacts **TARGET:** M.5. Develop best practices to mitigate anthropogenic impacts on EPO habitats **EXECUTION**: Data Collection and Database Program, Ecosystem and Bycatch Program	
Objectives	Evaluate the extent of stranded, abandoned or lost FADs (SAL-FADs) in the EPO. Evaluate the impact of SAL-FADs on coastal areas and islands of the EPO, with special emphasis on identification of deploying locations. Identify or develop oceanographic models to forecast strandings of FADs. Based on findings, develop mitigation and management measures and strategies to minimize SAL-FADs. Promote recovery of SAL-FADs and evaluate its effectiveness.
Background	SAL-FADs have an impact on coastal areas in the EPO, but the information available is mostly anecdotal. Some FAD components lost at sea or not retrieved, particularly those made of plastics or other materials that are not readily degradable, can last many years in the environment as pollutants and threaten vulnerable ecosystems. SAL-FADs can also be a danger to navigation. SAL-FADs may produce 'ghost-fishing' in the EPO.
Relevance for management	Ecological impacts on vulnerable ecosystems are an important factor in FAD fishery management. Results may be useful for CPCs in the development of best fishing practices and management measures for FADs
Duration	28 months
Work plan and status	May 2022-March 2023: Survey stakeholders about areas and impacts of SAL-FADs. Previous versions of this document planned research on identifying or develop ocean circulation model to forecast FAD trajectories beyond fishing grounds. This plan has been combined with M.5.c Based on models from project K.1.a [Poseidon] and the result of surveys, identify levels of sensitivity and categorize possible stranding areas. As permitted by restrictions due to pandemic allow: Workshop with stakeholders and ISSF scientists to identify mitigation strategies for SAL-FADs, based on findings of survey and models Based on results from above: Present a report of all findings and proposals for mitigation strategies at.
External collaborators	Poseidon team
Deliverables	At this point, due to restrictions due to pandemic, a schedule of timing is not possible.

PROJECT M.5.b: Reducing losses, and fostering recovery of FADs in the purse-seine fishery in the EPO
Updated: May 2022
Progress summary for the reporting period Development and distribution of survey on impact of SAL-FADs. 20 responses to date: academic (1), consultant (1), industry (2), environmental NGOs (3), industry NGO (6), government (7). Two staff members attended the ISSF-sponsored workshop on the reduction of the impact of FADs in September 2018.
Challenges and key lessons learnt In despite to repeated notices to encourage stakeholders to participate in the survey, the response has been poor. Pandemic conditions have not allowed in-person meetings which in the opinion of the staff is necessary to foster discussion.
Reports/publications/presentations **None**
Comments: Original project start date was early 2018, but it was delayed, and to date only the first objective has been addressed, as noted with minimum success. The modelling of FAD movements is being combined with other projects (K1.a and M.5.c).

PROJECT M.5.c: Definition of guidelines to reduce the impact of lost and abandoned FADs on marine turtles	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** M. Mitigating ecological impacts **TARGET:** M.5. Develop best practices to mitigate anthropogenic impacts on EPO habitats **EXECUTION**: Bycatch Mitigation and Gear Technology Group	
Objectives	Minimize the impacts caused by lost and abandoned FADs on sea turtles, while also defining future guidelines to reduce the impact of FAD structures on sea turtles´ habitats
Background	It is estimated that around 20% of FADs are lost or abandoned every year in the Pacific Ocean Recent scientific literature identified potential FAD accumulation areas in Papua New Guinea, Solomon Islands, French Polynesia, Hawaii, Perú and Galapagos, among others Most of these areas are essential habitats for many sea turtles, including nesting areas for leatherback turtle Despite most of the FADs in the region are low entanglement risk FADs, the exact magnitude of turtles that become entangled, partially or permanently, is unknown, as well as their effects on their habitats
Relevance for management	Reduce interaction of FADs with non-target species as well as decreasing stranding events in habitats of interest for sea turtles, with special emphasis on foraging and nesting areas
Duration	20 months – December 2020 to July 2022, extended until the end of 2022 due to COVID-19 pandemic
Work plan and status	Evaluation of the starting point, through collecting information on current FAD loss and stranding events and FAD interactions with turtles Modelling FAD trajectories arriving at essential habitats for turtles, with special focus on leatherback turtle and Hawaiian Islands Evaluating options to reduce FAD impact and definition of guidelines for best practices, including outreach and conversations with stakeholders, fishing crew and managers Several workshops will be organized during the project to promote discussion and acceptance of results
External collaborators	Hawaii Pacific University, ISSF, NOAA, SPC
Deliverables	Reports of the workshops organized during the workshop A peer-reviewed publication on the results of the modelling of FAD drifts A report with guidelines to reduce the impact of FAD structures on sea turtles and their habitat Dissemination material for the Bycatch Working Group, likely in 2022 and 2023.

PROJECT M.5.c: Definition of guidelines to reduce the impact of lost and abandoned FADs on marine turtles

Updated: May 2022

Progress summary for the reporting period

A series of passive-drift Lagrangian simulation experiments were undertaken based on possible FAD drifting behavior.

Guidelines to reduce the impact of lost and abandoned drifting FADs on sea turtles have started to be drafted. The guidelines will identify means to reduce the interactions and mortalities associated with (i) entanglement in FADs structure, and (ii) FAD stranding events in turtle´s essential habitats.

Several workshops will be held to discuss results with the fleet and define potential guidelines for FAD construction that may reduce impacts on sea turtles.

An in-person workshop is being organized to discuss projects results in late 2022.

Challenges and key lessons learnt

Corridors of connectivity between industrial FAD fishing grounds and zones of important habitats for sea turtles were identified.

For FADs deployed in the EPO, the main areas of concern appear to be the turtle habitats in the south-eastern Pacific Ocean, corresponding to oceanic leatherback (*Dermochelys coriacea*) migration and feeding grounds. Moderate accumulation of FADs was also detected in the equator, coastal and oceanic habitats and nesting sites around Mexico, Costa Rica and Panama.

A large equatorial area, south of Hawai‘i, important leatherback foraging habitat, exhibited large numbers of FADs transiting when deployed in the equatorial zones north of the equator, from both the EPO and WCPO.

The detected connectivity patterns appear to be somewhat mitigated against by the current deployment distribution of FADs in the EPO.

Reports/publications/presentations

BYC-11-05 – Simulating FAD trajectories for key sea turtle habitats in the Pacific Ocean.

BYC-11-INF-A – Progress report on guidelines for to reduce the impact of lost FADs on sea turtles

Abstract submitted to the International Marine Debris Conference in Korea in 2022

Comments:

INTERACTIONS AMONG THE ENVIRONMENT, THE ECOSYSTEM, AND FISHERIES

PROJECT N.1 wind-induced microturbulence on yellowfin larval survival	
THEME: Interactions among the environment, the ecosystem. and fisheries **GOAL:** N. Understanding the interactions among environmental drivers, climate, and fisheries **TARGET:** N.1. Understanding the effects of short-term environmental fluctuations **EXECUTION**: Early Life-history Group	
Background	Studies have shown that feeding success and survival of marine fish larvae can be influenced by the levels of wind-induced microturbulence in the larval feeding environment Multiple experiments were conducted over 4 years to examine microturbulence effects on yellowfin larval survival, and optimal turbulence estimates for larval survival were converted to optimal wind speeds Estimated optimal wind speeds for larval survival have been examined for correlations with yellowfin recruitment during 1987-2007
Relevance for management	The wind speed-recruitment analysis is promising for assessing yellowfin recruitment patterns in relation to larval survival
Duration	24 months
Work plan and status	June-December 2019: Refine analyses of survival and feeding data and finalize wind speed-recruitment analysis January-December 2021: Complete manuscript and submit to scientific journal
External collaborators	University of Tokyo
Deliverables	Presentations for SAC-09, SAC-10 and SAC-11 Publication of results in a scientific journal

PROJECT N.1.b: Investigate the effects of wind-induced microturbulence on yellowfin larval survival
Updated: March 2022
Progress summary for the reporting period Analysis of experimental survival and feeding data in response to microturbulence completed. Feeding parameters examined in relation to microturbulence included average prey and biomass consumption and size of prey captured. A meeting with Dr. Shingo Kimura at University of Tokyo in August 2019 included adjustments and improvements to the final modeling of the experimental turbulence results. A manuscript summarizing experimental estimates of optimal microturbulence and a wind speed-recruitment analysis of select areas of the EPO is nearing completion
Challenges and key lessons learnt Measuring microturbulence in experimental tanks is difficult on a scale that is relevant to the foraging environment of larval yellowfin. This was addressed by using a microacoustic doppler velocimeter (ADV) to measure turbulent dissipation rates in the tanks at microscale (5 mm x 5 mm) precision; they were also estimated using a small-scale (m^3) model developed by a colleague at the University of Tokyo.
Reports/publications/presentations Presentation at SAC-10 and SAC-11
Comments: This project will be completed with the submission of a manuscript by late 2022.

PROJECT N.1.c: Developing dynamic species distributions models to inform conservation and management of non-target species and communities in the eastern Pacific Ocean	
THEME: Interactions among the environment, the ecosystem, and fisheries **GOAL:** N. Understanding the interactions among environmental drivers, climate, and fisheries **TARGET:** N.1. Understanding the effects of short-term environmental fluctuations **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	Contribute to the development of high-resolution dynamic habitat models for key non-target species and ecological functional groups impacted by tuna fisheries to better understand the dynamics of target-bycatch-environment co-occurrence and assess the vulnerability of the species under existing and projected effort and environmental regimes using EASI-Fish.
Background	Managing the diverse range of co-occurring species is a significant challenge owing to the dynamic biophysical environment of the EPO at different scales Understanding the likelihood of species-fishery interactions requires knowledge of each species' spatio-temporal distribution relative to that of the fishing effort under specific environmental conditions Besides, dynamic models can assist in the assessment of the potential vulnerability of species and ecological functional groups (e.g. hammerhead sharks) to existing or predicted levels of fishing effort using EASI-Fish The IATTC has done significant progress on dynamic models of distribution for the main tropical tuna species (e.g. SAC-10-INF-D) but models for some of the most important key bycatch species are missing The project will produce models for a total of 8 species, selected based on IATTC's current conservation and management priorities and data availability
Relevance for management	Advancing our understanding of the relationship between environment, biological community structure and vulnerable bycatch species to guide the development of alternative and/or complementary bycatch mitigation measures
Duration	18 months, starting in March 2021
Workplan and status	Mar-Apr 2021: Conduct exploratory data analysis and extraction of environmental covariates Apr-Dec 2021: Develop models and evaluations for 8 key bycatch species Dec 2021-Apr 2022: Run model predictions Dec 2021-Aug 2022: Preparation of written reports and peer-reviewed manuscripts Apr 2022-Aug 2022: Development of a beta online portal for decision makers Aug 2021-Aug 2022: Continuous engagement with IATTC CPCs, fishers, and other key EPO resource stakeholders
External collaborators	Stockholm Resilience Center at the University of Stockholm
Deliverables	A compendium of spatially-explicit dynamic species distribution models for key non-target bycatch species A beta-version user-friendly online platform to visualize main results and promote engagement and conversations with decision-makers Dissemination of material, including peer review publications, documents and presentations for the IATTC SAC and working groups on Bycatch and FADs, capacity building workshops with stakeholders, and other national and international scientific forums
PROJECT N.1.c: Developing dynamic species distributions models to inform conservation and management of non-target species and communities in the eastern Pacific Ocean	
Updated: May 2022	
Progress summary for the reporting period	

Long-term empirical data was analyzed to assess the effectiveness of static vs dynamic management options for two vulnerable shark species.
Machine-learning species distribution models were run for key bycatch species, including certain species of sharks and the critically endangered leatherback turtle.
A set of predictions for those key sensitive bycatch species are being run to help improve EASI-Fish models.

Challenges and key lessons learnt

Closing areas of high fishing inefficiency, and reallocating effort proportionally to reflect historical patterns, yearly tuna catch may have increased while the bycatch of certain sharks could have decreased significantly.
Static closures seem less effective than dynamic and adaptive measures, which should be considered to more efficiently fulfill conservation and sustainability objectives in the EPO.
Machine-learning algorithms are powerful tools to deal with data-limited species and can produce accurate and reliable species distribution models for sensitive species.
Data confidentiality issues were experienced by participants, which delayed the project significantly. However, a solution was found, and analyses are being run preserving all confidentiality aspects of the data.

Reports/publications/presentations

Presentation at BYC-10
Presentations and documents at BYC-11 (BYC-11-01, BYC-11-04)
At least one manuscript will be submitted to a peer-reviewed journal during the second quarter of 2022.

Comments:

The COVID-19 pandemic and issues with data sharing and confidentiality delayed the project. The number of SDMs to de delivered will be revised to meet conservation priorities and deadlines.

PROJECT N.2.a. Develop models of the effects of climate change on pre-recruit life stages of tropical tunas	
THEME: Interactions among the environment, the ecosystem. and fisheries **GOAL:** N. Improving our understanding of the EPO ecosystem **TARGET:** N.2. Understanding the effects of long-term climate drivers **EXECUTION**: Early Life-history Group	
Objectives	Investigate experimentally the effects of important climate change factors on early life stages of tropical tunas, and incorporate those results into models that can predict climate change effects on the distribution and abundance of tropical tunas
Background	Tuna populations are key components of pelagic ecosystems, but the effects of climate change on tuna biomass, distributions and recruitment are almost unknown The Achotines Laboratory provides an essential experimental center for investigations of the effects of climate change factors on pre-recruit life stages of tropical tunas A study of the effects of ocean acidification on yellowfin egg and larval stages was conducted at the Achotines Laboratory in 2011 and the results published in two papers in 2015 and 2016, with an additional two papers in preparation A new study investigating molecular effects of ocean acidification and ultraviolet irradiance on yellowfin eggs and embryos was conducted by University of Miami scientists at the Achotines Laboratory in late 2019. The IATTC early life history group is collaborating on the study. The effects of additional climate change factors, such as ocean warming and anoxia, can be studied at the Achotines Laboratory and incorporated into models of multifactor effects on pre-recruit life stages
Relevance for management	Potential impacts of climate change on early life stages are an important consideration in future assessments of tunas in the EPO, and experimental results can allow models to be parameterized to include climate change effects on pre-recruit survival and spawning and nursery habitat
Duration	3 years
Work plan and status	January 2018-June 2022: Completion of analyses and manuscripts from the 2011 study describing ocean acidification effects on larval otolith morphology and genetic expression of resistant traits in yellowfin May 2020 – June 2022: Completion of analyses and manuscript from the 2019 molecular study led by University of Miami January 2020-December 2022: There are plans to develop experimental investigations to study the effects of ocean warming and anoxia on pre-recruit life stages of yellowfin
External collaborators	ABARES and AFMA, Australia; Secretariat of the Pacific Community, Macquarie University, Australia Drs. Rachael Heuer, Christina Pasparakis and Martin Grosell, University of Miami
Deliverables	Presentations for SAC-09, SAC-10 and SAC-11 Publication of results in several scientific journals

PROJECT N.2.a. Develop models of the effects of climate change on pre-recruit life stages of tropical tunas

Updated: March 2022

Progress summary for the reporting period

Analysis of the effects of ocean acidification on yellowfin larval otolith morphology has been completed; studies of the genetic expression of resistant traits continue.

The larval otolith analysis was completed and submitted as a manuscript in early 2022. The genetic analysis of expression of resistant traits in response to ocean acidification has been slower

The experimental results from the 2011 study have been used in several modeling efforts to estimate the impacts of ocean acidification on yellowfin in the Pacific Ocean

The molecular study of ocean acidification effects led by University of Miami was conducted at the Achotines Laboratory in late 2019 with 3 scientific publications produced

Challenges and key lessons learnt

Combining rearing larval tunas with precise control of the physical carbonate system was particularly challenging. A large collaborative research group, with expertise in larval ecology, carbonate system testing, and modeling was developed to complete the study.

Studies of the effects of additional climate change factors, such as ocean warming and anoxia, will require additional funding, which to-date has not been secured.

Reports/publications/presentations

Presentations:

- SAC-10, SAC-11 and SAC-12
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- 69th Tuna Conference (May 2018) and 71st Tuna Conference (May 2021)
- 42nd Larval Fish Conference (June 2018) and 43rd Larval Fish Conference (May 2019)
- Three scientific papers using experimental results from the 2011 study presented modeling predictions of the effects of ocean acidification on yellowfin abundance in the Pacific Ocean
- Three manuscripts summarizing results of the 2019 molecular study led by University of Miami with IATTC collaboration have been published or are in review as of March 2022
- SAC-12-15 Review of research at the Achotines Laboratory

Comments:

The multirelational analyses of experimental results from the 2011 study should be completed in 2022.

PROJECT N.2.b: Supporting climate-ready and sustainable fisheries: using satellite data to conserve and manage life in the ocean and support sustainable fisheries under climate change	
THEME: Interactions among the environment, the ecosystem and fisheries **GOAL:** N. Improving our understanding of the EPO ecosystem **TARGET:** N.2. Understanding the effects of long-term climate drivers **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	Produce forecasted dynamic species and vessel distributions under different anomaly and climate change scenarios in the near, mid and long-term based on changing environmental drivers. Quantify shifts in overlap among species and vessels given shifting habitat for both. Understand the impact of climate anomalies, changing oceanographic conditions and future scenarios on forecasted dynamic species and vessel distributions with a specific focus on forecast skill and accounting for uncertainty.
Background	Balancing short, medium and long-term sustainability, food security and economic objectives in a changing environment is a challenge to fisheries management. Current conservation measures have not been specifically designed to adapt to a changing environment, particularly in the medium-long term. Previous research has documented distributional shifts of pelagic predators and fishing effort in response to climate-driven changes, but no particular study has been conducted for the tropical tuna and bycatch species in the EPO. A better understanding of climate-induced shifts in the spatial distribution of target and non-target species is needed to develop climate-resilient fisheries.
Relevance for management	Understanding tuna stocks and fishers' response to medium and long-term changing ocean conditions is important to develop subsequent policy and management strategies and ensure climate-resilient fisheries in the EPO.
Duration	24 months, extended to 36 months due to COVID-19
Work plan and status	2021 – Develop vessel distributions models; gather model outputs from target species; assemble projected environmental data. 2022 – Develop forecasted target and vessel distributions; target species and vessels models validation; gather distribution model outputs from bycatch species; develop forecasted bycatch distributions; bycatch models validations. 2023 – preparation of dissemination material; present at the SAC, the Bycatch WG and other IATTC meetings of interest.
External collaborators	San Diego State University-Conservation Ecology Lab, The Ocean Conservancy
Deliverables	A series of climate change medium and long-term projected dynamic species distributions for both target and non-target species and vessels. Compilation of reliable environmental data for different climate scenarios. Web-based tools and forecast products. Open source code to allow replication. Dissemination material, including documents and presentations for the Scientific Advisory Committee and the Bycatch working Group in 2021 and 2022.

PROJECT N.2.b: Supporting climate-ready and sustainable fisheries: using satellite data to conserve and manage life in the ocean and support sustainable fisheries under climate change
Updated: May 2022
Progress summary for the reporting period Several coordination and discussion meetings have been conducted with the FaCet (Fisheries and Climate Toolkit) group in 2020, 2021, and 2022. In house produced dynamic size-specific tropical tuna species distribution models (e.g. SAC-10 INF-D) have been shared with collaborators, which will be used as a baseline to assess the impact of climate change on species' future distribution. Similar methods are expected to be applied to some key bycatch species. Dynamic vessel distribution models are being created to infer fleet's response to species distribution changes. A profound investigation on potential data sources for different climate scenarios is being conducted.
Challenges and key lessons learnt • The uncertainty associated with climate projections may need to be considered in detail, and solutions explored to find the best way to incorporate it in the final products.
Reports/publications/presentations A website has been created, here. A presentation was given at AGU 2020, which can be found here.
Comments:

PROJECT O.2.a: Develop and implement analytical tools for understanding the trophic ecology of apex predators	
THEME: Interactions among the environment, the ecosystem. and fisheries **GOAL:** O. Improve understanding of the EPO ecosystem **TARGET:** O.2. Improve analytical tools to evaluate anthropogenic and climate impacts on the EPO ecosystem **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	To further develop and validate statistical tools for the analysis of complex datasets in trophic studies of apex predators. To enhance external collaborations and professional development through the analysis of Atlantic bluefin tuna diets in relation to biological and environmental variables.
Background	IATTC staff have developed an innovative approach for analyzing complex diet data using classification trees. The approach has been used for regional diet studies of yellowfin tuna in the EPO and for a broad-scale global comparison of yellowfin, bigeye and albacore diets. To facilitate more widespread adoption of the method, it requires validation of regional studies in other ocean basins, given the importance of spatio-temporal differences in available prey taxa. Collaboration with other scientists studying the trophic ecology of apex predators can assist with validating the approach, while also enhancing collaborative relationships.
Relevance for management	Optimizing statistical tools to analyse trophic data is crucial for understanding the trophodynamics of apex predators in the EPO and whether predator-prey relationships may be impacted by fishing. Diet analyses are fundamental for the identification of ecological functional groups, which are required in the development of ecosystem models to understand the potential ecological impacts of fishing. Integrating environmental factors into analyses of regional studies provides managers with information on effects of climate change on variation in forage communities to verify observed global patterns.
Duration	9 months
Work plan and status	Jun 2018: data analyses Aug – Nov 2018: Discuss preliminary outputs with collaborators and implement necessary collaborator inputs into method development Nov 2018-Mar 2019: Manuscript preparation
External collaborators	Massachusetts Division of Marine Fisheries; numerous other universities and government agencies
Deliverables	Manuscript summarizing the revised approach, using an Atlantic-wide analysis of bluefin trophic ecology as a case study.

PROJECT O.2.a: Develop and implement analytical tools for understanding the trophic ecology of apex predators
Updated: May 2022
Progress summary for the reporting period Improvements have been made to a statistical tool for analyzing complex diet data, developed in collaboration with scientists at CSIRO (Australia), used to represent trophic interactions in ecosystem models
Challenges and key lessons learnt • The project has previously been stalled pending provision of data by external collaborators and then by COVID-19. Data assembly and quality checking of the various datasets by external collaborators is expected to occur in 2022. • Exploratory analyses and initial classification trees are expected to be run by IATTC staff in 2022.
Reports/publications/presentations • The statistical tool is being used by various organizations, including IRD (France) and SPC.
Comments: -

PROJECT O.2.b: An updated ecosystem model of the tropical EPO for providing standardized ecological indicators for monitoring of ecosystem integrity	
THEME: Interactions among the environment, the ecosystem, and fisheries **GOAL:** O. Improve our understanding of the EPO ecosystem **TARGET:** O.2. Improve analytical tools to evaluate anthropogenic and climate impacts on the EPO ecosystem **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	Update the Ecopath ecosystem model developed for the eastern tropical Pacific Ocean (ETP) by Olson and Watters (2003). Convert the model to Ecopath with Ecosim (EwE) software version 6.5. Update the model with annual catch, discards, fishing mortality and fishing effort data for each functional group from 1993 to present. Calibrate the model with new catch and effort time series to improve the reliability of model forecast outputs. Produce annual ecological indicators for inclusion in the *Ecosystems Considerations* report as standardized measures of ecosystem integrity.
Background	IATTC is committed, through the Antigua Convention, to ensuring the long-term sustainability of all target, associated and dependent species impacted by EPO tuna fisheries. Although the IATTC undertakes stock assessments for economically important species and ecological risk assessments (*e.g*. PSA, EASI-Fish) to prioritize research and management of non-target species, these single-species assessments do not take into account possible impacts on ecosystem dynamics through changes in the strength of trophic linkages due to anthropogenic and/or climate impacts. Olson and Watters (2003) developed an Ecopath ecosystem model of the ETP for 1993, with dynamic simulations extended to 1999. No further updates or development of ecosystem models for the EPO have been undertaken by the IATTC staff, due to the departure of key members with ecological modelling expertise.
Relevance for management	The ETP model will be available in EwE 6.6, which can more rapidly provide annual updates of a range of ecological indicators to provide standardized measures of the integrity of the ETP ecosystem. The ETP model can be used to simulate 'what if' hypotheses relating to changes in fishing activities (*e.g*. use of FADs) and/or climate drivers on the ETP ecosystem structure, and individual functional groups and key species. Conservation and management recommendations for vulnerable species may be developed, based on model outputs.
Duration	36 months
Work plan and status	Jun–July 2018: Convert model to EwE version 6.5. Mar 2019: Update model with new catch data for 1993-2017. Apr–May 2019: Produce ecological indicator values for 1993-2017 and run hypothetical fishery scenarios and present findings at SAC-10. Jun–Dec 2019: Collaborate with the Stock Assessment Group to update time series of biomass, fishing mortality and catch data for the ETP. Jan–Mar 2020: Calibration of model to new data time series. Apr–May 2020: Produce ecological indicator values for 1993-2018 and run hypothetical fishery scenarios and present findings at SAC-11. Jun–Dec 2020: Explore expansion of ETP model to be spatially explicit using Ecospace.

	Jan–Mar 2021: Update model with new data for 1993-2019 and calibrate model to new data time series. Apr–May 2021: Produce ecological indicator values for 1993-2019 and run spatially-explicit hypothetical fishery scenarios and present findings at SAC-12.
External collaborators	None
Deliverables	A new version of the ETP model Olson and Watters (2003) that will exist in the latest version of EwE software with updated data time series of catch, effort, and also biomass and fishing mortality where available. Annual updates of ecological indicators to provide standardized measures of the integrity of the ETP ecosystem.

PROJECT O.2.b: An updated ecosystem model of the tropical EPO for providing standardized ecological indicators for monitoring of ecosystem integrity

Updated: May 2022

Progress summary for the reporting period

- Model updated with new catch data time series for 1993–2018.
- Ecological indicator values for 1993–2018 produced from new model and included in the *Ecosystem Considerations report.*
- Staff successfully completed a 1-week Ecopath training course in Florida in December 2019 to develop skills that will be necessary to construct a spatially-explicit ecosystem model of the EPO.

Challenges and key lessons learnt

The predator-prey matrix underlying the ecosystem model is based on stomach contents data from the early 1990s. The staff recommends, that Proposal F.3.a be funded, to obtain updated morphometric measurements and biological samples to best represent the current dynamics of the EPO ecosystem.

Reports/publications/presentations

- SAC-12-13 Ecosystem model of the EPO: progress report
- Presentation at SAC-10
- SAC-10-14 Ecosystem considerations
- SAC-10-15 Towards standardized ecological indicators for monitoring ecosystem health: an updated ecosystem model of the tropical EPO
- SAC-12-13 Ecosystem model of the EPO: progress report

Comments:

-

PROJECT O.2.c: Temporal network analysis of bycatch communities caught in purse-seine fisheries	
THEME: Interactions among the environment, the ecosystem, and fisheries **GOAL:** O. Improve our understanding of the EPO ecosystem **TARGET:** O.2. Improve analytical tools to evaluate anthropogenic and climate impacts on the EPO ecosystem **EXECUTION**: Ecosystem and Bycatch Program	
Objectives	Investigate the connectivity among bycatch species caught in the purse-seine fishery and how the structure of these community relationships changes over time and space (if feasible) in the eastern Pacific Ocean (EPO). Investigate the vulnerability of those connections and the role of key bycatch species for the community/network
Background	Ecological risk assessment (ERA) is an approach currently used by IATTC staff to evaluate the ecological impact of tuna fisheries in the EPO ERA can also help ensure the long-term sustainability of 'associated' and 'dependent' species that share the same ecosystem as principal tuna species Scientists and managers require novel quantitative methods to reliably identify communities that may include vulnerable species Temporal network analysis (TNA) may help identify the communities with vulnerable species and their evolution, and, where appropriate, help prioritize the call for mitigation measures, further detailed analysis, or the prioritization of data collection on potentially vulnerable species
Relevance for management	The proposed TNA can support ERA by identifying distinct ecological assemblages within the purse-seine bycatch
Duration	12 months, extended to 24 months due to COVID-19 pandemic
Work plan and status	Understand the network structures that emerge from the recurrences of the relationships among bycatch species and how these networks change through time. Detect bycatch communities within networks and key bycatch species as centralized actors of these communities. Explore impacts of key bycatch species on their communities through control theory analysis (node removal simulation).
External collaborators	Scripps Institution of Oceanography
Deliverables	A series of dissemination material: documents and presentations for the IATTC Bycatch Working Group, as well as a peer-reviewed scientific publication

PROJECT O.2.c: Temporal network analysis of bycatch communities caught in purse-seine fisheries
Updated: May 2022
Progress summary for the reporting period • A number of meetings were organized with Scripps Institution of Oceanography during 2021-2022. • Exploratory analyses of different bycatch metrics by set type were conducted for 2006–2021 data. • Preliminary connectivity, network and temporal-network analyses were conducted for the most common bycatch species for each set type.
Challenges and key lessons learnt • Preliminary results suggest differences in the inshore vs offshore bycatch communities and their structures and between different set types.
Reports/publications/presentations
Comments: Results of the project are expected to be presented at the BYC-12 in 2023.

KNOWLEDGE TRANSFER AND CAPACITY BUILDING

PROJECT P.1.a: Fulfil requests for development of database and data processing applications for entities outside the IATTC	
THEME: Knowledge transfer and capacity building **GOAL:** P. Responding to requests from CPCs and other organizations **TARGET:** P.1. Respond to requests by CPCs **EXECUTION**: Data Collection and Database Program	
Objectives	Provide support to CPCs through the development of data collection forms and the most appropriate computer application to allow the collection, entry, editing and analysis of locally-collected datasets.
Background	IATTC staff receives requests to develop data entry and editing solutions for data collected by outside organizations. IATTC staff possesses years of experience in these tasks, which is not otherwise available to outside organizations. Through a policy of capacity-building, the staff collaborates with outside organizations to develop the requested applications.
Relevance for management	Through collaboration with data collectors, the staff may be granted access to new sources of data.
Duration	Ongoing
Work plan and status	Currently developing an MS Access database to process FAD information collected through Resolution C-16-01. Request for additional form to be incorporated into the OSPESCA artisanal longline database. Evaluate ability to accept participation in additional requests as they occur.
External collaborators	OSPESCA
Deliverables	Completion of requested computer applications. Provide technical support and training of the new applications.

PROJECT P.1.a: Fulfil requests for development of database and data processing applications for entities outside the IATTC
Updated: May 2019
Progress summary for the reporting period All requests received have been addressed.
Challenges and key lessons learnt -
Reports/publications/presentations -
Comments: The current system for dealing with such requests appears adequate.

PROJECT P.1.b: Respond to requests for scientific analyses	
THEME: Knowledge transfer and capacity building **GOAL:** P. Responding to requests from CPCs and other organizations **TARGET:** P.1. Respond to requests by CPCs **EXECUTION**: Stock Assessment Program	
Objectives	Respond to requests by CPCs and other entities in a timely manner
Background	The information necessary for making important management decisions is often situation-dependent and evolves as discussions progress. CPCs and other entities regularly make requests for analyses and other work that is not included in the staff work plan The type of requests varies widely.
Relevance for management	Many requests by CPCs are directly used to inform management decisions
Duration	Ongoing
Work plan and status	The workplan cannot be anticipated
External collaborators	Varies
Deliverables	Vary. Can include reports and/or presentations to SAC and the IATTC meetings.

PROJECT P.1.b: Respond to requests for scientific analyses
Updated: October 2020
Progress summary for the reporting period All requests received have been addressed.
Challenges and key lessons learnt -
Reports/publications/presentations -
Comments: The current system for dealing with such requests appears adequate.

PROJECT Q.1.a: Achotines Laboratory support of Yale University's Environmental Leadership Training Initiative (ELTI) in Panama	
THEME: Knowledge transfer and capacity building **GOAL:** Q. Training **TARGET:** Q.1. Host visiting scientists and students from CPCs **EXECUTION**: Early Life-history Group	
Objectives	To support the ELTI objectives of facilitating cooperation, training and research on the conservation, rehabilitation and restoration of forest lands and watersheds in Panama, and to conserve coastal and marine living resources and ecosystems
Background	The Yale-ELTI Program has been holding training workshops at the Achotines Laboratory for several years and has created a teaching trail in the Achotines Forest which is a key component of their training workshops To demonstrate good stewardship of the Achotines Forest and surrounding watershed, the Achotines Laboratory has expanded its support of the ELTI Program and will serve as the host center for the ELTI Program and training workshops The ELTI training workshops have no footprint on the tuna research facilities at the Achotines Laboratory, and are restricted to the Laboratory conference center and the Achotines Forest
Relevance for management	The Achotines Laboratory support of the ELTI Program in Panama provides an important contribution to regional watershed restoration and conservation of coastal ecosystems in Panama
Duration	4 years
Work plan and status	April 2018-March 2022: Four training courses will be held each year at the Achotines Laboratory, with ELTI affiliates coordinating periodic updates and annual technical reports of activities
External collaborators	Yale University, ELTI Program
Deliverables	Presentations for SAC-09, SAC-10 and SAC-11 Annual technical reports prepared by ELTI affiliates

PROJECT Q.1.a: Achotines Laboratory support of Yale University's Environmental Leadership Training Initiative (ELTI) in Panama
Updated: March 2022
Progress summary for the reporting period Ten training courses, focused on the conservation, rehabilitation and restoration of forest lands and watersheds in Panama, were held annually at the Achotines Laboratory during April 2019-March 2022. An agreement has been finalized to continue the Achotines-ELTI initiative for the period of April 2022 through September 2022.
Challenges and key lessons learnt -
Reports/publications/presentations Brief summaries of this initiative were included in presentations at SAC-09 and SAC-10. An ELTI technical report covering the April 2019-March 2020 period was completed.
Comments: This initiative has been very successful. The Yale/ELTI Program has continued its focus on training for reforestation without any footprint on the tuna research facilities of the Achotines Laboratory. The IATTC has promoted good stewardship of the Achotines forest and is supporting watershed restoration and conservation of coastal ecosystems in Panama.

SCIENTIFIC EXCELLENCE

PROJECT U.1.a: Long-term plan to strengthen research at the Achotines Laboratory	
THEME: Scientific Excellence **GOAL: U**. Strengthen research at the Achotines Laboratory **TARGET:** U.1. Strengthen and diversify the research program at the Achotines Laboratory **EXECUTION**: Early Life-history Group	
Objectives	Use of Achotines Laboratory as support for a wide array of research activities under the Strategic Science Plan Improved links among early life history research, stock assessment and management of tropical tunas under a changing climate Increased use of the Laboratory as support for IATTC's capacity-building activities
Background	A long-term (5-10 years) plan to strengthen and diversify the research program of the Laboratory is needed beyond 2020 The Director, Coordinator of Scientific Research and members of the Early Life History Group have identified areas of research emphasis to be expanded and diversified Planning will include improvements in infrastructure, optimal utilization of human resources and identification of new sources of funding The development of the plan will also include staff internal review, review by SAC, and external review of the draft plan and research programs of the Laboratory
Relevance for management	The plan will strengthen links among early life history research, stock assessment and management of tropical tunas The plan will improve the use of the Laboratory to develop a program of great return value to IATTC Members and the goals of the Antigua Convention
Duration	16 months. The plan will be developed during 2020 and 2021, and the implementation of the plan will extend long-term (5-10 years)
Work plan and status	November 2021 draft plan completed Mid-2022 staff internal review of the plan Late 2022 external review of plan Late 2022 final plan developed with initial implementation of plan In March 2021, a grant was awarded to the Achotines Laboratory by the Panamanian Secretaría Nacional de Ciencia, Tecnología e Innovación (SENACYT) for 2 years of funding for infrastructure and equipment improvements at the Achotines Laboratory.
External collaborators	Independent reviewers
Deliverables	Final plan developed by staff New sources of funding for infrastructure improvements

PROJECT X.1.a: Workshop on fisheries stock assessment good practices	
THEME: Scientific excellence **GOAL:** X. Promote the advancement of scientific research **TARGET:** X.1. Continue the annual CAPAM workshops **EXECUTION**: Stock Assessment Program	
Objectives	Bring together researchers to present and discuss the best practices for conducting fisheries stock assessment Review all the topics covered in previous CAPAM workshops Use the information learned to improve the tropical tuna assessments and assessments of other species
Background	All stock assessments have uncertain assumptions that need to be addressed Stock assessment authors make different assumptions The CAPAM workshop series has covered aa broad range of topics related to fishery stock assessment A review of the knowledge learnt from the CAPAM workshops and other research will help improve stock assessments
Relevance for management	Knowledge gained from the workshop will be uses to improve the tropical tuna stock assessment and stock assessments for ther species
Duration	2021-2022
Work plan and status	2021 – invite keynote speakers Summer 2022 – prepare background material October 2022 – Conduct workshop November 2022 – Write workshop report May 2023 – report to SAC
External collaborators	
Deliverables	Workshop report

PUBLICATIONS

Peer-reviewed journal publications

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Conference and workshop presentations

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Duffy, L.; Griffiths, S.; Lennert-Cody, C. 2018. Can we predict vulnerability of shark species in easternPacific Ocean tuna fisheries using environmental drivers and life history? PICES International Symposium: Understanding Changes in Transitional Areas of the Pacific, La Paz, Mexico. 24–26 April 2018.

Duffy, L.; Griffiths, S.; Lennert-Cody, C. 2018. Can we predict vulnerability of shark species in eastern Pacific Ocean tuna fisheries using environmental drivers and life history? 69th Annual Tuna Conference, Lake Arrowhead, USA, 21–24 May 2018.

Griffiths, S.; Duffy, L.; Roman, M. 2018. A flexible spatially-explicit ecological risk assessment approach for quantifying the cumulative impact of tuna fisheries on data-poor bycatch species caught in eastern Pacific Ocean transition areas. PICES International Symposium: Understanding Changes in Transitional Areas of the Pacific, La Paz, Mexico. 24–26 April 2018.

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Valero, J.L., Minte-Vera, C. 2018. Progress on MSE work at IATTC. Tuna RFMO Management Strategy Evaluation Working Group Meeting, Seattle, USA, 13-15 June 2018.

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Xu, H., Lennert-Cody, C.E., Maunder, M.N., Minte-Vera, C., Valero, J., Lopez, J., Schaefer, K., Fuller, F., Hampton, J., and **Aires-da-Silva, A**. 2018. Estimating the movement rate of bigeye tuna in the eastern Pacific Ocean. CAPAM workshop on the development of spatial stock assessment models, La Jolla, USA, 1-5 October 2018.

Awards

The Center for the Advancement of Population Assessment Methodology (CAPAM), cofounded by Mark Maunder of the IATTC staff, received the 2018 American Fisheries Society's (AFS) William E. Ricker Resource Conservation Award for improving the quantitative methods used in fisheries stock assessment.

PROJECTS COMPLETED SINCE PREVIOUS REPORT

PROJECT C.4.b: Long-term sampling program for shark catches of artisanal fisheries in Central America: Phase 1	
THEME: Data collection **GOAL:** C. Improve quality and expand coverage of data-collection programs **TARGET:** C.4. Artisanal longline fleet **EXECUTION**: Stock Assessment Program	
Objectives	Conduct Phase 1 (1st year) of a long-term sampling program of shark catches by artisanal fisheries in Central America, using sampling methods and logistics developed under the extended FAO-GEF project.
Background	Assessment modelling for shark species in the EPO is severely hampered by a lack of reliable data on shark catches. Previous work by IATTC staff identified specific data gaps and data collection needs, including the critical need for catch data from Central American fisheries, some components of which are believed generate a large fraction of the EPO catches of sharks. The FAO-GEF-funded project on developing sampling designs for the composition of the shark catches by artisanal fisheries in Central America, supplemented with IATTC capacity-building funds, was completed at the end of 2019. This extended FAO-GEF project has generated, and continues to generate, a wealth of information with which to develop sampling designs for various fleet components of Central American coastal fisheries that land sharks (SAC-10-16). However, no funding is available to implement a long-term sampling program using the methodology developed under the FAO-GEF project. Without data provided by a properly designed long-term sampling program for Central American artisanal fisheries, the IATTC will not be able to meet the goal of Resolution C-16-05 of EPO assessments of silky and hammerhead sharks. Phase 1 of the long-term sampling program will provide the necessary extensive field testing required to fine-tune sampling methodology, logistics and costs for Phase 2 (regular sampling).
Relevance for management	Data collected under a long-term monitoring program based on fully-tested sampling designs will allow for development of stock status indicators and conventional assessments of key shark species
Duration	21 months (April 1, 2020 – December 31, 2021)
Work plan and status	2021: Implement the sampling designs developed under the extended FAO-GEF project.
External collaborators	OSPESCA, Central American national authorities
Deliverables	Sampling designs and logistical plans for estimating the species and size composition of shark catches in Central American artisanal fisheries. IATTC-98-02c (2021): report on final sampling design methodology and costs.

PROJECT C.4.b: Long-term sampling program for shark catches of artisanal fisheries in Central America: Phase 1

Updated: May 2022

Progress summary for the reporting period:

March- 2020 to March 2021

The COVID-19 quarantine resulted in a 5-month delay to start this project (March to July 2020).

After issues related to the pandemic were resolved, the sampling program began in August 2020, at which point 14 sampling technician and two data editors were hired.

After January 2021, the sampling methodology changed, and field workdays increased as COVID-19 restrictions were reduced and businesses such as hotels and restaurants on shore opened.

As of the beginning of March 2021, a total of 1,300 vessels were sampled. The samples contained a total of 1,986 fish, of which 49% were sharks and 28% rays, the rest of the sampled fish were dorado, billfishes and tunas. Also reported were juveniles of manta species (Fam. Mobulidae), pregnant thresher sharks, and others.

New task: with the collaboration project between The Manta Trust, The Monterey Bay Aquarium, The Conservation Action Lab at University of California Santa Cruz, and the Inter-American Tropical Tuna Commission (**Project M.2.c)**, opportunistic tissue sampling started in March 2021 for mantas and devil rays to better understand their population structure.

April-June 2021

Around 1,000 records were collected in this period. The most important species group reported was sharks (53%), followed by rays (24%), dorado (11%), billfishes (4%), and tuna (7%). The main shark species were silky sharks and hammerhead sharks.

65 tissue samples were collected for mantas and devil rays in Nicaragua (85%), Guatemala (15%); all samples from Nicaragua were delivered to the Conservation Action Lab at the University of California Santa Cruz (UCSC).

July-September 2021

As of September 2021, a total of 4,190 samples were registered. The number of samples in this period was higher than at the beginning of the project (>1,200 samples). As a result, the catches of dorado and rays increased to 18% and 26%, respectively, and shark catches decreased by 42%.

77 tissue samples were collected for mantas and devil rays in Nicaragua and were delivered to UCSC for analysis.

October-December 2021

- The number of records decreased in this period (<800 samples). The catches of sharks and rays decreased compared to the last period, to 33% and 19% respectively, but dorado catches increased (30%).
- A total of 4,964 samples were registered; these data were distributed in order of the number of samples: Nicaragua (38%), Panama (28%), Guatemala (14%), El Salvador (13%), and Costa Rica (6%). The countries with the highest distribution of large pelagic catches was Nicaragua (61% sharks, 24% dorado, 11% billfishes, and 4% tuna); followed by Costa Rica (64% sharks, 20% dorado, and 8% billfishes and tuna); El Salvador (69% sharks, 15% dorado, 11% billfishes and 5% tuna); Guatemala (82% sharks, 10% dorado, 1% billfishes and 6% tuna); and the catch of sharks and related species in Panama had the least interaction with others large pelagic species (97% sharks, 1% dorado, and 1% tuna).
- Because the project was nearing completion (December 2021), sampling days were reduced in the last month. The sampling technicians worked in the field until 15 December. The remaining days were used to prepare the final report.
- All the tissue samples from Nicaragua and Guatemala have been sent to UCSC for analysis. The staff is in process of obtaining CITES permits to export the samples from Ecuador at the moment.

Challenges and key lessons learnt

Due the pandemic, numerous issues were encountered related to all data collection, which varied by country; in particular, there was a ban on fishing activity in areas with the potential for a high density of fishers and buyers. Also, size composition sampling had to be suspended to avoid close contact between fishers an samplers . However, these issues were overcome as the COVID-19 pandemic regulations became less restrictive, so sampling days and biometric data collection increased.

The effects of the pandemic are evident, with the number of *pangas* changing considerably at many sites. Although 2020–2021 catch rate data are still being analyzed, preliminary results indicate that sites where catches of silky shark and hammerhead sharks were identified from the fisher interviews in 2019 as primary and secondary sites seem to actually operate as tertiary sites (no catch of those sharks) or vice-versa.

Reports/publications/presentations

Lennert-Cody, C.E., Mccracken, M., Siu, S., Oliveros-Ramos, R., Maunder, M.N., Aires-da-Silva, A., Carvajal Rodríguez, J.M., Opsomer, J., Barros, P., 2022. Single-cluster systematic sampling designs for shark catch size composition in a Central American longline fishery. Fisheries Research 251 (2022) 106320, p. 14. https://doi.org/10.1016/j.fishres.2022.106320

Oliveros-Ramos, R., Lennert-Cody, C.E., Siu, S., Salaverría, S., Maunder, M.N., Aires-da- Silva, A., 2019. Pilot study for a shark fishery sampling program in Central America. Inter-Am. Trop. Tuna Comm. Doc. SAC-10-16.

Oliveros-Ramos, R., Lennert-Cody, C.E., Siu, S., Salaverría, S., Maunder, M.N., Aires-da- Silva, A., Carvajal Rodríguez, J., 2020. Pilot study for a shark fishery sampling program in Central America. Inter-Am. Trop. Tuna Comm. Doc. SAC-11-13.

Comments:

The project concluded in December 2021. Unfortunately, it was not possible to obtain financial support from the Members for its continuation.

PROJECT D.2.a: Pilot study of electronic monitoring (EM) of the activities and catches of purse-seine vessels	
THEME: Data collection **GOAL:** Investigate use of new technologies (pilot studies) **TARGET:** D.2 Electronic monitoring **EXECUTION**: Bycatch and Gear Technology group	
Objectives	A proof-of-concept study to evaluate the types of data that can be reliably collected by electronic monitoring (EM) on Class 1-5 purse-seine vessels.
Background	Fisheries management and assessments require complete catch and bycatch information. Logbook data for Class 1-5 vessels provide basic catch information for target species, but no information on tuna discards and incomplete information on catches of non-target species. EM systems may provide cost-effective and practical solutions.
Relevance for management	Better-quality and higher-resolution data on catches and discards of target and non-target species by unobserved purse-seine vessels would improve the staff's stock assessments and management advice
Duration	23 months
Work plan and status	2018: January-February: Identify EM capabilities from manufacturers. March-May: Survey of infrastructure configuration and fishing operations of small vessels. Identify candidate vessels; purchase EM equipment. June 2018-January 2019: collect EM and observer data on small purse-seine vessels. 2019: February-April: process EM data. May-August: Statistical comparisons of EM and observer data; write project report. September-November: if proof-of-concept warranted, development of a sampling design for a pilot study using EM aboard small purse-seine vessels.
External collaborators	Collaboration of fishing industry, observers and technology companies is essential.
Deliverables	May 2018: Progress report to SAC-09 meeting.

PROJECT D.2.a: Pilot study of electronic monitoring (EM) of the activities and catches of purse-seine vessels

Updated: May 2022

Progress summary for the reporting period:

Since the previous report (Oct 2020), the IATTC staff in combined effort with Digital Observer Services (DOS) has been generating and analyzing EM data; to date, the resulting EM-data from 22 fishing trips have been analyzed (12 trips IATTC; 10 trips DOS). Also, the EM standards document (SAC-11-10) was presented in the SAC.

Progress will be reported at SAC-12, including a condensed document with the staff recommendation to the CPCs on the minimum standards for EM (EMS-01-01), and the workplan for the implementation of EM in the EPO (EMS-01-02).

Progress summary for the reporting period:

2020:

June: IATTC staff started generating EM-data for all four participant vessels.

October: IATTC staff presented the document on minimum standards for EM (SAC-11-10) for tuna fishery, including purse-seine vessels.

2021:

January - March:

Produced and analyzed EM-data for 22 fishing trips.

Write project report.

April:

EM workshop to discuss the document SAC-11-10 and minimum standards for data collecting based on the results of this project.

May:

Submit the final report of the project.

Presented a draft for final minimum standards recommendations (document EMS-01-01) and a workplan to present revised standards on the purse-seine fishery, based on the results of the project, as part of the implementation of an EMS in the region (document EMS-01-02).

Challenges and key lessons learnt

COVID-19 pandemic delayed the review of EM-data for 3 months. The delay was mitigated by subcontracting DOS for generation of EM data.

Reports/publications/presentations

May 2019:

Progress report presented at SAC-10.

SAC-10-12 Electronic monitoring of purse-seine vessel activities and catches

July 2019:

Presentation: *Progress of electronic monitoring testing in the Eastern Pacific*. Side event hosted by the ISSF at 94th Meeting of the IATTC.

October 2019:

Participation: *SPC/FFA/PNAO DCC Longline Electronic Monitoring (EM) Planning Workshop*. Honiara, Solomon Islands. To gain and share experiences on EM with other RFMOs. Participation sponsored by The Pew Charitable Trusts.

October 2020:

Progress report at SAC-11

Proposal for minimum standards in EM for the EPO (SAC-11-10).

March 2021

Project terminated.

April 2021

An EM workshop was held to discuss the document SAC-11-10, to present a compilation of the EMS recommendations, and to present a workplan for EMS implementation.

May 2021

Progress report at SAC-12. EM sampling coverage and EM data review rates analyses for the purse-seine fishery.
Comments: For Class-6 vessels, the objective is to assess which activities of the on-board observers can be performed by EM (Project D.2.c, now combined with this project).

PROJECT E.1.a: Evaluate potential improvement of growth model for bigeye in the EPO based on presumed annuli counts from otoliths of large fish	
THEME: Life-history studies for scientific support of management **GOAL:** E. Life history, behavior, and stock structure of tropical tunas **TARGET:** E.1. Age and growth of tropical tunas **EXECUTION**: Biology and Ecosystem Program	
Objectives	Evaluate the potential improvement in accuracy of the growth model for bigeye in the EPO resulting from including more age-at-size data for large fish
Background	Growth model for bigeye is based on validated counts of daily otolith increments, corroborated by extensive tagging data, but age-at-size data for larger fish (150-200 cm) are lacking High-confidence tagging data for bigeye >150 cm are limited The National Research Institute for Far Seas Fisheries (NRIFSF) of Japan's collections of otoliths from large bigeye captured in the EPO are now available for evaluating age estimates from counts of presumed annuli
Relevance for management	Improving the accuracy of the bigeye growth model, particularly for larger fish, would help resolve some of the uncertainty regarding the status of the stock, and improve the framework on which management advice is based
Duration	24 months; initiated November 2017
Work plan and status	Fish Ageing Services (FAS) in Australia counted annuli on 140 pairs of bigeye otoliths from up to 20 fish within each 10 cm length interval between 110 and 200 cm and estimated the ages of the fish FAS age estimates for 110-150 cm fish will be compared to published age-at-size data Growth rates for 150-180 cm fish based on EPO tagging data will be compared with growth rates based on the FAS age estimates. Age estimates from otoliths of 150-200 cm fish will be combined with the existing data set and used in an integrative growth model.
External collaborators	NRIFSF, Japan
Deliverables	Presentation for SPC-OFP bigeye pre-assessment workshop, 2018 Potential update of bigeye growth model for use in stock assessments

PROJECT E.1.a: Evaluate potential improvement of growth model for bigeye in the EPO based on presumed annuli counts from otoliths of large fish
Updated: June 2019
Progress summary for the reporting period Annual and daily increment counts from 70 otolith pairs, from fish 80-150 cm from the South EPO, were compared. The daily increment counts were compared to decimal ages for 133 fish 112-207 cm from the South EPO. Decimal ages for fish > 150 cm were compared with the integrated growth model for fish from the EPO, including high-confidence tagging data for fish 150-201 cm.
Challenges and key lessons learnt The decimal age estimates based on the 70 otolith pairs are greater for fish 130-150 cm than those based on daily increment counts. Distinguishing annual increments is problematic. For fish 120-150 cm from the South EPO, the decimal age estimates are on average 1.3 years greater than the age at length for fish from the equatorial EPO estimated by the integrated growth model. For fish 150-200 cm from the South EPO, the adjusted annual increment counts estimate age at length 2.4 years greater, on average, than the integrated growth model for the equatorial EPO. These results indicate that the annual age estimates should not be included in a new integrated growth model for bigeye in the EPO.
Reports/publications/presentations Schaefer, K., Fuller, D., and Satoh, K. Abstract *in* Report of the workshop on age and growth of bigeye and yellowfin tunas in the Pacific Ocean, 23-25 January 2019, La Jolla, USA
Comments: -

PROJECT E.2.b: Workshop to evaluate differences in bigeye tuna age estimation methods and resulting growth models utilized in current stock assessments by the IATTC and WCPFC	
THEME: Life history studies for scientific support of management **GOAL:** E. Life history, behavior, and stock structure of tropical tunas **TARGET:** E.2. Conduct spatiotemporal research on the reproductive biology of tropical tunas **EXECUTION**: Biology and Ecosystem Program	
Objectives	Resolve concerns about differences in age estimation methods and resulting growth models used in bigeye tuna stock assessments by IATTC and WCPFC
Background	Although there are documented differences in the life history characteristics of the bigeye stocks from the EPO and WCPO, the magnitude of the discrepancies in the estimated length-at age data, growth models, and L_∞ estimates used in the recent IATTC and WCPFC stock assessments, along with the dramatic shift in stock status of WCPO bigeye population is concerning. The estimated L_∞ from the WCPO bigeye growth model is 157 cm, unrealistically low, and is highly influential in the assessment model and resulting stock status determination.
Relevance for management	Age and growth models and their estimates of L_∞ are highly influential in assessing the status of bigeye in integrated assessment models
Duration	2 days
Work plan and status	Workshop to be held in La Jolla, November 2018, or as soon as possible in 2019
External collaborators	SPC; CSIRO and FAS, Australia; FSFRL, Japan; PIFSC
Deliverables	A workshop report to be shared with all interested parties

PROJECT H.1.b: Improve the yellowfin tuna stock assessment	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.1. Improve routine tropical tuna assessments **EXECUTION**: Stock Assessment Program	
Objectives	Improve the yellowfin tuna stock assessment by exploring the use of an age-structured length-based catch-at-age statistical model with a monthly time step
Background	The assessment of yellowfin is conducted every year, using Stock Synthesis There are inconsistencies between the indices based on CPUE for longline and purse-seine sets on dolphins Management quantities are sensitive to the longline CPUE data The current assessment is no longer considered reliable for management advice and stock status indicators are used instead Recent advances in stock assessment modelling allow several important improvements of the assessment model, with regard to a spatial stock assessment model, growth curves, time-varying selectivity, recruitment assumptions, data weighting, and diagnostics A benchmark assessment is scheduled for 2020
Relevance for management	The stock assessment is used to provide management advice The duration of recommended seasonal closures is based on the multipliers of fishing mortality (*F*) estimated in the bigeye and yellowfin assessments Improvements in the yellowfin assessment will make the staff's management advice more accurate and precise
Duration	2018-2020
Work plan and status	2019: Explore different hypotheses to explain the difference between the indices of abundance, improve estimates of growth, re-evaluate the natural mortality assumptions, apply data weighting, conduct diagnostic tests 2019: Workshop to finalize improvements to the longline CPUE and length-composition data (Project H.1.e) 2020: Re-evaluate the model assumptions
External collaborators	
Deliverables	Report(s) to SAC in 2019 Report to SAC in 2020

PROJECT H.1.b: Improve the yellowfin tuna stock assessment

Updated: April 2021

Progress summary for the reporting period

Most of the research and analyses to improve the bigeye stock assessment (Project H.1.a) is also applicable to yellowfin.

Several workshops were conducted that highlighted other areas where the stock assessment of yellowfin could be improved

February 2018: CAPAM workshop on the development of spatio-temporal models of fishery catch-per-unit-effort data to derive indices of relative abundance.

October 2018: CAPAM workshop on the development of spatial stock assessment models.

January 2019: workshop to evaluate bigeye and yellowfin tuna ageing methodologies and growth models in the Pacific Ocean.

February 2019: workshop to improve the longline indices of abundance of bigeye and yellowfin tunas in the EPO.

December 2019: An external review of the assessment of yellowfin tuna was held

May 2020: Benchmark assessment of yellowfin tuna

November 2021: IATTC-95-05 B. Yellowfin tuna (pag.50)

Challenges and key lessons learnt

Management quantities are sensitive to the longline index, and the research had to be refocused to address several issues identified with the assessment

Lessons learnt from work on the bigeye assessment are applicable to yellowfin

An additional workshop to finalize the work on improving the longline CPUE and length-composition data was needed (Project H.1.e), but was not funded. Thanks to the collaboration of Japan and Korea, the work was advanced and indices from longline data were obtained

The standardized indices by size class from purse-seine and longline data where still incompatible pointing towards spatial differences in abundance trends of the northwest area (purse-seine index) and the southeast area (longline index), consistent with the a more complex stock structure, than the high-mixing hypothesis.

The benchmark assessment was done by modelling several hypotheses, resulting in a reference set of 48 models.

Time and data constraints limited the stock structure scenarios that could be included in the risk analysis

Reports/publications/presentations

See links above for workshop reports and presentations

SAC-10 INF-F Evaluating inconsistencies in the yellowfin abundance indices

Xu *et al*., *Fisheries Research* 213

External review report

External review presentations

SAC-11-07 Benchmark assessment of yellowfin tuna

IATTC-95-05 B. Yellowfin tuna (pag.50)

Comments:

The workplan for improving the bigeye assessment was changed in 2019 to encompass both bigeye and yellowfin tuna

PROJECT H.1.e: Construct indices of abundance and composition data for longline fleets	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.1. Improve routine tropical tuna assessments **EXECUTION**: Stock Assessment Program	
Objectives	Construct indices of relative abundance and length compositions from longline data for yellowfin and bigeye, ideally using spatiotemporal models
Background	Indices of relative abundance derived for longline CPUE data are the most important piece of information in the bigeye and yellowfin stock assessments Only Japanese data are currently used to create these indices A workshop was held in February 2019 to understand the data from other CPCs that could be used to improve the indices of abundance (WSLL-01) Preliminary results on constructing indices on combined data were obtained during the workshop The resulting indices are needed for the benchmark assessments of bigeye and yellowfin scheduled for 2020
Relevance for management	The indices have a direct impact on the stock assessment, and any improvements in the indices will directly improve management advice for bigeye and yellowfin
Duration	18 months, starting June 2019
Work plan and status	Jun-Sep 2019: Preparatory work depending on the availability of operational level data Oct-Dec 2019: Collaborative work and workshop Jan- May 2019: Preparation of documents
External collaborators	Scientists from Japan, Korea, Chinese Taipei, China Invited researchers
Deliverables	Indices of relative abundance SAC documents

PROJECT H.1.e: Construct indices of abundance and composition data for longline fleets
Updated: April 2021
Progress summary for the reporting period This project was not funded but some activities took place: Japanese (Dr. Keisuke Satoh) and Korean (Dr. Sung-Il Lee) scientists visited the IATTC for a second tome to continue the collaborative work The longline indices of abundance by size class for bigeye and yellowfin tuna were obtained using spatiotemporal models. The indices were used in the benchmark assessment for bigeye tuna (SAC-11-06), in models for yellowfin tuna done in preparation for the external review of the yellowfin tuna assessment, and as indicators for both species (SAC-11-05) One manuscript was prepared and submitted for publication in a peer-review journal
Challenges and key lessons learnt The operational data essential for improving the assessment are not permanently available to the staff. Matching size-composition and operational data for Japan proved difficult, and is not yet completed, the indices were obtained by modelling data aggregated into a 1° latitude by 1° longitude Adding the data for Korea to the standardized indices proved difficult for two reasons: the comparison with the Japanese data could not be done as operational data was only available to the staff when the scientists were present, and the visits took place in different times, the aggregated data indicated that the two fleets may have different size distributions, but this differences may be due to changes in the sampling protocol (Japan changed from fishermen sampling to observer sampling after 2011, and after 2014 all measurement were taken by observers, Korean data include both fishermen and observer sampling, after 2013 a larger proportion of the data comes from observers), or small sample size (the observer coverage is less than 5%).
Reports/publications/presentations SAC-11-06 Benchmark assessment for bigeye tuna External review of the yellowfin tuna assessment SAC-11-05 Indices used as indicators for yellowfin and bigeye tuna Satoh et al, manuscript submitted
Comments:

PROJECT I.3.a: Evaluate potential reference points for dorado in the EPO	
THEME: Sustainable fisheries **GOAL:** I. Test harvest strategies using management strategy evaluation (MSE) **TARGET:** I.3. Evaluation of harvest strategies for data-limited species based on stock status indicators **EXECUTION**: Stock Assessment Program	
Objectives	Build upon the previous collaborative work and continue to develop dorado stock assessment methodologies Expand the MSE for dorado by evaluating alternative reference points and harvest control rules.
Background	Some Members of the IATTC are interested in obtaining MSC certification for their dorado fisheries, and have requested guidance in developing of reference points (RPs) and harvest control rules (HCRs). Other Members are seeking guidance regarding data collection, research efforts, and management options
Relevance for management	The results of the project, such as alternative estimates of stock status (*e.g.* assessments, depletion estimator), reference points, and harvest control rules, could be used by the Commission, or by individual Members, in developing, adopting, and subsequently modifying as necessary, a harvest strategy for dorado.
Duration	6 months, starting January 2019
Work plan and status	Alternative RPs and HCRs will be evaluated, and their respective advantages and disadvantages will be discussed, to assist Members considering the implementation of reference points and harvest control rules for dorado. The performance of alternative assessment methods, HCRs and RPs will be evaluated by simulation methods, using Stock Synthesis. Candidates for the different components of a management strategy (data, assessment method, HCR, RPs) and the performance measures to judge such strategies will be identified. Options will include minimum size limits, precautionary lower CPUE levels that would trigger management actions. Alternative RPs will be developed with yield-per-recruit considerations, as well as alternative expected reductions of recruitment without fishing (R_0) and unfished biomass (B_0).
External collaborators	Work carried out by external contractor
Deliverables	List of candidate RPs and HCRs to be tested using a management strategy evaluation (MSE) framework; Simulation study to evaluate candidate HCRs and RPs; Written report summarizing the results; and presentation at SAC-10.

PROJECT I.3.a: Evaluate potential reference points for dorado in the EPO
Updated: May 2019
Progress summary for the reporting period A review of potential reference points (RPs) and harvest control rules (HCRs) for dorado in the South EPO was conducted, using updated catch, CPUE, and size-composition data.
Challenges and key lessons learnt This simulation study was delayed to accommodate work required for the bigeye assessment review in March 2019. The lack of stock assessments for dorado in the South EPO is problematic, since determining RPs and HCRs depends on assessment estimates. Obtaining complete and timely data is critical, given the dynamics of dorado and of the fishery, but this is not always easy.
Reports/publications/presentations SAC-10-11 Potential reference points and harvest control rules for dorado in the EPO
Comments: Project was completed

PROJECT M.2.a: Evaluate the post-release survival of silky sharks captured by longline fishing vessels in the equatorial EPO, using best handling practices	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** M. Mitigating ecological impacts **TARGET:** M.2. Develop best practices for release of bycatch species **EXECUTION**: Biology and Ecosystem Program	
Objectives	Estimate the post-release survival of silky sharks captured by longline vessels in the equatorial EPO, using archival tags
Background	Apparent severe decline in the population of silky sharks in the EPO, based on trends in standardized catch-per-unit-of-effort indices Domestic longline fleets from Latin America conduct multi-species fisheries including retaining silky sharks
Relevance for management	Resolution C-16-06 on conservation measures for silky sharks stipulates to improve handling practices for live sharks to maximize post-release survival
Duration	2016-2018
Work plan and status	2016-2017: 40 total silky sharks were tagged and released with satellite tags, and the resulting data have been analyzed to estimate a post-release survival rate, , and evaluate movements, dispersion, and potential entanglement in FADs 2017: A final report for this project was submitted to the EU (funding source) 2018: A manuscript is in progress and will be submitted to a scientific journal
External collaborators	INCOPESCA, Costa Rica; WWF, Ecuador; University of Hawaii
Deliverables	Silky shark post-release survival rate following capture by longline vessels, using best handling practices Presentation of preliminary results at SAC-08 Manuscript for publication in a peer-reviewed scientific journal

PROJECT M.2.a: Evaluate the post-release survival of silky sharks captured by longline fishing vessels in the equatorial EPO, using best handling practices
Updated: June 2019
Progress summary for the reporting period Manuscript accepted for publication in the *Bulletin of Marine Science*.
Challenges and key lessons learnt
Reports/publications/presentations Schaefer, K.M., Fuller, D.W., Aires-da-Silva, A., Carvajal, J.M., Martinez, J. and Hutchinson, M.R., 2019. Post-release survival of silky sharks (*Carcharhinus falciformis*) following capture by longline fishing vessels in the equatorial eastern Pacific Ocean. Bulletin of Marine Science.
Comments:

PROJECT O.1.c: A review of methods to determine prey consumption rates, gastric evacuation and daily ration of pelagic fishes: a precursor to experimental estimation for key predators in the EPO	
THEME: Interactions among the environment, the ecosystem, and fisheries **GOAL:** O. Improve our understanding of the EPO ecosystem **TARGET:** O.1. Conduct trophodynamic studies for defining key assumptions in EPO ecosystem models **EXECUTION**: Ecosystem Group	
Objectives	Review available methods to estimate prey consumption and gastric evacuation rates and daily ration to reliably estimate the consumption biomass ratio (Q/B) for tropical tunas and tuna-like fishes in ecosystem models being developed for the EPO. Recommend a reliable method(s) that is feasible, practical and cost-effective for estimating Q/B for key predators in the EPO ecosystem.
Background	Fisheries management strategies are increasingly considering impacts on ecosystems supporting target tuna species. Tuna fisheries impact apex predators in marine ecosystems and have the potential to disrupt ecosystem structure and function. Ecosystem models, such as Ecopath with Ecosim, are being increasingly used to explore and forecast the potential effects of fishing and climate on marine ecosystems. A key parameter in such models is Q/B. However, this highly influential parameter can be difficult to estimate experimentally, especially for large pelagic fishes. A review of methods to estimate Q/B is required to determine which methods are feasible for parameterizing ecosystem models.
Relevance for management	The Antigua Convention requires the IATTC to consider the ecological impacts of tuna fisheries in the EPO. The SSP details the development of a spatially-explicit ecosystem model of the EPO. Without reliable estimates of Q/B for key species in the EPO ecosystem, the ecosystem model will produce unreliable results that will be of little use for tactical or strategic fisheries management.
Duration	3 years
Work plan and status	Jan–Mar 2019: Collate all available literature on methodologies used to estimate prey consumption and Q/B in marine fishes, with an emphasis on predatory pelagic fishes. Mar–Apr 2019: Write a comprehensive literature review of methods to estimate Q/B and make recommendations as to which method(s) may be useful for IATTC to use in the future. May 2019: Present the review document at SAC-10 and at the 70th Tuna Conference Jun–Dec 2019: Revise the review document for submission to a peer-reviewed scientific journal. Jan-June 2020: Simulations and sensitivity analyses of a bioenergetics model for inclusion in the review document. July-Dec 2020: Proposal considerations for consumption and gastric evacuation experiments of dolphinfish. Refinement of input parameters for several predatory species and development of a new age-structured consumption model. Jan-May 2021: Continued development of the consumption model; simulations and uncertainty analyses.
External collaborators	University of Miami for proposed laboratory experiments
Deliverables	Information paper for SAC-10 Publish the literature review in an international scientific journal.

PROJECT O.1.c: A review of methods to determine prey consumption rates, gastric evacuation

and daily ration of pelagic fishes: a precursor to experimental estimation for key predators in the EPO
Updated: May 2022
Progress summary for the reporting period • Review manuscript revised to update method descriptions in text and tables. • Yellowfin tuna feeding, growth, metabolic, and reproductive data were compiled as input data for bioenergetics models using Fisheries Bioenergetics 4.0 software to examine consumption rates/energy requirements based on variations in biological/physical parameters. • tuna. • Limitations of the software to estimate parameter uncertainty and variability in consumption/daily ration estimates prompted development of a custom age-structured bioenergetics model at the individual and population levels. • Model equations and VBA code complete for yellowfin; refinement of variance parameter estimates and equations for active metabolic rate (i.e. estimates of minimum and average swim speeds) continues. • Modifications to all model input files complete and sensitivity analyses in progress. • Life history data on dolphinfish and skipjack compiled for consumption model development.
Challenges and key lessons learnt Significant challenges were encountered learning the new software and its limitations. As a result, a custom model was required to be built, which has delayed the work, but greatly improved the quality of the analyses. Proposals to conduct gastric evacuation experiments, the sampling for predator/prey caloric values and additional experiments to refine bioenergetics parameters were delayed due to the pandemic.
Reports/publications/presentations • Document SAC-10 INF-E, May 13-17, 2019; Internal summary report of Fisheries Bioenergetics 4.0 modeling simulations to estimate consumption of yellowfin tuna, *Thunnus albacares*/70th Tuna Conference, May 20-23, 2019 • A draft manuscript for the scientific journal, *Reviews in Fish Biology and Fisheries*, will be submitted for review in September 2021.
Comments: This project is a critical precursor to experimental work required to estimate values of the consumption/biomass ratio (Q/B) for an ecosystem model in development for the EPO.

PROJECT R.1.a: Workshop on training, communication and evaluation of management strategies for tuna fisheries in the EPO	
THEME: Knowledge transfer and capacity building **GOAL**: R. Improve communication of scientific advice **TARGET**: R.1. Improve communication of the staff's scientific work to CPCs **EXECUTION**: Stock Assessment Program	
Objectives	Provide training and enhance communication between scientists and managers on management objectives, harvest strategies and management strategy evaluation (MSE).
Background	Several tuna RFMOs are strengthening communications among scientists, managers and other stakeholders throughout similar workshops, including an initial one for the EPO in Panama (2015). The IATTC Performance Review and Strategic Science Plan recommend improving knowledge sharing, human-institutional capacity building and communication of scientific advice.
Relevance for management	Key elements of IATTC's management strategy, such as its harvest control rule and reference points, along with alternatives, are being evaluated via MSE. Improving participation and communication among all stakeholders is important throughout the development, evaluation and implementation of a management strategy
Duration	Planning and organization: 1-2 weeks Workshop: 2 days (last quarter of 2018)
Work plan and status	Form organizing committee to develop workshop agenda. Develop/tailor workshop materials (preferably in Spanish) to EPO tuna-management needs. Likely topics: Objectives, tactics and strategies, Kobe plots, harvest control rules, reference points. MSE components, development and implementation. Logistics: Confirm presenters, host country (Ecuador has expressed interest), travel, venue, accommodations, invite Commissioners (mainly from coastal CPCs). Conduct workshop with a format of both presentations and hands-on sessions with MSE "toy" models to illustrate main points, issues, trade-offs, and foster dialogue among Workshop participants.
External collaborators	WWF; Ocean Outcomes; ISSF
Deliverables	Workshop report and associated materials

PROJECT R.1.a: Workshop on training, communication and evaluation of management strategies for tuna fisheries in the EPO
Updated: March 2019
Progress summary for the reporting period • The workshop was conducted in August 2018.
Challenges and key lessons learnt The full cycle of an MSE will need several iterations of dialogs with stakeholders.
Reports/publications/presentations Presentations, glossary and workshop report available on request. Interactive application (in Spanish) illustrating major MSE features
Comments: The workshop was very well received. The participants from other t-RFMOs and institutions (FAO, ISSF, WWF, *etc*.) with direct experience of MSE greatly enriched the discussions.

Project R.1.b: Development, communication and evaluation of management strategies (MSE) for tropical tuna fisheries in the EPO involving managers, scientists and other stakeholders.	
Objectives	Continue support of IATTC Staff on technical development of MSE for tropical tunas. Provide training and enhance dialogue / communication among scientists, managers and other stakeholders regarding the MSE process for tropical tunas through the facilitation of a series of workshops. Elicit candidate reference points, harvest control rules, and performance measures from stakeholders to be tested in addition to the interim ones.
Background and statement of the problem	The Performance Review of the IATTC, the proposed Strategic Science Plan, and the SAC all recommended improving knowledge sharing, human- institutional capacity building and communication of scientific advice. MSE is a major objective of the IATTC and other organizations. Part of the MSE process is highly technical and done by scientists. Another part, such as defining objectives, performance metrics and candidate management strategies, requires input and participation of managers and other stakeholders. Those two parts evolve in synergy. Stakeholder participation throughout the MSE process is central to its success and will be facilitated by the understanding of the MSE process, its components and by strengthening the communication among scientists, managers and other stakeholders. Initial workshops on MSE where held in 2015 and 2018 but were restricted to Latin-American developing countries and focus on understanding of the process.
Key reference(s)	• Resolution C-16-02; IATTC Review; CAF-05-04_Appendix-1; SAC-07-07h; SAC-08-05e(ii); SAC-08-05e(iii); SAC-09 Recs
Relevance for management	Key elements of IATTC's current management strategy, such as its control rule and reference points, along with alternatives, are currently being evaluated via MSE. Technical support for better model development and relevance of the MSE results. Workshops will improve scientists, managers and other stakeholder communication. The current proposal will advance the MSE process for tropical tunas to assess the performance of interim Harvest Control Rule (HCR) and alternatives. Results will facilitate adopting a permanent HCR for tropical tunas as per Res. C-16-02
Duration	18 months (from second half of 2019 through 2020). Continuation via
Work-plan	Continue support of IATTC Staff on technical development of BET MSE. Development/tailoring of MSE Workshop materials and online resources to EPO tropical tuna fisheries including presentations and hands-on working sessions. Conduct two Workshops in 2019 (Asia in English, Latin America in Spanish) with managers and other stakeholders aiming to improve understanding of the MSE process, elicit objectives, performance metrics, alternative control rules, and risk. Conduct two 2020 Workshops with managers and other stakeholders to show initial results and gather feedback, plus a technical Workshop
Collaborators	External contractor, other external tuna and communication experts
Challenges encountered and anticipated	Need for continuing workshops to cover specific topics related to IATTC's MSE work. Turnover of commissioners and their staff makes important to revisit workshops. 2nd IATTC MSE Workshop postponed due to COVID pandemic, rescheduled as videoconference during May 2021
Deliverables	Reporting to SAC of MSE development, progress, and preliminary results. 1st IATTC MSE Workshop conducted in December 2019, Workshop report and associated training and online materials.

PROJECT T.1.a: External review of bigeye tuna assessment	
THEME: Scientific Excellence **GOAL:** T. Implement external reviews of the staff's research **TARGET:** T.1. Facilitate external reviews of stock assessments **EXECUTION**: Stock Assessment Program	
Objectives	Review the assessment model used for bigeye tuna Improve the assumptions made in the assessment
Background	The bigeye tuna stock assessment was last independently reviewed in 2010 Several issues have been identified in the stock assessment The CAPAM workshop series has identified several modelling good practices that should be incorporated into the bigeye tuna assessment Major improvements to the stock assessment are underway, including modelling of spatial structure Review of the assessment is important to get external input into improving the assessment
Relevance for management	The results of the bigeye assessment are used for management advice Improvements in the stock assessment will improve the management advice
Duration	The project will extend over 2019, but the workshop will be a single week in Fall
Work plan and status	Early 2019: Identify review panel Mid 2019: Prepare documents describing major developments in the model Fall 2019: Hold workshop Fall 2019: Write workshop report
External collaborators	Independent reviewers
Deliverables	Workshop report

PROJECT T.1.a: External review of bigeye tuna assessment
Updated: May 2019
Progress summary for the reporting period The review was conducted in March 2019 by a panel of 7 independent reviewers The panel identified several potential improvements to the assessment
Challenges and key lessons learnt Several hypotheses were identified to explain the regime shift in recruitment, a few were able to substantially reduce the shift, but the cause could not be clearly identified
Reports/publications/presentations Presentation at SAC-10 Documents prepared by the staff for the review Report of the Review panel
Comments:

PROJECT T.1.b: External review of yellowfin tuna assessment	
THEME: Scientific Excellence **GOAL:** T. Implement external reviews of the staff's research **TARGET:** T.1. Facilitate external reviews of stock assessments **EXECUTION**: Stock Assessment Program	
Objectives	Review the assessment model used for yellowfin tuna Improve the assumptions made in the assessment
Background	The yellowfin tuna stock assessment was last independently reviewed in 2012 Several issues have been identified in the stock assessment The CAPAM workshop series and research on the bigeye tuna assessment have identified several modelling good practices that should be incorporated into the yellowfin tuna assessment Review of the assessment is important to get external input into improving the assessment
Relevance for management	The results of the yellowfin assessment are used for management advice Improvements in the stock assessment will improve the management advice
Duration	The project will extend over 2019, but the workshop will be a single week in winter
Work plan and status	Mid-2019 identify review panel Fall 2019 prepare documents describing major developments in the model Winter 2019 Hold workshop Winter 2019 Write workshop report
External collaborators	Independent reviewers
Deliverables	Workshop report

PROJECT T.1.b: External review of yellowfin tuna assessment
Updated: May 2020
Progress summary for the reporting period Review held December 2019 Workshop report completed
Challenges and key lessons learnt -No single model identified and multiple models need to be considered
Reports/publications/presentations Workshop report
Comments:

PROJECT X.1.a: Workshop to advance spatial stock assessments of bigeye tuna in the Pacific Ocean	
THEME: Scientific excellence **GOAL:** X. Promote the advancement of scientific research **TARGET:** X.1. Continue the annual CAPAM workshops **EXECUTION**: Stock Assessment Program	
Objectives	Bring together researchers to present and discuss the development and application of spatial stock assessments Improve the bigeye tuna stock assessment
Background	Properly accounting for the spatio-temporal distribution of both fishing effort and fish abundance has been one of the largest sources of uncertainty ignored in most stock assessments Substantial progress has been made in both the statistical methodology and the practical implementation (e.g. software) of spatial stock assessment models Tagging data show substantial directional movement of bigeye tuna in the EPO. The current stock assessment model for bigeye lacks spatial structure, and does not explicitly take local depletion into account, thus resulting in apparent regime shifts in the estimated recruitment.
Relevance for management	Knowledge gained from the workshop will be uses to improve the bigeye tuna stock assessment Improvements in the bigeye assessment will improve management advice
Duration	October 2018
Work plan and status	April 2018 – invite keynote speakers August 2018 – prepare background material October 2018 – Conduct workshop November 2018 – Write workshop report May 2019 – report to SAC
External collaborators	
Deliverables	Workshop report

PROJECT X.1.a: Workshop to advance spatial stock assessments of bigeye tuna in the Pacific Ocean
Updated: May 2019
Progress summary for the reporting period The workshop was held in October 2018, with 10 invited presentations and 18 contributed presentations IATTC staff gave six presentations and conducted a tutorial on implementing spatial models in Stock Synthesis
Challenges and key lessons learnt There are few examples of spatial models used for management advice
Reports/publications/presentations Six presentations by staff members A special issue of *Fisheries Research*, containing the presentations from the workshop, has been published (https://www.sciencedirect.com/journal/fisheries-research/special-issue/101C0G9RFPW)
Comments: The workshop informed the staff's assessment of bigeye in the EPO