INTER-AMERICAN TROPICAL TUNA COMMISSION

95th MEETING

(*by videoconference*)
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DOCUMENT IATTC-95-08

STAFF ACTIVITIES AND RESEARCH PLAN

This document is an update of Document IATTC-94-04, 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 SAC-11-01 (Add.).

CONTENTS

A. INTRODUCTION

This document presents the staff's research and work plans, as well as brief summaries of the 47 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'; June 2019-September 2020 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,

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

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 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:

1. Data collection for scientific support of management
2. Life history studies for scientific support of management
3. Sustainable fisheries
4. Ecological impacts of fishing: assessment and mitigation
5. Interactions among the environment, ecosystem, and fisheries
6. Knowledge transfer and capacity building
7. 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 are listed in Section F.

Since the previous report to the Commission in 2019, the following projects have been completed; details in Section G.

C.4.a	Improving data collection for Central American shark fisheries
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.5.a	Revise trend estimation methods for purse-seine silky shark indices for the EPO
H.8.a	Design a survey for dolphins in the eastern tropical Pacific Ocean (ETP)
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
T.1.a	External review of bigeye tuna assessment
T.1.b	External review of yellowfin tuna assessment

Proposals for projects pending funding are listed in Document SAC-11-01 (Add.).

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M.1.c: Acoustic discrimination to avoid purse seine catches of undersized yellowfin tuna	
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.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.1.a: Analyze EPO bycatch data to assess the influence of environmental drivers on catches and vulnerability	
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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.1.b: Quantify spatial and ontogenetic variation in the feeding ecology of skipjack tuna in the eastern Pacific Ocean	
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O.2.a: Develop and implement analytical tools for understanding the trophic ecology of apex predators	
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U.1.a: Long-term plan to strengthen research at the Achotines Laboratory	
X.1.a: Workshop to advance spatial stock assessments of bigeye tuna in the Pacific Ocean	

C. 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 silky shark and dorado, at the Commission's request. It 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, and 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 updated assessments. Other less intensive methods, such as stock status indicators, are also used.

Stock assessment work during 2018-2020 focused primarily on delivering benchmark assessments of bigeye and yellowfin tunas in 2020, when Resolution C-17-02 expires and new management measures for tropical tunas will be needed. 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 (2020-2023) which complete the 5-year cycle of the Strategic Science Plan (2018-2023), the staff will continue to improve the bigeye and yellowfin benchmark assessments, as well as the risk analysis approach. New benchmark assessments for bigeye, yellowfin and skipjack (conditional on multi-year tagging program), and an improved risk analysis will be available in 2023. Progress reports on the tropical tuna assessment and risk analysis work will be presented at the SAC in 2021 and 2022. Considering that a new benchmark assessment methodology is being constructed for skipjack based on tagging data, a review of potential methodologies for the skipjack assessment and an exploratory assessment will be presented in 2021 and 2022, respectively.

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. SPC will also be conducting an assessment for southwest Pacific swordfish in 2021. Therefore, 2021 will be a good time for the staff to conduct its previously planned benchmark assessment for south EPO swordfish and take advantage of coordination with SPC (e.g. stock structure definitions). Similar to the previous dorado assessment by the staff, the south EPO swordfish assessment will be conducted in close collaborations with scientists from Members and Cooperative non-Members (e.g. Chile) interested on this fishery.

In 2022, an exploratory Pacific wide bigeye assessment will be conducted, also in collaboration with SPC. Although this work and collaboration has 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	2018	2019	2020	2021	2022	2023
IATTC								
Yellowfin tuna	H.4.a	2018	Update	Indicators/ Update[2]/ Exploratory/ Review	Benchmark	Indicators	Indicators, Exploratory assessment	Benchmark
Skipjack tuna	H.4.a	2004/2018 Indicators	Indicators	Indicators	Indicators	Indicators Review assessment methods	Indicators Exploratory Assessment	Indicators/ Tagging[3]
Bigeye tuna (EPO)	H.4.a	2017/2018 Indicators	Indicators/ Update[4]	Indicators/ Exploratory/ Review	Benchmark	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	Indicators/ Benchmark
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

[3] Conditional on multi-year tagging program

[4] A bigeye update assessment was conducted, but was not considered reliable enough to use for management advice

Species	SSP ref.	Last assessed	2018	2019	2020	2021	2022	2023
COLLABORATIONS								
Pacific bluefin tuna	H.6.a	2016 benchmark/ 2018 update	Update	Projections	Benchmark	Projections	Update	Projections
North Pacific albacore tuna	H.6.a	2017			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	Benchmark					
Swordfish (north Pacific)	H.7	2014					Benchmark	

D. 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.

1. WORK PLAN 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 of yellowfin and bigeye tunas and its stock status indicators for skipjack, and in 2018 identified some issues in the bigeye assessment that needed to be addressed.

In the past, the staff based its recommendation for the duration of the closure of the purse-seine fishery on the *F* multiplier, a parameter in the assessment model that relates fishing effort (*F*) to the maximum sustainable yield (MSY) of a stock. In 2018 the staff concluded that the results of its stock assessment of bigeye in the EPO were not reliable enough to be used as a basis for management advice to the Commission, and in 2019 extended this conclusion to its assessment of yellowfin (IATTC-94-03). The main problem with both assessments was that their results became overly sensitive to the inclusion of new data, in particular recent observations for the indices of relative abundance from the longline fishery (SAC-09 INF B; SAC-10 INF-F). These and other issues were addressed in the staff's workplan to improve the stock assessments for tropical tunas, which included a core set of projects developed specifically to address the issues identified in the assessments within the required time frame (Table A), as well as other projects that will contribute to improving the assessments in general, some of which extend beyond 2020. The workplan included external reviews of the assessments for bigeye and yellowfin, and has now been successfully completed. Neither external review singled out a particular model configuration as a replacement for the previous base case models, but both suggested a variety of alternatives for the staff to consider.

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;
- **Stock status indicators** (SAC-11-05) for all three tropical tuna species (yellowfin, bigeye, and skipjack); and;
- The following **recommendations** by the staff for the conservation of tropical tunas, based on the above.

Main expected work plan deliverables (see individual project reports for details)**:**
2018: Develop a spatially-structured stock assessment for bigeye tuna and other model improvements
2019: Exploratory bigeye and yellowfin assessments (Report to SAC-10; SAC-10 INF-F)
2020: Benchmark bigeye and yellowfin assessments (SAC-11-06, SAC-11-07)
2022: Exploratory Pacific-wide bigeye assessment

TABLE A. Timeline for tropical tuna work plan, 2017-2020.

2017	
Collaboration with Japanese scientists on identifying targeting changes	Report, SAC-09
2018	
February: CAPAM workshop on the development of spatiotemporal models of fishery CPUE data to derive indices of relative abundance (Special Issue of Fisheries Research)	SAC-09-09
Develop a spatially structured stock assessment for bigeye tuna and other model improvements	Project H.1.a
October: CAPAM workshop on spatial stock assessment models, focusing on bigeye tuna	Project X.1.a
2019	
January: Workshop on methodologies for estimating age of bigeye and yellowfin tunas from otoliths	Project E.2.b
February: Workshop to improve the longline indices of abundance of bigeye and yellowfin tunas in the EPO	Project H.1.d
March: 2nd External review of the bigeye assessment (report)	Project T.1.a
May: SAC-10, exploratory bigeye and yellowfin assessments	SAC-10 INF-F, INF-G
Oct-Nov: Construct indices of abundance and composition data for longline fleets	Project H.1.e
Nov-Dec: 2nd External review of yellowfin assessment	Project T.1.b
2020	
May: Benchmark bigeye and yellowfin assessments	SAC-11-06, SAC-11-07
May: Development of risk analysis methodology for management of tropical tuna fishery	SAC-11-08
July: New management recommendations to the Commission	SAC-11-15, IATTC annual meeting

TABLE B. Projects included in the tropical tuna work plan, 2017-2021. **Green**: completed; **blue**: funded; **red**: unfunded; **pink**: partially funded (funded components completed, other components pending). Text ~~struck through~~ indicates completed or terminated projects.

SSP ref.	Target/Project	Timeframe & status				
		2017	2018	2019	2020	2021
1. 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					
2. ASSESSMENT RESEARCH						
H.1.a	Improve the bigeye tuna stock assessment					
H.1.b	Improve the yellowfin tuna stock assessment					
~~X.1.a~~	~~Workshop to advance spatial stock assessments of bigeye tuna in the Pacific Ocean~~					
~~X.1~~	~~CAPAM workshop on recruitment: theory, estimation, and application in stock assessment models~~					
~~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~~					
~~T.1.a~~	~~External review of bigeye tuna assessment~~					
~~T.1.b~~	~~External review of yellowfin tuna assessment~~					
X.1.c	CAPAM workshop on natural mortality					
H.7.a	Pacific-wide bigeye tuna exploratory assessment					
3. LIFE HISTORY DATA						
~~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.5.a	Evaluate the Pacific-wide population structure of bigeye and skipjack tunas, using genetic analyses					
4. CPUE						
~~X.1~~	~~CAPAM workshop on the development of spatiotemporal models of fishery CPUE data to derive indices of relative abundance (Document SAC-09-09)~~					
H.1.c	Investigate potential changes in the selectivity of the longline fleet resulting from changes in gear configuration					
H.1.d	Improve indices of abundance based on longline CPUE data			*		
H.1.e	Construct indices of abundance and composition data for longline fleets					
5. NEW DATA SOURCES						
C.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**					
E.4.a	Multi-year tuna tagging study					

* Partially funded; workshop held in 2019 ** Project D.2.c combined with D.2.a; see SAC-10-12

2. 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. However, although the IATTC Performance Review, the Strategic Science Plan, and the SAC all endorsed improving knowledge-sharing, human-institutional capacity-building, and communication of scientific advice, there are currently no dedicated channels of communication specifically focusing on MSE within the IATTC. 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 with a series of workshops for training and enhancing dialogue and communication among all interested parties regarding the MSE process for tropical tunas. The initial MSE work will continue to focus on bigeye tuna, and will move to the other species towards the end of the 5-year timeframe. The work will include improvements to the bigeye stock assessment model, which will be used as a basis for the operating model used in the MSE. 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; work on alternative reference points and harvest control rules (HCRs) for dorado.
Introductory harvest strategies workshops for the Industry
Workshops for scientists-managers to elicit objectives, performance metrics, alternative HCRs

2020: Workshops with managers and other stakeholders to show initial results and gather feedback, plus a technical workshop
SAC-11: Report on revised MSE plan and preliminary results based on outcomes of workshops

2021: Updated MSE results based on input from managers and stakeholders
SAC-12: Report on revised MSE plan and preliminary results based on outcomes of workshops

2022: Final MSE results based on revised input from managers and stakeholders
SAC-13: Report on revised MSE plan and preliminary results based on outcomes of workshops

2023: SAC-14: Report final results
IATTC annual meeting: Recommend evaluated HCR/management procedure for bigeye for adoption; present plan for other tropical tunas

GREEN: COMPLETED; BLUE: FUNDED; RED: UNFUNDED

SSP ref.	Target/Project		2018		2019		2020		2021		2022		2023	
			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.	MSE for tropical tunas in the EPO: bigeye tuna													
I.1.a	1. Conduct an MSE for tropical tunas in the EPO													
	a. Improve the bigeye assessment for use as spatial OM													
	b. Run preliminary simulations with spatial OM													
	c. Technical meeting to agree on overall/revised MSE Plan by IATTC staff and collaborators													
	2. Continue technical development of MSE, HCR, MP, outputs (with Project R.1.b)													
	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. Propose evaluated HCR/MP to Commission for adoption, 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													
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														
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~~													
	a. Other MSE workshops for scientists-managers (to be planned)													
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	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													

3. 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), FAD buoy data to be provided to the IATTC staff under Resolution C-17-02 (plus several supplements recommended by the SAC and the Working Group on FADs), and the use of electronic monitoring to supplement data collected by on-board observers. Second, because the FAD fishery has different impacts on the ecosystem, in terms of marine pollution, 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 mitigating these effects, such as gear modifications and new FAD designs, 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

2018-2021: Training workshops to expand and improve data collection

2020-2021: 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, fishing mortality and its ecological impacts

2021: State-of-the-art data-collection procedures for the purse-seine fishery; improved data quality and reporting procedures

New ecologically-friendly FAD designs, and guidelines for their implementation and use

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

SSP ref.	Target/Project	Timeframe & status				
		2017	2018	2019	2020	2021
1. DATA						
Goal B: Identify and prioritize opportunities to improve data quality and expand data types and coverage						
B.2.	Expand on-board data collection to small purse seiners: train observers					
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 19-01 and 17-02; SAC and WG-FADs recommendations)					
C.1.a	Exploring technologies for remote identification of FADs					
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					

SSP ref.	Target/Project	Timeframe & status				
		2017	2018	2019	2020	2021
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-17-02 (WG-FADs Recommendation endorsed by SAC)					
2. 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.2.a	Quantification of the relationship between vessel operational characteristics and fishing mortality					
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					

4. 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
1. 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.2.	Expand on-board data collection to small purse seiners						
Goal C: Facilitate the improvement of data quality, coverage, and reporting by CPC data collection programs							
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)						
	a. Identify all unloading sites and obtain order-of-magnitude estimates of total catch and effort						
	b. 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						
2. LIFE HISTORY DATA							
F.2.a	Investigate the movements, behavior, and habitat utilization of silky sharks in the EPO						
3. 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							
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						
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						
4. 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.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.3.a	Estimate bycatch and discard rates at FADs, by species, and identify “hot spots”						

E. CURRENT AND PLANNED PROJECTS, BY THEME

1. 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 523 observed trips initiated during 2019. • Observer training, 2019: two courses, in Mexico (for the IATTC observer program from May 27 to June 13) and Nauru (August 28 to Sep 3) (with WCPFC program). • Required alignment of dolphin safety panel in purse-seine net, 2019: two, one in Ecuador (August 25) and one in Mexico (January 20).

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 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 2020

Progress summary for the reporting period

- A temporary life-history database has been developed for all species reported to have interacted with purse-seine and large-scale longline fisheries
- Values for fisheries-related susceptibility parameters have been obtained for about 30 of the 110 bycatch species that interact with EPO tuna fisheries.
- 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

- Four manuscripts that use these life-history and susceptibility data have been prepared for submission to scientific journals or IATTC presentations:
- 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 C.4.b: Long-term sampling program for shark catches of artisanal fisheries in Central America: Phase 1	
THEME: 1. 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 current 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, will be 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	1 year (April 1, 2020 – March 31, 2021)
Work plan and status	2020: 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. • SAC-12 (2021): report on final sampling design methodology and costs.

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: September 2020

Progress summary for the reporting period:

- Since the previous report (May 2019), the staff has been trained on the software for reviewing EM-records; to date, the resulting EM-data resulting from eight fishing trips have been analyzed, and collection and processing of both EM-records and observer data from all four vessels continues.
- Progress will be reported at SAC-11, including preliminary results of comparisons of EM and observer data (SAC-11 INF-G);
- Draft minimum standards for EM in the EPO (SAC-11-11) were developed, for consideration by the SAC.

Progress summary for the reporting period:

- June: IATTC staff trained on the software for reviewing EM-records.
- July: IATTC staff started producing EM-data from all four vessels.

2020:

- January - March:
  - Continue collecting EM-records and observer data from all four vessels.
  - Produced and analyzed EM-data for eight fishing trips.
- April - July: Continue production and processing of EM-data.
- October: Report progress at SAC-11, including preliminary results of comparisons of EM and observer data; propose minimum standards for EM in the EPO (SAC-11-11).
- July – December:
  - Continue statistical comparisons of EM and observer data.
  - After presentation and discussion at SAC-11, draft final minimum standards for EM data collection with the purpose of obtaining reliable information on Class 1-5 vessel related to set type, FAD deployments, catches, and bycatches.
  - Determine additional data that can be reliably collected by EM on Class-6 vessels, as accurately as the observer.
  - Write project report.
  - October-December: If results indicate that EM collection aboard Class 1-5 vessels is warranted, develop a sampling design for a pilot study using EM on Class 1-5 vessels.

Challenges and key lessons learnt

Difficulties in finding Class 1-5 vessels willing to participate delayed the project and led to changes in its scope. Similarly, COVID-19 pandemic delayed the review of EM-data for 3 months.

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.

June 2020:

- Presentation: *Progress of electronic monitoring testing in the Eastern Pacific tuna purse-seine fishery.* Borchard Foundation Fisheries Colloquium on "'Modernizing global fisheries surveillance with molecular genetics and electronic monitoring technologies". June 21-24. Missillac, France. Participation sponsored by the Borchard Foundation. (Suspended until June 2021, due to COVID-19)

September 2020:

- Progress report at SAC-11
- Proposal for minimum standards in EM for the EPO (SAC-11-11)
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May 2021:

- Final project report, and if appropriate, sampling design for EM data collection, to be presented at SAC-12. A revised draft of EM minimum standards may also need to be presented at SAC-12, subject to SAC-11 and Commission feedback.

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).

An unfunded project proposal has also been prepared by the staff to extend the EM pilot project to longline vessels.

2. 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 and Ecosystem 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	• 2017-2021: Preparation and reading of otolith samples for age estimates • 2018-2021: Preparation and reading of ovarian tissue samples for maturity and fecundity estimates • 2019-2021: Analyses of age and growth and reproductive biology data, and preparation of manuscripts
External collaborators	
Deliverables	• Presentation for SAC-12 • 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: October 2020
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 prepared for reading.
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
Comments:

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 and Ecosystem 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	• Presentation for SAC-12 • 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: January 2020
Progress summary for the reporting period • This project starts in 2020

PROJECT E.4.a: Multi-year tuna tagging study	
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 and Ecosystem 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	4 years (2019-2022)

PROJECT E.4.a: Multi-year tuna tagging study
Updated: October 2020
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).
Work Plan and Status • Phase 2 of the IATTC multi-year regional tuna tagging project will consist of two tagging cruises conducted during 2020 and 2021 of approximately 90 days each. • A pole-and-line live-bait tuna fishing vessel has been chartered to conduct a tuna tagging cruise during the period of February through April of 2020. • Permits have been 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 is to go directly from the vessel's homeport of San Diego to the Galapagos Islands to begin fishing/tagging operations, focusing on SKJ.
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 and Ecosystem 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	4 years (2017-2020)
Work plan and status	• 2017-2019: Tissue samples from the Pacific and other oceans processed at CSIRO using genotyping and sequencing techniques • 2018-2020: Analyses of genetic data at CSIRO with software specifically designed for uncovering and evaluating genetic heterogeneity in population structure • 2019-2020: Manuscript in preparation on assessment of skipjack population structure from samples from Indian Ocean, western and eastern Pacific. • 2019-2020: 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: January 2020
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 and Ecosystem 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 2020: 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: May 2020
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 2011-2013 completed; analysis of 2014 data is continuing. • 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 World Aquaculture Society Annual Meeting, March 2019, and the 43rd Larval Fish Conference, May 2019 • SAC-10-18 Review of research at the Achotines Laboratory • In preparation: Publication of results in a scientific journal
Comments: The genetic study will be 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
External collaborators	INCOPESCA Costa Rica; WWF Ecuador; and INAPESCA Mexico
Deliverables	• Presentation for SAC-12, May 2021 • 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: January 2020
Progress summary for the reporting period • This project starts in 2020

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 and Ecosystem 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 2020: Continued experimental studies of pre-recruit life stages at the Achotines Laboratory with a focus on early-juvenile life stages
External collaborators	Kindai University University of Texas
Deliverables	• Presentations for SAC-09, SAC-10 and SAC-11 • 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: May 2020
Progress summary for the reporting period • Analysis of survival and growth patterns of larval and early-juvenile yellowfin continued through 2018 and 2019. • 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 19 years is ongoing.
Challenges and key lessons learnt -
Reports/publications/presentations Presentations: • SAC-09 (May 2018) • 69th Tuna Conference (May 2018) and 70th Tuna Conference (May 2019) • 42nd Larval Fish Conference (June 2018)and 43rd Larval Fish Conference (May 2019) Two publications on this topic are being developed SAC-10-18 Review of research at the Achotines Laboratory
Comments: The planned collaboration with the University of Miami did not develop due to a change in funding arrangements in late 2018. The juvenile studies continue to be supported by the regular IATTC budget with periodic collaboration with Kindai University.

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 and Ecosystem 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 2019: Continue experimental studies of comparative larval growth and finalize data analyses • June-December 2020: 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: May 2020

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.
- 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 will be completed in early 2021.

Challenges and key lessons learnt:

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Reports/publications/presentations

Presentations:

- SAC-09 (May 2018)
- 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 (March 2019)

SAC-10-18 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.

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 and Ecosystem 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	3.5 years
Work plan and status	• June 2018-December 2021: Conduct quarterly or seasonal nightlight surveys of yellowfin at the Achotines Laboratory • January 2020-June 2021: 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 and SAC-11 • Publication of results in a scientific journal

PROJECT G.3.a: Develop a larval growth index to forecast yellowfin recruitment
Updated: May 2019
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 2020.
Challenges and key lessons learnt • Funding has not yet been secured for the at-sea surveys and subsequent analyses necessary for the development of the growth index
Reports/publications/presentations Presentations: • SAC-09 (May 2018) • 42nd Larval Fish Conference (June 2018) and 43rd Larval Fish Conference (May 2019) SAC-10-18 Review of research at the Achotines Laboratory
Comments: -

3. SUSTAINABLE FISHERIES

PROJECT H.1.a: Improve the bigeye 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 bigeye tuna stock assessment
Background	• The assessment of bigeye is conducted every year, using Stock Synthesis • The apparent regime shift in recruitment when the floating-object fishery expanded in the 1990s indicates that the assessment model is misspecified • Management quantities are highly 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 bigeye assessment will make the staff's management advice more accurate and precise
Duration	2018-2020
Work plan and status	• 2018: Create a spatial model, integrate the new growth curve into the assessment, and implement time-varying selectivity • 2019: Explore different recruitment assumptions, apply data weighting, conduct diagnostic tests • 2019: Conduct a workshop to finalize the improvements to the longline CPUE and length composition data (Project H.1.f) • 2020: Re-evaluate the model assumptions
External collaborators	Work conducted under the MSE project will contribute to this project
Deliverables	Reports for SAC-10 and SAC-11 in 2019 and 2020

PROJECT H.1.a: Improve the bigeye tuna stock assessment
Updated: October 2020
Progress summary for the reporting period • Identified stock and spatial structure • Developed spatial stock assessment model • February 2018: CAPAM workshop on the development of spatio-temporal models of fishery CPUE 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. • Analyses for the external review, including exploring different recruitment assumptions, applying data weighting, and conducting diagnostic tests • March 2019: External review of IATTC staff's stock assessment of bigeye tuna in the EPO. • March 2020: Benchmark assessment of bigeye tuna in the EPO
Challenges and key lessons learnt • The operational level longline data essential for improving the assessment are not permanently available to the staff • An additional workshop to finalize the work on improving the longline CPUE and length-composition data is needed (Project H.1.f), but not currently funded. • The results used in the risk analysis produced a bimodal probability distribution making their interpretation in respect management advice complicated.
Reports/publications/presentations See links above for workshop reports and presentations
Comments: -

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: May 2020

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

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

Comments:

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

PROJECT H.1.c: Investigate potential changes in the selectivity of the longline fleet resulting from changes in gear configuration	
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	Evaluate potential changes in targeting on the size composition of the longline catches of bigeye and yellowfin
Background	• The current yellowfin stock assessment shows a pattern of residuals for the recent longline length-composition data • Analyses of operational-level longline data from the Japanese fleet have identified possible changes in targeting that may affect the indices of relative abundance and size composition of the catch • The changes in targeting appear to be related to changes in longline gear configuration. • The effect on catch rates and species composition is being investigated in related collaborative research between the IATTC staff and NRIFSF, Japan
Relevance for management	Currently, the longline indices are the main information in the stock assessments of yellowfin and bigeye, therefore unaccounted-for changes in the longline selectivity may compromise management advice
Duration	12 months
Work plan and status	• Month 1: match set-by-set gear characteristics and catch data with the size-composition data from the Japanese fleet • Months 2-3: analysis of the set-by-set data • Months 5-11: Apply the lessons learnt from the set-by-set data to the aggregated level data used in the stock assessment
External collaborators	NRIFSF, Japan
Deliverables	• Presentation for SAC-10, 2019 • Procedure to be used in the next full assessment of yellowfin

PROJECT H.1.c: Investigate potential changes in the selectivity of the longline fleet resulting from changes in gear configuration
Updated: October 2020
Progress summary for the reporting period • This project was not funded, but progress was made in the context of Project H.1.d
Challenges and key lessons learnt • Matching the length-frequency and operational data has proved difficult, and is not yet completed
Reports/publications/presentations • SAC-10 INF-F: Evaluating inconsistencies in the yellowfin abundance indices • Materials for the workshop to improve indices of abundance held under Project H.1.d • SAC-11 INF-L: Comparison of tuna length data collected by observers and fishermen from the Korean longline fleet
Comments: This project was not funded, but progress was made in the context of Project H.1.e

PROJECT H.1.d: Improve indices of abundance based on longline CPUE 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
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 the Japanese data are currently used to create these indices • The characteristics, tactics, and spatial distribution of the fishery have been changing over time • The same length composition data is used for the index and for the catch, but these could differ • New methods, such as spatio-temporal modelling, have been developed and should be used in the creation of the indices
Relevance for management	The indices have direct impact on the stock assessment and any improvements in the indices will directly improve the management advice for bigeye and yellowfin
Duration	18 months, starting June 2018
Work plan and status	• June-Dec 2018: Evaluate the data available in the IATTC database and implement the spatio-temporal models • Jan-Feb 2019: Hold a one-week workshop to discuss approaches to resolve issues in using the longline CPUE data • May-June 2019: Hold a two-week working group to analyze the data (not funded)
External collaborators	• NRIFSF, Japan • Invited speakers
Deliverables	• Workshop report • Working group report (not funded) • Indices of relative abundance • Project report to SAC

PROJECT H.1.d: Improve indices of abundance based on longline CPUE data
Updated: October 2020

Progress summary for the reporting period
• Preparations for the workshop included:
  • Provision of operational-level longline data for main distant-water longline fleets
  • Visits by Japanese (Dr. Keisuke Satoh) and Korean (Dr. Sung-Il Lee) scientists to work with the staff on analyses
  • Visit by external expert (Dr. Simon Hoyle, supported by ISSF).
• A workshop was held on February 2019: 23 participants, including 7 invited speakers
• The work continued after the workshop and the context of the project H.1.1

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 proved difficult, and is not yet completed, the indices were obtained by modelling data aggregated into a 1° latitude by 1° longitude • The additional workshop needed to finalize the work (Project H.1.e) is not currently funded.
Reports/publications/presentations • Materials for the workshop • Presentation at SAC-10
Comments: The work related to this project continued in Project H.1.e

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: October 2020
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)
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

Comments:

Peer review papers resulting from the collaborative work are in preparation

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 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 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: October 2020
Progress summary for the reporting period • Benchmark assessment conducted for bigeye • Benchmark assessment conducted for yellowfin • Indicators constructed for bigeye • Indicators constructed for yellowfin • Indicators constructed for skipjack
Challenges and key lessons learnt • The results of the bigeye assessment in 2018 were considered unreliable, and the assessment is being improved for the 2020 full assessment (Project H.1.a). • The model used for the assessment of yellowfin is unable to reconcile data that apparently carry contradictory signals about the status of the stock. A work plan for improving several aspects of the model took place (Project H.1.b)
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
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	2018 ISC schedule: April: Working groups on sharks, billfishes May: Working groups on albacore, MSE July: Plenary; also working groups on albacore, Pacific bluefin, billfishes, sharks, statistics
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: October 2020
Progress summary for the reporting period • May 2018: Attended the Albacore working group workshop • January 2019: data preparation for benchmark stock assessment for Swordfish in the western and central north Pacific Ocean • 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: Attended the virtual Albacore working group workshop about the progress on Management Strategy Evaluation
Challenges and key lessons learnt -
Reports/publications/presentations See working group reports on the ISC website
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	2019-2021
Workplan and status	• Obtain data • Conduct assessment • Report to SAC-11 in 2021
External collaborators	• Scientists from Chile, European Union, Peru, Japan, Korea, Chinese Taipei, China and the Pacific Community (SPC)
Deliverables	Report to SAC-11 in 2021

PROJECT H.7.b: South Pacific swordfish assessment
Updated: October 2020
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); the majority of the work will be conducted in 2020-2021 • The staff gained considerable experience in analyzing operational data, and developed methods and code. • Exploratory work for the workshop in February 2019 included analyses that used the data for swordfish. • Contacts in key areas of expertise have been established to start collaborative work • A virtual workshop on stock structure is planned for December 2020
Challenges and key lessons learnt • Continued access to operational longline data is essential for conducting the assessment • Collaboration with CPCs is needed to complete the assessment • Funding is needed for a workshop in 2020 (remove?)
Reports/publications/presentations -
Comments: -

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. • Currently no dedicated channels of communication about MSE within the IATTC. • Current funding for technical and dialogue work expires end of 2020. SAC-10 supported the MSE Workplan and recommended continued funding support.
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. • The current proposal will advance the MSE process for tropical tunas to assess the performance of the interim Harvest Control Rule (HCR) and alternatives. • Results will facilitate adopting a permanent tropical tuna HCR as per Res. C-16-02
Duration	MSE Workplan extends to 2023, funding ends December 2020. Proposal available.
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 to be 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: October 2020

Progress summary for the reporting period

- 1st IATTC MSE Workshop conducted (Dec 2019), 2nd WS postponed due to pandemic.
- 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

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 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. 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.
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Comments:

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, need 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: September 2020

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. an agreement to provide high-resolution buoy data, including biomass, in a voluntary basis for a pilot project (X.X.X);
  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 proposal (C.1.a) for a pilot project on remotely and electronically identifying FADs.
- **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, FAD-04-01 and FAD-05-INF-A 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 (XXX) (see FAD-05 presentation). Preliminary indices are expected to be presented in 2021 SAC.
- **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 and SAC-11-INF-M).

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.
- 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 are needed to link IATTC databases (*i.e*. observers, FAD logbooks, buoy data). Also, a single reporting format for all CPCs would be desirable.
- 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 and considered in SAC-11-INF-M but may need to be repeated with FAD tracking data

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
- SAC-11-INF-M FAD management measures

Comments:

- Because the lead researcher of the project is now permanent staff, additional research will be conducted for some of the tasks in 2020 and 2021

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
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 K.1.a: POSEIDON project	
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 (external collaboration)	
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	18 months (end year 2020)
Work plan and status	• A post-doctoral 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, Arizona State University, International Seafood Sustainability Foundation
Deliverables	• A computer algorithm with which to run simulations to explore management options. • A project report and possibly publications in peer-reviewed journals.

PROJECT K.1.a: POSEIDON project

Updated: May 2019

Progress summary for the reporting period

- **Researcher**: Dr. Katyana Vert-pre Kirk will work on this project. She has extensive experience in modeling and statistical analysis of fisheries data.
- **Refinement of research to match IATTC management priorities**. The project has been modified to address specific management questions, including:
  i. biological and social/economic impact of FAD limits, alongside measures to reduce mortality of small bigeye;
  ii. impact of advances in FAD technology on catchability of skipjack;
  iii. ecosystem impacts and management implications of FAD drift.
- **Modification of model framework**. This involves adapting (a) the model infrastructure to better represent the EPO tuna fishery, including oceanographic currents and FAD drift, and (b) the dynamic fleet model to represent the decision-making process, information flow, and trip structure of the purse-seine fishery. A decision-flowchart representing a typical purse-seine fishing trip has been developed, also a survey of vessel captains, to be implemented in August 2019.
- **Analysis of IATTC datasets.** The parameterization, calibration, and cross-validation of the model require supplemental analyses of IATTC fishery datasets, including:
  i. Statistical analysis of trends in logbook data to understand fleet dynamics, spatial patterns of fishing effort;
  ii. Assessment of spatial and temporal patterns of FAD handling and drift; and
  iii. Assessment of effect on skipjack catchability of changes in technology and spatial patterns in FAD sets.

Challenges and key lessons learnt

Having a team member onsite has already yielded great benefits in terms of project coordination and efficient communication with IATTC staff.

Reports/publications/presentations

February 2019: Presentation to IATTC scientific staff

Comments:

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4. 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 Group	
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 (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.
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	12 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.
External collaborators	CPCs
Deliverables	• Presentations at SAC-10 • 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 2020

Progress summary for the reporting period

- Models were developed using Integrated Nested Laplace Approximation (INLA) and Generalized Additive Models (GAMs) for one species of mobulid, which formed the basis of an EASI-Fish assessment for the species.
- Relative Environment Suitability (RES) models were used with presence-only data to develop habitat maps suitable for input into the EASI-Fish model to undertake a vulnerability assessment for the eastern Pacific leatherback turtle stock in 2020.

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.
- Simple RES models can produce ecologically plausible habitat predictions, especially if the presence points are widely spread spatially.

Reports/publications/presentations

Four manuscripts that use the habitat models have been submitted (or prepared for submission) to scientific journals or IATTC presentations:

- 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*.
- A manuscript entitled "*A 40-year chronology of vulnerability of the spinetail devil ray (Mobula mobular) to tuna fisheries and options for future conservation and management*" has been completed and is currently undergoing IATTC internal review before it will be submitted to a scientific journal.

Comments:

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PROJECT 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	
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 Group	
Objectives	• To develop a spatially-explicit model for quantifying the cumulative impact of multiple fisheries on data-limited bycatch species in the EPO • To use the model to prioritize potentially vulnerable species for further research and/or management • To design the model in a user-friendly format to maximize uptake and utilization by IATTC CPCs
Background	• IATTC is committed, through the Antigua Convention, to ensure the long-term sustainability of all target and associated species impacted by EPO tuna fisheries. • Many associated (*i.e*. bycatch) species lack detailed biological and fisheries data for stock assessment, so data-limited approaches required to identify and assess the most vulnerable species. • Productivity-Susceptibility Analysis (PSA) has been widely used, but it cannot provide a quantitative measure of risk, nor can it assess cumulative impacts of multiple fisheries.
Relevance for management	The new model will more reliably identify potentially vulnerable bycatch species and assess their status under current fishing effort regimes to better guide managers
Duration	48 months
Work plan and status	• Jan-Apr 18: complete the development of a preliminary model • May 18: present preliminary model and results at SAC-09. • Jun-Dec 18: continue model development with feedback from CPCs • Jan-Feb 19: Finalize model and user-friendly module • Mar-May 19: Finalize assessment of cumulative impacts of EPO tuna fisheries for all bycatch species to identify most vulnerable species. • May 19: present final model and assessment results at SAC-10.
External collaborators	CPCs
Deliverables	• Presentations at SAC-09 and SAC-10 • Scientific journal publication • Procedure, if successful, to be used annually to assess the vulnerability of bycatch species in the EPO.

PROJECT 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

Updated: May 2020

Progress summary for the reporting period

- An EASI-Fish model was developed for the eastern Pacific stock of the critically endangered leatherback turtle, in collaboration with the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC) and scientists from the USA and Peru. The stock's current vulnerability was assessed as well as the potential impacts of implementing a range of conservation and management measures.
- The 2019 EASI-Fish assessment for *Mobula mobular* was revised after IATTC internal review and extended to analyze the historic impacts of EPO tuna fisheries on the species' vulnerability over the past 40 years.
- The EASI-Fish model itself was further developed and is now a stand-alone Excel package where all uncertainty analyses are undertaken within Excel and no longer relies on the expensive add-in tool "CrystalBall"

Challenges and key lessons learnt

- In order for EASI-Fish to be widely available and updateable, a web-based version is desirable, although further IATTC resources are needed.
- More sophisticated habitat models (*e.g*. MaxEnt, INLA) may provide more reliable base maps for habitat and will be considered in future analyses.

Reports/publications/presentations

- BYC-10-XX Vulnerability status and efficacy of potential conservation measures for the eastern Pacific leatherback turtle (*Dermochelys coriacea*) stock using the EASI-Fish approach
- A manuscript entitled "*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*" was been published in the scientific journal "Marine Ecology Progress Series" in December 2019.
- A manuscript entitled "*A 40-year chronology of vulnerability of the spinetail devil ray (Mobula mobular) to tuna fisheries and options for future conservation and management*" has been completed and is currently undergoing IATTC internal review before it will be submitted to a scientific journal.
- An invited keynote presentation entitled "EASI-Fish: a flexible vulnerability assessment tool for quantifying the cumulative impacts of tuna fisheries on data-poor bycatch species" was given at the Joint tRFMO Bycatch Working Group Meeting in Porto, Portugal, 16-18 December, 2019.
- A presentation was given at the 70Th Tuna Conference "Assessing potential conservation measures for data-poor mobulid bycatch in the eastern Pacific Ocean tuna fishery using the "EASI-Fish" ecological risk assessment tool" in May 2019.

Comments:

EASI-Fish was developed in Microsoft Excel to maximize its acceptance and utilization by IATTC CPCs and more broadly.

PROJECT L.2.a: Develop and update Productivity-Susceptibility Analyses (PSAs) of tuna fisheries in the EPO	
THEME: Ecological impacts of fisheries: assessment and mitigation **GOAL:** L. Evaluating ecological impacts **TARGET:** L.2. Conduct ERAs of EPO fisheries to identify and prioritize species at risk **EXECUTION**: Ecosystem Group	
Objectives	• To improve the currently used PSA methodology by reducing the number of redundant biological attributes without compromising PSA results. • Apply the new PSA methodology to existing assessments of the purse seine fishery (class 6 vessels) and the industrial longline fishery. • To prepare manuscripts for publication in a peer-reviewed scientific journal for (1) improved PSA methodology, and (2) purse seine and longline fishery PSA results.
Background	IATTC's PSAs have not yet been published in a peer-reviewed journal therefore access of this information to the broader scientific community is limited to IATTC's website. Publication of IATTC's approaches to ecosystem-based research is one step towards demonstrating IATTC's commitment to ecosystem-based fisheries management.
Relevance for management	• Results in the PSA papers may be used to prioritize data collection, mitigation, and/or management measures for species identified as vulnerable by the method. • Improving the methodology by reducing the number of biological parameters will optimize reliability of results from the PSA method, while decreasing the data requirements to further expedite this rapid assessment approach for data-limited fisheries.
Duration	8 months
Work plan and status	• Jan-Jun 18: prepare a manuscript for the existing PSA for the large purse-seine fishery and submit to co-authors for review • Aug 18: submit PSA manuscript on the large purse-seine fishery for publication in a peer-reviewed scientific journal • Jan-May 18: Submit PSA-methods manuscript for publication in a peer-reviewed scientific journal
External collaborators	-
Deliverables	Manuscripts demonstrating IATTC's approaches to ecosystem-related research for data-limited species

PROJECT L.2.a: Develop and update Productivity-Susceptibility Analyses (PSAs) of tuna fisheries in the EPO

Updated: May 2020

Progress summary for the reporting period

- This project has now been completed and the IATTC has no immediate plans to use PSA for future ecological risk assessments since the new quantitative EASI-Fish approach is now being used in favor of PSA.
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Challenges and key lessons learnt

- This key lesson learned from this project is the PSA approach actually requires far more data inputs than other quantitative ERA approaches but provides only a relative measure of risk for each species.
- The exploratory statistical work undertaken in this project demonstrated that the subjective weightings previously recommended to apply to susceptibility and productivity parameters can have variable impacts on model outcomes and increase uncertainty regarding the risk level of a species.

Reports/publications/presentations

- A manuscript entitled "Assessing vulnerability of bycatch species in the tuna purse-seine fisheries of the eastern Pacific Ocean" has been published in the journal *Fisheries Research*
- A manuscript entitled "Assessing attribute redundancy in the application of productivity-susceptibility analysis to data-limited fisheries" has been published in the journal *Aquatic Living Resources*

Comments:

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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 • 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
Challenges and key lessons learnt -
Reports/publications/presentations -
Comments: -

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**: Bycatch Mitigation and Gear Technology	
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**: Bycatch Mitigation and Gear Technology Group	
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 • April-May2021 install sea cage and collect juvenile yellowfin in waters adjacent to the Achotines Laboratory • May-June 2021 staging of ISSF acoustic equipment at Achotines Laboratory • May-June 2021 conduct acoustic trial • Mid 2021 draft report of study results completed by ISSF researchers • Mid 2021 workshop organized to present the results and discuss them with scientists and buoy manufacturers
Duration	24 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.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: June 2019
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
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**: Bycatch Mitigation and Gear Technology Group	
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

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

Updated: August 2020

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 Collection of data 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.

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 (balsa wood, bamboo) was satisfactory during the period observed.
- Materials like canvas and ropes made with abaca fiber showed good condition after 2-3 months at sea.
- The use of the selected cotton seems to be inappropriate. Modifications have been made to accommodate fleet's concerns. Modified prototypes are being currently tested.
- Preliminary analyses of tuna catches between close NEDs and FADs showed similar values.
- COVID-19 pandemic caused delays on NED construction. Meetings with fleet managers and stakeholders have been held to adapt to the exceptional situation. Most of the works have been already resumed.

Reports/publications/presentations

- Presentations made at 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.
- SAC-11: progress presentation
- SAC-11-12: progress report

Comments:

Project was suspended during March-July 2018, thus missing the fishing season off Peru. Next opportunity for deployment will be second half of 2019, for the season west of Galapagos. A project extension proposal was approved on October 2019 for a total of 38 months. Matters related to COVID-19 pandemic may lead to an additional project extension request.

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, Bycatch Mitigation and Gear Technology Group	
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 2019-March 2020: Survey stakeholders about areas and impacts of SAL-FADs. • May-Dec 2019: Identify or develop ocean circulation model to forecast FAD trajectories beyond fishing grounds. • May 2020 (SAC-11): Present results of ocean circulation model • June-Dec 2020: Based on models and surveys, identify levels of sensitivity and categorize possible stranding areas. • Dec 2020: Workshop with stakeholders and ISSF scientists to identify mitigation strategies for SAL-FADs, based on findings of survey and models • May 2021 (SAC-12): Present a report of all findings and proposals for mitigation strategies at.
External collaborators	To be decided. An oceanographic modeler, and ISSF scientists working on similar projects in other oceans
Deliverables	• May 2020 (SAC-11): Report on results of survey and circulation model • December 2020: Workshop with stakeholders • March 2021: Workshop report • May 2021 (SAC-12): Report on results • October 2021: Proposals for mitigation strategies and management options to reduce SAL-FADs

PROJECT M.5.b: Reducing losses, and fostering recovery of FADs in the purse-seine fishery in the EPO
Updated: May 2019
Progress summary for the reporting period • Development and distribution of survey on impact of SAL-FADs. 14 responses to date: academic (1), consultant (1), industry (2), environmental NGOs (3), industry NGO (5), government (2). • Two staff members attended the ISSF-sponsored workshop on the reduction of the impact of FADs in September 2018.
Challenges and key lessons learnt -
Reports/publications/presentations -
Comments: • Original project start date was early 2018, but it was delayed, and to date only the first objective has been addressed. • The modelling of FAD movements will require collaborative work with an oceanographer

5. INTERACTIONS AMONG THE ENVIRONMENT, THE ECOSYSTEM, AND FISHERIES

PROJECT N.1.a: Analyze EPO bycatch data to assess the influence of environmental drivers on catches and vulnerability	
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	To better understand environmental drivers that might be responsible for increasing the vulnerability of non-target species to being caught in EPO fisheries, and devise management measures that may reduce their vulnerability to capture (*e.g*. space-time closures).
Background	• Each year the IATTC reports catch estimates for non-target species in its Fishery Status Report. • Nominal catches of bycatch species may not fully explain the magnitude of inter-annual variability in fishing effort, since environmental factors may drive key processes such as recruitment. • To improve our understanding of processes affecting catches in the EPO purse-seine fishery, we assess ecosystem components including catches of vulnerable shark species in relation to variability in oceanographic conditions and life history characteristics.
Relevance for management	Catch prediction models to better manage data-poor species
Duration	12 months
Work plan and status	• Jan-Apr 18: exploratory analyses of IATTC observer catch data and oceanographic conditions over the past two decades • Apr-May 18: present results at the international PICES conference, "Understanding Changes in Transitional Areas of the Pacific" and the 69th Tuna Conference • Jun-Jul 18: Prepare a manuscript for publication in a scientific journal
External collaborators	None
Deliverables	• Reporting of bycatch estimates in the Ecosystem Considerations report • Manuscript that contributes to IATTC's ecosystem approach through evaluation of potential environmental drivers influencing catches in the EPO purse-seine fishery and relationships between environment and life history characteristics

PROJECT N.1.a: Analyze EPO bycatch data to assess the influence of environmental drivers on catches and vulnerability
Updated: May 2020
Progress summary for the reporting period • Bycatch estimates for 2019 documented in the *Ecosystem Considerations* report • Oceanographic data (SST, chlorophyll-*a,* etc.) and environmental indices (ONI, PDO, others) included in the *Ecosystem Considerations* report •
Challenges and key lessons learnt • Models are now being revised and run with target species to ensure their reliability before being applied to other species of bycatch
Reports/publications/presentations Presentations: • PICES International Symposium on Understanding Changes in Transitional Areas of the Pacific (April 2018) • 69th Tuna Conference (May 2018)
Comments: • The Ecosystem Group has been collaborating with the Bycatch and Gear Technology Group to determine an appropriate model to apply to bycatch species. •

PROJECT N.1.b: Investigate the effects of 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	
Objectives	Estimate the optimal microturbulence and wind speed for the survival of yellowfin larvae and examine any association between yellowfin recruitment and historical wind speeds in the EPO
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	18 months
Work plan and status	• June-December 2019: Refine analyses of survival and feeding data and finalize wind speed-recruitment analysis • January-December 2020: 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 2020
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 the end of 2020.

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 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 2021: 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 – March 2021: Completion of analyses and manuscript from the 2019 molecular study led by University of Miami • January 2020-December 2021: 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; Macquarie University, Australia Drs. Rachael Heuer 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: May 2020
Progress summary for the reporting period • Analysis of the effects of ocean acidification on yellowfin larval otolith morphology and genetic expression of resistant traits continued. • The larval otolith analysis will be completed and submitted as a manuscript by mid-2021. 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
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-09 • SAC-10 • 69th Tuna Conference (May 2018) • 42nd Larval Fish Conference (June 2018) and 43rd Larval Fish Conference (May 2019) • Two 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 • A manuscript summarizing results of the 2019 molecular study led by University of Miami with IATTC collaboration will be submitted for review in late 2020 •
Comments: The analysis of experimental results from the 2011 study should be completed in 2021.

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**: Bycatch Mitigation and Gear Technology Group	
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
Work plan and status	• 2020 – Develop vessel distributions models; gather model outputs from target species; assemble projected environmental data. • 2021 – 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. • 2022 – 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 O.1.b: Quantifying spatial and ontogenetic variation in the feeding ecology of skipjack tuna in the eastern Pacific Ocean	
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	• Broadly describe the trophic ecology of skipjack tuna in the EPO using classical stomach-contents analysis • Quantitatively disentangle spatial, temporal, and ontogenetic differences in diet to identify important habitats of skipjack and their forage
Background	• Early accounts of skipjack stomach contents in the EPO have been limited to measurements of prey volume by size class with sampling strata determined *a priori* based on presumed areas of high skipjack densities • Other studies have used calculations of prey weight, number and frequency of occurrence of skipjack sampled opportunistically throughout the EPO • Little attention has been placed on quantitatively assessing the potential relationships between oceanography, ontogeny and skipjack feeding ecology Such information is essential for informing a planned spatially-explicit ecosystem model of the EPO (Project O.2.b) to account for direct and indirect impacts from fishing on the ecosystem, as mandated by the Antigua Convention
Relevance for management	Quantifying trophic linkages in ecosystem models provide descriptions of the magnitude of biomass transfer through the ecosystem and assist in assigning a more reliable proportion of both predator and prey in spatial strata using spatially-explicit ecosystem models, such as Ecospace.
Duration	12 months
Work plan and status	**Task 1:** Exploratory analysis of skipjack tuna diet data 1.1: Map locations of skipjack stomach samples overlaid with Longhurst bio-geochemical Provinces; 1.2: Assess size distribution of skipjack sampled for stomach-contents analysis; 1.3: Explore the relationship of predator-prey size. **Task 2:** Diet composition and classification tree analysis using analytical tools developed at CSIRO in collaboration with IATTC 2.1: Compute gravimetric, numeric and occurrence indices of diet composition to examine prey importance; 2.2: Run classification trees using skipjack diet data as the response variable and Longhurst Province and skipjack size as the explanatory variables; 2.3: Interpret results with respect to ecosystem-related goals outlined in the SSP; 2.4: Prepare manuscript
External collaborators	• CICIMAR, La Paz, Mexico
Deliverables	• Manuscript that contributes to IATTC's ecosystem approach to fisheries management through identification of ontogenetic functional groups and quantifying their predator-prey interactions for use in ecosystem models.

PROJECT O.1.b: Quantifying spatial and ontogenetic variation in the feeding ecology of skipjack tuna in the eastern Pacific Ocean
Updated: April 2020
Progress summary for the reporting period • A manuscript entitled “Spatial and ontogenetic relationships in the trophic ecology of skipjack tuna, Katsuwonus pelamis, in the eastern Pacific Ocean” was submitted for publication in the journal “Marine Biology” in December 2019.
Challenges and key lessons learnt • An extensive exploratory analysis is essential for appropriate interpretation of the classification tree results.
Reports/publications/presentations • A manuscript entitled “Spatial and ontogenetic relationships in the trophic ecology of skipjack tuna, Katsuwonus pelamis, in the eastern Pacific Ocean” has been submitted for publication in the journal “Marine Biology
Comments: This project will help improve diet matrices in EPO ecosystem models.

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	12 months
Work plan and status	• Jan–Mar: Collate available literature on methodologies used to estimate prey consumption and Q/B in marine fishes, with an emphasis on predatory pelagic fishes. • Mar–Apr: 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 future. • May: Present the review document at SAC-10 and at the 70th Tuna Conference • Jun–Dec: Prepare and revise the review document for a peer-reviewed scientific journal.
External collaborators	-
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 2020
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. • Modifications to all model input files complete and sensitivity analyses in progress.
Challenges and key lessons learnt • Significant challenges were encountered learning the new software.
Reports/publications/presentations • Document SAC-10 INF-E, May 13-17, 2019/70th Tuna Conference, May 20-23, 2019
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 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 Group	
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 2020
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 is stalled pending provision of data by external collaborators and then by COVID-19.
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 Group	
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 6.5, 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 2020
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, for a third time that Proposal O.1.a be funded, to obtain updated trophic samples to best represent the current dynamics of the EPO ecosystem.
Reports/publications/presentations • 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
Comments: -

6. 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	3 years
Work plan and status	April 2018-March 2021: 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: May 2020
Progress summary for the reporting period • Six training courses, focused on the conservation, rehabilitation and restoration of forest lands and watersheds in Panama, were held at the Achotines Laboratory during April 2019-March 2020. An agreement has been finalized to continue the Achotines-ELTI initiative for the period of April 2020 through March 2021.
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 is in preparation.
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.

7. 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 early 2021, and the implementation of the plan will extend long-term (5-10 years)
Work plan and status	• Mid-2020 prepare a draft plan • Fall 2020 staff internal review of the plan • Winter 2020-2021 external review of plan • Early 2021 final plan developed with initial implementation of plan
External collaborators	Independent reviewers
Deliverables	Final plan developed by staff

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, is in preparation
Comments: The workshop informed the staff's assessment of bigeye in the EPO

F. PUBLICATIONS

1. Peer-reviewed journal publications

Compean, G.A. 2018. Review of Management and Conservation Measures for Tropical Tunas in the Eastern Pacific Ocean. Ocean Year Book 32: 317-328.

Frisk, M. G., Dolan, T. E., McElroy, A. E., Zacharias, J. P., **Xu, H.**, & Hice, L. A. (2018). Assessing the drivers of the collapse of Winter Flounder: Implications for management and recovery. Journal of sea research, 141, 1-13.

Gilman, E., Chaloupka, M., Dagorn,L., **Hall, M**., Hobday,A., Musyl,M., Picher,T., Poisson,F., Restrepo,V., Suuronen,P. Robbing Peter to Pay Paul; replacing unintended cross-taxa conflicts with intentional tradeoffs by moving from piecemeal to integrated fisheries bycatch management.January 2019.Rev Fish Biol. Fisheries Online Dec 2018

Griffiths, S.P.; Allain, V.; Hoyle, S.D.; Lawson, T.A.; Nicol, S.J. 2018. Just a FAD? Ecosystem impacts of tuna purse-seine fishing associated with fish aggregating devices in the western Pacific Warm Pool Province. Fisheries Oceanography. 28: 94-112.

Kwan, G.T**., Wexler, J.B.,** Wegner, N.C., Tresguerres, M. 2019. Ontogenetic changes in cutaneous and branchial ionocytes and morphology in yellowfin tuna (*Thunnus albacares*) larvae. Journal of Comparative Physiology B 189:81–95 (https://doi.org/10.1007/s00360-018-1187-9).

Lennert-Cody, C. E., Buckland, S. T, Gerrodette, T., Webb, A., Barlow, J., Fretwell, P., **Maunder, M. N**., Kitakado, T., Moore, J. E., **Scott, M. D**., Skaug, H. J. 2018. Review of potential line-transect

methodologies for estimating abundance of dolphin stocks in the eastern tropical Pacific. Journal of Cetacean Research and Management, 19: 9-21.

Lennert-Cody, C.E. Moreno, G., Restrepo, V., **Román, M.H**., **Maunder, M.N.** 2018. Recent purse-seine FAD fishing strategies in the eastern Pacific Ocean: what is the appropriate number of FADs at sea? ICES Journal of Marine Science 75 (5), 1748-1757.

Lezama-Ochoa, N; Hall,M; Roman,M; Vogel, N. Spatial and temporal distribution of mobulid ray species in the eastern Pacific Ocean ascertained from observer data from the tropical tuna purse-seine fishery. 2019. Springer Nature B.V.pdf Online Dec 2018

Maunder, M.N., Deriso, R.B., Schaefer, K.M., Fuller, D.W., Aires-da-Silva, A.M., Minte-Vera, C.V., Campana, S.E. 2018. The growth cessation model: a growth model for species showing a near cessation in growth with application to bigeye tuna (Thunnus obesus). Marine Biology (2018) 165:76.

Minte-Vera,C.V., Maunder, M.N., Schaefer, K.M. Aires-da-Silva, A. M. in press The influence of metrics for spawning output on stock assessment results and evaluation of reference points: An illustration with yellowfin tuna in the eastern Pacific Ocean. Fisheries Research (https://doi.org/10.1016/j.fishres.2018.09.022)

Pethybridge, H.; Choy, C.; Logan, J.; Allain, V.; Lorrain, A.; Bodin, N.; Somes, C.J.; Young, J.; Ménard, F.; Langlais, C.; **Duffy, L**.; Hobday, A.; Kuhnert, P.; Fry, B.; Menkes, C.; **Olson, R.** 2018. A global meta-analysis of marine predator nitrogen stable isotopes: Relationships between trophic structure and environmental conditions. Global Ecology and Biogeography. 27:1043-1055.

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. Bull. Mar. Sci. 95(3):355-369.

Stein, M., **Margulies, D., Wexler, J.B., Scholey, V.P**., Katagiri, R., Honryo, T., Sasaki, T., Guillen, A., Agawa, Y., Sawada, Y. 2018. A comparison of the effects of two prey enrichment media on growth and survival of Pacific bluefin tuna, *Thunnus orientalis*, larvae. Journal of the World Aquaculture Society, 49: 240-255.

Valencia-Gasti, J.A., Weber, E. D., Baumgartner, T., Durazo, R., **Lennert-Cody, C.E.** and McClatchie, S. 2018. Spring Spawning Habitat of Pacific Sardine in US and Mexican Waters. CalCOFI Reports 59: 79-85.

Xu, H., Miller, T. J., Hameed, S., Alade, L. A., & Nye, J. A. (2018). Evaluating the utility of the Gulf Stream Index for predicting recruitment of Southern New England-Mid Atlantic yellowtail flounder. Fisheries oceanography, 27(1), 85-95.

Xu, H., Thorson, J. T., Methot, R. D., & Taylor, I. G. (2018). A new semi-parametric method for autocorrelated age-and time-varying selectivity in age-structured assessment models. Canadian Journal of Fisheries and Aquatic Sciences, 76(2), 268-285.

2. Reports

Clarke, S., Langley, A., **Lennert-Cody, C., Aires-da-Silva, A.,** and **Maunder, M**. 2018. Pacific-wide Silky Shark (Carcharhinus falciformis) Stock Status Assessment. Western and Central Pacific Fisheries Commission Document WCPFC-SC14-2018/SA-WP-08.

Duffy, L.; Griffiths, S. 2018. Ecosystem Considerations. SAC-09-11. Inter-American Tropical Tuna Commission Scientific Advisory Committee Ninth Meeting. La Jolla, CA USA. 14–18 May 2018.

Griffiths, S.P.; Kesner-Reyes, K.; Garilao, C.V.; **Duffy, L.; Roman, M**. 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. SAC-09-12. Inter-American Tropical Tuna Commission Scientific Advisory Committee Ninth Meeting. La Jolla, CA USA. 14–18 May 2018.

Johnson, K.F., Punt, A.E. and **Lennert-Cody, C.E**. 2018. Report fo the workshop on methods for monitoring the status of eastern Tropical Pacific dolphin populations. IATTC Special Report 22.

Lennert-Cody, C.E., Aires-da-Silva, A., Maunder, M.N. 2018. Updated stock status indicators for silky sharks in the eastern Pacific Ocean, 1994-2017. IATTC Document SAC-09-13.

Margulies, D., Scholey, V.P., Mauser, E., Cusatti, S., Tejada, L., Wexler, J.B. Review of research at the Achotines Laboratory. IATTC Document SAC-10-18.

Maunder, M.N. 2018. Updated indicators of stock status for skipjack tuna in the eastern Pacific Ocean. Pages 25-31 in IATTC Stock Assessment Report 19.

Maunder, M.N., Xu, H., Minte-Vera, C., and **Aires-da-Silva, A**. 2018. Investigation of the substantial change in the estimated F multiplier for bigeye tuna in the eastern Pacific Ocean. IATTC Document SAC-09-INF-B.

Maunder, M.N., Lennert-Cody, C.E., and **Román, M**. 2018. Stock status indicators for bigeye tuna in the eastern Pacific Ocean. Pages 18-24 in IATTC Stock Assessment Report 19

Minte-Vera, C.V., Maunder, M.N., and **Aires-da-Silva, A**. 2018. Status of yellowfin tuna in the eastern Pacific Ocean in 2017 and outlook for the future. Pages 3-17 in IATTC Stock Assessment Report 19.

Moreno, G; Murua, J; **Hall, M; Altamirano, E**; Cuevas, N; Grande, M; Moniz, I; Sancristobal, I; Santiago, J; Uriarte, I; Zudaire, I y Restrepo, V. 2018. Technical Report ISSF 19A. Workshop for the reduction of the impact of fish aggregating devices structure on the ecosystem.

Murua, J., Moreno, G., Itano, D., **Hall, M**.., Dagorn, L., and Restrepo, V., 2018. ISSF Skippers Workshop Round 7. ISSF Technical Report 2018-01, International Seafood Sustainability Foundation, Washington, D.C., USA..pdf

Oedekoven, C.S., Buckland, S.T., Marshall, L., and **Lennert-Cody, C.E.** 2018. Design of a survey for eastern tropical Pacific dolphin stocks. IATTC Document MOP-37-02.

Scott, M.D.; Lennert-Cody, C.; Gerrodette, T.; Chivers, S.J.; Danil, K.; Hohn, A.A.; **Duffy, L.M.; Olson, R.;** Skaug, H.J.; **Minte-Vera, C.V**.; Fiedler, P.C.; Ballance, L.T.; Forney, K.A.; Ferguson, M.C.; Barlow, J. 2018. Data available for assessing dolphin population status in the eastern tropical Pacific Ocean. Inter-American Tropical Tuna Commission, Special Report 23:1-31.

Valero, J.L., Aires-da-Silva, A., Maunder, M.N., and Lennert-Cody, C. 2018. Exploratory spatially-structured assessment model for bigeye tuna in the eastern Pacific Ocean. Pages 32-97 in IATTC Stock Assessment Report 19.

Wang, S-P., **Maunder, M.N., Lennert-Cody, C.E., Aires-da-Silva, A**. 2018. CPUE standardization for bigeye tuna and yellowfin tuna caught by Taiwanese longline in the eastern Pacific Ocean. IATTC Document SAC-09-INF-F.

Xu, H., Minte-Vera, C., Maunder, M.N., Aires-da-Silva, A. 2018. Status of bigeye tuna in the eastern Pacific Ocean in 2017 and outlook for the future. IATTC Document SAC-09-05.

Xu, H., Lennert-Cody, C.E., Maunder, M.N., and Minte-Vera, C. 2018. Spatiotemporal dynamics of the dolphin-associated purse-seine fishery for yellowfin tuna in the eastern Pacific Ocean. IATTC Document SAC-09-09.

3. Conference and workshop presentations

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? 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.

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 the eastern Pacific Ocean. 69th Annual Tuna Conference, Lake Arrowhead, USA, 21–24 May 2018.

Lennert-Cody, C.E., Moreno, G., Restrepo, V., Lopez, J., **Román, M., Maunder, M.N**. Recent purse-seine FAD fishing strategies in the eastern Pacific Ocean: What is the appropriate number of FADs at sea? ISSF Side Event at IATTC Annual Meeting, August 24, 2018, San Diego, CA.

Lennert-Cody, C.E., Maunder, M.N., Minte-Vera, C., Xu, H., Valero, J., Aires-da-Silva, A., Lopez, J. A Multivariate Tree-based Method for Exploring Stock Structure in Multiple Data Sets. CA CAPAM workshop on the development of spatial stock assessment models, La Jolla, USA, 1-5 October 2018.

Margulies, D., Scholey, V.P., Mauser, E., Honryo, T., Wexler, J.B., Stein, M.S., Kurata, M., Katagiri, R., Agawa, Y., Sawada, Y. 2019. Laboratory-based comparative studies of the effects of environmental and climate variables on early life stages of yellowfin tuna and Pacific bluefin tuna in Panama and Japan. 43rd Annual Larval Fish Conference, Mallorca, Spain, 20-24 May, 2019.

Maunder, M.N. 2018. Likelihood functions for including CPUE based indices of abundance in stock assessment. CAPAM workshop on the development of spatio-temporal models of fishery catch-per-

unit-effort data to derive indices of relative abundance in La Jolla, CA, USA, February 26-March 2, 2018.

Maunder, M.N., Thorson, J.T., **Xu, H**. 2018. Using spatio-temporal models of tagging data to deal with incomplete mixing. CAPAM workshop on the development of spatial stock assessment models, La Jolla, USA, 1-5 October 2018.

Mauser, E., Margulies, D., Scholey, V., Cusatti, S., Tejada, L., Wexler, J., Stein, M., Honryo, T., Katagiri, R., Kurata, M., Agawa, Y., Sawada, Y. 2019. Comparative analysis of the laboratory growth of yellowfin tuna *Thunnus albacares* and Pacific bluefin tuna *Thunnus orientalis* larvae, and growth of early-juvenile yellowfin reared in land based tanks and a sea cage. World Aquaculture Society Annual Meeting, New Orleans, LA, USA., 7-11 March, 2019.

Mauser, E., Margulies, D., Scholey, V., Cusatti, S., Wexler, J., Stein, M. 2019. Review of recent research activities focused on yellowfin tuna (*Thunnus albacares*) at the IATTC's Achotines Laboratory. 70th Annual Tuna Conference, Lake Arrowhead, USA, 20-23 May, 2019.

Scholey, V.P., Margulies, D., Mauser, E. 2019. Research activities at the Inter-American Tropical Tuna Commission Achotines Laboratory. 43rd Annual Larval Fish Conference, Mallorca, Spain, 20-24 May, 2019.

Valero, J.L. 2018. Modeling of EPO Tropical tunas and dorado. Shark-Tuna Stock Synthesis Workshop, La Jolla, Feb 21-23, 2018.

Valero, J.L. 2018. Spatial models in Stock Synthesis. CAPAM workshop on the development of spatial stock assessment models, La Jolla, USA, 1-5 October 2018.

Valero, J.L. 2018. Incorporating tagging data in Stock Synthesis. CAPAM workshop on the development of spatial stock assessment models, La Jolla, USA, 1-5 October 2018.

Valero, J.L. 2018. Estrategias de ordenación: objetivos, estrategias y tácticas, RCE. Taller de entrenamiento, comunicación y evaluación de estrategias de ordenación para pesquerías de atunes en el OPO. San Diego, USA, 25-26 de agosto de 2018.

Valero, J.L. 2018. Evaluación de estrategias de ordenación mediante simulación. Taller de entrenamiento, comunicación y evaluación de estrategias de ordenación para pesquerías de atunes en el OPO. San Diego, USA, 25-26 de agosto de 2018.

Valero, J.L., Minte-Vera, C. 2018. Progress on MSE work at IATTC. MSE Communications Workshop, San Diego, 14-16 January 2018.

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.

Valero, J.L., Maunder, M. N., Haikun Xu, Minte-Vera, C., Lennert-Cody, C., Aires-da-Silva, A. 2018. Exploratory spatial stock assessment of Bigeye tuna (*Thunnus obesus*) in the EPO. CAPAM workshop on the development of spatial stock assessment models, La Jolla, USA, 1-5 October 2018.

Wexler, J 2019. Tag-recapture oxytetracycline-marking experiments to investigate daily increment deposition rate in yellowfin otoliths. Workshop to evaluate bigeye and yellowfin tuna ageing methodologies and growth models in the Pacific Ocean 23-25 January, 2019 La Jolla, California, USA.

Wexler, J, and Griffiths, S. 2019. 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 eastern Pacific Ocean ecosystem. The 70th Tuna Conference, Lake Arrowhead, California USA, May 20-23, 2019.

Xu, H., Lennert-Cody, C.E., Maunder, M.N., and Minte-Vera, C. 2018. Spatiotemporal dynamics of the dolphin-associated purse-seine fishery for yellowfin tuna in the eastern Pacific Ocean. 69th Annual Tuna Conference, Lake Arrowhead, USA, 21–24 May 2018.

Xu, H., Lennert-Cody, C.E., Maunder, M.N., and Minte-Vera, C. 2018. Spatiotemporal dynamics of yellowfin tuna in the eastern Pacific Ocean. CAPAM workshop on the development of spatio-temporal models of fishery catch-per-unit-effort data to derive indices of relative abundance in La Jolla, USA, February 26-March 2, 2018.

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.

4. 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.

G. PROJECTS COMPLETED SINCE PREVIOUS REPORT

PROJECT C.4.a: Improving data collection for Central American shark fisheries	
THEME: Data collection **GOAL:** C. Facilitate the improvement of data quality, coverage, and reporting by CPC data collection programs **TARGET:** C.4. Artisanal longline fleet **EXECUTION**: Stock Assessment Program	
Objectives	• Obtain an order-of-magnitude estimate of shark catch for the artisanal fleet. • Design and test sampling protocols for estimating shark species and size composition for the industrial fleet. • Produce a sampling protocol for the catch and effort of the shark artisanal fisheries that can be operatively implemented in Central America, by field-testing during Project C.4.b.
Background	• There is a critical need for stock assessments of sharks to better inform their management and conservation. • This has not been possible in the EPO to date due to the lack of reliable fishery statistics from all important fisheries. • In September 2017, with funding from FAO-GEF in the framework of the *Common Oceans* project, a "Workshop to Develop a Pilot Study for a Shark Fishery Sampling Program in Central America" was convened to bring together sampling design experts, and scientific and technical experts from OSPESCA's GTEAM, to discuss how to address data deficiencies. • Based on recommendations from this workshop, activities were funded in 2018 under the *Common Oceans* tuna project (GCP/GLO/365/GFF) and 2019 by IATTC Capacity-Building Fund to improve data collection for Central American shark fisheries.
Relevance for management	Improving catch data collection will help to fill the current data gaps and thus lead to better management of shark fisheries in the EPO.
Duration	24 months
Work plan and status	• Collect data to create a Google Earth map of all landing sites of artisanal shark fisheries in Central America, with associated levels of fishing activity. • Use this map to guide sampling of catches at select landing sites in Central America. • Compute an order of magnitude estimate of total shark catch for the artisanal fleet from sample data and map information. • Conduct a survey of industrial vessel unloading characteristics that can be used to develop catch sampling protocols. • Develop and test several sampling designs for shark catch size and sex composition of the industrial fleet.
External collaborators	OSPESCA; Central American national authorities
Deliverables	• SAC-11-13 Pilot study for shark fishery sampling program in Central America

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:

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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.5.a: Revise trend estimation methods for purse-seine silky shark indices for the EPO	
THEME: Sustainable fisheries **GOAL:** H. Research and development of stock assessment models and their assumptions **TARGET:** H.5. Improve stock assessments for data-limited species **EXECUTION**: Stock Assessment Program	
Objectives	Develop new methods to estimate trends in relative abundance of silky sharks from purse-seine observer data that are less influenced by inter-annual variability in oceanographic conditions.
Background	• Fluctuations in the index of relative abundance for juvenile silky sharks correlate with inter-annual variability in oceanographic conditions in the offshore area of the northern EPO. • Recent fluctuations in the index are not biologically realistic, compromising the reliability of the index as a stock status indicator. • The index based on purse-seine observer data is the only index available for management because of data deficiencies in other fisheries. • New methods are necessary to estimate more reliable trends in relative abundance for the silky shark using purse-seine observer data.
Relevance for management	Improving the reliability of the purse-seine index will improve management advice for the silky shark in the EPO.
Duration	9 months
Work plan and status	• Months 1-6: develop new methods for catch-per-set standardization. • Months 7-9: apply new methods to estimate a revised index.
External collaborators	
Deliverables	• SAC-10-17 Purse-seine indicators for silky sharks in the EPO • BYC-10 INF-A Purse-seine indicators for silky sharks in the EPO

PROJECT H.8.a: Design a survey for dolphins 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**: Stock Assessment Program	
Objectives	Design, in consultation with the IATTC staff and other relevant scientists, a ship-based line-transect survey for ETP dolphin species, including development of a comprehensive budget for implementation of the survey and analysis of survey results.
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 US 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 requires that the status of all species potentially impacted by the tuna fisheries be monitored. • In addition, abundance estimates are needed to ensure that incidental dolphin mortalities are both sustainable and insignificant, because the AIDCP 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.
Relevance for management	Improve the management of dolphin stocks in the ETP.
Duration	8 months
Work plan and status	• January - May: draft a report with survey design and budget. • June-August: obtain an external review of draft the draft report and revise as necessary.
External collaborators	University of St Andrews, Scotland

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 to be 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 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 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 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: