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**DEVELOPMENT, COMMUNICATION AND EVALUATION OF
MANAGEMENT STRATEGIES (MSE) FOR TROPICAL TUNA
FISHERIES IN THE EPO INVOLVING MANAGERS, INDUSTRY,
SCIENTISTS AND OTHER STAKEHOLDERS**

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1. INTRODUCTION

The main purpose of fishery management is to foster the sustainable exploitation of fishery resources, ensuring both the long-term viability of fish stocks and of the fisheries and other activities that depend on them. Fishery management is a complex interplay of multiple stakeholders with potentially different interests, roles and objectives. Among some of those stakeholders are fishermen, industry, managers, members of the public, and fishery scientists. The roles and involvement of different stakeholders in fisheries management varies depending on cultural, institutional, and historical factors. The role of fishery scientists has traditionally been to conduct analysis in support of the decision-making process, particularly by providing quantitative information about the status and trends of fish stocks both historically and projected under alternative management choices. The provision of scientific advice for fisheries management can take many forms, depending on the fishery, their historical context, the level of monitoring, available analyses and management systems.

The traditional approach for providing management advice typically relies on a “best assessment” model that integrates available data (e.g. catches, size compositions), external estimates of important processes (e.g. growth), assumptions about non- or poorly estimable parameters (e.g. natural mortality) and structure (e.g. stock structure). This approach has shown to be problematic due to over-sensitivity of model results (independently of the true changes in the stock) to changes in new data, data types, data analyses and assessment methodology or modeler. Since results of the assessment are often fed to a harvest control rule (HCR) that specifies management actions in relation to estimated stock status relative to estimated reference points, problems with assessment models can translate into management issues when the estimation of

reference points may also be problematic. Further issues are the lack of proper consideration of mid- to long-term tradeoffs (e.g. between exploitation and biological risk), tendency to focus on immediate or short term considerations of particular levels of management actions (e.g. the actual TAC or effort level) rather than on the decision process of setting them, tendency to a system of minimal management changes (particularly when assessment results are uncertain), incomplete treatment of uncertainty (i.e. typically only assessment uncertainty is considered).

Management strategies (often referred as management procedures) are the integrated combinations of agreed upon specific data inputs, specific analyses applied to that data and HCR used to determine specific management actions (e.g. catch quotas, length of fishing seasons). Management strategy evaluation (MSE) is widely considered to be the most appropriate way to evaluate the trade-offs achieved by alternative management strategies, integrating multiple sources of uncertainty, for achieving management goals. A fundamental difference between the traditional approach and MSE is the former focus on just assessment uncertainty, while the later integrates and appropriately deals with multiple sources of uncertainty such as implementation uncertainty, management/institutional uncertainty, sampling uncertainty, projection uncertainty. Another difference is the proper evaluation of risk through the feedback loop between a management strategy and the simulated system, differentiating MSE from risk assessments which tend to overestimate risk by failing to consider management responses to future data. MSE is the process of evaluation of management strategies using computer simulations, but it goes beyond being a scientific exercise since the process necessitates the involvement of stakeholders for refinement of current strategies and its elements (objectives, performance metrics, etc.) and the development of alternatives to evaluate. That is, while part of the MSE process is highly technical and done by scientists, another equally important part, such as defining objectives, performance metrics and candidate management strategies, requires input and participation of managers and other stakeholders. Those two parts should evolve in synergy for a successful MSE process. MSE has been widely used both nationally and internationally, including by all five regional fisheries management organizations for tuna (t-RFMOs: IATTC, IOTC, WCPFC, ICCAT, CCSBT) which are in different stages of development and implementation with CCSBT the furthest along with a successful MSE development, testing and implementation of management procedure already in place and with IATTC at the earliest stage in the process.

Fisheries for tropical tunas in eastern Pacific Ocean (EPO) ranged around 500 to 800 thousand tons since the year 2000, representing almost 14% of the world production of tuna and around 1.7 billion US\$ ex-vessel value in 2012. Management advice for EPO tropical tunas in the IATTC has traditionally been based on a ‘best assessment’ approach. Two species, bigeye (BET) and yellowfin (YFT) tunas, are assessed via formal stock assessment models, while skipjack (SKJ) tuna is leveraged relative to BET. The IATTC staff concluded that their BET (2018) and YFT (2019) stock assessments were not reliable to be used as the basis to provide management advice. Although Stock Status Indicators (trends in catch, CPUE, etc.) are often used in support of the assessments, they are not operationalized for example in a HCR to link them to specific management actions. When lacking reliable assessments there is no currently quantitative default process to provide management advice. The assessments were improved in 2020, but several uncertainties remain. To overcome issues with current assessments for BET and YFT, the staff recently proposed a weighted multi-model risk analysis that considers parameter and assessment model structure uncertainty (2020). Incorporating assessment uncertainty in the management advice is an improvement over the previous approach, allowing the evaluation of probability statements included in the current HCR. However, the IATTC staff recognizes ongoing unresolved issues in the understanding of the stocks, particularly for BET that can have large management implications for the combined species tropical tuna fishery, which is managed based on the species needing the strictest management. The staff proposed two venues to address ongoing issues and to improve management advice: improving stock assessments and continuing ongoing MSE for tropical tunas (one of the main goals of the IATTC [Strategic Science Plan](#)). The IATTC has adopted elements of a harvest strategy such as [interim HCR and reference points](#), however some elements may need to be refined (e.g. specificity of management objectives, probability of being

above target reference points) and other elements added (e.g. type, duration and derivation of management actions) to conform a complete strategy. On the technical component of MSE work, initial simulation testing work of a simplified HCR was conducted in 2016 and 2018 and substantial progress has been made on developing operating models, however a proper MSE process requires a complete specification or alternative strategies to evaluate, for which the input and participation of managers and other stakeholders is desired. There are no dedicated communication channels on MSE (such as Working Groups) within the IATTC, with SAC meetings and occasional workshops providing dialogue, communication and training on MSE. Introductory MSE workshops on MSE were held in Panama (2015) and the United States (2018), aimed at managers, and a further [five](#), aimed at the tuna industry, took place during 2019 in Colombia, Ecuador, Mexico, Panama, and USA. The [1st IATTC sponsored MSE workshop](#) was held in 2019, part of the [2018-2023 MSE workplan](#). The [2nd IATTC sponsored MSE workshop](#) was held virtually during 2021.

This document describes continuation of the two components of ongoing tropical tuna MSE work for years 2021 to 2023: 1) continuation of technical development, 2) organization and facilitation of stakeholder dialogue / communication workshops. Both components of the MSE work have been conducted by a contractor funded by external funds or a combination of external and IATTC funds, working with IATTC staff. Although [SAC-10 supported the MSE Workplan](#) and recommended continued funding support for this work, the current delay in IATTC meetings and funding uncertainties due to COVID-19 were a challenge for the continuation of funding of the MSE work beyond 2020. Recent funding was awarded by a contribution by the European Union to continue funding for the MSE of tropical tunas from 2021 to the end of 2023 (see Table 1 Timeline).

2. METHODS

2.1. OBJECTIVES

The general objective is to develop, evaluate and implement sustainable management strategies for tropical tunas in the EPO, continuing the ongoing MSE process at IATTC. Specific objectives are to provide technical support for the IATTC staff and to improve stakeholders understanding and communication of the MSE process, elicit objectives, performance metrics, alternative control rules, and specification of risk. The development of MSE workshop materials and online resources, along with of workshops with managers, industry and other stakeholders will allow communication of MSE results and feedback.

2.2. WORKPLAN

The proposed work plan combines support for the staff in the technical development of MSE for tropical tunas and a series of workshops for training and enhancing dialogue and communication among all interested parties regarding the MSE process. Tropical tuna fisheries in the EPO are multispecies (BET, YFT and SKJ), however management has been based on the species needing the strictest management based on results of single species stock assessments of BET and YFT. Historically, the estimated status of BET has determined management for tropical tunas and was therefore selected as the initial focus of MSE work. Although the ultimate goal is to evaluate harvest strategies in a multispecies context, experience from RFMOs and other organizations show that MSE processes are multi-year undertakings, even for single species. Given the limited and time-constrained funds available for MSE of EPO tropical tunas to date, it was decided to start with BET on the technical work, adding the other species as their current assessment models are improved (YFT) or implemented (SKJ). The stakeholder engagement will focus on dialogue on the three species, and the technical work conducted for BET will streamline the MSE work on YFT and SKJ as their modelling improves. Therefore, ongoing MSE work will continue to focus on bigeye tuna, moving to the other species towards the end of the timeframe. Both components of the MSE work will be conducted by a contractor working with IATTC staff. Computer work will be conducted at the IATTC headquarters, La Jolla, California, USA, and at the contractor's location of choice in similar arrangement

to what has worked effectively in previous years. Workshop locations will be depending on interest and logistics of stakeholders, including IATTC staff.

2.3. WORKPLAN IMPLEMENTATION

The proposed work consists of two components that evolve in synergy 1) technical development and execution of MSE simulation framework to evaluate alternative harvest strategies, 2) enhance stakeholder dialogue, and two-way communication of required inputs for the MSE and via development of online resources and workshops. Both components are described below:

2.3.1. TECHNICAL COMPONENT

The technical work of MSE involves writing, testing and implementing computer code and models of tropical tunas (continuing ongoing work with BET) under exploitation following simulated alternative harvest strategies, summarizing results and communicating them effectively. MSE will be structured as a modular system consisting of three major components (Conditioning, Projection and Evaluation) around several model types including operating models (OM), sampling models, estimation models (EM), management models and summary models.

- **OMs** describing the assumed true population (under different scenarios of growth, natural mortality, steepness, productivity regimes) and fishery dynamics (selectivity, catchability) will be implemented in the modeling platform *Stock Synthesis*. Both parameter and structural uncertainty will be considered when developing OMs, which will be weighted using a combination of Bayesian methods (MCMC, for model parameters) and grids across models with different structure (e.g. number of potential stocks).
- **Sampling models** will simulate how data (e.g. catches, size compositions, CPUE) are collected from the simulated “true” population and how they relate to simulated data (including observation uncertainty, the effect of measurement error and bias). The bootstrap functionality of *Stock Synthesis* is used to generate the observed data.
- **EMs** will use the simulated data to derive perceived stock status and trends, either using simplified assessment models or empirical stock status indicators (e.g. CPUE trends), allowing for evaluating their value as actual elements of empirical HCRs.
- **Management models** will use the perceived stocks status and trends to derive management action (e.g. closure days, catch limits) either via alternative model-based (simplified assessment models) or empirical HCRs (based on linking changes in a stock status indicators, such as CPUE, to a particular management action for example closure days). Implementation uncertainty will be incorporated, for example in the relationship between intended and realized changes in effort by adjusted closure days.
- **Summary models** will use performance metrics (e.g. variability in the catch, probability of falling below target or limit reference points) to evaluate the relative performance of alternative harvest strategies in achieving management objectives and inform the quantitative trade-offs among competing goals.

OMs will be conditioned (a process to ensure consistency with historical data) similarly to the process involved while fitting an assessment model but allowing for further processes (e.g. time varying parameters) depending on the scenario considered. OM parameters are then fixed to represent the underlying “true” population dynamics. Projections will be done with stochastic recruitment and provisions to incorporate other stationary or directional (e.g. changes in productivity or exploitation regimes) future dynamics. The basic procedure of the modeling component of the MSE includes the following steps, to be modified as needed:

1. Fit a set of assessment models to historical data under alternative population and fishery scenarios. This provides the parameters of the OMs that will be fixed for the analysis;
2. Compile the historical data and structure of the OMs to be used in either simplified assessment models (i.e. grouping of fisheries, reduced model complexity) or stock status and trends indicators (e.g. longline CPUE, simulated standardized purse-seine index);

3. Project the OMs forward for alternative management cycle lengths (e.g. 3 years) using the derived management action from a HCR of a candidate strategy using simulated data and random recruitment deviation (process error). This updates the stock trajectory for 3 years;
4. Change the data files of the updated OMs by a) adding 3 years to the model end year; b) put the catch calculated from the projected years from (3) in as catch of the updated 3 years; c) put the random recruitments used in the projected period into the updated 3 years; and d) add dummy data (CPUE, length composition, and last five years' average of sample size for the length composition) to the data file for the 3 new years;
5. Bootstrap to generate “perceived” catch observations, CPUE, and length composition for the whole time period (historical and forecast period). (historical and projected period). Update the fishery data by replacing the catch and dummy data with bootstrapped data only for the updated 3 years;
6. Repeat (2) - (5) for as many times as desired;
7. Repeat (2) - (6) for as many times as desired with different random recruitments;
8. Repeat (1) - (7) for each scenario and candidate strategy. The random recruitment deviations and simulated data for the historic period will be the same across scenarios to eliminate the impact of random recruitments when making comparisons between different scenarios and candidate strategies.
9. Results will be summarized across candidate strategies for different performance metrics to illustrate tradeoffs between different goals and the performance of candidate harvest strategies in achieving management objectives will be compared relative to each other.

The success and relevance of the technical work relies on inputs on elements and integration of candidate harvest strategies, such as management objectives, performance metrics, specification of HCRs. At the same time, results of the implementation of those inputs and preliminary results should be communicated effectively and regularly to stakeholders. These aspects are described in the next section.

2.3.2. STAKEHOLDER DIALOGUE COMPONENT

Strategies are based on choosing tactics (temporal or spatial closures, catch or effort limits) to achieve management objectives. If management objectives are not explicit and clear, alternative strategies cannot be realistically evaluated. Since there are no dedicated communication channels on MSE within the IATTC, SAC meetings (if time for other business allows) and recent workshops (such as the 2019 Industry workshops and the 1st IATTC sponsored MSE workshop) have provided opportunity for dialogue, communication and training on MSE, along with initial discussions on potential candidate management objectives. This component of the project consists of providing training and enhancing dialogue / communication among scientists, managers and other stakeholders regarding the MSE process for tropical tunas through the facilitation of a series of workshops between 2021 and 2023. The work involves development/tailoring of MSE Workshop materials and online resources to EPO tropical tuna fisheries including presentations and hands-on working sessions. Annual workshops will be conducted 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 and gather feedback. Training, communication materials and online interactive tools in English and Spanish will be continued to be developed to enhance understanding of the MSE process and results. See for example the online MSE demonstration tool used in recent workshops: https://valeromaspez.shinyapps.io/TunaMSE_EPO_ENG/ https://valeromaspez.shinyapps.io/TunaMSE_OPO_SPN/

The proposed timeline of workshops (WS) is as follows, subject to modifications for example as with [Resolution 17-02](#) with regards to [1st IATTC MSE WS](#), or for other unanticipated events such as the recent COVID-19 pandemic.

2021: WS to discuss alternative HCRs and refine strategy elements from previous WS

2022: WS to show MSE updated results, gather feedback, plan additional evaluation work

2023: WS to discuss MSE results, plan for other tropical tunas

3. EXPECTED RESULTS

The results will show the performance of the IATTC interim reference points and HCR for tropical tunas under different sources of uncertainty, facilitating adoption a permanent HCR for tropical tunas as per [Resolution C-16-02](#). The focus will continue initially on BET, which has been the species driving management measures for tropical tunas in the EPO, moving to other tropical tunas later in the process. The results will be used to inform IATTC staff, Commissioners and their scientific advisers, Industry and other stakeholders so that the current strategy can be refined, improved or modified based on results of the MSE. Reporting of MSE development progress and results will be done at regular SAC meetings, MSE workshops and other meetings, both as presentations, reports and communication materials and tools. This project will contribute to at least three of the seven overarching themes in the [IATTC Strategic Science Plan](#): *Sustainable Fisheries* (Evaluating the robustness of alternative harvest strategies with a proper treatment of uncertainty and risk using MSE, widely recognized as best practice for promoting sustainable management strategies), *Knowledge Transfer and Capacity Building* (Multiple opportunities for stakeholder input, dialogue and training) and *Scientific Excellence* (Promoting training and advancement of scientific staff in the MSE process and promoting the advancement of scientific research on MSE). It is expected that results of the project will be used by the Commission or its members in the development, evaluation and adoption of robust harvest strategies. The tools developed during the project will be useful in future MSE work not only for tropical tunas but for other related species. Although the scope of the MSE plan is initially on BET (as outlined in the MSE work plan in the IATTC Strategic Science Plan), this project will help expand the process to the other species towards the end of the proposed plan pending securing of funding.

4. FUNDING

The MSE process for tropical tunas has been carried out by an external contractor funded by IATTC, external sources, or a combination of both. At present funding is available through the end of 2023 via a funded proposal to the European Union. Continuation of the MSE process after 2023 is pending securing additional funds.

Table 1. Timeline for current Management Strategy Evaluation (MSE) workplan.

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

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.	Conduct a comprehensive MSE for bigeye tuna and plan MSEs for the other tropical tuna species												
I.1.a	1. Stakeholder and technical MSE workshops												
	a. Technical meetings to agree on overall/revised MSE Plan by IATTC staff and collaborators												
	b. Stakeholder workshops on training and communication on MSE development and results												
	2. Technical development of MSE, HCR, MP, outputs												
	a. Improve the bigeye assessment for use as spatial-OM												
	b. Run preliminary simulations with spatial-OM												
	a. Run preliminary MSE based on initial input from managers and stakeholders												
	b. Run final MSE based on revised input from managers and stakeholders												
	c. Present evaluated HCR/MP to Commission, plan work for other tropical tunas												
I.2.	Collaborate with ISC in Pacific-wide MSEs for albacore and Pacific bluefin tunas (*dependent on ISC scheduling)												
		ALB											
		PBF											
I.3	Initiate MSE work to evaluate indicator-based harvest strategies for prioritized species and species of specific interest												