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RELATIONSHIP BETWEEN THE CHARACTERISTICS OF PURSE-SEINE VESSELS AND FISHING MORTALITY (PROJECT J.2.a): PROGRESS REPORT

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CONTENTS

1. Background 1
2. Tasks 2
3. Progress and prospects 2
4. Collaboration with other projects 5
References 5
Appendix 1: Timeline 6
Appendix 2: FAD form 2018-09 7
Appendix 3: FIR 8

1. BACKGROUND

The constantly increasing effort of the purse-seine fleet in the eastern Pacific Ocean (EPO) requires more stringent management measures to conserve the stocks of tropical tunas. Extending the closures of the fishery, from the 1999 ban on sets on floating objects to the current 72 days of total closure, has been difficult for the Members of the Commission. Sometimes, additional measures have been tried as alternatives to adding more days to the closure, such as catch limits by set type in 2017, and limiting the number of active fish-aggregating devices (FADs) per vessel in 2018. Nevertheless, the current tuna conservation measure (Resolution C-17-02) may not be as effective as desired, and new and different measures may be required.

As such, the staff has recently received a growing number of requests for further analyses of alternative management measures. Also, using vessel well volume as the measure of fleet capacity when determining the days of closure needed to meet a conservation target is somewhat simplistic, and a more precise measure of capacity, and of the relationship between capacity and fishing mortality, needs to be quantified. In addition, the relationship between catches and the number of FADs deployments, active FADs, FAD history, environment, and technology, needs to be better understood. The staff has conducted some preliminary analyses in the past, but did not have the time or resources to undertake the in-depth investigations necessary to meet these requests. Therefore, a full-time researcher was hired in early 2018 for two years to address six related questions, requiring quantitative analysis, that were grouped into one project (J.2.a) in the Strategic Science Plan (SSP). This document describes the progress achieved during the first year of the project and presents the plan for the second year (Appendix 1), and outlines current needs and interactions with other projects of interest for the Commission.

2. TASKS

Project J.2.a responds, through an integrated investigation, to a series of management-related research requests recently made to the IATTC staff:

1. Evaluate the reliability of the data obtained on identification of FADs (per paragraphs 2-4 of Section 1 of Resolution C-16-01; now C-18-05).
2. Investigate methods for determining purse-seine set type from data currently collected by the AIDCP On-Board Observer Program and from vessel logbooks, canneries, and the IATTC port-sampling program (recommendation of the meeting of the *Ad Hoc* Working Group on FADs in May 2017).
3. Evaluate the relationship between catch and number of FAD deployments (continuation of work presented in Document SAC-08-06d).
4. Investigate more precise measures of fishing capacity that take into consideration days fished, set type, and vessel efficiency (SAC-08 Recommendation 13, Document IATTC-92-04c).
5. Investigate the relationship between fishing mortality and fleet capacity (SAC-08 Recommendation 13, Document IATTC-92-04c).
6. Evaluate alternative management measures, such as closed areas, individual vessel limits, and gear restrictions (SAC-08 Recommendation 13, Document IATTC-92-04c).

The results of these investigations will assist the staff in developing alternative recommendations for managing tropical tunas in the EPO, and provide the Commission with additional tools when developing management measures.

3. PROGRESS AND PROSPECTS

3.1. Task 1: Evaluate the reliability of the data obtained on identification of FADs

Although originally this task only considered Resolution C-16-01 (and later C-18-05), the analysis was extended to Resolution C-17-02, in order to conduct a more comprehensive evaluation of FAD data reporting. This led to document FAD-03 INF-A, presented at the 3rd meeting of the *ad hoc* Working Group on FADs in 2018, which served as the basis for the recommendations on FAD data collection and training by the staff (section B.4), the SAC, and the *ad hoc* Working Group on FADs. The document also presented proposals for improving the monitoring the FAD fishery in the EPO, which resulted in the following events during 2018-2019:

i. A **modified FAD form 9/2018** (Appendix 2), to meet the data requirements of Resolution C-18-05: allows tracking of satellite buoy changes, improves FAD tracking over time, and facilitates data recording. Available on the IATTC website, in print or electronic format.

ii. A **modification of the AIDCP On-Board Observer Program's *Flotsam Information Record*** (Appendix 3), to include new fields that allow FADs to be tracked over time, *e.g.* by recording satellite buoy changes. The modified form is being introduced in both the IATTC and national components of the AIDCP program.

iii. **Training workshops on the use of the new forms**. A workshop is scheduled in early May 2019 in San Diego, USA, and regular IATTC and national program training sessions will include this topic. The staff is working on video tutorials, which will be made available on the IATTC website.

iv. A **database on FADs reported under Resolution C-17-02**. Currently, this includes data on 151 vessels of 7 different CPCs, although availability, resolution and format differ at the CPC-company-vessel level. A preliminary analysis of the potential impacts of reducing the number of active FADs per vessel has been conducted (see section 3.5).

In addition, the evaluation led to a proposal for a pilot project (C.1.a) on FAD marking and tracking. However, this project has yet to be funded.

3.2. Task 2: Investigate methods for determining purse-seine set type

Because fishing sets are directly related to fishing mortality, in 2018 the IATTC staff proposed limiting the number of floating object and unassociated sets. However, this proposal was not adopted, due in part to anticipated difficulties with implementation and monitoring.

The staff has been working on automatic set type classification algorithms that analyze set data and categorize sets into either two groups (mammal/non-mammal) or three (mammal/unassociated/floating object). This would relieve observers of the responsibility of making the final decision on set type, and will allow retroactive monitoring of a vessel's fishing activities if catch limits by set type are implemented in the future. Preliminary versions of the algorithms were presented at the third meeting of the *ad hoc* Working Group on FADs in August 2018. The random-forest classification algorithm developed was based on observer data for 2013-2017, and included operational characteristics, catch and bycatch information (excluding marine mammals), and certain environmental parameters (*e.g.*, sea surface temperature). The misclassification error ranged between 2 and 11% for the 3-group algorithm, and 1 and 4% for the 2-group algorithm. These results were promising, and the staff is working on a new version of the algorithm, incorporating additional information (size of tuna in the catch, more detailed environmental data, *etc*.) that may improve these misclassification rates. Biodiversity metrics and multidimensional parameters are also being estimated for inclusion in the algorithm. Also, as alternatives to the random forest technique, algorithms using classification trees or bagging predictors will also be tested to help interpretation and inform consistency. A new version of the algorithm is expected to be ready for the meeting of the *ad hoc* Working Group on FADs in July 2019, and the final algorithm will be presented to the SAC and the *ad hoc* Working Group on FADs in 2020.

3.3. Task 3: Evaluate the relationship between catch and number of FAD deployments

A recently-published study led by IATTC staff members produced interesting results on the relationship between catch and number of FAD deployments (Lennert-Cody *et al*. 2018). These results will assist future management measure planning, as the effect of number of FAD deployments on the catch is better understood. However, it may still be necessary to refine the study once FAD tracking data, and thus FAD history, can be incorporated in the analysis. Currently, there are no plans to pursue this task further.

3.4. Tasks 4 and 5: Investigate more precise measures of fishing capacity/investigate the relationship between fishing mortality and fleet capacity

As mentioned above, the relationship between fishing mortality and fishing capacity is not perfect and alternative metrics should be explored. Tasks 4 and 5 aim to investigate in detail the relationship between fishing mortality and a number of factors, including operational, technological and environmental characteristics. However, some preparatory steps need to be taken before conducting in-depth analyses, such as developing probability maps of tunas, by species and size, based on environmental conditions (Section 3.5), indices of potential local and regional FAD densities, estimates of the number of active FADs each vessel can access at any given moment (Task 1; iv), and a compilation of FAD indicators that could be used to improve analysis and interpretation (see below). The staff is actively working on all these requirements, and expects to be able to incorporate them into Task 4 and 5 analyses in year 2 of the project. The results will be presented at the appropriate meetings in 2020.

3.4.1. FAD indicators

This section describes, as an example, the staff's work to date on developing FAD indicators.

Using a wide variety of indicators can improve both the evaluation of the impacts of a fishery and the utility of the results. Single indicators can be misleading, and lead to conservation measures that do not meet management objectives. Because of this, in 2018 the *ad hoc* Working Group of FADs recommended, as a priority, the development of a series of indicators for the FAD fishery before the Commission meeting in 2019. Also, in late 2018 a joint tuna-RFMO Technical Working Group on FADs (TWG-FADs) was created, as recommended by the 1st joint tuna-RFMO FAD Working Group meeting in 2017. The IATTC staff is actively collaborating in the TWG-FADs, and is leading the task on FAD indicators. A first draft of a list of FAD indicators has been developed, with more than 30 potential indicators ranging from catch and effort to ecosystem indicators. It is currently being used to guide discussions in the TWG-FADs, and will form the basis for a set of minimum FAD indicators to be adopted for global use during the 2nd joint tuna-RFMO FAD Working Group meeting in May 2019.

The TWG-FADs and the IATTC staff are working on the following tasks, directly related to this project:

a. Develop harmonized definitions of FAD-related terms.
b. Develop common minimum standards and formats to optimize and harmonize the collection of data on FADs.
c. Define minimum standards for FAD marking and tracking systems.
d. Define comprehensive systems to accurately quantify numbers of FADs and active buoys.
e. Facilitate coordination and collaboration on research plans on FADs.

3.5. Task 6: Evaluate alternative management measures

In 2017, the SAC recommended prioritizing work on the analysis of various options for the management and conservation of tropical tunas, such as developing alternative closures and limiting the number of active FADs. The work undertaken for this task aimed to respond to these recommendations; some of the lines of investigation the staff has been working on are described briefly below.

3.5.1. A dynamic ocean management approach for bigeye tuna

This investigation aims to develop adaptive closures and/or restrictive fishing systems (*e.g.* TAC[2]-based catches supported by weekly probability maps of the species) based on environmental conditions and operational characteristics. The methodology used and results obtained are described in document SAC-10 INF-D, including the effect of net depth and FAD depth on catches of juvenile bigeye and yellowfin tuna. For this project, collaborations were established with the Environmental Research Division of NOAA, responsible for the ECOCAST program off the US west coast (https://coastwatch.pfeg.noaa.gov/ecocast/) (Hazen *et al*. 2018), and CSIRO, responsible for the bluefin tuna seasonal forecasting program in Australia (Hobday *et al*. 2011).

During year 2, the focus will be on developing similar models for skipjack and yellowfin tunas, so that inputs can be weighted based on user preference to obtain potential spatial catch ratios to assist decision making by fishers. In addition, some of the work in the second year will be directed towards making this tool operational (*e.g.* automatic download of environmental data and model updates, development of a user-friendly front-end interface).

3.5.2. Analysis of buoy data

In order to facilitate future discussions by the Commission, and following SAC-08 recommendation 8, a preliminary analysis is being conducted on the impact of reducing the current limits on the number of active FADs a vessel can have at any given time. The study, which includes 151 vessels of 7 different CPCs and is based on data reported to the IATTC staff in 2018, aims to estimate how vessels would be affected

[2] Total allowable catch

by 25%, 33% and 50% reductions, and how many less FADs they could have. The results of this exercise will be presented at the meeting of the *ad hoc* working group on FADs scheduled for July 2019.

4. COLLABORATION WITH OTHER PROJECTS

During its first year, project J.2.a has been involved in the following additional activities, from which bilateral benefits are expected:

1. **Creation of an accessible open-source environmental database,** to be used by the J.2.a project and beyond. Having access to a detailed environmental data set can positively impact a range of current and future studies that are of interest for the Commission and the staff, including stock assessment, ecosystem, biology and ecology-related analyses. The terms of reference for the environmental task force have been established, and a series of high-resolution environmental variables for 1995-2017 have been downloaded and stored.
2. **Collaboration with the EU Purse-seine CPUE Working Group**, including attending its 3rd meeting in September 2018. The aim of the working group is to better understand PS CPUE and produce standardized indices to be used in the assessments of the Indian and Atlantic Ocean stocks. The progress and insights attained by this group could help improve EPO purse-seine indices in both the short and long term. In the light of the success of the longline CPUE workshop in February 2019, the staff is considering organizing a similar workshop on purse-seine CPUE in the near future.
3. **Contacts with the Global Fishing Watch program** (https://globalfishingwatch.org/) to investigate how VMS/AIS data can be analyzed to generate effort approximations for purse-seine fleets.
4. **Collaborate with components of the POSEIDON project** (K.1.a). This project aims to build and evaluate an agent-based, adaptive fishing fleet model as an analytic tool to support management, particularly for the FAD fishery.
5. **Collaborate with projects M.5.a** (*Develop and test non-entangling and biodegradable FADs*) **and M.5.b** (*Reducing losses, and fostering recovery, of FADs in the purse-seine fishery in the EPO*). The goal of these projects is to identify the key issues to prevent the loss or to recover FADs, test a series of non-entangling and biodegradable materials for FAD construction, and propose a plan to mitigate their impacts.
6. Collaborate with an internal project studying the **evolution of FAD strategies in the EPO** (Target J.1). This project aims to identify and monitor changes in fishing strategies to improve stock assessments and management advice by understanding spatio-temporal variability of FAD-oriented activities.

REFERENCES

Hazen EL, Scales KL, Maxwell SM, Briscoe DK, Welch H, Bograd SJ, Bailey H, Benson SR, Eguchi T, Dewar H, Kohin S, Costa DP, Crowder LB, Lewison RL (2018) A dynamic ocean management tool to reduce bycatch and support sustainable fisheries. Science Advances 4

Hobday AJ, Hartog JR, Spillman CM, Alves O (2011) Seasonal forecasting of tuna habitat for dynamic spatial management. Canadian Journal of Fisheries and Aquatic Sciences 68:898-911

Lennert-Cody CE, Moreno G, Restrepo V, Román MH, Maunder MN (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:fsy046-fsy046

Appendix 1: Timeline

TABLE 1. Timeline of the tasks and phases in project J.2.a. Each task has a color.

	Year 1 (March 2018-February 2019)												Year 2 (March 2019-February 2020)											
Task\Month	M 1	A 2	M 3	J 4	J 5	A 6	S 7	O 8	N 9	D 10	J 11	F 12	M 13	A 14	M 15	J 16	J 17	A 18	S 19	O 20	N 21	D 22	J 23	F 24
1	Evaluate resolu-tions					Modify data collection forms					Prepare buoy dataset				Train-ing	Assess new FAD forms and data								
2					Prepare dataset						De-velop algo-rithm					Refine algorithm							Final algo-rithm	
3	Done																							
4					Prepare dataset								Quantify relationship between various indicators and *F*										Develop manage-ment pro-posals	
5																								
6				Prepare dataset			Modelling												Additional modelling and operationalization					
Others							Establish collaborations; Environmental task force terms of reference						Implement Environmental task force											

Appendix 2: FAD form 2018-09

Append:

https://www.iattc.org/Downloads/Forms/FADs_Fish-aggregating%20device%20form%20(FADs)%20Sep-2018.pdf

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INTER-AMERICAN TROPICAL TUNA COMMISSION

FAD RECORDS

These forms (*FAD inventory and information* and *Activity on FADs*) are based on IATTC Resolution C-18-05 on the collection of data on fish-aggregating devices (FADs). They are designed to enable monitoring of FADs throughout a fishing trip.

GENERAL INSTRUCTIONS

it is the responsibility of the person in charge of fishing operations to ensure that the forms are properly filled out, and that the data recorded on the forms are correct, accurate, and complete, although the task of filling out the forms may be delegated to any vessel officer. **Do not write in the shaded spaces.**

You can fill the form out electronically, as an Excel workbook, or on paper, as you prefer.

Electronic forms: The MS Excel version of this form can be downloaded from the IATTC website (https://www.iattc.org/Downloads.htm). **Save it in xslm** (Excel Macro-Enabled Workbook) **format**, with the filename *'Vessel-Year-Trip.xslm'*, where *'Vessel'* is the name of the vessel, *'Year'* is the year the trip started, and *'Trip'* is a consecutive number of the trip in that year. For example, for the second trip in 2018 by the vessel *Guadalcanal*, it would be *'Guadalcanal-2018-02.xlsm'*.

Paper forms: Use as many forms as necessary to record all the required data during the trip.

a. **Page numbering:** In the corresponding space at the foot of each form, enter the sequential number of the form and, at the end of the trip, the total number of pages.
b. **Electronic copies**: If you scan the completed forms, save the file, in PDF format if possible, with the name as for the electronic forms.

1. FAD INVENTORY AND INFORMATION

a. Header

Vessel name: Enter the name of the vessel

IATTC vessel no.: Enter the number **allocated by the IATTC** on the Regional Vessel Register, available on the IATTC website: https://www.iattc.org/VesselRegister/VesselList.aspx?List=RegVessels&Lang=ENG

Trip start date: In the spaces provided, enter the date the trip started, in DDMMYY format; for example, May 10, 2018, would be entered as *'100518'*.

b. FAD details

FAD ID: The ID to enter depends on the system that you use for identifying your FADs.

- **If you use the number of the satellite beacon**, enter the manufacturer's make and model code from Table 1 and the beacon's unique serial number. If you use a make or model not included in the table, enter it in the table and provide as much information as possible under *Comments/Observations*.
- **For other types of beacon**, enter a unique identifier that your vessel assigns to the FAD or locating beacon, and that can be used as a reference for future encounters with that FAD.
- **If you use the alphanumeric code provided by the IATTC**, enter the code that you assigned to this particular FAD. Enter the letters in the first column, and the sequential number in the second column.
- For cases not covered here, describe under *Comments/Observations*.
- **If you use the satellite beacon's number as the FAD ID and you change the beacon on a FAD, it is important that you record the ID of both beacons**, the original and the replacement, on separate lines. Under *Comments/Observations*, make a note that the beacon was changed on the FAD.

IATTC FAD form 09-2018 Ver. 2. General instructions

Appendix 3: FIR

Append:

https://iattc.sharepoint.com/:b:/r/SAC%20Documents/BYC-09/8-F%20-%20FIR%2004-2019.pdf?csf=1&e=fIAFus