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REVIEW OF IATTC RESOLUTIONS C-16-01 AND C-17-02: AVAILABLE INFORMATION, DATA GAPS, AND POTENTIAL IMPROVEMENTS FOR MONITORING THE FAD FISHERY

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CONTENTS

ABSTRACT

The use of fish-aggregating devices (FADs) in tropical waters has increased significantly worldwide since the 1990s. Because their extensive use may have implications for the ecosystem, including target and non-target species and habitats, all the tuna regional fisheries management organizations have implemented conservation measures intended to monitor and control the impacts of these devices, including more comprehensive data collection and reporting schemes.

In general, but in particular for the eastern Pacific Ocean, these FAD-related measures (IATTC Resolutions C-16-01 and C-17-02), although in force and implemented, are in their early stages. Consequently, both resolutions ask the IATTC staff, the Scientific Advisory Committee, and the *Ad-Hoc* Permanent Working Group on FADs to review the progress and results of the implementation of the FAD provisions and make recommendations to the Commission, as appropriate.

This document presents a review of Resolutions C-16-01 and C-17-02, analyzes the current forms and proposals for collecting data on FADs, describes current data availability, identifies data gaps, explores new methodologies for FAD marking and tracking, and discusses the potential implications of the current situation and the suggested changes for monitoring and managing the FAD fishery more holistically and from a global perspective. It also makes several recommendations on FAD data collection and monitoring, such as updating data collection forms, requiring high-resolution buoy data, revising the text of resolutions regarding FAD issues, and developing an effective FAD marking scheme, which are in line with the recommendations by the IATTC staff outlined in document SAC-09-15, and also support the staff's research work plan (SAC-09-02) and the IATTC Strategic Scientific Plan (SAC-09-01) in the short and the long term, respectively.

1. INTRODUCTION

The use of fish-aggregating devices (FADs) in tropical waters has increased significantly worldwide since the 1990s, and particularly in recent years with the use of new technologies for tracking FADs, such as satellite-linked echo-sounder buoys (Fonteneau *et al*. 2013; Lopez *et al*. 2014). It has been estimated that about 15,000-20,000 FADs have been deployed annually in the eastern Pacific Ocean (EPO) in recent years (Gershman *et al*. 2015; Hall and Román 2017), and about 100,000 globally (Scott and Lopez 2014; Gershman *et al*. 2015). The potential impacts associated with FAD use (Dagorn *et al*. 2012), including higher catch rates of juvenile bigeye and yellowfin tunas, increased bycatches, perturbation of ecosystems, and alteration of the normal behavior and ecology of the species associated with FADs, emphasize the need for management measures for this fishing gear.

Because of these impacts, all the tuna regional fisheries management organizations (t-RFMOs) have implemented conservation measures intended to monitor and control the impacts of FADs on the ecosystem and on exploited resources in their respective areas (Commission 2015). For example, FAD data collection systems and management plans have been implemented at both RFMO and national levels, the number of FADs a vessel can have at any time has been limited, the use of more ecologically friendly FADs has been promoted (*e.g.* use of non-entangling and biodegradable materials), and a FAD marking and identification scheme has been identified as key to resolving the scientific questions. The issue of marking FADs is a global and contemporary concern, and not only in tuna RFMOs: the FAO Code of Conduct for Responsible Fisheries (Article 8.2.4; FAO 2011)) and the Technical Consultation on the Marking of Fishing Gear (Gilman *et al*. 2018), as well as the United Nations Fish Stocks Agreement (Article 18(3) d) (Örebech *et al*. 1998), require marking of all fishing gears, including FADs.

The IATTC has taken some specific measures to mitigate the impacts of FAD fishing in the EPO. For example, since 2004 the purse-seine fishery has been subject to a seasonal closure, and an offshore area known as the "*corralito*" is closed for an additional 30 days; these measures were originally imposed because of concerns about the effect of the FAD fishery on juvenile bigeye. Also, since 1 January 2018, Resolution C-17-02 limits the number of active FADs a vessel can have at any one time to between 70 and 450, depending on the vessel size class, and requires CPCs[1] or their vessels to report daily information on all active FADs to the IATTC staff at monthly intervals. Furthermore, to better understand the potential impacts of these devices on the ecosystem, and to complement the data collected by the onboard observer program, Resolution C-16-01 requires all CPCs, or their vessels, to provide, as of 1 January 2017, information on the characteristics of all

[1] Members and Cooperating Non-Members of the Commission

FADs used during a fishing trip.

Resolutions C-16-01 and C-17-02, although in force and implemented, are in their early stages. Consequently, both resolutions ask the IATTC staff, the Scientific Advisory Committee (SAC) and the *Ad-Hoc* Permanent Working Group on FADs (WG-FADs) to review the progress and results of the implementation of the FAD provisions and make recommendations to the Commission, as appropriate. This document presents a review of these measures, analyzes the current forms and proposals for collecting data on FADs, describes current data availability, identifies data gaps, explores new methodologies for FAD marking and tracking, proposes potential improvements where necessary, and discusses the potential implications of the current situation and the suggested changes for monitoring and managing the FAD fishery more holistically and from a global perspective.

2. THE RESOLUTIONS: OBJECTIVES, REQUIREMENTS, ASSUMPTIONS, AND ISSUES

2.1. Resolution C-16-01

2.1.1. Objectives

The principal aim of Resolution C-16-01, which amends resolution C-15-03 on the collection and analyses of data on FADs, is to ensure that the best available scientific information is collected in order to meet the long-term conservation and sustainable exploitation goals of fisheries in the EPO. To this end, it aims to assess and reduce the negative impacts of FAD fisheries (Table 1), through: i) collection of data related to FAD activity; ii) a FAD identification scheme; iii) non-entangling FADs; iv) prohibition of sets on whale sharks; and v) an *Ad-Hoc* Permanent Working Group on FADs. This document focuses on the first two, FAD data collection and FAD identification, which are strongly related. As with the other resolution considered in this document (C-17-02), there are FAD-related compliance matters associated with the resolution.

2.1.2. Requirements

Resolution C-16-01 states that "*beginning 1 January 2017, CPCs shall require the owners and operators of all purse-seine vessels flying their flag, when fishing on FADs in the EPO, to collect and report*" the following information "*for each interaction with a FAD:*

i. *Position;*
ii. *Date;*
iii. *Hour;*
iv. *FAD identification;*
v. *FAD type (e.g., drifting natural FAD, drifting artificial FAD);*
vi. *FAD design characteristics (dimension and material of the floating part and of the underwater hanging structure);*
vii. *Type of the activity (set, deployment, hauling, retrieving, loss, intervention on electronic equipment, other (specify));*
viii. *If the activity is a set, the results of the set in terms of catch and bycatch; and*
ix. *Characteristics of any attached buoy or positioning equipment (positioning system, whether equipped with sonar, etc.).*"

However, while the Resolution states, in paragraph 2, that "*the data may be collected through a dedicated logbook, modifications to regional logsheets, or other domestic reporting procedures*", in Annex 1 of the same resolution it states that data collection should be done "*using a standard format to be developed by the Commission staff*". A form for this purpose (FAD form 9/2016) has been developed, and is available on the IATTC website[2].

[2] https://www.iattc.org/Downloads/Forms/FAD-Form-3.1.3-ENG.pdf

Resolution C-16-01 recognizes the importance of FAD identification, and in paragraph 9 states that "*No later than 1 January 2017, CPCs shall require the owners and operators of their applicable flagged purse-seine fishing vessels to identify all FADs deployed or modified by such vessels in accordance with a Commission identification scheme detailed in footnote 1 of Annex 1*". The scheme in that footnote is that "*CPCs shall obtain unique alphanumeric codes from the IATTC staff on a periodic basis and distribute those numbers to the vessels in their fleets for FADs that may be deployed or modified, or in the alternative, if there is already a unique FAD identifier associated with the FAD (e.g. the manufacturer identification code for the attached buoy), the vessel owner or operator may instead use that identifier as the unique code for each FAD that may be deployed or modified*". Thus, the responsibility of marking FADs lies with the operators and CPCs, but the IATTC staff is responsible for defining and administering the marking scheme.

Beginning 1 January 2017, CPCs are required to provide the information reported to them by their vessels for the previous calendar year to the Director "*no later than 60 days prior to each regular meeting of the SAC*" (14 March in 2018). Also, "*no later than the IATTC annual meeting in 2018, the scientific staff of the IATTC, in coordination with the SAC … shall present to the Commission the preliminary results of its analyses of the information collected … and shall identify additional elements for data collection, as well as specific reporting formats*, *necessary to evaluate the effects of the use of FADs on the ecosystem of the EPO fishery*" and "*taking into account the outcomes of the Ad Hoc Working Group on FADs, shall present to the Commission initial recommendations for the management of FADs … including a region-wide FAD management plan*". It is also a responsibility of the IATTC staff to find the best way to combine and link the FAD database with the AIDCP database, on which progress is being made.

2.1.3. Assumptions and issues

In the IATTC staff's opinion, the following aspects of Resolution C-16-01 are potentially problematic, and may have implications for achieving the objectives of the resolution.

Firstly, the resolution does not appear to require that natural floating objects (*e.g.* flotsam, logs) not equipped with a transmitter buoy be reported. If such unmonitored natural floating objects are not reported, the data collected pursuant to the resolution will be incomplete, and will not provide comprehensive information for evaluating the potential impacts of floating objects in general.

Secondly, the following apparent assumptions in the resolution may not be justified:

a. **Data provided by Class 1-5 vessels are accurate**
   FAD form 9/2016 is the only source of data on FAD activity of Class 1-5 vessels, as these vessels do not have to carry observers. Not subjecting the data to some kind of quality control, and simply assuming that they are accurate, could be risky. Captains, unlike observers, are not trained in FAD data collection, and there is no debriefing or data review for captains after the trip.
b. **All FADs are marked with some type of identifier**
   FADs deployed without a buoy may be unmarked, unless they are physically marked in accordance with the IATTC identification scheme.
c. **FADs can be effectively tracked using the buoy identifier**
   A buoy can be transferred from one FAD to another, or removed from a FAD or floating object that is left in the water, or substituted when a vessel starts monitoring a FAD that it was not monitoring previously ("buoy-swapping"). Also, there is no guidance on how to handle buoy changes, and this could lead to a FAD being misidentified, misreported, or unreported.
d. **The buoy identifier is always available to the observer/captain**
   The buoy identifier may not be always available to the captain (or the observer, if there is one aboard), particularly when buoy-swapping occurs or the vessel does not approach the object sufficiently closely.

TABLE 1. Summary of the objectives, assumptions, and data requirements of Resolutions C-16-01 and C-17-02.

Applies to	Objectives	Assumptions	Requested data	Responsible (filling/reporting)
C-16-01; entered into force 1 January 2017				
All purse-seine vessels* * only source of FAD-related information for Class 1-5 vessels	• FAD data collection • FAD identification • Use of non-entangling FADs • Ban setting on live whale sharks • Establish an *ad hoc* WG on FADs	• Data provided by Class 1-5 vessels (mainly with no observer) is accurate • Logs do not need to be reported (unless they are equipped with a buoy) • All FADs are marked with some type of identifier • FADs can be tracked using Buoy ID • Buoy ID is always available to the observer/captain	FAD Form 9/2016 or similar, but containing all the information in annex 1: For each interaction with a FAD: i. Position; ii. Date; iii. Hour; iv. FAD identification; v. FAD type (*e.g.*, drifting natural FAD, drifting artificial FAD); vi. FAD design characteristics (dimension and material of the floating part and of the underwater hanging structure); vii. Type of the activity (set, deployment, hauling, retrieving, loss, intervention on electronic equipment, other (specify)); viii. If the activity is a set, the results of the set in terms of catch and bycatch; and ix. Characteristics of any attached buoy or positioning equipment (positioning system, whether equipped with sonar, *etc*.).	Captain/CPCs [FAD Form 9/2016 or similar]
C-17-02; entered into force 1 January 2018				

All Class 4-6 purse-seine vessels and longline vessels over 24 m
 	
* FAD management measures also apply to PS 1-3.
	Conservation of tropical tunas in the EPO 2018-2020, including:
	• Monitor and limit the number of active FADs at sea at any one time.
	• Per-vessel FAD limits:
	  • Class 6 (≥ 1,200 m^3): 450 FADs
	  • Class 6 (< 1,200 m^3): 300 FADs
	  • Class 4-5: 120 FADs
	  • Class 1-3: 70 FADs
		• Each vessel deploys its own FADs.
		• No FADs deployed without a buoy attached,
		• All FAD deployments are conducted with active buoys.
		• Buoys cannot be activated/deactivated remotely,
		• FADs are tracked solely by the owner (and the fishing company).
		• Active FADs (as defined in the Resolution) represent a good proxy of total number of FADs at sea.
			Buoy daily information, not clearly specified, but FAD-WG suggested the following:
			• Date
			• Time
			• Buoy ID
			• Owner (Vessel)
			• Location
			• Speed
			• (also suggested daily deactivation data for computing parameters of interest for stock assessment [CPUE standardization]).
				Buoy manufacturer/national verification entity (NVE)-CPC [Guidelines proposed by the IATTC WG on FADs] 60-90 days of delay

2.2. Resolution C-17-02

2.2.1. Objectives

Resolution C-17-02, which amends Resolution C-17-01, establishes conservation measures for tropical tunas for the 2018-2020 period (Table 1). It continues the existing spatiotemporal closures for the purse-seine fishery and the catch limits for the longline fishery, as well as other provisions, such as the use of non-entangling FADs and prohibitions on landings and transshipments of tuna or tuna products originating from illegal fishing activities. Among the specific actions for the FAD fishery, this document focuses on the measures established to monitor and control the number of FADs used in the fishery.

Like Resolution C-16-01, Resolution C-17-02 contains compliance requirements for the FAD fishery. It sets the maximum number of FADs that a vessel may have active at any one time between 70 and 450, depending on the vessel's capacity (Table 1). It should be noted that the resolution also establishes that "*A FAD shall be activated exclusively onboard a purse-seine vessel*" (paragraph 9) and that "*a FAD is considered active when it is (a) deployed at sea, and (b) starts transmitting its location and is being tracked by the vessel, its owner, or operator*" (paragraph 10). Paragraph 10 makes a distinction between "*the vessel*" and "*its owner, or operator*", yet paragraph 9 does not make reference to ownership of the FAD. Since tender vessels, whose role is to deploy, repair, pick up, and maintain FADs at sea, have been prohibited in the EPO since 1998 (C-98-05), the intent of the text of the resolution is unclear; it could be interpreted that the FAD/buoy can be deployed by a vessel that does not own it, an activity that is prohibited by the Commission (C-98-05, paragraph 12). Similarly, paragraph 10 also uses the term "*operator*", which is broad, and may refer to various persons or entities, such as fishing companies, the vessel captain, *etc*.

2.2.2. Requirements

Resolution C-17-02 states that "*CPCs shall report, or require their vessels to report, daily information on all active FADs to the Secretariat, in accordance with guidance developed under Paragraph 12, with reports at monthly intervals submitted with a time delay of at least 60 days, but no longer than 90 days*" (paragraph 11). The resolution entered into force in 1 January 2018, and thus data for January should be received no later than 1 April 2018. Paragraph 12 requires the IATTC staff and the WG-FADs to develop guidelines for reporting FAD data "*in accordance with paragraphs 10 and 11*". Those guidelines have already been developed (Annex 2), and are described and discussed further in section 3.2.1 of this document; however, they have not yet been formally adopted by the SAC. Thus, while specific data are stipulated in Resolution C-16-01, this is not the case for Resolution C-17-02. Moreover, the resolution does not define the source of the data to be used to monitor compliance (*e.g.* buoy data), in contrast to other t-RFMOs (IOTC Resolution 17/08; ICCAT Recommendation 16-01).

2.2.3. Assumptions and issues

If the intent of the resolution was to set a limit on overall FAD activity, then it would appear to be making the following assumptions:

a. Each vessel deploys its own FADs;
b. No FAD is deployed without a buoy attached;
c. All FADs are deployed with an active buoy;
d. Buoys cannot be activated/deactivated remotely;
e. FADs are tracked solely by the owner vessel (and the fishing company), and not by other vessels;
f. Active FADs (as defined in the resolution) represent a good proxy of total number of FADs at sea.

For the resolution to be effective, it should consider the abovementioned assumptions. However, none of these points is explicitly covered in the text of the resolution. This creates considerable ambiguity and

confusion with respect to data collection. An issue is the fact that the data that may ultimately be provided may not be adequate to monitor compliance with FAD limits. Specific shortcomings are outlined in Section 3.2.2, where they are discussed in the context of the information that is currently being proposed to be collected.

3. DATA COLLECTION FORMS, EXISTING OR PROPOSED, AND SHORTCOMINGS

The data sources, forms, data flows and working schemes used in the implementation of the two resolutions show some similarities, but also significant differences (Figure 1). This section reviews the data the current forms are collecting, or are intended to collect, and the current or proposed data flow processes, and highlights potential shortcomings.

3.1. Resolution C-16-01: FAD form 9/2016

3.1.1. Data collection

Currently, the FAD data required by Resolution C-16-01 are being collected through FAD form 9/2016, developed by the IATTC staff (Annex 1). The vessel crew are responsible for completing the form, but the data are reported to the IATTC staff through the CPC. Observers also collect information on FADs through the Flotsam Information Record (Annex 3), which can serve for validation purposes. However, Class 1-5 vessels rarely carry an observer aboard, and thus the information collected through FAD form 9/2016 is usually the only source of information specific to FAD activities for these vessels.

FAD form 9/2016 includes, in addition to general instructions and guidance for completing the form, two

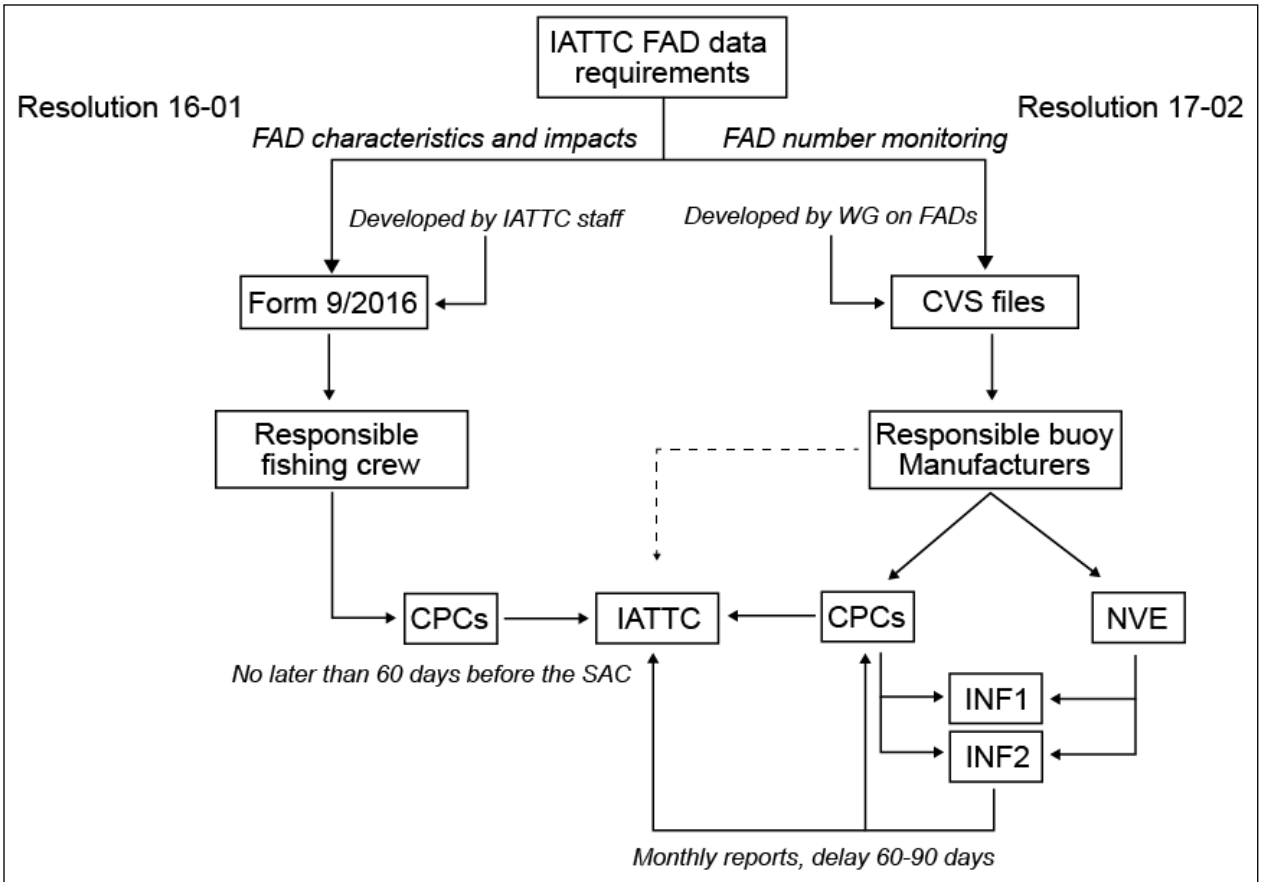

FIGURE 1. Data flow and working scheme for the data required to be reported to the IATTC, CPCs, or NVEs under Resolutions C-16-01 and C-17-02.

independent records (*FAD activity* and *Information on FADs*) that are linked through the buoy identification code. The first, *FAD activity*, records information on the type of the activity undertaken on the FAD (assessing, deploying, setting on, recovering, or other), as well as the date, time, and position of the activity and, if a set was conducted, the resulting catch of target species (in weight) and of most sensitive non-target species (either in weight or number). The second, *Information on FADs*, records, in addition to the buoy identification data, information on the type (natural, owned FAD, not owned FAD, anchored FAD), dimensions (depth x width x length), and main components and configuration of the different parts of the floating object, as well as on the type of buoy attached. The buoy identification code, the field that links these two forms, was intended to be a specific to the FAD according to the resolution C-16-01 (see section 2.1.2), but in practice, most fishers use the buoy identifier for this purpose.

3.1.2. Shortcomings

To identify potential shortcomings with respect to data collection, Figure 2 summarizes the main situations a floating object (whether FAD or flotsam) can experience at sea, and the ability of FAD Form 9/2016 to capture them. Of particular importance is that the form is not set up to record data on multiple buoy identifiers, which would be necessary in cases where buoy-swapping occurs. Without adding a new field to the form for recording both current and previous buoy identifiers, it will be difficult to monitor the use of, and the activities associated with, a FAD if the buoy is changed. This means that the form is only useful for collecting data on, and tracking and identifying, FADs that remain attached to a single buoy. So, as it is now, it is very unlikely that FAD form 9/2016 is useful to properly track and identify all FADs throughout their entire lifetime. Section 5.1 proposes changes to improve this situation. It is worth noting that, while it is technically possible to record data on unmonitored flotsam (*i.e.* natural objects not equipped with some form of tracking device) on the form, the resolution does not require those data to be recorded. Of course, as with unmonitored FADs, unmonitored flotsam cannot be tracked over time unless it has some form of identifier.

3.2. Resolution C-17-02: guidelines developed by the *Ad-Hoc* Working Group on FADs

3.2.1. Data collection

Paragraph 12 of Resolution C-17-02 requires the IATTC staff and the WG-FADs to "*develop, at the latest by 30 November 2017, guidance on the reporting of FAD data in accordance with Paragraph 10 and 11 of [the] resolution, including the format and specific data fields to be reported*". The current version of the guidelines, prepared in February 2018, after the capacity building workshop on the topic held in Panama City in December 2017, is presented in Annex 2. It includes guidelines on the specific format of the data to be reported and details of the proposed data flow.

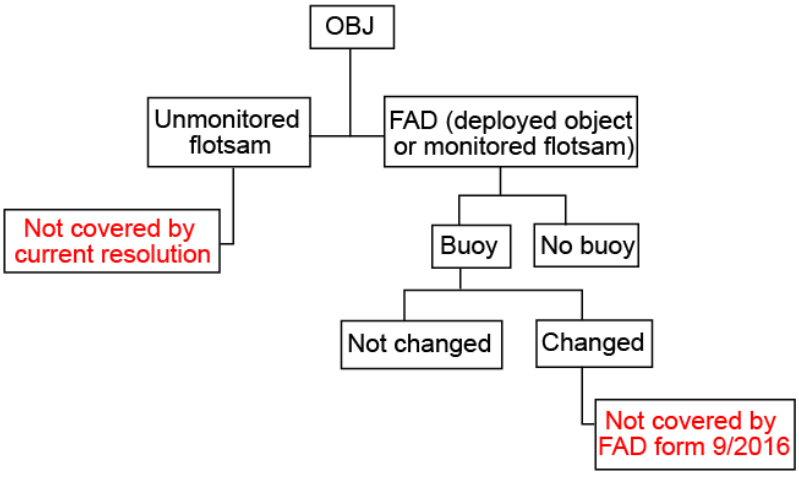

FIGURE 2. Summary of the main situations a floating object can experience at sea, and the ability of FAD Form 9/2016 to capture them.

The data flow and working scheme for Resolution C-17-02 are summarized in Figure 1. The data used to monitor compliance with the FAD limits set in the resolution

are to be reported by buoy manufacturers at monthly intervals to a verification body designated by each CPC for that purpose. Unlike for other compliance determinations involving purse-seine vessels, the verification body need not be the IATTC staff, but can be any entity designated by the CPC for that specific purpose (*e.g.* a national verification entity, NVE) or the CPC itself.

Data should be submitted by buoy manufacturers "*with a time delay of at least 60 days, but no longer than 90 days*". A standard data request letter to buoy manufacturers was also developed by the WG-FADs in January 2018 for use by CPCs and fishing companies in a coordinated data petition to buoy manufacturers.

The data should be provided in a csv file containing daily records of all the active FADs[3] monitored by an individual vessel. Each csv file, which must include the vessel identifier in its name, is to contain the following fields:

a. Date [YYYY/MM/DD],
b. Time [hh:mm],
c. Buoy identification code [specific alphanumeric code provided by the buoy manufacturer],
d. Latitude [decimal degree],
e. Longitude [decimal degree],
f. Speed [knots].

The guidelines suggest a number of filtering steps to eliminate data that do not correspond to active FADs. For example, records outside the EPO, on land, or aboard the vessel should be removed.

Estimates of the daily number of active FADs per vessel are to be made by the verification body. If the verification body is not the IATTC staff, then, in accordance with paragraph 11 of the resolution, for compliance monitoring purposes, "*CPCs shall report, or require their vessels to report, daily information on all active FADs*" to the IATTC staff. In such cases, the report needs to contain only three fields: Date, Vessel identifier, and the number of active FADs per day. The WG-FADs is considering requesting an additional report, with monthly 1°x1° information, for research purposes, and has drafted a preliminary format, with the following fields:

a. Year [Year of activity],
b. Month [Month of activity],
c. CPC,
d. Number of vessels,
e. Latitude [decimal degree],
f. Longitude [decimal degree],
g. Average number of active FADs [Average number of active FADs belonging to the vessels of the CPC over the month[4]].

3.2.2. Shortcomings

The flowchart in Figure 3 summarizes the potential situations that a floating object and its associated buoy can experience when at sea, and which situations would be addressed or not by the proposed data

[3] The term 'active FAD', as defined in the resolution, means a FAD that was activated exclusively aboard a vessel and deployed at sea, and is transmitting its location and is being tracked by the vessel, its owner or operator, but may be interpreted and reported by buoy manufacturers as any buoy that is transmitting its position and other information

[4] Calculated by summing the total number of active buoys recorded per day during the month in a particular 1°x1° square grid and dividing by the total number of days

collection scheme. A floating object can be flotsam or a FAD, and the latter can be equipped with a buoy or not, and the buoy can be transmitting or not transmitting. None of these conditions is permanent, and buoys can change from transmitting to not transmitting, or vice versa, following human decisions that can be made for a variety of reasons. To better understand the potential shortcomings of the proposed data collection scheme, a detailed description of FAD buoy specifics follows.

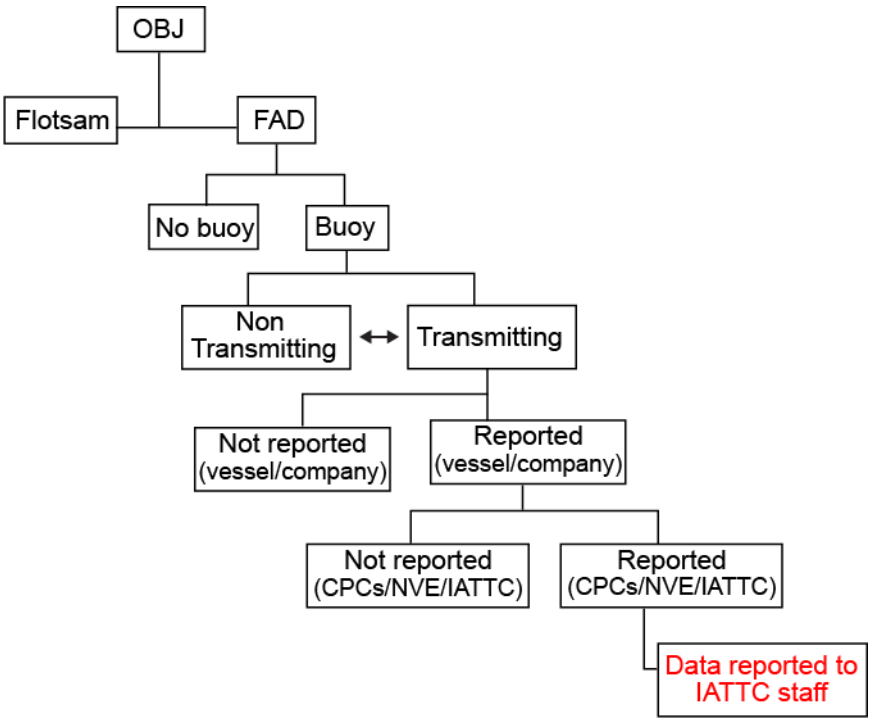

FIGURE 3. Summary of the potential situations a floating object and its associated buoy can experience when at sea, and which situations would be considered or not by the proposed data collection scheme.

Satellite buoys can be attached by fishers to any natural or artificial floating object, and it is believed that they are usually activated before they are deployed. Buoys can transmit, in addition to location and time, information on their course and drift speed, water temperature, and the size of the fish aggregation associated with the FAD. Once the buoy is activated, the transmission frequency, which is usually brand-specific, can be adjusted according to the intended use of the FAD: the most common frequencies are hourly, two-hourly, twice a day, and daily (Lopez *et al*. 2014; Escalle *et al*. 2017). However, there is a broad range of possible transmission frequencies, and can differ both among FADs and among time periods for the same FAD. It is worth mentioning that the transmission rate varies during specific time windows, like for example, when the vessel is approaching the object or a particular request (*e.g.* configuration changes) needs to be sent to the buoy. Thus, receiving a single transmission per day may not be enough to properly monitor FAD use activities and patterns.

In addition to the transmission frequency, other parameters necessary to analyze buoy data with respect to the FAD limits of Resolution C-17-02 are uncertain. First, it is unclear whether the drift speed information is instantaneous speed or an estimated value (*e.g.* mean between two points). Speed data appear to be highly variable, and instrumentation may be inconsistently calibrated among buoys, so may not be a good indicator of actual speed (Escalle *et al*. 2017). Also, low speed values do not necessarily mean that the FAD is drifting; the buoy may be aboard a vessel that is drifting, setting, investigating a tuna school, or visiting a FAD, so speed data alone may incorrectly classify a FAD as adrift. Second, because purse-seiner activities change over the course of the day (typically inactive or cruising at night, searching for tuna during the day, with most fishing sets conducted at sunrise), the time selected for a daily data transmission may also be important. Information on how and why each buoy manufacturer selects the time for the data transmission would be important for standardize the data provided. Third, it is unknown whether buoys can be remotely activated or deactivated. If remote activation/deactivation is possible, determining whether a buoy was activated aboard the vessel will be difficult under the current working

scheme of only one daily transmission. Fourth, active buoys are continuously streaming data to end users, usually fishing vessels and offices on land. The number of users that can be included in the data transfer at no additional cost is unclear, especially if the transmission is not conducted in real time but with a certain time delay. Trials undertaken by PNA (Parties to the Nauru Agreement) in 2013 indicate that it is technically feasible for satellite buoys to send information to more than one receiver, at no additional charge (MRAG 2017). Fifth, in addition to data transmission frequency, the end user can select what data are transmitted: for instance, by geo-fencing (Escalle *et al.* 2017), or displaying only buoys over a minimum biomass threshold (*J. Lopez, pers. comm.*). Finally, for these and more reasons, a preliminary analysis of the PNA FAD tracking data by the staff of the South Pacific Commission (SPC) (Escalle *et al.* 2017) suggested that the received dataset may only represent a subset of the buoys used by the fleets. Therefore, all these issues should be clarified as much as possible, as they are fundamental to the analysis and interpretation of buoy data with respect to the requirements of Resolution C-17-02.

Acknowledging the limitations of the data provided by the buoy manufacturers can help with finding solutions and improvements for enhancing data provided for compliance monitoring and for improving the data available for the accurate estimation of FAD densities at sea. Section 5.2 of this document identifies the data gaps and proposes solutions for the main issues regarding Resolution C-17-02.

4. FAD-RELATED DATA PROVIDED TO THE IATTC STAFF AS OF 13 APRIL 2018

4.1. Data provision related to Resolution C-16-01

Although Resolution C-16-01 requires CPCs to provide the data corresponding to the previous calendar year (*i.e.* 2017) to the Director "*no later than 60 days prior to each regular meeting of the SAC*" (*i.e.* 14 March 2018), compliance to date has been poor, as indicated by the data in Table 2.

Table 2 summarizes the data required by the resolution that was actually provided to the IATTC staff, for trips that started between 1 January and 31 December 2017, for vessels of all size classes. Under the AIDCP, there is 100% coverage by observers of vessels of carrying capacity greater than 363 tons (Class 6). Occasionally, for various reasons, observers are also placed on vessels of lesser capacities (Class-5 (capacity 273-363 t), Class-4 (182-272 t), or Class 1-3 (< 182 t)), but coverage of these vessels is not mandatory, and is very low.

The data collected by observers is the main source of FAD information used by the IATTC staff. For unobserved trips, the IATTC staff abstracts information recorded in the vessels' logbooks whenever possible, but as some of these vessels operate in areas where no IATTC staff are available, the information on

TABLE 2. Data provided to the IATTC staff, as of 13 April 2018, under Section 1 of Resolution C-16-01, from trips starting in 2017, by fleet.

2017	Número de viajes - Number of trips								
	A			B			C		
	Total			Con lances OBJ			Formularios provistos		
				With OBJ sets			Forms provided		
Clase - Class	**1-4**	**5**	**6**	**1-4**	**5**	**6**	**1-4**	**5**	**6**
COL	9	7	44	9	6	44	2		44
ECU	255	70	369	248	67	347			
MEX	1	2	198			87			
NIC			30			17			
PAN			80			77			9
PER	10	17	18			11			
SLV			12			11			11
EUR			8			8			
USA	83		46			46			
VEN			41			26			
Subtotal	**358**	**96**	**846**	**257**	**73**	**674**	**2**	**0**	**64**
Total			**1,300**			**1,004**			**66**
%									**6.6%**

various aspects of the fishery, including arrival and departure dates of the trips, may not be very accurate. For vessels that the staff cannot visit, the IATTC staff tries to obtain trip date information through national agencies or the vessel owners, but this is not always possible.

For the above reasons, the total number of trips (Table 2, Column A), is an estimate, although the number of trips by Class-6 vessels is well known. Column B identifies the number of trips from column A for which the IATTC staff has information that any activity on floating objects occurred, including fishing sets. Column C details the number of FAD forms 9/2016 provided to the IATTC staff as of 13 April 2018.

It is evident from the table that compliance with the provision of these data is minimal: only 66 forms (6.6%) have been received from over a thousand trips, and only two (0.2%) from Class 1-5 vessels. Moreover, this percentage could be even smaller if trips for which the staff does not yet have any information are included.

4.2. Data provision related to Resolution C-17-02

According to the guidelines for data reporting developed by the WG-FADs (Annex 2) and Resolution C-17-02, data for January 2018 should be received by 1 April 2018 (*i.e.* 60-90 days of delay). As of 13 April 2018, only one CPC has submitted data to the IATTC staff, a total of 14 files for 14 different vessels, each file containing daily information from one brand of buoy used by one vessel during January. It is possible that additional data have been submitted to CPCs or national verification entities, but the staff has no information on this, and thus on the overall level of compliance with the data provision requirements of Resolution C-17-02.

5. SUMMARY OF DATA GAPS FOR RESOLUTIONS C-16-01 AND C-17-02, AND POTENTIAL SOLUTIONS

5.1. Resolution C-16-01

FAD form 9/2016 (Annex 1) and the IATTC *Flotsam Information Record* (Annex 3) are reasonable sources of data on FAD structures, characteristics, and associated catch, and they record a large part of the data necessary to assess the impacts of FADs on the ecosystem. However, they are not designed to track floating objects over time, and the resulting lack of tracking data is impeding scientific research.

The FAD fishery is dynamic, and objects remain at sea for extended periods of time. Ideally, FADs should be tracked and monitored during their entire lifetime, but this cannot be done with the current FAD form 9/2016, for two main reasons. First, FADs are currently identified only by the buoy identifier, and the form does not contain a field for recording buoy changes. Buoy-swapping is a common practice worldwide (Abascal *et al*. 2014; Lopez *et al*. 2014; Maufroy *et al*. 2015; Snouck-Hurgronje *et al*. 2018), and the inability to record this information makes effective tracking of FADs difficult. Second, re-deployment of a FAD is not an option among the type of activities on the form. The number of FAD retrievals in the EPO seem to be relatively high (Hall and Román 2017), and it is likely that many of the retrieved FADs are re-deployed at some point (Scott and Lopez 2014). Both these problems could be easily solved with two simple modifications of FAD Form 9/2016: (1) replace the "Identification" field with three fields ("Buoy change (Y/N)", "Previous Buoy ID", and "Current Buoy ID"); (2) add a code for "FAD re-deployment". These changes would make it possible to estimate rates of buoy-swapping and FAD re-deployment, thus making it possible to both quantify these effort-related activities and evaluate the availability of buoy IDs to vessels who are not the owners of a FAD.

Another consideration is that Paragraph 1 of the Resolution C-16-01 defines the term "FAD", but does not consider unmonitored natural objects as items to be reported. If the objective of the resolution is to gather information to improve the understanding on the potential impacts of FAD fisheries in general, it would be useful to record data on all floating objects in the ocean, natural or artificial, monitored or unmonitored. For that purpose, extending the requirements and the definition of Resolution C-16-01 to

include activities on all floating objects, and a concomitant modification of the instructions for FAD Form 9/2016, should suffice.

The above changes are easy to implement, but are based on the assumption that FADs can be effectively tracked using only the buoy identifier. However, this is not always the case, and the current marking scheme is inadequate for tracking a floating object throughout its lifetime. There are different schemes for marking FADs (FAD ID only, Buoy ID only, or a combination of both FAD and Buoy IDs); Table 3 summarizes the advantages and disadvantages of each scheme, to facilitate discussion of the best solution

TABLE 3. Advantages and disadvantages of different FAD marking schemes.

	Advantages	Disadvantages
FAD ID only	- Relatively easy to implement - Agreed in Res. 16-01 - Gear marking requirements (FAO, UN) met - Partial life history obtained - Patterns of FAD use (number of sets, visits, soak time, *etc*.)	- Lose track information between sightings - Lose information on effective life (deactivations, lost, *etc*.) - Need to generate non-reusable ID codes - Need to specify marking rules (size, color, material, pre-printed tags, *etc*.) - Observer presence for verification
Buoy ID only	- Easy to implement - Automatic ID using the buoy - No additional cost (tracking data can be sent to various users) - Full life history of the FAD (if buoy changes are recorded) - Patterns of FAD use (number of sets, visits, soak time, stranding areas, *etc*.) - Patterns of Buoy use (reporting frequency, activation/deactivation areas, swapping rate, *etc*.)	- Difficult to obtain lifetime track if a buoy change is missed - Assumes all FOBs are equipped with buoys - No info on FOBs equipped without a buoy - Observers not always have access to buoy ID information (*e.g.* remote activation-deactivation, buoy info inaccessible, wrong ID) - Data entry of large codes is difficult and prone to errors - - Potential loss of information if geo-fencing or similar occurs - Previous initiatives noted that this data may only be a subset of all used buoys (Escalle *et al*. 2017)
Both FAD and Buoy ID	- Complete track of the lifetime - Gear marking requirements (FAO, UN) met - Low cost (tracking data can be sent to various users) - Will increase info on the real number of FADs (new deployments + FOBs at sea progressively) - Info on swapping rates - Better knowledge of total FOBs, including FOBs with no buoy - The more complete info to progress in several scientific topics. - Patterns of FAD use (number of sets, visits, soak time, stranding areas, *etc*.) - Patterns of Buoy use (reporting frequency, activation/deactivation areas, swapping rate, *etc*.)	- Need to generate non-reusable ID codes - Need to specify marking rules (size, color, material, pre-printed tags, *etc*.) - Observer presence for verification

to this problem.

Although all marking schemes have positive and negative aspects, the combination of physical marking of FADs (FAD ID) and buoy ID (as used currently) seems to be the best option currently available to effectively identify and track FADs. A new FAD marking system that includes both these elements is described in the next section.

5.1.1. Web-based secure FAD database

Monitoring and tracking FADs from the moment of their deployment is a key element for better understanding the effects of these devices on the fishing strategy of the fleet, as well as on the ecosystem and the exploited resources. The best way to mark and monitor FADs has been broadly discussed globally in recent years by scientists, managers, and the industry (MRAG 2017; Gilman *et al*. 2018; He and Suuronen 2018), and marking FADs with both a specific FAD ID and the buoy ID has been recognized as the best option (Table 3). The FAD marking scheme adopted by the IATTC in Resolution C-16-01 is based on applying a unique physical marking to the FAD. However, it has not yet been implemented in practice and as an alternative, the use of the buoy ID has been suggested to CPCs to collect data for FAD Form 9/2016. Here, we present a proposal for a FAD marking and monitoring scheme that combines the best features of each marking option, and uses both FAD ID and Buoy ID, which has a number of advantages compared to single-ID marking schemes.

Any monitoring scheme must be able to accommodate the diverse vessel behaviors in floating-object fisheries. When a vessel is at sea, it is continuously or potentially interacting with floating objects. Fishing vessels can carry out several activities related to FADs when at sea, such as deploying new FADs, modifying existing ones, visiting them, starting to monitor objects that were unmonitored or monitored by others, and retrieving or re-deploying objects. Additionally, fishers can activate or deactivate buoys independently of any of these activities; the combinations are endless. Also, vessels can interact with floating objects that are not equipped with satellite-linked buoys.

Most, if not all, vessels fishing on FADs have a satellite internet connection, and the method proposed here is based on vessels registering FADs in a web-based dataset/system (Figure 4). This could be done in advance, while in port, or in real time, at sea, and FADs could be registered individually or in batches. Normally, batch registrations would be done in advance (when building and storing FADs in port) and single registrations in real time, occasionally or as needed, as when a user cannot anticipate activities on particular FADs. The vessel or company registering a FAD would have to provide information on the FAD's characteristics (structures, materials, *etc*.), associated buoy ID (if applicable) and its activity information, including catch of target and specified non-target species (similar to FAD Form 9/2016). When a FAD is registered, the vessel or company would be issued a unique identifier for the FAD, and a system-generated certification to prove that the FAD was registered, which would be the official record of FADs for each vessel. Every floating object that is deployed, set on, monitored, or re-deployed would have to be registered (*i.e.* retrieved FADs would still be recorded by the observer, but need not have a specific FAD ID unless they were re-deployed); if a previously-unregistered floating object became involved in any of these activities, it would have to be registered and entered into the system. In this way a large proportion of the floating objects that are currently at sea would be progressively incorporated into the system, which would give us a much better idea of the total number of floating objects at sea, both monitored and unmonitored.

Registration would need to be done via a web-based platform, and the information would be automatically uploaded to a secure database in the cloud. A vessel temporarily without a satellite connection would have 48 hours after an activity to register the floating object and the associated information. In such cases, the object would be allocated an identifier by the vessel itself, from a set of

identifiers that would be assigned to the vessel prior to the fishing trip. If a vessel needs to obtain identifiers, those could be generated through the system, or requested from the IATTC by email. For vessels with observers, all the events and activities should be validated by the observer, who would also record the activity in his notebook, which would be provided to the IATTC after the fishing trip. The observer debriefing processes would include validation of several randomly-selected FAD IDs (similar to an audit).

The database would be maintained and managed by the IATTC staff, and would need to be linked to the AIDCP database, and also with the buoy data received in the context of Resolution C-17-02. Ideally, the information should be automatically sent to both the IATTC and the vessel's flag CPC simultaneously, so that the debriefing-validation with the observer could be done right after the fishing trip. Alternatively, the information could be sent from the web-based system to each CPC, NVE or similar, which would then forward the information to the IATTC at some agreed frequency (*e.g.* after each fishing trip, monthly, quarterly, annually).

5.2. Resolution C-17-02

Resolution C-17-02 limits the number of active FADs that a vessel may have at any one time, and allows activating FADs "*exclusively aboard a purse-seine vessel*". Also, it states that "*a FAD is considered active when it: (a) is deployed at sea; and (b) starts transmitting its location and is being tracked by the vessel, its owner, or operator*".

The data currently requested from the buoy manufacturers contains a single data point per vessel per day, the selection criteria for which are still unclear (see Section 3.2.2). These data may not have a high enough resolution to allow validation of the conditions listed above, especially on-board activation, but some simple measures may help to improve monitoring of the number of active FADs per vessel in the context of Resolution C-17-02. One possibility is to obtain high-resolution data with the same characteristics that vessel operators are receiving, which would significantly increase the chances of properly identifying on-board activations. High-resolution buoy data can be forwarded to multiple users at no additional cost in other oceans (MRAG 2017), but if this is not economically or technically possible

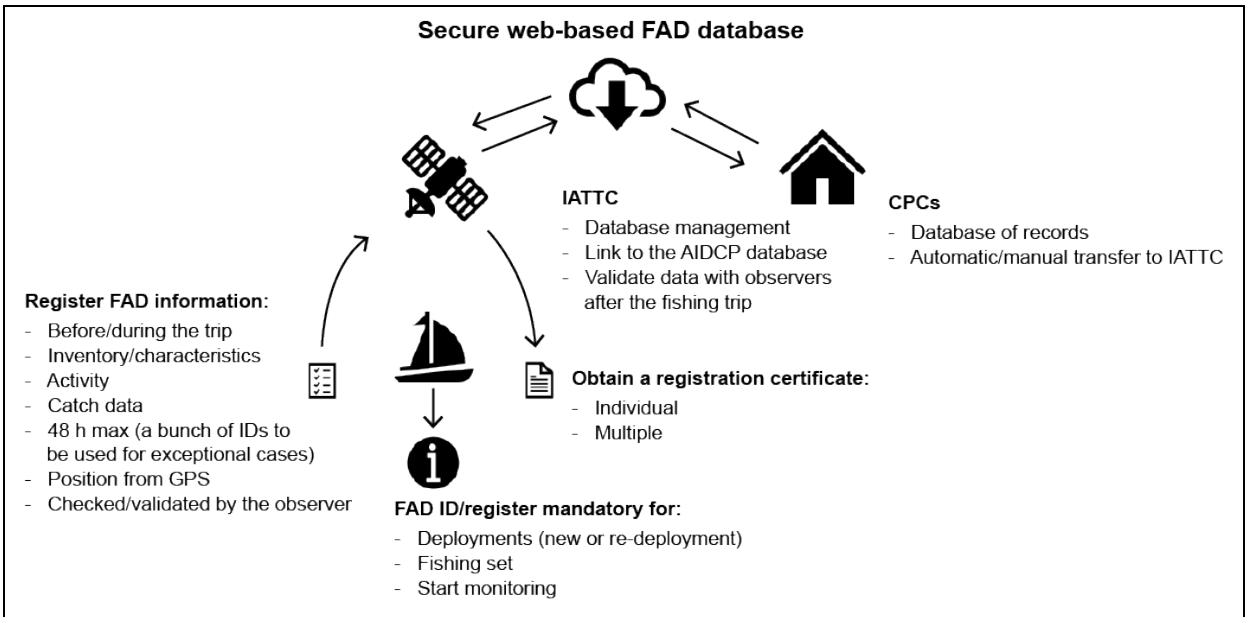

Figure 4. A summary of the working scheme proposed to create the web-based secure FAD database.

in the EPO, observers could copy the buoy information for the fishing trip from the vessel computers to password-protected USB drives (60 days of data represent relatively few megabytes, *J. Lopez pers. comm.*). Another option is to obtain from buoy manufacturers, in addition to the daily position, finer-scale information at the time of first transmission(s) upon activation. Similar fine-scale data, but for deactivations, is being requested from the buoy companies for comparable initiatives in the Indian and Atlantic Oceans (*J. Lopez pers. comm.*). Higher-resolution buoy data during critical periods (*i.e.* activation and deactivation events) may increase scientists' ability to validate onboard activations.

Apart from modifying the frequency of requested buoy data transmissions, the previous measures can also be complemented with additional control mechanisms, such as comparing buoy first appearances with data from Vessel Monitoring Systems (VMS), observer data, and/or FAD Form 9/2016 information. Observer and FAD Form 9/2016 data also make it possible to randomly select buoy IDs associated with different activities (*e.g.* deployments) and verify their active status in the buoy data system.

6. DISCUSSION

This document aims to provide context for discussions regarding the data that are being currently collected under Resolutions C-16-01 and C-17-02, and to propose possible solutions and improvements that can be relatively easily implemented. It also explores global and local patterns in FAD-related issues, and discusses what FAD data are necessary to answer certain contemporary scientific questions. However, to do so, a number of considerations need to be taken into account.

If the FAD limits are to be monitored by several entities (*i.e.* NVE, CPCs, with or without the IATTC staff), it is essential to develop and establish standardized and harmonized working methodologies. Without a harmonized and standardized approach to estimating the daily number of active FADs per vessel, it seems very unlikely that results by CPC could be assembled. Under a project sponsored by the European Union, standardized regional estimation methodologies are being developed for use by scientists of different countries, and this could be extended to the Pacific Ocean.

As noted above, the data collected on FAD Form 9/2016 and from the buoy manufacturers, while useful, have several shortcomings. They are, for instance, inadequate for tracking FADs over their entire lifetime (*e.g.* unmarked FADs, FADs without a buoy, unavailability of the buoy ID), for verifying compliance with some aspects of Resolutions C-16-01 and C-17-02 (*i.e.* buoys activated exclusively onboard), for identifying and analyzing the many different activities and strategies of the fishing fleet (*e.g.* buoy swapping, re-deployment events), and for assessing their impacts on the target stocks in particular and the ecosystem in general. This has implications for the scientific study and assessments of the tuna stocks, and thus for their conservation and management, as the results derived from the data collected in the context of the resolutions can contribute significantly to answering some important scientific questions. For example, these data may be used to estimate FAD densities but also to derive parameters that may be of declared interest for standardizing catches per unit of effort (CPUEs). Although observer data by themselves can provide information on many aspects of fishing strategies and FAD use, such as the proportions of FADs with and without buoys, type of buoys used, FAD deployment and retrieval ratios by area and season, *etc.*, it is necessary to combine and compare the observer and captain/buoy manufacturer databases to provide more reliable results that could ultimately improve stock assessments and our understanding of the impacts of the FAD fishery.

The data reported by buoy manufacturers do not represent the whole FAD trajectory history, but only a unique data point per day; also, buoy IDs are currently being used in place of FAD markings. These shortcomings are significantly impeding progress on many scientific questions related to the FAD fishery. If FADs were fully marked and buoy data were reported with higher resolution for the entire trajectory of the FAD (ideally the original data transmitted by the buoys), a number of scientific projects could be

developed, such as: estimating local FAD densities; FAD dynamics and their links to CPUEs and fishing mortality; identifying patterns of buoy use (transmission frequencies, FAD-approaching strategies, geo-fencing, biomass thresholds, *etc*.) and FAD use (*e.g.* areas and seasons of deployment and retrieval); estimating buoy-swapping rates and their link to fishing power; identifying FAD drift patterns, stranding rates and areas; and relationships between soak time and catch, including size and species composition differences in the catch. In addition, if buoy data are accompanied by the automatically-sampled biomass information, the following projects could also be developed: investigation of environmental preferences of FAD-associated fish; relationship between biomass distribution and FAD density, including the school fragmentation hypothesis; evaluation of operational patterns of vessels relative to the biomass dynamics along the trajectory; studies of the colonization process of floating objects, including natural objects; and the development of fisheries-independent abundance indices to complement current stock assessment results. Many of these projects have been identified as short- and long-term priorities in the staff research work plan (SAC-09-02) and the Strategic Scientific Plan (SAC-09-01), respectively. Some of the activities in those plans that are linked to these data are: development of an abundance index based on echo-sounder buoy data, investigating the relationship between operational characteristics of the FAD fishery and mortality, mitigating the impacts of the FAD fishery on the ecosystem, and improving the quality of data-collection programs, including FAD data.

6.1. Data collection and FAD limits in other t-RFMOs

FAD marking and identification, as well as limiting numbers of FADs per vessel as part of effort control, are current and common issues among t-RFMOs. All t-RFMOs have recently implemented measures to monitor, assess, control, and/or reduce the use of FADs and their potential impacts on the ecosystem and exploited resources (Table 3). Also, the four major t-RFMOs[5] have recently established working groups on FADs, and a joint t-RFMO FAD working group was established in 2017.

Although all t-RFMOs agree on the need for robust FAD marking and tracking systems, there is no common agreement on how to implement them. For example, the IATTC agreed, in Resolution C-16-01, a FAD marking scheme through physical marking of all FADs or, alternatively, using buoy IDs. In practice, buoy ID is being used and no physical marking of FADs is being conducted so far. If physical marking of FAD is ultimately implemented, marking standards would need to be defined, in collaboration with industry and other stakeholders. In the western Pacific, WCPFC agreed a FAD marking scheme based on buoy ID, and is exploring a complete marking system (SC13, TC13, CMM 17-01); countries have to establish FAD plans to collect and report data, but no forms have been developed for submitting data to the Secretariat. In the Atlantic, ICCAT agreed that FAD plans should include FAD marking, but provided no specific guidance (Recommendation 16-01); the ICCAT WG on FADs in 2016 proposed using buoy IDs. ICCAT uses Form ST08-FadsDep for FAD data reporting; this was analyzed by EU scientists (Báez *et al*. 2017) and modifications are under discussion, mainly related to the availability of data for completing each field and unclear definitions of some terms. In the Indian Ocean, the IOTC agreed that artificial FADs should be marked using either buoy ID or FAD physical marking (Resolutions 15-08 and 17-08); flotsam is not mentioned, and the system is still to be adopted in practice. IOTC Form 3FA, used for FAD data reporting, was also reviewed by EU scientists (Báez *et al*. 2017), with results similar to those for the ICCAT form.

All four t-RFMOs have imposed FAD limits, but monitoring arrangements vary (Table 4). IATTC and WCPFC have limited the number of FADs per vessel to 70-450 and 350, respectively, since January 2018, while ICCAT has had a 500-FAD limit since 2016, and IOTC has a progressively-decreasing limit, from 550 in 2015 to 350 currently. IOTC also limits the number of buoys a vessel can purchase annually, to twice the daily limit (*i.e.* 1100 in 2015, and now 700). Both IOTC and ICCAT have explored methodologies for monitoring

[5] IATTC, ICCAT, IOTC, WCPFC

TABLE 4. Comparison of measures on FAD marking, data collection, FAD limits and monitoring, among t-RFMOs.

	FAD marking and data collection	FAD limits and monitoring
IATTC	- Measure: Res. 16-01 - FAD marking: FAD physical marking; Buoy ID as alternative - Data reporting: FAD Form 9/2016 (or similar but containing the same information)	- Measure: Res. 17-02 - Limit: 70-450, depending on vessel capacity; on-board activation - Data reporting: under discussion, but INF1 and INF2 of Annex 2 - Monitoring: daily buoy data.
ICCAT	- Measure: Rec. 16-01 - FAD marking: no specific guidance; buoy ID proposed by WG FADs - Data reporting: Form ST08-FadsDep	- Measure: Rec. 16-01 - Limit: 500; no on-board activation requirement - Data reporting: Form ST08-FadsDep - Monitoring: daily buoy data.
IOTC	- Measure: Res. 15-08, 17-08 - All artificial FADs to be marked; decision on FAD ID or buoy ID pending - Data reporting: Form 3FA	- Measure: Res. 17-08 - Limit: 350 (+ 700 annual buoy purchases); on-board activation - Data reporting: Form 3FA - Monitoring: daily buoy data.
WCPFC	- Measure: SC13, TC13, and CMM 17-01 - FAD marking: buoy ID; exploring fully marking system - Data reporting: no standard form	- Measure: CMM 17-01 - Limit: 350, on-board activation - Data reporting: not specified - Monitoring: not specified

daily FAD usage per vessel and CPC (Santiago *et al*. 2017); they currently use a single position per active buoy per day, provided by buoy manufacturers. Only ICCAT does not require that buoys be activated exclusively aboard. This measure is, in theory, a good mechanism for preventing remote activation of buoys and evasion of control systems.

The data in Table 4 reflect the significant progress made in controlling FAD use in recent years, although requirements and terminology are not harmonized among t-RFMOs, as noted by Báez *et al*. (2017). Currently, buoy IDs are generally used to identify FADs, although physical marking is also required (but not implemented) in the Pacific and Indian Oceans. Daily data from buoy manufacturers are generally used for monitoring compliance with FAD limits but, with increasingly restrictive management measures, more precise validation mechanisms will be needed.

7. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are in line with the recommendations of the IATTC staff outlined in document SAC-09-15, the research work plan (SAC-09-02), and the Strategic Scientific Plan (SAC-09-01).

7.1. Provision of data on FADs

CPCs are required by Resolution C-16-01 to provide data on FADs for the previous calendar year "*no later than 60 days prior to each regular meeting of the SAC*", and the scientific staff of the IATTC is required to present a preliminary analysis of that information to the SAC. However, given the many other tasks required of the staff in preparation for the meeting of the SAC, this does not allow sufficient time for a thorough analysis of the data, therefore more timely provision of data is desirable.

RECOMMENDATION:

CPCs should provide the FAD data from each fishing trip to the IATTC staff as soon as they receive them at the end of that trip.

7.2. Updates of FAD data-collection forms

As noted in Section 5.1, FAD form 9/2016 (Annex 1) and the IATTC *Flotsam Information Record* (Annex 3) are reasonable sources of data on FAD structures, characteristics, and associated catch, and they record a large part of the data necessary to assess the impacts of FADs on the ecosystem. However, they are not designed to track floating objects over time, and the resulting lack of tracking data is impeding scientific research.

RECOMMENDATION:

Modify FAD form 9/2016, and the observer program's *Flotsam Information Record*, to include new fields that will enable FADs to be tracked over time

7.3. Provision of high-resolution buoy data and additional control mechanisms

As noted in Section 5.2, Resolution C-17-02 limits the number of active FADs that a vessel may have at any one time, and allows activating FADs "*exclusively aboard a purse-seine vessel*". Also, it states that "*a FAD is considered active when it: (a) is deployed at sea; and (b) starts transmitting its location and is being tracked by the vessel, its owner, or operator*". The data currently requested from the buoy manufacturers contain a single data point per vessel per day, the selection criteria for which are still unclear. These data may not have a high enough resolution to allow validation of compliance with these requirements, especially on-board activation, but some simple measures may help to improve monitoring of the number of active FADs per vessel in the context of Resolution C-17-02.

RECOMMENDATION:

CPCs should provide to the IATTC staff:
(a) the same raw buoy data received by original users (*i.e.* vessels, fishing companies).
(b) Vessel Monitoring System (VMS) data to assess compliance with respect to Resolution C-17-02 more robustly.

7.4. Review and refine the texts of Resolutions C-16-01 and C-17-02 with regard to FADs

Some terms and language in Resolutions C-16-01 and C-17-02 are unclear and/or undefined, or conflict with definitions used in other IATTC programs or other t-RFMOs. For example, the definition of a FAD in the AIDCP observer manual is different to that of Resolution C-16-01, the terms "active FAD" and "operator" in C-17-02 are not defined, nor is the distinction between "vessel" and "owner". Also, as noted in Sections 2.1.3 and 2.2.3, there are apparent assumptions made in the resolutions that should be clarified and resolved, and apparent oversights, such as not requiring unmonitored natural floating objects to be reported, should be rectified. A partial list of such terms is included in Annex 4.

Some of this work could be carried out in coordination with the *ad-hoc* working group established under Resolution C-17-05 to review the legal and operative coherence of IATTC resolutions.

RECOMMENDATIONS:

1. Define and/or clarify terms and concepts used in instruments and documents related to FAD issues.
2. As appropriate, standardize and harmonize the terminology related to FAD issues used in different ocean regions, especially within tuna RFMOs.

7.5. An effective and reliable FAD marking scheme

As noted in Section 5.1.1, monitoring and tracking FADs consistently from the moment of deployment is key to a better understanding of the effects of these devices on the fishing strategy of the fleet, as well as on the ecosystem and the exploited resources. The most effective way to mark and monitor FADs has been widely discussed globally in recent years by scientists, managers, and other stakeholders, but has not been implemented yet. Considering that proper FAD marking and identification would enable progress on many scientific questions, developing a robust and effective FAD marking scheme should be a priority.

RECOMMENDATION:

Conduct field research on FAD marking to develop a robust and effective FAD identification scheme supported by the fishing industry, managers, and scientists (Document SAC-09-02, Proposal C.1.a)

7.6. Web-based secure FAD database

FAD data are currently collected using different forms, and may not be easily accessible and ready to store and use efficiently. As a natural step in the technological era, cloud-based databases should be developed to advance in this field, where a variety of data can be merged in a single database that reduces the workload for captains and accelerates data availability and reliability (Section 5.1.1).

RECOMMENDATIONS:

Develop a secure, remotely-accessible, web-based database that includes all available information on FADs (activity, structures, identification, etc.).

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Annex 1. FAD Form 9/2016

COMISION INTERAMERICANA DEL ATUN TROPICAL – INTER-AMERICAN TROPICAL TUNA COMMISSION

Fish-aggregating device form (FADS)

GENERAL INSTRUCIONS.

This form is designed to satisfy the requirements in Annex I of Resolution C-16-01. It is important that it be completed as thoroughly as possible.
Do not write in the shaded areas.
This form should be completed by the master or the person in charge of the fishing operations. The master can delegate this duty to another appropriate officer.

HEADING

Vessel: The name of the vessel.

Trip number: Write the calendar year of the start of the trip and the consecutive number of the trip for that calendar year in the spaces provided. For example:*' 2015-001'*, denotes the first trip in 2015.

License No.: This makes reference to the vessel's unique identification provided by the flag State.

FAD ACTIVITY

Date: The date of the event in the format DD/MM/YY (day/month/year)

Time: The local time of the event in a 24 hour format (13:00 = 1 pm).

Identification (of the locating buoy): Record the unique identification number of the locating buoy. If this is a satellite buoy, it **must** be the unique serial number. If it is another type of locating buoy, use a unique identification code that you provide to the FAD or the locating buoy and that can be use as reference for future encounters. For cases not described here, use the space under *Comments.*

Activity: From the following list, chose the numeric code that best describes the activity that you are registering.

1. Assessing: The vessel approaches the FAD to evaluate the quantity of tuna, but makes no set.	**2. Deployment:** A new or replacement FAD is deployed.
3. Set: The vessel makes a set on the object. If the set is made on a recently deployed FAD, make notes in *Comments* section.	**4. Recovered.** The FAD is recovered and placed onboard.
5. Other: Record any other activity not described above, on comments.	

Geographic location: Write the geographic location of the event (Latitude and Longitude) in degrees and minutes. Note the corresponding hemisphere (N=North, S=South, E=East, W=West).

Tuna catch: If the event is a set, write the catch in metric tons of each of the tuna species denoted. When the catch includes other tunas (OTH), record the quantities and species under *Comments.* For events that are not sets, leave blank.

Incidental catch: For the groups noted (Sharks – SHRK –, Turtles – TURT –, Billfishes – BILL –, Manta rays – MANT – and Other vertebrates – OTR –), present in the set, indicate either the number of individuals (N) or metric tonnage (t) caught. Use the line below to record the quantity of these, released alive.

Comments: Use this space as noted above or to make observations that you deem important.

FAD Form 9/2016

COMISION INTERAMERICANA DEL ATUN TROPICAL – INTER-AMERICAN TROPICAL TUNA COMMISSION

INFORMATION ON FADS

Identification (of the locating buoy): Record the unique identification number of the locating buoy. If this is a satellite buoy, it **must** be the unique serial number. If it is another type of locating buoy, use a unique identification code that you provide to the FAD or the locating buoy and that can be use as reference for future encounters. For cases not described here, use the space under *Comments*

Description: From the following list, chose the numeric code that best describes the floating object.

1. Natural (log, ropes, pallets/racks, fronds, dead animal)	**2.** FAD owned by your vessel
3. FAD owned by another vessel	**4.** Anchored object

Components of the surface structure: Choose from the following list the predominant materials used in each section of the surface structure of the floating object.

Raft:

1. Bamboo Rack	**2.** Bamboo in a sausage form	**3.** Metallic
4. PVC or plastic	**5.** No raft	**6.** Other

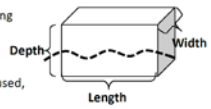
Wrapping/covering:

1. Entangling net	**2.** Non-entangling net	**3.** Cloth
4. Palm fronds	**5.** No wrapping	**6.** Other

Floating devices:

1. Net corks	2. Plastic buoys	3. Plastic containers
4. No floats	5. Other	

Dimensions (in meters); W –Width -, L –Length–, D –Depth–: Record the dimensions of the floating object in the provided spaces. Do not consider the hanging structure (tail) if one is present.



Hanging structure (tail)

Components 1 and 2: Choose the numeric code from the following list, of the two predominant materials used in the construction of the tail. If only one is used, leave the second space blank.

1. Nylon	**2.** Palm fronds	**3.** Bamboo
4. No tail	**5.** Other	

Config. (Configuration) : Choose the configuration that best describes the tail.

1. Sausage	2. Ropes	3. Cloth	4. Other

Mesh size: If the tail is made of net, indicate the mesh size. Otherwise, leave blank.

Type of loc. buoy (attached to the FAD): Choose from the following list the numeric code that describes the locating beacon attached to the FAD.

1. GPS, SHERPE type	**2.** Satellite with eco-sounder	**3.** Satellite with no eco-sunder	**4.** Other

Comments: Use this space to provide additional information.

FAD Form 9/2016

COMISION INTERAMERICANA DEL ATUN TROPICAL – INTER-AMERICAN TROPICAL TUNA COMMISSION

FAD ACTIVITY

VESSEL		IATTC Ves. No		Trip Number		IATTC Trip. No.		License No.	

				Geographical position		Tuna catch (mt)				Incidental catch: Number [N] o tonnage [t].										
Date	Hour	Identification	Activity	Latitude N/S	Longitude E/W	YFT	BET	SKJ	OTR	SHRK	N/t	TURT	N/t	BILL	N/t	MANT	N/t	OTR	N/t	Comments
INCIDENTAL CAPTURE RELEASED ALIVE:																				
INCIDENTAL CAPTURE RELEASED ALIVE:																				
INCIDENTAL CAPTURE RELEASED ALIVE:																				
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INCIDENTAL CAPTURE RELEASED ALIVE:																				

FAD Form 9/2016

COMISION INTERAMERICANA DEL ATUN TROPICAL – INTER-AMERICAN TROPICAL TUNA COMMISSION

INFORMATION ON FADS

		Components of the surface structure			Dimensions (m)			Components and configuration of the hanging structure					
Identification	Description	Raft	Wrapping	Floating devices	W	L	D	Mat. 1	Mat. 2	Config.	Mesh size (mm)	Type of loc. buoy	Comments

FAD Form 9/2016

Annex 2. Guidelines for FAD data reporting under C-17-02

REPORTING ON FADs IN ACCORDANCE WITH IATTC RESOLUTION C-17-02 DURING 2018

Document prepared by the chair of the *Ad hoc*
Permanent Working Group on FADs

1. BACKGROUND

During the 92nd meeting of the IATTC in July 2017, a new resolution (C-17-02) on conservation measures for tropical tunas was adopted that includes new measures for the fishery on fish-aggregating devices (FADs), including limits on the number of active FADs per vessel. Paragraph 11 of the resolution requires CPCs to "*report, or require their vessels to report, daily information on all active FADs to the Secretariat*", at monthly intervals, "*with a time delay of at least 60 days, but no longer than 90 days*", and paragraph 12 tasks the IATTC scientific staff and the *Ad Hoc* Permanent Working Group on FADs with developing, "*at the latest by 30 November 2017, guidance on the reporting of FAD data in accordance with Paragraphs 10 and 11 of this Resolution, including the format and specific data to be reported*".

On November 25, 2017, the chair and several members of the ad hoc Working Group of FADs, together with the scientific staff of the IATTC, presented a document with the guidelines on FAD data reporting. However, there are still several doubts to clarify and they will be analyzed by the Group, the SAC and the Commission during 2018. Meanwhile, **this document aims to provide a basic guide to address the data collection established in resolution C-17-02 on a transitional basis during 2018.**

2. NATURE AND FORMAT OF DATA TO BE PROVIDED TO CPCs [1]

The basic information used to monitor the number of active FADs (as defined in the resolution) will be provided by the buoy provider company directly to the designated verification body of each CPC, on a monthly basis, with a two-month delay; *i.e.* the **data received in APRIL 2018 corresponds to JANUARY 2018**.

Data should be received in csv files named "X-YYYY-MM-ZZZZZZZ.csv" where X is the code of the buoy manufacturer (M, S, T, Z, for Marine Instruments, Satlink, Thalos, and Zunibal, respectively), YYYY is the year, MM the month, and ZZZZZZZ the purse-seine vessel's IATTC registry number. Each file should contain the daily records of all the active FADs managed by each individual vessel in month MM of year YYYY. The information included in these csv files should be: date [YYYY/MM/DD], time [hh:mm], buoy identifier code, latitude and longitude [expressed in degrees and minutes in decimal values] and speed [knots].

In order to identify records that do not correspond to active FADs, as defined in the resolution, the data must be filtered to eliminate:

a. Records outside the EPO (from position data).
b. Records on land (from position and FAD speed (= 0 knots) data).
c. Records of FADs aboard the vessel before deployment (from FAD speed data (> 4 knots) and/or VMS information).

[1] The basic information used to monitor the number of active FADs should be provided by the buoy provider company directly to the CPC and/or to the IATTC staff if so requested by the CPC.

3. INFORMATION TO BE REPORTED TO THE SECRETARIAT

In accordance with paragraph 11 of resolution C-17-02, "… CPCs shall report, or require their vessels to report, daily information on all active FADs to the Secretariat, …".

3.1. Daily information to be reported to the Secretariat [INF 1]

Variable	Description
Date	YYYY/MM/DD
Vessel	IATTC registry number
No. active	Number of active FADs on that date

Below is an example of the daily information to be provided:

Date	Vessel	No. active
2018/04/01	9003421	345
2018/04/02	9003421	342
2018/04/03	9003421	340
…	…	…

3.2. Monthly information to be reported to the Secretariat [INF 2 - PRELIMINARY]

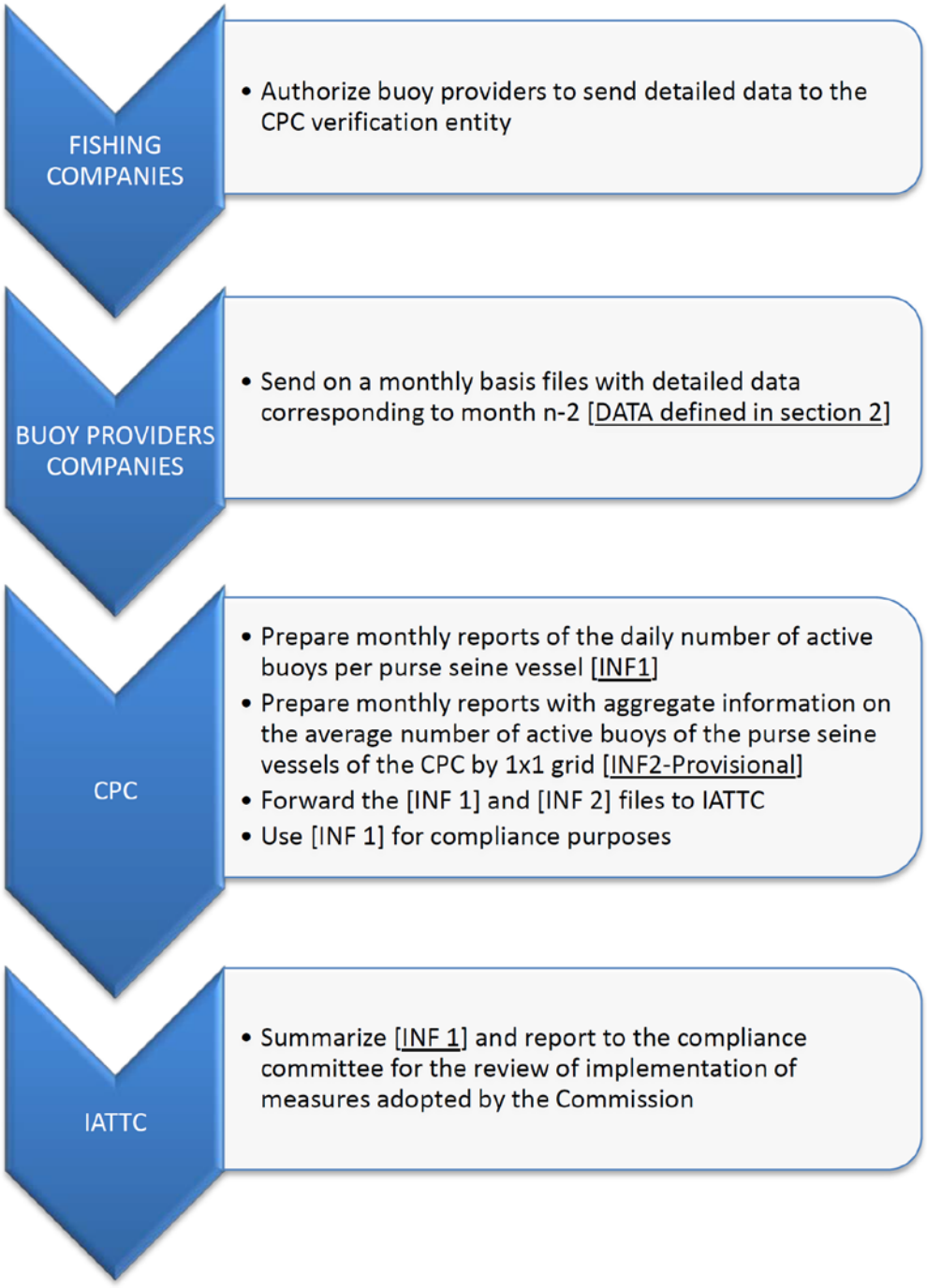
The type of information to be included in the monthly summaries for science purposes will be discussed during the meetings of the FAD Working Group and the SAC in May 2018. The following proposal, at this stage, can be considered as preliminary until a new format is agreed.

Variable	Description
Year	Year of activity
Month	Month of activity
CPC	Name of the CPC
Vessels	Number of vessels
Lat	Latitude of the 1-degree square grid [square center]
Lon	Longitude of the 1-degree square grid [square center]
Average no. active FADs	Average number of active FADs belonging to the vessels of the CPC over the month (by summing up the total number of active beacons recorded per day over the entire month and dividing by the total number of days)

Below is an example of the monthly summaries to be provided:

Year	Month	CPC	Vessels	Lat	Lon	Average no. active FADs
2018	1	xxx	6	10.5	-132.5	1.93
2018	1	xxx	6	9.5	-132.5	0.84
2018	1	xxx	6	8.5	-132.5	2.32
…	…	…	…	…	…	…

Flow chart of the process of reporting of FAD data by CPCs in accordance with Resolution C-17-02



Annex 3. Flotsam Information Record

Inter-American Tropical Tuna Commission

FLOTSAM INFORMATION RECORD (FIR)

Trip Number	Object No.	Count No.	Set No.	DATE YY MM DD	TIME	LATITUDE N/S	LONGITUDE W

A. COMPONENTS (check all that are applicable)

	As found		As left
Tree	[ ]	1	[ ]
Dead animal _____	[ ]	2	[ ]
Chain / cable / rings / weights	[ ]	3	[ ]
Cane / bamboo	[ ]	4	[ ]
Bait container / bait	[ ]	5	[ ]
Cord / rope	[ ]	6	[ ]
Floats / corks	[ ]	7	[ ]
Artificial light for attracting fish	[ ]	8	[ ]
Netting material	[ ]	9	[ ]
Sacks / bags	[ ]	10	[ ]
Planks / pallets / plywood / spools	[ ]	11	[ ]
Metal drum / plastic drum	[ ]	12	[ ]
PVC or other plastic tubes	[ ]	13	[ ]
Plastic sheeting	[ ]	14	[ ]
Unknown	[ ]	15	[ ]
Other _____	[ ]	16	[ ]

B. LOCATING EQUIPMENT (check all that are applicable)

	As found		As left
Flag	[ ]	1	[ ]
Satellite buoy	[ ]	2	[ ]
Buoy, corks, etc.	[ ]	3	[ ]
Lights	[ ]	4	[ ]
Radio transmitter / beeper	[ ]	5	[ ]
Radar reflector	[ ]	6	[ ]
Unknown	[ ]	7	[ ]
Other _____	[ ]	8	[ ]

C. LOCATING METHOD (check only ONE)

Radar	[ ]	1	
Direction finder	[ ]	2	
Satellite	[ ]	3	check
Visual – the object itself	[ ]	4	only
Visual – birds	[ ]	5	one
Not applicable	[ ]	6	
Unknown	[ ]	7	
Other _____	[ ]	8	

D. IF THERE IS NETTING ON THE OBJECT:

	Yes	No	Unk
Netting hanging from the object?	[ ]	[ ]	[ ]

Estimated area of hanging netting (m^2) _____

Predominant mesh size (inches) _____ . _____

E. OTHER DATA

	Yes	No	NA	Unk
Bait container refilled?	[ ]	[ ]	[ ]	[ ]
Fauna entrapped? _____	[ ]	[ ]	[ ]	[ ]

Maximum depth of the object (m) _____ . _____

Dimensions (m) _____ . _____ . _____ . _____

Water clarity Clear [ ] Turbid [ ] Very turbid [ ]

% epibiota _____ Tag number _____

F. CAPABILITY OF TRANSMITTING EQUIPMENT (check all that are applicable)

	As found		As left
Direction to the object	[ ]	1	[ ]
Geographic position of the object	[ ]	2	[ ]
Water temperature	[ ]	3	[ ]
Tuna quantity	[ ]	4	[ ]
Tuna species	[ ]	5	[ ]
Unknown	[ ]	6	[ ]
Other _____	[ ]	7	[ ]

G. PRIOR ORIGIN OF OBJECT (check only ONE)

Your vessel – this trip	[ ]	1	
Your vessel – previous trip	[ ]	2	
Deployed	[ ]	3	
Other vessel – with owner consent	[ ]	4	check
Other vessel – no owner consent	[ ]	5	only
Drifting object found	[ ]	6	one
Unknown	[ ]	7	
Other _____	[ ]	8	

H. EXPERIMENTAL EQUIPMENT (continue on back)

IATTC FIR 08/2005

I.a. OVERHEAD VIEW (Include dimensions)	I.b. SIDE VIEW (Include dimensions)

J. ADDITIONAL COMMENTS

IATTC FIR 08/2005

Annex 4. FAD-related terminology

Partial list of FAD-related terms used in resolutions, data-collection forms, etc., that need to be defined and/or clarified.

Activate/activation	FAD
Buoy	Floating object
Deploy/deployment	Operator
Active buoy	Owner
Active FAD	Reactivate/reactivation
Deactivate/deactivation	Re-deploy/re-deployment