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Stakeholders' views on methods to identify the ownership and track the position of drifting fish aggregating devices used by tuna purse seine fisheries

Executive Summary

Fish aggregating devices (FADs) used by tuna purse seine fisheries improve fishing efficiency relative to other purse seine fishing strategies and make it possible to successfully fish in new areas. However, when not responsibly managed, FADs can cause adverse effects. Use of physical and electronic methods to assign a unique identification code and track the position of drifting FADs can contribute to improved monitoring, understanding and management of drifting FADs' ecological and socio-economic effects. In 2016 the Food and Agriculture Organization of the United Nations (FAO) convened an Expert Consultation on the Marking of Fishing Gear, resulting in the development of Draft Guidelines on the Marking of Fishing Gear. Recognizing challenges with applying conventional methods of marking fishing gear to identify drifting FAD ownership and to implement a recommendation made by the Committee on Fisheries, in 2017, FAO conducted a global survey to obtain stakeholder views on FAO's Draft Guidelines. This Circular presents the survey results on marking and tracking the position of drifting FADs; defining drifting FAD ownership; and defining, reporting and recovering abandoned, lost and discarded drifting FADs. Stakeholder assessments of existing measures on drifting FAD marking and tracking are also reported.

FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER

STAKEHOLDERS' VIEWS ON METHODS TO IDENTIFY THE OWNERSHIP AND TRACK THE POSITION OF DRIFTING FISH AGGREGATING DEVICES USED BY TUNA PURSE SEINE FISHERIES

WITH REFERENCE TO THE FAO *DRAFT GUIDELINES ON THE MARKING OF FISHING GEAR*

by

Eric Gilman
FAO International Consultant

Beau Bigler and Bobby Muller
Marshall Islands Marine Resources Authority

Gala Moreno
Fisheries Consultant

Erick D. Largacha and Martin Hall
Inter-American Tropical Tuna Commission

François Poisson
Institut Français de Recherche pour L'exploitation de la Mer

Wei-Chuan Chiang
Eastern Marine Biology Research Center, Fisheries Research Institute

Joanna Toole and Pingguo He
FAO Fisheries and Aquaculture Department

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PREPARATION OF THIS DOCUMENT

At the 31st session of the Committee on Fisheries (COFI) held in 2014, concern was expressed about ghost fishing by abandoned, lost and otherwise discarded fishing gear (ALDFG). COFI recommended that Members and regional fishery bodies (RFBs), including regional fisheries management organizations (RFMOs), increase attention to mitigating ALDFG impacts, noting that cost-effective technologies and practices were available. In response, in 2016, the Food and Agriculture Organization of the United Nations (FAO) convened an Expert Consultation on the Marking of Fishing Gear, resulting in the development of *Draft Guidelines for the Application of a System on the Marking of Fishing Gear*. Upon considering the recommendations of the Expert Consultation, COFI, at their 32nd Session in 2016, encouraged FAO to support the implementation of the Draft Guidelines by conducting pilot projects on fishing gear marking. COFI also supported the further development of the Draft Guidelines via a Technical Consultation on the Marking of Fishing Gear, which was convened in February 2018. To implement COFI's recommendations and support the work of the Technical Consultation on the Marking of Fishing Gear, in 2017, FAO conducted a global survey on fish aggregating devices (FADs) to obtain stakeholder views as related to the FAO Draft Guidelines. This document reports the process and outcomes of the survey.

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Stakeholders' Views on Methods to Identify the Ownership and Track the Position of Drifting Fish Aggregating Devices Used by Tuna Purse Seine Fisheries with Reference to the FAO Draft Guidelines on the Marking of Fishing Gear

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ABSTRACT

Fish aggregating devices (FADs) used by tuna purse seine fisheries improve fishing efficiency relative to other purse seine fishing strategies and make it possible to successfully fish in new areas. However, when not responsibly managed, FADs can cause adverse effects. Use of physical and electronic methods to assign a unique identification code and track the position of drifting FADs (dFADs) can improve the monitoring, understanding of ecological and socio-economic effects and management of this fishing gear. In 2016 the Food and Agriculture Organization of the United Nations (FAO) convened an Expert Consultation on the Marking of Fishing Gear, resulting in the development of *Draft Guidelines for the Application of a System on the Marking of Fishing Gear*. Recognizing challenges with applying conventional methods of marking fishing gear to identify dFAD ownership, and tasked by the FAO's Committee on Fisheries (COFI) to further develop the Draft Guidelines and conduct pilot projects, in 2017, FAO conducted a global survey to obtain purse seine fisheries stakeholder views on the FAO Draft Guidelines. This Circular presents the survey results on marking and tracking the position of dFADs; defining dFAD ownership; and defining, reporting and recovering abandoned, lost and discarded dFADs. Stakeholder assessments of existing measures on dFAD marking and tracking are also reported.

EXECUTIVE SUMMARY

Fish aggregating devices (FADs) used by tuna purse seine fisheries improve fishing efficiency relative to other purse seine fishing strategies and make it possible to fish successfully in new areas. However, when not managed responsibly, FADs can cause adverse effects. Abandoned, lost and otherwise discarded FADs cause ghost fishing, damage sensitive coastal habitats and litter coastlines. FADs with conventional entangling designs can capture turtles, sharks and other sensitive species. Recently introduced non-entangling designs, however, have reduced such incidents. The effects of the density, drift and distribution of FADs on tuna population ecology, stock dynamics and concomitant fishing efficiency are poorly understood, as are the broader community- and ecosystem-level effects. The use of physical and electronic methods to assign a unique identification code and to track the position of drifting FADs (dFADs) can improve the monitoring, understanding and management of ecological and socio-economic effects of this fishing gear.

In 2016 the Food and Agriculture Organization of the United Nations (FAO) convened an Expert Consultation on the Marking of Fishing Gear, resulting in the development of *Draft Guidelines for the Application of a System on the Marking of Fishing Gear*. The Draft Guidelines included recommendations on marking and tracking the position of FADs, and on defining, reporting and recovering abandoned, lost and discarded FADs. FAO has tasked a Technical Consultation on the Marking of Fishing Gear, to be convened in 2018, with the continued development of the Draft Guidelines. Having considered the recommendations of the Expert Consultation, and recognizing that gear marking, in conjunction with other measures, can mitigate abandoned, lost and otherwise discarded fishing gear (ALDFG) and illegal, unreported and unregulated (IUU) fishing, at their 32nd Session in 2016 the Committee on Fisheries (COFI) encouraged FAO to support the implementation of the Draft Guidelines by conducting pilot projects on fishing gear marking.

Recognizing challenges with defining dFAD ownership and with applying conventional methods of marking fishing gear to identify dFAD ownership, in 2017 FAO conducted a global survey to obtain stakeholder views on the sections of the FAO Draft Guidelines on physical and electronic methods to identify the owner and track the position of dFADs used by tuna purse seine fisheries. Conducted to support both the work of the forthcoming Technical Consultation and implement COFI's recommendations, the survey obtained stakeholders' views on defining dFAD ownership and defining when a dFAD or its components are abandoned, lost or discarded. The survey also compiled views on reporting and retrieval of derelict dFADs, and the use of port reception facilities for retired dFAD components. Stakeholder assessments of measures adopted by tuna regional fisheries management organizations, Parties to the Nauru Agreement (PNA) and Republic of Kiribati on dFAD marking and tracking were also collected. This report presents the results of the survey of 91 experts. Survey respondents were purse seine fishing masters and skippers, support vessel captains, vessel owners, purse seine fishery associations, manufacturers of instrumented buoys that are attached to FADs and other floating objects used by purse seine fishers, fishing gear technologists, and fisheries management authorities.

Current practices for dFAD marking and position tracking

Satellite buoys, now attached to almost all dFADs, enable the purse seine industry to track the spatial position of dFADs. When these satellite buoys are equipped with echo-sounders, fishers obtain an estimate of the biomass of fish aggregated at individual dFADs. PNA and some scientific bodies receive parallel feeds of satellite buoy positional data, enabling them to track the spatial position of dFADs and potentially to monitor the history of companies that sequentially exchanged buoys and tracked the position of an individual dFAD. Some respondents delay their provision of satellite buoy data to avoid the possibility of leaking current dFAD positions to competitors. In addition to a physical mark included on dFADs by satellite buoy manufacturers, which enables fishery managers to identify the company that is currently tracking the attached dFAD, satellite buoy owners also add their own unique physical mark onto satellite buoys, typically by painting a code onto the buoy surface. This mark enables other vessels that encounter a dFAD to identify who owns the attached satellite buoy, reducing the incidence of exchanging

buoys. The mark added by the buoy owner also enables buoys removed by other vessels to be returned to the owner. This also enables the return of buoys attached to abandoned dFADs that are found when they drift into coastal waters. Many ports have facilities where skippers turn in satellite buoys that they have removed or found, and retrieve their buoys exchanged or found by other vessels. A very small proportion of dFADs have unique physical identification marks directly on the dFAD structure, and these marks are not used by managers to monitor dFAD fishing activities.

When they encounter dFADs with attached satellite buoys belonging to other vessels, purse seine and support vessels routinely exchange satellite buoys, taking control over the dFAD from the company that had previously been tracking it. While the frequency of buoy exchanges varies by region, this practice is conducted globally. This practice may reduce the abandonment of dFADs: If there were no buoy exchanging, then a larger proportion of dFADs would drift out of range and be abandoned than is currently the case.

Mainly synthetic materials are used to construct dFADs. A majority of respondents' dFADs in the western and central Pacific Ocean have conventional designs, with open netting used for the subsurface appendage and to cover the surface structure. These conventionally designed dFADs risk entangling marine animals, including endangered, threatened and protected species, such as species of sharks and sea turtles. Most dFADs used by respondents in other regions, however, have non-entangling (no netting) or less-entangling (appendage netting tied into sausage-like bundles and/or with small meshes) designs that have a lower entanglement risk. While there is variability by region and vessel capacity, respondents indicated that each purse seine vessel has a mean of 343 dFADs with attached satellite buoys at sea at one time, and actively monitors about 10 percent of these dFADs, which are located in nearby fishing grounds. Respondents reported that they lose about 21 percent of their satellite buoys due to buoy exchanges, and to a lesser extent, buoy malfunctions.

Desired improvements to identify the company controlling a dFAD

Almost all survey participants considered current satellite buoy technology and methods for physically marking satellite buoys to be effective, affordable and practical techniques for identifying the company that is currently tracking a dFAD and for tracking the position of dFADs. Respondents, however, identified some desired improvements in technology. Respondents indicated that it would be useful to be able to predict the trajectory of dFADs so that they could be intercepted before grounding on sensitive habitat and drifting out of fishing grounds. Use of navigable dFADs, propelled either autonomously or remotely, could reduce the proportion of dFADs that are abandoned and that run aground. Improving the durability of physical marks added by owners to satellite buoys, used to identify the owner, and enabling owners to add marks without obstructing buoys' solar panels were two additional desired improvements identified by survey respondents.

Considerations for physically marking dFAD structures

Respondents suggested that the following issues be addressed when considering a requirement to have a physical mark directly on the structure of dFAD rafts or appendages:

- a mark on the dFAD structure would identify the company that originally deployed the dFAD but not companies that subsequently took over control of the dFAD by exchanging the attached satellite buoy;
- the physical mark would need to be sufficiently durable to last for the life of a dFAD;
- marks on biodegradable dFADs may have lower durability than marks on dFADs made of conventional synthetic materials;
- in regions with per-vessel caps on the number of dFADs or satellite buoys, vessels may falsely mark dFADs to indicate they are owned by a competitor;
- vessels exchanging buoys on a dFAD may remove or modify the physical mark on the dFAD structure;
- the fishing industry would not want to use a mark that would increase the visibility of a dFAD to competitors searching from vessels or helicopters;

- purse seine vessels need to be in close proximity to a dFAD in order to enable observers and electronic monitoring systems to read physical marks on the dFAD structure (as well as physical marks on satellite buoys);
- when dFADs change hands, they are often modified by refurbishing and replacing components, which could result in the removal of a physical mark.

Defining dFAD ownership

Almost all respondents stated that the owner of a dFAD and responsibility for any damage caused by a dFAD should be the company that owns the satellite buoy that is currently attached to the dFAD. If a satellite buoy is not attached, then the company that last had their satellite buoy attached, if this can be determined, should be considered the dFAD's owner. Defining dFAD ownership is complicated because the fishing company tracking the position of dFADs may change numerous times over the lifetime of a dFAD, and because fishers refurbish and add new components to dFADs so that over time, many of the materials of the original dFAD may no longer be present.

Defining and reporting abandoned, lost and discarded dFADs

A proportion of dFADs deployed each year by purse seine and support vessels are abandoned when the dFAD drifts out of fishing grounds, including into areas where a vessel does not have access and into areas with piracy. The high at-sea operating cost for purse seine vessels makes it cost-prohibitive to retrieve distant dFADs. Some respondents explained that when a dFAD that they are tracking drifts far from their fishing grounds, they monitor the buoy location and try to identify another vessel that can exchange buoys on the dFAD so that the vessel can return their satellite buoy. When a dFAD drifts out of their fishing grounds, some respondents direct their satellite buoy service provider to unsubscribe (stop the transmission of) the buoy attached to that dFAD, resulting in the dFAD being abandoned.

In addition to losing dFADs as a result of another vessel removing an attached satellite buoy, respondents explained that, although infrequent, they genuinely lose dFADs. This includes losing dFADs when a satellite buoy permanently malfunctions, when a satellite buoy detaches from the dFAD due to mechanical action, and when a dFAD and attached satellite buoy sink.

Respondents explained that dFADs and components are very rarely discarded at sea. Fishers routinely refurbish dFADs, reusing old, worn-out components of the appendage and raft. A very small proportion of worn-out dFAD components cannot be reused. Some vessels modify dFADs by replacing unwanted components that have entangling designs with less- or non-entangling designs. Most respondents retain unwanted synthetic materials from dFADs that cannot be reused. They either incinerate the unwanted synthetic components on board or dispose of it in port. However, some respondents reported that worn-out dFAD gear is also discarded at sea. When vessels exchange satellite buoys, fishers may let the old satellite buoy drift away after detaching it from the dFAD, or may destroy the old satellite buoy and discard the debris at sea. The most common practice, however, is to retain the old buoy and return it to port so that it can be retrieved by the owner. When they replace the worn-out biodegradable components of the dFAD raft, including reeds and bamboo, fishers discard these old components at sea.

Onboard observers are tasked with recording satellite buoy exchanges. However, observers are not always able to record the identification number of the old buoy removed from a dFAD. Observers are not able to detect all buoy exchanges, such as those conducted by helicopters and support vessels. In some regions, observers are also currently tasked with recording incidents when fishers discard garbage, including fishing gear, at sea. However, observers likely do not detect some discard incidents, such as when discarding occurs at night, when the observer is on the well deck, or when the observer is asleep.

Given the large number of dFADs that each vessel tracks, loses and abandons, some respondents suggested that having fishers periodically report to management authorities their loss and abandonment of dFADs, such as at monthly intervals, would make such a reporting requirement more feasible. The selection of a maximum time period for reporting lost dFADs to management authorities should also account for issues such as that satellite buoys can temporarily cease but then resume transmissions after a few days, and that determining that a satellite buoy has been removed from a dFAD can require a substantially longer time period.

Retrieving derelict dFADs at sea

There are substantial challenges to establishing programmes to retrieve derelict dFADs that are adrift at sea. The largest challenge identified is that the cost to the purse seine sector of abandoning dFADs and replacing them with new ones is much lower than the cost of retrieving dFADs that drift out of range, especially if purse seine vessels conduct the retrieving. The expense for fuel and availability of vessels to retrieve dFADs over extensive areas would be the main costs for dFAD retrieval. The logistics of tracking the position of a large number of primarily abandoned dFADs over broad areas, including areas where purse seine and support vessels are prohibited from entering, was another commonly referenced constraint. Respondents also raised the question of whether the environmental impacts from fuel required to be consumed to retrieve derelict dFADs would exceed the environmental costs of leaving derelict dFADs at sea. It is not possible to track a dFADs position, which is necessary to retrieve it, when a dFAD is truly lost, including when a satellite buoy permanently malfunctions, becomes detached from the dFAD, or is switched off, and when a dFAD sinks or breaks down into multiple pieces. Clear definitions would need to be adopted to enable dFAD retrieval programmes to differentiate between active, in-use and derelict dFADs, and to identify dFADs at risk of grounding.

Conversely, some survey respondents commented that it is feasible to establish site-specific programmes that monitor dFAD satellite buoy data to determine when dFADs approach specific, sensitive sites so that the dFADs could be intercepted by locally-based vessels before running aground. Respondents referenced an existing dFAD retrieval programme in the Seychelles as evidence that this is feasible. Some respondents clarified that it would likely be feasible to retrieve derelict dFADs in some 'hot spot' areas where dFADs accumulate in relatively high densities during certain seasons. Furthermore, on the open ocean some respondents explained that 'sister' vessels from the same company routinely communicate the positions of the dFADs that they are tracking and have drifted out of their fishing grounds so that sister vessels may be able to take over control of these dFADs, reducing the incidence of abandonment. Based on the efficacy of this current practice, some respondents commented that it may also be feasible to coordinate all purse seine and support vessels of a region to avoid and minimize dFAD abandonment. Issues over maintaining the confidentiality of data on dFAD positions, however, would need to be addressed. Some respondents commented that it is technically feasible for the purse seine sector to stop the practice of abandoning dFADs and instead retrieve them, and that these companies should adjust their annual operating budget to cover the costs to retrieve their fishing gear, which may require reducing the number of dFADs that they currently deploy. Other respondents suggested that management authorities should charge purse seine operators a per-dFAD fee to cover the costs incurred by managers to track and retrieve all dFADs deployed by vessels that they authorize to fish.

Disposal of unwanted dFADs

Almost all respondents explained that they very infrequently dispose of synthetic dFAD components, either at sea or in port, but instead reuse them to refurbish dFADs. Furthermore, the reasons that fishers decide to abandon dFADs do not include issues with port disposal (availability, cost, practicality). Therefore, most respondents commented that incentivizing disposal of unwanted dFADs and components in port instead of discarding and abandoning at sea is not needed. However, a few respondents conversely stated that low or no-cost port disposal facilities that are practical to use might possibly increase the likelihood of vessels disposing unwanted dFAD components in port instead of discarding them at sea. A few respondents suggested that having facilities in port that assist vessels to refurbish and reuse worn-out components of dFADs would be useful.

Potential technological and management improvements

Respondents recommended investing in technology research to develop self-navigable or remotely navigable dFADs to reduce or eliminate the current causes of abandonment and risk of grounding. Respondents suggested that developing the technology to enable observers to remotely detect, from a distance of several hundred metres, the unique electronic identification number of satellite buoys would eliminate observer reliance on crew to obtain the identification of buoys being removed from dFADs. Research to develop the technology to remotely sink biodegradable dFADs that are at risk of grounding on sensitive coastal habitat was another recommended research priority. Respondents also recommended research to enable satellite buoys to detect and transmit the unique identity of an attached

electronically tagged dFAD as a potential means to track the history of fishing companies successively exchanging satellite buoys on individual dFADs.

Respondents also identified potential improvements in dFAD management methods. Some respondents recommended developing additional site-specific programmes to retrieve dFADs at risk of grounding on sensitive coastal habitat, and developing regional programmes that coordinate the retrieval of dFADs that are drifting out of fishing grounds and are at risk of being abandoned. If reporting satellite buoy spatial positions to managers were prescribed, then industry concerns over maintaining the confidentiality of data on the current and recent positions of their dFADs require consideration. These concerns could be addressed, for example, by allowing a delay in reporting buoy data and using best practices to manage time-sensitive confidential fisheries data. Having management authorities own dFADs and satellite buoys and lease them to the purse seine companies that they license to fish was identified as a potential approach being considered by one sub-regional management authority in order to improve government control of dFAD designs, densities, numbers, buoy exchanging practices, and dFAD abandonment, loss and discarding.

Comments on the FAO *Draft Guidelines*

Based on survey responses, considerations to improve the sections on dFADs in the FAO Draft Guidelines were presented. Regarding the guidelines' recommendations on marking dFADs, applying conventional methods for marking fishing gear to identify ownership of dFADs is complicated by the prevalent practices of exchanging satellite buoys attached to, and the concomitant control over, dFADs, and as well as the frequent refurbishing and replacing of dFAD components at sea. Considerations related to the guidelines' recommendations on tracking the position of dFADs included industry concerns over maintaining the confidentiality of data on the current and recent spatial positions of their dFADs when there is near real-time reporting of satellite buoy data to management authorities. Considerations related to the guidelines' recommendations on defining, reporting and retrieving abandoned, lost and discarded dFADs included issues related to defining dFAD ownership, complications in determining when dFADs are lost due to satellite buoy exchanging, and difficulties with differentiating between in-use active vs. derelict dFADs. Gaps in the draft guidelines on issues related to the marking and tracking of dFADs and on priority research to assign a unique identification code to dFADs and track dFAD spatial location were also identified.

Conclusions

Applying conventional methods of marking fishing gear to identify ownership to dFADs used by tuna purse seine fisheries is complicated by the prevalent practices of exchanging satellite buoys and the concomitant control over dFADs and refurbishing dFAD components at sea. Despite the complexity of defining dFAD ownership, however, existing practical and affordable technology can effectively assign a physical or electronic unique identification code to a dFAD and enable the tracking of its position to meet various management objectives. The use of satellite buoys by the purse seine industry to track the real-time spatial position of dFADs, the increasing use of non- and less-entangling dFAD designs, and the possible future industry uptake of biodegradable dFAD designs would help minimize adverse effects of abandoned, lost and otherwise discarded dFADs. Recent dFAD management measures in some regions, including requiring dFAD marking and near real-time reporting of satellite buoy positional data to management authorities, have strengthened management authorities' capacity to identify the history of companies sequentially tracking the position of this fishing gear. Various potential technological improvements, combined with opportunities for strengthened management, would augment the capacity to: track the history of dFAD control; further avoid and reduce dFAD abandonment, loss and discarding; and mitigate the adverse ecological effects of derelict dFADs.

TABLE OF CONTENTS

Tables

Figure

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ACRONYMS

aFAD	Anchored fish aggregating device
ALDFG	Abandoned, lost or otherwise discarded fishing gear
ANABAC	Asociación Nacional de Armadores de Buques Atuneros Congeladores
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CMM	Members and Cooperating Non-members (of WCPFC)
COFI	United Nations Committee on Fisheries
CPC	Members and Cooperating Non-members (of IATTC, ICCAT and IOTC)
dFAD	Drifting fish aggregating device
EEZ	Exclusive Economic Zone
ETP	Endangered, threatened and protected
FAD	Fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
IMO	International Maritime Organization
IOTC	Indian Ocean Tuna Commission
IRD	Institut de Recherche pour le Developpement
ISSF	International Seafood Sustainability Foundation
IUU fishing	Illegal, unreported and unregulated fishing
MARPOL	International Convention for the Prevention of Pollution from Ships
OPAGAC	Organización de Productores de Grandes Atuneros Congeladores
PNA	Parties to the Nauru Agreement
RFMO	Regional fisheries management organization
WCPFC	Western and Central Pacific Fisheries Commission

1. INTRODUCTION

1.1. Socio-economic and ecological effects of fish aggregating devices

Tuna resources supply the fourth most valuable globally traded fishery products, and provide substantial economic revenue, employment and food security to fishing and coastal states (Gillett, 2009; FAO, 2014). Tropical tunas and other large pelagic (open ocean) species associate near and aggregate at natural and artificial floating objects (Freon and Dagorn, 2000; Castro *et al.*, 2002; Hall and Roman, 2013). Floating objects that aggregate pelagic marine organisms include drifting logs, drifting algae, live and dead large marine organisms, marine debris (e.g. crates, pallets, nets), vessels, as well as artificial objects that are built and deployed by fishers and are designed specifically to aggregate pelagic fishes (Castro *et al.*, 2002; Hall and Roman, 2013). This latter category of artificial floating object is referred to as a fish aggregating devices (FAD) (Gaertner *et al.*, 2016).

In the early 1990s the use of drifting FADs (dFADs) by purse seine fisheries targeting tropical tunas rapidly increased globally (Miyake *et al.*, 2010; Hall and Roman, 2013). The use of FADs, including the development of instrumented buoys that enable the remote tracking of dFAD geolocation (satellite buoys) and provide rough estimates of the biomass aggregated near the FAD (echo-sounder buoys), as well as support vessels that deploy and service dFADs and assist with searching, have made it possible for purse seine vessels to successfully fish in new areas as well as increase fishing efficiency (Dagorn *et al.*, 2012; Fonteneau *et al.*, 2013; Koehler and Moreno, 2016; Lopez *et al.*, 2014, 2016). Over 65 percent of the global landings of principal market tunas is derived from purse seine fisheries, and about 50 percent of global purse seine landings is from sets on FADs (ICCAT, 2017; ISSF, 2017).

Relative to unassociated purse seine sets, which are sets made on a free-swimming school of tunas not associated with a floating object, sets on FADs are substantially more efficient at catching skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*) and bigeye (*T. obesus*) tunas in terms of catch-per-unit-of-effort and fuel consumption. For example, over 90 percent of purse seine sets on dFADs are successful, compared to only 50 percent of sets on free-schooling tuna (i.e. half of free school sets are null sets, meaning the fishers were unsuccessful in encircling the school, or the school escaped before the bottom of the net was closed) (Dagorn *et al.*, 2012). And, for example, the total catch of tuna in weight per set is higher in dFAD sets relative to unassociated sets (Gilman, 2011; Hall and Roman, 2013). Furthermore, fuel consumption by purse seine vessels is generally lower when making sets on FADs because there is no need to search for schools as required when making free school sets (Dagorn *et al.*, 2012).

Anchored FADs (aFADs, called rumpons in Indonesia, and payaos in the Philippines) also provide numerous socio-economic benefits. In some developing coastal states, networks of aFADs, typically located in nearshore waters, support fisheries for pelagic species, including pole-and-line and handline fisheries, as well as tuna purse seine fisheries in the western Pacific Ocean (Beverly *et al.*, 2012; Albert *et al.*, 2014). These are mainly small-scale, artisanal fisheries. Small-scale purse seine vessels that fish at aFADs cannot successfully make sets on free swimming schools. Fisheries using these aFADs might reduce fishing pressure on coral reefs and other heavily exploited, relatively sensitive nearshore ecosystems (Adams, 2012; Beverly *et al.*, 2012).

However, when not responsibly monitored and managed, FADs can result in adverse ecological and socio-economic effects:

Bycatch by entanglement in active (in-use) FADs

When conventional FAD designs are used, sharks and turtles can become entangled in the subsurface appendage, which is the netting suspended beneath the surface structure of the FAD. Turtles can also entangle in netting meshes covering the FAD surface structure when they haul-out onto it to rest (Chanrachkij and Loog-on, 2003; Filmalter *et al.*, 2013; Hall and Roman, 2013; Gilman, 2011, 2015; ISSF, 2015).

Ghost fishing by entanglement in derelict FADs

Abandoned, lost and discarded (derelict) FADs with entangling and 'less' entangling (appendage netting tied into tight sausage-like bundles and/or with small meshes) designs cause ghost fishing mortality of turtles, sharks and other fishes (e.g. Anderson *et al.*, 2009; Gaertner *et al.*, 2016). A substantial proportion of dFADs deployed by purse seine and support vessels, which globally may deploy 50,000 to 120,000 dFADs annually (Baske *et al.*, 2012; Scott and Lopez, 2014; Gershman *et al.*, 2015) are abandoned (Maufroy *et al.*, 2015). For example, between 2003 and 2015, observers of the Pacific Community and Pacific Islands Forum Fisheries Agency regional observer programme recorded over 1,300 incidents of purse seine fishers abandoning, losing or discarding fishing gear (Richardson, 2016).

Damaged and littered coastal habitats, interaction with other marine industry activities, pollution effects

Derelict FADs, including biodegradable FADs, can damage coral reefs and other sensitive coastal habitats. Derelict dFADs can also litter coastlines, including tourist beaches (Balderson and Martin, 2015; Duhec *et al.*, 2015; Maufroy *et al.*, 2015; Gilman *et al*., 2016; Island Conservation Seychelles, 2016; MRAG, 2016). For example, in the Atlantic and Indian Oceans, about 9.9 percent of dFADs with satellite buoys deployed by French purse seine vessels ended up running aground on coastlines (Maufroy *et al.*, 2015). And in the western and central Pacific Ocean, 3.7 percent of ca. 17,000 monitored dFADs with satellite buoys ran aground during a ca. 16 month period (Escalle *et al.*, 2017). Derelict FADs can adversely affect other marine industry users such as through obstructing navigation, fouling fishing gear, and damaging mariculture facilities. Derelict FADS might transport alien invasive species. Synthetic compounds, including microscopic plastic material and toxic chemicals from materials used to construct dFAD components and instrumented buoys (e.g. echo-sounder and satellite buoys), can accumulate in marine food webs (Gilman *et al*., 2016).

Potential effects of FADs on the ecology of species that aggregate at FADs and on fishing efficiency

The increasing use of dFADs has modified pelagic habitat by increasing the density of floating objects in regions where natural floating objects were already present, and possibly by introducing floating objects to areas where they did not previously occur. While not well understood, it is possible that dFADs detrimentally alter the natural behavior and ecology of species that associate with FADs, potentially causing population-level and broader community- and ecosystem-level effects. It is hypothesized that dFADs change the spatial distributions, migration patterns, schooling dynamics and vertical habitat use of aggregated organisms. In turn, by altering their distributions and movement, dFADs modify aggregated organisms' diet, condition, growth, reproductive success and other biological characteristics (Marsac *et al.*, 2000; Hallier and Gaertner, 2008; Amande *et al.*, 2010; Dagorn *et al.*, 2013; Sempo *et al.*, 2013). These hypothetical effects of the density and distribution of dFADs on tuna behavior and biology may affect fishing efficiency, where above some threshold, the higher the density of FADs, the lower the mean size of tuna schools aggregating at the FADs (Hall and Roman, 2017). The density and distribution of FADs may also affect the fishing efficiency of non-FAD purse seine fishing and of non-purse seine surface tuna fisheries (Dagorn *et al.*, 2013; Sempo *et al.*, 2013).

Bycatch of at-risk species in sets on FADs

Associated purse seine sets are less selective than free school sets in that a larger number of non-retained organisms are caught in sets on aggregations under floating objects than on free swimming tuna schools (Amande *et al.*, 2010; Hall and Roman, 2013; Torres-Irineo *et al.*, 2014; Gaertner *et al.*, 2016). Silky and oceanic white-tip sharks have highest catch rates in dFAD sets when the rate is expressed as shark catch per unit of effort. However, free school sets have relatively higher catch rates of other endangered, threatened and protected (ETP) species, including species of mobulid rays and sea turtles. And, when catch rate is expressed as shark catch per unit weight of market tunas, shark catch rate by set type is variable, where in some cases free school sets can have highest shark catch rates (Williams *et al.*, 2009; Amande *et al.*, 2010; Dagorn *et al.*, 2013; Hall and Roman, 2013; Gilman, 2016).

Effects of set type on tuna stock status

Effects of purse seine set type on tuna species catch composition, size of the catch, and volume of tuna caught per set affect stock status (Dagorn *et al.*, 2013). FAD sets catch more immature and smaller yellowfin and bigeye tunas than free school sets (Fonteneau *et al.*, 2013). Some bigeye and yellowfin tuna stocks are overexploited (ISSF, 2017). Associated sets have higher bigeye tuna catch rates than free school sets (Harley *et al.*, 2015). Free school sets have higher yellowfin tuna catch rates. Also, mentioned previously, the tuna catch per set is highest in FAD sets (Hall and Roman, 2013).

Standardizing purse seine effort

Fisheries scientists require data on factors that affect relative fishing efficiency so they can standardize purse seine effort, improving the certainty of stock assessment and ecosystem models. In addition to the effect of purse seine set type on fishing efficiency, described above, the number of dFADs tracked by purse seine vessels; use of supply vessels to deploy, service and track dFADs; and use of different dFAD tracking technologies also affect fishing efficiency (Gaertner *et al.*, 2015, 2016). For example, echo-sounder buoys provide information to purse seine and support vessels on the estimated amount of fish biomass that is aggregated under each dFAD. Marking and tracking dFADs may provide data needed for research to determine if there are significant differences between alternative dFAD designs and materials on species- and size-specific aggregating capacities, the behavior of tunas associated with the object, and concomitant fishing efficiency (Abascal *et al.*, 2014).

IUU fishing

Monitoring and managing purse seine FAD ownership and spatial position can contribute to deterring illegal, unregulated and unreported (IUU) fishing. IUU fishing can compromise conservation and management measures from achieving ecological and socio-economic objectives, and can reduce the certainty of population and stock assessments and multispecies and ecosystem models (FAO, 2001; Agnew *et al.*, 2009).

Identifying the ownership and tracking the position of dFADs from physical marks on FAD components and attached buoys, and from the electronic signals of attached instrumented buoys, can contribute to improving the monitoring, the understanding the ecological and socio-economic effects of dFADs and the management of this fishing gear, including the mitigation of some of these adverse ecological and socio-economic effects of purse seine dFADs.

1.2. Study aims

We conducted a survey of experts to obtain comments and identify key issues related to a section of the Food and Agriculture Organization of the United Nations' (FAO's) *Draft Guidelines for the Application of a System on the Marking of Fishing Gear* on physical and electronic methods to identify the ownership and track the position of dFADs (Appendix 1) (FAO, 2016). The survey also obtained stakeholder views on: definitions of dFAD ownership; definitions of when a dFAD or its components are abandoned, lost or discarded; the reporting and retrieval of derelict dFADs; and the use of port reception facilities for disposing of components of dFADs. Furthermore, the survey compiled stakeholders' views on resolutions adopted by the tuna regional fisheries management organizations (RFMOs) regarding FAD marking and tracking.

The study was conducted to implement a recommendation made by the 32nd Session of the Committee on Fisheries (COFI) convened in 2016 (FAO, 2017) and to support the continued development of the FAO guidelines through a Technical Consultation on the Marking of Fishing Gear, to be convened in February 2018.

2. METHODS

2.1. Survey scope

The project team developed a survey form (Appendix 2) in Chinese (traditional and simplified), English, French and Spanish. The survey form was designed to collect information on stakeholder perspectives on:

- The efficacy, economic viability and practicality of alternative methods to determine the owner and track the position of dFADs, including for conventional dFAD designs, less- and non-entangling dFAD designs, and biodegradable dFADs. See ISSF (2015) and Moreno *et al.* (2016) for descriptions of dFAD designs.
- A section of the FAO Draft Guidelines calling for information on the spatial position of dFADs to be provided in near real-time to relevant management authorities (FAO, 2016) (Appendix 1).
- The value to fishers and vessels owners of physical and electronic methods to identify the vessel that is tracking a dFADs.
- The optimal physical and/or electronic identification method or combination of methods to mark and track dFADs.
- Defining dFAD ownership.
- Defining when a dFAD or a component has been abandoned, lost or discarded.
- Reporting abandoned, lost and discarded dFADs.
- Retrieval of derelict dFADs in coastal and open ocean areas
- A section of the FAO Draft Guidelines which states that the, “Responsibility for the recovery of lost, abandoned or discarded FADs lies with the owner, in cooperation with relevant authorities with due regard to other conditions within the guidelines” (FAO, 2016) (Appendix 1).
- Port reception facilities for derelict and unwanted dFADs.
- Measures adopted by tuna RFMOs, Parties to the Nauru Agreement (PNA) (MRAG, 2016; Escalle *et al.*, 2017) and the Republic of Kiribati (MFMRD, 2014) on dFAD marking and tracking (Appendix 3).

2.2. Targeted stakeholders

Project team members contacted and requested stakeholder participation in the project between February and July 2017. The following categories of stakeholders were contacted: purse seine fishing masters and skippers, support vessel captains, purse seine vessel owners and managers, purse seine fishery associations, at-sea observers, management authorities (domestic, sub-regional, regional), purse seine gear technology experts and manufacturers and service providers of instrumented buoys used by tuna purse seine companies.

The project team contacted the secretariats of the four tropical tuna regional fisheries management organizations (RFMOs) seeking their assistance. Three tuna RFMO secretariats issued circulars to their commissioners encouraging their participation in the project (IATTC, 2017; IOTC, 2017a; WCPFC, 2017). The survey prioritized for inclusion the domestic management authorities, purse seine associations and companies that own and manage purse seine vessels of the main flag states of large-scale dFAD purse seine vessels (the Republic of Korea, Taiwan Province of China, Spain and associated flags [Ecuador, El Salvador,

Seychelles, Belize, Curaçao], USA, France, Japan, China, the Philippines) (SPC, 2016), as they are stakeholders of the largest global purse seine dFAD fisheries. They were contacted to request their participation in the project and to provide assistance in encouraging other stakeholders to participate. Relevant regional and sub-regional bodies and international non-governmental organizations were also contacted, including the International Seafood Sustainability Foundation, Pacific Community (formerly named Secretariat of the Pacific Community), PNA, Secretariat of the Pacific Regional Environment Programme, and World Tuna Purse Seine Organization. In-person interviews were conducted by project team members in Ecuador, the Marshall Islands and Spain.

2.3. Synthesizing survey responses

Survey participants' responses were compiled and summarized. In order to promote candid responses, comments were not associated with the individual survey participants that contributed them, and captains, crew and observers were offered the option of anonymity.

3. RESULTS

3.1. Survey respondents

Ninety-one stakeholders participated in the survey. Table 1 identifies the number of survey participants by stakeholder category. Appendix 4 lists the names and affiliations of individuals who submitted completed surveys, excluding those who requested anonymity. While some participants identified as belonging to multiple stakeholder categories, the summary in Table 1 assigns each participant to a single category deemed the best fit.

Table 1. Summary of survey respondents

Stakeholder category	Number
Purse seine skipper, fishing master and crew	40
Support vessel captain	1
Purse seine vessel owner	18
Purse seine association	5
Fisheries observer	12
Management authority (domestic, sub-regional, RFMO)	9
Gear technologist	3
Manufacturers of instrumented buoys for FADs	2
Regional intergovernmental scientific body	1

3.2. Synthesis of survey responses

3.2.1. Designs of dFADs currently in use

Table 2 summarizes the responses of fishers, vessel owners and purse seine associations regarding the dFAD designs they use. Respondents who indicated using multiple designs are recorded as using each identified design in Table 2a. In Table 2b, responses from respondents that fish in multiple regions were attributed to multiple regions. No respondents reported using dFADs made entirely of biodegradable materials. However, a few respondents indicated that they are participating in trials of biodegradable dFAD designs.

Table 2. Percent of purse seine fishers, vessel owners and purse seine associations, by region, that use (a) each specified dFAD design; and (b) only less- or non-entangling designs of dFADs. See ISSF (2015) and Moreno *et al.* (2016) for definitions of dFAD designs. N – number of responses

(a) dFAD design(s) used	%	N
Traditional open netting appendage	38	61
"Less" entangling appendages with tightly wrapped sausage-like netting	52	61
Non-entangling appendages and surface structure	43	61
dFADs made completely or mostly of conventional synthetic materials	100	60

(b) Only less- and/or non-entangling dFADs used	%	N
Atlantic Ocean and Mediterranean Sea	75	4
Eastern Pacific Ocean	81	26
Indian Ocean	100	12
Western and central Pacific Ocean	41	29

Several respondents indicated that their conventional dFADs are constructed of a mix of synthetic and biodegradable materials. For example, the surface structure can include bamboo and other biodegradable materials, while components used to augment floatation are made of synthetic material. The appendage can include rope made of cotton but meshes made of synthetic compounds. While most respondents indicated that they build their own dFADs, one of the few vessel owners who purchases dFADs commented that dFADs made only of biodegradable materials are not commercially available, and if they were, they might use them if the cost, durability and effectiveness at aggregating target tunas were satisfactory.

3.2.2. Current practices to assign unique identification to dFADs and attached satellite buoys, and to track dFAD position

Table 3 summarizes the responses from captains and vessel owners on current technology used to identify the company that is currently tracking a dFAD, to track a dFAD's position, and to identify the company that deployed a dFAD.

Table 3. Current methods employed to assign unique identification to dFADs and attached satellite buoys, and to track dFAD position. N – number of responses

Technology	N
Hard, physical unique identification number on satellite buoys, both pre-printed tags incorporated by buoy manufacturer, and a code added by the buoy owner using paint, permanent marker or epoxy	57
Satellite buoy data transmission used by catch sector	63
Satellite buoy data transmission parallel feed to management authority	9
Satellite buoy data transmission parallel feed to scientific body	5
Unique dFAD design, which enables other vessels in a fishery to identify who deployed it	11

Several respondents explained that it is a prevalent practice for the purse seine industry to exchange control over dFADs by exchanging the attached satellite buoy. Buoy exchanging occurs both on dFADs that were being actively tracked by another vessel and that had been abandoned by the vessel that had most recently been tracking it. While the frequency of exchanging buoys varies by region (as discussed in Section 3.2.3), this practice is conducted in all regions. Several respondents commented that this widespread practice reduces the abandonment of dFADs, which assumes that if there was no buoy exchanging, then many more dFADs would drift out of range and be abandoned than currently occurs. However, some respondents commented that buoy exchanging results in a higher number of dFAD deployments in order to maintain a desired number of tracked dFADs. A few respondents commented that, in some regions, buoy exchanging can maximize purse seine fishing efficiency when it results in vessels spending less time traveling to dFADs to make sets. However, respondents also commented that, in regions where the degree of buoy exchanging is extremely high, this reduces fishing efficiency because it obstructs following a dFAD fishing strategy of deploying and tracking dFADs over a sufficient time period to enable a large biomass of aggregated tunas to accumulate before making a set on the dFAD. A high degree of dFAD exchanging likely increases dFAD deployments, where the higher the density of dFADs, the lower the mean size of tuna schools aggregating at the FADs, and results in 'premature' sets that produce lower catches per set (Dagorn *et al.*, 2013; Sempo *et al.*, 2013; Hall and Roman, 2017). The purse seine catch sector identifies the control of a dFAD through the owner of the attached satellite buoy. Several respondents clarified that, given this prevalent practice of exchanging buoys, the purse seine industry does not mark the structure of dFADs because this would not enable them to identify the company that is currently controlling the dFAD, and because the purse seine industry is not interested in identifying the company that originally deployed the dFAD.

Related, a few vessel owners and fishers commented that when dFADs change hands, they are often modified by the new purse seine or support vessel conducting the buoy exchanging. The new owner may restore and replace components of the dFAD, so that it is no longer the same structure as originally deployed. For example, one Spanish captain explained that when they exchange buoys on a dFAD that had an entangling appendage, they will replace it with a new appendage with a non-entangling design in order to meet their obligations under a voluntary industry code of good practice (Goñi *et al.*, 2015). This comment was made by a vessel owner to support the argument that the original company deploying a dFAD should not be considered the owner.

Almost all fishers, vessel owners and purse seine associations explained that they build their own dFADs, and that they do not put a physical identification code on the dFAD structure. Some respondents (18) reported that they purchase their dFADs and that these come with a unique manufacturer code. One respondent clarified that the subsurface structure typically has an identification number on it, while less frequently, some vessels mark the raft. However, some of these respondents clarified that they do not use the unique identification code on the dFAD structure when reporting information on dFAD activities to management authorities, but instead report the satellite buoy unique identification number. Thus, Table 3 does not identify physical, hard marking of dFADs as a method currently employed to identify the company that is tracking or owns a dFAD.

All fishers and vessel owners reported that they use satellite buoys on almost all of their dFADs. Captains and vessel owners report that a mean of 99 percent (±0.9 SE, N=58 respondents) of their dFADs have satellite buoys attached. 81 percent of these captains and vessel owners reported using satellite buoys on all of their dFADs. In addition to the unique identification tag included on satellite buoys by the manufacturer, owners also mark the surface of their satellite buoys to identify the vessel that owns it (Table 3). Figure 1 shows examples of two brands of satellite buoys used by purse seine fishers to track the geospatial position of dFADs, showing the physical identification numbers included by the buoy manufacturer and the physical mark added by the owner. Buoy manufacturers include duplicate unique identification code tags on each satellite buoy to reduce the risk of biofouling obscuring all of the tags.

Almost all respondents indicated that hard, physical marks on a satellite buoy require being in close proximity, between 3 and 50 m, to be read. A few respondents indicated that, when using binoculars, a hard, physical mark painted on the surface of buoys can be read in good weather conditions from the vessel at distances of between 50 m and 1 km. However, if the buoy belongs to the vessel, then the observer does not need to look at the physical hard mark on the buoy to identify the owner, and instead can identify the unique identification code of the buoy by viewing a monitor on the fishing vessel. Most captains report that they paint a code (e.g. vessel name or initials plus a number, or call sign), using various colours, onto their satellite buoys using small letters, so as to avoid covering the solar panels (which could cause the buoy to malfunction), with lettering between 5–20 cm in height. A few respondents (two captains, one observer) reported that recently they have started marking a code on a plastic plate that they attach to the satellite buoy.

Some captains (11) and vessel owners (1) reported that they usually bring the satellite buoy to the ship so that the observer can read the unique identification number on the buoy. A few observers (3) commented, however, that some captains have refused to bring the buoy to the vessel to enable them to record the identification number. One purse seine association representative clarified that they will bring buoys aboard, where the observer can read the code, and will retain these buoys, only if the buoy does not belong to them. Otherwise, if they own the

buoy attached to the dFAD, then they do not bring the buoy aboard, as the captain and observer can identify the buoy identification number remotely from the vessel. One vessel owner commented that it would not be practical to bring the observer to the dFAD to record the identification code on the buoy as this would take too much time if it had to be done at each dFAD. One captain, one vessel owner and one purse seine association commented that it might be unsafe to bring the observer to the FAD to read unique identification numbers due to boarding and de-boarding speedboats and when sea conditions are rough.

Figure 1. Examples of brands of satellite buoys used by purse seine fishers to track the geospatial position of dFADs. The locations of buoy manufacturer unique identification codes are identified with red ovals. White and red codes painted on the buoy surface are identification codes added by owners. Bottom-right: a used buoy with biofouling. Bottom-left and top: new buoys (bottom left image courtesy of Beau Bigler, Marshall Islands Marine Resources Authority; other images courtesy of Mikel Basterretxea, AZTI Tecnalia)

Vessels have an average of 343 (±32.4 SE, N=22) satellite buoys deployed at one time, and vessels each actively track an average of 33 (±3.9 SE, N=31) satellite buoys at one time. One captain explained that of the 350 or so dFADs with satellite buoys that he has deployed at one time, he actively tracks a proportion of these, between 5 and 50, which are located in nearby fishing grounds. Similarly, another captain clarified that he actively tracks dFADs near his vessel and some distant dFADs with a relatively large biomass underneath, as indicated by an echo-sounder. Some captains and vessel owners that operate in the convention areas of two tuna RFMOs that have adopted measures capping the number of active dFADs per vessel indicated that the number of FADs that they track when fishing in these regions is below the limit. In the Atlantic Ocean, ICCAT (2016) has a measure that limits parties to the following: “No more than 500 FADs with or without instrumented buoys are active at any one time in relation to each of its vessels”. In the Indian Ocean, IOTC (2017b) “set the maximum number of instrumented buoys active and followed by any purse seine vessel at 350 instrumented buoys at any one time.”

Respondents reported that an average of 21.4 percent (±2.8 SE, N=50) of satellite buoys permanently stop transmitting a signal (due to another vessel turning it off or destroying the buoy, or a permanent buoy malfunction). Some of these respondents clarified that they later recover some of these buoys from vessels that exchanged buoys on dFADs. Very few respondents (1 vessel owner, 3 captains) reported that they use radio buoys to locate dFADs.

3.2.3. Value to the catch sector of methods to assign unique identification to dFADs and attached satellite buoys, and to track dFAD positions

Table 4 summarizes benefits, identified by purse seine catch sector stakeholders, of having a unique identification number attributed to dFADs through a hard, physical mark and electronic signal on the attached satellite buoy, and by using a unique dFAD design. As discussed in Section 3.3.2, respondents explained that they do not obtain benefits from having hard marks directly on the dFAD structure. Respondents explained that the benefits of marking satellite buoys to identify the vessel owner are region-specific. Only fishers operating in the eastern Pacific Ocean identified having a unique dFAD design as enabling other vessels in the fleet to identify who deployed that dFAD. In some regions where there are relatively high densities of dFADs, such as in the Indian Ocean and the eastern Pacific Ocean close to the continents, the practice of exchanging satellite buoys is most prevalent and the benefit of marking buoys to identify the owner is thus more important in these regions.

Table 4. Benefits of current practices for hard and electronic unique identification of satellite buoys attached to dFADs and unique dFAD designs, identified by vessel owners, captains and fishing masters. N – number of responses

Method to provide dFAD unique identification	Benefit to industry	N
Paint, write with a permanent marker, or write with an epoxy on the cover of the satellite buoy or on a plastic plate attached to the buoy, an identification number, such as the name or initials of the fishing vessel and a number such as the vessel's call sign (Figure 1)	When another vessel comes across a dFAD with your buoy attached, the vessel will be able to identify who owns the buoy, and if they know the buoy owner (e.g. when the owner is of the same company or fleet), they might not exchange satellite buoys on the dFAD. The mark does not increase the visibility of the dFAD or buoy by other vessels.	32
	If another vessel of your company/fleet comes upon your satellite buoy, they may report to you the size of the aggregation at the dFAD	1
	If another vessel is close enough to your vessel, where you can see or detect the vessel with radar and determine that it is close to your dFAD, then you can radio the vessel and request that they not exchange buoys on the dFAD. The vessel that was going to exchange buoys on the dFAD can check the mark that the owner added to the buoy and confirm that it belongs to the other vessel, and not exchange buoys on the dFAD.	5
	Satellite buoys that are removed and retained by another vessel may be turned in to a facility in port where the buoy owners can retrieve them.	18

	Artisanal fishers who find derelict dFADs in nearshore waters will recover the satellite buoy, identify the owner from the mark placed on the buoy by the owner, and sell them back to the owners.	11
	This enables industry self-policing. When we come across a dFAD, we can determine which vessel is tracking it from the mark on the buoy, and determine if they are using a non-entangling dFAD design as required under a code of good practice signed by Spanish purse seine companies (Goñi *et al.*, 2015).	1
Satellite buoy unique identification number incorporated by manufacturer (Fig. 1)	Used by the captain and observers to meet management authority reporting requirements for FAD-related activities.	18
Satellite buoy data transmission	Used by captains to remotely track the spatial location of individual dFADs	23
	When used in combination with an echo-sounder, enables determining on which dFADs we will make sets	6
Unique dFAD design	Enables other vessels from a fishery to identify who deployed the dFAD, which might result in the other vessel to not exchange satellite buoys	11

3.2.4. Considerations for alternative methods to assign unique identification to dFADs and attached satellite buoys, and to track dFAD positions

Suitability of existing technology to identify who is currently tracking a dFAD and to track dFAD positions

Almost all survey participants considered the technology currently used for hard physical marking of satellite buoys, and existing satellite buoy technology, to be adequate to identify who is currently tracking a dFAD and to track a dFAD's position. Stakeholders consider existing technology to be practical and affordable. Satellite buoys can be feasibly used with all dFAD designs, with conventional and biodegradable materials, with conventional entangling, less-entangling and non-entangling designs, and for dFADs designed with a submerged structure with only buoys on the surface (to reduce the ability of other vessels to detect and exchange buoys on their dFADs) as well as those with a raft on the surface.

However, stakeholders identified some desired improvements in technology. A few respondents suggested that it would be useful to be able to estimate the trajectory of dFADs in order to identify when a dFAD is at risk of grounding on sensitive habitat so that they could be intercepted. And a few respondents commented that it would be helpful for dFADs to be navigable, either autonomously (self-propelled) or remotely (e.g. Davies *et al.*, 2017; ICCAT, 2017), in order to reduce the incidence of abandonment and groundings. One respondent suggested that it would be useful to develop the technology to enable observers to detect the

unique electronic identification number of satellite buoys remotely, from a distance of several hundred metres. This would eliminate observer reliance on crew to bring buoys being exchanged on dFADs to the vessel, or observers to the dFAD, to record the identification code of the old buoy.

A few captains commented that they would like a more permanent, durable method to mark buoys to identify the owner, because the painted or written marks deteriorate and can become obscured by biofouling over time (Figure 1). They also explained that they have to write the mark with small lettering to minimize the area of the solar panels that they obstruct. Two captains estimated that the code painted on the buoy lasts about 2–3 months, while a vessel owner estimated that it lasts over 6 months. One vessel owner reported using an epoxy to mark the vessel name and a number on buoys, which might be more durable relative to the other methods described by captains, fishing masters and vessel owners to mark their buoys (using paint and permanent marker, Table 3). One satellite buoy manufacturer reported that they are creating new buoy designs that have a specific area where owners can write their code without obstructing the solar panels, and a simple floating marking panel for attachment to the buoy. A few skippers reported that they are now using a plastic plate on which they mark the name of their vessel to attach to their satellite buoys.

Hard physical marks on the structure of dFADs

Most captains, vessel owners and purse seine associations replied that, given the common practice of exchanging satellite buoys, that the catch sector does not benefit from having a hard mark on the dFAD structure as they have no interest in identifying who originally deployed or previously tracked the dFAD. Instead, the unique ID of the satellite buoy currently attached to the dFAD is adequate to identify the company that is currently tracking the position of the dFAD.

As discussed in Section 3.2.2, a small number of captains and vessel owners reported that the structures of their dFADs have a unique hard mark. Most of the respondents who reported that their dFAD structures have a unique ID purchase their dFADs, where the manufacturer adds the physical mark. A few survey participants commented that, if they were required to add a unique, hard identification mark to their dFADs, then the methods for hard marking fishing gear used in other fisheries would likely be suitable for use on dFAD surface and subsurface components. A few other respondents, however, remarked that it would be a challenge to find a durable hard marking method for the dFAD appendage. Some respondents indicated that, if dFAD marking was required, then hard marking both the surface and submerged components of the dFAD with a unique identification number would be useful in the event that the mark on the surface structure was removed or replaced. A few respondents remarked that the durability of methods for hard physical marking of biodegradable dFADs requires consideration, as the marks might last for a shorter period when attached to biodegradable materials than when applied to synthetic materials.

As previously discussed in Section 3.2.2, some fishers and vessel owners commented that when dFADs change hands, the new purse seine or support vessel often modifies them by refurbishing and adding new components. Thus, the dFAD is no longer the same structure as originally deployed, and if there was a mark on the original structure the refurbishment might remove it. Some respondents referred to this practice as a basis for why the current or most current company tracking a dFAD should be considered the owner, and why there would be no benefits from marking dFAD structures.

A few respondents commented that it would be easy for vessels exchanging buoys on dFADs to remove or replace a mark on the structure of a dFAD. Two respondents raised the possibility

that, if hard marking dFAD structures was required, in regions where measures have been adopted that limit the number of dFADs that a vessel can track at one time (Section 3.2.2), vessels might falsely mark dFADs to indicate that they are owned by a competitor. This could result in the other company being found to be in violation of the limit measure, and might cause the other company to be held responsible for any damage caused by the falsely-marked dFAD.

Several respondents explained that purse seine operators want their dFADs to be difficult for other vessels to detect in order to reduce the probability of their being stolen. Purse seine and support vessels commonly use helicopters and bird radars to detect dFADs that they are not tracking with a satellite buoy. As a result, any physical or electronic method for marking and tracking dFADs/buoys must not increase its detectability by other vessels.

One respondent noted that, because there is often little more than a ring of net floats on the surface of a dFAD, only small hard physical markings would be able to be used on the surface structure. However, the same respondent suggested that it could be feasible to attach a buoy or other floating device to a dFAD so as to provide a unique ID. This would allow them to use larger lettering that could be read from a larger distance, but would not increase the ability of other vessels to find the dFAD. However, like satellite buoys, this could easily be removed and exchanged.

Satellite buoys

All vessels now use satellite buoys on almost all their dFADs to track their position and to identify the vessel that is currently tracking a dFAD (Section 3.2.3). Most respondents commented that there is nominal cost for the purse seine industry to have satellite buoy providers deliver a parallel feed of the buoy data to management authorities (Section 3.2.10). One respondent commented that observers may share satellite buoy data obtained from one vessel with fishers of other vessels. Related to this, as discussed in Section 3.2.5, respondents identified maintaining the confidentiality of commercially sensitive dFAD positions when reporting satellite buoy data to managers as a substantial concern.

Acoustic tags

Some respondents commented that they were unfamiliar with acoustic tag technology and did not know if the technology was appropriate for use on dFADs. Several respondents remarked that acoustic tags would be much less effective than satellite buoys at achieving the objective of tracking dFAD position. But, if attached directly to the dFAD, acoustic tags might be a better method than satellite buoys to assign a unique ID to a dFAD.

One respondent noted that it might not be practical to get within 1 km to detect an acoustic tag. One captain and one vessel owner explained that they approach dFADs within about 400 m to determine whether they will make a set, so it would be practical for an observer to use an acoustic tag to determine the unique ID of the dFAD. One respondent commented that the acoustic tag may not be able to be attached to a dFAD with a submerged raft, unless it could be attached to the floats on the raft. If not, then it would need to be attached to the satellite buoy.

A few respondents stated that, while acoustic tags might feasibly be used by observers and fishers to detect a unique identification number of a dFAD that they deployed and are tracking, the signal would need to be encrypted in order to prevent detection by other purse seine fishers. If it was not possible for acoustic tags to have encrypted signals, then the catch sector would not want to use them as it would increase the risk of other vessels finding, setting on and exchanging the satellite buoys on their dFADs.

Reconstructing the history of entities tracking dFAD positions

A few respondents stated that management authorities should be able to use satellite buoy time series data to determine the history of companies that had sequentially exchanged buoys and tracked the position of an individual dFAD. A respondent clarified that, because satellite buoy ownership can change over time, to be able to determine which entities tracked an individual dFAD over time, management authorities require data from satellite buoy service providers on changes in assignment of the ownership of a buoy. It may be possible to reconstruct the history of companies that had tracked an individual dFAD for those that were continuously tracked via satellite buoys while at sea: i.e. in cases where there was no period during their life without a reporting satellite buoy attached, including while drifting, brought aboard a support vessel for repairs, etc. Related to this previous point, some respondents commented that it has yet to be tested under various circumstances whether it is possible to identify the company that was last tracking a dFAD found with no satellite buoy attached.

Some survey respondents indicated that the combination of the following three methods would be necessary to determine the history of companies that had tracked an individual dFAD: a hard, unique mark on a dFAD structure; a satellite buoy attached to the dFAD, with parallel data reporting to a management authority; and an onboard observer to record the unique ID on the dFAD structure so that it could be linked to the satellite buoy. This would allow managers to identify the original owner, and may also enable them to determine which company had most recently been tracking a derelict dFAD found without a satellite buoy attached.

Some respondents commented that in regions such as the eastern central Pacific Ocean, far from the continents, there are relatively low densities of both purse seine vessels and dFADs (Section 3.2.3). In these regions, there are likewise many fewer exchanges of satellite buoys. As a result, in these regions, it would be much less complex to reconstruct the history of companies that had tracked an individual dFAD.

One survey participant suggested that one improvement would be to develop the technology for satellite buoys to detect and transmit a unique identification code for a dFAD to which the buoy is currently attached. Hard physical marks require being within very close proximity to a dFAD to read a mark, making it impractical for observers and electronic monitoring systems (via cameras on the vessel) to detect. Purse seine operators do not want to use marks that can be seen from a greater distance from the dFAD because this might increase its visibility to competitors searching from vessels and helicopters. The suggestion for instrumented buoys to be designed to detect a unique ID on dFADs would solve this current problem, augmenting the ability of management authorities to reconstruct the history of change in companies tracking an individual dFAD over its life.

One respondent explained that PNA may be considering leasing dFADs to purse seine companies authorized to fish in PNA member country exclusive economic zones (EEZs), where PNA would own and track all dFADs and satellite buoys in the PNA zone. This might enable this sub-regional management authority to control the number and density of dFADs, control dFAD designs, track real-time spatial positions, and control the current widespread practices of exchanging satellite buoys on dFADs and abandoning dFADs that drift out of the fishing zone.

Objectives met by alternative methods to mark dFADs, satellite buoys attached to dFADs and track dFAD positions

Table 5 summarizes responses on which objectives of the purse seine industry and fisheries management authorities are met or could theoretically be met by alternative methods to mark a hard, physical unique identification code on dFADs and on satellite buoys attached to dFADs,

and to track the spatial position of dFADs. The first six methods in Table 5 are individual approaches. Subsequent methods entail various combinations of these individual approaches. Other combinations of the six individual approaches not listed in Table 5, some of which are commonly used, would achieve the same objectives that are met by the individual methods, and no additional objectives through their combined use.

In response to the question of which method or combination of methods is optimal to identify a dFAD owner, when considering practicality, cost and effectiveness for the purse seine industry and management authorities, almost all respondents indicated that current methods of satellite buoy transmissions and hard physical marks on satellite buoys are best.

Table 5. Purse seine industry and management authority objectives met by alternative methods for marking dFADs and satellite buoys with unique identifications and for tracking spatial position

Method number	Method	Objectives
1	Satellite buoy transmission	Enable catch sector to track dFAD spatial location Enable manager to track dFAD spatial location and therefore dFAD density in an area Enable manager to identify entity currently tracking the dFAD Enable manager to determine history of companies tracking a unique dFAD Enable manager to verify E-logbook catch data Enable manager to monitor compliance with seasonal FAD closures and other measures Enable catch sector to not increase the visibility of the dFAD to other vessels
2	Acoustic tag on dFAD with unique signal	Enable manager to identify who originally deployed dFAD Enable catch sector to locate dFAD at short range
3	Hard, unique mark on satellite buoy added by owner	Enable other vessels to identify the satellite buoy owner to reduce the incidence of exchanging satellite buoys Enable the return of buoys that are exchanged, abandoned and lost Enable catch sector to not increase the visibility of the dFAD to other vessels

4	Hard, unique mark on satellite buoy added by manufacturer	Enable manager to identify the company that is currently tracking the attached dFAD, and when attached to grounded dFADs, to identify the company that was most recently tracking the dFAD Enable catch sector to not increase the visibility of the dFAD to other vessels
5	Hard, unique mark on dFAD	Enable manager to identify who originally deployed dFAD
6	Unique dFAD design	Enable other vessels of a fishery to know who deployed the dFAD
1, 5	Satellite buoy transmission and hard, unique mark on dFAD	Same as objectives met by the individual methods, and enable manager to determine the history of companies that tracked the dFAD
1, 2	Satellite buoy transmission and acoustic tag on dFAD with unique signal	Same as objectives met by the individual methods, and enable manager to determine the history of companies that tracked the dFAD
1, 3, 4, 5	Satellite buoy transmission, hard, unique mark on satellite buoy added by owner, mark on satellite buoy added by manufacturer, and mark on dFAD	Same as objectives met by the individual methods, and enable manager to determine the history of companies that tracked the dFAD
1, 2, 3, 4, 5	Satellite buoy transmission, acoustic tag on dFAD with unique signal, hard, unique mark on satellite buoy added by owner, mark on satellite buoy added by manufacturer, and mark on dFAD	Same as objectives met by the individual methods, with duplication to provide a backup in case one method fails, and enable manager to determine the history of companies that tracked the dFAD

3.2.5. Reporting dFAD satellite buoy positional data to management authorities

Eighteen respondents indicated that there should be mandatory near real-time reporting of satellite buoy data to management authorities. Several of these respondents added the caveat that near real-time reporting should only be required if robust measures to ensure the confidentiality of data are in place. Forty-two respondents stated that near real-time reporting is not acceptable because improper management of the data would likely result in leaks, revealing the positions of dFADs to competitors. Thirty-one respondents indicated that reporting satellite buoy data with an adequate delay to protect the sensitive commercial data is acceptable. Twenty-nine respondents recommended a delay in reporting satellite buoy data to managers ranging between three days and six months, with most respondents suggesting one month as an appropriate delay period. Five respondents commented that reporting satellite buoy positional data to management authorities should not be required, even with a delay, because there would be too great a risk of the data being leaked, where these data on recent dFAD positions is also commercially sensitive.

Because some satellite buoy service providers currently require 24 hours to convert the format of satellite buoy data to meet PNA system requirements, PNA currently requires that vessels report their buoy position data within a maximum of 24 hours. Five respondents report satellite buoy data to PNA with a one-month delay, one with a two-month delay, and one with a one- to two-day delay (Table 3). Two respondents who indicated that they fish in PNA waters stated that they do not comply with the requirement to report their satellite buoy data. Four respondents enable a parallel feed of their satellite data with a two-month delay to AZTI Tecnalia, a private scientific body. One respondent provides satellite buoy data with a three-month delay to the Institut de Recherche pour le Développement (IRD), a French government science and technology agency (Table 3).

A few respondents commented that management authorities could use near real-time satellite buoy data to monitor the current location of dFADs, identify which company is currently tracking individual dFADs, verify E-logbook catch data, and monitor compliance with seasonal FAD closures and other measures (Table 5). One respondent suggested that if purse seine vessel owners were required to report satellite buoy data to management authorities, and if exchanging satellite buoys on dFADs was prohibited, managers might be able to monitor the satellite buoy data to identify infractions of the ban on buoy exchanging. Reporting satellite buoy data might also create an incentive for industry compliance with a ban on exchanging buoys if one was adopted.

One respondent indicated that some operators, including in regions where there are caps on the number of dFADs that can be tracked by a vessel at one time (Section 3.2.2), have begun to deploy networks of dFADs, where several dFADs lacking satellite buoys are deployed in the vicinity of one dFAD with an attached satellite buoy. This effectively enables them to track more dFADs than the number that management authorities identify based on the number of satellite buoys assigned to the vessel.

3.2.6. Defining dFAD ownership

Almost all respondents (56) stated that the owner of a dFAD, and similarly, responsibility for damage caused by a dFAD if it runs aground on coastal habitat, should be the company that owns the satellite buoy that is currently attached to the dFAD, or if no satellite buoy is attached, then the company that last had one attached, if this can be determined. Several (11) respondents clarified that in cases where a buoy ceases to report because it malfunctions, then the company that owns the non-reporting buoy attached to the dFAD, and was last tracking the dFAD, should be considered the dFAD owner. And, almost all respondents (33) commented that ownership and responsibility for a dFAD should not be relinquished by reporting to a management authority when they have lost, abandoned or discarded a dFAD. Some of these respondents (12) clarified that relinquishing responsibility for abandoned, lost and discarded dFADs by reporting them to management authorities would eliminate all incentives for the catch sector to not abandon and discard dFADS and to recover their derelict dFADs (Section 3.2.7).

A small proportion of respondents recommended various alternative definitions of dFAD ownership and responsibility for damage:

- The company that last made a set on the dFAD should be considered the owner and be responsible for any damage that the dFAD causes (2 respondents).
- The company that originally deployed a dFAD should be considered the owner and be responsible for any damage that the dFAD causes, regardless of subsequent exchanges in satellite buoys (12 respondents).

- The company that was last tracking a dFAD should not be responsible for the dFAD if it is lost (due to an exchange in satellite buoys, because their buoy malfunctioned, because the dFAD sank), but they should be responsible for abandoned and discarded dFADs (1 respondent).
- Neither the company that last tracked a dFAD nor the original owner should be responsible for damage caused by the dFAD because it is not possible for the catch sector to control where a dFAD will drift (3 respondents), and similarly, no one should be considered the owner of a dFAD (2 respondents).
- Neither the company that originally deployed the dFAD nor the company currently tracking it should be used as the basis for assigning liability because this would incentivize mislabelling dFADs and would create a disincentive for reporting the deployment of dFADs (3 respondents).
- The dFAD owner should be the company that originally deployed the dFAD unless they report to their management authority that they have lost it or it has been stolen (15 respondents). There would, however, need to be a rigorous method to independently verify the claim that the dFAD was lost or stolen (and not abandoned or discarded) (5 respondents).
- A dFAD with no satellite buoy attached should be considered owned by the company that originally deployed the dFAD, if this can be determined (2 respondents).
- Both the original company that deployed a dFAD and the company currently tracking the dFAD with their satellite buoy, if they are not the same company, should be considered owners of the dFAD. Both should be responsible for any damage caused by the dFAD (3 respondents).
- Both the original company that deployed a dFAD, unless they report to their management authority that they lost it or it has been stolen, and the company that is currently tracking the dFAD with an attached satellite buoy should be considered the owner and be responsible for any damage that the dFAD causes (1 respondent).
- The vessel owner should not be responsible for derelict dFADs because the captains' actions are not controlled by the vessel owners (1 respondent).
- The flag state of the vessel and the management authorities that issues licenses to fish should be considered owners of dFADs and should be responsible for any damage caused by the dFADs (1 respondent).
- The determination of who owns a dFAD and who is responsible for damage caused by a dFAD should be determined on a case-by-case basis (4 respondents).
- The definition of ownership should be consistent with international law regarding ownership and liability of unattended fishing gear deployed at sea (2 respondents).

While outside the scope of the current study, one purse seine association representative commented that tracking natural floating objects through the attachment of a satellite buoy should not be subject to the same requirements as dFADs for marking, identifying ownership, reporting data on spatial position and other requirements. On a related point, one respondent recommended that the use of supply and other vessels as FADs to support fishing by purse seine vessels, documented at some shallow seamounts (e.g. see Koehler and Moreno, 2016), should be subjected to the same requirements for identifying ownership and tracking position as FADs.

As discussed in Section 3.2.4, one respondent explained that PNA is considering leasing dFADs to purse seine companies authorized to fish in PNA member country EEZs, where this sub-regional management authority would own and track all dFADs and attached satellite buoys in the PNA zone.

3.2.7. Defining and reporting when a dFAD or component has been abandoned, lost or discarded

Defining abandoned dFADs

Several respondents explained that dFADs are abandoned when they drift out of a company's fishing grounds, including into areas where a vessel is not authorized to fish and unsafe areas where there is piracy, as well as at the beginning of a dFAD seasonal closure period. A purse seine or support vessel may also retrieve their satellite buoy but abandon the attached dFAD if the fishing grounds were not productive and if the dFAD was worn-out and damaged.

Some respondents noted that when a dFAD that they are tracking drifts far from their fishing grounds, they monitor the buoy location to try to identify another vessel that can exchange buoys on the dFAD and retain and return their buoy. While their aim is to avoid abandoning their satellite buoy, this practice also avoids abandoning the dFAD.

A few respondents explained that when a dFAD drifts out of their fishing grounds, they direct their satellite buoy service provider to unsubscribe (stop the transmission of) the buoy attached to that dFAD (also documented in Escalle *et al.*, 2017). One of these respondents stated that, if provided with access to data for these instances, management authorities could determine when dFADs are abandoned. However, vessels may also unsubscribe a buoy when its signal ceases. Thus, information on incidences of buoy owners directing their services providers to unsubscribe buoys alone might not enable management authorities to determine whether a vessel lost or abandoned a dFAD.

One respondent commented that the definition of dFAD abandonment should not be linked to legal liability as this would create an incentive to mislabel dFADs and misreport data on deployed dFADs.

When is dFAD abandonment acceptable?

Several respondents stated that when a dFAD drifts into an area where purse seine vessels lack access rights, such as the EEZs of some countries, they have to abandon the dFAD. One observer commented that when a dFAD drifts into an area where pirates are active, the vessel should be permitted to abandon it. As discussed below, six respondents commented that the purse seine sector should be required to recover all dFADs, and that abandonment is not acceptable.

A few respondents suggested that the ecological impact of abandoned dFADs could be reduced by requiring the use of biodegradable and non-entangling designs. One respondent proposed that abandonment could be acceptable if the technology were developed to enable a purse seine vessel tracking a dFAD that is approaching a coastline to use a satellite-based signal to trigger the release of a biodegradable dFAD appendage and raft from the floats and satellite buoy. This would enable the appendage and raft to sink in deep water instead of risking grounding on sensitive coastal habitat. Two respondents commented that abandonment may result in a lower environmental impact than retrieval because of the large carbon footprint that would result from vessel fuel consumption to reach the abandoned dFADs.

Defining lost dFADs

Companies routinely 'lose' dFADs when other vessels exchange the attached satellite buoys. The vessel exchanging buoys may turn off the old buoy and typically retain and it so it can eventually be returned to the owner. But they may also destroy it, or leave it turned on and let it drift away after they have detached it from the dFAD. One respondent explained that sometimes a vessel exchanging buoys will take the old buoy aboard and discard it far from the dFAD. Companies may also lose dFADs when the attached satellite buoy malfunctions and permanently stops reporting data, when the buoy becomes detached from the dFAD, and when a dFAD sinks. Also, a vessel that deploys dFADs without satellite buoys attached may lose track of them. Several respondents stated that it is unlikely that a satellite buoy would become detached from a dFAD without someone removing it. Some respondents explained that over time, portions of the dFAD subsurface structure may detach from the raft and sink.

Several respondents explained that when a satellite buoy signal ceases, they do not know the cause: they do not know if the buoy was exchanged by another company, if the buoy malfunctioned or if the dFAD and buoy sank.

A few respondents suggested that, if a management authority requires reporting of satellite buoy data that is close to real-time, then the management authority may be able to detect when a company has exchanged satellite buoys on a dFAD. In this case, when a company is tracking a satellite buoy that ceases to report a signal and thus loses the dFAD, the management authority may be able to determine which company has taken over tracking that dFAD.

Many respondents explained that 24 hours is too short a period to determine if a buoy is permanently non-reporting and lost. Satellite buoys may stop reporting temporarily, for two to three days, and then resume reporting. Respondents explained that these intermittent breaks in buoy transmissions are sometimes due to battery problems or issues with the solar charging cells. One respondent suggested that three days would be an adequate time period to determine whether a satellite buoy has permanently ceased to report and can be safely assumed to be lost. A few captains explained that because they pay their satellite transmission fees for satellite buoys monthly, they wait until just before the payment due date to report lost buoys, just in case they recover the buoys or another vessel can use them, in which case they would have the satellite buoy provider reassign the buoy to another company. Furthermore, if a satellite buoy becomes detached from the dFAD and drifts away, either due to malfunction/mechanical action or more likely because another vessel stole the dFAD and discarded the old satellite buoy without first turning it off, then the previous owner will not know that they have lost the dFAD unless one of their vessels goes to fish on the FAD and finds only the satellite buoy not attached to a dFAD, which could take a long time. However, a few observers commented that it should be possible to differentiate between a satellite buoy that is attached to vs. detached from a dFAD, as the latter will drift at a substantially faster speed. For these reasons, these captains suggested using one month as the required maximum period to report lost FADs.

One respondent explained that electronic monitoring systems and conventional human observers can identify some, but not all, dFAD deployments and buoy exchanges. For example, electronic monitoring and human observers on board purse seine vessels will not detect dFAD deployments and buoy exchanges by helicopters and support vessels. Managers may be able to monitor satellite buoy exchanges if they receive all satellite buoy data and if satellite buoys were attached to all dFADs. It would otherwise be difficult for managers to determine when vessels misreport having lost a dFAD that they actually abandoned.

Defining discarded dFADs
As discussed in greater detail in Section 3.2.9, almost all captains, vessel owners and purse seine associations explained that dFADs and components are almost never discarded, while a few captains and observers reported that fishers will occasionally discard unwanted dFAD components. For example, when fishers replace worn-out dFAD materials, they may discard the old materials at sea, and when they exchange buoys on a dFAD, fishers may replace the existing appendage with a design that they prefer, and discard the old appendage at sea.

When is dFAD discarding acceptable?
In response to the question when should vessels be permitted to discard a dFAD or components at sea, 27 respondents indicated that this is never acceptable. Three respondents stated that the vessels should comply with Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL; see Appendix 5), without clarifying whether they perceive discarding dFAD components at sea as violating MARPOL measures. Six respondents replied that it would be acceptable to discard biodegradable and non-entangling FADs. However, some respondents pointed out that dFADs made completely of biodegradable materials would still pose a risk of grounding on, and damaging, sensitive coastal habitat and damaging deep-sea communities if they sink before the materials degrade. A few respondents commented that discarding dFADs should be permissible in rare cases where it is a matter of safety. One respondent suggested that discarding dFADs should be permitted if a retrieval programme were in place. One respondent stated that it is a health risk to store old dFADs on board, and therefore discarding old dFAD components should be permitted.

What issues might arise with a requirement for vessel owners to report to management authorities within 24 hours of having lost, abandoned or discarded a dFAD?
As discussed above, several respondents expressed reasons why 24 hours is too short a period to require reporting a dFAD as having been lost. However, vessels that are tracking a dFAD and decide to abandon (or less likely, discard) it could feasibly report this to management authorities at close to real-time, within 24 hours. Seventeen respondents stated that vessel owners should be required to report their loss, abandonment or discarding of dFADs to a relevant management authority, but several clarified that due to the issues discussed above, a longer minimum period than 24 hours should be used. Eight respondents commented that it would be too large a burden on vessel owners and captains to have to report their dFAD loss and abandonment because each vessel tracks a large number of buoys and it would take too much time to report each individual lost and abandoned dFAD. One respondent suggested that the proposed measure should require weekly or monthly reporting of abandoned, lost and discarded dFADs instead of within a day of each individual event. Several respondents expressed that compliance with such a measure would be low.

One respondent raised the concern that reporting the location of a lost, abandoned or discarded dFAD would risk having management authorities leak this confidential, sensitive commercial data. Another respondent commented that management authorities of coastal states would misuse such a reporting requirement to issue penalties without there having been infractions.

Eight respondents commented that management authorities can be difficult to communicate with and that this should be accounted for when defining a reporting requirement. One respondent commented that a requirement for reporting lost, abandoned or discarded dFADs should fall to the vessel captain, and not the owner.

One respondent remarked that a mechanism for reporting derelict dFADs is useful only if there is capacity to then retrieve the derelict dFADs.

Would a no-fault provision increase compliance with a requirement to report lost or abandoned dFADs?

Forty-six respondents indicated that they believed a no-fault provision would likely increase compliance with a reporting requirement, while 14 believed it would not. As discussed in Section 3.2.6, 33 respondents commented that no-fault provisions for abandoning, losing or discarding dFADs should not be employed because it is the responsibility of the purse seine sector to recover all of their dFADs, and reporting dFAD abandonment, loss and discarding should not eliminate the prohibitions of MARPOL Annex V (Appendix 5). Several respondents stated that a no-fault reporting measure would be a disincentive for not abandoning and discarding dFADs and for recovering derelict dFADs. Two respondents commented that a no-fault provision for reporting lost dFADs would result in a large incentive to misreport abandoned FADs as lost. Some captains raised the concern that if they reported a dFAD as lost or abandoned, and as a result their satellite buoy was removed from an active buoy register, if they subsequently retrieved the satellite buoy, then they might not be able to have the buoy reactivated and continue to use it.

Six respondents commented that purse seine companies should budget dFAD recovery as part of their operational costs, and if the cost to recover dFADs is currently too high given the number of dFADs they currently deploy, then these companies should deploy fewer dFADs (discussed further in Section 3.2.8). Conversely, three respondents stated that if liability for dFADs was defined based on who originally deployed the gear and/or who was currently tracking it, then this would result in a large incentive not to comply with requirements on reporting dFAD deployments and tracking, and therefore a no-fault provision is necessary to achieve high compliance with a requirement to report lost and abandoned dFADs.

What issues arise for onboard observers to be tasked with recording when the vessel discards synthetic components of a dFAD at sea?

Almost all respondents indicated that, in some regions, onboard observers are already tasked with recording discharges of garbage, including fishing gear, at sea (IOTC and WCPFC: SPC, 2009a,b; IOTC, 2014; Gilman, 2015), and therefore having observers record when fishers discard synthetic FAD components at sea would not pose a problem. A few respondents commented that observers are not always able to detect when crew discard dFADs and components, such as when discarding occurs at night, when the observer is on the well deck, or when the observer is asleep. A few respondents remarked that observers may be pressured by fishers to not report MARPOL violations, and that sometimes fishers will bribe the observer with money or alcohol to not record discarding incidents. Six respondents commented that if observer data were used to identify MARPOL infractions and as the basis for issuing penalties, then this would result in substantial problems for onboard observers. However, some respondents clarified that data collected through tuna RFMO observer programmes for purse seine vessels are used only for scientific purposes and not for surveillance and enforcement. There is therefore no problem at present for observers to record MARPOL violations.

Six respondents commented that observers may lack the knowledge of what materials are prohibited from being discarded at sea, including under MARPOL Annex V (Appendix 5), and observers should therefore receive relevant training. Several respondents explained that a vessel might abandon an entire dFAD, which the observer would not detect, but vessels do not typically discard dFAD components at sea, as discussed below.

If there were a no-fault provision in place, whereby the vessel owner would not be penalized or held responsible for having lost or abandoned a dFAD if they report it to their management authority, would that eliminate potential problems for observers to record incidences of dFADs being lost or abandoned?
Thirty-three respondents commented that such a no-fault provision would likely help eliminate concerns with observers reporting the abandonment, loss and discarding of dFADs and components, while nine respondents replied that a no-fault provision would not address issues observers face with this reporting. Eight respondents stated that observers are not able to determine when a vessel loses or abandons a dFAD. Four respondents commented that a no-fault provision would eliminate incentives not to abandon dFADs and should therefore not be implemented. As previously discussed, a few respondents commented that no-fault provisions for losing and abandoning dFADs should not be used because: it is the responsibility of the purse seine sector to recover all of their dFADs, reporting their loss and abandonment should not eliminate this responsibility, and companies should budget dFAD recovery as part of their operational costs.

What issues might arise with a requirement for purse seine captains and/or observers to record and report to management authorities the unique ID on a dFAD or a buoy attached to the dFAD when the vessel encounters a dFAD that it does not own and is not tracking?
Almost all who responded to this question explained that if a vessel finds a dFAD that is not theirs and decides to make a set on it (they use long-range sonar to scan the dFAD from about 800 m away to determine whether there are sufficient fish aggregated at the FAD to make it worth making a set) and/or to exchange satellite buoys, then it is feasible for the captain and observer to record the unique ID of the original buoy, which is the current practice. However, in cases where a dFAD is sighted but the vessel does not intend to go near the dFAD to make a set or exchange buoys, if an observer were to request the vessel to bring the dFAD to the vessel so that they could record a unique identification of the dFAD or attached buoy, the captain would likely not comply if it were voluntary. Several respondents commented that it would not be appropriate to require purse seine fishers to do this, as it would be a substantial burden for fishers to have to stop fishing activities to perform this management task. Related to this, a few respondents suggested that an incentive scheme would be necessary to have purse seine fishers perform this task. One respondent remarked that identifying the location of derelict and IUU dFADs in this manner would only be useful if management authorities also developed the capacity to retrieve these dFADs.

A few respondents commented that if the dFAD did not have an attached buoy, then it would not likely be feasible to determine who deployed it or was last tracking it.

Five respondents commented that, under some management systems, a purse seine vessel stopping at a FAD is counted towards their allocation of fishing effort, even if they do not make a set. This would therefore be a disincentive for vessels to approach a FAD when they do not intend to set on it or exchange the buoy attached to it.

Twelve respondents indicated that there would be no problems for captains or observers to perform this function. Some of these respondents clarified that this would aid managers in determining compliance with measures that limit the number of FADs at sea that are being tracked by an individual vessel. Two respondents suggested that the source of the report should be kept confidential in order to avoid retribution by the company that owned the satellite buoy attached to the dFAD that they inspected.

3.2.8. At-sea and coastal retrieval of derelict adrift dFADs

Would having vessels on standby to collect dFADs when notified that the dFAD is approaching a designated sensitive coastal habitat be feasible?
Most respondents commented that derelict dFADs disperse over extensive areas, making it logistically infeasible and too expensive to have a programme that would retrieve adrift dFADs that are approaching coastal areas. This was most strongly expressed for the western and central Pacific Ocean due to the large number of islands in the region. Some respondents commented that coastal states lack the institutional capacity and financial resources to implement a dFAD retrieval programme. Numerous respondents explained that vessels may lack the authorization to enter coastal waters to retrieve their dFAD, as discussed in Section 3.2.7.

Conversely, a few survey respondents stated that it is feasible to establish site-specific programmes that monitor dFAD satellite buoy data to determine when dFADs approach specific sensitive sites, so that the dFADs could be intercepted by locally-based vessels before running aground. Some respondents clarified that the buoy service providers would need to participate in the coastal retrieval programmes to make it possible to determine when dFADs are approaching coastal areas and to provide data on their locations so that they can be retrieved. One respondent explained that they are currently participating in such a programme in the Seychelles (Island Conservation Seychelles, 2016). One respondent commented that the more onerous the fine a coastal state issues for grounded FADs, the higher the incentive and greater the feasibility of implementing a dFAD coastal retrieval programme. A few respondents replied that the feasibility of implementing coastal dFAD retrieval programmes is site-specific.

Some captains and vessel owners that operate in the eastern Pacific Ocean explained that artisanal fishers recover satellite buoys from derelict dFADs in nearshore waters in order to sell the buoys back to the owners. These coastal fishers, however, do not retrieve the dFADs. A few of these respondents suggested that if there were a market for derelict dFADs, larger vessels operating in coastal areas might recover the dFADs if the economic incentive was adequate.

One respondent commented that coastal retrieval programmes should consider how close a dFAD can come to a coastline before removing it from the water, as a dFAD may come very close, within 1 nautical mile (1.9 km) of islands without running aground.

One respondent noted that when FADs entangle on sensitive habitat, experts should determine whether and how to remove the derelict gear to minimize the risk of exacerbating the environmental impacts.

Is the collection of abandoned dFADs on the high seas and pelagic areas of EEZs feasible?
Most respondents commented that a retrieval programme for abandoned dFADs on the open ocean would either not be feasible or would be very difficult and too expensive. Among other reasons, such a programme would require a tremendous amount of fuel, given the extensive area over which dFADs are distributed. As indicated in Section 3.2.7, a few respondents stated that the adverse environmental effects from the consumption of fuel that would be necessary to retrieve derelict dFADs on the high seas may be greater than those caused by not retrieving them. A few respondents remarked that purse seine vessels lack the space to store retrieved dFADs. One respondent commented that fuel-efficient vessels, or non-fuel-based vessels (using sails or solar energy, for example), could be used to retrieve dFADs at sea.

Nine respondents explained that vessels of the same company (‘sister’ vessels) routinely communicate the positions of dFADs that they are tracking and that drift out of their fishing grounds so that sister vessels can make sets on them. Four respondents believed it would be feasible to establish regional programmes where all purse seine and support vessels of a region were organized to communicate the position of dFADs that drift out of range of one company’s vessels, so that vessels of other companies within range could take over tracking and setting on them. One respondent commented that he would like to have a supply vessel recover dFADs that drift eastward in the Indian Ocean, out of the fishing zone.

Additional considerations related to derelict dFAD retrieval

As discussed in Section 3.2.7, a few respondents commented that it is technically feasible for the purse seine sector to retrieve their dFADs, that these companies should plan their operating costs to account for the expense of retrieving their fishing gear, and that this would likely require reducing the number of dFADs that they currently deploy.

Some respondents clarified that it would likely be feasible to retrieve dFADs in some ‘hot spot’ areas, where dFADs accumulate in relatively high densities during certain seasons. In some regions, such as in the Indian Ocean at convergence zones, and in the eastern Pacific Ocean close to the continents, the density of dFADs is high relative to other regions such as the central Pacific Ocean.

A few respondents indicated that it is not possible to determine when a dFAD is abandoned, lost or otherwise discarded fishing gear (ALDFG or derelict gear) as opposed to in-use, active gear, particularly in open ocean areas away from coastlines. Retrieval programmes would need to develop standard operating procedures in partnership with the catch sector to determine when a dFAD is in use vs. derelict, or at risk of being abandoned because it is drifting out of fishing grounds.

Several vessel owners, fishers and purse seine association representatives noted that implementation of a section of the FAO draft gear marking guidelines that states the, “Responsibility for the recovery of lost, abandoned or discarded FADs lies with the owner, in cooperation with relevant authorities” (Appendix 1), if interpreted to mean that all dFADs were required to be recovered by the purse seine sector, would have a substantial, adverse effect on the economic viability of the purse seine sector. They further commented that it would not be feasible to recover dFADs that are truly lost or that drift into zones where their vessels are prohibited.

One respondent commented that, if the statement from the FAO draft guidelines, "in cooperation with relevant authorities" (Appendix 1) is intended to indicate that, along with the ‘owner’ of the dFAD, management authorities are obligated to retrieve derelict dFADs, then complex situations may arise in situations where multiple domestic management authorities are involved. For instance, responsibility for implementation would be unclear when a vessel fishing in the EEZ of a coastal state is flagged to a different country and is owned by a company from a different state.

A few respondents expressed the view that management authorities should use part of the fee for purse seine fishing licenses, PNA vessel days, and/or foreign vessel access agreements to enable government agencies to cover the costs of managing coastal and high seas dFAD retrieval programmes.

When a dFAD becomes lost because a satellite buoy malfunctions or becomes detached from the dFAD, or when a satellite buoy is switched off, then it would not be possible to track the dFAD position in order to retrieve it. Similarly, it may not be possible to locate or recover dFADs that sink or degrade into multiple pieces.

Suggestions for systems to retrieve derelict and unwanted dFADs at sea
Respondents proposed several additional methods to retrieve derelict and unwanted dFADs:

- Use negative incentives to have the purse seine industry retrieve dFADs. Domestic management authorities could prosecute companies that last controlled dFADs that enter waters where the fishing gear is prohibited, and prosecute companies that last controlled dFADs that run aground.
- Use positive incentives to have the purse seine industry retrieve dFADs. For example, management authorities could provide rewards, subsidies or increased allocations of fishing effort to vessels that retrieve FADs identified as abandoned, lost, discarded or IUU fishing gear.
- Require vessels to pay a deposit for each dFAD that they are authorized to deploy each year. The deposit would be returned when vessels document that they retrieved the dFADs at the beginning of a seasonal dFAD closure period (in regions with dFAD seasonal closures). The amount of the deposit fee would exceed the esimated cost for dFAD retrieval. Given the practice of exchanging buoys on dFADs, vessels would need to cooperate to retrieve dFADs attached to each other's satellite buoys at the beginning of each seasonal closure period.
- Develop the technology for autonomous (self-propelled) or remotely controlled dFADs (Section 3.2.4) (Davies *et al.*, 2017; ICCAT, 2017). This could enable owners to keep dFADs near their fishing vessels and support vessels when servicing is desired, and prevent groundings.
- Use only biodegradable materials to construct dFADs, and collect satellite buoys attached to biodegradable dFADs that drift ashore.
- Establish a fund to cover the costs of a dFAD retrieval programme. Each incidence of loss, abandonment or discarding of a dFAD would require the responsible company to contribute a specified amount to the fund.
- Establish programmes that coordinate activities by fishing companies, coastal states, and where relevant, coastal fisheries, in order to retrieve dFADs before they ground. The programme in the Seychelles (Island Conservation Seychelles, 2016) might serve as a model for replication.
- To address the lack of space on board purse seine vessels to store unwanted dFADs, require purse seine vessels to have incinerators on board to dispose of unwanted synthetic dFAD components.
- Coastal and flag states authorizing purse seine fishing could charge the catch sector a per-dFAD user fee to cover costs for a government-administered programme that retrieves derelict dFADs. The user fees could be scaled, based on the number of dFADs deployed, with higher fees for non-biodegradable and entangling dFAD designs.
- Develop simulation models to predict dFAD drift patterns for specific areas and seasons, and ban dFAD deployment at sites and times that have an unacceptably high likelihood of grounding in sensitive areas.
- Require purse seine companies to retrieve all of the dFADs that they deploy, and to develop operating budgets that cover these retrieval costs.

3.2.9. Port reception facilities for unwanted dFADs and components

Which dFAD components do you dispose of, and how often?
Almost all respondents explained that they almost never dispose of synthetic dFAD components, either at sea or in port, but reuse them to refurbish dFADs. When a vessel encounters a damaged dFAD at sea, they will either repair and redeploy it, or leave it where they found it. A few fishing masters and captains explained that they refurbish rafts and submerged appendages, and change out satellite buoys every 4 to 12 months.

Some captains and vessel owners explained that they routinely replace small sections of nets and ropes of dFAD appendages when they become worn-out, corroded or encrusted with barnacles and other biofouling organisms. While a few of these respondents explained that they typically discard this unusable gear at sea, and a few stated that they incinerate the old material on their vessel at sea, most respondents said that they retain the retired gear and discard it when in port. One captain explained that when refurbishing dFADs they remove and replace sections of old netting and ropes, and parts of these old materials may inadvertently be discarded at sea while conducting the repair work, but the bulk of the worn-out gear that cannot be reused is stored on board and thrown away with their other garbage once they are in port. Two vessel owners reported that, except for floats, they discard all dFAD surface and subsurface components at sea when they are worn-out and not reusable. Three captains commented that they discard worn-out floats used as part of the dFAD raft at sea. Two observers explained that purse seine fishers will on occasion, though very infrequently, discard dFAD components at sea. Another observer commented that, on occasion, when a vessel exchanges satellite buoys on a dFAD, if they do not like the design of one of the dFAD components, the fishers will replace it and discard the old unwanted materials at sea. For example, as discussed in Section 3.2.2, vessels that are members of the Spanish purse seine owner associations Asociación Nacional de Armadores de Buques Atuneros Congeladores (ANABAC) and Organización de Productores de Grandes Atuneros Congeladores (OPAGAC), are required under a voluntary industry code of good practice to use only non-entangling dFAD designs (Goñi *et al.*, 2015). When these vessels exchange buoys on a dFAD with an entangling design, they change out the dFAD components to comply with the non-entangling design requirement.

Several captains, fishing masters, vessel owners and purse seine association representatives explained that when they replace biodegradable components of the floating structure of their dFADs, including reeds and bamboo, they discard these old materials at sea.

Some respondents explained that when vessels exchange satellite buoys attached to dFADs, the fishers may detach the old satellite buoy and let it drift away, or may destroy the old satellite buoy and discard the debris at sea. This represents an additional source of discarded fishing gear. However, these respondents clarified that retaining the old buoy and returning it to port so that it can be retrieved by the owner, with the expectation that other vessels will do the same, is the more common practice.

When in port, how do you dispose of unwanted dFADs and components?
As discussed above, most captains and vessel owners responded that they do not dispose of dFADs or components either in port or at sea. However, a few respondents explained that they dispose of unwanted dFAD components using disposal services available at port. More specifically, a few captains and vessel owners explained that they will occasionally retain worn-out dFAD sections of netting and rope on board and will dispose of these materials once they are in port. These materials end up at local landfills.

What would increase the incentive for purse seine and support vessels to dispose of unwanted dFADs and components in port?
Respondents explained that because almost no one disposes dFADs or components (either at sea or in port), incentives to encourage in-port disposal are not necessary. Section 3.2.8 summarizes respondents' suggestions on how to incentivize the retrieval of dFADs instead of the prevalent practice of abandoning them. However, if vessels retrieved dFADs instead of abandoning them, fishers would want to reuse the dFAD, and if needed would refurbish worn-out components. As a result, even if dFAD abandonment ceased, there would still only be limited demand for port facilities to dispose of worn-out dFAD components.

If there were facilities for the disposal of dFADs and other gear at your seaports, and there was no or very low cost for disposal, would you be more likely to refrain from discarding or abandoning the gear at sea, and instead dispose of it in port?
Almost all respondents replied that having free port facilities to dispose of unwanted dFADs and components would not result in an increase in purse seine fishers using them. Several respondents explained that they already have the ability to dispose of debris in port for free or at a low cost, and that this does not create an incentive for them to retrieve dFADs to dispose of them in port. Section 3.2.7 summarizes respondents' explanations of why dFADs are abandoned. The reasons that fishers decide to abandon dFADs do not include issues with port disposal (such as availability, cost and practicality). The main issue is that the cost of abandoning dFADs at sea is much lower than the cost of retrieving them. Furthermore, no purse seine or support vessel would recover a damaged dFAD to dispose of it in port under current circumstances. Some respondents commented that purse seine vessels lack space to store a large volume of unwanted dFADs. One captain explained that he is not willing to store old dFADs or components on board because it might be a health hazard due to the biofouling organisms on the gear, and because of the bad smell. Conversely, seven respondents replied that low or no-cost port disposal facilities might possibly increase the likelihood of vessels disposing of unwanted dFAD components in port instead of at sea.

What would make port reception facilities for the disposal of unwanted gear practical for you to use?
A few respondents commented that having facilities at port that assist vessels to refurbish and reuse worn-out components of dFADs would be useful. The facility could provide equipment that would enable them to easily offload old dFAD components and provide adequate space to refurbish dFADs. One respondent suggested developing a programme to collect worn-out dFAD components from vessels and send them to dFAD manufacturers so that they could be reused.

As discussed above, almost all respondents explained that accessibility and practicality of use of port reception facilities are not factors which lead the purse seine industry to not discard unwanted dFADs and components in port.

One respondent indicated that port reception facilities would need to be near vessel anchorages, and clarified that because many purse seine vessels transship their catch when in port, they might not come alongside a dock. This makes it difficult to offload debris, including unwanted fishing gear such as FAD components. A few captains suggested that having trucks on call to pick up garbage from the vessels or from an adjacent dock would be convenient. One respondent commented that in ports where there currently are no waste disposal facilities it would be desirable to establish them.

How much would you be willing to pay to dispose of unwanted dFAD components at a port facility?

Almost all captains, vessel owners and purse seine association representatives replied that they would not be willing to pay to dispose of dFAD components in port. Some respondents replied that they currently do not have to pay to dispose of their debris in port. One respondent indicated that the cost to discard unwanted fishing gear in port is covered by their company's general fee for garbage collection services.

3.2.10. Measures adopted by tuna RFMOs, Parties to the Nauru Agreement and national governments on dFAD marking and tracking

Table 6 summarizes experiences with dFAD marking and tracking requirements of tuna RFMOs, PNA and domestic management authorities (Appendix 3).

Table 6. Experiences with regional dFAD management measures. N – number of responses

dFAD Management Programme	Comment	N
Compliance		
PNA	A majority of vessels have been complying / the vessels of our flag state have been complying / the clients for whom we provide satellite buoy service have all been complying.	22
	A majority of vessels probably have not been complying / our vessel has not been complying.	2
	About 80 percent of vessels have been reporting satellite buoy data, and these vessels have registered about 20 percent of their satellite buoys with PNA.	1
	Almost all companies that have been reporting their satellite buoy data to PNA have been geo fencing, where they have their satellite buoy service provider report positional data only when they are in the EEZs of PNA member countries, and not when they are on the high seas (Escalle *et al.*, 2017).	1
Kiribati	All vessels have been complying / all vessels of our flag state have been complying.	3
	Most vessels have likely not been complying.	2
IATTC	Likely all vessels have been complying. Almost all vessels use satellite buoys and these come with a manufacturer identification code.	30
	The vessels of our country are beginning to implement the measures.	1
	A majority of vessels have not been complying.	1

ICCAT	A majority of vessels have been complying / the vessels of our flag state have been complying.	4
	Vessels have been partially complying. While the ICCAT measure requires vessels that exchange a buoy to record both the ID code of the old and new buoys, vessels have only been recording the ID of the new one. However, onboard observers record codes for both.	1
IOTC	A majority / all of vessels have been complying / all vessels of our flag state have been complying	12

Reasons for non-compliance

PNA	There is reluctance for dFAD regulation, in part, because many of the vessels that are deploying dFADs may be illegal.	1
	Industry concerns over maintaining the confidentiality of data on the recent positions of their dFADs, which might reveal the location of good fishing grounds to competitors, is an incentive for non-compliance	4
Kiribati	Enforcement for vessels of some flag states has been weak (different enforcement standards are applied based on the vessel flag state).	1

Practicality for catch sector

PNA	The requirement to report satellite buoy data to PNA is easy to comply with. The vessel owner instructs their satellite buoy service provider, who sends the data to PNA by email.	20
	The requirement to report satellite buoy data to PNA is not easy for vessels to comply with.	2
Kiribati	The requirement to mark dFADs is easy to comply with (instead of marking the required information on a detachable plate attached to the dFAD, we record the information on the surface of the attached satellite buoy)	3
IATTC	The requirement to mark dFADs or satellite buoys is very easy to comply with. Almost all vessels had already met the requirement prior to the measure being adopted as all vessels now use satellite buoys on most or all of their dFADS, which have a unique identification number on them assigned by the manufacturer.	25
	The IATTC FAD reporting forms are difficult to complete and training is needed.	8
ICCAT	The measure is easy for vessels to comply with.	4
IOTC	The measure is easy for vessels to comply with.	11
	The measure is not easy for vessels to comply with.	1

Cost for catch sector

PNA	There is no additional cost for vessel owners to have their satellite buoy data reported to PNA.	20
	The cost is not reasonable.	2
	It required about three weeks of work by satellite buoy service provider companies to enable the buoy position data to be sent to PNA, a cost born by the buoy service provider companies. But other than this initial cost, there is no ongoing cost to enable this parallel feed of data to PNA.	1
Kiirbati	The cost is reasonable / there is no additional cost.	3
IATTC	The cost is reasonable.	27
	Vessels conventionally marked their satellite buoys, so there was no added cost or burden resulting from the measure.	13
ICCAT	The cost is reasonable / there is no additional cost	5
IOTC	The cost is reasonable / there is no additional cost.	12
	The cost is not reasonable.	1

Efficacy – unique ID detectable by captain and observer

PNA	A unique satellite buoy signal can easily be detected by the vessel tracking it, and by an observer on board the vessel that is tracking it.	17
	A physical hard mark on the satellite buoy is easy to detect if the vessel is inspecting or setting on the FAD, however it may become obscured over time. It may be able to be read when the vessel is very close to the dFAD and may require the buoy to be brought to the vessel or the observer brought to the dFAD.	10
	In some cases the observer cannot read the physical hard mark on the satellite buoy if the fishers do not bring aboard an old buoy that they are replacing.	1
Kiribati	The physical hard mark on the satellite buoy can be easily detected by the captain and observer.	3
	A physical hard mark on the satellite buoy is easy to detect if the vessel is inspecting or setting on the FAD, however it may become obscured over time. It may be able to be read when the vessel is very close to the dFAD and may require the buoy to be brought to the vessel or the observer brought to the dFAD.	1
IATTC	A physical hard mark on the satellite buoy is easy to detect if the vessel is inspecting or setting on the FAD, however it may become obscured over time. It may be able to be read when the vessel is very close to the dFAD and may require the buoy to be brought to the vessel or the observer brought to the dFAD.	27
	The satellite buoy unique signal is detectable remotely and eliminates the need to physically inspect the buoy if the dFAD the vessel is setting on had that vessel's satellite buoy attached.	4

ICCAT	A physical hard mark on the satellite buoy is easy to detect if the vessel is inspecting or setting on the FAD, however it may become obscured over time. It may be able to be read when the vessel is very close to the dFAD and may require the buoy to be brought to the vessel or the observer brought to the dFAD.	5
	The satellite buoy unique signal is detectable remotely and eliminates the need to physically inspect the buoy if the dFAD the vessel is setting on had that vessel's satellite buoy attached.	3
IOTC	A physical hard mark on the satellite buoy is easy to detect if the vessel is inspecting or setting on the FAD, however it may become obscured over time. It may be able to be read when the vessel is very close to the dFAD and may require the buoy to be brought to the vessel or the observer brought to the dFAD.	13
	The satellite buoy unique signal is detectable remotely and eliminates the need to physically inspect the buoy if the dFAD the vessel is setting on had that vessel's satellite buoy attached.	4

Durability

PNA	The satellite buoy signal remains available as long as the satellite buoy does not malfunction and the vessel changes out their buoys periodically (every few weeks/months). The satellite buoy is not likely to become detached from the dFAD unless another vessel removes it.	12
	Given that vessels routinely exchange satellite buoys, the unique ID of a particular satellite buoy does not remain associated with an individual dFAD for very long.	12
Kiribati	A unique ID painted onto buoys by the vessel owner is durable, but wears off in time.	2
	Given that vessels routinely exchange satellite buoys, the unique ID of a particular satellite buoy does not remain associated with an individual dFAD for very long.	1
IATTC	A unique ID painted or written onto buoys by the vessel owner is durable.	22
	The manufacturer's ID on the satellite buoy is very durable and should be detectable for the life of the buoy. It can, however, become obscured from view by biofouling over time.	22
	Using an epoxy putty to mark a unique ID on buoys is extremely durable.	1
	Given that vessels routinely exchange satellite buoys, the unique ID of a particular satellite buoy does not remain associated with an individual dFAD for very long.	21

ICCAT	The manufacturer's ID on the satellite buoy is very durable and should be detectable for the life of the buoy. It can, however, become obscured from view by biofouling over time.	5
	Given that vessels routinely exchange satellite buoys, the unique ID of a particular satellite buoy does not remain associated with an individual dFAD for very long	5
IOTC	The unique ID painted or written onto buoys by the vessel owner is durable but wears off in time. The manufacturer's ID on the satellite buoy is very durable and should be detectable for the life of the buoy. It can, however, become obscured from view by biofouling over time.	12
	Given that vessels routinely exchange satellite buoys, the unique ID of a particular satellite buoy does not remain associated with an individual dFAD for very long.	5

Can the method for assigning a unique ID be easily removed by another vessel?

PNA	Vessels easily change out satellite buoys. It is not possible to remove the unique ID assigned to a satellite buoy.	16
Kiribati	The manufacturer ID on buoys and the ID marked on the buoy by the vessel owner are easily removed from the dFAD by exchanging the buoy.	4
IATTC	The manufacturer ID on buoys and the ID marked on the buoy by the vessel owner are easily removed from the dFAD by exchanging the buoy.	22
	It is not possible to remove the unique ID assigned to a satellite buoy.	4
ICCAT	The manufacturer ID on buoys can be easily removed from the dFAD by exchanging the buoy. It is not possible to remove the unique ID assigned to a satellite buoy.	4
IOTC	The manufacturer ID on buoys and the ID painted or written on to the buoy can be easily removed from the dFAD by exchanging the buoy. It is not possible to remove the unique ID assigned to a satellite buoy.	11

Other issues

PNA	Maintaining the confidentiality of satellite buoy positional data has been an issue.	10
	There are no benefits to the catch sector as a result of reporting satellite buoy data to PNA.	2
	There have been no issues	7
	One issue reported with the PNA requirement for reporting satellite buoy data is that vessels often have satellite buoys on deck reporting, which makes it difficult to distinguish buoy position data coming from deployed dFADs vs. those on vessels. The data from buoys on vessels may be able to be distinguished from deployed dFADS due to differences in speeds of drifting FADs vs. vessels when cruising. However, when purse seine vessels are drifting at night, setting or investigating a tuna school, the vessel speed may be similar to that of a dFAD (Maufroy *et al.*, 2015; Escalle *et al.*, 2017).	1

Harmonizing measures
Some respondents commented that there would be benefits from harmonizing dFAD marking and tracking requirements across the tuna RFMOs, particularly for companies that operate vessels that fish in multiple regions / tuna RFMO conventional areas.

4. RECOMMENDATIONS TO IMPROVE THE FAO DRAFT GUIDELINES

Here we present excerpts from the *Draft Guidelines for the Application of a System on the Marking of Fishing Gear* related to purse seine dFADs (Appendix 1) (FAO, 2016). Based on the survey responses, we identify considerations to improve the Draft Guidelines' effectiveness in identifying ownership and tracking the position of dFADs and in defining, reporting and retrieving abandoned, lost and discarded dFADs. Gaps in the Draft Guidelines on issues related to marking and tracking dFADs, and priority research on assigning a unique identification code to dFADs and tracking dFAD spatial location, identified through survey responses, are also discussed.

4.1. Hard physical marking

Text in FAO Draft Guidelines

- "The authorization to fish using any form of FAD (anchored or drifting, single or multiple) should be made on the condition that they are marked, applying the same principles as other fishing gear."
- "The mark indicating ownership of a FAD should be placed in a conspicuous position and attached to the buoy system."
- "Webbing used as an aggregator should have the mark of the vessel embedded in it."

Considerations
Conventional gear marking methods for identifying ownership may not be appropriate for use on dFADs. This is due to the prevalent practices of exchanging satellite buoys attached to and

concomitant control over dFADs and of refurbishing dFAD components at sea, including by new vessels when a dFAD changes hands. If the definition of dFAD ownership is the fishing company currently tracking the spatial position, then the current practice of attaching satellite buoys to dFADs may represent the best practice to assign a unique identification code to dFADs, eliminating the need for physical marks. The purse seine sector currently attaches satellite buoys to dFADs to remotely track their spatial position. The satellite buoys are physically marked to identify the owner. Physical marks on the dFAD structure (raft, floats and appendage) are not currently used to identify ownership or the company that is currently tracking the dFAD. It is a prevalent practice for purse seine fishers (both of purse seine vessels and support vessels) from different companies to remove an existing satellite buoy attached to a dFAD, if one was attached, and replace it with their own. For example, French and Italian purse seine skippers reported that 30 percent of their dFADs were stolen within 45 days of deployment (Goujon *et al.*, 2017). Therefore, having a hard, physical mark on a dFAD structure that identifies the original owner does not enable identifying the company that is currently or was most recently tracking the dFAD. It also does not enable determining the history of companies that had tracked the dFAD since it was deployed.

The second bullet could be revised to clarify whether it is recommending that a mark be included on floats attached to FAD rafts, instrumented buoys attached to dFADs, or both. If the intent is to prescribe that marks be attached to satellite or other instrumented buoys, then FAO will be recommending the status quo, where satellite buoy marks (physical marks and electronic signals) identify the company currently tracking dFADs, and not necessarily companies that originally deployed dFADs. However, if the intent is to recommend having a physical mark on floats attached to FAD rafts, then FAO is recommending that the mark identify the company that originally deployed the FAD.

If the FAO Guidelines recommend physically marking the structure of dFADs for the purpose of identifying the vessel/company that originally deployed the fishing gear, including derelict FADs that run aground, then recommending unique identification marks on both the surface and subsurface structures is advised. While marks on the surface structure would be relatively easy to remove at sea, the removal of marks from the subsurface structure at sea would be more difficult. This is especially relevant in the Atlantic and Indian Oceans where measures capping the number of dFADs that can be tracked by a vessel at one time are in place, and as a result, there is an incentive for vessels to mislabel or remove marks that identify dFAD ownership. The purse seine sector would want the prescribed physical mark to not increase dFAD detectability by other vessels.

Purse seine and support vessels routinely refurbish dFADs at sea, replacing and repairing worn-out and lost components with new ones. This could result in inadvertent or intentional removal of physical marks identifying the company that originally deployed a dFAD and needs to be taken into account when prescribing best practice methods to physically mark dFADs.

FADs with non-entangling and less-entangling appendage designs are now in commercial use in some regions (based on findings from this survey as well as from past surveys of purse seine skippers conducted by the International Seafood Sustainability Foundation (ISSF) [ISSF, 2016]), and are required by three of the four tuna RFMOs. Therefore, if marking dFAD subsurface structures is retained as a recommendation in the Guidelines, then replacing “webbing used as an aggregator” with “FAD subsurface structure” or with “FAD appendage” is advised.

Developing the technology to enable satellite buoys to detect a unique identification code of the attached dFAD via a device or devices imbedded in the dFAD structure might be a viable alternative, or a complementary approach to, hard, physical marking of dFADs.

Where feasible, having management authorities own and lease dFADs and the attached instrumented buoys to purse seine companies could be an effective approach to address some dFAD management issues. This would enable managers to conduct real-time tracking of the spatial positions of all dFADs, provide fisheries managers and scientific bodies with access to real-time echo-sounder buoy data, allow managers to have stronger control over the number and density of dFADs and enable managers to better control dFAD materials and designs.

4.2. Tracking dFAD spatial position

Text in FAO Draft Guidelines

- "For unattended FADs that are allowed to drift, in addition to the identifier mark, some means of providing real-time information on the location of the FAD, such as an electronic transponder, where practicable, should be provided. Location information should be provided in near real-time to the relevant authority for monitoring purposes."
- "Radio or Satellite buoys marked and attached for both monitoring and tracking."

Considerations

In recommending practices on reporting dFAD spatial position, the FAO guidelines should consider and address industry concerns over maintaining the confidentiality of data on the current and recent spatial positions of their dFADs. For example, the FAO guidelines could identify potential approaches, such as allowing a delay in reporting buoy data and employing best practices for managing time-sensitive confidential fisheries data, which management authorities could consider to address this issue.

Radio buoys and self-call buoys are largely no longer in use. Instead, almost all dFADs are now equipped with a satellite transmitting buoy to enable vessels to locate them, and in some fisheries, to enable scientific bodies and management authorities to track dFAD positions. For example, PNA requires all dFADs deployed by vessels licensed to fish in PNA member country EEZs to have satellite buoys attached to their dFADs and to report positions to PNA (even when the buoys drift out of the PNA region) (Escalle *et al.*, 2017). And, for example, two Spanish purse seine owner associations, ANABAC and OPAGAC, have the independent scientific body AZTI, in cooperation with the instrumented buoy manufacturer companies, monitor the number of active instrumented buoys being tracked by each vessel (Santiago *et al.*, 2017). This is conducted to assess compliance with what had originally been a voluntary measure but is now a requirement under IOTC and ICCAT measures that cap the number of instrumented buoys that can simultaneously be tracked by a single purse seine vessel (ICCAT, 2016; IOTC, 2017b).

In the two regions with per-vessel caps on the number of satellite buoys or dFADs that a vessel can have deployed at one time (ICCAT, 2016; IOTC, 2017b), and in remaining regions if they adopt similar caps, operators may increasingly deploy dFADs lacking satellite buoys in the vicinity of dFADs with satellite buoys, thereby enabling them to track more dFADs than the number reported to management authorities based on the number of satellite buoys that are assigned to the vessel. Observer records of sets on dFADs lacking satellite buoys may deter this potential practice.

4.3. Defining abandoned, lost and discarded dFADs

Text in FAO Draft Guidelines
"In the design of a marking system for FADs, relevant authorities should clearly define when a FAD is considered lost, discarded or abandoned."

Considerations
The guidelines should explicitly consider and address the complications of determining when dFADs are lost given that the company tracking the position of dFADs may change numerous times over the course of a dFAD's life.

4.4. Reporting abandoned, lost and discarded dFADs

Text in FAO Draft Guidelines
"When FADs are lost or abandoned, the relevant authorities should be notified of the last known position for the FAD by the FAD operator."

Considerations
While discarding dFADs is understood to be rare, the scope of this section of the FAO guidelines could be expanded to include discarded dFADs and components of dFADs.

In prescribing protocols to report abandoned, lost and discarded dFADs, the FAO guidelines should consider and address the complex issues related to defining dFAD ownership and defining abandoned, lost and discarded dFADs.

4.5. Retrieving abandoned, lost and discarded dFADs

Text in FAO Draft Guidelines
"Responsibility for the recovery of lost, abandoned or discarded FADs lies with the owner, in cooperation with relevant authorities with due regard to other conditions within the guidelines."

Considerations
As discussed above, complex issues related to defining dFAD ownership, as well as defining abandoned, lost and discarded dFADs, need to be considered to ascribe responsibility for retrieving abandoned, lost and discarded dFADs.

Derelict dFAD retrieval programmes would require clear definitions to differentiate between active, in-use vs. derelict dFADs and dFADs that are at risk of grounding.

It may not be possible to locate or recover truly lost dFADs, including when a satellite buoy has permanently malfunctioned, has become detached from the dFAD, or has been switched off. And it may be impossible to recover dFADs that have sunk or that have degraded into multiple components and dispersed.

4.6. Gaps in measures prescribed by the Draft FAO Guidelines

Defining dFAD ownership: The Draft Guidelines prescribe FAD marking to identify ownership, and state that the dFAD owner is responsible for reporting and recovering derelict dFADs. The guidelines could highlight issues related to defining dFAD ownership due to the prevalent practices of exchanging satellite buoys attached to and concomitant control over dFADs, and of refurbishing dFAD components at sea.

Regional harmonization: There would be benefits to harmonizing FAD marking and tracking requirements across the tuna RFMOs, as highlighted at the recent first meeting of the joint tuna RFMO FAD Working Group (ICCAT, 2017).

Port reception facilities: Management authorities have developed incentives for fishers to retrieve ALDFG encountered at sea and to deliver the derelict fishing gear to port reception facilities for recycling and disposal (Gilman *et al*., 2016). If the status quo of purse seine vessels abandoning dFADs that drift out of range, drift into prohibited or unsafe areas, and at the beginning of dFAD seasonal closure periods changes, and retrieval programmes are instituted, including through site-specific systems designed to mitigate groundings at priority coastal areas (e.g. Island Conservation Seychelles, 2016), then there may be increased demand for port reception facilities for retrieved dFADs. However, given that the purse seine catch sector typically refurbishes and reuses worn-out dFAD components, port reception facilities should be designed to support industry refurbishment and reuse.

dFAD designs: Transitioning dFAD designs away from synthetic and entangling to biodegradable and non-entangling materials would contribute to mitigating ghost fishing, habitat degradation and other adverse ecological and socio-economic effects of derelict fishing gear. Making dFADs commercially available that are made only of biodegradable materials, and with non-entangling materials, that are of commensurate cost, durability and efficacy at aggregating target species as conventional designs, would contribute to achieving this objective for the minority of purse seine companies that purchase their dFADs.

4.7. Research priorities

Survey respondents identified the following research related to assigning a unique identification code to dFADs and tracking dFAD spatial location.

Satellite buoy automated detection and reporting of unique FAD ID: Develop the technology to enable an instrumented buoy to detect and transmit a unique identification code of the dFAD that it is attached to. This could increase the ability to document the history of companies tracking a dFAD during its lifetime.

Technology to navigate dFADs: Augment research and development to enable purse seine companies to remotely navigate dFADs, or for dFADs to self-navigate, so that they do not drift out of their fishing grounds and avoid contact with vulnerable coastal habitat (Davies *et al.*, 2017; ICCAT, 2017). This would contribute to preventing having dFADs become abandoned and lost and would reduce the risk of dFADs grounding on sensitive coastal habitats.

Hard physical markings on the structure of dFADs: Identify best practice options for hard physical markings on the structure of dFADs that are likely to remain attached and legible for the lifetime of a dFAD, including when it is refurbished at sea. The marking method should be

cost effective and not increase the risk of detection by other vessels. It may be possible to adopt marking methods currently used for other fishing gears. Whether different technology is needed for hard marking different dFAD designs requires consideration, such as for marking dFADs with submerged structures and only buoys on the surface vs. those with rafts at the surface, and for marking synthetic vs. biodegradable materials.

Remote detection of a satellite buoy's unique ID: Develop the technology to enable observers to remotely detect, from a distance of several hundred metres, the unique electronic identification number of satellite buoys. This would eliminate observer reliance on crew to bring buoys to the vessel or observers to the dFAD to record the ID of buoys.

Satellite buoy marking to identify vessel owner: Improving buoy designs to improve the durability of the hard markings that owners add would increase the likelihood of lost and abandoned satellite buoys of being returned and reused, as well as augmenting other benefits that buoy owners derive from marking their buoys (Table 4). One satellite buoy manufacturer reported that they are creating new buoy designs that have a specific area where owners can write their code without obstructing the solar panels, and a floating marking panel for attachment to the buoy.

Satellite-based signal to detach biodegradable dFAD from floats: Develop the technology to enable a company that is tracking a biodegradable dFAD that is approaching a coastline to trigger, using a satellite-based signal, the release of the dFAD appendage and raft from the floats and satellite buoy. This causes the appendage and raft to sink in deep water and avoid grounding on sensitive coastal habitat.

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Appendix 1

Sections on fish aggregating devices from the FAO *Draft Guidelines for the Application of a System on the Marking of Fishing Gear*

The following are the sections on FADs from the FAO *Draft Guidelines for the Application of a System on the Marking of Fishing Gear* (Appendix E of FAO, 2016).

64. The authorization to fish using any form of FAD (anchored or drifting, single or multiple) should be made on the condition that they are marked, applying the same principles as other fishing gear.

65. For unattended FADs that are allowed to drift, in addition to the identifier mark, some means of providing real-time information on the location of the FAD, such as an electronic transponder, where practicable, should be provided. Location information should be provided in near real-time to the relevant authority for monitoring purposes.

66. In the design of a marking system for FADs, relevant authorities should clearly define when a FAD is considered lost, discarded or abandoned

67. When FADs are lost or abandoned, the relevant authorities should be notified of the last known position for the FAD by the FAD operator.

68. Responsibility for the recovery of lost, abandoned or discarded FADs lies with the owner, in cooperation with relevant authorities with due regard to other conditions within the guidelines

Annex B.2. (1) The mark indicating ownership of a FAD should be placed in a conspicuous position and attached to the buoy system. (2) Webbing used as an aggregator should have the mark of the vessel embedded in it. (3) Radio or Satellite buoys marked and attached for both monitoring and tracking.

Appendix 2

Survey form

The English version of the survey form is included in this appendix. Versions of the survey are also available in Chinese (traditional and simplified), French and Spanish.

Survey on Physical and Electronic Methods to Identify the Ownership and Track the Position of drifting Fish Aggregating Devices Used by Tuna Purse Seine Fisheries

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BACKGROUND

The Food and Agriculture Organization of the United Nations (FAO) is conducting a survey to obtain comments and suggestions to improve a section of the FAO *Draft Guidelines for the Application of a System on the Marking of Fishing Gear* on methods to identify the ownership and track the position of artificial drifting fish aggregating devices (dFADs) used by tuna purse seine fisheries. The survey also collects views on reporting and retrieving abandoned, lost and discarded FADs, and on measures adopted by tuna Regional Fisheries Management Organizations on FAD marking and tracking.

FADs have made it possible to successfully fish in new areas and substantially improved fishing efficiency. Using physical marks and electronic tracking of dFADs to identify ownership and monitor position, and reporting and removing derelict and unwanted dFADs, contribute to improved monitoring and management, including deterring illegal purse seine fishing and reducing the abandonment, loss and discarding of dFADs. Tracking dFADs may also improve the understanding of the effects of different densities of dFADs on tuna stock dynamics and oceanic communities so that optimal dFAD densities might be achieved.

We seek the participation of purse seine captains and crew, purse seine vessel owners, purse seine at-sea observers, purse seine fisheries management authorities, purse seine associations, gear technology experts, manufacturers of FAD satellite and sonar buoys, and manufacturers of acoustic tags and receivers. FAO will produce a report summarizing the survey responses, which will be presented to the participants of the FAO Gear Marking Technical Consultation in early 2018 in order to improve the guidelines on marking and tracking FADs.

We hope that you will participate in the survey to improve the FAO international guidelines on gear marking. In order to encourage candid responses, individual comments will not be associated with the contributor.

To submit completed surveys and for more information:
Eric Gilman, FAO Consultant, Egilman@UTas.edu.au

SECTION 1. BACKGROUND

Today's date	
First (given) name	
Last (family) surname	
Affiliation (employer)	
Mailing address	
Phone	
Email	

Are you a (check all that apply):	
Purse seine captain	
If captain, are you responsible for decisions on fishing operations?	
Purse seine crew and position	
Purse seine vessel owner	
Purse seine association	
At-sea observer	
Management authority	
Fishing gear scientist or technologist	
Manufacturer of FAD satellite buoys	
Manufacturer of FAD sonar buoys	
Manufacturer of acoustic tracking equipment	
Other (specify)	

If you are a captain, crew or vessel owner:	
In which area(s) do you predominantly fish: a. Atlantic Ocean b. Indian Ocean c. Mediterranean Sea d. Eastern Pacific Ocean e. Western and Central Pacific Ocean	
Do you use dFADs that are: a. Non-entangling submerged portion b. Non-entangling floating surface structure c. Traditional submerged portion with open netting d. "Less" entangling submerged portion with tightly wrapped sausage-like netting	
Do you use FADs that are: a. Biodegradable, or b. Made of conventional synthetic materials?	
If biodegradable: a. Is the floatation material biodegradable? b. Is the submerged material biodegradable?	
Is the raft of your FADs at the sea surface or submerged with only floats at the surface?	

SECTION 2. FAD PHYSICAL AND ELECTRONIC MARKING AND POSITION TRACKING
In this section, we request your opinion on the efficacy, economic viability and practicality of options for marking the ownership and tracking the position of dFADs. When answering the questions below, refer to these four categories of options to identify the owner of dFADs:

a. Manufacturer's unique ID on dFAD
b. Manufacturer's unique ID on satellite or sonar buoy
c. Unique ID added to dFAD by owner
d. Unique ID added to satellite or sonar buoy by owner
e. Have satellite buoy service provider submit satellite buoy data to management authority
f. Acoustic or other type of electronic tag attached to FAD. The observer would use a device to receive the ID from the electronic tag. The observer may need to be within 1 km of the FAD.

2.1. If you are a purse seine vessel owner, captain or crew then answer the questions below. Otherwise, go to Section 2.2.

Do you mark your dFADs or buoys with some object, such as by attaching a physical tag or painting on numbers?	
If yes: a. What type of mark do you use (e.g., pre-printed tag, paint a number). b. Identify on the illustration where you affix the mark. c. Height of the mark? d. Color of the mark? e. Background of the mark? f. Material the mark is made of? g. How close to the dFAD does the observer need to be to read the mark?	
If you buy dFADs, do they come with a unique manufacturer's number on them?	
Should both the FAD appendage and surface structure be marked to identify ownership of derelict dFADs? Why / why not?	
How do vessel owners and captains benefit from having a physical or electronic unique identification on dFADs?	

2.2. Which method is best to identify dFAD ownership:
a=physical hard mark on FAD
b=physical hard mark on buoy
c=satellite buoy data accessible to owner
d=provide satellite buoy data to manager
e=acoustic tag with unique ID
f=other (please describe)

Criterion	Best method to identify ownership of (a) conventional, (b) non-entangling and (c) biodegradable dFADs
Easiest for fishers – consider: • How much work captain/crew have to do • For options a, b and c, would the captain be willing to have a speedboat bring the buoy to the boat, or bring the observer to the FAD, so the observer can read the unique ID? • If you selected I acoustic tag, would the captain be willing to bring the vessel to within 1 km to the FAD so the observer can detect the signal with a receiver?	
Most effective for managers – consider: • Will the unique ID be removed when the FAD is stolen (buoy is changed)? • Remains attached and detectable for life of the FAD – e.g., mark will not deteriorate or fall from the FAD due to exposure to seawater, sunlight	
Lowest cost for vessel owner – consider: • Cost • Will the method increase visibility of dFAD by helicopters of competitor purse seine vessels – such as tag on a tether attached to the FAD?	
Lowest cost for manager- consider cost for fisheries management authorities	
Is real-time reporting to managers FAD position data acceptable? If no, then what delay (number of days or months) should be allowed to address the risk of revealing FAD positions to competitors?	
Considering all issues, which method or combination of methods is best to identify dFAD ownership?	

2.3. If you are a purse seine vessel owner, captain or crew then please answer the questions in this section, otherwise go to Section 3.

Do you use radio buoys to track your dFAD locations? If yes, what proportion of your dFADs has radio buoys attached?	
(a) Do you use satellite buoys to track your dFAD locations? If yes, (b) what proportion of your dFADs has satellite buoys attached, and (c) how many buoys does one vessel track at one time?	
If you use satellite buoys, what percent of your dFADs have satellite buoys that permanently stop transmitting (although you might recover the buoy if returned to you later)?	
If you use satellite buoys, do you direct your satellite buoy service provider to provide your satellite buoy data to a government management authority? If yes, which authority receives your satellite data, and what delay (number of days, months) if any is used.	

SECTION 3. REPORTING DERELICT FADS AND DEFINING OWNERSHIP

How would you modify these definitions defining when a dFAD is:	
Abandoned	Fishers opt not to retrieve a dFAD that they deployed or otherwise for which they are tracking the position. Fishers may do this, for example, because it would take too much time to retrieve a dFAD that has drifted far away, bad weather makes it too dangerous to retrieve, or they're operating illegally and risk of detection occurs. Modify to:
Lost	Fishers set gear to fish but cannot locate the gear to retrieve it. This may occur, for example, when a tracking buoy malfunctions or a dFAD is stolen. Modify to:
Discarded	Fishers discharge an unwanted dFAD or components at sea. Fishers may do this, for example, when this is deemed more practical or economical than retaining an unwanted dFAD aboard and disposing of it onshore, or when there may be insufficient room aboard to store it. Modify to:
The FAO draft gear marking guidelines state that the, "Responsibility for the recovery of lost, abandoned or discarded FADs lies with the owner, in cooperation with relevant authorities".	

What definition is appropriate for the **owner of a dFAD** in light of the frequent practice of vessel operators exchanging satellite buoys: a. The company that originally deployed it regardless of any subsequent exchanges of the satellite buoy b. The company that originally deployed it unless another company exchanges the attached satellite buoy c. The company that originally deployed it unless they report to their management authority that they have abandoned it d. The company that is currently tracking its position e. If dFAD is lost because the satellite buoy malfunctioned, then the company that was most recently tracking it with a satellite buoy f. Something else (please specify)?	
If a vessel owner reports to their management authority that they lost a dFAD (based on the signal from the satellite buoy ceasing to report), should this owner still be considered the owner and responsible for this dFAD?	
What other issues might arise in implementing the FAO draft statement?	
If a derelict dFAD damages sensitive coastal habitat or property, who should be responsible?	
Under what circumstances, if any, should fishers be permitted to discard a dFAD or components at sea?	

What issues might arise with a requirement for vessel owners to report to management authorities within 24 hours of having lost, abandoned or discarded a dFAD?	
If there is a no-fault provision in place where the vessel owner would not be penalized or held responsible for having lost or abandoned a dFAD if they report it to the management authority within 24 hours, would that make it more likely that owners would comply with a requirement to report lost and abandoned dFADs? Is 24 hours feasible to determine if a dFAD is lost?	
What issues arise for onboard observes to be tasked with recording when the vessel discards at sea synthetic components of a dFAD?	
If there were a no-fault provision in place, whereby the vessel owner would not be penalized or held responsible for having lost or abandoned a dFAD if they report it to the management authority, would that eliminate potential problems for observers to record incidences of dFADs being lost or abandoned?	
What issues might arise with a requirement for purse seine captains and/or observers to record and report to management authorities the unique ID on a dFAD or a buoy attached to the dFAD when the vessel encounters a dFAD that they do not own and are not tracking? This might enable the management authority to determine if the dFAD was legal in-use fishing gear, reported lost, abandoned or discarded, or otherwise illegal gear?	

SECTION 4. TUNA RFMO MEASURES ON FAD MARKING AND TRACKING

Refer to Appendix 3 for current tuna RFMO measures on FAD marking and tracking.

If you have knowledge and/or experience with implementation of **IATTC** measure (came into effect on 1 January 2017):

Have the majority of vessels been complying?	
If the majority of vessels have not been complying, why?	
Is the measure easy for vessels to comply with?	
Is the cost for vessels to implement the measure reasonable?	
Does the required marking enable it to be easily seen by the captain and observer?	
Will the marking remain attached to the FAD and remain detectable by an observer and captain for the life of the FAD?	
How easy would it be for another vessel to remove the mark if they wanted to exchange buoys on the dFAD?	

If you have knowledge and/or experience with implementation of **ICCAT** measure:

Have the majority of vessels been complying?	
If the majority of vessels have not been complying, why?	
Is the measure easy for vessels to comply with?	
Is the cost for vessels to implement the measure reasonable?	
Does the required marking (buoy and beacon numbers) enable it to be easily seen by the captain and observer?	

Will the marking (buoy and beacon numbers) remain attached to the FAD and remain detectable by an observer and captain for the life of the FAD?	
How easy would it be for another vessel to remove the mark if they wanted to exchange buoys on the dFAD?	

If you have knowledge and/or experience with implementation of **IOTC** measure:

Have the majority of vessels been complying?	
If the majority of vessels have not been complying, why?	
Is the measure easy for vessels to comply with?	
Is the cost for vessels to implement the measure reasonable?	
Does the required marking enable it to be easily seen by the captain and observer?	
Will the marking remain attached to the FAD and remain detectable by an observer and captain for the life of the FAD?	
How easy would it be for another vessel to remove the mark if they wanted to exchange buoys on the dFAD?	

If you have knowledge and/or experience with implementation of Parties to the Nauru Agreement (PNA) requirement on reporting satellite buoy positions, or Republic of Kiribati or other domestic rules on dFAD marking and tracking that have been adopted by a **WCPFC party**:

Which programme are you familiar with (e.g., PNA, Kiribati, other – please specify) that requires dFAD marking or tracking?	
Have the majority of vessels been complying?	
If the majority of vessels have not been complying, why?	
Is the measure easy for vessels to comply with?	
Is the cost for vessels to implement the measure reasonable?	
If marking is required, does the required mark enable it to be easily seen by the captain and observer?	
If marking is required, will the marking remain attached to the FAD and remain detectable by an observer and captain for the life of the FAD?	
If marking is required, how easy would it be for another vessel to remove the mark if they wanted to exchange buoys on the dFAD?	
If you have experience with the PNA requirement to report satellite buoy positions, what issues have you experienced, if any (e.g., practicality, cost, effectiveness at tracking dFADs, maintaining confidentiality of the position data)?	

SECTION 5. RETRIEVING ABANDONED ARTIFICIAL dFADS

When an owner detects that a dFAD has drifted out of vessel range (too expensive for the purse seine vessels to make sets on or to retrieve, causing them to abandon them):	
Coastal retrieval: Would having vessels on standby to collect dFADs when notified that the dFAD is approaching a designated sensitive coastal habitat be feasible?	
Open ocean retrieval: Could collection of abandoned dFADs at sea be feasible?	
Any other ideas for a system to retrieve abandoned and other unwanted dFADs?	

SECTION 6. PORT RECEPTION FACILITIES FOR UNWANTED AND DERELICT FADS

If you are a purse seine vessel owner, captain or crew, then please answer the questions below.

Which components of dFADs do you dispose of, and how often?	
Where do you currently dispose of unwanted, old, 'retired' components of FADs or other gear when you return to port?	
If there were facilities for unwanted dFADs and other gear at your seaports, and there was no or very low cost for disposal, would you be more likely to not discard or abandon the unwanted gear at sea, and instead dispose of it in port?	
What would make port reception facilities practical for the disposal of unwanted gear?	
How much would you be willing to pay to dispose of unwanted dFAD components at a port facility?	
What other features should a port reception facility for dFADs have to result in purse seine vessels being more likely to use them to dispose of unwanted dFAD components?	

Appendix 3

Tuna RFMO, PNA and national government measures on dFAD marking and tracking

Inter-American Tropical Tuna Commission
An excerpt from Inter-American Tropical Tuna Commission (IATTC) Resolution C-16-01 Annex I, Footnote 1, which came into effect on 1 January 2017, follows:

"CPCs [Members and Cooperating non-Members] 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.

The alphanumeric code shall be clearly painted in characters at least 5 cm in height. The characters shall be painted on the upper portion of the attached radio or satellite buoy in a location that does not cover the solar cells used to power the equipment. For FADs without attached radio or satellite buoys, the characters shall be painted on the uppermost or emergent top portion of the FAD. The vessel owner or operator shall ensure the marking is durable (for example, use epoxy-based paint or an equivalent in terms of lasting ability) and visible at all times during daylight. In circumstances where the observer is unable to view the code, the captain or crew shall assist the observer (*e.g*. by providing the FAD identification code to the observer)."

International Commission for the Conservation of Atlantic Tunas
Recommendations on FAD marking made by the International Commission for the Conservation of Atlantic Tunas (ICCAT) Ad Hoc Working Group on FADs at their 2nd meeting in 2016, established under Recommendation 15-02, follows:

"The ICCAT FAD Working Group recommends the Commission to consider that monitoring of active FADs is achieved by:

- using the identifying buoy-number provided by the buoy manufacturer;
- recording the identifying buoy-number associated with any newly deployed FAD and the identifying beacon-number associated with any recovered FAD; In cases where there is a change of buoy in a FAD, both the ID code of the buoy associated with the FAD and the ID code of the buoy that serves as a replacement need to be recorded.
- establishing a consolidated database of records of FAD activity across all purse seine fleets."

Indian Ocean Tuna Commission
Relevant excerpts from Indian Ocean Tuna Commission (IOTC) Resolution 15/08 follow:

"8. CPCs shall require vessels flying their flag and fishing on DFADs to submit by 1 January 2016, the provisional purchase order for 2016 of instrumented buoys for their purse seine vessels under the confidentiality rules set by Resolution 12/02 (or any subsequent superseding Resolution)."

"9. CPCs shall require vessels flying their flag and fishing on DFADs to submit, by the end of 2016 the number of instrumented buoys activated, deactivated and active on each quarter during 2016 its purse seine vessel under the confidentiality rules set by Resolution 12/02."

"16. From January 2016, CPCs shall require all artificial FADs deployed or modified by their flagged fishing vessels in the IOTC area of competence to be marked in accordance with a detailed marking scheme, e.g. including FAD marking or beacon ID. The marking scheme shall be developed and considered for adoption by the Commission at its regular annual session in 2016, based on recommendations from the IOTC Scientific Committee as requested by the Commission. The marking scheme should take into account, as a minimum, the following:

a. All artificial FADs shall be marked with a unique identification number, based on a specific numbering system and format to be adopted by the Commission;
b. The marking should be easy to read before the vessel operator engages in any artificial FAD related activity (e.g. setting on the artificial FAD, retrieving the artificial FAD, servicing the artificial FAD, fishing on the artificial FAD), but if not visible for any reason, (time of day, weather, etc.), the vessel operator shall ensure to obtain the unique artificial FAD identifier as soon as feasible;
c. The marking should be easy to apply to the artificial FAD, but should be applied in such a manner that it will not become unreadable or disassociated with the artificial FAD."

Western and Central Pacific Fisheries Commission
The Western and Central Pacific Fisheries Commission (WCFPC) has not adopted a measure prescribing dFAD marking or tracking. WCPFC Conservation and Management Measure 2015-01, Attachment E, Preparation of FAD Management Plans, calls for members and cooperating non-members (CCMs) to submit management plans for the use of FADs by their vessels on the high seas to the Commission. The measure states that these plans are to include a description of specifications and requirements on FAD marking. Vessels fishing only on the high seas in the WCPFC convention area are currently not subject to FAD marking or tracking requirements under a WCPFC measure.

Parties to the Nauru Agreement
In 2016 the Parties to the Nauru Agreement (PNA) adopted a requirement for companies fishing on FADs in PNA waters to register their satellite buoy identification numbers with PNA and report satellite buoy data to PNA within 24 hours (MRAG, 2016; Escalle *et al.*, 2017). For all buoys that are in the PNA waters at some point after being deployed, the PNA measure requires the reporting of satellite buoy data from port-to-port, including data for when the buoy is within and outside of PNA waters.

Republic of Kiribati

The Republic of Kiribati FAD management plan includes requirements on dFAD marking by Kiribati-flagged purse seine vessels fishing on the high seas, and by purse seine vessels operating within the Kiribati EEZ (MFMRD, 2014). The management plan requires that dFADs be marked with the name of the deploying vessel, the date of deployment, and a dFAD number assigned by the Kiribati government. These markings are required to be written with a waterproof marker or paint on a detachable plate.

Appendix 4

List of survey participants

The following table identifies 62 of the 91 survey participants. It excludes 29 respondents who requested to remain anonymous, which included 17 captains and fishing masters from Ecuador (N=2), Panama (N=1), Spain (N=8), and the United States (N=6); 1 supply vessel captain from Spain; 6 vessel owners from Ecuador (N=1), Marshall Islands (N=1), Spain (N=1), and the United States (N=3); 1 fisheries association from Ecuador (N=1); 2 domestic fisheries management authorities from Ecuador (N=1) and Spain (N=1); and 2 fisheries observers from the Marshall Islands (N=2). Participants that met more than one stakeholder category were included under the category deemed the best fit, with the multiple categories identified in the third column of the table.

Name	Affiliation	Stakeholder Category
Purse Seine Industry		
Franklín Bazán	Empresa Atunera del Ecuador S.A., Ecuador	Captain
Luigi Benincasa Azua	Asociación de Atuneros del Ecuador, Ecuador	Vessel owner association
Ricardo Buehs	MANACRIPEX, Ecuador	Vessel owner
Zhuse Cai	Koo's Fishing Company, Marshall Islands	Captain
Daniel Calvo	Garavilla Co., Spain	Vessel owner
José Vera Cevallos	MANACRIPEX, Ecuador	Captain
Chia Ziang Chen	Koo's Fishing Co., Marshall Islands	Captain
Chun-feng Chen	Kuo Chang Fishery Co., Chinese Taipei	Captain
Jing-ting Chen	Yuh Yow Fishery Co., Chinese Taipei	Crew
Wen-chen Chen	Yue Hong Fishery Co., Chinese Taipei	Vessel owner
Stuart Chikami	Western Pacific Fisheries, Inc., USA	Vessel owner
Luis Colombo	Nirsa Co., Ecuador	Fishing Master
Marcelo Cuka	Yeten Services Corp., Ecuador	Captain
Leonardo Farfán	Elvayka Kyoei S.A., Ecuador	Captain

Paúl Fernandez	AACH Holding Co., No. 2 LLC, Ecuador	Captain
Benoit Furic	CFTO, France	Captain
Ibon Gamecho	ATUNBI S.A., Panama	Vessel owner
Zhi-zheng Gao	Guan Yu Fishery Company, Chinese Taipei	Vessel owner
Maitane Grande	Albacora Co., Spain	Vessel owner
Brian Hallman	American Tunaboat Association, USA	Vessel owner association
Alfredo Heres	Nirsa Co., Ecuador	Fishing master
Miguel Herrera	Organización de Productores de Grandes Atuneros Congeladores, Spain	Vessel owner association
Shao-feng Hong	Fong Kuo Fishery Group, Chinese Taipei	Vessel owner
Pi-tsung Hsia	Kuo Hsiung Fishery Co., Chinese Taipei	Captain
Japan Far Seas Purse Seine Fishing Association	Japan Far Seas Purse Seine Fishing Association, Japan	Vessel owner association
Laurent Jourdren	Sapmer Co., Spain	Fishing master
Ren-qi Lai	Fair Bravo Fishery Co., Chinese Taipei	Captain
Zhanzi Li	Koo's Fishing Company, Marshall Islands	Fishing master
Eduardo Mera	Pesquera Miriam, S.A., Ecuador	Captain
Enrique Mero	Pesquera Atunes Del Pacifico S.A., Ecuador	Captain
Eugene Muller	Koo's Fishing Company, Marshall Islands	Vessel owner
Bo Ping Shen	Shanghai Fisheries Group, Co., China	Captain
Ming-hao Tsai	Yiyou Aquatic Products Co., Chinese Taipei	Vessel owner
Eliseo Villar	Pesquera UGAVI, Spain	Vessel owner
Ping Wang	Min Feng Ocean Co., Chinese Taipei	Captain
Eva Wong	Fair Well Fishery Co., Chinese Taipei	Vessel owner

Ming-ming Yang	Gong Cheng Fishery Co., Chinese Taipei	Captain
Yu Hong Yu	Shanghai Fisheries Group, Co., China	Captain
Sheng-zheng Zou	Min Shuen Ocean Co., Chinese Taipei	Captain
Government		
Maurice Brownjohn	Parties to the Nauru Agreement, Marshall Islands	Sub-regional fisheries management authority, gear technology
Gladys Cardenas	Instituto del Mar del Perú, Peru	Domestic fisheries management authority
Lindsay Chapman	Pacific Community, New Caledonia	Regional intergovernmental organization
Michael Donoghue	Secretariat of the Pacific Regional Environment Programme, Samoa	Regional intergovernmental organization
Glen Joseph	Marshall Islands Marine Resources Authority	Domestic fisheries management authority
Fabien Le Galloudec	Direction des Pêches Maritimes et de l'Aquaculture, Ministère de l'Agriculture et de l'Alimentation, France	Domestic fisheries management authority
NOAA Fisheries	NOAA Fisheries, USA	Domestic fisheries management authority
Jose Luis Pacheco	Instituto Nacional de Pesca, Ecuador	Domestic fisheries scientific body
Fisheries Observer		
Arlington Abjja	Marshall Islands Government	Fisheries observer
Mikel Basterretxea	AZTI Tecnalia, Spain	Fisheries observer
Marion Bourasseau	Société Océanic Development, France	Fisheries observer
Jackson Debrum	Marshall Islands Government	Fisheries observer
Stephen Domenden	Marshall Islands Government	Fisheries observer
Lawrence Jitiam	Marshall Islands Government	Fisheries observer
Simon Lucky	Marshall Islands Government	Fisheries observer

Arjun Sami	Marshall Islands Government	Fisheries observer
Manuel Santos	AZTI Tecnalia, Spain	Fisheries observer
Roy Woodling	Marshall Islands Government	Fisheries observer
Gear Technology Scientist and Manufacturer of Instrumented Buoys for FADs		
Francisco Blaha	Fisheries Advisor, New Zealand	Gear technology, former purse seine crew and observer
Patrick Moelo	Thalos, France	Instrumented buoy manufacturing company
Jefferson Murua	AZTI Tecnalia, Spain	Gear technology
Ibone Rodriguez de Pablo	Zunibal, Spain	Instrumented buoy manufacturing company
Liming Song	Shanghai Ocean University, China	Gear technology

Appendix 5

Summary of MARPOL Annex V

In July 2011, the International Maritime Organization (IMO), a specialized agency of the United Nations that sets global standards for the safety, security and environmental performance of international shipping, adopted amendments to the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V *Regulations for the Prevention of Pollution by Garbage from Ships*. The amendments entered into force on 1 January 2013 (IMO, 2011).

Annex V Regulation 3 prohibits the disposal of all plastics, including fishing gear, into the sea in all locations (IMO, 2011; IMO, 2012). Fishing vessel operators are required to record the discharge or loss of fishing gear in a Garbage Record Book or ship's log as specified within regulations 7.1 and 10.3.4 of MARPOL Annex V. Annex V Regulation 8 also obligates governments to provide adequate port reception facilities for garbage from ships and to facilitate and promote their use (IMO, 2012).

Furthermore, under Annex V Regulation 10.6, fishing vessel operators are required to report the accidental loss or discharge of fishing gear, “which poses a significant threat to the marine environment and navigation,” as determined by each Member State, and provide these reports to the flag state and, also if relevant, to the coastal state in whose jurisdiction the ALDFG occurred (IMO, 2011; IMO, 2012). The IMO *2012 Guidelines for the Implementation of MARPOL Annex V* clarify that the Party’s governments should determine whether accidentally lost and discharged fishing gear is required to be reported under Annex V Regulation 10.6 by considering factors including: (i) the amount of lost and discharged gear; (ii) the conditions of the marine environment where it was lost or discharged; (iii) the characteristics of the lost gear, including type(s), weight and/or length, quantity, material and buoyancy; and (iv) the vulnerability of habitat and protected species to gear interactions in the location where the gear was lost/discharged, for example, was the gear lost or discharged in a sensitive area such as coral reefs, or in a protected species’ foraging or breeding area (IMO, 2012). The IMO guidelines use the example of, “whole or nearly whole large fishing gear or other large portions of gear,” as lost or abandoned fishing gear which could be considered as meeting the Annex V Regulation 10.6 definition of posing, “a significant threat to the marine environment and navigation” (IMO, 2012).

Fish aggregating devices (FADs) used by tuna purse seine fisheries improve fishing efficiency relative to other purse seine fishing strategies and make it possible to successfully fish in new areas. However, when not responsibly managed, FADs can cause adverse effects. Use of physical and electronic methods to assign a unique identification code and track the position of drifting FADs can contribute to improved monitoring, understanding and management of drifting FADs' ecological and socio-economic effects. In 2016 the Food and Agriculture Organization of the United Nations (FAO) convened an Expert Consultation on the Marking of Fishing Gear, resulting in the development of *Draft Guidelines on the Marking of Fishing Gear*. Recognizing challenges with applying conventional methods of marking fishing gear to identify drifting FAD ownership and to implement a recommendation made by the Committee on Fisheries, in 2017, FAO conducted a global survey to obtain stakeholder views on FAO's Draft Guidelines. This Circular presents the survey results on marking and tracking the position of drifting FADs; defining drifting FAD ownership; and defining, reporting and recovering abandoned, lost and discarded drifting FADs. Stakeholder assessments of existing measures on drifting FAD marking and tracking are also reported.