

Anchored FADs: relevance of the use and overall impact on juvenile tuna and the environment

Final Report

EUROPEAN COMMISSION

European Climate, Infrastructure and Environment Executive Agency
Unit D3 Sustainable Blue Economy

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Specific Contract No. 02
Implementing CINEA/2023/OP/0010
FRAMEWORK CONTRACT FOR THE PROVISION OF
SCIENTIFIC ADVICE FOR FISHERIES BEYOND EU
WATERS

This report should be cited as:

Pearce, J., Mangi, S., Moir-Clark, J., Howarth, P., Khan, A.M.A., Peat, W., Stacy, R., Merino, G., Zudaire, I., Manso, I., Krug, I., Salgado, A., Murua, J., Arrizabalaga, H., Benoit, B. *Anchored FADs: relevance of the use and overall impact on juvenile tuna and the environment.*, Publications Office of the European Union, 2026, doi:10.2926/2465190

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Manuscript completed in May 2026

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PDF ISBN 978-92-9405-415-9 doi:10.2926/2465190 HZ-01-26-090-EN-N

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Acronyms

Acronym	Definition
AFAD	Anchored Fish Aggregating Device
AZTI	Centro de Investigación Marina y Alimentaria
CCSBT	Convention for the Conservation of Southern Bluefin Tuna
CINEA	European Climate, Infrastructure and Environment Executive Agency
CMM	Conservation and Management Measures
CPC	Contracting Parties and Cooperating Non-Contracting Parties
CPFD	Catch Per Fishing Day
CPUB	Catch Per Unit Bait
CPUE	Catch Per Unit Effort
CRFM	Caribbean Regional Fisheries Mechanism
DCP	Dispositif de Concentration de Poissons
DFAD	Drifting Fish Aggregating Device
FFFA	Department of Forestry, Fisheries and the Environment
EDF	European Development Fund
EEZ	Exclusive Economic Zone
EMFAF	European Maritime, Fisheries and Aquaculture Fund
ETP	Endangered, Threatened or Protected (species)
FAD	Fish Aggregating Device
FAO	Food and Agricultural Organisation
FDAM	Fisheries Development Authority of Malaysia
FEK	Fisher Ecological Knowledge
FMA	Fisheries Management Area
FRP	fibre-reinforced plastic
GFCM	General Fisheries Commission for the Mediterranean
GND	Gillnets
GPS	Global Positioning System
GRT	Gross Registered Tonnage
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
IFREMER	French Research Institute for Exploitation of the Sea
IOC	Indian Ocean Commission
IOTC	Indian Ocean Tuna Commission
IPB	IPB University (aka Bogor Agricultural University)
ISSF	International Seafood Sustainability Foundation
JICA	Japan International Cooperation Agency
KES	Kenyan Shilling
KKP	The Ministry of Maritime Affairs and Fisheries (Kementerian Kelautan dan Perikanan)
LHD	Vertical handline
LHDMX	Groundfish handline
LHPGP	large pelagic handline
LHPPG	small pelagic handline
LLD	Longline drifting
LLDDP	surface drifting longline

Acronym	Definition
LLSDX	groundfish longline
LOA	Length Overall
LTl	Trolling lines
LTlGP	large pelagic drifting line
LVDGP	large pelagic vertical longline
MAF	Timor-Leste's Ministry of Agriculture and Fisheries
MFAD	Moored Fished Aggregating Device
MFOR	Ministry of Fisheries and Ocean Resources
MMAF	Ministry of Marine Affairs and Fisheries
MPNM	Mayotte Parc Naturel Marin
NAFO	Northwest Atlantic Fisheries Organisation
NEAFC	Northeast Atlantic Fisheries Commission
NOAA	National Oceanic and Atmospheric Administration
NTT	Nusa Tenggara Timur (East Nusa Tenggara)
PPS	The Bitung Oceanic Fishing Port
PSDKP	Pengawasan Sumber Daya Kelautan dan Perikanan (Directorate General of Marine and Fisheries Resources Surveillance (DG-MFRS))
RDF	Radio Direction Finder
RFMO	Regional Fisheries Management Organisation
SAC	Science Advisory Committee
SAG	Scientific Advisory Group
SEAFDEC	Southeast Asian Fisheries Development Center
SFA	Seychelles Fishing Authority
SFPA	Sustainable Fisheries Partnership Agreement
SIPR	Surat Izin Pemasangan Rumpon (FAD Installation Permit)
SST	Sea Surface Temperature
UNCLOS	United Nations Convention on the Law of the Seas
UNDP	United Nations Development programme
UVC	Underwater Visual Census
WCPFC	Western Central Pacific Fisheries Commission
WECAFC	Western Central Atlantic Fishery Commission
WPP	Indonesia Fisheries Management Areas

Executive Summary

This final report analyses the relevance, use, and overall impact of Anchored Fish Aggregating Devices (AFADs) on juvenile tuna and the environment, with a particular focus on the Indian Ocean. The study was commissioned by the European Climate, Infrastructure and Environment Executive Agency (CINEA) under the European Maritime, Fisheries and Aquaculture Fund (EMFAF).

The use of AFADs has increased in artisanal and industrial fisheries in developing countries. AFADs allow fishers to maintain food and livelihood security, but there are concerns about their selectivity, insufficient monitoring of catches, and potential negative impacts on target, non-target species, and marine ecosystems.

The main objective of the project is to gather detailed information on tuna fisheries using AFADs, map their global distribution (with a focus on the Indian Ocean), assess their impact on tuna behaviour and juvenile catch, characterize the socio-economic dimension, and review existing management measures.

The initial plans for the study included desk-based work and a field trip to Indonesia to collect information about the use of AFADs, their number, location, target and bycatch species, and socioeconomic relevance. However, the fieldwork component was not possible because repeated research permit requests by the scientific team responsible for the project were systematically rejected by the Indonesian authorities. The European Commission's services in charge of Scientific Advice and Data Collection for fisheries also requested permission for the onsite study from Indonesia's Ministry of Marine Affairs and Fisheries, but the request was again denied, de facto preventing the research team from gaining onsite knowledge about the overall management of AFADs in Indonesia.

Therefore, the report is based on a systematic review of scientific and grey literature, as well as data collection from Regional Fisheries Management Organizations (RFMOs) and national fisheries departments.

This study includes a description of the global distribution of the use of AFADs, a quantification of the impact on juvenile populations of bigeye and yellowfin, a description of AFADs environmental impacts beyond fish stocks, a description of the socioeconomic dimension of AFADs for developing coastal states, a summary of the current regulatory frameworks and specific recommendations to ensure the sustainable use of AFADs.

The key findings of this study are the following:

- Although AFADs are widely used in tropical and subtropical regions like the Mediterranean, Western Central Pacific, and Indian Oceans, quantitative data on their use is scarce. For instance, estimates of AFAD numbers in Indonesia vary greatly by source.
- AFADs are typically employed by artisanal or semi-industrial fisheries, utilising a range of fishing gear, including small-scale purse seine fleets operating in Indonesia.
- Within the IOTC, AFADs are utilised to target both tropical and temperate tuna species—including bigeye, yellowfin, skipjack, and albacore—as well as neritic and smaller tunas.
- The influence of AFADs on the sustainability of commercial tuna populations remains highly uncertain, mainly due to the lack of operational data detailing set-by-set activity, including information on whether sets are made on AFADs or free school. Nonetheless, current estimates indicate that approximately 18% of bigeye tuna and 11% of yellowfin tuna are likely harvested using AFADs.
- Based on the references cited in this study, the incidence of bycatch involving endangered species, including vulnerable sharks, under AFADs is reported to be small.
- Approximately 92–99% (in weight) of AFADs are constructed from synthetic materials, including anchoring cement blocks, plastics, and metals. These components have the potential to contribute substantially to marine litter and pollution if abandoned, lost, or discarded. Preliminary estimates indicate that the loss of AFADs could result in between 14 and 71 thousand tonnes of marine litter every year in Indonesia.
- Oceanographic models suggest up to 75% of released AFADs in Indonesia may drift to coastal zones, with those released south of Sumatra and Java most affecting vulnerable habitats.
- The IOTC is the sole RFMO that has established specific regulations pertaining to AFADs, whereas other RFMOs incorporate provisions for AFADs within their broader management frameworks for floating objects and drifting FADs.
- The main recommendation from this study is the development and implementation of AFAD management plans that include information that would enable the quantification, tracking, and assessment of their effects on tuna fisheries and the broader environment.
- We recommend strengthening the systems for licensing, monitoring and ensuring fisher compliance to stand alongside AFAD regulations. Also, specific data collection programmes should be developed for AFADs. In particular, it would be highly recommended to include catch reporting with reference to the type of set.
- We also highlight the need to monitor the release of AFADs in terms of quantity, location and materials.
- We also recommend promoting the use of biodegradable materials in as many AFAD components as feasible.

1. Introduction

There is increasing public and scientific attention on Fish Aggregating Devices (FADs) and their impact specifically on juvenile tuna and the marine environment. While several studies have focussed on drifting FADs (DFADs) (e.g. Dupaix et al., 2024), less is known about anchored FADs (AFADs). AFADs are used in several artisanal and small-scale industrial fisheries in developing countries. Coastal fishers switching to fishing on AFADs further offshore are better able to maintain food and livelihood security when coastal resources have been depleted. It is therefore important to acquire data and information on AFADs use to determine a clear understanding of the situation at sea and to assess the impacts of AFADs on target and bycatch species.

The fleets that fish on AFADs may in some cases be very selective, using very size and species-specific gear to catch only the target species, with little or no bycatch of non-target fish or potentially Endangered, Threatened or Protected (ETP) species such as sharks or turtles (Widodo et al. 2025). Fishing on AFADs however, may result in increasing the pressure on juvenile tunas (mostly bigeye and yellowfin tunas), potentially similar in size composition to those from DFADs. There is concern that the catches from AFADs are not monitored effectively (Hargiyatno et al 2025) and the potential impacts may not be fully understood. Reporting and understanding of the impacts need to be improved to allow AFAD fishing to be incorporated into an effective management framework to achieve balance between the needs of the ecosystems, coastal communities and industrial fisheries. If this does not occur, AFADs could contribute to overexploitation, particularly when stocks, are already at risk of overexploitation and fishing effort may exceed sustainable levels.

The Indian Ocean Tuna Commission regulates tropical tunas through Conservation and Management Measures (CMMs) to keep bigeye, yellowfin, and skipjack stocks at sustainable levels, including catch limits set by stock assessments or management procedures (Resolutions 21/01, 25/03, 25/04, 26/01). Broader CMMs target overall tuna sustainability, such as Resolution 24/02, which regulates DFAD use and limits the number of deployable DFADs to help reduce juvenile mortality in bigeye and yellowfin tunas among other objectives. In contrast, there is no limitation or restriction on AFADs number or use.

For this project, literature was collected based on a systematic review of anchored FAD related search terms covering related fisheries, biological and ecological aspects as well as a detailed review on management measures and socio-economic considerations. This project aims to assess the size and nature of the AFAD fisheries worldwide and their impacts, with a particular emphasis on the Indian Ocean where tropical tuna stocks are under significant pressure. The aim is to provide a sound understanding of the current situation, existing knowledge gaps and a set of recommendations on measures to address the

impact of AFADs, data needs and monitoring requirements described through the objectives laid out below.

1.1. Objectives

The overall aim of this project is to gather detailed information on the tuna fisheries using AFADs by mapping their distribution globally and with specific focus on the Indian Ocean; studying the potential impacts of these fisheries on the behaviour of tunas and quantify their impact on juvenile tunas; characterising the social-economic dimension of these fisheries and evaluating the extent to which AFADs are contributing to non-tuna targeted fisheries.

The study has six specific objectives:

1. **Global mapping of the use of AFADs** to understand their approximate number and geographical location.
2. **Characterisation of fisheries using AFADs in the Indian Ocean**, including the number of AFADs deployed by coastal states within IOTC Contracting Parties and their socio-economic characteristics.
3. **Qualitative assessment and quantitative estimation of the potential impact of AFADs** on target and non-target species in the Indian Ocean with a specific focus on three components (a) impact on tuna behaviour (b) impact on juvenile tuna, and (c) impact on non-target species.
4. **Review of the environmental impacts of AFADs** including methods deployed and their impact on marine habitats such as contributing towards marine litter.
5. **Review of existing measures covering AFADs** at IOTC level and comparing them with other existing measures around the world.
6. **Formulating recommendations on possible additional measures** to address (a) the impact of AFADs on target and non-target species with a specific focus on juvenile tuna and (b) possible additional data needs and monitoring requirements.

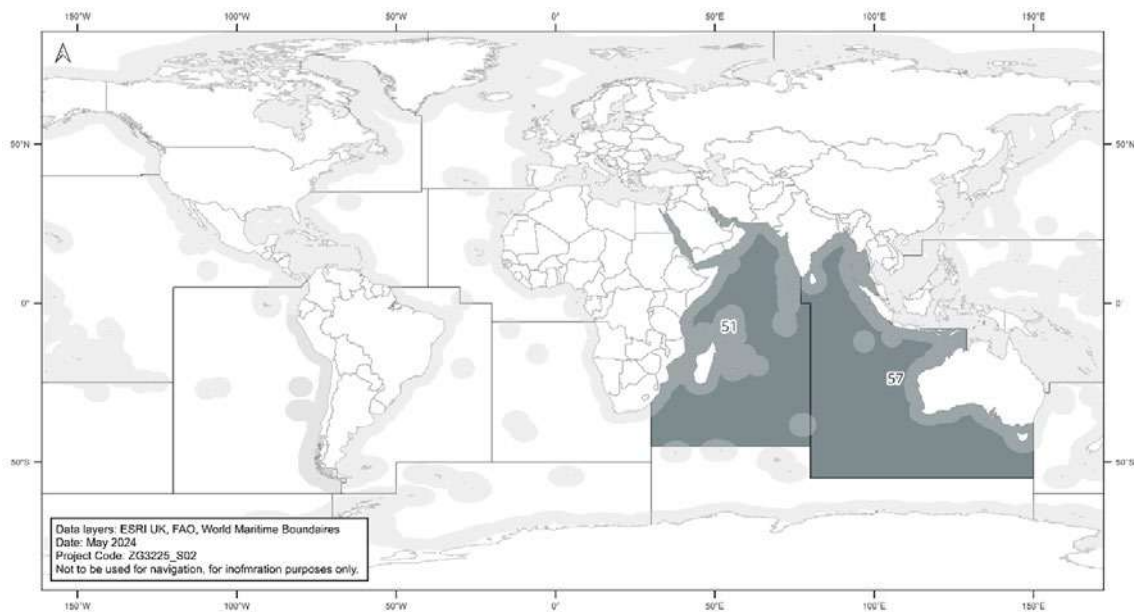
1.2. Scope

The geographic scope of this project is global, with a special focus on the Indian Ocean i.e. within FAO Areas 51 and 57 for specific Objectives 2 – 6 (see Figure 1). The fisheries covered are those targeting large pelagic fish and using AFADs with special focus on the fisheries under the competence of the IOTC but also making best use of information from other relevant Regional Fisheries Management Organizations (RFMOs) such as the International Commission for

the Conservation of Atlantic Tunas (ICCAT). Indonesia was chosen as a case study given its very high level of catches from AFADs and variety of gears using AFADs to catch tuna.

The stocks of interest are tropical tuna, but consideration has also been given to impacts on non-target species and fisheries impacting tuna but targeting other pelagic species.

Figure 1. Global geographical study scope with emphasis on the Indian Ocean, specifically within FAO Areas 51 and 57 (in gray shade).



Source: Created by MRAG for this project.

2. Mapping of AFAD Fisheries

This section covers the work done to fulfil specific Objective 1 (global mapping of the use of AFADs) and Objective 2 (characterisation of fisheries using AFADs in the Indian Ocean). The overall objectives were to review and describe the global distribution of fisheries using AFADs, their extent, main contributors, annual trends, temporal and spatial variability. The first part of this section therefore examines the global AFAD related fisheries and the second focusses on the Indian Ocean.

2.1. Task 1 - Global Mapping of AFAD Fisheries

The expected outcome of this task was to provide a comprehensive description and overview table of existing data sources and information (including peer-reviewed and grey literature, and online databases). Within this report, AFAD fisheries are described in terms of their fisheries effort (using common metrics where possible), vessel numbers, gear types, target fishing grounds, target catch, bycatch (including Endangered, Threatened or Protected (ETP) species).

To address knowledge gaps in AFAD fisheries in Indonesia, workplan for this study included desk-based work and a field trip to Indonesia to collect information about the use of AFADs, their number, location, target and bycatch species, and socioeconomic relevance. However, the fieldwork component was not possible because repeated research permit requests by the scientific team responsible for the project were systematically rejected by the Indonesian authorities. The European Commission's services in charge of Scientific Advice and Data Collection for fisheries also requested permission for the onsite study from Indonesia's Ministry of Marine Affairs and Fisheries, but the request was again denied, de facto impeding the research team to gain onsite knowledge about the overall management of AFADs in Indonesia.

2.1.1. Task 1 – Methodology

A comprehensive literature review of existing data sources and information (including peer-reviewed and grey literature, and online databases) was conducted for use throughout the study. These data are presented in a tabular form and outline various characteristics of each data and information source including, but not limited to, spatial coverage (e.g. delineated by FAO Area, RFMO or Country); temporal coverage (e.g. delineated by year), links to data sources (e.g. hyperlinks or references). Literature searches were conducted using Google Scholar to access peer-reviewed and grey literature sources. Search terms employed Boolean logic to combine terms relevant to the technical and geographical focus of this study, as well as the objectives of

subsequent tasks (e.g. "anchored FADs" AND "Indian Ocean" OR "IOTC" OR "FAO Area 51" AND "environmental impacts"). Searches were limited to the last ten years to ensure relevance. All references for data and information sources listed are stored in Zotero (www.zotero.com), an open-source reference management software. The literature gathered was used to provide a characterisation of the tuna fisheries using AFADs on a global scale.

Additionally, data requests were made to RFMOs such as the Western and Central Pacific Fisheries Commission (WCPFC), the IOTC and the International Commission for the Conservation of Atlantic Tunas (ICCAT), and National fisheries departments from countries known to use AFADs extensively, such as the Philippines, Indonesia, Japan, and various Pacific Island nations. Also, we requested information to other non-tuna RFMOs (Northwest Atlantic Fisheries Organisation (NAFO) and North-East Atlantic Fisheries Commission (NEAFC)). Please see Annex 7 for details of data requests and information with all RFMOs.

To address knowledge gaps in Indonesia AFAD fisheries, in-country fieldwork was defined to gather both quantitative and qualitative data on key factors characterizing AFADs deployed, including but not limited to their locations, categorization, technical characteristics, and lifespan. Fieldwork materials were developed including a semi-structured questionnaire targeting stakeholder groups including, but not limited to, government officials, fishers, middlemen, fishing community organisations, and fishing companies. Due to the impossibility to receive the research permit by the Indonesian government, the planned research was not possible during the project timeframe. An alternative desk-based review was used to gather as much information as possible without the planned fieldwork and in country stakeholder engagement. The results of this alternative yet extensive desk-based study are provided in section 2.1.4.

2.1.2. Task 1.1 Results - Review and compile existing data sources and information available to map the global distribution of AFAD fisheries

A total of 125 information sources were identified, including 95 that were specific to the Indian Ocean (Table 1). These comprised 71 peer-reviewed articles (53 Indian Ocean), 16 grey literature sources (13 Indian Ocean), one website and 36 stakeholder contributions (7 Indian Ocean). Annex 1 and Annex 2 provide a comprehensive summary of the diverse array of data sources available to inform the characterisation of AFAD fisheries globally and in the Indian Ocean respectively, including peer-reviewed and grey literature. This also included any website material and inputs from stakeholders also collected.

The distribution of literature is logically skewed toward the two FAO areas comprising the Indian Ocean, recognised as one of the largest regional deployers of AFADs globally and one of the best studied and documented. For

instance, 24 sources provided empirical estimates of AFAD deployments across eight coastal states in FAO Area 51 (Western Indian Ocean), spanning from 1988 (e.g. La Réunion) to 2024 (e.g. Mauritius). Similarly, 13 quantitative estimates were identified for AFAD deployments in four coastal states in FAO Area 57 (Eastern Indian Ocean) between 2013 and 2020.

Table 1. Summary of information sources (numbers) by FAO region

Task	Peer-review	Grey	Website	Stakeholder	Total
FAO Area 21: Northwest Atlantic	-	-	-	1	1
FAO Area 27: Northeast Atlantic	-	-	-	1	1
FAO Area 31: Western Central Atlantic	9	2	-	4	15
FAO Area 34: Eastern Central Atlantic	1	-	-	-	1
FAO Area 37: Mediterranean and Baltic	5			4	9
FAO Area 41: Southwest Atlantic	2	1	-	-	3
FAO Area 47: Southeast Atlantic	-	-	-	-	-
FAO Area 51: Western Indian Ocean	27	11	1	5	44
FAO Area 57: Eastern Indian Ocean	26	2	-	2	30
FAO Area 71: Western Central Pacific	1	-	-	19	20
FAO Area 77: Eastern Central Pacific	-	-	-	1	1
FAO Area 87: Southeast Pacific	-	-	-	-	-
Total	71	16	1	37	125

Data Source: Project literature review.

Although peer-reviewed and grey literature reports provide estimates of spatial and temporal trends in AFAD fisheries (including AFAD numbers and associated fisheries characteristics) the availability of quantitative data remains limited. These data are not consistently available across global regions, and often lack up-to-date, publicly accessible information. This highlights a significant reliance on national and regional stakeholders to supply evidence to support this task. Furthermore, data on temporal trends in AFAD deployment and utilisation are also limited. Some regional-specific patterns have emerged (e.g. AFAD retrieval in the Caribbean during the hurricane season), but these are based on a small number of sources and are often nation-specific. It is known from anecdotal information that there has been a gradual and continuing increase in the deployment of AFADs, but no information on global temporal trends in AFAD use was found in the literature.

2.1.3. Task 1.2 Results - Review of spatial and temporal distribution of AFAD fisheries on a global scale

The global distribution of AFADs demonstrates distinct regional trends characterized by spatial concentration and temporal variability. Current AFAD use, illustrated in red (see Figure 2), is predominantly concentrated in tropical and subtropical regions, where these devices play a critical role in enhancing fishing efficiency for artisanal and commercial fleets targeting pelagic species such as skipjack (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*) and dolphinfish (*Coryphaena hippurus*). The Western and Central Pacific Ocean, particularly around Southeast Asia, Australia, and Pacific Island Countries and Territories (PICTs), emerges as a major hub, coinciding with fisheries managed under regional frameworks like the WCPFC (Welch et al., 2022).

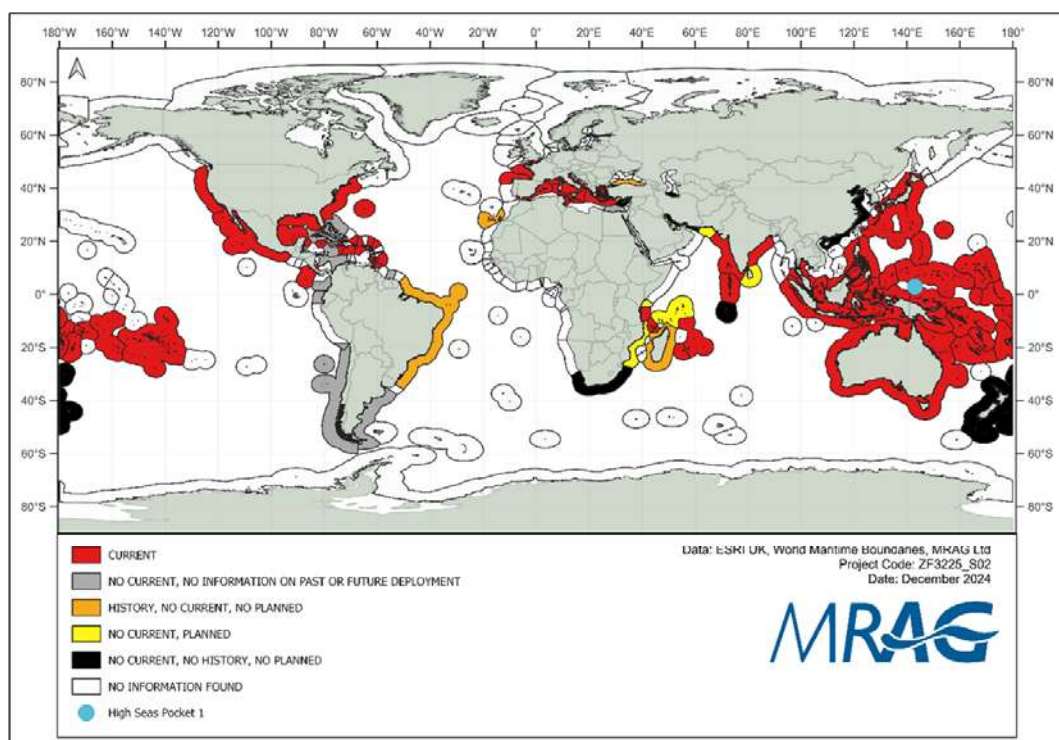
In the Western Central Atlantic, extensive AFAD deployment is evident in the Caribbean, emphasising their utility in small-scale fisheries with Wilson et al., 2020 estimating over 3500 AFADs across 20 of the 25 Caribbean States studied and fleet utilization (percentage of the fleet that utilises AFADs) of AFADs ranging from 17% (US Virgin Islands) to 85% (Dominican Republic) across the Caribbean.

Similarly, in the Mediterranean Sea, countries including Malta, Sicily, Tunisia, and the Balearic Islands demonstrate significant AFAD use, primarily to target dolphinfish (Sinopoli et al., 2019), under nation-specific regulatory frameworks. The Mediterranean is documented as one of the world's hotspots for AFAD deployment and associated fisheries with estimates of 60000 of the world's estimated 73000 AFADs to be moored in the Mediterranean (Morales-Nin, 2011; Scott and Lopez, 2014). It should be noted that these estimates are based on data from the 2010th decade and should be considered with caution until updated official statistics can be collected and verified.

The Indian Ocean reflects both active and emerging AFAD use, encompassing established AFAD utilising nations such as Indonesia and the Maldives and those developing their use e.g. coastal East African states. Here, both artisanal and industrial fisheries rely heavily on AFADs for key pelagic stocks, reflecting their economic and ecological importance in this region.

Areas with historical but now inactive AFAD use, denoted in orange, are primarily observed in Madagascar, the Canary Islands (Spain) and parts of South America, such as Brazil. This trend indicates a decline in reliance on AFADs due to regulatory shifts, evolving fishing practices or socioeconomic changes. It should be noted that this trend is very region specific, with the global trend of AFAD utilisation remaining relatively high but stable. Furthermore, other nations have recently deployed, or are looking to deploy, new AFADs in their waters (e.g. Seychelles, Bonaire, and Barbados) – denoted in yellow. This information of potential future deployment is noted through correspondence with named officials through stakeholder engagement.

Figure 2. AFAD use showing current (red), historical (orange) and planned use (yellow), no information found (white), no current, historical or planned use (black), and no current with no information found on future or past deployment (grey).



Source: Created by MRAG for this project.

Regions marked in black, representing no evidence of current, historical, or planned AFAD activity, are largely located in temperate and polar latitudes,

such as the South Atlantic, North Atlantic, and parts of Northern Africa. The absence of AFADs in these areas likely stems from environmental constraints, economic limitations, or governance policies that restrict their deployment.

The following sub-sections provide a detailed examination of these high-level trends by RFMO and FAO Area.

2.1.3.1. Western Central Pacific Fisheries Commission (WCPFC)

FAO Area 71: Western Central Pacific has a high concentration of AFAD fisheries across the EEZs of Member States, with most Pacific Island Countries and Territories (PICTs) supporting artisanal small-scale fisheries using AFADs. States with notably high AFAD usage include Papua New Guinea, French Polynesia, the Solomon Islands, and Japan, with the latter supporting industrial AFAD fishery. Common AFAD types are lagoon AFADs (set in shallow lagoons), nearshore AFADs (used by artisanal fishers, often privately owned), offshore AFADs (deployed by fishers or institutions to develop local fisheries) and industrial offshore AFADs (set at as deep as 2000-meter depths). Individually set AFADs often use cheap, accessible materials (e.g. plastic containers, makeshift anchors), while institutionally deployed AFADs use durable components (e.g. chains, buoys, concrete anchors). AFADs in the region primarily attract tuna and other large pelagic species, which artisanal fishers catch by trolling. A unique offshore AFAD fishery exists in High Seas Pocket 1 (between Papua New Guinea, Palau, and Micronesia), where industrial purse seine vessels target skipjack tuna.

To summarise, AFADs are commonly used in inshore, nearshore and offshore areas of the WCP supporting artisanal and industrial fisheries.

FAO Area 77: Eastern Central Pacific includes a designated overlap between the WCPFC and IATTC Convention Areas, referred to as the "Overlap Area" (NOAA, 2024). For this review, FAO Area 77 is defined as the portion of the IATTC Convention Area that excludes overlap with the WCPFC Convention Area. Therefore, the use of AFADs in FAO Area 77 is described under section 2.1.3.3 (Inter-American Tropical Tuna Commission).

2.1.3.2. International Commission for the Conservation of Atlantic Tunas (ICCAT)

FAO Area 21: Northwest Atlantic was found to have no evidence of AFAD fisheries. Northwest Atlantic Fisheries Organisation (NAFO) confirmed that no AFADs are used in any fisheries in the NAFO Regulatory Area.

FAO Area 27: Northeast Atlantic was found to have no evidence of AFAD fisheries. North-East Atlantic Fisheries Commission (NEAFC) confirmed that no AFADs are used in any fisheries in the NEAFC Regulatory Area.

FAO Area 31: Western Central Atlantic is a hotspot for AFAD use in small-scale fisheries. AFADs have been used in the Caribbean since the 1960s, initially with bamboo rafts in Curaçao, Bonaire, Barbados, and Anguilla. By the 1980s, their use expanded due to recognised benefits for both artisanal and recreational fisheries, particularly in Guadeloupe, Martinique and Curaçao. In the mid-2010s, Haiti experienced significant improvements in fisher livelihoods due to AFAD introduction (Macías, 2014; CRFM, 2015). However, AFAD deployment remains largely unregulated (Vallès and Taconet, 2023). Regionally referred to as Moored FADs (MFADs), they are typically anchored 10 to 55 nautical miles from shore, using inexpensive materials like plastic containers, palm fronds, and old engine blocks. Fisheries predominantly consist of small vessels under 10 metres, often using trolling to target large pelagic species such as billfish and tuna. AFAD deployment is often disrupted by seasonal weather events such as hurricanes, with significant seasonal losses reported in Barbados and the US Virgin Islands (Hutt et al., 2023).

FAO Area 34: Eastern Central Atlantic was found to have no evidence of active AFAD fisheries. West African artisanal fisheries may rely on AFADs (Scott and Lopez, 2014); however, the use of AFADs across West Africa is poorly documented. Historical use of AFADs was documented in the Canary Islands by Castro et al. (1999), where 16 AFADs were deployed at depths of 50–500 m. Their polystyrene construction composition suggests it is unlikely that they are still in place.

FAO Area 37: Mediterranean and Black Sea Key AFAD hotspots are noted in Malta, Sicily, the Balearic Islands (especially Majorca) and Tunisia. Small-scale fisheries in these areas deploy AFADs in designated waters using vessels typically 8 to 15 metres long with multiple crew members. AFADs are deployed at depths of up to 1500 metres and up to 60 nautical miles offshore, with 10 to 75 AFADs used per vessel during the season. The AFADs are anchored at intervals of 50 to 300 metres. The primary target species is dolphinfish (*Coryphaena hippurus*), with greater amberjack (*Seriola dumerilii*) and bluefin tuna (*Thunnus thynnus*) also targeted. The dolphinfish fishing season runs from August to December (Morales-Nin et al., 2000), with AFADs deployed before the season. However, it is unclear whether AFAD retrieval occurs, making it difficult to assess trends beyond deployment periods. AFAD use has increased in the region since 1990, particularly in Tunisia and Sicily (Sinopoli et al., 2019). No information on the current, future, or historical deployment of AFADs in the Black Sea was found during the literature review.

FAO Area 41: Southwest Atlantic shows no current evidence of active AFAD fisheries. Brazil first introduced the use of AFADs in 1984 to support the commercial skipjack tuna fishery along the continental shelf break (Scott, 1985).

Véras et al. (2020) found that while pelagic species like blackfin tuna (*Thunnus atlanticus*) and blue runner (*Caranx crysos*) aggregated near AFADs off Recife, they did not remain for long periods of time. Aside from experimental use, AFADs have been prohibited in Brazil since 2018, although fishing around anchored oceanographic buoys for artisanal purposes remains permitted (Martin et al., 2023; Silva et al., 2018). The ban was later formalised under *Instrução Normativa* nº 53/2019, which defines authorized fishing gear for tuna and tuna-like species and excludes the use of anchored FADs in commercial fisheries (MAPA, 2019). No official justification was provided, but the ban likely reflects concerns over bycatch of juvenile tuna, ecological disruption, and the difficulty of monitoring anchored FAD deployments as described in Schroeder and Castello (2008).

FAO Area 47: Southeast Atlantic shows no evidence of active AFAD fisheries. West African artisanal fisheries may rely on AFADs (Scott and Lopez, 2014); however, the use of AFADs across West Africa is poorly documented.

To summarise, under the purview of ICCAT, AFADs are most widely used in the Mediterranean, Black Sea, and Caribbean. Their use is only monitored in the Mediterranean, mainly for impacts on dolphinfish.

2.1.3.3. Inter-American Tropical Tuna Commission

FAO Area 77: Eastern Central Pacific exhibits no confirmed evidence of AFAD use, except for their deployment in recreational fisheries in Costa Rica and Mexico. While the potential use of AFADs by small-scale fisheries cannot be ruled out, the existing literature provides limited insight into their application in the region. Although IATTC could not verify AFAD deployment in specific States, it was suggested that recreational fishers may utilise AFADs in certain coastal areas of Central America.

FAO Area 87: Southeast Pacific presents no documented evidence of AFAD use in fisheries. While it is plausible that small-scale fisheries may employ AFADs in tropical waters within the region, such as those off Colombia, Ecuador, Peru, and northern Chile, their use remains unrecorded in the literature. Furthermore, IATTC could not confirm the presence of AFADs in any coastal State within this area.

In summary, the use of AFADs in the Eastern Pacific area under the purview of the IATTC is not documented except for the occasional use for recreational fisheries.

2.1.3.4. Indian Ocean Tuna Commission

The regulatory area of the IOTC is addressed in detail in Task 2 - Characterisation of fisheries using AFADs in the Indian Ocean.

2.1.4. Task 1.3 Results - Case study: Indonesia

This section provides a summary of the effectiveness of various types of AFADs, in Indonesia known locally as *rumpon*. AFADs are essential tools in Indonesia fisheries for attracting pelagic fish species such as tuna, mackerel, and scads, especially for small-scale fisheries. Relevant data and information were collected to identify and analyse the current situation regarding the use of AFADs in Indonesia. The full case study report can be found in Annex 5.

Indonesia was selected as a case study due to the number of AFADs used and their impact on fisheries management for both artisanal and industrial fisheries. Fishing using AFADs in Indonesia is important to study because it directly impacts fishing efficiency, food security, the sustainability of fish stocks, and the livelihoods of coastal communities. The effective management of AFADs is crucial to ensure that they contribute to sustainable fisheries and do not lead to overfishing or harm the marine environment. Based on the latest data published by Widodo et al. (2023 and 2025) and Widyatmoko et al. (2021) and by FAO (2023), it is estimated that the number of AFADs installed in Indonesia is approximately between 5000 to 10000 units and contributes to approximately 72% of total tuna catch by Indonesia.

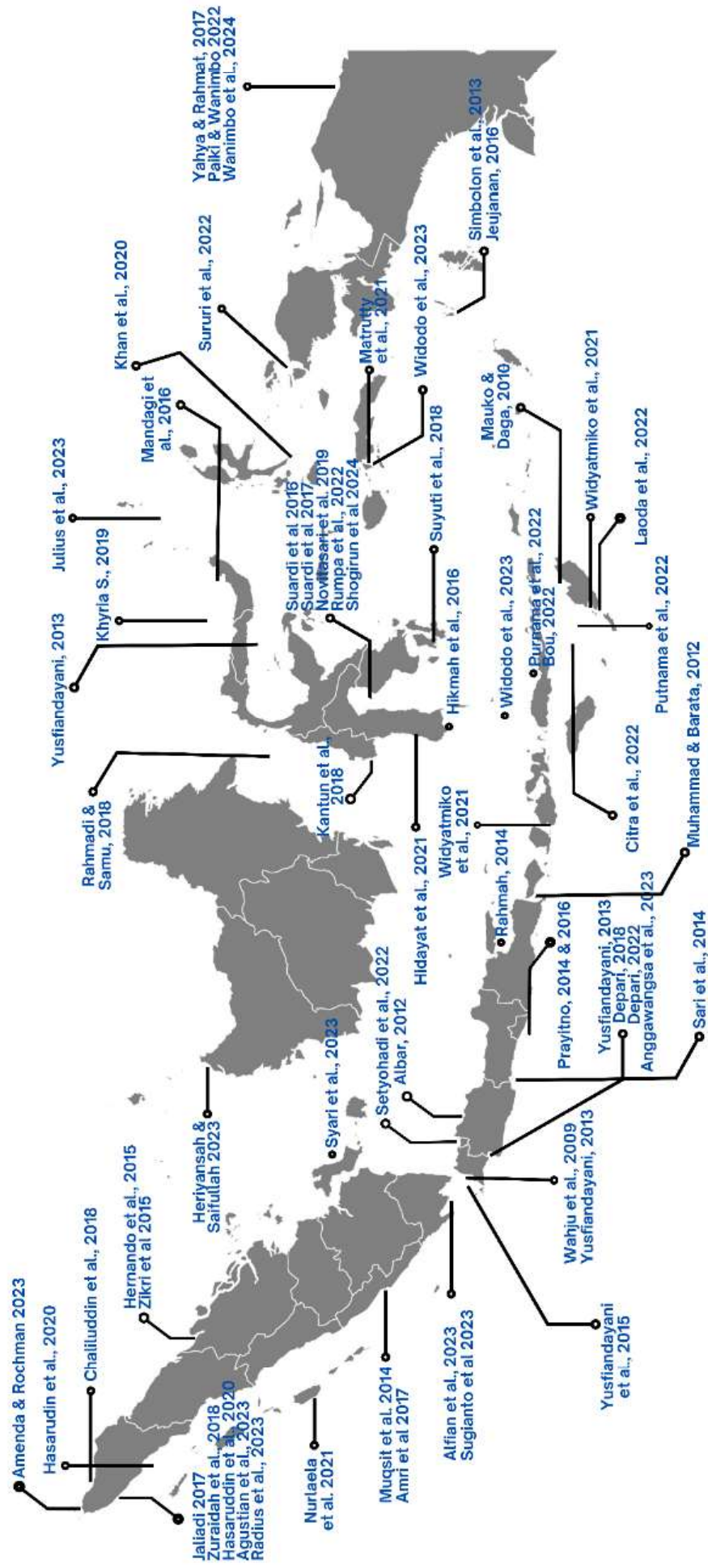
To complete the objectives of this project, a fieldtrip to Indonesia was planned to collect information about the use of AFADs, their number, location, target and bycatch species and socioeconomic relevance. However, the fieldwork was not possible because repeated research permit requests by the scientific team responsible for the project were systematically rejected by the Indonesian authorities. The European Commission's services in charge of Scientific Advice and Data Collection for fisheries also requested permission for the onsite study from Indonesia's Ministry of Marine Affairs and Fisheries, but the request was not granted, de facto impeding the research team to gain onsite knowledge about the overall management of AFADs in Indonesia.

Therefore, a case study without direct sampling and stakeholder interviews has been completed through extensive literature and local expert knowledge as the only viable alternative. A systematic literature review was used to identify and analyse the current situation regarding the use of AFADs in Indonesia. This method was chosen as it allows for the retrieval, evaluation and synthesis of various scientific sources and related documents to obtain a comprehensive understanding of the technical, regulatory, ecological, social, and economic implications of AFAD utilisation in the fishing industry (see Mengist et al., 2020). Few studies provide a comprehensive review of anchored FAD use in Indonesia that cover the entire country and all related fisheries. The most recent summary, Hargiyatno et al. (2025) provides results from eight major Indonesian fishing ports in the Indian Ocean from a semi-structured survey of 293 tuna fishers

covering purse seiners, troll-line, and handline vessels that utilise AFADs in over 90 % of their tuna-targeted fishing. The overall review identified 59 studies that have been conducted between 2009 and 2024 (Figure 3). An online stakeholder survey that was developed and planned to be implemented is included as Annex 6. It should be noted therefore that the results of this section of study were derived in the most part using a series of ad hoc studies and not a single source of official information provided by the relevant national authorities.

In Indonesia, AFADs have become a primary tool in tuna and pelagic fisheries across various Fisheries Management Areas (WPPs). They are generally placed in deep waters, sometimes exceeding 1000 metres in depth and up to 100 km offshore. For example, in Labuhan Lombok, Oeba Kupang, and Bone (WPP 713), AFADs are installed in waters deeper than 1000 metres (Widyatmoko et al., 2021). Meanwhile, in the northern Java Sea and southern Sulawesi Sea (WPP 713), AFADs are placed in shallow (50–200 metres) and deep waters (400–4000 metres) (Khyria, 2019). In Semaui and Sawu Sea (WPP 573), AFADs are positioned at depths exceeding 45 metres with a sandy-muddy substrate (Citra et al., 2022). The operation of AFADs involves three main stages: setting, towing and hauling. For handline fishing, the setting involves lowering fishing lines, towing consists of dragging lines around the FAD at 2-4 knots, and hauling is performed when fish take the bait (Depari, 2018).

Figure 1. Distribution of research on AFADs in Indonesia from 2009-2024. Based on Hargiyatno et al (2025).



AFADs play a crucial role in supporting both commercial and small-scale fisheries across various Indonesian waters. These devices not only improve fishing efficiency but also help fishers reduce operational costs, particularly fuel consumption. With AFADs, fishers can go directly to the fishing location without spending time and resources searching for fish in the open sea. This advantage is particularly evident in Teluk Talengen, North Sulawesi, and Labuhan Lombok, West Nusa Tenggara, where AFADs have become an integral part of local fishing strategies (Julius et al., 2023; Widyatmoko et al., 2021). In Fisheries Management Area (WPP) 713, which includes the Makassar Strait and the Flores Sea (Hikmah et al., 2016; Rahmadi & Samu, 2018), AFADs serve as essential tools for purse seine operations targeting small pelagic fish and neritic tuna. Meanwhile, in Sorong Regency (WPP 715) (Citra et al., 2022; Khan et al., 2020; Sururi et al., 2022b), AFADs are utilised in handline tuna fishing, one of the most environmentally friendly and sustainable fishing methods.

Apart from their role in fisheries, it is noted anecdotally in Indonesia that AFADs may also contribute to the physical regulation of fishing activities in line with conservation efforts. However, there is no evidence for this or detailed information on public maintenance or precise rules governing who can fish, catch limits, or effort restrictions on these AFADs. In Komodo National Park, for instance, AFADs are used as fishing devices but also function as markers for marking the edges of conservation zones, helping fishers clearly identify the permitted operational areas (Khyria, 2019). From our research however, we cannot explicitly determine whether these AFADs are publicly maintained or privately managed or provide any proof for their impacts on conservation efforts.

In Ambon, AFADs have been shown to improve fish catch productivity and ensure the sustainability of fishing activities, as their placement must consider the migration routes of small pelagic fish (Matrutty et al., 2021). It is not made clear however, how these migration routes would be considered when placing AFADs.

Support for AFAD use is evident in Kupang, NTT, where fishers have welcomed the installation of FADs to enhance their catch and optimise fishing operations (Antara News, 2024). According to a report from Antara News Kupang, fishers hope these AFADs will help them reduce operational costs and increase their income. However, while AFADs provide benefits through increasing catch rates, they also have been described as increasing risks as gateways for illegal fishing. The installation and use of AFADs may inadvertently enable illegal fishing by providing accessible and concentrated fishing spots that are exploited by illegal operators who evade formal regulations and monitoring efforts. Local AFADs may be installed at a regional level of organisation, setup and paid for by local authorities, not regionally or nationally, with the purpose of allowing local artisanal fisheries to benefit from them. These same local authorities, however, do not have the MCS capacity to enforce rules limiting their use and the AFADs are therefore at risk of use for IUU fishing. Recent reports highlight cases of foreign vessels poaching fish around FADs in Indonesian waters,

particularly in border areas such as the Sulawesi Sea, Anambas (Riau Islands), Aru (Maluku), Pieh Island, and Waigeo (West Papua) (Ambarwati, 2023).

AFADs may also support fisheries management by reducing the use of destructive fishing gear, that may be used in alternative fishing methods (e.g. bottom trawling or dredging), fishers getting access to resources through AFAD use that would not be available. AFADs may also lower operational costs through reduced fuel consumption. AFADs provide fixed, efficient fishing sites that allow fishers to reduce reliance on destructive or indiscriminate fishing gear, which tend to damage habitats and catch non-target species. The use of AFADs in Indonesia also supports, what have been described as more selective fishing methods, like handlines and pole-and-line, as shown in Table 3, which may minimise bycatch and ecosystem harm, though explicit numbers of vessels, fishers or catch is not available. However, it is not possible to fully define the selectivity of the different gears operating around AFADs due to the aggregation of the available catch data.

The literature analysed from Indonesia highlights the importance of regulatory frameworks at international, regional, national, and local levels in controlling AFAD deployment, including limits on the number of devices per vessel, zoning, and licensing (SIPR permits from an Indonesian perspective). Law and policy enforcement of these regulations and proper engagement and communication with fishers are critical to managing overcapacity. It is recommended to strengthen the systems for licensing, monitoring and ensuring fisher compliance to stand alongside AFAD regulations. Sustainable management of AFADs requires multi-sectoral cooperation among government, academia, fishers and NGOs to maintain fish stocks and ecosystem health.

The potential advantages of AFADs aligning with sustainable fisheries management, food security, and ecosystem protection are considered highly positive within Indonesia. There is little in the way of direct comparison between fishing gears to demonstrate this for either food security or ecosystem protection apart from anecdotal information. The precautionary approach and ecosystem-based management, e.g. through RFMOs, FAO Code of Conduct etc with AFAD use can fit well with these objectives by enhancing fishing efficiency, reducing environmental impacts and supporting coastal communities when properly regulated, managed and with good data collection, monitoring, control and surveillance systems in place.

The use of AFADs comes with several risks, including high costs, as expenses are needed for materials, surveys, installation, monitoring, and maintenance. Therefore, a cost-benefit analysis is necessary before initiating an AFAD programme. Moreover, the lifespan of an AFAD can vary depending on damage caused by other fishing gear or by vessels. Conflicts among users may also arise if access to AFADs is not well-managed. Another risk is the overexploitation of pelagic species that gather around AFADs, making it crucial for fishers to collect catch data to support fish stock management. Additionally,

placing FADs in inappropriate locations can disrupt sensitive ecosystems, such as conservation areas and habitats vital for protected species (FAO, 2012) although care must be taken when addressing AFAD location to ensure that minimal damage is done to those species and habitats on the seabed. No evidence of seabed sampling before and after AFAD installation has been seen from Indonesia and therefore no estimates of damage rates to seabed habitats are available.

2.1.4.1. Overview - Number of AFADs used in Indonesia

Table 2. Estimate of the number of AFADs used in Indonesia.

No	Name of Administrative Province	Number of AFADs from government sources	Number of AFADs reported from other sources	Source
1	Atapupu, NTT	n/a	23 units	Mauko & Daga. 2010
2	Rhu Bay, Bengkalis	n/a	80 units	Hernando et al. 2015
3	Jeneponto Waters	n/a	28 units	Hikmah et al. 2016
4	Uloulo Beach, Bone Bay, Luwu	n/a	6 units	Suardi et al. 2016
5	Ambon	n/a	25 units	Matrutty et al. 2021
6	FMA 572 (West Sumatra)	n/a	11 units	Nurlaela et al. 2021
7	Kupang, NTT	n/a	1 unit	Laoda et al. 2022
8	Palabuhanratu, West Java	n/a	40 units	Anggawangsa et al. 2023
9	FMA 713 (Makassar strait, Bone bay, Flores sea, and Bali sea)	n/a	661 units	Widodo et al. 2023
10	FMA 714 (Tolo bay and Banda sea)	n/a	608 units	Widodo et al. 2023
11	FMA 715 (Tomini bay, Maluku sea, Halmahera sea, Seram sea, and Berau bay)	n/a	291 units	Widodo et al. 2023
12	West Sumatera	n/a	11 units	Yusfiandayani 2013
	Total		1785 units	

A summary of the number of AFADs reported in Indonesia is presented in Table 2 along with a summary of the fisheries that use these AFADS with their target species and characteristics of the fishing vessels in Table 3. On the reliability of these figures, our research suggests that some uncertainties and limitations exist in the reporting. Specifically, the data on the number of AFADs come from various government sources and other related studies, but the availability of

official and consolidated data is limited, as reflected by many "n/a" (not available) entries in the table summarising AFAD numbers from different provinces. This suggests incomplete data coverage and potential gaps in reporting. Additionally, challenges in data collection due to factors such as undocumented or illegal AFAD installations, weak enforcement of regulations, and fishers' reluctance to report AFAD positions, could undermine the accuracy and completeness of the available figures. Therefore, while our research provides the best available current estimates of AFAD numbers based on the available information, it implicitly acknowledges that these figures have a degree of uncertainty and recommends improved monitoring, registration, and data collection efforts to enhance the reliability of AFAD statistics in Indonesia context.

Table 3. Characterisation of the main fishing methods used in AFADs to target tuna

Gear	Target species	Target schools	Duration of fishing trip	Vessel size	Number of crew	Number of active vessels
Pole and line	Skipjack tuna (<i>Katsuwonus pelamis</i>) Yellowfin tuna (small (<i>Thunnus albacare</i>))	AFAD, free swimming	n/a	n/a	n/a	n/a
Handline	Goldstripe sardinella (<i>Sardinella gibbosa</i>) Yellowstripe scad (<i>Selaroides leptolepis</i>) Shortfin scad (<i>Decapterus macrosoma</i>) Indian mackerel (<i>Rastrellinger kanagurta</i>) Imposter trevally (<i>Carangoides talamparoides</i>) Common ponyfish (<i>Leiognathus equulus</i>) <i>Caranx ignobilis</i> <i>Pomadasys argyreus</i> <i>Lutjanus vitta</i> <i>corangoides</i> <i>Epinephelus sp</i> <i>Trichiurus lepturus</i> <i>Valamugil bachanani</i> <i>Siganus vermiculatus</i>	AFAD, free swimming	3-4 weeks	5-30 GT	3-5 people	n/a
Trolling line	Yellowfin tuna (<i>Thunnus albacares</i>) Frigate tuna (<i>Auxis thazard</i>) Bigeye trevally (<i>Caranx sexfasciatus</i>) Hairtail (<i>Trichiurus sp.</i>)	AFAD, free swimming	15 days	2-5 GT	n/a	15
Purse seine	Scad mackerel (<i>Decapterus Ruselli</i>) Frigate tuna (<i>Auxis thazard</i>)	AFAD, free swimming	4-5 weeks	7-29 GT	21 people	n/a

Gear	Target species	Target schools	Duration of fishing trip	Vessel size	Number of crew	Number of active vessels
Gillnet	Scad mackerel (<i>Decapterus Ruselli</i>) Frigate tuna (<i>Auxis thazard</i>) Narrow-barred Spanish mackerel (<i>Scomberomorus commersoni</i>)	AFAD, free swimming	14 days	2-4 GT	n/a	n/a

2.1.4.2. Overview – catches from AFADs in Indonesia

The species and groups of fish caught around Indonesian AFADs vary greatly depending on the location, depth and fishing gear used. AFADs generally attract a range of pelagic fish species, from small to large, which are the main targets in AFAD-based fisheries in Indonesia. An overview of the reported volume of tuna caught in the Indonesian AFAD-related fisheries is shown in Table 4.

Table 4. Volume (tonnes) of tuna caught using AFADs in Indonesia based on literature review

Number	Reference	Location	AFAD Catch	Total catch
1	Soghirun et al. 2024	Bone Bay Waters, South Sulawesi Province	Yellowfin tuna (YFT): 6481 fish Bigeye tuna (BET): 842 fish Skipjack tuna (SKJ): 1353 fish	SKJ: 29.8 tonnes Frigate tuna (FRI): 37.4 tonnes Other tunas (OT): 19.9 tonnes
2	Anggawangsa et al. 2023	Palabuhan ratu, West Java, Indonesia	Bullet tuna (BLT): 1.8 tonnes FRI: 2.3 tonnes	SKJ 2 tonnes FRI 972 tonnes OT 1.7 tonnes
3	Widodo et al. 2023	East Nusa Tenggara	YFT, BET, SKJ: 1326.1 tonnes	SKJ 4.2 tonnes FRI 469 tonnes OT 627 tonnes
4	Radius et al. 2023	Banyak Island waters, Aceh Singkil Province, Aceh	FRI	SKJ: - FRI: 530 tonnes OT: 376 tonnes
5	Arnenda & Rochman, 2023	Kutaraja, Banda Aceh	SKJ: 1580 fish BLT: 1037 fish FRI: 407 fish	SKJ: 14 tonnes FRI: 3.6 tonnes OT: 4.3 tonnes
6	Laoda et al. 2022	Kupang City, East Nusa Tenggara Province (NTT)	FRI: (with baited FADs): 4.7 tonnes (without baited FADs): 2.5 tonnes	SKJ 8.2 tonnes FRI 8.0 tonnes OT 3.7 tonnes

Number	Reference	Location	AFAD Catch	Total catch
7	Sururi et al. 2022	Makbon waters Sorong, West Papua	Baby tuna: 53 fish FRI: 7 fish SKJ: 3 fish	SKJ 765 tonnes FRI 1.4 tonnes OT 2.6 tonnes
8	Purnama et al. 2022	East Nusa Tenggara waters	Thunnus tonggol (LT): 1.2 tonnes FRI: 5 tonnes SKJ: 1.5 tonnes	SKJ 8.2 tonnes FRI 8.0 tonnes OT 3.7 tonnes
9	Paiki & Wanimbo, 2022	Jayapura waters, Papua Province	SKJ: 29 fish FRI: 0.03 tonnes YFT: 0.01 tonnes	SKJ: 0.9 tonnes FRI: 1.6 tonnes
10	Nurlaela et al. 2021	West Sumatera waters, specially around Kepulauan Mentawai Regency		
11	Khan et al. 2020	3 locations of FAD (rumpon) in eastern Indonesia:	SKJ, YFT: 1.7 tonnes	SKJ 8.2 tonnes FRI 8.0 tonnes
12	Novitasari et al. 2019	Bone Bay, Luwu Regency, South Sulawesi	YFT: 1976 fish	SKJ: 29.8 tonnes FRI: 37.4 tonnes OT: 19.9 tonnes
13	Zuraidah et al. 2018	West Aceh Waters, Meulaboh – Aceh Province	FRI: 167 fish	SKJ: 2963 tonnes FRI: 2.3 tonnes OT: 2309 tonnes
14	Chaliluddin et al. 2018	Pusong waters, Lhokseumawe City, Aceh Province	SKJ: 0.7 tonnes FRI: 0.5 tonnes	SKJ: 2350 tonnes FRI: 1942 tonnes OT: 619 tonnes
15	Kantun et al. 2018	Babana waters, Center Mamuju Regency, West Sulawesi	SKJ: 268 fish Kawakawa (KWA): 258 fish YFT: 283 fish	SKJ: 116 tonnes FRI: 97 tonnes OT: 207 tonnes
16	Amry et al. 2017	Malabero Beach, Bengkulu City	FRI: 5 kg/trip = 1.1 tonnes/year	SKJ: 1.2 tonnes FRI: 3046 tonnes OT: 1078 tonnes
17	Prayitno, 2016	Pacitan, East Java	SKJ: 810.7 tonnes YFT 1063.8 tonnes BET: 5.9 tonnes	
18	Rahmah, 2014	Sendang Biru, Malang	YFT: 0.97 tonnes SKJ: 0.8 tonnes ALB: 0.1 tonnes	SKJ 3282 tonnes FRI 2004 tonnes ALB 723.3 tonnes OT : 1562.3 tonnes
19	Sari, 2014	Puger, Jember, East Java	YFT: 0.5 tonnes	SKJ 187.1 tonnes FRI 1984 tonnes OT 11.9 tonnes
20	Muqsit et al. 2014	Kaur Regency waters, Bengkulu	YFT – 0.1 tonnes	SKJ: 0.3 tonnes FRI: 1.2 tonnes OT: 192 tonnes
21	Simbolon et al. 2013	Southeast Maluku waters	FRI Purse seine : 11144 fish Gillnet: 1040 fish	SKJ: 2977 tonnes FRI: 10096 tonnes OT: 2334 tonnes

Number	Reference	Location	AFAD Catch	Total catch
22	Muhammad & Barata. 2012	Indian Ocean, southern Bali and Lombok	YFT: 1124 fish	SKJ: 8531 tonnes FRI: 54291 tonnes OT: 13996 tonnes

Data Source: Various research papers as identified in Table 2.

Major tunas and large pelagics

Yellowfin tuna (*Thunnus albacares*) is one of the main targets in the Flores Sea, as well as eastern Indonesian waters such as Sorong, Bacan Island, and Larantuka. AFADs are widely used in handline and pole-and-line operations to catch this species (Khan et al., 2020; Widyatmoko et al., 2021). In addition to yellowfin tuna, other tuna species such as albacore (*Thunnus alalunga*) and bigeye tuna (*Thunnus obesus*) are also frequently caught using AFADs. In Pacitan, Banten, Lampung, Palabuhanratu, Puger, Bengkulu, Lombok and Bone Bay these species are also commonly caught (Anggawangsa et al., 2023; Muhammad & Barata, 2012; Muqsit et al., 2017; Novitasari et al., 2019; M. R. E. Prayitno, 2016; Sari, 2014; Wahju et al., 2009). Likewise record high yellowfin tuna yields through small-scale landings at Sendang Biru Malang described by (Rahmah, 2014; Soghirun et al., 2024) further validate this dominance in South Sulawesi.

Bigeye tuna (*Thunnus obesus*) is a deep-water pelagic species regularly caught around AFADs in both western and eastern Indonesian waters. In WPP southern Java: Pacitan, Banten, Lampung, Pelabuhanratu), it appears alongside yellowfin and albacore in handline and pole-and-line fisheries (Prayitno, 2016). In WPP 573 (NTT), significant *T. obesus* landings occur in drop-line and trolling operations (Hargiyatno et al., 2018; Restrepo et al., 2015; Widodo, Wudianto, et al., 2023), while off South Sulawesi, Soghirun et al., (2024) report consistent catches associated with steep slopes and thermocline habitats. Its depth range (100–400 m) and endurance make bigeye tuna a prized, high-value target in Indonesia’s AFAD-based fleets.

Skipjack tuna (*Katsuwonus pelamis*) is commonly found in the Maluku Sea, Jayapura waters, Makassar Strait, and Flores Sea, as well as in Pacitan, Banten, Lampung, and Palabuhanratu (Anggawangsa et al., 2023; Hidayat et al., 2021; M. R. E. Prayitno, 2016; Wahju et al., 2009). Skipjack is often targeted in purse seine, pole-and-line, and handline operations, especially in deep waters (Khyria, 2019; Widyatmoko et al., 2021). Aceh also reports strong skipjack tuna catches, including juvenile “baby tuna” assemblages in Sorong (Sururi et al., 2022a).

Albacore (*Thunnus alalunga*) is a temperate-affinity species that appears intermittently in Indonesia’s AFAD catches. Along the southern coast of Java—around Pacitan, Banten, Lampung, and Pelabuhanratu—handline and pole-and-line vessels report albacore as a notable bycatch alongside yellowfin

and bigeye tunas (M. R. E. Prayitno, 2016; Wahyu et al., 2009). Similarly, small numbers of *T. alalunga* are landed at Sendang Biru Malang, where (Rahmah, 2014) observed occasional albacore captures in mixed tuna assemblages. Although less abundant than tropical species, albacore's occurrence under AFADs indicates the devices' capacity to aggregate a broader suite of pelagic fauna, extending fisheries reach into cooler upwelling zones and deeper isotherms around 100–200 m. Their seasonal incursions—often peaking during austral winter months when the Java Sea cools—provide important supplemental biomass for coastal tuna fisheries and underscore the need to monitor thermocline dynamics in AFAD placement strategies.

Bullet tuna (*Auxis rocheii*) and **frigate tuna** (*Auxis thazard*) often co-occur around AFADs across Indonesia's archipelagic waters, reflecting their similar ecological niches as small, schooling tunas. Both species are regularly recorded in Aceh, where gillnet and mini-purse seine fleets exploiting FAD aggregations report them as significant bycatch (Arnenda & Rochman, 2023; Zuraidah & Jaliadi, 2018). In the Nusa Tenggara Timur region, Purnama et al. (2022) found that bullet and frigate tunas formed dense schools beneath rumpon structures in the Savu and Timor Seas, facilitating efficient capture by purse-seine vessels. Their broad tolerance for temperature and salinity gradients allows *A. rocheii* and *A. thazard* to inhabit both coastal shelf zones near the Kei Islands (Simbolon et al., 2013) and more oceanic settings around West Sulawesi (WPP 713) (Kantun et al., 2018), underscoring their pan-archipelagic distribution driven by prey availability and FAD current dynamics.

Longtail tuna (*Thunnus tonggol*) represents a medium-sized tuna species that preferentially aggregates around AFADs in tropical Indonesian waters. Purnama et al. (2022) documented substantial schools of *T. tonggol* beneath rumpon in the Flores and Timor Seas, where its schooling behaviour and resistance to moderate depth variations (20–100 m) make it a primary target for both handline and purse-seine fisheries. Additionally, (Amry et al., 2017) recorded notable longtail tuna landings off Bengkulu, highlighting the species' capacity to exploit both eastern archipelagic and western shelf ecosystems. The widespread occurrence illustrates its ecological plasticity and its economic importance to small-scale and industrial tuna fleets alike.

Eastern little tuna (*Euthynnus affinis*) is commonly caught in East Nusa Tenggara (NTT) waters, Makassar Strait, Flores Sea, and Palabuhanratu. In Jayapura waters, eastern little tuna is often caught using trolling lines and handlines (Citra et al., 2022; Yahya & Rahmat, 2017). Meanwhile, in Palabuhanratu, it is frequently caught using trolling lines (Depari et al., 2022). Moreover, the species is dominant in WPP 573 (NTT) and Makassar Strait approaches (Laoda et al., 2022; Citra et al., 2022). In Aceh, both (Chaliluddin et al., 2018; Zuraidah & Jaliadi, 2018) Zuraidah & Jaliadi, 2018 note its importance for handline and trolling operations.

Mahi-mahi (*Coryphaena hippurus*) is commonly caught in Jayapura waters and Palabuhanratu using trolling lines, which are pulled by boats at specific speeds to attract large pelagic fish (Depari et al., 2022; Wanimbo et al., 2024b). Moreover, it appears as a seasonal bycatch in trolling sets, particularly in Jayapura and Palabuhanratu (Depari et al., 2022; Wanimbo et al., 2024)).

Bycatch with commercial value

For AFAD fisheries in Indonesia, by-catch mostly consists of small pelagic species which add economic value (Widodo, 2025). However, demersal species like groupers are also captured under AFADs:

Mackerel scad (*Decapterus macarellus*, *Decapterus russeli*) are found in the Sawu Sea and Pacitan and Ambon Bay (Matrutty et al., 2021; M. R. E. Prayitno, 2016). In Semaun and Sawu Sea waters, mackerel scad is one of the dominant species in purse seine catches (Citra et al., 2022).

Short mackerel (*Rastrelliger spp.*) are dominant in waters around Jayapura. Short mackerel and other small pelagic fish are also caught around Aceh waters (Hasaruddin et al., 2021). These fish are often caught around AFADs used by mini purse seine and gillnet fishers (Hikmah et al., 2016; Laoda et al., 2022).

Sardines (*Sardinella spp.*) are commonly found around FADs in Aceh waters, Atapupu Beach, Belu Regency, as well as Semaun and Sawu Sea. Fishers in these waters often use gillnets and purse seines to catch sardines in large numbers (Citra et al., 2022; Hasaruddin et al., 2021; Mauko & Daga, 2010).

Scads (*Decapterus spp.*). Members of the genus *Decapterus* (notably *D. russelli*, *D. macrosoma*, and related species) are small, schooling pelagic fish frequently reported as bycatch in a variety of Indonesian fisheries. These scads inhabit neritic waters from the surface down to about 100 m, favoring transitional upwelling zones where productivity is high. In Palabuhanratu (West Java), (Anggawangsa et al., 2023) documented *D. russelli* as the predominant non-tuna catch in trolling operations (Purnama et al., 2022). Similarly, (Bou, 2022; Rahmah, 2014) recorded *Decapterus* species in Kupang and Sendang Biru assemblages, respectively, underscoring their broad geographic distribution from Java's south coast to Maluku islands. Although not targeted commercially, scads serve as critical forage fish for larger predators (e.g. *Scomberoides*, *Cephalopholis*) and their removal in large numbers may cascade through the pelagic food web (Agustian et al., 2023; Matrutty et al., 2021; Syari et al., 2023).

Mackerel (*Rastrelliger spp.*). The mackerels *Rastrelliger kanagurta* and *R. brachysoma* are among the most ubiquitous small pelagics in Indonesian coastal waters, ranging across Aceh (Hasaruddin et al., 2021), Lampung (Alfian et al., 2023), and Sulawesi (Chaliluddin et al., 2018). These species form dense schools in the upper 50 m, particularly during cooler austral winter months when upwelling enhances plankton availability. In Meulaboh, WPP 571, *R. kanagurta*

comprised over 28% of handline bycatch, reflecting their seasonal aggregations around AFADs and natural structures (Hasaruddin et al., 2021; Jaliadi, 2017). Elevated bycatch rates—up to 8% in Jenepono (Hikmah et al., 2022)—highlight the need to refine gear selectivity and temporal closures to mitigate unintended removals that could undermine both ecosystem stability and local livelihoods.

Yellowstripe cad (*Selaroides leptolepis*) frequently ranks among the top three non-target species in dropline, trolling, and handline fisheries across Indonesia. Recorded from Rebo (Syari et al., 2023) to West Aceh (Radius & Edwarsyah, 2023), it thrives along continental shelf edges between 30–150 m depth, often concentrating near steep slopes and thermoclines where AFADs are deployed. In Bangka Belitung, Syari et al., (2023) reported scads in over 60% of mixed tuna gatherings, while in Kupang, Bou (2022) noted their presence as bycatch alongside tuna juveniles. Yellowstrip also found in Kei, Maluku (Jeujuanan, 2016). Owing to their high abundance and schooling behaviour, they can constitute more than 25% of bycatch biomass in some WPPs, potentially altering competitive dynamics and energy transfer within pelagic communities (Sururi et al., 2023).

Groupers (*Cephalopholis spp*) appear intermittently in handline-bycatch assemblages, notably in WPP 712 (Prayitno, 2016) and Makbon (Sururi et al., 2023). These reef-associated species venture into deeper slopes during feeding migrations, making them vulnerable to drop-line operations targeting tuna. Although their bycatch volumes are lower than pelagic scads or mackerels, their life-history traits, —low growth and late maturity—raise concerns about population resilience if incidental mortalities remain unmonitored (Khyria; Sururi et al., 2023).

Mahi-mahi (dolphin fish) is a fast-growing, epipelagic species that appears as seasonal bycatch in trolling operations, particularly around Jayapura and Palabuhanratu. Depari et al., (2022) and Wanimbo et al., (2024a) describe its capture at trolling speeds of 6–10 knots, with peak bycatch in austral summer months when surface temperatures rise above 28°C. While mahi-mahi supports a modest fishery of its own, its incidental capture can affect juvenile tuna survival through gear interactions and habitat shifts, underlining the importance of gear modification (e.g. hook type) to reduce collateral impacts.

Rainbow fish and **bramidae** are common bycatch species in purse seine and handline operations in WPP 573 and 713 (Widodo, Wudianto, et al., 2023).

Demersal fish, such as those caught in Hurun Bay, Bandar Lampung, including pufferfish (*Tetraodon lineatus*), lemon damsel (*Pomacentrus moluccensis*), butterflyfish (*Chaetodon auripes*), black damsel (*Neoglyphidodon melas*), barracuda (*Sphyraena*), blue devil (*Chrysiptera cyanea*), green chromis (*Chromis viridis*), red sea dascyllus (*Dascyllus*), yellowtail (*Caesio cuning*), tiger grouper (*Cephalopholis boenak*), *Stegastes fasciolatus*, Abudedefduf (*Pomacentridae*), giant travelly (*Caranx ignobilis*), redbtail butterflyfish

(*Chaetodon collare*), moorish idol (*Zanclus cornutus*), tiger cardinalfish (*Cheilodipterus macrodon*), tail-spot wrasse (*Halichoeres melanurus*), triplepot wrasse (*Halichoeres trispilus*), bluestripe snapper (*Lutjanus kasmira*), *Polynemus tectradactylus*, Napoleon wrasse (*Cheilinus undulatus*), *Parajulis poecilepterus*, bridled parrotfish (*Scarus frenatus*), rabbitfish (*Siganus canaliculatus*) and barred thicklip (*Hemigymnus fasciatus*) (Alfian et al., 2023; Paiki & Wanimbo, 2022; Saifullah & Heriyansah, 2023; Suardi, 2017; Suardi et al., 2016; Sugianto et al., 2023; Syari et al., 2023; Zikri et al., 2015).

Squid (*Loligo spp.*) are frequently found in WPP 573 and 716, particularly around Semau Sea and Talengen Bay and Belanakan Subang (Albar, 2012). AFADs in these areas often attract squid, which then serve as bait for large pelagic fish such as tuna (Citra et al., 2022; Julius et al., 2023).

Bycatch of vulnerable species

Overall, vulnerable species such as sharks, rays or turtles occur at low frequencies in AFADs and are generally released alive (Widodo, 2025). In the Maldives, the tuna fleet is composed by pole and line vessels, and this is a highly selective method with little or no bycatch (Thambithurai et al., 2025).

Small sharks are often caught around AFADs deployed in deep waters, particularly in purse seine operations (Widodo, Wilcox, et al., 2023). However, details are limited in catch records. Our research shows small sharks in relation to fish aggregating devices (FADs) in Indonesia, but only sparingly and without extensive catch records. Small sharks are noted primarily as bycatch species around AFADs, particularly in purse seine operations based on a manuscript by Widodo et al., (2023). However, detailed quantitative data or comprehensive catch records for small sharks are largely absent from the tables and catch composition summaries provided in our document. Our report underscores that the focus of catches and data collection is mainly on commercially important pelagic fish, and small sharks, while present, are not quantitatively significant enough to have detailed catch statistics in the datasets reviewed. Thus, the minimal information on small sharks seems to be due to their low catch volume and lower emphasis in the fisheries data, rather than simply missing or unrecorded catch from our report. It would be recommended that the catches of sharks along with all other bycatch species are recorded in more detail in the future.

Indonesia does report a high catch of blue shark (995.74 tonnes in 2024), but this is mostly attributed to deep longline gear (75%), to lines (25%) and anecdotal reporting for purse seine (0.28 tonnes) and gillnet (1.65 tonnes) (IOTC database: IOTC-DATASETS-2025-10-22-NC-ALL_1950-2024).

The diversity of catches around AFADs indicates that this technology not only helps improve fishing efficiency but also supports multispecies fisheries that accommodate various fishing gears.

In summary, the use of AFADs has become a key strategy in Indonesia's fishing industry, particularly in improving the efficiency of catching pelagic fish such as tuna, skipjack, and eastern little tuna. AFADs allow fishers to reduce fish-searching time, minimize fuel consumption, and increase catches. Besides economic benefits, AFADs also contribute to better fisheries management by helping regulate fishing grounds and reducing the use of environmentally destructive fishing gear.

However, despite their great potential, the use of AFADs also presents serious challenges, including overexploitation, juvenile fish catches that threaten fish stock sustainability, and ecological impacts on marine habitats. Existing regulations, both national and international, govern the installation and use of AFADs to mitigate these risks, but implementation still faces various challenges, such as the lack of monitoring on illegal AFAD deployment and fishers' compliance with licensing regulations. Therefore, a multi-sectoral approach involving the government, academia, the fishing industry, and coastal communities is needed to ensure the sustainable use of AFADs. Strategic measures such as strengthening licensing systems, implementing eco-friendly technologies, and increasing education for fishermen on sustainable fishing practices are key to balancing economic benefits and marine resource conservation.

2.1.4.3. Summary of Task 1

Under this task we have provided an overview of the use of AFADs worldwide with a special focus on Indonesia. We outline that AFADs are widely used in tropical and subtropical regions like the Mediterranean, Western Central Pacific and the Indian Oceans. However, we also highlight that there is a large uncertainty on the exact numbers of AFADs deployed every year.

AFADs are generally used to target tropical and temperate tunas in the Western Central Pacific and Indian Oceans but other commercially valuable bycatch is also captured (including neritic and small tunas). Incidental catch of vulnerable species like shark species is small.

We highlight that the information from Indonesia has been collected from previous studies as it has been impossible to carry on the fieldwork planned for this study. As mentioned, the research permit requests were systematically rejected by Indonesian authorities.

2.2. Task 2 - Characterisation of fisheries using AFADs in the Indian Ocean

This task aims to characterise AFAD fisheries in the Indian Ocean, including their socio-economic aspects across artisanal and industrial fleets, countries, gears, target species, and contributions to non-tuna fisheries. Findings from the two sub-tasks 2.1 and 2.2 are presented in this next section. Within these two sections, a review of the available sources of information is provided (2.1) as well as a summary overview of the Indian Ocean regions AFAD use characteristics in terms of which countries are reporting their use.

Findings from Task 2.1 indicate sources of information are more widely available for the Western Indian ocean (FAO Area 51) than for the eastern region (FAO Area 57). While from task 2.1, overall findings indicate AFAD fisheries in the Indian Ocean are predominantly artisanal, diverse in gear and target species, and more thoroughly documented in the Western region (FAO Area 51) than the eastern (FAO Area 57), with significant variation in data availability, fleet composition, and socio-economic reliance among countries.

2.2.1. Task 2.1 - Review and compile existing data sources and information available to characterise AFAD fisheries in the Indian Ocean

A total of 74 information sources were identified, comprised of 53 peer-reviewed articles, 13 grey-literature, one website material, and seven stakeholder contributions (Table 5). Peer-reviewed studies dominate, reflecting a reliance on academic research to monitor and assess AFAD use, often at the national level.

The literature on AFAD fisheries in the Indian Ocean is more extensive for FAO Area 51. Descriptions of the fleets (sectors, vessel types and gear types) are commonly addressed or described in the literature (Table 5). Data on fleet behaviour is widely available, detailing interactions with AFADs, gear types (e.g. longlines, gillnets), operational strategies, and spatial-temporal deployment patterns. Studies such as Widodo et al. (2023 and 2025) and Koya et al. (2019a) explore the effectiveness of gear types, fleet size, fishing strategies, and spatial usage associated with AFADs.

Socio-economic impacts are a prominent theme, especially in countries with significant artisanal fisheries. Reports frequently highlight the economic benefits of AFADs, such as increased catch rates, economic stability, job creation, and contributions to food security and community development (Mbaru et al., 2018; Tilley et al., 2019a; Widodo et al., 2023 and 2025).

Table 5. Number of information sources by characterising theme

Theme	FAO Area 51	FAO Area 57
AFAD Materials and Lifespan	12	10
Spatial Data on AFAD Distribution	15	7
Description of Fleets (and Gear Types)	38	19
Description of Target Species	19	11
Catch and Effort Statistics	38	6
Impact on Tuna Behaviour	6	1
Environmental Impacts	7	7
Socio-economic Dimension	9	3
Management Measures	4	4

Data Source: Project literature review.

The availability of spatial data for AFAD fisheries varies widely across regions, with substantial disparities in detail and source reliability. For some countries, such as Australia, India, the Maldives and Mauritius, fine-scale spatial data at the longitude and latitude level is available for the entire AFAD array. In contrast, other nations, such as Malaysia, have fine-scale location data for only a limited number of AFADs within their waters. In some cases, spatial information is only accessible through maps embedded in reports, as observed for Comoros and La Réunion.

The sources of spatial data also differ Table 6. In countries such as the Maldives and Mauritius, government authorities often publish detailed spatial information. Conversely, in regions where AFAD usage is widespread, such as Indonesia, spatial data is typically derived from peer-reviewed studies. These studies either aim to detect AFADs, or document fisheries based on a limited number of devices, highlighting the limitations in comprehensive data availability.

The depth of AFAD deployments also varies significantly, reflecting the influence of oceanographic conditions and target species. Shallow deployments, typically under 400 metres, are common in countries such as Comoros, Timor-Leste and Tanzania. Conversely, deeper deployments, exceeding 1800 metres, are characteristic of fisheries in India and Indonesia. Some nations, such as Mauritius, exhibit a broad depth range (215–3560 metres), indicative of diverse fisheries targeting species across multiple ecological zones.

Table 6. Summary of spatio-temporal data available for AFADs in the Indian Ocean

Country	File	Source(s)	Date	Depth	From shore	Estimated Number
Australia ¹	GPS	Victorian Fisheries Authority	2024	6–306 m	1.5 – 36 km	153 (40)
Comoros	Map	Failler et al., 2011	2010	30–50 m	Inshore	16
Description of Fleets (and Gear Types)	n/a	FIDA, 2024	2024	<400–1200 m	Unknown	NA
India	GPS	Koya et al., 2019a	2019	1800–2200 m	10 – 18 km	9
Indonesia	Map	Anggawangsa et al. 2023 Hikmah et al. 2016 Laoda et al. 2022 Matrutty et al. 2021 Mauko & Daga. 2010 Suardi et al. 2016 Widodo et al. 2023 Yusfiandayani 2013	2016–2018	1300–3000 m	Unknown	5000 – 10000
Malaysia	GPS	Peer-review	2018	Unknown	Unknown	66 – likely '000s
Maldives	GPS	Maldivian Gov Website ²	2024	Unknown	6.5 – 56 km	91
Mauritius	GPS	Ministry of Agro-Industry, Food Security, Blue Economy and Fisheries. (n.d.)	2022	215–3560	0.9 – 11.8 (no distance metric)	28
EU Mayotte	GPS	Mayotte Gov Website ³	2022	Unknown	<25 km	14
EU Reunion	Map	Le Roy et al., 2020	2019	Unknown	<4 - <19 km	39
	GPS	Guyomard et al., 2012	2012	400–2100 m	Unknown	38
Tanzania	GPS	Failler et al., (2011)	2005	300–650	Unknown	6
Timor Leste	Nearest port	Tilley et al., 2019	2016–2018	65–340 m	0.45 – 3.6 km	6
Thailand	Map	Southeast Asian Fisheries Development Center. (2011)	2011	Unknown	Unknown	Unknown

¹ Australian AFADs numbers are across all territories, including those outside of the Indian ocean, with the number of AFADs in Western Australia in brackets. Furthermore, the estimated numbers should be treated as highly uncertain. Limitations in recent reporting coupled with the short lifespan of some AFADs due to regional material characteristics and oceanographic forces mean these numbers are prone to high temporal variation

² <https://www.fisheries.gov.mv/fad>

³ <https://parc-marin-mayotte.fr/actualites/linstallation-des-dcp-du-parc-marin-est-terminee>

2.2.2. Task 2.2 - Characterisation of AFAD Fisheries in the Indian Ocean, Countries, Fleets and Gear, Target Species and Socio-Economic Dimension

The IOTC is the RFMOs responsible for managing tuna and tuna-like species in the Indian Ocean. The IOTC Convention Area spans two FAO-defined regions. FAO Area 51(Western Indian Ocean) and FAO Area 57 (Eastern Indian Ocean).

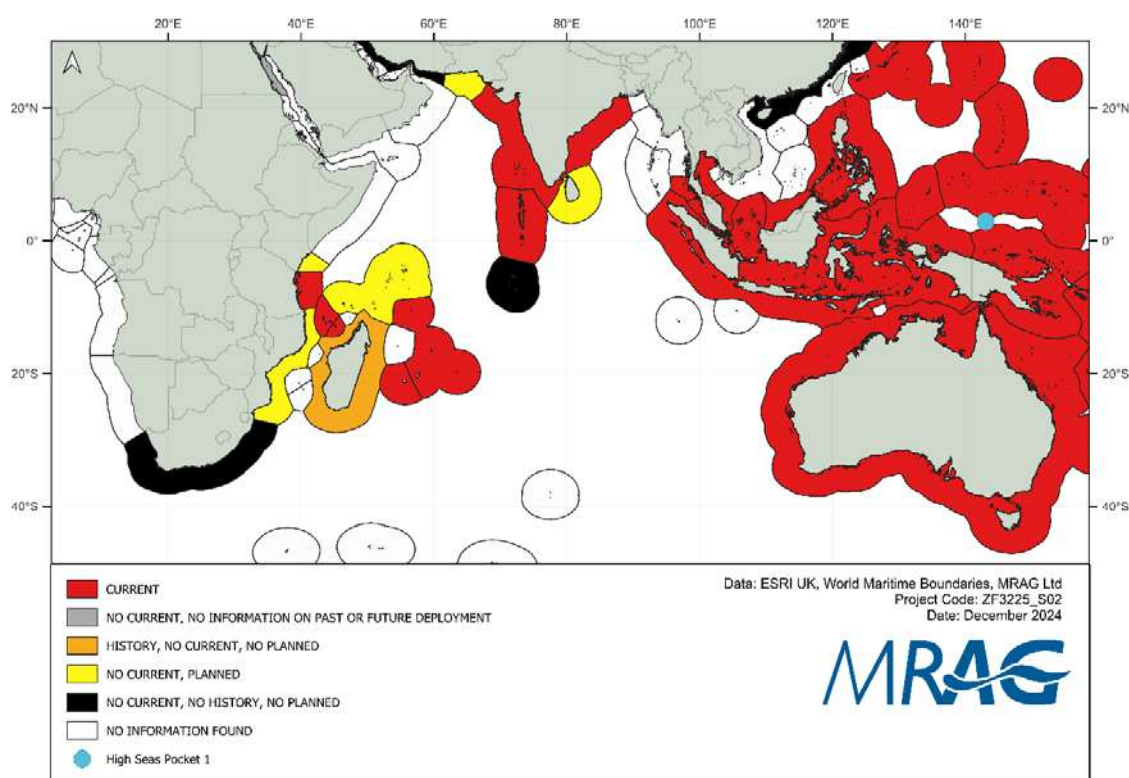
2.2.2.1. Countries

Ten Contracting Parties and Cooperating Non-Contracting Parties (CPCs) to IOTC currently deploy AFADs in their fisheries: Australia, Comoros, India, Indonesia, Malaysia, Maldives, Mauritius, EU (La Réunion and Mayotte), Tanzania and Thailand. In addition, the non-Member Timor-Leste, which technically is partly in the IOTC Regulatory Area is known to have AFADs.

In contrast, Sri Lanka, Bangladesh, Iran, Oman, Pakistan, Seychelles, and South Africa have reported no evidence of AFAD deployment in their waters¹. However, Seychelles, Sri Lanka and Mozambique have indicated potential plans for future use, Pakistan expressed interest in possible deployment on a limited basis for research purposes and Seychelles plan to deploy 'a few' in the future (See Figure 4).

¹ *pers. comm* Ministry of Maritime Affairs Pakistan, 2024; *pers. comm* IOTC, 2024; *pers. comm* Iran Fisheries Organisation, 2024; *pers. comm* The Department of Forestry, Fisheries and the Environment South Africa, 2024; *pers. comm* Seychelles Fishing Authority, 2024

Figure 2. Indian Ocean AFAD status from this study's research



Data Source: Project literature review and official submission of AFAD Management Plans to IOTC.

The Report of the 6th IOTC Working Group on FADs reports that the IOTC Secretariat has received AFAD management plans from the Maldives ($n = 88$ AFADs), Mauritius ($n = 28$ AFADs), La Reunion ($n = 43$ AFADs), Mayotte ($n = 14$ AFADs) and Indonesia ($n = 1909$ AFADs). These management plans include information on scope, institutional arrangements AFAD design and materials, applicable areas and a means for monitoring and reviewing the AFAD management plan (IOTC–WGFAD06 2024).

These values represent the number of AFADs reported by CPCs in their respective management plans. Under IOTC Resolution 19/02, all AFADs, defined as fish aggregating devices tethered to the ocean floor, are required to be covered by a management plan. While the Resolution does not appear to contain any provisions exempting specific types of AFADs from this requirement, it is worth noting that some CPCs with known AFAD arrays have not submitted plans. For example, Australia operates an AFAD array solely for recreational fisheries, and India has an array in the waters around Lakshadweep, yet neither has submitted a management plan to date.

2.2.2.2. Fleets and Gear

Artisanal fisheries dominate the deployment of AFADs in the Indian Ocean. These small-scale fisheries typically involve vessels under 20 metres in length and constructed of wood or fibreglass. Semi-industrial fleets are also present, particularly in island States such as Malaysia and Mauritius. Recreational fisheries using AFADs are limited, with only a few countries, including Mauritius and Australia, reporting such activity. Industrial fleet involvement in AFAD fisheries is minimal within the Indian Ocean, with notable exceptions such as the Maldives pole-and-line fishery where vessels extend between 25-30 metres, and Indonesia's diverse small- and medium-scale fleets, which include purse seine and pole-and-line vessels of varying sizes.

Artisanal fleets exhibit significant gear diversity, including longlines, pole-and-line, handlines, trolling, purse seines and gill nets. Longlines are more commonly associated with semi-industrial operations, while artisanal fleets predominantly use simpler gear types such as handlines and trolling. In some cases, as in Mauritius, trolling is supported using both artificial and live bait.

Certain regions show specialisation in gear types. For example, Malaysia, Indonesia, and Timor-Leste are the only nations employing gill nets in AFAD fisheries. The Maldives primarily relies on pole-and-line fishing, reflecting how local ecological, cultural and economic factors influence fishing practices.

However, data gaps persist, particularly regarding the specificity of gear and fleet descriptions related to AFADs. Consequently, some aspects of fleet composition and gear usage remain categorised as "unknown".

A summary of fleet usage is provided in Table 7.

Table 7. Countries, Fleets, and Gear Types in FAO Areas 51 and 57

	Industrial	Semi-Industrial	Artisanal (subsistence)	Artisanal (semi-industrial)	Recreational	Longline	Pole and line	Handline	Troll	Purse seine	Gill nets	Encircling nets	Unknown
Australia					✓								
Comoros			✓										✓
India				✓		✓	✓	✓	✓		✓		
Indonesia	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		
Malaysia		✓	✓	✓				✓	✓	✓	✓		
Maldives	✓		✓		✓		✓		✓				
Mauritius		✓	✓	✓		✓		✓	✓				
EU La Reunion				✓		✓		✓	✓				

	Industrial	Semi-Industrial	Artisanal (subsistence)	Artisanal (semi-industrial)	Recreational	Longline	Pole and line	Handline	Troll	Purse seine	Gill nets	Encircling nets	Unknown
EU Mayotte				✓	✓							✓	✓
Tanzania				✓		✓			✓				
Timor-Leste				✓				✓		✓	✓		
Thailand			✓	✓						✓			

Data Source: IOTC Catch and effort database (<https://iotc.org/data/reference>). (Accessed on 04/11/2025)

2.2.2.3. Target Species

When considering target species related with AFAD fisheries, 34 species have been identified. There is a large diversity targeted across gear types (see Table 8), ranging from large pelagic species like yellowfin tuna, bigeye tuna and swordfish to smaller pelagic. High-value species, including marlins, sailfish, and sharks, are also targeted, reflecting the ecological and economic importance of AFAD fisheries. Additionally, the reliance on specific live bait species, particularly in the Maldives where its estimated live bait to be equivalent to 9% of the tuna catch, highlights the use of small pelagic species in AFAD fisheries. This diversity indicates the multi-species nature of AFAD fisheries and the adaptability of gears to exploit both high-value and locally significant species.

Longlines and trolling are among the most versatile fishing methods, enabling the harvest of the widest range of species. Artisanal gears, such as handlines and trolling, play a critical role in the exploitation of smaller pelagic species, emphasising the contribution of small-scale fisheries to AFAD operations

Table 8. Gear-Target Species Matrix for AFAD Fisheries in FAO Area 51

Species / Gears	Longline	Pole and line	Handline	Troll	Purse seine	Gill nets	Encircling nets
Yellowfin tuna	✓	✓	✓	✓	✓	✓	
Bigeye tuna	✓	✓	✓	✓	✓		
Albacore tuna	✓	✓	✓	✓		✓	
Skipjack tuna	✓	✓	✓	✓	✓	✓	
Sailfish	✓	✓	✓	✓		✓	
Wahoo	✓		✓	✓			

Species / Gears	Longline	Pole and line	Handline	Troll	Purse seine	Gill nets	Encircling nets
Mackerel tuna			✓	✓	✓		
Bullet tuna	✓			✓	✓		
Dogtooth tuna							
Frigate tuna	✓		✓	✓	✓		
Longtail tuna			✓	✓	✓		
Rainbow runner		✓					
Dolphinfish		✓					
Black Marlin	✓	✓	✓	✓			
Blue Marlin		✓	✓	✓			
Striped Marlin	✓	✓	✓	✓			
Swordfish	✓	✓	✓	✓			
Narrow-barred Spanish mackerel							
Indo-Pacific king mackerel	✓						
Blue shark	✓		✓	✓			
Silky shark	✓	✓	✓	✓			
Mako sharks	✓						
Oceanic Whitetip	✓			✓			
Tiger shark				✓			
Live bait sp:							✓
<i>Spratelloides delicatulus</i>							✓
<i>Spratelloides gracilis</i>							✓
<i>Gymnoaesio argenteus</i>							✓
<i>Caesio striatus</i>							✓
<i>Pterocaesio pisang</i>							✓
<i>Caesio chrysozona</i>							✓
<i>Chromis caeruleus</i>							✓
<i>Lepidozygus tapeinosoma</i>							✓
<i>Archamia fucata</i>							✓
<i>Apogon thermalis</i>							✓
<i>Rhabdamia gracilis</i>							✓

Data Source: IOTC Catch and effort database (<https://iotc.org/data/reference>). (Accessed on 04/11/2025)

2.2.2.4. Socio-Economic Dimension

The use of AFADs in the Indian Ocean is dominated by use by the artisanal sector. Documented cases of industrial and semi-industrial in AFAD fisheries are not widespread. Much of the artisanal fleet operating in the Maldives is under 24 m, which is the length criteria for artisanal fisheries according to the IOTC. However, classifying these vessels in the same category as small dugout canoes/pirogues could be misleading and fails to capture the significant differences in technology and fishing practices. While both may fall under the same length category, some of the vessels in the 'artisanal' fleet often employ more advanced methods and have greater capacities, making a direct comparison to small, traditional dugout canoes inadequate for understanding the scope and impact of their operations. For example, AFAD fisheries in the Comoros, Mauritius, and Timor-Leste use small pirogues, while in the Maldives, Indonesia, Thailand and the Philippines often larger vessels are used, which may align more suitably with semi-industrial fisheries classification.

The socio-economic aspect of fuel use amongst AFAD fishers is not well documented and remains a gap requiring further research. With regards to fisheries dependence on AFADs, this ranges within different regions: For example, much of the semi-industrial/artisanal Maldivian pole and line fishery depends on their use (50%), as is the same in La Réunion, where 50% of fishers describe the AFADs as "indispensable", and a further 45% indicating they were important or very important (Miller et al., 2017; Guyomard et al., 2012).

Typically, it is seen that AFAD fisheries use vessels <24 m in length, of which two further classifications can be roughly seen. Those of an artisanal/subsistence nature and those that are more commercial / semi-industrial. Those of a more commercial nature are found in the Maldives, Indonesia, Thailand, and those more artisanal include places such as Timor-Leste, Mauritius, Mayotte and La Réunion. Catch values are not well documented but information from Mauritius shows CPUE increasing because of AFAD use.

2.2.2.5. Summary of Task 2

AFADs are typically employed by artisanal or semi-industrial fisheries including a wide range of gears such as longlines, pole and line, gillnet, trolling, handlines and purse seine fleets. Overall, in the Indian Ocean, these fisheries target tropical tunas (bigeye, yellowfin, skipjack), albacore and other pelagic species like swordfish, and neritic tunas. The socio-economic dimension of the use of AFADs is significant as their use is widespread in artisanal fleets (vessels less than 24 metres) in developing states like Comoros. Semi-industrial purse seine fleets in Indonesia, Maldives and others also operate on AFADs, generally set at lower depths offshore.

3. Analysis of AFAD Data

This section describes the analysis of AFAD data across two tasks, Task 3 (Qualitative assessment and quantitative estimation of the potential impact of AFADs on target and non-target species in the Indian Ocean) and Task 4 (Review of the environmental impact of AFADs).

3.1. Task 3 - Qualitative assessment and quantitative estimation of the potential impact of AFADs on target and non-target species in the Indian Ocean

3.1.1. Task 3 - Organisation

Task 3 was divided up into four subtasks:

- Sub-task 3.1: Review and compile existing data sources and information available to assess the impact of AFADs on target and non-target species in the Indian Ocean, also using information from other areas / RFMOs where available and appropriate.
- Sub-task 3.2: Evaluation of impact of AFADs on the behaviour of target species.
- Sub-task 3.3: Evaluation of impact of AFADs on tuna juveniles
- Sub-task 3.4: Evaluation of impact of AFADs on non-target species.

3.1.2. Methodology

For subtask 3.1 all the information available at IOTC with regards to the catch and size distribution of catch associated to AFADs were analysed. The information used in the analysis was that directly submitted to the IOTC Secretariat, its own estimates and how it is aggregated for stock assessments.

Subtask 3.2 reviewed the available information and theories about tuna behaviour in relation to floating objects. Scientific publications and meeting documents were reviewed to explain the potential impact of tunas to change their spatial behaviour when they encounter floating objects. The most recently collected and reviewed information was from a recently published PhD thesis on this topic (Utama, 2024).

The information used for tropical tuna stock assessments was used in subtask 3.3 to estimate the proportion of the total catch and the catch of juveniles that

can be attributed to AFADs. This included catch from pole and line, bait-boat and small purse seine fisheries when available.

Finally for subtask 3.4 a review was conducted to investigate the species captured by small purse seine fleets operating in AFADs, mostly in Indonesia. For this section, we also used the information described in the PhD thesis from Utama (2024).

3.1.3. Expected Outcomes

The expected outcome from subtask 3.1 was an overview table of existing data sources and information available with spatial and temporal coverage, links to actual data sources and an indication how they are used in the subsequent review and analysis. Subtask 3.2 was to provide a review and qualitative analysis of AFADs' impact on the behaviour of target stocks in the Indian Ocean. This would be accompanied by supporting data summary tables, maps and graphs, a description and critical analysis of data used, and any methodologies applied and any supporting datasets and/or spatial layers. For subtask 3.3, the expected outcome was a qualitative analysis of the impact of AFAD fisheries on juvenile tuna in the Indian Ocean, again accompanied by supporting data summary tables, maps and graphs, a description and critical analysis of data used, and any methodologies applied and any supporting datasets and/or spatial layers where available. The proportion of the total catch and juveniles attributed to AFADs is compared to the catch attributed to DFADs and to other gears targeting tropical tunas. Finally, subtask 3.4 would review and provide a qualitative analysis of the impact of AFAD fisheries on non-target species in the Indian Ocean. As for subtasks 3.2 and 3.3 this would be accompanied by supporting data where available.

3.1.3.1. Qualitative assessment and quantitative estimation of the potential impact of AFADs on target and non-target species in the Indian Ocean

The objective of this task is to assess both qualitatively and quantitatively the potential impact of AFADs on target and non-target species in the Indian Ocean with a specific focus on (a) impact on behaviour of tuna, (b) impact on tuna juveniles (% of catches) and (c) impact on non-target species.

3.1.3.2. Review and compile existing data sources and information available to assess the impact of AFADs on target and non-target species in the Indian Ocean, also using information from other areas/RFMOs where available and appropriate

The data available for IOTC stock assessments of tropical tunas were compiled and that corresponds to nominal catch data and stock assessment files. Additionally, to investigate the proportion of catch from bait-boat fisheries on AFADs, the catch and effort dataset for surface fisheries was used (See <https://data.iotc.org/reference/latest/>, <https://iotc.org/data/datasets/latest/CE/Surfaceast> accessed 04/11/2025).

The foreseen impact on non-target species (bycatch) required results from Tasks 1 and 2. In other words, it would be estimated from the data collected in the fieldtrip in Indonesia. However, the fieldwork component was not possible because repeated research permit requests by the scientific team responsible for the project were systematically rejected by the Indonesian authorities. The European Commission's services in responsible for Scientific Advice and Data Collection for fisheries also requested permission for the onsite study from Indonesia's Ministry of Marine Affairs and Fisheries, but the request was again denied, effectively preventing the research team to gain onsite knowledge about the overall management of AFADs in Indonesia. As the fieldtrip has not finally been possible, we limit this section to analyses made from the information available in the IOTC Secretariat and information from previous research.

To summarise, the scientific data currently available, we provide the current information on anchored FADs available at the IOTC Secretariat (after consultation) in Table 9. In general, observer coverage for fisheries operating on AFADs is very low.

Table 9. IOTC current data summary

CPC	Summary of data
General	Following Resolution 23/01, information on AFAD management plans have been received from Indonesia, Maldives and the coastal fisheries of Reunion (France, EU), Mayotte (France, EU) and Mauritius.
Indonesia	The number and status of AFADs is poorly known at the Secretariat but their number has been estimated to be very high, up to several thousands (Widyatmoko et al. 2021 and previous sections of this report). There is little information on the extent of the fishing activities conducted around AFADs, but it is expected to be high for small-scale handline and trolling line vessels, pole and line vessels, coastal purse seiners, and possibly the large-scale purse seiners. The current raising process for stock assessments of the IOTC assumes that all catches from large-scale purse seine corresponds to associated schools while the fishing mode for the catches from the coastal purse seiners is assumed unknown. It is difficult to estimate the real contribution of AFADs to the total catch of large and small purse seine vessels. However, it is likely that the assumption that all catch from Indonesian large purse seine vessels corresponds to AFADs be inaccurate and might overestimate the impact of AFADs to the bigeye and yellowfin populations. On the other hand, it is likely that a significant part of the small purse seine fleets' catch corresponds to AFADs. It is important to highlight that the fieldwork in Indonesia was not possible because repeated research permit requests by the scientific team responsible for the project were systematically rejected by the Indonesian authorities. The European Commission's services in charge of Scientific Advice and Data Collection for fisheries also requested permission for the onsite study from Indonesia's Ministry of Marine Affairs and Fisheries, but the request was again denied, de facto impeding the research team to gain onsite knowledge about the overall management of AFADs in Indonesia. Therefore, it has not been feasible to carry out a field study to generate independent estimates of the number of AFADs and their effects on target stocks and the marine ecosystem. Therefore, the estimates provided are derived from existing information in the IOTC Secretariat and prior scientific studies.
Maldives	The information on the fishing mode is not available for the pole and line fishery, but it is available for the size frequency data submitted for this fishery. From these, around two thirds (2/3) of the data correspond to AFADs while one third (1/3) would corresponds to free-swimming schools. Also, the Maldivian AFAD management plan indicates that AFADs are not used in the handline fishery targeting yellowfin.
Mauritius	Catch of yellowfin attributed to AFADs unknown. The reason for the lack of data may be the costs of maintaining a data collection programme for this CPC. However, the catch of yellowfin and bigeye by coastal fleets in association with AFADs is probably negligible.
Tanzania	No information received at the IOTC Secretariat on the use of AFADs. The reason for the lack of data may be the costs of maintaining a data collection programme for this CPC. However, the catch of yellowfin and bigeye by coastal fleets in association with AFADs is probably negligible (personal communication).
Comoros	No information received at the IOTC Secretariat on the use of AFADs. The reason for the lack of data may be the costs of maintaining a data collection programme for this CPC. However, the catch of yellowfin and bigeye by coastal fleets in association with AFADs is probably negligible (personal communication).
Madagascar	No information received at the IOTC Secretariat on the use of AFADs. The reason for the lack of data may be the costs of maintaining a data collection programme for this CPC. However, the catch of yellowfin and bigeye by coastal fleets in association with AFADs is probably negligible (personal communication).
Thailand	Coastal purse seine fleets seem to operate on AFADs but their contribution to bigeye and yellowfin seems null or very small.

As a summary, some coastal fisheries may be fishing on AFADs without reporting on the fishing modality (e.g. Madagascar, Comoros, Tanzania). However, the estimated catch of bigeye and yellowfin for these countries is probably minor.

Some follow-up research may be required to determine the potential catch of industrial purse seine fleets from Indonesia on AFADs. However, assigning 100% of purse seine and Danish seines to AFADs may represent an overestimation. Indonesia may be fishing on AFADs in other artisanal gears such as trolling, handlines and pole and line without reporting the type of school.

Also, not all the catch assigned to pole and line from Maldives in the stock assessments corresponds to AFADs. Therefore, the impact of these fleets is probably lower than assumed in the figures presented in the next section.

3.1.4. Evaluation of impact of AFADs on the behaviour of target species

It has been impossible to carry out the expected fieldtrip and therefore, the information provided in this section has been compiled from previous studies. One of these studies, the PhD thesis by Utama (2024) is summarised in this section. The PhD is publicly available.

According to Utama (2024) the aggregation of pelagic fish is a common and natural behaviour that has been used to facilitate fishing since ancient times. Different explanations have been provided to this behaviour, but the real reasons are still unknown. Alternative hypotheses suggest that aggregation may help protect from predators, increase food availability and serve as a spatial reference for young fish (Castro et al., 2002) and Freón and Dagorn (2000).

Utama (2024) collected fishermen's knowledge through a method known as Fisher Ecological Knowledge (FEK) to investigate the behaviour of fish under AFADs. He combined FEK information with data from underwater acoustic measures and stereo-cameras to identify patterns in the aggregation of different fish species and geographical areas in Indonesia. Utama identified eleven species of fish aggregated under AFADs including rainbow runner as the most dominant species. Skipjack tuna was the most common tuna target species identified in the experiments and FEK analyses indicate that handline fishers believe that juveniles of yellowfin and bigeye are driven to the locations of AFADs where they aggregate, which produces the ideal conditions for high catch rates. Fish behaviour is strongly influenced by currents and AFADs would offer protection. The availability of food and environmental conditions such as temperature would also be driven by these currents. Experiences using FEK in other areas such as the Maldives and Philippines seem to corroborate that fishers consistently mention currents as the main factor that drives fish

aggregation under AFADs. According to this, AFADs act as wake-forming obstacles and create hydrodynamic habitats that are attractive to fish. Fish will aggregate underneath the AFADs that are reached at the minimum energy and oxygen cost.

This would explain why fish aggregate in the up-current area of the AFAD, optimising their energy cost and maximising gains by intercepting the prey incoming with the currents.

With regards to fish behaviour under AFADs, Utama describes silky sharks and other type of sharks displaying circular movements in anticlockwise direction followed by rainbow runners. Utama describes the presence of silky, whitetip, silvertip and grey reef sharks under DFADs but the bycatch associated with AFAD fishing remains unknown. The behaviour of fish under AFADs is sometimes reactive to the presence or absence of these sharks.

With regards to depth, the results of the study from Utama indicate that small fish tend to aggregate at shallower waters with a large biodiversity while deeper AFADs are populated by single or small groups of larger fish such as tunas.

In the Maldives, a recent study (Thambithurai et al., 2025) investigated tunas' associative behaviour with AFADs. Using echosounder buoys, this study estimated a high presence of tunas under AFADs (occupancy >60%), suggesting that AFAD density in the Maldives is low compared to the population size. In other words, the population of tropical tunas is large enough to maintain AFADs aggregation at high levels and facilitating a sustainable fishery. This study estimated that fish remains under AFADs for 7.96 days on average.

3.1.5. Estimation of proportion of the total catch and the catch of juveniles under AFADs

In the Indian Ocean, concerns have been raised about the sustainability of two tropical tuna stocks in recent years: yellowfin and bigeye. Yellowfin was estimated to be overfished and subject to overfishing from 2015 until 2024, when a new assessment estimated that the stock is no longer overfished and not currently subject to overfishing. In the IOTC Scientific Committee report (2024), Indian Ocean bigeye tuna is estimated as to be overfished and subject to overfishing. These stocks are captured by several gears (i.e. purse seine, baitboat, longline, gillnet, handlines and other artisanal gears). Due to their recent state of exploitation, special attention has been placed on the mortality of juveniles of these two stocks. Juveniles of bigeye and yellowfin (fish smaller than 100 cm, the size where 50% of the fish are mature (L50)) are mostly captured by bait-boat, purse seine fleets operating on drifting FADs (DFADs), gillnets and other artisanal gears. The catch on AFADs is not officially reported to the IOTC but some gears such as small purse seiners, Danish seine, bait-boat and other artisanal gears fish juveniles under AFADs.

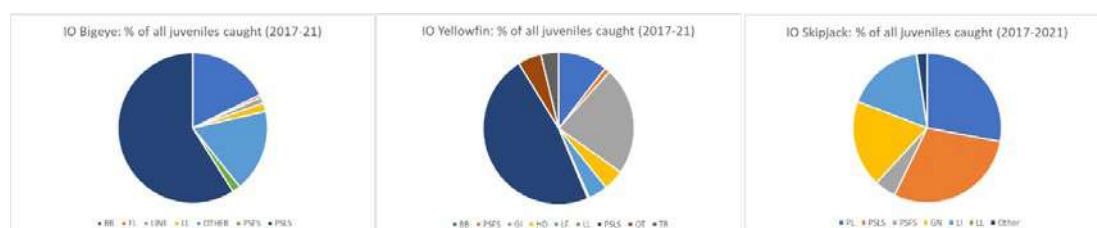
In the case of skipjack, the status of the stock is estimated to be sustainable (i.e. not overfished and not subject to overfishing). In addition, for this stock, the proportion of fish below the size used to distinguish juveniles and adult individuals (L50 = 40 cm) is relatively small.

Table 10 (Impact of different gears targeting yellowfin and bigeye in the Indian Ocean) and Figure 5 (Proportion of all juvenile catch from each gear for each tropical tuna stock) show the proportion of juveniles on each gear's catch, the proportion of juveniles from the total catch of juveniles and the proportion of total catch for each gear for the three tropical tuna stocks. Also note the proportion of juveniles from the total catch are 44% for bigeye, 36% for yellowfin and 1% for skipjack.

Table 10. Impact of different gears targeting yellowfin and bigeye in the Indian Ocean

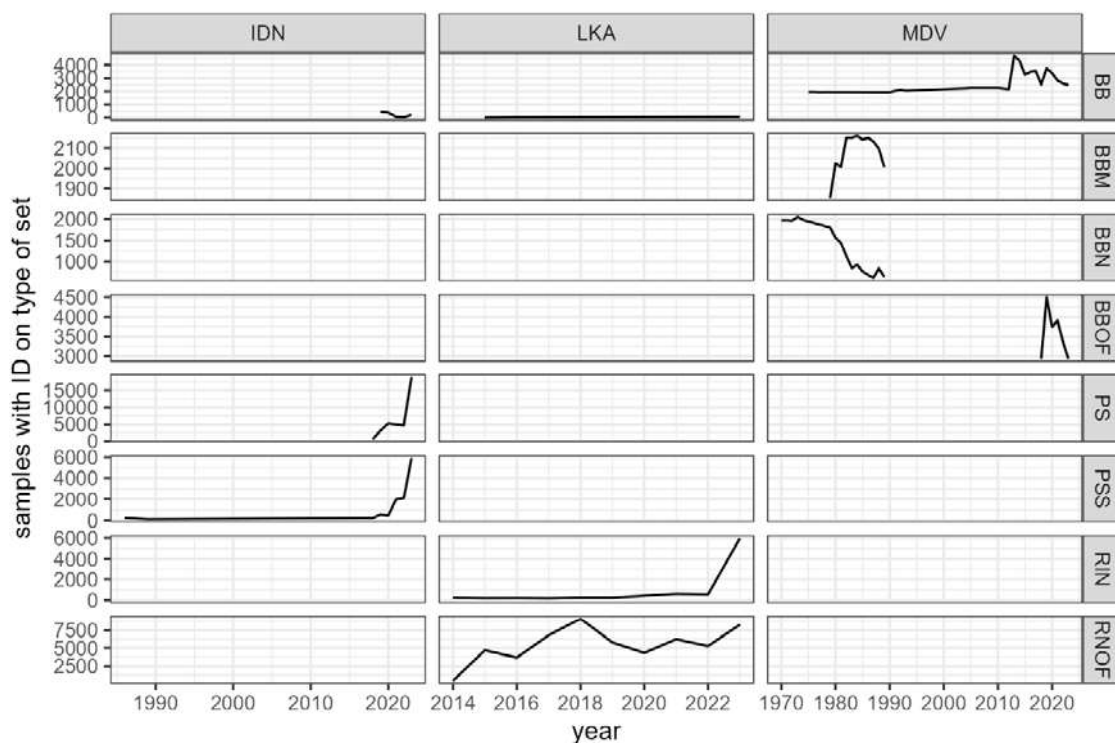
From CAS BET SA					
Avg2017-2021	Tonnes fish < 100 cm	% Juveniles in gear's catch	% of all juveniles	Weight (Tonnes)	% total catch
BB	34189	99%	18%	34406	8%
FL	1154	3%	1%	42325	10%
LINE	2483	5%	1%	48170	11%
LL	3533	3%	2%	120313	27%
OTHER	34127	84%	18%	40499	9%
PSFS	3362	10%	2%	34043	8%
PSLS	113789	97%	59%	117876	27%
% Juveniles in T Catch		44%			
From CAS YFT					
BB	83660	97%	11%	86040	4%
PSFS	9334	5%	1%	178707	8%
GI	182231	46%	23%	398014	18%
HD	34958	8%	4%	459475	21%
LF	32775	11%	4%	308784	14%
LL	2649	3%	0%	94875	4%
PSLS	375891	72%	48%	518483	24%
OT	39804	77%	5%	51995	2%
TR	29984	40%	4%	74997	3%
% Juveniles in T Catch		36%			
From CAS SKJ SA					
Avg2017-2021	Tonnes fish < 38 cm	% Juveniles in gear's catch	% of all juveniles	Weight (Tonnes)	% total catch
PL	17694	14%	28%	126362	29%
PSLS	18584	10%	29%	189801	43%
PSFS	2976	9%	5%	31360	7%
GN	11898	10%	19%	116829	27%
LI	10693	57%	17%	18611	4%
LL	77	4%	0%	1769	0%
Other	1434	1%	2%	163965	37%
% Juveniles in T Catch		10%			

Figure 3. Proportion of all juvenile catch from each gear for each tropical tuna stock



The attribution of these impacts to AFADs is not straightforward. Bait-boat or pole and line fleets fish under AFADs but also on free schools at different proportions. Likewise, Indonesian artisanal fisheries and small purse seiners usually included as *Others* in the stock assessments. There is no direct estimate of the impact of AFADs on the juveniles of tropical tuna stocks because catch data is not submitted with information on the type of set (associated or unassociated) as it is for industrial purse seine. However, in recent years, researchers can estimate the percentage of the catch of different fisheries that comes from associated, free or unclassified sets, as some information has started to be collected and received at the IOTC Secretariat. Nevertheless, current information is not sufficient to differentiate if the associated schools were caught in relation to a DFAD or AFAD. The number of samples for each CPC and gear with information of the type of set are increasing recently for Indonesia for small (PSS) and large purse seine (PS), for Sri Lanka (RIN) and Maldives for baitboat inshore (BB) and offshore (BBOF) (Figure 6). The main conclusion from this figure is that still, there is very little information on the type of set (associated or un-associated) for fisheries beyond industrial purse seiners. Also, the gear type recorded does not include any reference to free schooling, AFAD or DFAD related catch in many cases.

Figure 4. Number of samples for each CPC and gear with detail on the type of set (associated, un-associated and unknown). CPCs: Indonesia (IDN), Sri Lanka (LKA), Maldives (MDV). Fishing gears: Baitboat (BB), mechanized baitboat (BBM), non-mechanized baitboat (BBN), baitboat offshore (BBOF), purse seine (PS), small purse seine (PSS), ring net (RIN), ring net offshore (RNOF)



3.1.5.1. Summary of Task 3

To assess how fisheries sustainability is affected, one can examine how AFADs influence fish behaviour and measure how much fisheries using AFADs contribute to the total catch of commercially valuable species.

AFADs, like other floating objects, alter fish behaviour by attracting them and making them easier to catch.

There is uncertainty about how much baitboat, small purse seine, and other gear catches are taken under AFADs, since set types are rarely reported. Purse seine fisheries using drifting FADs provide this information. Similar reporting requirements for AFADs, would improve the estimates of their impact on target stocks.

Estimates using the output of recent stock assessments suggest that approximately 18% of bigeye tuna and 11% of yellowfin tuna are harvested using AFADs in the Indian Ocean.

3.2. Task 4 - Review of the Environmental Impact of AFADs

The objective of this task was to summarise and synthesise the available information on the wider environmental and ecological impact of AFADs. The task includes but is not limited to a review of different methods of deployment, the impact of the deployment on marine habitats, the contribution to marine litter, and the potential impact of AFADs loss.

Two subtasks were defined for Task 4.

- Sub task 4.1: Review and compile existing data sources and information available to assess the environmental impact of AFADs globally and with specific focus on the Indian Ocean.
- Sub-task 4.2: Evaluation of AFADs wider environmental/ecological impacts.

3.2.1. Methodology

Task 4 was developed to build on work undertaken during the previous sections, originally to be developed on information collected during the fieldwork during Task 1 but was adjusted to be based on the literature available and expert knowledge via questionnaire after the fieldwork in Indonesia was not possible, and a specifically built methodology to estimate AFADs contribution to marine debris. For this, we first characterised AFADs (construction and use) regarding biodegradable and non-biodegradable materials and, developed an

oceanographic model to estimate drifts of AFADs when detached from their floating element.

Across subtasks 4.1 and 4.2 it includes review and analysis of:

- Evaluation of marine litter associated to the loss of AFADs: This includes the estimation of % of biodegradable components in the construction of AFADs, and the estimation of marine litter associated to lost AFADs. We have developed methodology and a questionnaire to help make these estimates. The response rate to the questionnaires has fallen below expectations (5 out of 15); as a result, these findings should be interpreted with caution.
- Recommendation to reduce the marine litter associated with AFADs; and
- Simulation of AFAD loss and drift towards sensitive habitats: This has entailed some modelling work comparable to what has been done to predict beaching on sensitive habitats for DFADs. This has also required the characterization of AFADs in terms of volume, materials etc.

3.2.2. Expected Outcomes

The expected outcome from subtask 4.1 is an overview table of existing data sources and information available with spatial and temporal coverage, (with links to actual data sources), giving an indication how they are used in the subsequent review and analysis. First-hand accounts from stakeholders of the impacts AFADs have on the environment, both negative and positive, is provided to support existing studies.

Subtask 4.2 provides a review of AFADs' wider environmental/ecological impacts globally and with specific focus in the Indian Ocean, including a summary of different methods of deployment, the impact of the deployment on marine habitats and contribution to marine litter. This was to be supported by data summary tables, maps and graphs, a description and critical analysis of data used, and any methodologies applied and any supporting datasets and/or spatial layers.

3.2.3. Review and compile existing data sources and information available to assess the *environmental* impact of AFADs globally and with specific focus on the Indian Ocean

The information available on these issues is scarce and we expected to compile new information from the fieldwork planned during this project. After the refusal by Indonesia to permit the foreseen survey, we have based this section on the available information and personal expertise. We have also prepared a

questionnaire (Annex 6) to help characterize the composition of AFADs (materials, biodegradability), duration, occurrence of losses and their contribution to marine litter. We have characterized the expected drifting trajectories of lost AFADs using ocean currents' simulation techniques and the characteristics of AFADs (size, weight, materials etc). Finally, we characterize the potential impact on the seabed of the anchors of AFADs being dragged across the seabed.

3.2.4. Evaluation of AFADs wider environmental / ecological impacts

3.2.4.1. AFAD Characterization (construction and use) and estimated global impact

The use of AFADs has been reported in all oceans, although in most countries their numbers are limited and often set up with the aid of governmental or international organisations to help local fishers (Scott et al., 2014). This is for example the case in many Pacific Island nations of the Western Pacific and some Indian Ocean countries such as the Maldives and Mauritius, where governments or other management bodies finance and oversee the deployment and maintenance of most AFADs (Beverly et al., 2012; Jauharee et al., 2021; Appadoo et al., 2023). However, in countries like Indonesia and the Philippines, AFADs are owned privately by fishers or fishing companies, and the scale of their use is much higher (Macusi et al., 2015; Proctor et al., 2019; Widodo et al., 2023a).

Aside from the fact that AFADs, like DFADs and other natural floating objects, attract greater proportions of juvenile tuna (Jaquement et al., 2011; Yuniarta et al., 2017) and bycatch species such as sharks, sea turtles and non-tuna bony fishes (Proctor et al., 2019; Sadiyah et al., 2020), little is known about their impacts on the marine environment caused by their structures. Particularly, the extent of the impacts generated by AFAD mooring anchorage on the seabed and detached rafts drifting at sea and reaching the coast, are poorly understood.

Elements of the AFADs, such as the raft, attractor and part of the mooring can become drifting floating objects if these structures break away from the principal mooring line connected to the anchored weight at the bottom (Shainee and Leira, 2017; De Domenico et al., 2023). Although maximum lifetimes of two to five years have been reported for Indonesian AFADs (Hargiyatno et al., 2025), they often decay and are lost much faster (Proctor et al., 2019). To minimize AFADs breakage or loss, fishermen often carry spare materials and repair them during each fishing trips (Widodo, et al., 2023a). However, the extent of their maintenance work is very limited as they can only reach the superficial part of the AFAD (e.g. 0-20 m depth) with the help of divers (Gates et al., 1998).

Thus, the connections to the raft and the attractor rope are the ones that get serviced more often, but deeper parts are not repaired after their deployment. In areas like Bitung and Sulawesi of the Banda Sea, waters are relatively calm and AFADs will suffer less wave action, presumably reducing AFAD loss. However, in the zones of the Indian Ocean, particularly those on the southern coasts, wave energy is very pronounced and will likely result in more AFAD structure deterioration (Rizal, and Ningsih, 2022). Furthermore, vandalism leading to AFAD loss caused by competing purse seiners or by other gears fishing in the same area is common (Widodo et al., 2023a), leading to shorter lifetimes of AFADs in prime fishing areas. For these reasons we consider that after a limited period (e.g. 1-3 years) most AFADs will be lost, and new ones will have to be deployed to replace them.

Regarding the types of AFADs, the traditional *rumpons* were once employed in coastal areas by small artisanal vessels (i.e. <12 nm from the shore), ranging from depths of 20 to 1500 m. Originally these AFADs were relatively simple and consisted mostly of natural plant-based materials such as bamboo for the floating part and saran rope and palm leaves for the attractor, while the mooring rope was also made of saran and stones for the anchor. However, due to the fragility of these biodegradable materials, the use of synthetic materials such as polypropylene ropes, wire rope or chain, and concrete blocks in the submerged parts has increased (Beverly et al., 2013; Yusfiandayani et al., 2013).

Regarding the offshore AFADs (i.e. > 12 nm to 200 nm and beyond EEZ waters), these can range from 1000 to 4000 m depth and are used mainly by larger purse seiners and pole and line vessels (Murua et al., 2018). Three types of AFAD can be found depending on their floating raft type, while the attractor and mooring elements are basically the same between all of them. The first raft type is the “rakit” or “house FAD”, which is constructed with bamboo and wood and often has tyres or plastic drums to add buoyancy. The rakits have a small home built on it, where a person permanently stays to monitor and guard the AFAD. The second type is the “pontoon raft”, which is built with Styrofoam encased in 3-4 welded metallic oil drums or covered by fibreglass and resin. The third type is the “gabus” which is a large block of Styrofoam, rectangular or cylindrical, encapsulated in a plastic case and surrounded by small netting or ropes to tie it to the attractor and the mooring. All three have an attractor polypropylene rope of 30-50 m with palm leaves attached at intervals and a long mooring line with chain or wire rope elements in both extremes connected with swivels to the main body of rope which is of polypropylene of a diameter 18-22 mm. At the bottom of the mooring line, concrete blocks (30-40 units) are attached to maintain the AFAD in position. In some instances, an extra anchor and rope are also connected to the mooring line. Tables 11 and 12 show the characteristic elements and approximate weights of each component and the total weight per type of AFAD. For the offshore AFADs the length of the rope used was 2 000 m (as the range is from 1 000-4 000 m) and the number of cement blocks used was 35 (as many use between 30-40 blocks). These tables

serve as a reference but noting that the diversity of AFAD configurations (e.g. mooring line length and width, number of concrete blocks, etc.) might change.

The Indonesian fishery is a dynamic one, and the type of AFADs employed can change relatively rapidly. While for the coastal AFADs the traditional rumpon was substituted by a bamboo raft with synthetic materials below since the 2000's, for the offshore AFADs it seems that the dominant type of raft before 2015 was the pontoon, but in recent years the gabus has become the primary form of raft because it is lighter to manipulate and cheaper (Proctor et al., 2019; Widodo et al., 2023 a).

In Indonesia, the deployment of AFADs is extensive, with Proctor et al. (2019) estimating a “realistic” number between 5 000 and 10 000 units and more recently by Widyatmoko et al. (2021) in 10 000 and 50 000 unlicensed units, while Natsir (2011) reported that over 5 000 AFADs were actively used by small-scale tuna fishers. To estimate the total amount of non-biodegradable materials generated by AFADs in Indonesia we used the numbers reported by Widyatmoko et al. (2021). This estimation already had considered that a very large number of illegal AFADs deployed by vessels from the Philippines in Indonesian waters had disappeared in the last decade due to the introduction of Indonesian Government strict laws in 2014 banning fishing by foreign owned vessels in their territorial waters. However, this law required that AFADs are not deployed closer than 10 km from each other, but it is thought that they in some regions the average is about 5 km away only (Widyatmoko et al., 2023; Widodo et al., 2023).

Table 11. Estimated weights for a coastal and offshore AFAD used in Indonesia by material. *For all offshore AFAD types, the same attractor and mooring materials are employed

LOCATION	Type AFAD	Part of AFAD	Material	Type material	Size per unit (m)	Weight per unit (kg)	Number	Total weight per material (kg)	Total weight/Part (kg)
COASTAL	MODERN	Raft	Bamboo cannes	Biodegradable	2x3x0.3	1,2	8	10	12
			Tyres	Synthetic	0.2 x 0.2x 0.05	1	2	2	
		Attractor	Palm leaves	Biodegradable	1 x 0.4 x 0.05	0,2	10	2	49
			Polypropylene rope	Synthetic	0.032	0,7	10	7	
			Cement block	Synthetic	0.5 x 0.6 x 0.3	40	1	40	
			Polypropylene rope	Synthetic	0.032	0,7	10	7	
		Mooring	Cement block	Synthetic	0.5 x 0.6 x 0.3	70	7	490	501
			Half tyres	Synthetic	0.2 x 0.2x 0.05	0,5	7	4	
	TRADITIONAL	Raft	Bamboo canes	Biodegradable	2x3x0.3	1,2	8	10	10
			Rattan/Jute rope	Biodegradable	0.028x30	0,16	30	5	
		Attractor	Palm leaves	Biodegradable	1 x 0.4 x 0.05	0,2	10	2	27
			Stones	Biodegradable	0.5 x 0.5	20	1	20	
			Rattan/Jute rope	Biodegradable	0.028x30	0,16	100	16	
		Mooring	Stones	Biodegradable	0.5 x 0.5	50	10	500	516
OFF SHORE	GABUS	Raft	Styrofoam	Synthetic	3x3x 0.8	1	1	1	11
			Plastic coat	Synthetic	0.03 x3x3	3,2	1	3	
			Polypropylene rope	Synthetic	0.032	0,7	10	7	
	RAKIT	Raft	Bamboo cannes	Biodegradable	5x 7x 0.3	2,79	50	140	223
			Wood	Biodegradable	2x2x 0.3	1,2	20	24	
			Plastic drums	Synthetic	1x 0.6 x 0.3	8,5	6	51	
			Tyres	Synthetic	0.2 x 0.2x 0.05	1	8	8	
	PONTOON	Raft	Styrene foam	Synthetic	4x 0.9x 0.8	1	1	1	68
			Steel case	Synthetic	0.9x 0.8x 0.08	16	4	64	
			Tyres	Synthetic	0.2 x 0.2x 0.05	1	3	3	
	GABUS, RAKIT & PONTOON	Attractor*	Polypropylene rope	Synthetic	0.032	0,7	40	28	106
			Swivel/shackle	Synthetic	0.025x0.03x0.10	1,2	3	4	
			Cement block	Synthetic	0.5 x 0.6 x 0.3	70	1	70	
			Palm leaves	Biodegradable	1 x 0.4 x 0.05	0,2	20	4	
		Mooring *	Wire/Chain rope top	Synthetic	0.005x0.028x0.0	2,1	30	63	4123
			Wire/Chain rope bottom	Synthetic	0.005x0.028x0.0	2,1	20	42	
			Polypropylene rope	Synthetic	0.032	0,7	2000	1400	
			Cement block	Synthetic	0.5 x 0.6 x 0.3	70	35	2450	
			Half tyres	Synthetic	0.1 x 0.1x 0.02	0,5	35	18	
			Steel anchor	Synthetic	1x 0.5 x 0.05	150	1	150	

In terms of weight, depending on the type of material (synthetic vs biodegradable), of the offshore AFADs, the percentages of the different types of rafts are not so important, as the primary source of weight in the three of them comes from the anchoring rope and chains and the concrete blocks. For example, the total estimated weight of the synthetic AFAD materials in the gabus type was 4.2 tonnes, in the rakit 4.3 tonnes, and in the pontoon 4.3 tonnes Table 11. Except for the traditional AFAD with no synthetic materials, for the remainder, between 92 to 99% of the weight is composed of synthetic materials, with the anchoring cement blocks constituting the largest part in all, followed by plastics (i.e. polypropylene rope, motorcycle tires, Styrofoam) and finally metallic materials (i.e. chain and cable wire).

Table 12. Total weight of an AFAD in Indonesia by type and biodegradable and synthetic material weights and percentages

Type AFAD	Total weight AFAD (kg)	Biodegradable Total (kg)	Synth Total (kg)	Synth Plast (kg)	Synth Metal (kg)	Synth Cement (kg)	Bio (%)	Synt (%)
MODERN	561	12	550	20	0	530	2	98
TRADITIONAL	552	552	0	0	0	0	100	0
GABUS	4239	4	4235	1439	276	2520	1	99
RAKIT	4451	168	4284	1505	259	2520	8	92
PONTOON	4296	4	4292	1450	323	2520	1	99

To then make a calculation based on the number of AFADs that belong to the coastal and the offshore categories, we employed the estimates from Yusfiandayani et al. (2015), who reported 36% as coastal and 64% as offshore AFADs. For the coastal AFADs we estimated that given current proportions reported, the predominant type is the bamboo raft with synthetic materials (80%), as natural material *rumpons* (20%) are weaker. With regard to the offshore AFADs, we estimated that 70% had the gabus raft, while pontoons made 20% and rakits 10% of the total (Proctor et al., 2019).

Given the large volume of materials employed per AFAD construction and less than two percent being biodegradable, except as noted earlier for the old style coastal *rumpons*, the potential contribution of these structures to marine pollution once they are abandoned, lost or discarded is considerable. When the number of AFADs are estimated by type of AFAD, then the minimum total synthetic weight used in AFAD construction was estimated at 28 790 tonnes to 143 952 tonnes (see Table 13).

Table 13. Estimated total weight of synthetic materials contributed by type of AFAD in Indonesia if 10000 to 50000 AFADs were deployed annually

Type AFAD	Min. # AFADs	Max. # AFADs	Min. # AFADs Synth. Weight (kg)	Max. # AFADs Synth. Weight (Kg)
MODERN	2880	14400	1582560	7912800
TRADITIONAL	720	3600	0	0
GABUS	4480	22400	18972800	94864000
RAKIT	640	3200	2741440	13707200
PONTOON	1280	6400	5493760	27468800
TOTAL	10000	50000	28790560	143952800

3.2.4.2. Questionnaire to characterise AFAD use

The primary aim of the questionnaire shown in Annex 6, which investigates the environmental and ecological impacts of AFADs, was to gather expert insights on the design, usage and environmental impacts of AFADs in the Indian Ocean, with a specific focus on their application in Indonesian fisheries. For that, we

developed an expert-based survey directed to professionals across various sectors (e.g. academia, industry, government, NGOs) with expertise in fisheries, environmental management, or related fields. The questionnaire was structured as a mix of closed ended (multiple choice, ranking, yes/no) and open-ended questions to gather both quantitative and qualitative data. Respondents were asked to provide insights based on their knowledge of specific areas within the Indian Ocean.

The questionnaire was divided into four key sections to address the following main points:

- Respondent Profile
 - Geographic area of expertise.
 - Field of expertise (e.g., fisheries research, policy).
 - Type of organisation (e.g., academia, government).
 - Experience level with AFADs.
- Technical Inputs – AFAD Characterization
 - Types of AFADs used (Traditional, gabus, rakit, pontoon).
 - Deployment distances (coastal vs. offshore).
 - Materials used in construction for: i) Raft, ii) Attractors and iii) Mooring
- Technical Inputs – AFAD Use
 - Average lifespan of each AFAD type.
 - Components most prone to degradation.
 - Practices regarding repair, replacement, and loss of parts.
 - Recovery of lost components.
- Technical Inputs – AFAD Impacts
 - Identification of harmful fishing practices.
 - Observations of derelict AFADs (drifting, entangled, beached).
 - Perceived impacts of derelict AFADs on: i) Fish, ii) Coral, iii) Environment and iv) Ecosystem functioning
 - Identification of the most harmful AFAD components.
 - Suggestions for improving: i) Design, ii) Materials, iii) Management and iv) Overall impact mitigation

The questionnaire was distributed via email, including a link and a QR code for access. Only 5 of the 15 individuals contacted responded to the questionnaire.

The low response rate limits the robustness of the analysis and the representativeness of the findings in relation to the broader context of AFADs in Indonesia.

However, the open-ended questions designed to collect both quantitative and qualitative data provide insights into various aspects, such as potential bad practices, the possible effects of abandoned, lost or discarded AFADs, and different measures that could be implemented to minimize these potential impacts.

- To question #17 of “Recent research indicates that some of the main risks to coral reefs in the Indian Ocean include climate change, coastal development, and “bad” fisheries practices”. The five responses indicate that while Indonesian AFADs are primarily deployed in deep offshore waters, typically between 2 000 and 3 000 metres in depth, and therefore do not directly impact coral reefs, there are still concerns about their indirect effects. When AFADs become detached due to natural forces like storms or human actions such as deliberate cutting of mooring lines, they can drift into shallow reef areas and cause physical damage. Additionally, some respondents highlighted that AFADs can become ghost gear, contributing to marine pollution and posing risks to maritime navigation by obstructing shipping lanes. Other concerns include the excessive concentration of AFADs in certain areas, lack of effective management and monitoring, and the presence of illegal or unlicensed devices. Degraded components, particularly rafts and ropes, may detach and damage coral reefs when they drift ashore. Furthermore, dense deployment of AFADs can interfere with vessel navigation and lead to spatial conflicts or the privatization of marine areas (e.g. known conflicts with maritime cable laying operations). These insights underscore the need for improved regulation, design, and management of AFADs to mitigate their environmental and operational impacts.
- To question #20 “Which is the part of the AFAD that you think is responsible of most of the negative impacts (if any) that they can cause?” Several respondents identified synthetic materials, such as plastic ropes, tires, plastic drums, and Styrofoam, as key contributors to environmental pollution when AFADs degrade or are lost. One response highlighted that in the case of abandoned, lost or discarded AFADs, the long mooring ropes (3 000–6 000 metres) may sink and potentially form artificial reefs, although this effect is speculative and not well-documented in the literature. Another respondent noted that some AFADs use biodegradable ropes, which would eventually decompose and pose less risk. One participant expressed the view that no specific part of the AFAD significantly contributes to environmental or ecosystem harm. Lastly, the plastic coating on floats and the anchoring ropes were also mentioned as components with potential negative impacts.

- To question # 21 regarding “How to minimize the potential negative impacts of AFADs industry”): Respondents emphasized several key strategies to reduce the environmental and operational impacts of AFADs. A common recommendation was the use of biodegradable and environmentally friendly materials, particularly for ropes and floats, to reduce pollution when components are lost at sea. Some suggested specific alternatives, such as rosella rope, to replace polyethylene. The importance of tracking and monitoring systems was also highlighted, including the use of radar reflectors, FAD IDs, and GPS devices to locate AFADs if they become detached. Several responses pointed to the need for stronger enforcement and implementation of existing regulations, noting that while Indonesia has good policies in place, their effectiveness is limited by poor enforcement. Additionally, respondents called for better data collection and transparency, such as maintaining records of AFAD locations and numbers. Other suggestions included non-entangling designs, adequate mooring systems, and collaboration with the fishing industry to promote sustainable practices. Finally, education and awareness-raising among fishers and stakeholders were seen as essential to improving understanding of AFAD impacts and encouraging compliance with regulations.

3.2.4.3. Impact of AFADs as contribution to marine litter.

Marine litter, as defined by UNEP and NOAA (2012), includes any human-made solid material discarded into the marine environment. Plastics are the dominant component, making up 60–90% of marine litter, with an estimated 4.8 to 12.7 million tonnes entering the oceans annually (Jambeck et al., 2015). The primary sources are land-based (~80%) and sea-based (~20%), with rivers playing a key role in transporting waste to the ocean (EEA 2015, UNEP 2016; González et al., 2016).

Sea-based debris stems mainly from fishing activities, especially Abandoned, Lost, or Discarded Fishing Gear (ALDFG), as well as shipping and recreational vessels (Macfadyen et al., 2009; Bilkovic et al., 2014). ALDFG is particularly harmful due to its persistence and ability to cause ghost fishing, habitat damage, and economic losses for fisheries (Macfadyen et al., 2009; Bilkovic et al., 2014). It also contributes to microplastic pollution, posing risks to ecosystems and human health (Rochman, 2015). Despite growing global research efforts, significant data gaps remain, especially in regions like the Indian Ocean, due to the diversity of fishing gear and localized studies (Macfadyen et al., 2009; Bilkovic et al., 2014).

While most tuna RFMOs, including the IOTC, have adopted schedules to implement biodegradable DFADs by 2030 at the latest, there is no specific regulation for a transition to biodegradable AFADs. The only AFADs that has no

impact on marine pollution is the traditional coastal biodegradable material *rumpon* which was composed entirely of plant-based materials and rocks. However, this type of AFAD is the least frequent and has been replaced by modern synthetic materials, at least for the subsurface component.

Based on the results presented in Section 3.2.4.1 and adopting a conservative approach, if we estimate that all AFADs are lost at sea within two years of use, and assuming that the lost components are not recovered, the amount of synthetic waste generated and polluting the Indian Ocean off Indonesian coasts would range between 14 395 and 71 976 tonnes annually. Regarding plastic materials, the annual contribution from AFADs would range between 4 661 and 23 305 tonnes per year. The largest contributors to the total waste would be the cement blocks left on the seabed and the mooring lines that remain after being disconnected from the floating rafts. Indonesia has been identified as the second-largest contributor of mismanaged plastic waste to the ocean, following China according to Jambeck et al. (2015). In 2010, Indonesia generated approximately 3.22 million metric tonnes of mismanaged plastic waste, with an estimated 0.48 to 1.29 million metric tonnes entering the ocean every year. According to this data, AFADs represents approximately 0.4% to 2.1% of Indonesia's total plastic contribution to marine litter. These findings have influenced Indonesian environmental policy that has committed to reduce marine plastic waste by 70% by 2025.

In line with this, proper management and regulation of AFADs, like those established for other fishing gear such as drifting FADs, could significantly help minimize the potential impact and contribution of AFADs to marine litter.

Besides the pollution associated to plastic and other non-degradable materials that may drift in the ocean, it is difficult to characterise the effects the numerous heavy concrete blocks employed per AFADs on the seafloor. This is because the blocks in most AFADs are deep in the water column and direct observations have not been reported. While such blocks can create an “artificial reef” that might attract fish and other species in the very shallow AFADs (e.g., 20-50 m), it is unlikely fish biomass will aggregate around such structures if these are anchored at deeper waters. It is expected that the concrete blocks will slowly disintegrate over time, releasing a large amount of contaminant particles into the ocean (Zhi and Yi, 2023). The metal elements, such as steel anchors and the mooring chain will also break down after degrading and will leak polluting the sea with heavy metals (Sonone et al., 2020). Similarly, once detached from the floating element of the AFAD, the polypropylene rope and motorcycle tires will stay on the seabed for decades until it degrades into smaller plastic particles (Welden and Cowie, 2017; Arias et al., 2022) that can become micro- and nano-particles and potentially enter the marine food web (Habumugisha et al., 2024).

Little data is available on the fate of lost or abandoned AFAD materials. Regarding the stranding of AFAD rafts that have broken off the mooring line,

these have been found in surveys conducted in the Western Pacific. For example, Escalle et al. (2022) reports on 58 elements of AFADs found stranded in their Pacific Ocean surveys, with more than 50% appearing beached, but others appearing in coral reefs, the lagoon or in mangroves. Large pontoon rafts were found on reefs or already on land (having passed over the reef and lagoon all the way to the beach). Few studies have used divers at coral reefs to investigate if FADs, drifting or anchored, leave tracks on the reef when they pass over them on the way to the lagoon and beach. The survey by Escalle et al. (2022) was conducted mostly around Small Island countries of the Western Pacific, and no data were collected from Indonesia. However, if AFADs had reached these distant islands, it is quite likely that lost AFADs near Indonesia, depending on the oceanographic patterns, will end up on reefs and coastlines of this the world's largest archipelago. It is assumed that due to their size and volume that rakits will generate the largest damage if they encounter coral reefs, followed by pontoons. On the other hand, gabus rafts would a priori be less impactful on the reefs. However, one concern with all types of lost AFADs is that if they still have parts of chain or wire rope trailing below the raft. This element can drag over or get stuck in the reef structure damaging the seafloor. AFADs have no tracking devices (e.g. GPS buoys) and once they start drifting it is very difficult to locate them and evaluate their fate. Furthermore, AFADs that are near islands may quickly reach the coast before retrieval. Indonesian's coral reefs provide multiple ecological and economical services, essential for the subsistence of many coastal communities, and their deterioration by anthropogenic effects is a problem that needs solving, including AFAD stranding (Capriati et al., 2025).

In addition, to environmental contamination, poorly marked stationary AFADs can represent a navigational hazard, especially in high vessel transit areas. Although not common, should a vessel accidentally hit a floating AFAD structure it can potentially detach it from the mooring line (Proctor et al., 2019).

3.2.4.4. [Analyses of the potential environmental impact of drifting gabus AFADs in Indonesia from a Lagrangian approach](#)

As previously mentioned, AFADs might be eventually detached from the floating element due to the failure (break) of the line connecting the surface float to the moored seabed weights. This failure is typically caused by severe sea conditions or material fatigue. Once released, the floating component drifts across the open ocean as marine debris, potentially impacting the surrounding environment.

Indonesia is particularly vulnerable to the environmental consequences of such releases due to the extensive deployment of AFADs. The movement of these devices is influenced by regional wind patterns and ocean currents, most notably the Pacific–Indian or Indonesian Throughflow (ITF). The ITF is a key element of the global ocean circulation and supports the heat and freshwater

circulation from the Pacific the Indian Ocean via the Indonesian archipelago (Sprintall et al., 2009; Gordon et al., 1999, 2008, 2010, 2012). The intensity of the ITF varies seasonally, reaching its peak during the Southeast Monsoon (June to August) and weakening during the Northwest Monsoon (December to February). Additionally, the El Niño–Southern Oscillation (ENSO) significantly modulates ITF, with a particularly intensified flow observed during La Niña events.

Given the high number of AFADs deployed in Indonesian waters and the potential environmental consequences of their release, this analysis aims to evaluate their impact by simulating their drift trajectories using a Lagrangian model. This model requires the incorporation of ocean current and atmospheric wind velocity data derived from global oceanographic and meteorological datasets for estimating the trajectories. The environmental impact is assessed quantifying the stranding of drifting AFADs in marine vulnerable areas, including coral reefs, marine protected areas (MPAs), seagrasses, saltmarshes, and mangroves across Indonesian waters (Figure 7). Additionally, overall stranding events were analysed to quantify the marine debris reaching the coastline. As the gabus type has been the most used surface structure since 2015, the analysis focuses specifically on this AFAD configuration. Note that this is a theoretical study based on realistically modelled current and wind data, which considers all potential anchoring areas simultaneously to analyse the potential behaviour of drifting AFADs.

Data

Currents' velocity data were extracted from the GLOBAL_MULTIYEAR_PHY_001_030 product (<https://doi.org/10.48670/moi-00021>) of Copernicus Marine Environment Monitoring Service (CMEMS). These are reanalyses of daily currents with a spatial resolution of $0.083^\circ \times 0.083^\circ$ that assimilate sea level anomaly, sea surface temperature and in-situ temperature and salinity vertical profiles. Data were not available from 2021 on (they should be in future CMEMS releases), therefore, the analyses was built upon data from 2015 to 2021.

Hourly wind data were retrieved from the ERA5 product, the fifth generation of the ECMWF reanalysis for the global climate and weather of the Copernicus Climate Change Service (C3S) and Climate Data Store (CDS) (<https://doi.org/10.24381/cds.4991cf48>). This product has a spatial resolution of $0.25^\circ \times 0.25^\circ$ and assimilates observations from across the world.

Lagrangian model and simulation set-up

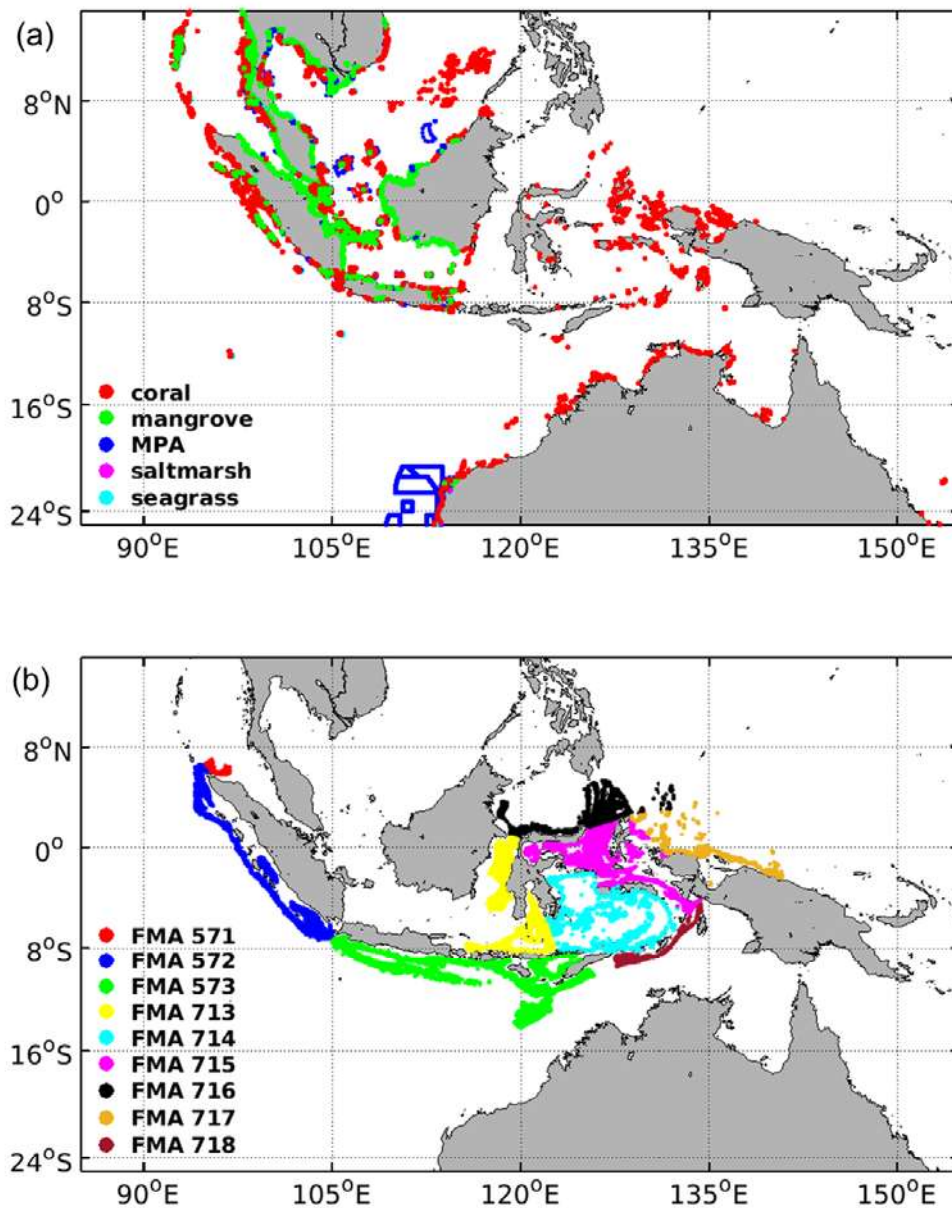
Trajectories were simulated using the OpenDrift Lagrangian particle tracking model (Dagestad et al., 2018), which has been widely used in oceanic transport studies (e.g. Andruszkiewicz et al., 2019; Opdal et al., 2023; Soares et al., 2023; van Sebille et al., 2020). The simulated particles represent horizontally drifting AFADs.

To the best of our knowledge, there is not a single source of information specifying the exact anchoring locations of AFADs in Indonesia. Therefore, this study assumes all potential deployment sites as release points. According to Table 7, AFADs are typically anchored in areas with depths ranging from 1300 to 3000 metres in Indonesia. Furthermore, they are expected to be located within Indonesia's Fishing Management Areas (FMAs). Consequently, the spatial domain for the simulations was defined based on bathymetric constraints and the boundaries of the FMAs. The resulting distribution of release points, covering nine FMAs, is shown in Figure 7 (a) Vulnerable marine areas considered in the analyses around Indonesia. (b) The FMAs considered in the analyses.

To account for different possible scenarios, several simulation cases were considered. Although the precise location of the break in the line connecting the surface float to the seabed is unknown, the surface structure and the palm leaves suspended below are the components most susceptible to ocean currents due to their large area of exposure. Palm leaves typically degrade within a few months, and fishers often replace them monthly. Consequently, the drifting behaviour of AFADs depends on their condition: if the palm leaves are degraded, the device is primarily influenced by surface currents; if intact, it is affected by the average current within the upper 40 metres of the water column. Accordingly, simulations were conducted using two types of current forcing: (i) surface currents and (ii) the average current over the upper 40 metres.

Additionally, the extent to which the wind influences AFADs drift, referred to as windage, depends on the volume of the structure that emerges above the water. The greater the exposed volume, the stronger the wind effect. Given that the gabus-type AFADs have a prominently emergent surface structure, two windage scenarios were considered: (i) 50% emergence, and (ii) 75% emergence. These correspond to windage values of approximately 3% and 6% of the total wind velocity, respectively.

Figure 5. (a) Vulnerable marine areas considered in the analyses around Indonesia. (b) The FMAs considered in the analyses



Each simulation was therefore run under four combined conditions:

- 3% windage with surface currents;
- 6% windage with surface currents;
- 3% windage with average upper-40m currents; and
- 6% windage with average upper-40m currents.

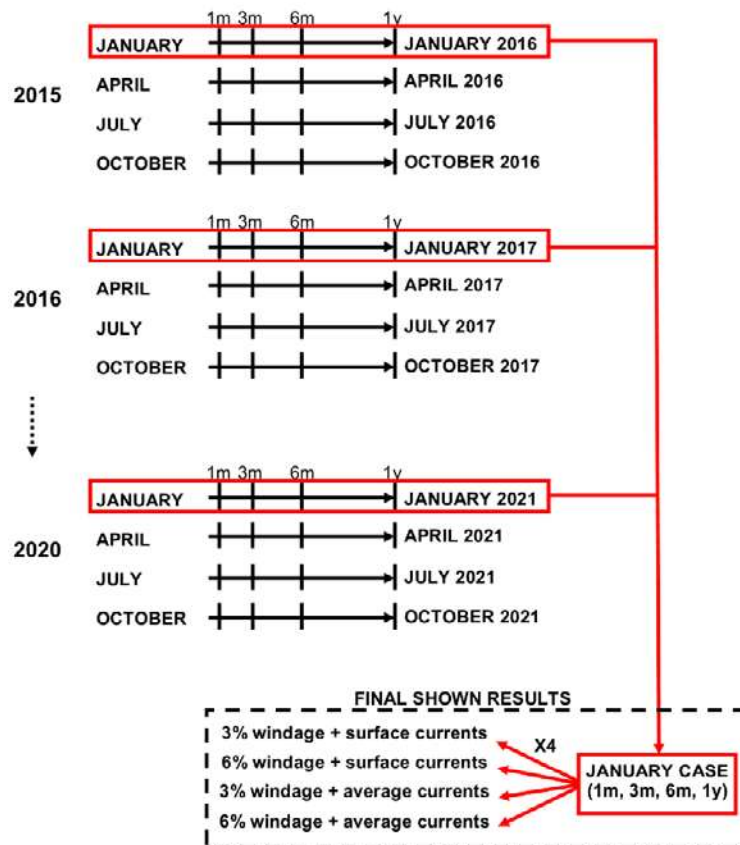
Simulations were run for over one year and we show results at 1, 3, 6 and 12 months (i.e. 1 year) after release to assess the potential impact over different periods. To capture seasonal variability in current and wind conditions,

simulations were initiated in four representative months spaced evenly throughout the year: January, April, July, and October. For each of these starting months, results were aggregated across all simulation years (2015–2021). For instance, the results of all the simulations starting in January were grouped as the January case. Note that the results for each of these simulation scenarios were repeated 4 times to consider the different windage and current forcings described in the previous subsection. For clarity, the structure and organisation of the simulation framework are illustrated in Figure 8.

The results are first presented as spatial maps to analyse the transport and distribution of AFADs from different FMAs across various simulation periods (i.e. 1, 3, 6 and 12 months) and release months (i.e. January, April, July and October release cases). Subsequently, the potential environmental impact was quantified by calculating the percentage of AFADs from each FMA stranded in each vulnerable area for each simulation period and release month. Percentages were used instead of absolute counts to account for the varying number of AFADs deployed in each FMA.

Figure 6. Scheme of the simulation and analysis framework.

The results at 1, 3, 6 and 12 months (i.e. 1 year) of every simulation with the same starting month are grouped to obtain the results if AFADs are released in January, April, July and October. Then, analyses are multiplied by 4 to test the differences under different possible currents and wind conditions



Distribution maps

Figure 9, Figure 10, Figure 11, Figure 12 show the spatial distribution of released AFADs across all simulation scenarios. This analysis enables a qualitative assessment of the evolution of their distribution at different time scales and under various conditions.

Overall, minimal differences were obtained between simulations using surface or averaged currents, regardless of the release month. The choice of 3% or 6% windage results in more pronounced differences in the distributions, particularly after 3 months. However, the most differing patterns are obtained for different release months:

- **January release:** During the first month, AFAD drift is relatively limited, with only a slight eastward movement of the northeastern AFADs toward the Pacific Ocean. Many AFADs located near the coast strand early in this period. After three months, this pattern persisted: northeastern AFADs continue drifting toward the Pacific, while western and southwestern ones begin a gradual movement toward the Indian Ocean. Some AFADs from the southern and southeastern regions start reaching the northern coast of Australia. Meanwhile, those initially deployed in central areas largely remain in place, though a few begin drifting southward.

By six months, coinciding with the peak intensity of the Indonesian Throughflow (ITF), which transports water from the Pacific to the Indian Ocean, AFADs from the western and southwestern regions exhibit a pronounced drift towards the Indian Ocean, with some stranding along the coast of Myanmar. Southern and southeastern AFADs continue to strand along the Australian coastline. Northeastern AFADs maintained their eastward drift into the Pacific, while central AFADs remained relatively stationary.

After one year, most AFADs either strand along the Indonesian coastline or disperse into the Pacific or Indian Oceans. Strandings of AFADs are also estimated in neighbouring countries, particularly Myanmar and Australia.

- **April release:** As the January case, the first month shows limited displacement, with many AFADs stranding near their initial coastal release areas. The northeastern AFADs again exhibit a slight eastward drift toward the Pacific Ocean. After three months, coinciding with the peak intensity of the ITF, the western and southwestern AFADs display a pronounced drift towards the Indian Ocean, with some reaching the coast of Myanmar. Central AFADs move westward through the Java Sea, eventually arriving at the Malaysian coastline. Northeastern AFADs also show a marked eastward drift, with some reaching the Philippine coast.

By six months, the drift patterns estimated at three months are intensified. Western and southwestern AFADs continue their movement toward the Indian Ocean, while northeastern AFADs advance further into the Pacific. Several central AFADs begin drifting northward toward the South China Sea, and another portion of them cross the straits of southwestern Indonesia, entering the Indian Ocean. After one year, during the ITF's weakest phase, the overall distribution remains similar to that estimated at six months, with continued drift into both the Pacific and Indian Oceans.

- **July release:** Within the first month, a strong drift is estimated among AFADs in the western and southwestern regions towards the Indian Ocean, and among those in the northeast towards the Pacific Ocean. This period aligns with the peak ITF intensity. AFADs located near the coast also strand locally during this time. After three months, these drift patterns become more pronounced. In the central region, some AFADs move westward, while others remain near their initial positions.

By six months, many AFADs exit the study domain, drifting towards the Indian and Pacific Oceans. Some of them reach the coasts of Myanmar and the Philippines. After the next six months, coinciding with a period of reduced ITF intensity, the overall distribution remains largely unchanged. By this point, most AFADs either strand or drift beyond the study area.

- **October release:** After the first month, AFADs in the western and southwestern regions exhibit slight westward and southward drift, respectively, with some stranding in nearby coastal areas. Southern AFADs remain largely stationary, with a minor northward drift. In contrast, northeastern AFADs show a pronounced drift towards the Pacific Ocean, while central AFADs remain near their initial positions, with some stranding along adjacent coastlines.

After three months, western, southwestern, and southern AFADs continue drifting westward, south-westward, and southward, respectively. In the latter case, several AFADs reach the northern coast of Australia. Central AFADs remain relatively stationary, while northeastern AFADs continue drifting towards the Pacific Ocean.

By six months, these patterns further develop. More AFADs reach the coasts of Australia, and some also arrive along the coast of Myanmar and the Philippines. During the next six months, during which the high-intensity phase of the ITF occurs, some AFADs exit the study area into the Indian and Pacific Oceans. Nevertheless, several AFADs remain adrift in the open ocean, and some central AFADs continue near their original release locations.

Overall, across all scenarios, according to the simulations, a significant proportion of AFADs would strand within the first three months, particularly during the first month and in areas near their release locations. Strong transport

patterns are estimated during periods of high ITF intensity (June-August), with AFADs from the western and southwestern (mainly from FMAs 571, 572 and 573) drifting towards the Indian Ocean. Throughout the one-year simulation period, this behaviour is consistently obtained in the simulations, with many of these AFADs (from FMAs 571 and 572) eventually stranding along the coast of Myanmar. In contrast, during periods of low ITF intensity (December-February), drift patterns are more stationary.

Northeastern AFADs (from FMAs 715, 716 and 717) tend to consistently drift towards the Pacific Ocean across all simulated scenarios. Some of these AFADs exit the study area, while others strand along the Indonesian or Philippine coasts. The Australian coast is reached only for releases in January and October, mainly by AFADs from FMAs 573, 714 and 718 and sporadically from the southernmost AFADs from FMA 715. Central AFADs (from FMAs 713 and 714) generally remain within the central Indonesian region. However, AFADs from FMA 714 exhibit slight southward drift when released in January and October, and northward drift in the April and July releases. Notably, some AFADs released in April from FMA 713 cross the Indonesian straits into the Indian Ocean, while others first move through the Java Sea before drifting northward.

Figure 7. AFAD dispersion maps for January releases for different periods, windage values and forcing currents

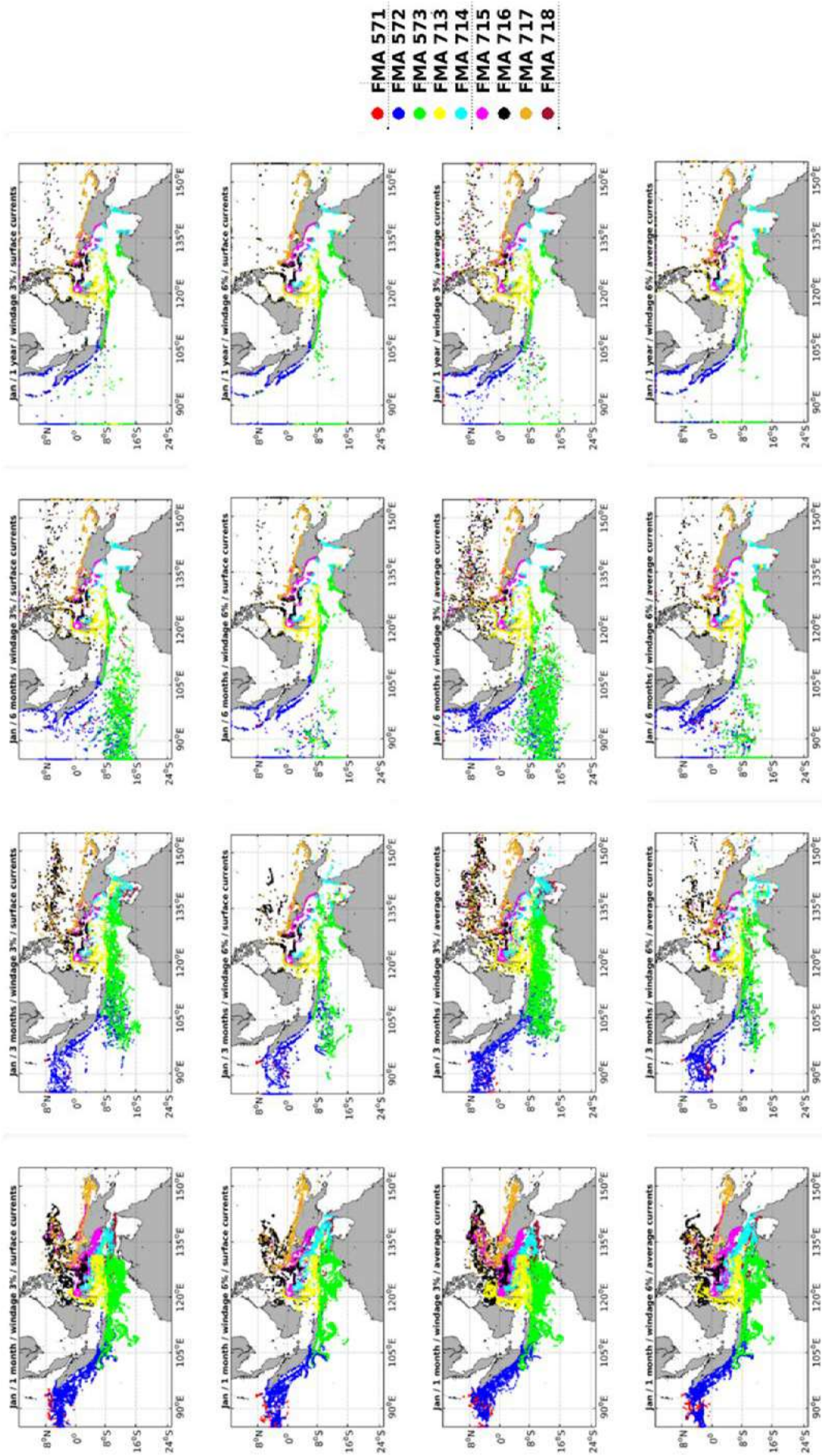


Figure 8. AFAD dispersion maps for April releases for different periods, windage values and forcing currents

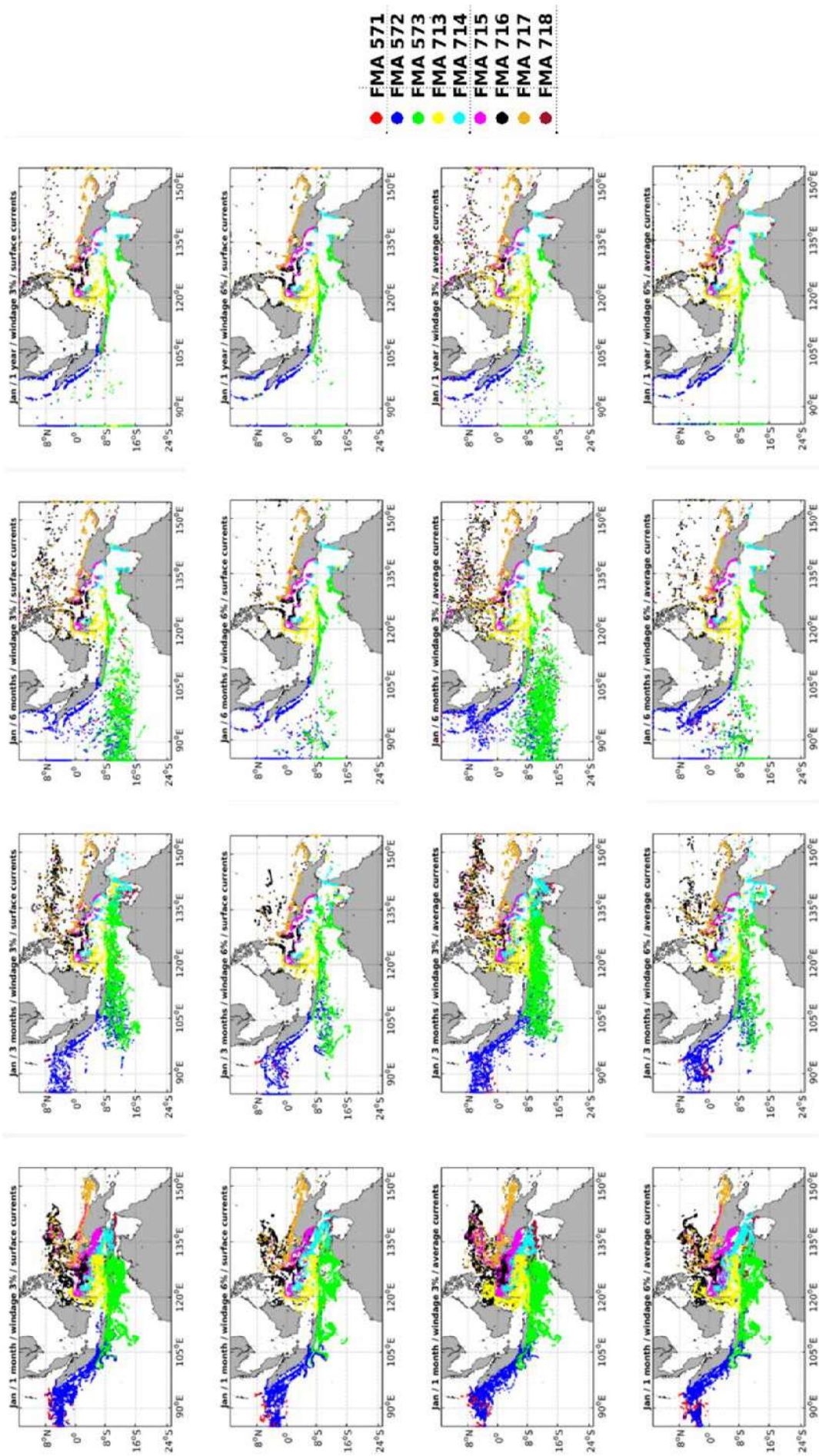


Figure 9. AFAD dispersion maps for July releases for different periods, windage values and forcing currents

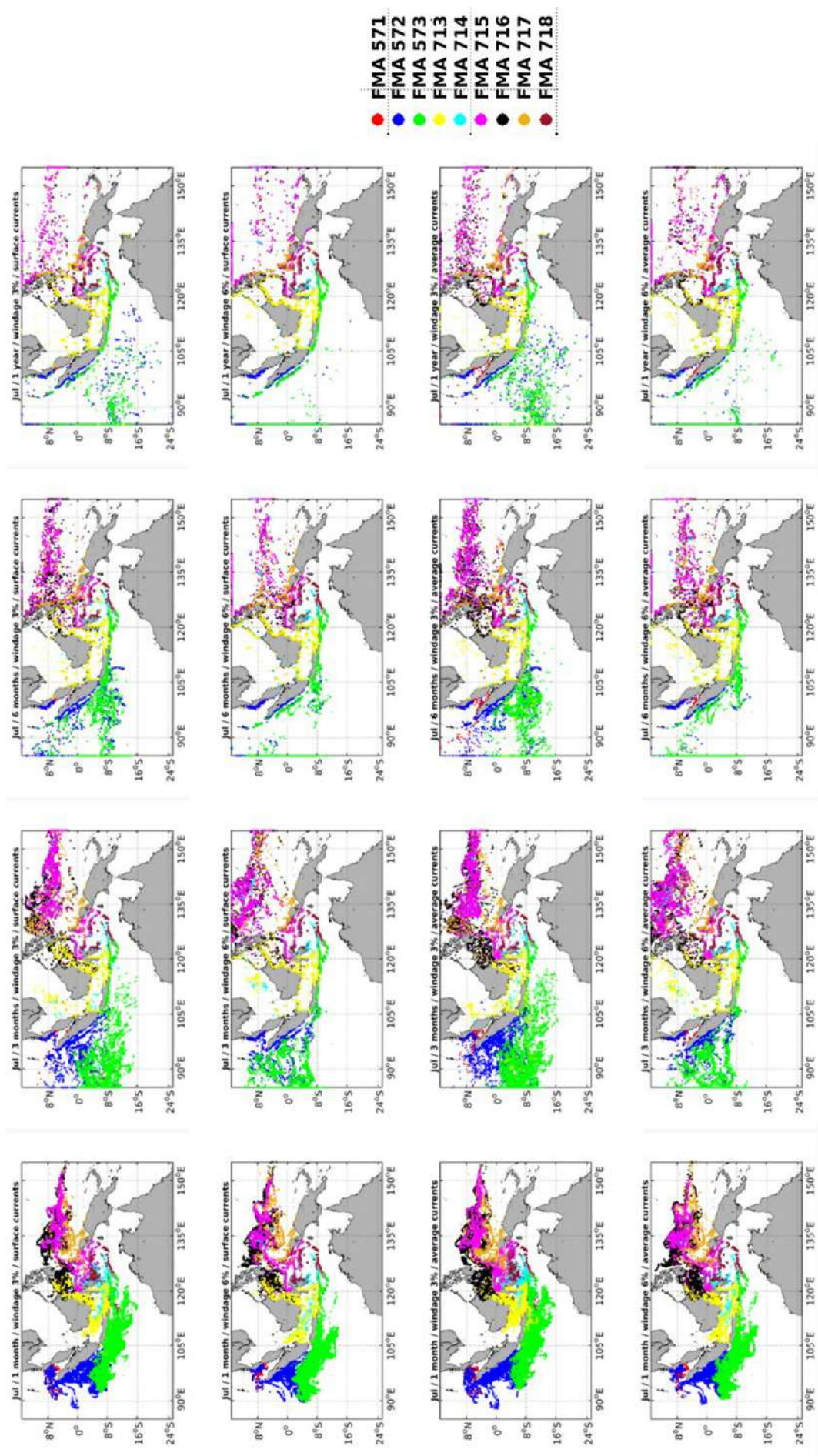
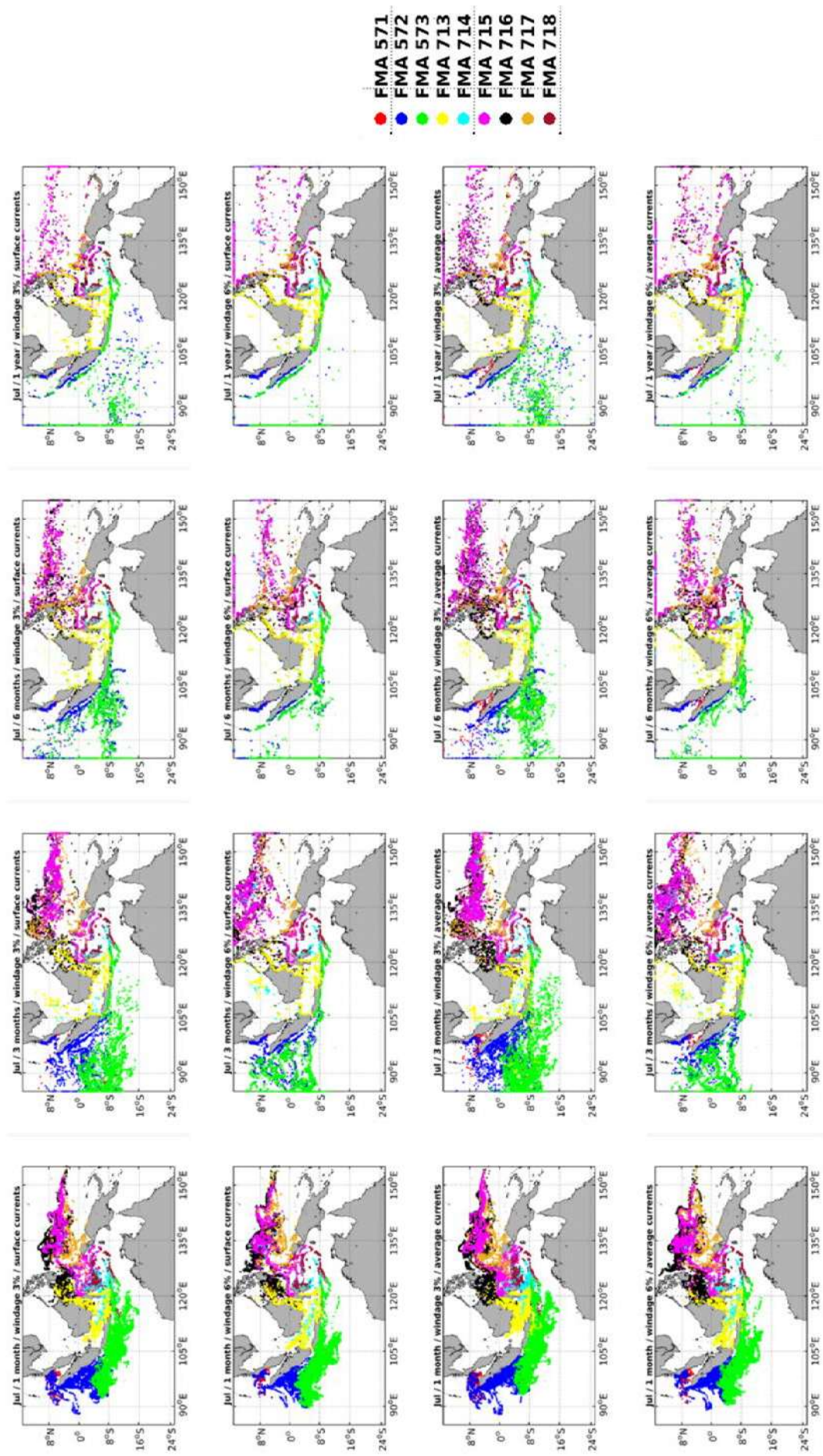


Figure 10. AFAD dispersion maps for October releases for different periods, windage values and forcing currents



Stranding tendencies

Figure 13 presents the percentage of stranded “simulated” AFADs at each vulnerable area, categorised by release month and FMA. Overall, minor differences are observed between surface and averaged currents. In contrast, more substantial differences are observed when comparing windage values of 3% and 6%, with the higher windage generally resulting in slightly increased stranding percentages. In some cases, the main stranding period changes for different windage values, particularly in the MPAs and mangroves (Figure 15 and Figure 16).

The overall percentage of simulated AFAD strandings is high, exceeding 50% in most scenarios and surpassing 75% in several cases, indicating that the majority of released AFADs eventually would reach the coast. Due to the varying spatial extent of different vulnerable areas, their likelihood of receiving drifting AFADs differs significantly (see Figure 13). This is reflected in the results: the highest stranding percentages were observed in the general stranding case, followed by areas with broad spatial coverage such as MPAs and corals (Figure 15 and Figure 14, respectively). In contrast, mangroves, despite their wide distribution in the study region, exhibited proportionally lower stranding percentages, suggesting they may be less impacted by drifting AFADs compared to MPAs or corals. Seagrasses and saltmarshes, which occupy much smaller areas, showed very low stranding rates, with no strandings detected in saltmarshes.

Despite some exceptions, we estimate that the majority of released AFAD strandings would occur within the first month following release, with a substantial portion during the subsequent two months. This trend is also evident in the distribution maps (Figure 9 to Figure 12). Beyond the third month, the estimated increase in stranding percentages over the remaining nine months is relatively low.

Regarding the origin of stranded AFADs, simulations suggest that those released from FMAs 571, 572, and 573, located in the western and southwestern regions south of Sumatra and Java, would be the most impactful, showing the highest estimated stranding percentages and affecting the widest range of vulnerable areas. AFADs from FMAs 717 and 718, located to the north and south of Papua, also contributed to strandings in coral areas (Figure 14). Additionally, AFADs from FMA 713, located in the Makassar Strait and Flores Sea, showed a modest impact on corals, mangroves, and seagrasses (Figure 14, Figure 15 and Figure 17).

Figure 11. General stranding percentage of AFADs released at different FMAs and months for different periods, windage values and forcing currents

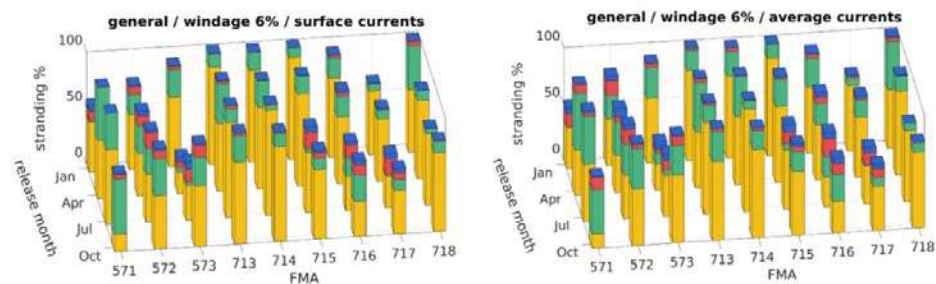
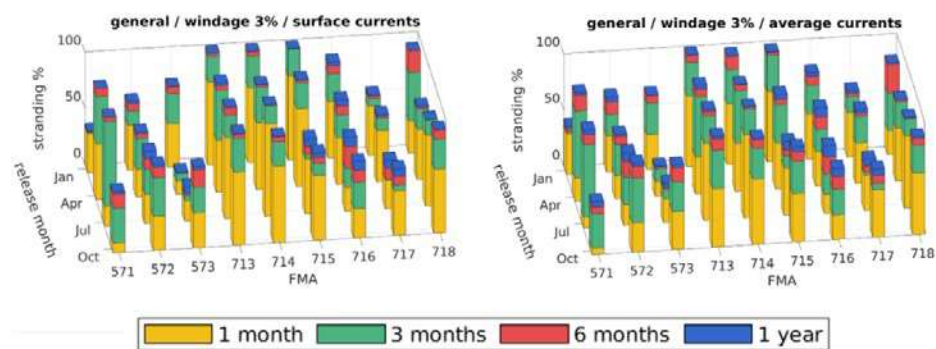


Figure 12. Stranding percentage at corals of AFADs released at different FMAs and months for different periods, windage values and forcing currents

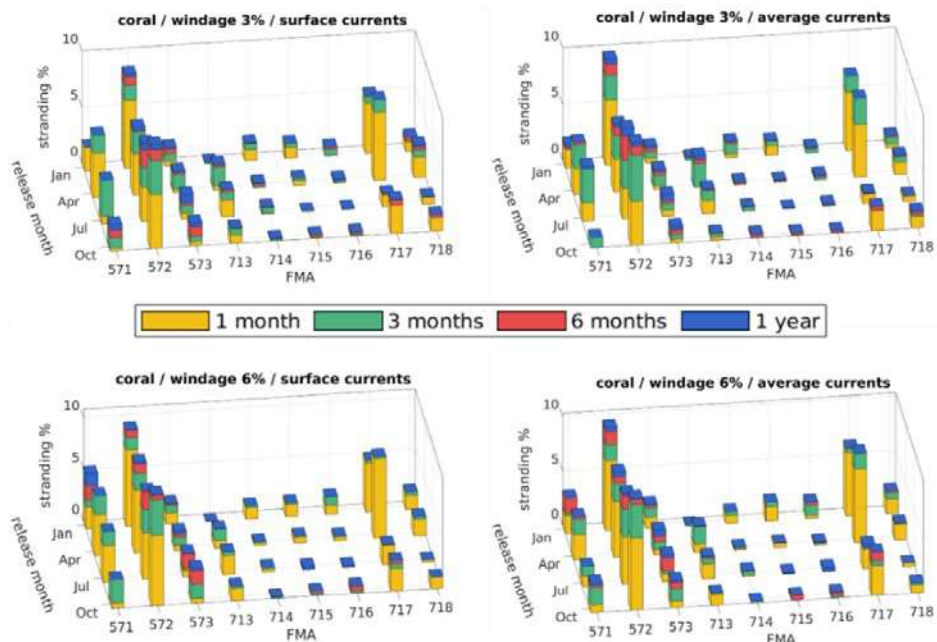


Figure 13. Stranding percentage at MPAs of AFADs released at different FMAs and months for different periods, windage values and forcing currents

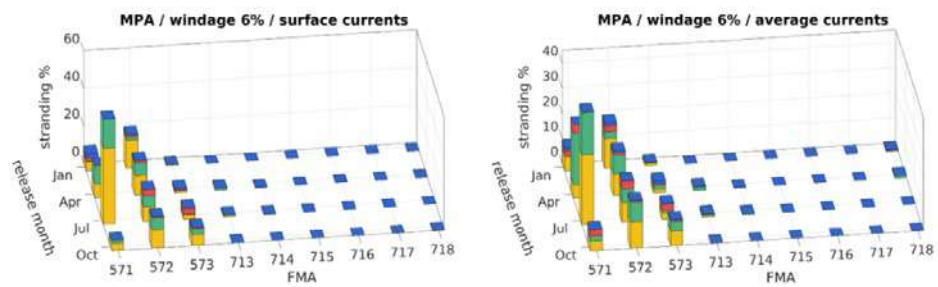
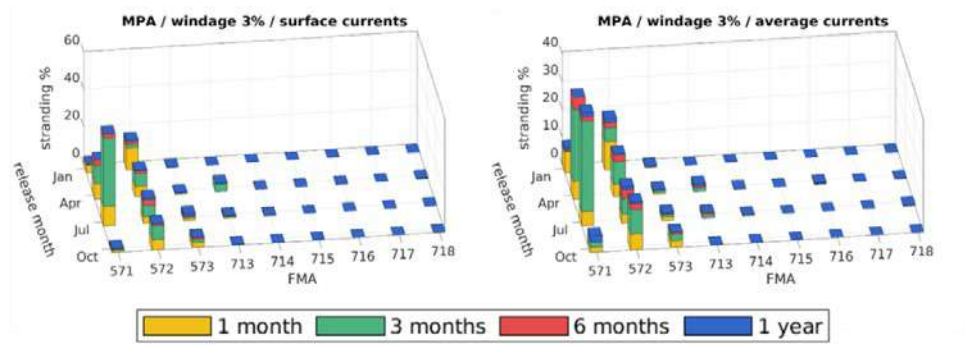


Figure 14. Stranding percentage at mangroves of AFADs released at different FMAs and months for different periods, windage values and forcing currents

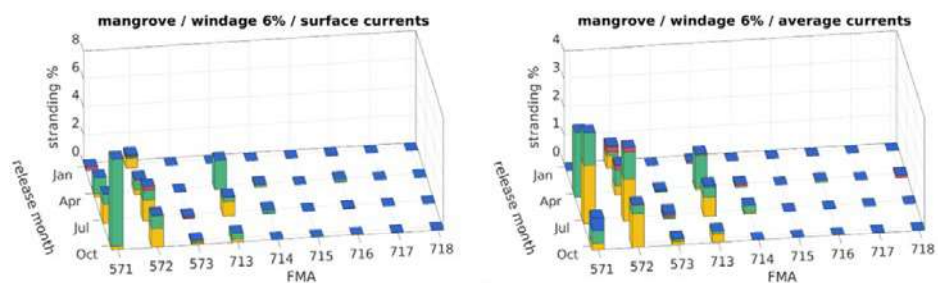
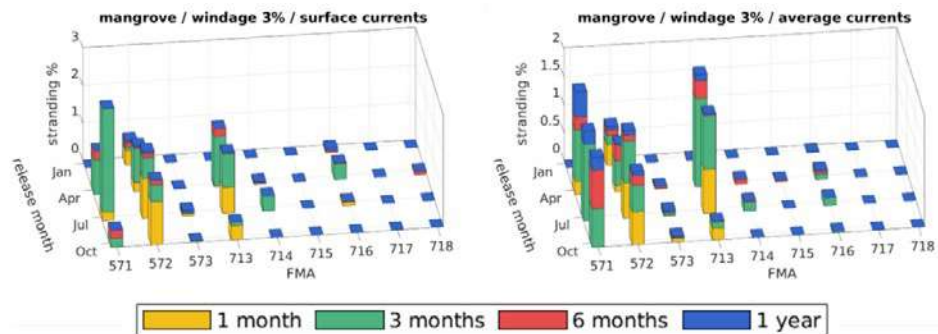


Figure 15. Stranding percentage at saltmarshes of AFADs released at different FMAs and months for different periods, windage values and forcing currents

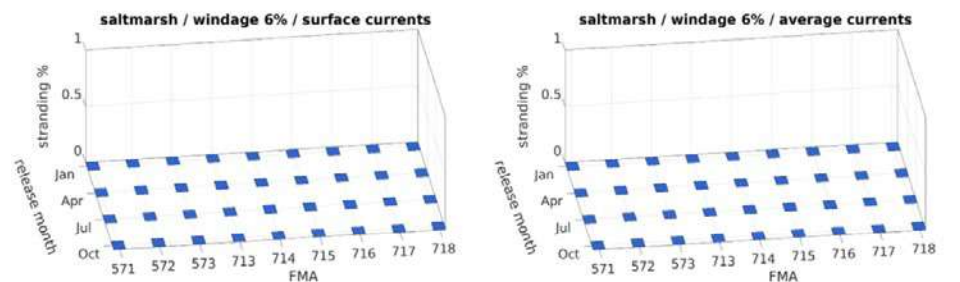
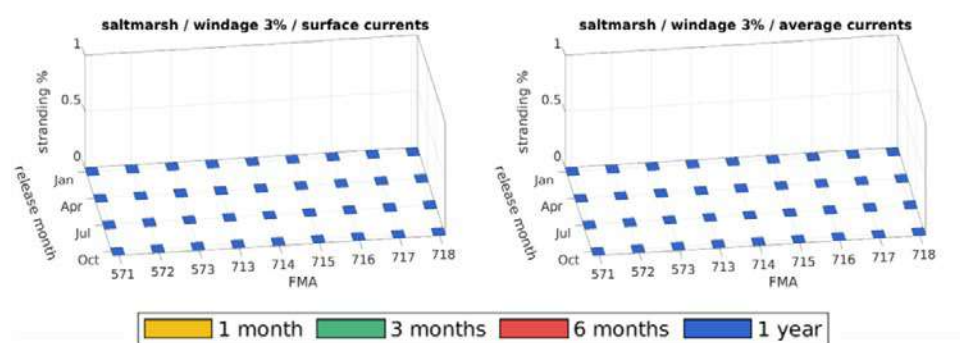
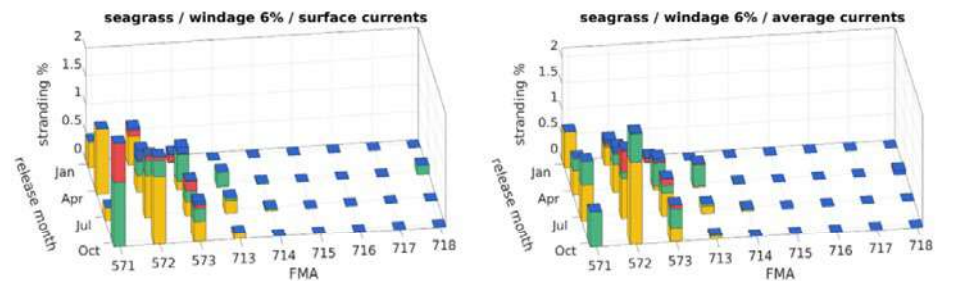
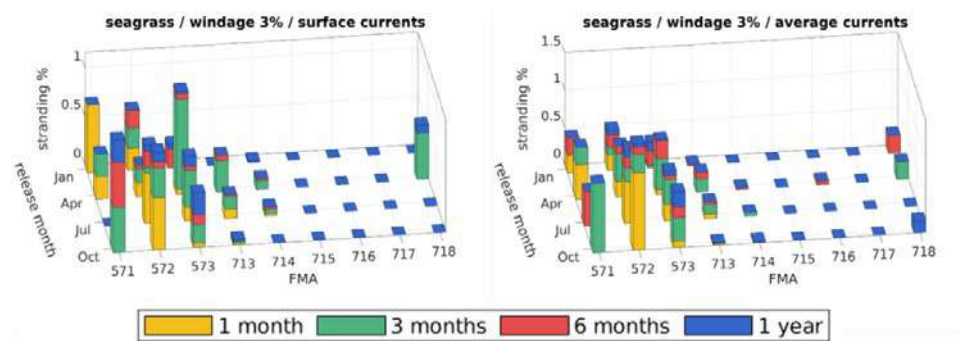


Figure 16. Stranding percentage at seagrasses of AFADs released at different FMAs and months for different periods, windage values and forcing currents



Conclusions

This section assesses the potential environmental impact of drifting AFADs in Indonesian waters by simulating their trajectories using a Lagrangian model. Overall, these results suggest that up to 75% of released AFADs in Indonesia may drift to coastal zones, with those released south of Sumatra and Java most affecting vulnerable Indonesian coasts. However, we note that these results are subject to uncertainty and are based on a theoretical particles drift model based on oceanographic forcing.

The greatest value of this section is to demonstrate that there is a methodological framework capable of evaluating the location and probability of stranding of AFADs considering oceanographic conditions and the location of AFAD release. We also highlight the need to monitor the release of AFADs in terms of quantity, location and materials, which would increase the reliability of the analysis.

The simulations incorporated ocean current and wind data and considered multiple scenarios based on seasonal variability, current regimes and windage levels. AFADs were simulated with releases in every potential deployment location; however, this approach could be refined if the positions of the AFADs were known. Nevertheless, the analyses provide a general overview of the potential impact of AFADs deployed in different areas of Indonesia.

Although, to the best of our knowledge, there are currently no AFAD stranding studies or observational data available to validate the simulation results, the current and wind data used are well-established and widely validated reanalysis products (see <https://doi.org/10.48670/moi-00021> and <https://doi.org/10.24381/cds.4991cf48>).

Moreover, the simulated drift patterns agree with the main circulation patterns in the area, particularly the ITF (Sprintall et al., 2009; Gordon et al., 1999, 2008, 2010, 2012). While the approach is generic and preliminary, the simulations offer a valuable framework for assessing/predicting the potential impact of AFADs. Comparable modelling approaches have been applied to evaluate the influence of drifting FADs on critical turtle habitats (Escalle et al., 2022) and beaching zones in the Pacific Ocean (Escalle et al., 2019). In the future, validation using observed strandings or AFADs equipped with GPS would be highly beneficial to better assess the reliability of the simulations and the overall methodology.

This approach could be used to analyse AFAD impacts in other geographical areas and arises as a promising assessment tool to predict potential impacts. Given the high number of AFADs deployed in Indonesia, the results underscore the need for improved management strategies to mitigate their environmental effects, particularly in vulnerable areas.

3.2.4.5. Summary of Task 4

Under this task we have developed methodologies to evaluate the environmental impacts of AFADs looking at their potential contribution to marine litter and pollution and their potential drift to sensitive habitats.

Although the analyses have been developed using different sources of data often including incomplete information, we underscore that 92-99% in weight of AFADs are constructed from synthetic materials, including anchoring cement blocks, plastics, and metals. These components have the potential to contribute substantially to marine litter and pollution if abandoned, lost, or discarded. Preliminary estimates indicate that the loss of AFADs could result in between 14 000 and 71 000 tonnes of marine litter every year.

With regards to the potential drift of AFADs towards sensitive habitats, we estimate that up to 75% of released AFADs in Indonesia may drift to coastal areas, with those released south of Sumatra and Java most affecting vulnerable habitats.

4. Review of Existing AFAD Measures and Recommendations

This section describes the analysis of AFAD data across two tasks, Task 5 “Review of existing AFADs measures” and Task 6 “Recommendations”.

4.1. Task 5 - Review of existing AFADs measures.

The objective of this task is to review the existing regulatory measures covering AFADs at IOTC level and comparison with potentially other existing measures around the world. Task 5 was divided up into two subtasks:

- Sub-task 5.1: Review and compile existing data sources and information available to describe the existing regulatory measures covering AFADs at IOTC level and in other RFMOs/areas.
- Sub-task 5.2: Compare the existing regulatory measures covering AFADs at IOTC level and in other RFMOs/areas.

4.1.1. Task 5 - Methodology

The main aspects of IOTC Resolution 23/01 on AFADs adopted in 2023, were reviewed. We also evaluated how the CPCs using AFADs are submitting the required AFAD management plans and specific information. Furthermore, we discuss the specific regulations for AFADs across tuna and non-tuna RFMOs.

4.1.2. Task 5 - Expected Outcomes

The expected outcome from subtask 5.1 was an overview table of existing data sources and information available concerning the existing regulatory measures covering AFADs in the Indian Ocean and in other RFMOs/areas. We also summarise the information on AFAD management plans and fishery data being submitted to the IOTC Secretariat.

Similarly, subtask 5.2 provides an overview table of existing regulatory measures covering AFADs in the Indian Ocean and in other RFMOs/areas and critical evaluation of their efficacy.

4.1.3. Review and compile existing data sources and information available to describe the existing regulatory measures covering AFADs at IOTC level and in other RFMOs/areas.

Of the five tuna RFMOs four, the Inter-American Tropical Tuna Commission (IATTC), the International Commission for the Conservation of Atlantic Tunas (ICCAT), the IOTC and Western and Central Pacific Fisheries Commission

(WCPFC), only IOTC has specific rules relating to AFADs. ICCAT and WCPFC mention AFADs in wider FAD related measures, IATTC only notes DFADs. The Commission for the Conservation of Southern Bluefin Tuna (CCSBT), has, a single species focus, and no fisheries that interact with AFADs. We also discuss the regulatory measures for AFADs of a non-tuna RFMO, the General Fisheries Commission for the Mediterranean (GFCM).

Anchored FADs are regulated in the IOTC under Resolution 23/01 on the Management of Anchored Fish Aggregating Devices (AFADs). This Conservation and Management Measure (CMM) recognises the need for coastal states to collect and share data concerning all fishing activities for a better understanding of the state of exploitation of fish stocks. This resolution provides general definitions of FADs and AFADs and sets a scope and timeline for the development of AFADs management plans, including specifications for data collection.

The definition of FADs and AFADs are the following:

- **Fish Aggregating Device (FAD)** means a permanent, semi-permanent or temporary object, structure or device of any material, man-made or natural, which is deployed and/or tracked, for the purpose of aggregating target tuna and tuna like species for consequent capture.
- **Anchored Fish Aggregating Devices (AFADs)** means a FAD tethered to the bottom of the ocean, usually consisting of a buoy, and is anchored to the bottom of the ocean.

Regarding to the application, this Resolution applies to all CPCs that deploy AFADs for the purpose of fishing for tuna and tuna-like species in the IOTC area of competence and entered into force on 1 January 2024.

Regarding AFAD management plans, the Resolution calls for CPCs to develop AFAD management plans and submit them to the IOTC Secretariat. The plans will be developed in accordance with a set of guidelines that include (i) an objective, (ii) its application with respect to vessel types, number of AFADs, reporting and recording of deployments, plans for monitoring and retrieval of lost AFADs and statement of ownership, (iii) institutional arrangements for the management of AFAD plans including responsibilities, regulations to the setting and use of AFADs, repair and replacement policy, data collection system and reporting obligations, (iv) construction specifications including design characteristics, marking and identifiers, specific equipment (lighting, radar, buoys, satellite transceivers and echosounders) if any, (v) applicable areas, (vi) means for monitoring and reviewing AFAD management plans and (vii) methodologies for recording and reporting data on any activity around AFADs including catch, bycatch (retained, discarded dead or alive) and, for each activity on AFADs, position, data and AFAD identifier allowing to identify the owner.

The AFAD management plan shall include a marking scheme and a plan for inspections to ensure AFADs are built and used in accordance with Resolution 23/01.

All the data on AFAD activities will be submitted to the IOTC Secretariat consistent with standards of data collection and confidentiality policies adopted by the IOTC (Resolution 15/01 and Resolution 12/02).

With regards to the construction of AFADs, these will be using non-entangling and non-mesh materials in the sub-surface aggregates of the AFADs to avoid unintended catch of vulnerable species and CPCs will aim at choosing sites and designs streamlined to reduce AFAD loss and environmental impacts such as dragging the seafloor.

4.1.4. Other regulatory measures for AFADs in other RFMOs and comparison with IOTC.

The International Commission for the Conservation of Atlantic Tunas (ICCAT) and the Western Central Pacific Fishery Commission (WCPFC) include AFAD regulations together with DFAD measures as part of their measures to maintain the sustainability of tropical tuna stocks:

ICCAT's Recommendation 24/01 On a multi-annual conservation and management programme for tropical tunas, splits FADs into anchored and drifting and contains specific requirements for each. In the preparation of FAD management plans for CPCs the FAD type needs to be described (AFAD or DFAD), and the following information is required:

- The minimum distance between AFADs,
- A code (AFAD), name (Anchored FAD) and an example such as "Very large buoy".
- Information from observers onboard fishing boats includes:
 - For FADs in general (both AFADs and DFADs): Whether the FAD is built with biodegradable materials, it is non-entangling, contains mesh materials, the size of the largest mesh, distance between the surface and the deepest part of the FAD, surface area of the FAD, identification of the FAD, whether it is tracked with a device or echosounder, the materials used for the floating part of the FAD, of the underwater structure or the tracking device ID.
 - Specific requirements as for AFADs (AFAD registry): Anchorage type, presence of radar detectors, presence of lighting and visual range (in nautical miles).

- A FAD closure of 45 days (17th March – 30th April) without specifying if that applies to both DFADs and AFADs.
- A FAD logbook that reports the activities or interactions with AFADs or DFADs (or other floating objects): Encounter, visit, deployment, strengthening, removing, fishing, tagging, removing the FOB or loss.

Likewise, the WCPFC has regulations in place for FADs including AFADs such as limits on the number of FADs that can be deployed and restrictions on fishing activity around them. CMM 2023-01 The Conservation and Management Measure for Bigeye, Yellowfin and Skipjack Tuna in the Western and Central Pacific Ocean, includes several restrictions for AFAD and DFADs such as:

- A one and a half months (July to mid-August) prohibition of deploying, servicing or setting on FADs.
- The use of mesh net is prohibited,
- The subsurface structure shall only be made with non-entangling materials and a transition to biodegradable materials is encouraged.
- No specific limitations on the number of AFADs are in place as there are for DFADs, but CPCs develop restrictions on their own FAD management plans. For example, the Federated States of Micronesia (FSM) specifies marking, design, construction standards for AFADs. Also, the FSM vessels will not deploy AFADs on the high seas and the limit to the number of FADs per vessel at any one time (100) includes AFADs as well.

For IATTC, Resolution C-24-06 FADs - Amends C-23-03 (amended C-99-07) and Resolution C-23-05 Amendment to Resolution C-19-01 on the collection and analyses of data on fish aggregating devices, only refers to DFADs. IATTC “Resolution C-23-04 on the design and biodegradability of drifting fish aggregating devices”, would also not apply to any AFADs in the IATTC Convention Area.

AFADs are widely used in the Mediterranean in common dolphinfish fisheries. Due to the overlap in fisheries for tuna and tuna-like species in the Mediterranean Sea between the General Fisheries Commission for the Mediterranean (GFCM) and ICCAT management where many fisheries managed by GFCM use AFADs and are also known to catch tuna and tuna-like species this is reported here. GFCM adopted specific regulations for the management of AFADs (Recommendation GFCM/43/2019/1) on a set of management measures for the use of anchored fish aggregating devices in common dolphinfish fisheries in the Mediterranean Sea. This recommendation defines AFAD as “any anchored equipment floating on the sea surface with the objective of attracting fish. This recommendation aims at (i) improving

knowledge on the characteristics of FADs, buoys, AFAD fishing and its related impacts on common dolphinfish and non-targeted species, (ii) managing the deployment and recovery of AFADs and their potential loss and, (iii) reduce the impacts of AFADs in the ecosystem.

The Recommendation of the GFCM contains a series of transitional management measures that have been slightly modified in 2021, but in summary aim at:

- Reducing the risk of the biomass of dolphinfish falling below biological limits; and
- Maintaining the current number of fishing vessels targeting dolphinfish.

The Science Advisory Committee of the GFCM (SAC) will monitor the state of the population of dolphinfish and recommend specific measures for AFADs.

The specific measures can be summarized as follows:

- Ensure that non-entangling materials are used in the surface structure to avoid risk for non-target species.
- Prioritize the use of biodegradable materials.
- Ensure that the rope sinks to the bottom if the raft section is detached and drifts away.
- In the event of loss, CPCs shall ensure the recording of the last position and its date.
- Prohibition for a CPC vessel to catch fish attracted by any AFAD not set by the same vessel.
- Any AFAD should be marked in a way that it can be readily identified using a registration number.

In general, all the current regulatory measures on AFADs aim to contribute to maintain fish stocks (bigeye, yellowfin, skipjack and dolphinfish) at sustainable levels. IOTC's Resolution 23/01 and GFCM's 2019/01 are both specifically adopted for the management of AFADs and ICCAT and WCPFC include specific requirements for AFADs in their conservation measures for tropical tunas.

4.2. Summary of existing AFAD measures and recommendations

Due to only IOTC providing dedicated AFAD measures in tuna fisheries, the need to create overview tables for a comparison of tuna RFMOs was redundant, but all available RFMO information was provided in Task 5. ICCAT rules on AFADs are limited. Recommendation 23/01, the current multi-annual Recommendation for the Conservation and Management Programme for tropical tunas, recommends that “effective measures be found to reduce FAD-related and other fishing mortality of small yellowfin and bigeye tuna”, which would include all drifting and anchored FADs. The majority of FAD related measures apply to drifting FADS, although AFADs would be considered under FAD Management Plans (paras 34-36) in a format provided and reporting for FAD interactions and catches do not specify anchored or drifting so it would be assumed they apply equally. Observer data collection requirements also have specific rules for AFADs and the appropriate data that should be collected when operating on an AFAD (Table 1 of Annex 7 of 22/01). In summary the rules for ICCAT and IOTC are quite similar in scope and requirements, only IOTC separates them into different Resolutions.

GFCM do not provide AFAD recommendations for tuna fisheries as these would be covered under ICCAT which also has responsibility for the Mediterranean. AFAD regulations do exist for the management of dolphinfish through Recommendation GFCM/43/2019/1. This recommendation was introduced to enable the identification of fishing gear, fishing authorisations and improve catch and effort information for the assessment of dolphinfish in the Mediterranean. It also allows for the management of information related to the deployment and recovery of AFADs and their potential loss, reduction and limiting the impacts of AFADs on the ecosystem. These are quite similar to the aims and objectives of the current IOTC measure in place.

WCPFC sets rules for FAD management under Conservation and Management Measure 2023-01. Similar to ICCAT, the rules appear to focus on drifting FADs, but rules on materials such as non-entangling and an increase in biodegradable materials would apply to all FADs (paras 16-20).

WCPFC FAD management plans have previously been published e.g. the latest is for Indonesia for the period 2015-2017 (see <https://www.wcpfc.int/doc/id/indonesia-fad-management-plan> for details. Last accessed: 04/11/2025).

These published plans although technically holding information on AFADs are clearly out of date as only the initial plans are shown. WCPFC has a dedicated FAD group the WCPFC FAD Management Options Intersessional Working Group (FADMO-IWG), though this has not met since 2021 and has been

primarily focussed on drifting FADs and the latest discussion on FAD logbook development only refer to drifting FADs and ignore AFAD data-collection.

In summary, from an RFMO perspective it appears IOTC is currently one of the leaders in AFAD management. Individual States within the Indian Ocean may have better defined rules, but these are often national systems and not widely described. They may be in the national AFAD management plans but as these are not publicly accessible it is not possible to determine good policy options from these.

4.3. Task 6 - Recommendations

4.3.1. Task 6 – Organisation

Task 6 was implemented through two subtasks:

- Sub-task 6.1: Define a set of recommendations covering possible additional data needs and requirements for monitoring and reporting.

4.3.2. Task 6 – Methodology

Recommendations will be critically analysed, examining the positives and negatives for each recommendation along with an expert evaluation within the project team of the potential for such recommendations to be taken up and implemented successfully by Members of the relevant RFMOs as part of subtask 6.1. We provided both general good practice recommendations for AFAD management but also where required specific examples of recommended text e.g. for suggested improvements to IOTC Resolution 23/01 on the Management of Anchored Fish Aggregating Devices (AFADs).

Subtask 6.2 described and analysed any additional data needs and requirements for monitoring and reporting to ensure a recommendation put forward under subtask 6.1 was sustainable and achievable.

4.3.3. Task 6 – Expected Outcomes

Subtask 6.1 was expected to provide a description and critical analysis of a set of recommendations to address and mitigate the impact of AFADs on target and non-target species with a specific focus on tuna juveniles, with support from subtask 6.2 with a set of related recommendations to address possible additional data needs and requirements for monitoring and reporting.

The following recommendations have been developed along best practice guidelines. This covers IOTC only at this stage, but due to the prevalence of

AFADs in fisheries worldwide (excluding the Eastern Pacific Ocean) it would provide the basis for specific AFAD management measures in the Atlantic and Western Pacific Oceans for ICCAT and WCPFC respectively.

4.3.4. Recommendations

4.3.4.1. Recommendation 1 - All countries with AFADs to complete AFAD Management Plan

A list of countries without AFAD management plan but with AFADs should be developed globally. This list should be developed acknowledging exemptions solely for recreational fisheries or fisheries that do not catch tuna or tuna-like species (e.g. Australia).

The management plans would help quantifying and monitoring the use of AFADs as well as their impact on target stocks and the entire ecosystem.

4.3.4.2. Recommendation 2 – AFAD Management Plans to be Transparent and Public

AFAD management plans as submitted to IOTC under Resolution 23/01 should be available to IOTC CPCs.

It is recommended further that commercially important data such as personal data and AFAD location data are not published and should be supplied to IOTC as an Annex to the Management Plan that can be removed for wider distribution whilst maintaining confidentiality.

4.3.4.3. Recommendation 3 – Content of AFAD Management Plans

Currently the content of the IOTC AFAD Management Plans is supposed to be developed in accordance with a set of guidelines that include (Resolution 23/01):

- (i) an objective;
- (ii) its application with respect to vessel types, number of AFADs, reporting and recording of deployments, plans for monitoring and retrieval of lost AFADs and statement of ownership;
- (iii) institutional arrangements for the management of AFAD plans including responsibilities, regulations to the setting and use of AFADs,

repair and replacement policy, data collection system and reporting obligations;

- (iv) construction specifications including design characteristics, marking and identifiers, specific equipment (lighting, radar, buoys, satellite transceivers and echosounders) if any; noting that AFADS should use non-entangling and non-mesh materials in the sub-surface aggregates of the AFADs to avoid unintended catch of vulnerable species; This would help scientific assessments on the environmental impacts of the use of AFADS.
- (v) applicable areas; noting that CPCs will aim at choosing sites and designs streamlined to reduce AFAD loss and environmental impacts such as dragging the seafloor;
- (vi) means for monitoring and reviewing AFAD management plans and
- (vii) methodologies for recording and reporting data on any activity around AFADs including catch, bycatch (retained, discarded dead or alive) and, for each activity on AFADs, position, data and AFAD identifier allowing to identify the owner; This would help quantifying how much of the total catch of commercial stocks has been captured under AFADs and therefore, increasing the confidence on the estimates of AFADs impact on the sustainability of fisheries.
- (viii) a marking scheme and
- (ix) a plan for inspections to ensure AFADs are built and used in accordance with Resolution 23/01.

Management plans are to be submitted to the IOTC Secretariat consistent with standards of data collection and confidentiality policies adopted by the IOTC (Resolution 15/01 and Resolution 12/02).

It is recommended that these are expanded to cover the results of sampling methodologies in (vii) above and logbook data collection. This should include a summary annually if not at higher resolution to also include data from observer programme as per recommendation 5:

- Estimation of effort by fleet métier on AFADs (by region if applicable);
- Catch of target species;
- Bycatch catch (retained and discarded);
- Summary of size frequency data collected from AFAD fisheries; and
- Summary of biological data collected from AFAD fisheries.

4.3.4.4. Recommendation 4 – AFAD data to be collected and submitted

Catch reporting from AFAD sets (consistent with the Standards for the provision of Catch-and-effort Data) set out in Resolution 13/03), including:

- a) Any visit in an AFAD.
- b) For each visit on an AFAD, whether followed or not by a set or other fishing activities, the, i. position; ii. date; iii. AFAD identifier (i.e. FAD Marking or beacon ID or any information allowing to identify the owner).
- c) If the visit is followed by a set or other fishing activities, the results of the set in terms of catch and bycatch.

Resolution 13/03 requires that the catch and effort reporting should apply to all purse seine, longline, gillnet, pole and line, handline and trolling fishing vessels over 24 metres length overall and those under 24 metres if they fish outside the EEZs of their flag States within the IOTC area of competence.

It is recommended that the following amendments are made:

- Catch and effort reporting on AFADs is made for all vessels not just those over 24m LOA.
- Catch estimates shall be made for all species retained and discarded by weight and by number where possible.
- Incidental mortality data of all seabirds, turtles or cetaceans recorded with AFADs shall be reported. Nil reports should be made where no incidental mortality is found.

Data submission requirements for catch and effort data will remain the same in that the flag State and the States which receive this information shall provide all the data for any given year to the IOTC Secretariat by June 30th of the following year on an aggregated basis. The confidentiality rules set out in Resolution 12/02 Data Confidentiality Policy and Procedures for fine-scale data shall apply.

4.3.4.5. Recommendation 5 – Specific observer programme data to be collected

Any AFAD related fishery should be represented pro rata within national observer programmes i.e. at a minimum of 5% and preferably 20% level of observer coverage.

The following data are recommended to be collected by observers operating in these fisheries:

- CPCs shall collect observer data, i.e. catch, effort and size frequency data *pro rata* for AFAD fisheries as per the Regional Observer Scheme (Res 24/02) and reported as coming from AFAD related fisheries at 5% for vessels over 24 metres LOA (para 3) and at 5% from landings sampling for those fleets of vessels under 24m LOA (para 8).
- CPCs shall collect detailed size frequency data and biological data where possible for AFAD fisheries to determine the potential impact of these fisheries on juvenile yellowfin and bigeye tuna as a priority. Identification of the proportion of juvenile yellowfin and bigeye in the catch is a priority to determine an accurate estimation of any misreporting of skipjack tuna.

4.3.4.6. Recommendation 6 – Consider development and implementation of an AFAD register

The IOTC has recently adopted Resolution 24/02 with specific requirements for the use of drifting FADs. One of these measures is the development and implementation of a DFAD register for all instrumented buoys to collect information on the buoy attached to the DFAD, the name of the owner, information on the vessel, flag state, specifications of the echosounder buoy, DFAD identifier, category of biodegradability, date, time and location of the deployment.

A similar register should be developed for AFADs. AFADs are normally not equipped with echosounder buoys but the register could be used to quantify the total number of AFADs, to inform on the biodegradability of its components and lifespan of the AFADs.

4.3.4.7. Recommendation 7 – Development of AFADs with increased proportion of biodegradable materials.

Like the stepwise process followed in tuna RFMOs for drifting FADs, a feasible calendar should be developed for replacing synthetic materials in the construction of AFADs by biodegradable materials. In this regard, the work already advanced for drifting FADs in terms of definitions and search for materials could help accelerate this replacement.

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Annexes

Annex 1: Output for Sub-Task 1.1 - Existing Data and Information Sources Across a Global Scale

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
FAO AREA 21 – Northwest Atlantic													
NEAFC	Stakeholder	Stakeholder	O										2024
Canada	N/a		O										
United States of America	N/a		O										
FAO AREA 27 – Northeast Atlantic													
NEAFC	Stakeholder	Stakeholder	O										2024
Belgium	N/a												
Denmark	N/a												
Estonia	N/a												
Faroe Islands	N/a												
France (Atlantic Coast)	N/a												
Germany	N/a												
Greenland	N/a												
Iceland	N/a												

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Ireland	N/a												
Lithuania	N/a												
Latvia	N/a												
Poland	N/a												
Portugal	N/a												
Netherlands	N/a												
Norway	N/a												
Spain (Atlantic Coast)	N/a												
Russia	N/a												
Sweden	N/a												
United Kingdom	N/a												
FAO AREA 31 – Western Central Atlantic													
Anguilla (British OT)	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
Antigua and Barbuda	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	Wilson et al., 2020	Peer-review	O										Pre-2020
Aruba	CRFM, 2015		O										2015
Bahamas	Wilson et al., 2020	Peer-review	O										Pre-2020
	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
Barbados	Vallès & Taconet, 2023	Peer-review					✓						2022
	Stakeholder		✓	✓									2024
Belize	CRFM, 2015		O										2015
Bermuda (British OT)	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Bonaire (Dutch Caribbean)	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
British Virgin Islands (British OT)	CRFM, 2015		O										2015
Brazil	FAO, 2023	FAO Report	O										2022
	CRFM, 2015		O										2015
	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
Cayman Islands (British OT)	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
Colombia	CRFM, 2015		O										2015
Costa Rica	CRFM, 2015		O										2015

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Cuba	Sportfishing, 2024		✓ ²						✓			✓	2024
	CRFM, 2015		O										2015
Curacao (Dutch Caribbean)	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
Dominica	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022

² Evidence of deployment of AFADs for recreational fisheries.

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Dominican Republic	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
French Guiana	n/a												
Grenada	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
Guadeloupe (French OT)	Said et al., 2021	Peer-review	✓	✓			✓	✓	✓	✓	✓		2015-2019
	Stakeholder		✓					✓	✓				2024
	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre 2014
	Vallès & Taconet, 2023	Peer-review					✓						2022

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
	Guyader et al., 2013	Peer-review	✓	✓	✓			✓	✓				2012
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
Guatemala (Atlantic Coast)	CRFM, 2015		O										2015
Guyana	CRFM, 2015		O										2015
Haiti	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre 2014
	Vallès, 2015	Peer-review	✓	✓	✓	✓		✓	✓	✓	✓	✓	
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
	Marcias, 2014	Peer-review	✓					✓					2013
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Honduras	CRFM, 2015		O										2015
Jamaica	CRFM, 2015		O										2015
Martinique (French OT)	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Stakeholder		✓					✓	✓				2024
	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre 2014
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
Monserrat (British OT)	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	CRFM, 2015		O										2015

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Mexico (Gulf Coast)	Stakeholder	Stakeholder	✓ ³										2024
Nicaragua (Gulf Coast)	CRFM, 2015		O										2015
Panama (Gulf Coast)	CRFM, 2015		O										2015
Puerto Rico (USA OT)	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	Hutt et al., 2023	Peer-review	✓	✓		✓	✓						2022
Saba (Dutch Caribbean)	FAO, 2023	FAO Report	✓	✓	✓		✓	✓	✓	✓	✓	✓	2022
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015

³ Evidence of deployment of AFADs for recreational fisheries.

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Saint Kitts and Nevis	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
Saint Lucia	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
Saint Vincent/Grenadines	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	Stakeholder		✓										
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
Sint Eustatius (Dutch Caribbean)	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
Sint Maarten (Dutch Caribbean)	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	Vallès & Taconet, 2023	Peer-review					✓						2022
St Barthelemy (French OT)	Vallès & Taconet, 2023	Peer-review					✓						2022
Suriname	CRFM, 2015		O										2015
Trinidad and Tobago	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
	Vallès & Taconet, 2023	Peer-review					✓						2022
	CRFM, 2015		✓	✓	✓			✓	✓	✓	✓	✓	2015

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	Vallès, 2023	Peer-review	✓	✓				✓	✓	✓	✓	✓	2021
United States of America	Vallès & Taconet, 2023	Peer-review					✓						2022
	Hutt et al., 2023	Peer-review	✓	✓		✓	✓						2022
US Virgin Islands (USA OT)	Wilson et al., 2020	Peer-review	✓	✓			✓	✓					Pre-2020
	Hutt et al., 2023	Peer-review	O										2022
Venezuela	CRFM, 2015		O										2015
FAO AREA 34 – Eastern Central Atlantic													
Morocco	N/a												
Spain (Canary Islands)	Castro et al., 1999	Peer-review	✓	✓	✓	✓							1999
Western Sahara	N/a												
Mauritania	N/a												
Senegal	N/a												
The Gambia	N/a												
Guinea-Bissau	N/a												
Guinea	N/a												

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Sierra Leone	N/a												
Liberia	N/a												
Côte d'Ivoire	N/a												
Ghana	N/a												
Togo	N/a												
Benin	N/a												
Nigeria	N/a												
Cameroon	N/a												
Equatorial Guinea	N/a												
Cabo Verde	N/a												
Gabon	N/a												
Republic of the Congo	N/a												
Democratic Republic of the Congo	N/a												
Angola	N/a												
FAO AREA 37 – Mediterranean and Black Sea													
France	Stakeholder	Stakeholder	✓										2024

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Italy	Morales-Nin et al., 2000	Peer-review	✓	✓	✓	✓	✓	✓		✓	✓	✓	2000
	Sinopoli et al., 2019	Peer-review	✓	✓	✓	✓		✓				✓	1990-2019
	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre 2014
	Said et al., 2021	Peer-review	✓	✓			✓	✓		✓	✓		2015-2019
	Addis et al., 2006	Peer-review	✓									✓	2001-2002
Slovenia	N/a												
Bosnia & Herzegovina	N/a												
Montenegro	N/a												
Albania	N/a												
Greece	Morales-Nin et al., 2000	Peer-review	✓										2000
	Stakeholder	Stakeholder	✓										2024
Turkey	Stakeholder	Stakeholder	O										2024
Cyprus	Stakeholder	Stakeholder	O										2024
Syria	N/a												
Lebanon	N/a												

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Israel	N/a												
Egypt	N/a												
Libya	N/a												
Tunisia	Morales-Nin et al., 2000	Peer-review	✓	✓	✓	✓		✓		✓	✓		2000
	Sinopoli et al., 2019	Peer-review	✓	✓	✓	✓		✓				✓	1990-2019
	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre 2014
Algeria	N/a												
Morocco	N/a												
Spain	Morales-Nin et al., 2000	Peer-review	✓	✓	✓	✓		✓		✓	✓		2000
	Sinopoli et al., 2019	Peer-review	✓	✓	✓	✓		✓				✓	1990-2019
	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre 2014
	Addis et al., 2006	Peer-review	✓									✓	2001-2002
Malta	Morales-Nin et al., 2000	Peer-review	✓	✓	✓	✓		✓		✓	✓		2000

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
	Sinopoli et al., 2019	Peer-review	✓	✓	✓	✓		✓				✓	1990-2019
	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre 2014
FAO AREA 41													
Brazil	Véras, 2020	Peer-review	✓	✓	✓	✓							2020
	FAO, 2023	FAO Report	✓										1984-2000
	Martins et al., 2023	Peer-review	O ⁴										
Uruguay	N/a												
Argentina	N/a												
Falkland Islands	N/a												
FAO AREA 47													
Angola	N/a												
Namibia	N/a												
South Africa	N/a												
FAO AREA 71 – Western Central Pacific													

⁴ The use of AFADs in Brazil's waters has been prohibited since 2018

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
American Samoa (overlaps with IATTC Convention Area)	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
Australia	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre-2014
Brunei Darussalam	N/a												
Cambodia	N/a												
China	N/a												
Cook Islands	Scott & Lopez, 2014	Peer-review	✓	✓				✓				✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
Federated States of Micronesia	Scott & Lopez, 2014	Peer-review	✓	✓				✓				✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
French Polynesia	Stakeholder	Stakeholder	✓										2024
Fiji	Scott & Lopez, 2014	Peer-review	✓	✓									Pre-2014
Guam	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Hawaii	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
Indonesia	Scott & Lopez, 2014	Peer-review	✓	✓				✓				✓	Pre-2014
Japan	Scott & Lopez, 2014	Peer-review	✓	✓				✓				✓	Pre-2014
Kiribati (overlaps with IATTC Convention Area)	Scott & Lopez, 2014	Peer-review	✓	✓									Pre-2014
	Stakeholder	Stakeholder	✓										2024
Malaysia	N/a												
Marshall Islands	Scott & Lopez, 2014	Peer-review	✓	✓				✓				✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
Nauru	Scott & Lopez, 2014	Peer-review	✓	✓				✓				✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
New Caledonia (French Territory)	Scott & Lopez, 2014	Peer-review											
	Stakeholder	Stakeholder	✓										2024
New Zealand	Stakeholder	Stakeholder	O										

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Niue	N/a												
Northern Mariana Islands (U.S. territory)	Scott & Lopez, 2014	Peer-review	✓	✓				✓				✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
Palau	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
Papua New Guinea	Scott & Lopez, 2014	Peer-review	✓	✓				✓				✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
Philippines	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
Pitcairn Islands (UK territory)	N/a												
	N/a												
Samoa	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre-2014
	Scott & Lopez, 2014	Peer-review	✓	✓				✓				✓	Pre-2014
Solomon Islands	Stakeholder	Stakeholder	✓										2024

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Tokelau (New Zealand territory)	N/a												
Tonga	Scott & Lopez, 2014	Peer-review	✓	✓				✓				✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
Tuvalu (overlaps with IATTC Convention Area)	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
Vanuatu	Scott & Lopez, 2014	Peer-review	✓	✓								✓	Pre-2014
	Stakeholder	Stakeholder	✓										2024
Vietnam	N/a												
Wallis and Futuna (French territory)	Scott & Lopez, 2014	Peer-review	✓	✓				✓				✓	Pre-2014
FAO AREA 77 – Eastern Central Pacific													
United States of America (Pacific Coast)	N/a												

Country	Source	Type	Presence ✓ / Absence O	Number of AFADs	Type (Material)	Spatial	Management Plan	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Temporal coverage
Mexico (Pacific Coast)	N/a ⁵												
Guatemala (Pacific Coast)	N/a ²												
El Salvador (Pacific Coast)	N/a ²												
Nicaragua (Pacific Coast)	N/a ²												
Costa Rica (Pacific Coast)	N/a ²												
Panama (Pacific Coast)	N/a ²												
FAO AREA 87													
Colombia	N/a												
Ecuador	N/a												
Peru	N/a												
Chile	N/a												

Key : ✓ = Positive response to question i.e. AFADs present; x = negative response i.e. no AFADs; empty cell = NULL or no response.

⁵ Suspected AFAD deployment by recreational fisheries

² Suspected AFAD deployment by recreational fisheries

Annex 2: Data and information sources across the Indian Ocean

NB: 'Stakeholder' under source and type denotes information obtained through direct contact with appropriate in-country representatives. Asterisk (*) under source type denotes official sources.

Country	Source	Type	Presence ✓ Absence x	Number of AFADs	Type (Material)	Lifespan	Spatial	Management Measures	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Behaviour	Socio-economic	Environmental Impact	Bathymetry	Temporal Coverage
Comoros	FIDA, 2024	Nat Report	✓	✓				✓										2024
	IOTC-WGFAD06, 2024	RFMO Paper*	✓						✓	✓	✓	✓						2011 - 2018
	IOTC-SC27-NR04E, 2024	RFMO Paper*							✓	✓		✓	✓					2024
	Faye et al., 2014	Peer-review	✓	✓														Unknown
	Cayré, 1991	Peer-review											✓	✓				1989
	Hanoomanjee, 2017	Peer-review	✓						✓			✓						-
India	Failler et al., 2011	Peer-review	✓	✓			✓		✓	✓		✓					✓	2010
	Koya et al., 2019a	Peer-review	✓	✓			✓	✓	✓	✓	✓	✓	✓			✓		2018 - 2019
	Koya et al., 2019b	Peer-review	✓								✓					✓		2019
Iran	Stakeholder	Stakeholder	x															
Kenya	Failler et al., 2011	Peer-review	✓						✓									2011
	Mbaru et al., 2018	Peer-review	✓	✓			✓			✓	✓	✓	✓				✓	2014 – 2015

Country	Source	Type	Presence ✓ Absence x	Number of AFADs	Type (Material)	Lifespan	Spatial	Management Measures	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Behaviour	Socio-economic	Environmental Impact	Bathymetry	Temporal Coverage
	Ndegwa et al., 2024	Peer-review							✓	✓	✓	✓	✓					2024
	Okemwa, 2023	Peer-review	✓							✓	✓	✓	✓		✓			2014 – 2020
	Onyango et al., 2021	Peer-review	✓									✓			✓			2011 - 2017
	Cayre et al., 1990	Peer-review	✓															1990
Madagascar	IOTC–SC27-NR14, 2024	RFMO Paper*							✓	✓	✓		✓					2024 -
	Jauharee et al., 2015	Peer-review	✓							✓	✓		✓			✓		2015
	Jauharee et al., 2021	Peer-review	✓	✓			✓		✓	✓	✓		✓	✓	✓	✓	✓	
	Jauharee et al., 2012	Peer-review	✓	✓					✓	✓	✓	✓	✓	✓	✓			
Maldives	Ministry of Fisheries and Ocean Resources, 2024	Stakeholder	✓	✓			✓		✓									Current
	Karama and Matsushita, 2019	Peer-review	✓	✓	✓	✓							✓			✓		- 2019
	Anderson et al., 1995	Peer-review	✓	✓										✓				1993 - 1995
	Naeem and Latheefa 1994	Peer-review	✓		✓					✓		✓	✓		✓			1994
	Miller et al., 2017	Peer-review	✓	✓			✓			✓	✓	✓	✓			✓		2014 - 2015
	Shimal et al., 2024	Peer-review	✓	✓						✓	✓	✓	✓			✓		2013 - 2024
Mauritius	Venkatasami and Sheik, 1996	Peer-review	✓	✓							✓	✓						1993 - 1995
	Stakeholder		✓	✓			✓										✓	Current

Country	Source	Type	Presence ✓ Absence x	Number of AFADs	Type (Material)	Lifespan	Spatial	Management Measures	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Behaviour	Socio-economic	Environmental Impact	Bathymetry	Temporal Coverage
	Chooramun and Senedhun, 2013	Peer-review	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			2010 - 2012
	Karama and Matsushita, 2019	Peer-review	✓	✓						✓			✓				✓	2010 – 2019
	Appadoo et al., 2023	Peer-review	✓	✓	✓	✓	✓		✓	✓			✓		✓		✓	2019 – 2020
EU – Mayotte	Stakeholder		✓	✓	✓		✓	✓	✓	✓							✓	Current
	Wendling and Le Calvé, 2000	Peer-review	✓	✓	✓				✓	✓								2000
	Stakeholder		✓					✓										2013
	Ifremer, 2023	Website*	✓	✓								✓						2020 – 2023
EU – La Reunion	Guyomard et al., 2012	Peer-review	✓	✓			✓		✓	✓	✓	✓	✓	✓	✓			
	Zanella et al., 2019	Peer-review	✓	✓	✓	✓	✓			✓	✓	✓	✓		✓			1988 - 2012
	Le Roy et al., 2020	Peer-review	✓	✓			✓										✓	2020
Mozambique	Stakeholder	Stakeholder	x															2024
	Stakeholder	Website	✓															2019
	Lima et al 2022	FAO Report	✓															2022
	Failler et al 2011	Grey Report	✓															Pre 2011
Oman	No data																	
Pakistan	Stakeholder	Stakeholder	x															2024
Seychelles	Stakeholder	Stakeholder	x															2024

Country	Source	Type	Presence ✓ Absence x	Number of AFADs	Type (Material)	Lifespan	Spatial	Management Measures	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Behaviour	Socio-economic	Environmental Impact	Bathymetry	Temporal Coverage
South Africa	Stakeholder	Stakeholder	x															2024
Tanzania	Richmond et al., 2006	Gray literature	✓	✓	✓		✓			✓							✓	Pre 2006
	Groeneveld et al., 2013	Gray literature	✓															Pre 2013
	Failler et al., 2011	Gray literature	✓	✓			✓			✓			✓				✓	Pre 2011
	Yahya et al., 2022	National report*	✓															2022
Australia	Womersley and Green, 2022	Peer-review			✓				✓		✓		✓					
	DRIPB	Stakeholder	✓	✓			✓										✓	
Indonesia	Scott and Lopez, 2014	Peer-review	✓	✓														
	Procter et al., 2019	Peer-review	✓	✓	✓				✓	✓						✓		-
	Widodo et al., 2023	Peer-review	✓	✓	✓					✓						✓		??
	Widyatmoko et al., 2021	Peer-review	✓	✓	✓		✓			✓			✓		✓	✓		2016 - 2018
	Karama and Matsushita, 2019	Peer-review								✓			✓			✓		2014
	Sunoko and Huang, 2014	Peer-review													✓			Years
	Chumchuen and Sukramongkol, 2022	Peer-review								✓								2010 - 2011
	Ministry of Marine Affairs and Fisheries, 2014	Mngmt plan						✓										

Country	Source	Type	Presence ✓ Absence x	Number of AFADs	Type (Material)	Lifespan	Spatial	Management Measures	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Behaviour	Socio-economic	Environmental Impact	Bathymetry	Temporal Coverage
	Mallawa, 2020	Peer-review								✓			✓					2018
	Matratty et al., 2021	Peer-review	✓	✓						✓			✓					2018
	Setyadji and Nugraha 2015	Peer-review	✓	✓						✓			✓					2013
Malaysia	Ahmad et al., 2004	Peer-review	✓		✓	✓							✓					2003
	Hasaruddin et al., 2015	Peer-review	✓				✓											2013
	Lugman et al., 2018	Peer-review	✓				✓						✓					
Thailand	Nootmorn et al., 2022	Peer-review						✓										
	Noranarttragoon et al., 2024	Peer-review								✓	✓		✓	✓		✓		2023
	Noranarttragoon et al., 2013	Peer-review					✓	✓	✓	✓	✓	✓	✓					2007
	Yingyuad and Chanrachkij 2010	Peer-review			✓	✓	✓		✓	✓							✓	
	IOTC SC National Reports	Nat. report*																
Timor-Leste	Chumchen et al., 2022	Peer-review	✓	✓												✓		2020
	Mills and Tilley, 2019	Peer-review	✓							✓								2015 - 1016
	Tilley et al., 2019	Peer-review	✓	✓		✓				✓					✓		✓	2016 - 2017
Sri Lanka	Tilley et al., 2022	Peer-review	✓	✓			✓		✓	✓	✓	✓						2016 - 2018
	Stakeholder	Stakeholder	x															

Country	Source	Type	Presence ✓ Absence x	Number of AFADs	Type (Material)	Lifespan	Spatial	Management Measures	Fleet (Ind. / Artisanal)	Gear Types	Catch (Quantities)	Effort	Target Species	Behaviour	Socio-economic	Environmental Impact	Bathymetry	Temporal Coverage
Bangladesh		Stakeholder	x															

Key : ✓ = Positive response to question; x = negative response; empty cell = NULL or no response.

Annex 3: Review of Spatial and Temporal Distribution of AFAD Fisheries on a Global Scale

Key	Description
	AFAD Management Plan complete
	AFAD Management Plan complete (submitted late)
	AFAD Management Plan not complete (submitted)
	No reporting on existence of AFADs
	No AFADs – NIL report to RFMO

Table 14. Summarises the presence of (AFADs) across coastal states, highlighting those states that have established AFAD management plans, along with the known number of AFADs for which data is available

Code	Name English	Mngt Plan	#
ALB	Albania		-
DZA	Algeria		-
AGO	Angola		-
AIA	Anguilla (British OT)		25
ATG	Antigua and Barbuda		28
ARG	Argentina		-
AUS	Australia		153
BHS	Bahamas		-
BGD	Bangladesh		-
BRB	Barbados		1
BEL	Belgium		-
BLZ	Belize		UKN
BEN	Benin		-
BMU	Bermuda (British OT)		1
BES	Bonaire (Dutch Caribbean)		7
BIH	Bosnia and Herzegovina		-
BRA	Brazil		-
VGB	British Virgin Islands (British OT)		-
CPV	Cabo Verde		-
CMR	Cameroon		-
CYM	Cayman Islands (British OT)		2

Code	Name English	Mngt Plan	#
CHL	Chile		-
COL	Colombia		-
COM	Comoros		28
CRI	Costa Rica		-
CRI	Costa Rica (Pacific Coast)		-
CIV	Côte d'Ivoire		-
CUB	Cuba		-
CUW	Curacao (Dutch Caribbean)		20
CYP	Cyprus		-
DNK	Denmark		-
DMA	Dominica		22
DOM	Dominican Republic		2500
ECU	Ecuador		-
EGY	Egypt		-
SLV	El Salvador (Pacific Coast)		-
GNQ	Equatorial Guinea		-
EST	Estonia		-
EUR	European Union (La Reunion)	✓ ⁶	39
EUR	European Union (Mayotte)	✓ ⁷	14
FLK	Falkland Islands		-
FRO	Faroe Islands		-
FRA	France		UKN
FRA	France (Atlantic Coast)		-
FRAT	France (OT)		-
GUF	French Guiana		-
GAB	Gabon		-
DEU	Germany		-
GHA	Ghana		-
GRC	Greece		-
GRL	Greenland		-
GRD	Grenada		3
GLP	Guadeloupe (French OT)		~630
FCA	Guatemala (Atlantic Coast)		UKN
GTM	Guatemala (Pacific Coast)		
GIN	Guinea		-

⁶ EU noted as partially complete for Reunion but not Mayotte (as of 2024).

⁷ EU noted as partially complete for Reunion but not Mayotte (as of 2024).

Code	Name English	Mngt Plan	#
GNB	Guinea-Bissau		-
GUY	Guyana		-
HTI	Haiti		9
HND	Honduras		-
ISL	Iceland		-
IND	India		9
IDN	Indonesia		~5000 – 10000
IRN	Iran (Islamic Republic of)		-
IRL	Ireland		-
ISR	Israel		-
ITA	Italy		-
JAM	Jamaica		-
KEN	Kenya		-
LVA	Latvia		-
LBN	Lebanon		-
LBR	Liberia		-
LBY	Libya		-
LTU	Lithuania		-
MDG	Madagascar		-
MYS	Malaysia		UKN
MDV	Maldives		88 - 91
MLT	Malta		UKN
MTQ	Martinique (French OT)		~30
MRT	Mauritania		-
MUS	Mauritius	√ ⁸	28
MEX	Mexico (Gulf Coast)		-
MEX	Mexico (Pacific Coast)		-
MSR	Montserrat (British OT)		4
MNE	Montenegro		-
MAR	Morocco		-
MOZ	Mozambique		3
NAM	Namibia		-
NLD	Netherlands		-
NIC	Nicaragua (Gulf Coast)		-
NIC	Nicaragua (Pacific Coast)		-
NGA	Nigeria		-

⁸ Mauritius complete but not completed within the time limit.

Code	Name English	Mngt Plan	#
NOR	Norway		-
OMN	Oman		-
PAK	Pakistan		-
PAN	Panama (Gulf Coast)		-
PAN	Panama (Pacific Coast)		-
PER	Peru		-
POL	Poland		-
PRT	Portugal		-
PRI	Puerto Rico (USA OT)		21
RCB	Republic of the Congo		-
RUS	Russia		-
BES	Saba (Dutch Caribbean)		~20
BES	Saint Eustatius (Dutch Caribbean)		6
KNA	Saint Kitts and Nevis		100
LCA	Saint Lucia		~10
SXM	Saint Marteen (Dutch Caribbean)		2
VCT	Saint Vincent/Grenadines		6
SEN	Senegal		-
SYC	Seychelles		-
SLE	Sierra Leone		-
SVN	Slovenia		-
SOM	Somalia		-
ZAF	South Africa		-
ESP	Spain		UKN
ESP	Spain (Atlantic Coast)		-
LKA	Sri Lanka		-
BLM	St Barthelemy (French OT)		100
SDN	Sudan		-
SUR	Suriname		-
SWE	Sweden		-
SYR	Syria		-
THA	Thailand		UKN
WAG	The Gambia		-
TGO	Togo		-
TTO	Trinidad and Tobago		100
TUN	Tunisia		
TUR	Turkey		-

Code	Name English	Mngt Plan	#
GBR	United Kingdom		-
TZA	United Republic of Tanzania		UKN
USA	United States of America		UKN
USA	United States of America (Pacific Coast)		-
URY	Uruguay		-
VIR	US Virgin Islands (USA OT)		4
VEN	Venezuela		-
ESH	Western Sahara		-
YEM	Yemen		-

Annex 4: Detail for Indian Ocean summary

This Annex provides detailed country-level profiles on the use of anchored Fish Aggregating Devices (AFADs) within the IOTC Convention Area, spanning FAO Areas 51 (Western Indian Ocean) and 57 (Eastern Indian Ocean). The information presented here complements the high-level findings outlined in the main body of the report (Section 4.2), offering in-depth insights into AFAD use across CPCs and non-Member States known or reported to utilise such devices.

Each profile collates the most recent and available data on national AFAD use, deployment practices, fleet composition, gear types, target species, and socio-economic considerations. Where available, details are provided on the number and type of AFADs, the nature of associated fisheries (e.g. artisanal, semi-industrial, recreational), and species targeted. This section also highlights data gaps and reporting inconsistencies, particularly in relation to gear-specific practices and socio-economic dimensions such as fuel use, employment dependency, and catch value.

The two sub-sections that follow group countries geographically according to FAO sub-areas, starting with the Western Indian Ocean (FAO Area 51), followed by the Eastern Indian Ocean (FAO Area 57).

4.3.4.8. FAO Area 51: Western Indian Ocean

The following section presents country-level information for States bordering or operating within the Western Indian Ocean (FAO Area 51). Where available, profiles summarise national AFAD characteristics, associated fleets and gears, spatial and temporal patterns of use, and socio-economic dimensions.

This region demonstrates a wide variation in AFAD adoption, management, and usage across countries. The artisanal and semi-industrial nature of most AFAD fisheries in the area reflects both local fishing practices and national approaches to management and development.

Countries identified as currently deploying AFADs in FAO Area 51 include:

- Comoros
- India
- Maldives
- Mauritius
- EU (Mayotte and La Réunion)
- Mozambique
- Tanzania

Conversely, the following countries are not known to currently use AFADs, although some have expressed interest or have historical use:

- Iran
- Kenya (past use only with interest in the future)
- Madagascar
- Oman
- Pakistan (potential future interest)
- Seychelles
- South Africa

The subsequent profiles explore each country's relationship with AFADs in greater detail, highlighting available data and identifying areas where information remains limited or uncertain.

4.3.4.9. Comoros

The Comoros has a history of anchored Fish Aggregating Device (AFAD) use dating back to 1987, initially introduced through the European Development Fund and the Indian Ocean Commission (FIDA, 2024). However, contemporary reporting on AFAD use is sparse, with no recent details provided in the IOTC Scientific Committee (SC) reports from 2022–2024.

Historical data, such as a 1991 tagging study, identified nine AFADs deployed near Anjouan Island (Cayré, 1991), while a later socio-economic report

documented 14 AFADs in 2010 (Fallier et al., 2011). A SWIOFISH report from 2014 noted the presence of 40 AFADs around Grande Comore, 22 near Anjouan, and 14 around Mohéli (Faye et al., 2014). Most recently, 28 AFADs were reportedly deployed in 2023 for artisanal fishers (La Gazette des Comoros, 2023). Despite these developments, information on the precise locations, characteristics, or management of these devices remains limited. Plans for future development, including the installation of three distinct AFAD types, suggest the introduction of management and maintenance mechanisms.

Despite several emails, no response was received from Comorian stakeholders. Despite this, this research identified that the Comoros Islands do use AFADs.

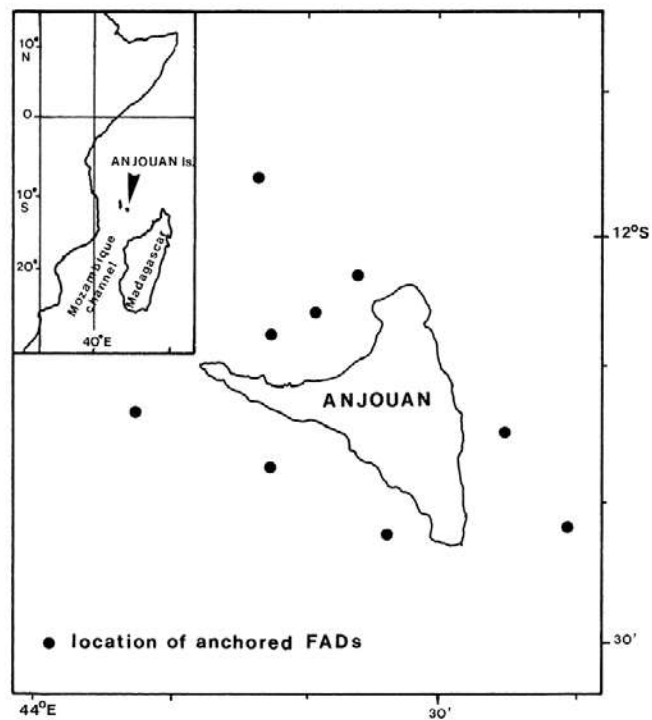
Reporting of AFAD use is scarce and difficult to identify, particularly from peer-reviewed scientific literature. This research found only a small number of key source documents from which to base this description on.

The number of AFADs in Comorian waters is not well reported. The number of AFADs, both historically and more recently is unclear, as is details of the fleets, gears, target fishing grounds, species, and socio-economic aspects specifically related to AFADs. The most recent reports to the IOTC SC (2024, 2023, 2022) have no mention of AFADs, highlighting this paucity of reporting. The 2019 National report to the SC details more information of Comorian fisheries, briefly mentioning the use of AFADs in their fisheries but provides no specific details. The 2019 national report to the IOTC SC is the most accurate and UpToDate account of Comorian fisheries this study could identify.

AFADs have been used in the Comoros since at least the 1987 when the first AFADs were installed by the European Development Fund (EDF/EU) and the Indian Ocean Commission (IOC) (FIDA, 2024). Contemporary numbers regarding the total numbers of AFADs, their locations as well any information pertaining to their life expectancy, management and characteristics are not readily available. However, a paper from around the years they were first installed documents a tagging study of yellowfin and skipjack behaviour around the installed AFADs (Cayré, 1991). In that study 9 AFADs were documented in the waters around Anjouan Island, the second largest island of the three main Comorian islands (Nzwani) (Figure 20. Location of AFADs in Comoros 2010 (Source: Failler et al., 2011).

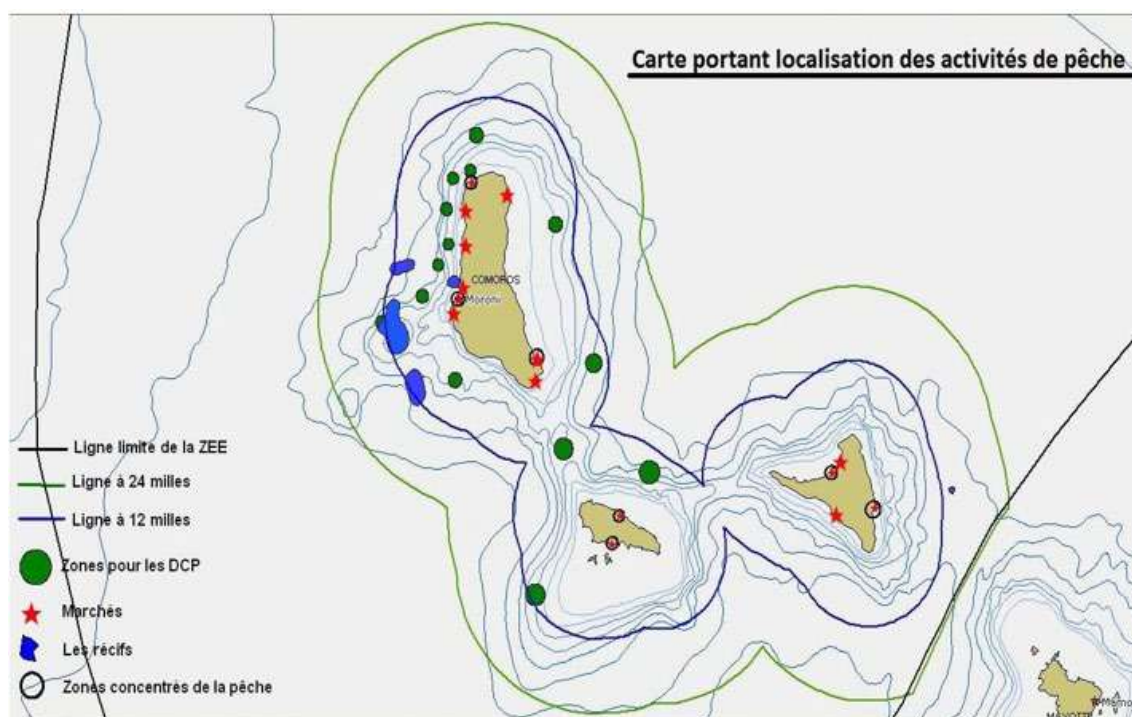
A later a socio-economic study of the South West Indian Ocean region highlights an additional 2 deep (500 m) AFADs to be launched as part of a SWIOF project, while also providing an indication of 14 AFADs in Comoran waters as of 2010 (Failler et al., 2011).

Figure 17. Location of Anjouan Island (Comoros), where the sonic tagging experiments took place: locations of the 9 moored FADs are also indicated



Source: Cayré (1991)

Figure 18. Location of AFADs in Comoros 2010



Source: Failler et al. (2011)

A later SWIOFISH report documents the highest number of AFADs in Comoran waters found, indicating the presence of 40 FADs around Grande Comore (Ngazidja), 22 around Anjouan (Ndzuani) and 14 in Mwali (Mohéli) (Faye et al., 2014).

A recent press report highlights that a further 28 AFADs were deployed in 2023⁹. The AFADs were deployed around the coast of the smallest of the three main islands, Mwali, and are mentioned to be specifically for the use by artisanal fishers.

A recent report highlights the continued use and development of AFAD use in the country by describing potential future development plans (FIDA, 2024). Three types of AFADs are planned to be installed, depending on the characteristics of the fishing zones chosen: (i) light FADs less than 200 m deep, (ii) mid-water FADs to be placed at a depth of 400 m or less, and (iii) Indo-Pacific FADs to be placed between 600 m and 1200 m deep. These planned installations will be accompanied by a FAD operating plan and the definition of a maintenance, management and replacement mechanism for the FADs drawn up, which will be the subject of a co-management agreement between the institutions and the fishermen.

⁹ <https://lagazettedescomores.com/soci%C3%A9t%C3%A9/des-dispositifs-de-concentration-des-poissons-install%C3%A9s-dans-la-zone-du-pnm-.html>

Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

Detailed characteristics of Comorian fleets and gears that use specifically utilise AFADs is not well reported. Future AFAD development plans indicate these installations are specifically to support the small-scale traditional fishery (FIDA, 2024). The most recent National report to the IOTC SC indicates the Comorian fleet to be exclusively artisanal and as such this section will use information the most recent IOTC national report to the SC in lieu specific AFAD associated data.

The Comoran fleet is exclusively artisanal, conducted by wooden or fibreglass boats ranging from 2 – 9 m in length and has around 7000 active fishers (IOTC–2024–SC27–NR04). The traditional vessels are pirogues (monoxyle canoes) with one or two outriggers, propelled by paddle, around 3 – 5 m in length. These traditional vessels are used for longline fishing, night fishing with and without lights as well as trolling. The fibreglass boats are motorised, ranging from 5 – 9 m in length and are fitted with engine from 15 to 40 hp. These vessels are mainly used for trolling, longlining and netting for small pelagic species.

The 2019 national report to the IOTC SC provides the most detailed breakdown of the Comoran fleet, with data reported originating from 2011, 2012 and 2014 (Table 15). This information indicates variation in the use of particular gears year on year, but that there is a heavy reliance on handlines troll lines and “others”, with small pelagic nets used in a very small proportion. Non-motorised boats between 1 – 6 m are the most commonly used vessel type.

Table 15. Breakdown of the Comoran fleet reported by Comoros to the IOTC operating in the IOTC area, by type of gear and size

Category	Subcategory	2011	2012	2014
Fishing Technique	Handline	29%	23.26%	51.1%
	Troll Line	24%	23.11%	13.7%
	Small Pelagic Net	3%	3.11%	1.62%
	Others	44%	50.52%	33.6%
Motorization	Non-motorized	4100	3601	3322
	Motorized	1770	1659	1684
	Unknown	13	8	0
Length Overall	0.1 - 5.9 m	2425	1960	4637
	6 - 11.9 m	279	291	279
	Unknown	3179	3017	0

Source: IOTC-2019-SC22-NR03

Fishing effort from the Comoran fleet is limited to that provided by the same national report to the IOTC SC. This is the most up-to-date publicly available information regarding efforts from the Comoros; however, it unfortunately does not provide proportional information on AFAD catches, only categorised by gear type. The data in Table 16 below provide details on the catch volumes (in kilograms), fishing effort, and catch per unit effort (CPUE) for the main species caught using trolling, longline, handline, and pirogues equipped with longlines in 2018. However, a description the effort statistics is missing, thus it is unknown what the effort values and subsequent CPUE represent, e.g. Catch per trip (most likely). Nevertheless, the highest CPUE (30) comes from skipjack caught with trolling lines, second and third to yellowfin with handlines (23.8) and trolling lines (19).

Table 16. Annual catch and effort by gear and main species in the IOTC area of competence

Tableau 2. Prises et efforts annuels par engin et principales espèces dans la zone de compétence de la CTOI

T2a Prise par espèces, effort et prise par unité d'effort Embarcation G18 pêchant à la traîne 2018				T2b Prise par espèces, effort et prise par unité d'effort Embarcation G18 pêchant à la palangrotte 2018				T2c Prise par espèces, effort et prise par unité d'effort Embarcation G18 pêchant à la ligne à main 2018			
Espèces	Capture kg	Effort	CPUE	Espèces	Capture kg	Effort	CPUE	Espèces	Capture kg	Effort	CPUE
ALB	23506	19137	1,23	ALB	13575	1698	8,00	ALB	6023	3852	1,56
BET	1031832	107265	9,62	BET	115152	7450	15,46	BET	65835	15487	4,25
BLM	14435	13566	1,06	BLM	1815	1165	1,56	BLM	3824	2509	1,52
BLT	196	7269	0,03	BLT	436	426	1,03	BLT	1401	1290	1,09
BUM	14526	17846	0,81	BUM	0		0,00	BUM	160	323	0,49
COM	0		0,00	COM	46	476	0,10	COM	0		0,00
FRI	703	6041	0,12	FRI	0,00	0	0,00	FRI	509	6979	0,07
GUT	0		0,00	GUT	442	832	0,53	GUT	0		0,00
KAW	25954	10718	2,42	KAW	0		0,00	KAW	106	2293	0,05
LOT	629	4252	0,15	LOT	0		0,00	LOT	161	2183	0,07
MLS	5	853	0,01	MLS	336	426	0,79	MLS	268	356	0,75
SFA	54314	76836	0,71	SFA	1611	2957	0,54	SFA	2903	3479	0,83
SKJ	3878259	127368	30,45	SKJ	10293	13264	0,78	SKJ	69115	19687	3,51
SWO	44449	19897	2,23	SWO	21633	5922	3,65	SWO	743	347	2,14
WAH	135481	80200	1,69	WAH	11869	10649	1,11	WAH	59299	19499	3,04
YFT	2224917	116898	19,03	YFT	503706	21097	23,88	YFT	129585	11899	10,89

Source: IOTC–2019–SC22–NR03

A fisheries mapping study of the Indian Ocean region found that, since 2011, Comoros had a single semi-industrial vessel owned by a private sector company (100% Comorian shareholder owned), ComPêche (Hanoomanjee, 2017). The 18-metre targeted demersal stocks and tuna, landing on average 600 tonnes annually, with the company owning their own cold storage facility. However, later reports of this vessel in other papers and national statistics reported to the IOTC were not found.

Furthermore, between 2006 – 2016 Comoros had a Sustainable Fisheries Partnership Agreement (SFPA) with the EU. In that time, it is reported that foreign industrial fleet caught around 5000 tonnes between 2004 and 2009,

compared with 19500 for the national small-scale fleet. That report also highlights “0” for both national industrial fleet and foreign artisanal fleet (Failler et al., 2011).

Target Fishing Grounds (i.e. Spatial temporal variability)

Seasonal variation in catch and fishing grounds is likely, however, this data is not currently available. The 1991 tagging study mentioned earlier set too few tags (8 fish tagged) that were not deployed for long enough (maximum 24 hours) to provide conclusive evidence of spatial or temporal variability of the target stocks. Variation in fleet activity is also not available.

Target Species (i.e. Catch)

AFAD associated catch is not reported. The most informative information available of catches from Comoros are those presented above, in Table 16 sourced from IOTC–2019–SC22–NR03. The species with the highest catch in terms of volume (2018) are yellowfin (3194 tonnes), skipjack (3965.9 tonnes) and bigeye (1252 tonnes), sailfish (0.27 tonnes) and Wahoo (220 tonnes).

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

Very little is reported about the socio-economic context of the AFAD fisheries in the Comoros. What is known is that the catch all goes to national markets and domestic consumption (IOTC–2022–SC25–NR04).

4.3.4.10. India

The use of AFADs in India’s waters was confirmed through this studies literature review. Despite several emails, no confirmation was provided by a stakeholder of the country.

Few reports or studies documenting AFAD use in Indian waters are published. The presence of AFADs in India’s waters come primarily comes from two documents (Koya et al., 2019a and Koya et al., 2019b), both containing limited information pertaining to AFADs. The following information on India AFAD fisheries is thus limited to that found within those documents.

AFADs have been deployed by the government to aid tuna fishing since 2006. As of 2019, there were nine deployed in Lakshadweep waters, a tropical archipelago of 36 atolls on the west coast of the Indian subcontinent (Koya et al., 2019a; Table 17). These are the only AFADs identified by this study in India waters.

Table 17. Anchored Fish Aggregating Devices (AFAD) in position in the Lakshadweep waters as on 31st January, 2019

Sl. No.	Name of the Island	Date of Deployment	Position	Distance from Island (Nm)	Depth of Deployment (metres)	Remarks
1	Kadmat	16.01.2018	Lat: 11°22'000"N, Log: 072°45'100"E	8	1860	Active
2	Androth I	07.03.2018	Lat: 10°45'745"N, Log: 073°46'695"E	6	2022	Active
3	Androth II	06.03.2018	Lat: 10°57'560"N, Log: 073°40'496"E	8.5	1800	Active
4	Kalpeni	07.05.2018	Lat: 10°07'480"N, Log: 073°45'000"E	6.5	2100	Active
5	Chetlath	14.11.2018	Lat: 11°43'622"N, Log: 072°39'800"E	5.5	1880	Active
6	Kavaratti	10.01.2019	Lat: 10°36'370"N, Log: 072°30'300"E	8	1850	Active
7	Agatti I	20.01.2019	Lat: 10°53'200"N, Log: 072°04'570"E	7.5	1850	Active
8	Agatti II	29.01.2019	Lat: 11°02'860"N, Log: 072°10'350"E	10	1900	Active
9	Kalpeni	29.01.2019	Lat: 10°03'240"N, Log: 073°28'440"E	10.3	2200	Active

Source: Koya et al. (2019a)

Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

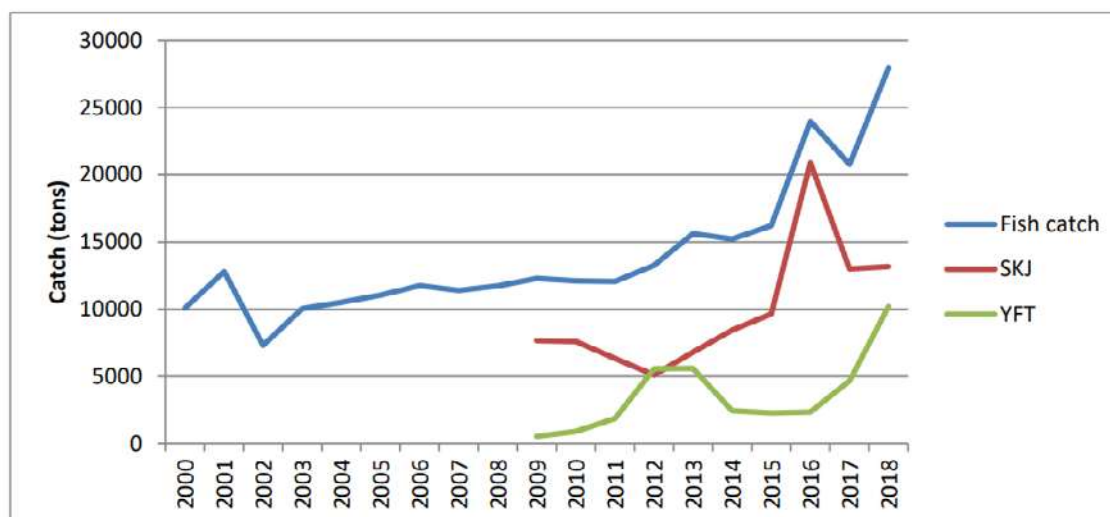
Very little information is available regarding the fleets and gears that specifically use these AFADs, as there is an absence of catch and effort data in the Lakshadweep fisheries (Koya et al., 2019a). However, Koya et al., (2019b) presents data recorded from the Department of Fisheries during 2009 to 2018

as well as onboard and landings center observation data collected from 2017 to 2019, to present an overview of tuna fisheries of Lakshadweep.

The major gears involved in the Lakshadweep tuna fishery are as follows:

- Pole and line (64%)
- Handline (24%)
- Troll line (9%)
- Gillnet with large mesh (2%)
- Longline (1%)

Figure 19. Trends of major tuna species landings in Lakshadweep



Source: Koya et al. (2019b)

Koya et al., (2019a) documents a livebait fishery management plan. In it, Catch per Unit Bait (CPUB) is reported for the tuna fishery. The findings were that the aggregated CPUB averages 11kg of tuna for one kg of livebait across Lakshadweep fisheries. AFADS are not use in the capture of the livebait.

Target Fishing Grounds (i.e. Spatial temporal variability)

The AFADs are located in deep, offshore waters ranging in depth from 1800 – 2200 metres (Table 17). The distance from shore ranges from 5.5 to 10.5 nautical miles. Little other information was documented regarding the spatial and temporal variability of AFAD related target fishing grounds.

Target Species (i.e. Catch)

The target species identified within the Lakshadweep tuna fishery are primarily tropical tuna species. Koya et al., (2019b) reports the main species caught in the tuna fishery in Lakshadweep as skipjack (67%), yellowfin (25%), Kawakawa (4%), bigeye (2%), bullet tuna (2%) and dogtooth (<1%).

Within the skipjack pole and line tuna fishery it is stated that most of the fishing events observed in the were taken near the AFADs. Catch comprising of skipjack, yellowfin and neritic tunas constitute 97%, with skipjack constituting to 75%. The associated bycatch in that fishery include rainbow runner, dolphinfish, billfishes, wahoo, sharks and triggerfish (3.1%).

The handline fishery that operates in these waters, mainly target yellowfin and bigeye. In this fishery 93% of the catch was yellowfin with sizes ranging from less than 10 kg to over 100 kg. The proportion of bigeye is not documented. Other species caught in this fishery are billfishes (mainly sailfish and occasionally marlin), rainbow runner and dolphinfish. Sharks and turtles are occasional incidental catches.

The auxiliary livebait fishery for tuna fisheries in the Lakshadweep archipelago targets a mix of species caught across the archipelago. In total, 45 species, 30 genera, and 19 families are reported (Koya et al., 2019a). The species used vary from island to island across the archipelago with many species also showing seasonal variation in their availability. The main species captured in the livebait fishery are: *Spratelloides delicatulus*, *spratelloides gracilis*, *Gymnocaesio argenteus*, *Caesio striatus*, *Pterocaesio pisang*, *Caesio chrysozona*, *Chromis caeruleus*, *Lepidozygus tapeinosoma*, *Archamia fucata*, *Apogon thermalis* and *Rhabdamia gracilis*.

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

This study did not identify information related to fuel, employment, catch value nor the socioeconomics of AFAD fisheries in India.

4.3.4.11. Iran

The use of AFADs in Iranian waters was not identified through this study's systematic literature review. A stakeholder response Iran stated that Iranian fishers do not utilise AFADs in their operations and that the Iranian Fisheries Organisation has no plans programmes to use them.

4.3.4.12. Kenya

Kenyan fisheries have utilised AFADs in the past, do not currently employ them, but may consider their use in the future. Through stakeholder engagement a respondent stated that Kenya fisheries do not currently use them and that previous trial had failed after losing them. A 2011 study of the socio-economic impacts of AFADs in the SWIO region found, at the time, little information about the characteristics of fisheries using them (Failler et al., 2011). However, another study carried out in-between 2014 – 2015 documented a positive effect on the local fishery after AFADs were introduced in the form of orders of magnitude increases in length, weight, commercial value, and catch per unit effort (CPUE) of landed catch (Mbaru et al., 2018). That study reports 5 AFADs within their experiment, which at the time, was the entirety of the AFADs deployed in Kenyan water, as stated in the supplementary material of Mbaru et al., (2018) as well as the FADs design. It was not found out when the fads were lost.

Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

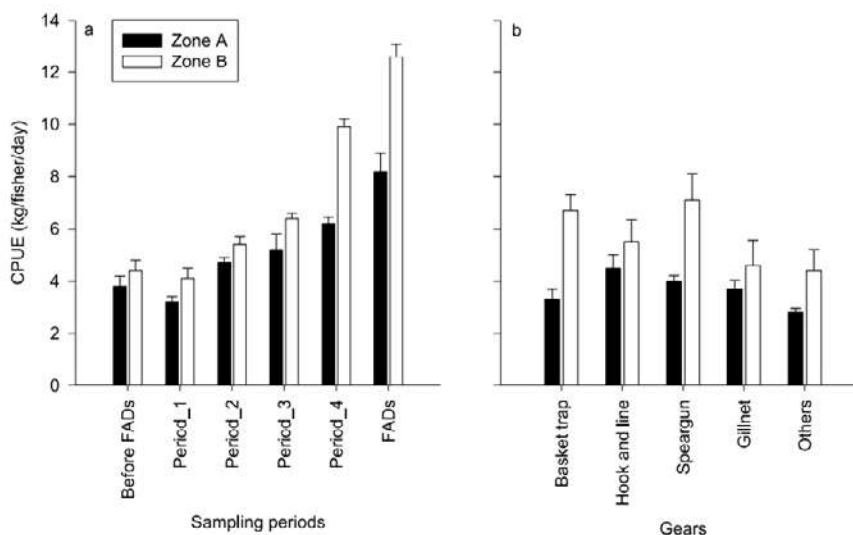
The catch surveys reported by Mbaru et al., (2018) in 2014 – 2015 at landing sites adjacent to the AFAD zones indicate gillnets, hook and lines, basket traps, spear guns and ‘others’ as being the most recorded. Although it is not clear if these gears are used directly around the FADs.

Their study included periodical sampling over the AFAD implementation period, clearly demonstrating an increase in CPUE expressed in kg of fish per fisher per day Figure 22. It is unclear how directly close the fishers in the artisanal catch survey fished to the AFADs, but in total, 10 basket trappers, 22 hook and liners, 12 spearfishers, 24 gillnetters and 9 “other” fishers were surveyed.

Figure 20. CPUE (kg fisher per day) from the two sampling zones before and after deployment of AFADs based on (a) sampling periods and (b) gears.

Sampling effort for gear used in Zone A and Zone B. Period_1 – April 2014; Period_2 – June 2014; Period_3 – November 2014; Period_4 – February 2015

E.K. Mbaru *et al.*: Aquat. Living Resour. 2018, 31, 6



Source: Mbaru et al. (2018)

Although not directly AFAD fisheries, Okemwa et al., (2023) is a recent report characterising gear-based exploitation patterns of artisanal tuna fisheries, focusing on Kenya. The report describes the 1,960 fishing trips from 2014 to 2020 representing 192 tonnes of fish. The most prevalent gears were ringnets, reef seine, handline, longline, troll lines and draft and set gillnets.

Target Fishing Grounds (i.e. Spatial temporal variability)

The 5 AFADs were deployed in April 2014 and were design and constructed following the South Pacific Commission guidelines (Mbaru et al., 2018). Moored in two clusters ~3 nautical miles from the shoreline, Zones A and B, the AFADs were separated by ~600 m within a cluster, and had depth ranges of 100 – 135 m and 140 – 165 m for Zone's A and B, respectively. These locations are just beyond fringing coral reef along the Mombasa coastline.

Target Species (i.e. Catch)

Due to losing the deployed AFADS sometime after 2015, information on the types of species caught around them by artisanal or commercial fishers is somewhat scarce. The 2014 – 2015 study by Mbaru et al., (2018) highlights common species caught around the AFADs, but does not detail the species landed by the artisanal fishers, only the experimental fishing survey and Under

Water Visual census. Their study used an experimental fishing survey (using trolls from a recreational angling boat and three motorised outrigger canoes) as well as under water visual census.

Through experimental fishing survey a total of 108 species from 42 families were caught at the FADs. The UVC observed 38 species from 20 families. From the UVC the most dominant family was Scombridae (6 species), followed by the Carangidae and Lutjanidae (4 species), Scaridae, Lethrinidae, and Acanthuridae with 3 species each. The pelagic species most frequently observed at the FADs included *Acanthocybium solandri*, *Coryphaena hippurus*, *Makaira indica*, *Gerres oyena*, and *Decapterus macarellus*. Most were assessed as adult specimens except for some juveniles of *Siganus sutor*, *Leptoscarus vaigiensis*, *Lethrinus lentjan*, *Parupeneus macronemus* and *Scarus ghobban*.

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

The most recent National report to IOTC indicates an estimated 606 artisanal vessels are engaged in fisheries for tuna and tuna like species within coastal waters (Ndegwa et al., 2024). However, it is reported by Mbaru et al., (2018) that the marine fishery in Kenya is predominantly small-scale and artisanal with roughly 12000 fishers intensively fishing nearshore coastal reefs using minimally selective gears. Handmade canoes using paddles or sail are the predominant methods to access fishing grounds, with few fishers using motorised craft to access offshore areas.

A socio-economic study by Onyango et al., (2021) found of the 98 career fishermen (all male) interviewed, only 13 % were adequately informed of AFADs and their uses and potential benefits. Of those that did, those involved in the previous AFAD projects rated their use as “highly effective” (72 %). The same study found that modal value for the daily income for fishers averaged KES 400 (around \$3.9 USD). Couple these findings with those from Mbaru et al., (2018) finding AFADS promoted a higher CPUE for fishers, it appears AFADS had positive socio-economic impacts.

4.3.4.13. Madagascar

The use of AFADs in Madagascan waters was not identified through this study’s systematic literature review. A stakeholder response stated that Malagasy fishers do not utilise AFADs in their operations and no further comment was received regarding potential future uses.

An old paper suggests the deployment of AFADs was not feasible due costly modification to the artisanal fleet in order to reach the very occasional aggregations of tuna, as well as tuna not being a popular within the population

(Cayre et al., 1990). While an old paper, this pattern of underutilisation of pelagic resources is highlighted in the most recent National report to scientific committee at IOTC (IOTC–2024–SC27–NR14, 2024).

4.3.4.14. Maldives

FAD use in the Maldives is reported to have first experimentally taken place as early as 1981-82, as a pilot programme in an FAO-assisted project to study their effectiveness, after which ten FADs were deployed in 1995 – 1988 sponsored by the United Nations Development programme (UNDP) (Naeem & Latheefa, 1994). From these first trials, FADs have been a success, showing a noticeable increase in productivity to fisheries. Subsequent trials were conducted to refine the design, and 20 more fads were installed in 1988 using a new design expected to last two years, this time sponsored by the government of the Maldives. By 1993, nine of the improved design FADs were still in service, with another five more installed in September 1993.

Today the FAD fishery in the Maldives is highly developed, with 91 AFADs listed on the most recent location document published on the Ministry of Fisheries and Ocean Resources website (Ministry of Fisheries and Ocean Resources (MFOR), (2024). Longitude and altitude positions are provided. However, the most recent report to the IOTC SC reports the Maldivian government maintaining 88 AFADs (Shimal et al., 2024). The majority of these AFADs are restricted to only the pole and line fleet.

The increase in FADs used in the Maldives through the early deployment period is somewhat reflected in the national tuna catch volumes, rising from 30000 tonnes in 1980 to 70000 tonnes by 1990 (Karama & Matsushita 2019).

Made using a modern design using material such as fibre-reinforced plastic (FRP) for the floating parts, a net is used as a mid-water attractor. These designs are suggested to have had a life-span around 2 years between 1993 and 2008, and about 82% of fads installed are lost each year (Karama & Matsushita 2019).

Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

Throughout the Maldives, only hook and line (pole and line, trolling and longline) is used. However, a ban on the use of longlines was put in place since July 2019. Other gear types including purse seine large gillnets or trawls have never been traditionally used methods and are forbidden to use to ensure the sustainability of the stock. Furthermore, no foreign fishing vessels or fleets operate in the Maldivian EEZ, with around half the total tuna catch landed in the Maldives consumed locally (Jauharee et al., 2021).

The largest fleets targeting the FADs are the artisanal fleet and the commercial pole and line fleet. The vessels of the artisanal fleet are small (<20 m in length) with crews ranging from 8 – 12, conducting daily trips more often than not selling their catch for local consumption (Jauharee et al., 2021). The vessels of the artisanal fleet do not hold capacity for ice and thus are limited in their ability to catch and store large volumes. The commercial fleet is composed of larger vessels (roughly 25 – 30 m in length) carrying 20 – 30 crew. Designed to cope with rough sea conditions, these vessels can be at sea for a number of days, as the vessel holds are insulated and carry ice for storage.

During a single fishing trip, it is reported that a vessel may fish at several AFADs and as many as 30 other vessels can be present at a single AFAD (Jauharee et al., 2021). It is estimated that around 50% of the Maldivian pole and line tuna catch is taken at AFADs (Jauharee & Adam, 2012), up from an estimate of 44% in the early 1990s (Anderson et al., 1995; Miller et al., 2017).

Target Fishing Grounds (i.e. Spatial temporal variability)

The FAD array uses deep-water design, with most situated in 1000 – 2800 m of water, around 20km from the shore (Jauharee et al., 2021). Much of the commercial fleet operates in the South of the Maldives but occasionally travel north. The behaviour of the fleet largely follows the movement of the tuna. A comparison of stakeholder perceptions to the movement of the vessels reported in logbooks indicates there is a general seasonal trend of tuna movement at the scale of the Maldivian FAD array (Jauharee et al., 2021). It's found that much of the fishing takes place on the east side through the northeast monsoon season, and more on the west side through the southwest monsoon. The study highlighted that skipjack and yellowfin abundance was higher at the FADs during the northeast monsoon.

Target Species (i.e. Catch)

Tuna fisheries in the Maldives are exclusively caught using hook and line methods (pole and line, handline, trolling). A study conducted with observers aboard both commercial and artisanal vessels found that 55.3 % of fishing events took place at AFADS, with 37 % of the tuna caught attributed to AFADS. The study found AFADs to have an average catch per fishing event of 0.54 tonnes. The species caught at the AFADs composed of skipjack (49.1 %), yellowfin (44 %), bigeye (3.7 %) Kawakawa (3 %) and Frigate tuna (0.2 %) (Miller et al., 2017).

The main bycatch species caught are rainbow runner and dolphin fish, but notable other species include silky shark and two bird species (the Lesser and Brown noddy). Bycatch amounts were not reported in relation to the proportion to catch of tuna, only numbers, which can be seen in Table 18.

Table 18. Maldivian pole and line bycatch numbers and sizes, by species**Table 3. Maldivian pole-and-line bycatch numbers and sizes, by species.**

Species	No. caught	No. measured	Mean length (cm)	No. weighed	Mean weight (kg)	Total weight (kg)
Rainbow runner	265	148	53.4	265	2.12	561.7
Dolphinfish	157	111	60.9	150	2.04	319.9
Silky shark	9	2	73.2	2	2.12	19.1
Round scad	56	27	29.2	53	0.50	28.2
Garfish	12	11	76.5	12	0.95	11.4
Oceanic trigger	7	7	31.0	6	0.71	5.0
Jacks / trevallies	13	13	19.5	13	0.14	1.9
Lesser noddy	1	0	-	0	0.10	0.1
Brown noddy	2	0	-	0	0.20	0.4
Skipjack tuna	1	0	-	0	1.5	1.5
Yellowfin tuna	1	0	-	0	1.5	1.5
Total	524	319	-	501	-	950.57

Source: Miller et al. (2017)

The fate of the bycatch is also reported, showing that much of the bycatch is sold or consumed, with small amounts discarded and the bird species and silky sharks released (Table 19).

Table 19. Fate of bycatch and discards, by species (in numbers)**Table 7. Fate of bycatch and discards, by species (in numbers).**

	Sold	Consumed	Discarded	Released	Total
Rainbow runner	212	53	-	-	265
Dolphinfish	48	96	13	-	157
Silky shark	-	-	2	7	9
Round scad	48	8	-	-	56
Garfish	-	12	-	-	12
Oceanic triggerfish	-	-	7	-	7
Trevally/Jacks	-	12	1	-	13
Noddies	-	-	-	3	3
Yellowfin tuna	-	-	1	-	1
Skipjack tuna	-	-	1	-	1
Total	308	181	25	10	524

An older study also found the main tuna species caught to be those five mentioned above, but noted the addition of sailfish, black and blue marlin too (Jauharee & Adam, 2012)

The pole and line fishery also uses live bait, a component not often reported. One study found livebait to be equivalent to 8.9 % of the tuna catch, or 11.3 kg of tuna per 1 kg of livebait (Miller et al 2017). This is comparable to another study who found similar rates, which reported 10 – 13% of tuna catch or equivalent to 7.4 – 10 kg of tuna per 1 kg of livebait used (Jauharee et al., 2015). The species exploited by the Maldivian pole and line tuna fishery are silver sprat (*Spratelloides gracilis*), bleu sprat (*Spratelloides delicatulus*), cardinalfishes (Apogonidae), anchovy (*Encrasicholina heteroloba*), fusiliers (Caesionidae) and chromis species (Chromis sp) (Jauharee et al., 2015). Table 20 provides an estimate of historic livebait utilisation, expressed in volumes measured in metric tonnes per year.

Table 20. Estimate of historic annual livebait utilisation in the pole and line fishery

Table 2. Estimates of historic annual livebait utilization in the pole-and-line fishery. After Anderson and Hafiz (1988), Anderson (1994, 1997 & 2009) and Adam (2006)

Period	Estimated bait catch	Bait utilization	
	(Mt / year)	Kg of bait / day	Kg of tuna / Kg of bait
1978-1981	3250 ± 800	32	7.4
1985-1987	5100 ± 1300	32	10.0
1993-1994	11000 ± 2700	49	7.5
2003	15000	72	9.6

Source: Jauharee et al. (2015)

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

Fishing trips generally last 1-2 days, but advancements of the vessels have extended that period to extend to multi-day operations (Shimal et al., 2024).

Jauharee et al., (2021) reports that as of 2018, there were 785 licenced local commercial tuna vessels operating in the Maldives. These vessels are owned by families or individuals living in the Maldives as there are no company owned fleets in the Maldives according to Jauharee et al., (2021), with more than 17500 active fishers working on the vessels. The AFADs have equal access to both the artisanal fleet and commercial fleet with most of them having gear restrictions within 3 miles around them, limiting the gear to pole and line only.

4.3.4.15. Mauritius

Mauritius was one of the first countries in the SWIO to have started a fishery associated with FADS, introduced in 1985 (Venkatasami and Sheik Mamode, 1999; Karama & Matsushita 2019). At the time of writing their paper in 1999, Venkatasami and Sheik Mamode, (1999) reported 21 AFADs in operation around the island. Another paper reports that by 2013, this number had risen to 28. This number is still relevant today, with their name/code, location (latitude/longitude), depth and distance from shore all publicly available on their website Mauritian Open data website (<https://data.govmu.org/dkan/?q=dataset/location-fish-aggregating-devices>).

It is reported that the average lifespan of the FADs is around 500 days (Appadoo et al., 2023; Chooramun & Senedhun (2013).

Set up through a grant from the Government of Japan, The Fisheries Training and Extension Centre, situated at Pointe aux Sables was created 2004 and now provides a three-week FAD fishery training course aimed teaching safety as well as fishing techniques to enable the efficient targeting of pelagic species (Ministry of Agro-Industry, Food Security, Blue Economy and Fisheries, n.d.).

Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

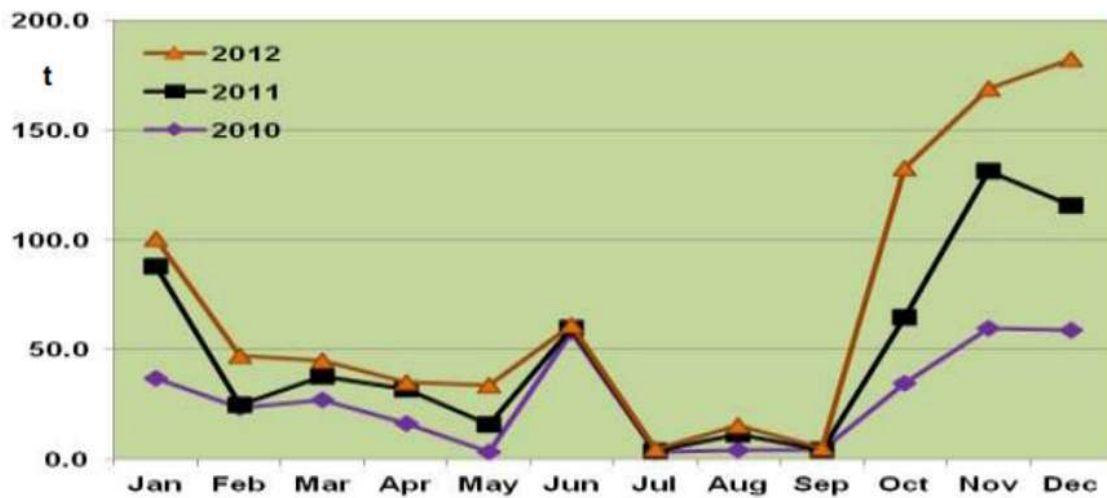
A 2013 paper describes the tuna fleet operating in Mauritius as composed of four segments. The licenced foreign flagged purse seiners, licenced foreign flagged longliners, national semi-industrial longliners and the artisanal FAD fishery. The artisanal FAD fishery is comprised of recreational/sports anglers and local professional artisanal fishers (Chooramun & Senedhun, 2013).

As of 2013, licenses for foreign-flagged purse seiners were primarily issued to vessels from Europe and Seychelles, fishing mainly outside of Mauritian waters. At the same time, an average of 120 licenses are issued yearly to the licensed foreign longliners, mainly comprised of countries of Eastern and South Eastern Asia, operating within largely within the EEZ of Mauritius (Chooramun & Senedhun, 2013). Species landed by the licensed foreign long liners composed mainly of Yellowfin tuna and Bigeye tuna. Landings from that fishery were around 7660 tonnes in 2010, 6000 tonnes in 2011 and 3650 in 2012.

The national semi-industrial longliners were at the time comprised of three local boats (<24m), targeting swordfish and landing some tuna species, all within the Mauritian EEZ. Landings in 2011 were 90t, declining to 36 tonnes in 2012, with catches comprised of around 50% swordfish, 20% yellowfin, 15% bigeye and 15% albacore.

Describing seasonal trends in abundance through landings at official fish landing stations. Records indicate total landings of around 300 tonnes in 2010, dropping to 250 tonnes in both 2011 and 2012. Seasonal trends in monthly catch are shown in Figure 23, showing a regular seasonal pattern through the year. The main gear types used include trolling with artificial bait, slow trolling with live bait, hand lining, horizontal long lining, vertical long lining and drift line.

Figure 21. Monthly total catch around AFADs over 2010 to 2012



Expressed in 'fmd' (fisherman days), the annual fmd was around 18400 in 2010, declining to around 16100 in 2011, and further to 11000 in 2012. Table 21 provides the annual effort alongside associated total catch and CPUE.

Table 21. Total catch, fishing effort, bad weather days and CPUE/CPFD (2010-2012)

Year	Total Catch (tonnes)	Fishing Effort (fmd)	Bad Weather (days)	Average Annual CPUE/CPFD (kg)
2010	330.6	18363	130	18
2011	249.2	16115	106	16
2012	243	10977	124	22.1

Source: Chooramun & Senedhun (2013)

Target Fishing Grounds (i.e. Spatial temporal variability)

Withing the 2010 – 2012 period, the average monthly landings indicate higher catches in the warm months though the austral summer (October to January), peaking in December, linked with Sea Surface Temperature (SST) show in Figure 24.

Figure 22. Av. monthly total landings, av. total effort and av. mean SST (2010-2012)

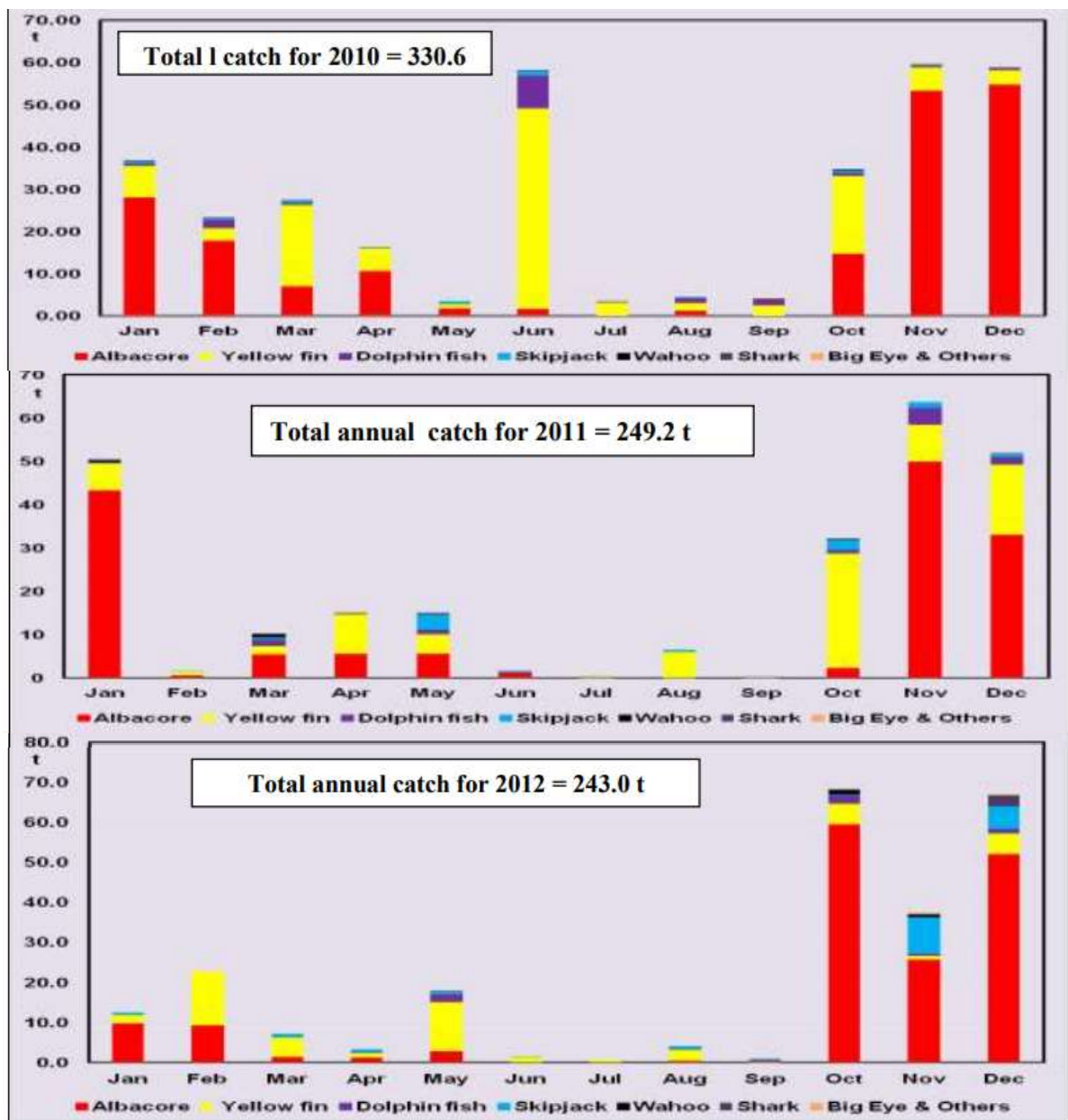


Source: Chooramun, V. M., & Senedhun, V. (2013)

Target Species (i.e. Catch)

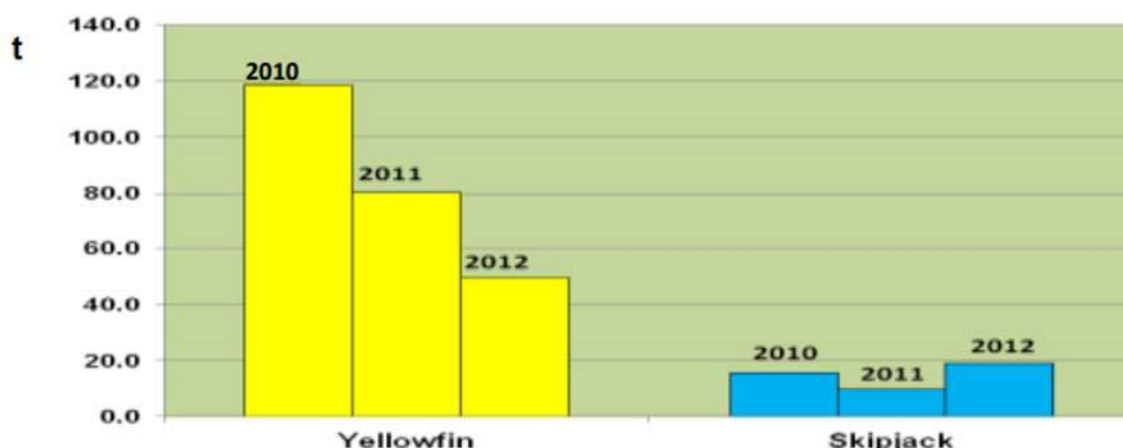
The composition of landed species from the artisanal fleet varies seasonally, and to a lesser extent annually, through 2010 – 2012. Landings mainly comprised of albacore, yellowfin, dolphinfish, skipjack, wahoo, sharks, bigeye and others (See Figure 25). The abundance of yellowfin in catches appears to vary substantially between years and within years but shows a decline over the period (Figure 26).

Figure 23. Monthly landings by species for the artisanal FAD fishery 2010 – 2012



Source: Chooamun, V. M., & Senedhun, V. (2013)

Figure 24. Catch of yellowfin and skipjack in Mauritius for the period 2011-2012



Source: Chooramun, V. M., & Senedhun, V. (2013)

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

A more recent socio-economic study conducted in of Mauritian artisanal fishers found, that around 50 % of those surveyed (n = 247, equal to around 12 % of registered fishers) fished the FADs (Appadoo et al., 2023). The study conducted between 2019 and 2020 used a cluster analysis of their stakeholder responses to identify six trait-based groups, that can somewhat be discriminated into two groups of three: those that catch demersal/reef species and those that catch pelagic species at FADs. Within the three groups identified using FADs, there is variability within approaches, for example those using small pirogues and those using fibreglass boats as well as engine size.

The first group of FAD-based fishers (n=47) use 'medium' (9–25 CV) engines (41/47) on mainly fibreglass boats (30/47) and were located from the West and North regions. This group report fishing in the deep sea, using handlines (45/47) and vertical lines (32/47), indicating the use of multiple gears by the same fisher.

The second group of FAD fishers also nearly all used fibreglass boats (10/11), but all with more powerful engines (>26 CV). This group favour handlines (8/11) or vertical lines (6/11) but also to a lesser extent use basket and gillnets (2/11). However, of this group, only 7 of the 11 fishers used the FADs.

The last FAD-base group are the Pirogue fishers, of which they surveyed 33, 25 from the West region and 8 from the South region, all of which fished near FADS. This group uses small wood pirogues (<8m) with outboard engines between 9 and 25 CV, fishing rarely along the coast (13/33) or in the reef (5/33), mainly using handlines (23/33) and vertical lines (23/33), and rarely baskets (7/33).

A chi-squared test of the 6 groups and the 14 main taxa groups was highly significant indicating all groups did not have the same target species, with the three FAD groups presenting links to tuna and tuna-like species. The aforementioned pirogue group of FAD fishers were found to be especially associated with YFT, while the first group that used medium engines on mainly fibreglass boats were more associated with tuna (unspecified) and the second group more with blacktip grouper and dolphin fish Appadoo et al., (2023).

4.3.4.16. Mayotte

Little information was found through this study's systematic literature regarding the use of AFADs in Mayotte. However, this study is able to confirm that Mayotte fishers do use AFADs and has been since at least 1989 since the first were moored there (Wendling & Le Calvé, 2000). By 2000, five FADs were in the lagoon, and eleven in the outer waters beyond the fringing reef (Figure 27).

More contemporary information available through the Mayotte Parc Naturel Marin website (MPNM, 2022)¹⁰ indicates a total of 14 AFADs in Mayotte waters. Deployed between 2021 and 2022 they sit in waters 750 – 2170 m deep. All the FADs are now positioned outside of the fringing reef roughly 10 to <20 kilometres from the shore (Figure 27). Long and latitude positions are available.

Despite some reporting of fishery statistics through the IFREMER regional fisheries data portal ¹¹, the only mention of AFADS or DCP (dispositif concentration de poisson) is reported in their data table navires actifs zones peches frequentees or “vessels active frequented fishing areas”, where the number of vessels active at a FAD is recorded alongside the number of months activity.

This data hints at few boats specifically targeting the AFADs, with a drop in the number of months activity was present at the few FAD used in later years. Furthermore, it appears that not all the FADs are utilised within a year's period.

It is interesting to note, the names in Table 22 do not match the names found on the map in Figure 27, implying the loss and/or addition of AFADs, but also a level of management by fisheries actors.

¹⁰ <https://parc-marin-mayotte.fr/actualites/linstallation-des-dcp-du-parc-marin-est-terminee>

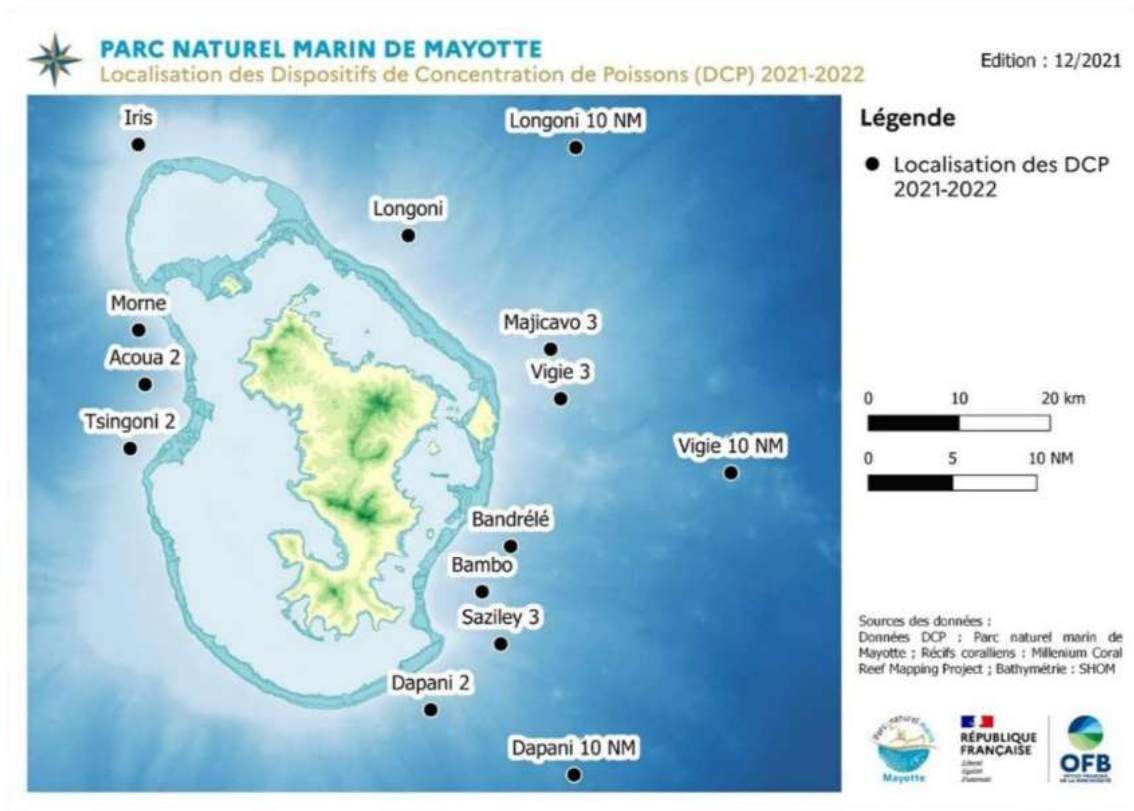
¹¹ <https://sih.ifremer.fr/Donnees/Donnees-brutes-des-fiches-regionales>

Table 22. Annual usage of AFADs (DCP): Summary by the number of months with activity and the number of active boats¹²

ANNEE	SECT_COD	SECT_LIB	NB_MOIS_ACTIVITE	NB_NAVIRES
2020	YTDCP010	DCP Varavara Mati	8	1
2020	YTDCP012	DCP Acoua	9	1
2020	YTDCP013	DCP Djamalini Yaju	7	1
2020	YTDCP016	DCP Chimrima	1	1
2021	YTDCP010	DCP Varavara Mati	1	1
2022	YTDCP003	DCP Vigie 1	2	1
2022	YTDCP005	DCP Saziley 1	2	1
2022	YTDCP010	DCP Varavara Mati	1	1
2022	YTDCP011	DCP Tsingoni	3	2
2022	YTDCP013	DCP Djamalini Yaju	1	1
2022	YTDCP016	DCP Chimrima	1	1
2023	YTDCP004	DCP Vigie 2	1	1
2023	YTDCP010	DCP Varavara Mati	1	1
2023	YTDCP013	DCP Djamalini Yaju	1	1

¹² <https://sih.ifremer.fr/Donnees/Donnees-brutes-des-fiches-regionales>

Figure 25. Map of AFAD locations in Mayotte waters



Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

Based on the rules available online, the AFADs are targeted by professional and recreational anglers, with recreational anglers prohibited to use them throughout the week¹³. Based on the data available through the IFREMER website, a breakdown of the main gears by the Mayotte fleet is provided, but more detailed statistics on which fleet segments use the FADs is not available. As of 2023 the active gears are: Hand lines (69 boats), Trolling lines (39 boats), Gillnets (9 boats), Encircling gillnets (6 boats), pelagic seines (4 boats), Diving (2 boats) and Drifting longlines (1 boat)¹⁴.

Target Species (i.e. Catch)

Catches directly related to FADs were not identified in this study and were not provided through contact with local stakeholders. The main species, with annual

¹³ <https://parc-marin-mayotte.fr/actualites/linstallation-des-dcp-du-parc-marin-est-terminee>

¹⁴ <https://sih.ifremer.fr/Donnees/Donnees-brutes-des-fiches-regionales>

landings over 1000 tonnes, reported in Mayotte datasheets ¹⁵ are skipjack, yellowfin and bigeye tuna.

Table 23. Annual landings from Mayotte: Summary of species and quantity landed (Tonnes)

Year	Species code	Species name	Local name	Tonnes
2023	SKJ	Listao	Listao	14069
2023	YFT	Albacore	Albacore	9521
2023	BET	Thon obèse(=Patudo)	Thon obèse(=Patudo)	1304
2023	DOL	Coryphène commune	Coryphène commune	108
2023	RRU	Comète saumon	Comète saumon	106
2023	FRI	Auxide	Auxide	104
2023	LTA	Thonine commune	Thonine commune	66
2023	AVR	Vivaneau job	Vivaneau job	59
2023	NXI	Carangue têteue	Carangue têteue	52
2023	SDX	Comètes nca	Comètes nca	51
2023	SNA	Vivaneaux nca	Vivaneaux nca	41
2023	GPX	Mérous nca	Mérous nca	38
2023	NXM	Carangue aîle bleue	Carangue aîle bleue	33
2023	ZZ9	Espèce hors domaine	Espèce hors domaine	21
2023	BEN	Orphies		

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

Information on the socio-economic aspects of the AFAD fishery in Mayotte is lacking/old. A 2000 paper indicates the Mayotte fishing fleet to consist of 1500 fishers that use both monooxyl (single tree) pirogues and polyester fishing boats (Wendling & Le Calvé, 2000). While the fishery is highly likely to have developed significantly, Wendling & Le Calvé, (2000) indicate the socio-economic aspects of the fishery were difficult to assess. This was suggested to be attributed to the poor utility of the FADs driven by fear off offshore fishing, little interest in tuna species and lack of education. This study has found that despite a well-developed FAD programme, the FADs appear underutilised.

4.3.4.17. La Réunion

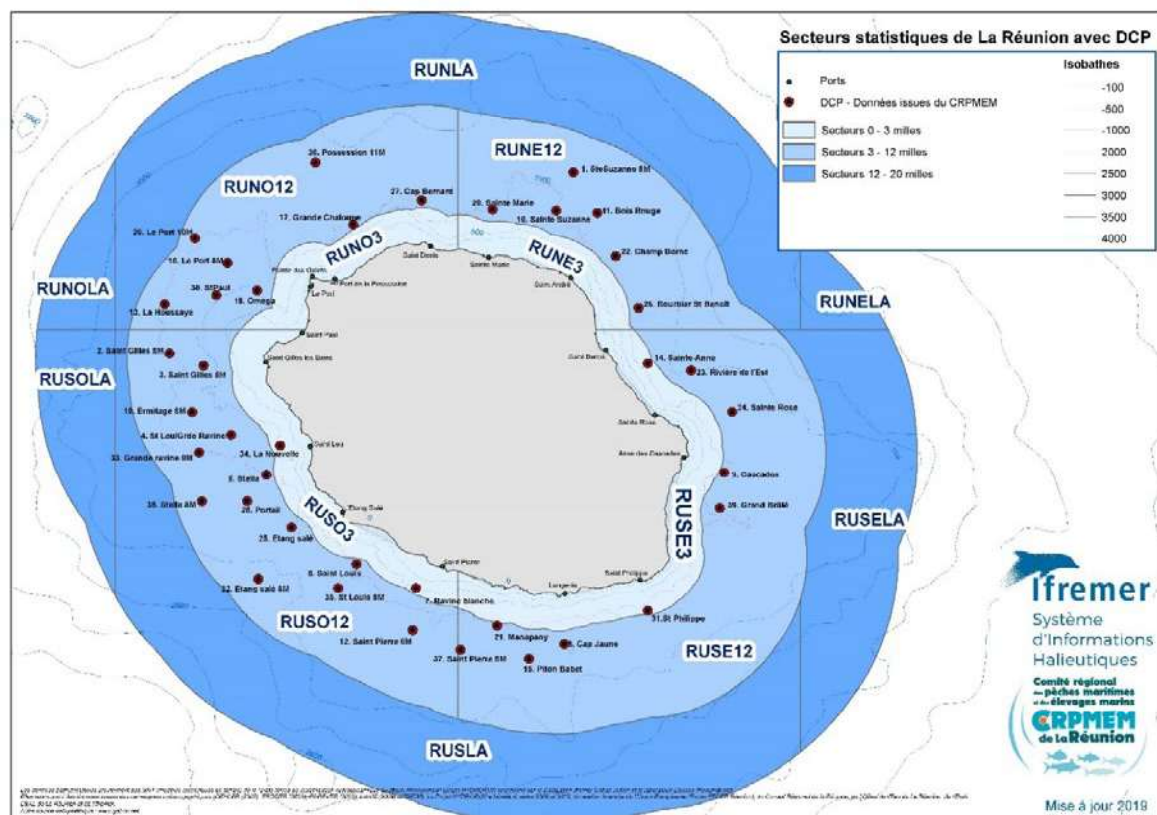
AFADs were first trailed in La Réunion in 1988 as a way re ‘revitalise’ the fleet after the small-scale and commercial sectors faced difficulties due to falling landings and income, leading to a mass disaffection of fishers from the sector. This was initially funded by the La Reunion region, and later co-funding from the

¹⁵ <https://sih.ifremer.fr/Donnees/Donnees-brutes-des-fiches-regionales>

EU was used to develop, install and maintain the AFAD park (Zanella et al., 2019).

With 11 deployed in 1988, 30 were installed by 1995, and a further 6 were added by 1997 (Zanella et al., 2019). The most UpToDate information on the number of AFADs in Reunion is from Le Roy et al., (2020) who published a map Figure 28 illustrating the position of the AFAD array dated 2019. The map illustrates 39 AFADs, with the majority situated in the zone 3 – 12 miles from the coast, except for 4 on the outer edge of the 0 – 3-mile zone.

Figure 26. Map of AFAD locations in La Reunion, published in 2019



Source: Le Roy et al. (2020)

<https://archimer.ifremer.fr/doc/00628/74013/73336.pdf>

<https://archimer.ifremer.fr/doc/00109/22027/>

Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

A 2012 study by Guyomard et al., (2012) presents a breakdown of the vessel length classes used in Reunion but does not directly discriminate those that fish AFADs. That study found that 78 % of the surveyed fishers (n = 103) said they practise FAD fishing throughout the year, with only 4 % saying they fish FADs

only a few months of the year. Figure 29 provides an estimate of the proportions of the gears used around AFADs in Reunion, indicating the main gears used around Reunion were drifting and vertical longlines and trolling. These gears are also noted by Zanella et al., (2019), expressing that the AFAD fishery is a hook and line only fishery, using handlines, trolling lines and vertical and drifting longlines.

Figure 27. Map of fishing gears used at FADs.

LTLGP - large pelagic drifting line; LHPGP - large pelagic handline; LVDGP - large pelagic vertical longline; LHPPG - small pelagic handline; LLDDP - surface drifting longline; LHDMX - groundfish handline; LLSDX - groundfish longline.

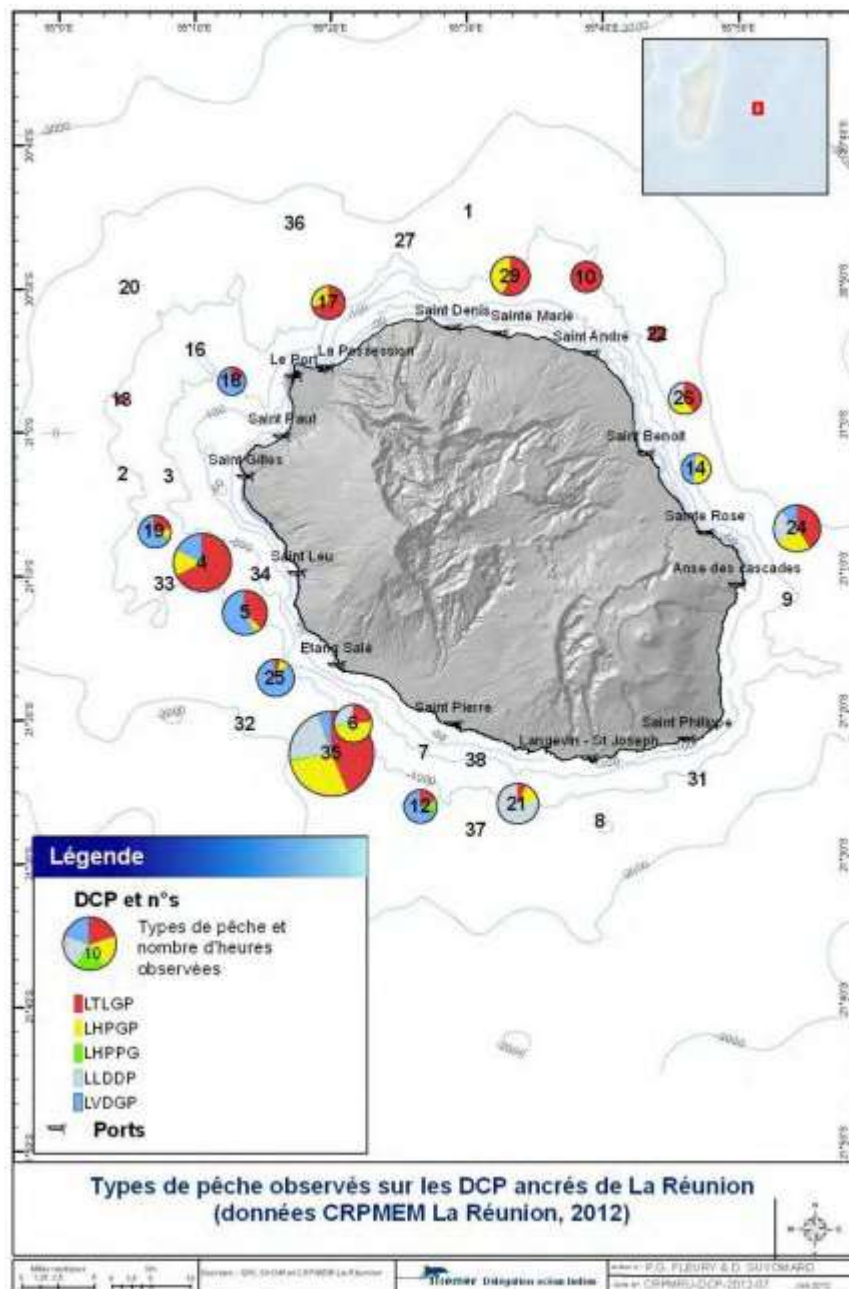
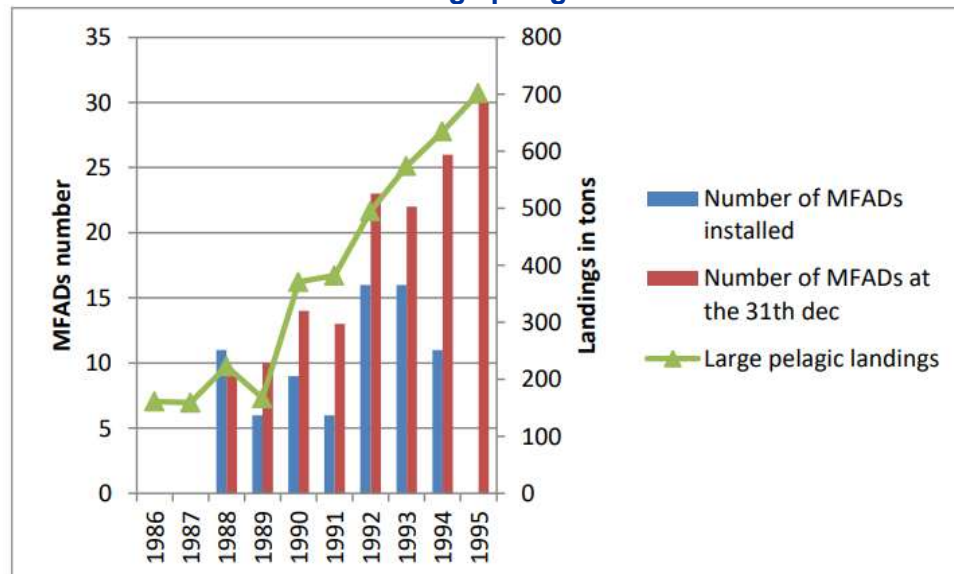


Figure 29 illustrates the historical trend in the number of AFADs in conjunction with the landings of large pelagic species, demonstrating the increased capture volume attributable to the use of these devices.

Figure 28. Number of FADs deployed between 1986 and 1995 alongside landings of large pelagics



Source: Zanella et al. (2019)

Data regarding fishing directly at AFADs was difficult to identify, except for a 2011 – 2012 study referenced in Zanella et al., (2019) (although not available publicly online; Pernak & Rodriguez, 2012). Findings included Catch per Unit Effort in number and weight around the AFADs, also discriminated by depth (mentioned in the next section: 0).

Guyomard et al., (2012) provides the most detailed description of effort used at AFADs in La Reunion.

Figure 31 provides a summary of the effort used at and around AFADs, along with estimates of CPUE expressed in kg/hour. A more detailed summary is provided in Figure 32, where the CPUE for each of the 38 FADs is provided along with the number of months a particular FAD is used.

Figure 29. Fishing time, share of sequences with non-zero catches and intervals CPUE by sequence class

Sequence Classes (Off-Road and Drift)	Total number of sequences	Duration total (fishing time; hours)	Number of sequences with non-zero fishing	Duration of sequences with non-zero fishing (hours)	% of sequences with non-zero fishing	% duration of sequences with non-zero fishing	CPUE range (mean $\pm$ 95% CI) (kg/hour)
Bottom fish	9	23.97	6	20.88	66.66%	87.10%	2.35-3.53
Hand line	7	15.31	5	12.88	71.42%	84.12%	1.85-3.95
Longline	2	8.66	1	8	50.00%	92.37%	2.37-3.63
Large pelagic	197	166.99	43	64.52	21.82%	38.63%	4.6-4.92
surface	179	145.24	40	58.23	22.34%	40.09%	3.72-3.9
Train	138	107.94	28	38.61	20.29%	35.77%	3.91-4.19
Hand line	28	20.78	8	11.37	28.57%	54.71%	2.72-3.3
Surface longline	13	16.52	4	8.25	30.77%	49.94%	2.46-3.94
Depth (Vertical longline)	18	21.75	3	6.29	16.66%	28.92%	7.88-14.46
-							
Total sequences							-
On DCP	119	100.44	36	52.5	30.25%	52.27%	6.97-7.61
Out of DCP	100	100.33	14	33.48	14.00%	33.37%	1.29-1.41
Big pelagic							
On DCP	114	98.46	36	52.50	31.58%	53.32%	7.1-7.78
Out of DCP	83	68.53	7	12.02	71.42%	8.43%	0.86-1
Train							
On DCP	57	41.59	22	28.44	38.59%	68.38%	8.76-9.62
Out of DCP	81	66.35	6	10.17	7.40%	15.32%	0.76-0.9
DCP <5 miles	44	22.01	17	9.33	38.63%	42.39%	7.52-9.18
5nm <DCP<=7nm	57	53.45	15	32.57	26.31%	60.93%	4.44-4.96
DCP>7nm	32	24.98	4	10.6	12.50%	42.43%	9.62-13.78

TABLE 21: FISHING TIME, SHARE OF SEQUENCES WITH NON-ZERO FISHING RESULTS AND INTERVALS CPUE BY SEQUENCE CLASSES

Source: Guyomard et al. (2012)

Figure 30. Duration of time spent fishing at individual AFADs with estimated CPUE expressed as kg/hour and number of months utilised

DCP No.	Duration of sequences (h)	% of sequences with non-zero fishing	CPUE range (mean $\pm$ 95% CI) (kg/hour)	Months exploited
1	x	x	x	x
2	x	x	x	x
3	x	x	x	x
4	12.73	55.61%	6.63-9.57	10,11,12,1,2
5	7.28	36.81%	4.11-5.91	8,12
6	4.82	46.26%	5.39-9.69	10,11,1
7	x	x	x	x
8	0.00	-	-	-
9	x	x	x	x
10	3.58	100%*	0-27.92	11
12	3.34	0%	0	2
13	0.25	0%*	0	11
14	3.18	0%	0	8
16	x	x	x	x
17	3.98	71.10%	0.65-5.85	10,11
18	2.83	17.67%	0-53.51	1
19	3.80	30.52%	4.28-19.92	11,12
20	x	x	x	x
21	5.43	74.95%	4.54-7.24 0	1
22	0.83	0%*		8
24	8.06	51.61%	1.79-3.17	1,2
25	5.07	88.75%	31.44-42.72	10,12
26	3.76	36.17%	0.71-4.59	8,1
27	0.00	-	-	-
29	5.55	70.63%	7.87-15.51	2
31	0.00	-	-	-
32	x	x	x	x
33	0.00	-	-	-
34	x	x	x	x
35	25.95	55.60%	2.78-3.88	8,10,11,2
36	x	x	x	x
37	x	x	x	x
38	x	x	x	x

: a single sequence, therefore not significant
X: DCP absent

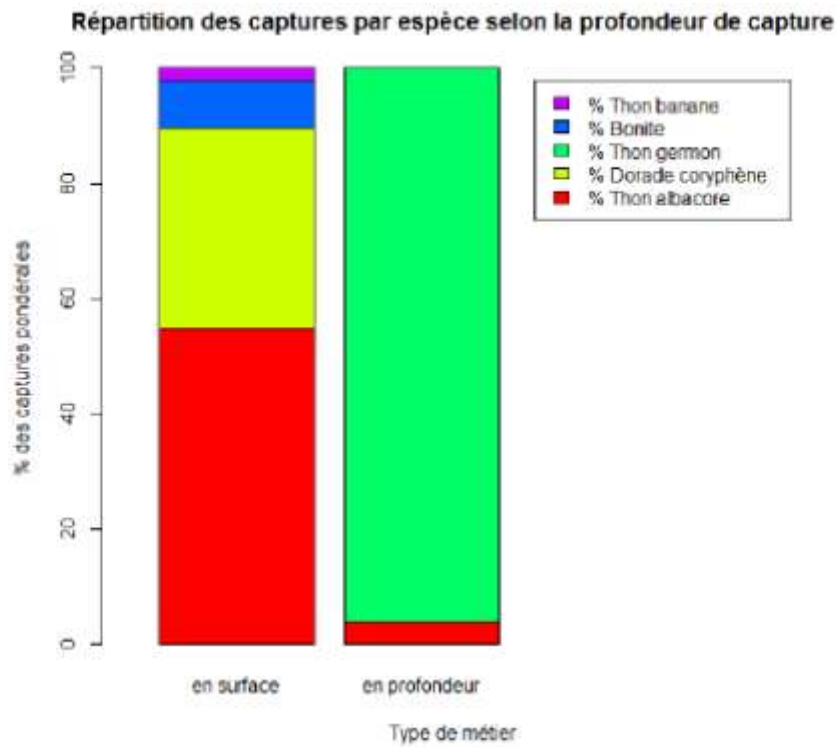
TABLE 22: FISHING TIME, SHARE OF SEQUENCES WITH NON-ZERO FISHING RESULTS, INTERVALS OF CPUE AND MONTHS EXPLOITED BY DCP

Target Fishing Grounds (i.e. Spatial temporal variability)

A 2011 – 2012 study referenced in Zanella et al., (2019) (although no available publicly online; Pernak & Rodriguez, 2012)) used representative gears of the AFAD fishery to study the spatio-temporal distribution of pelagic species around AFADs between August 2011 and February 2012. The study also collected information of the species caught on/near the surface and those caught at deeper depths (0-15 m and 50 – 100 m). Mainly large albacore and yellowfin were caught at depth, while dolphinfish, skipjack, yellowfin and wahoo of low to

medium weights were caught on the surface). Furthermore, the volumes of catches were far greater near the FAD than further away (Figure 33). Seasonal trends in CPUE were characterised with marked seasonality for albacore tuna.

Figure 31. Distribution of catches by depth (0 – 15 m and 50 – 100 m) for all species caught



Source Guyomard et al. (2012)

Figure 32. Distribution of large pelagic species according to fishing on or off FADs

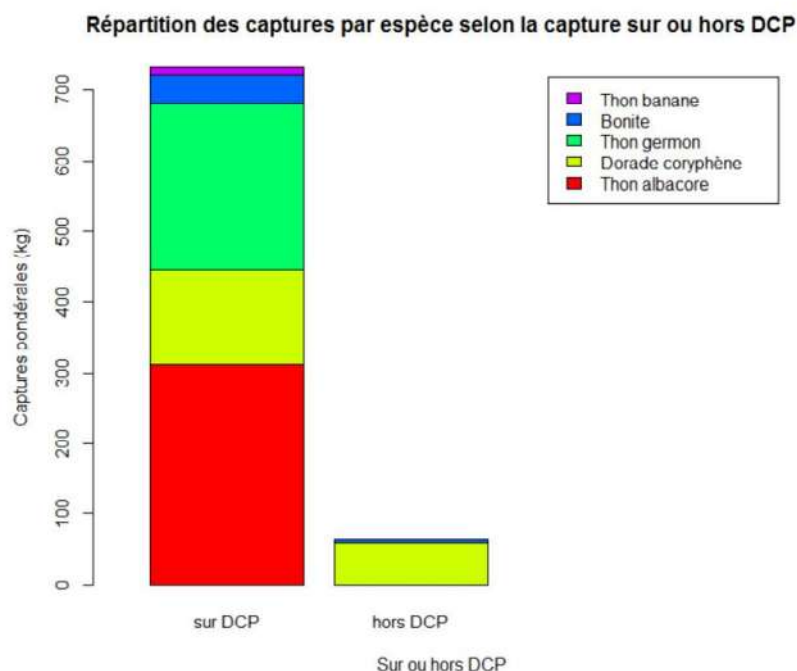


FIGURE 89: DISTRIBUTION OF LARGE PELAGIC SPECIES ACCORDING TO FISHING ON OR OFF FADS

Source: Guyomard et al. (2012)

Target Species (i.e. Catch)

Recent reporting breaking down the catch by species were not found this through this study. However, some information of the species caught through the surveys conducted in 2011 - 2012, as well as a review paper (Zanella et al., 2019).

Zanella et al., (2019) summarises the gear and main species targeted through the trails at the time, indicating the main species caught were oceanic whitetip (*Carcharhinus longimanus*), Yellowfin, shortfin mako (*Isurus oxyrinchus*), Albacore, dolphinfish, Oilfish (*Ruvettus pretiosus*), *Thyrsites sp*, rainbow runner and skipjack.

Table 24. Main gears used, depth of operation and main target species for a number of research projects on FADs in La Reunion

GND – Gillnets drifting; LLD Longling drifting; LHD verticle handline; LTL – Trolling lines.

Gears type used (FAO code)	Period	Depth of operation (m)	Type of target species	Main species in trials
MFAD	LLD (1989-1990)	0-150	Large pelagic	<i>C. longimanus</i> (3) <i>H. Pelamis</i> (1)
	LLD ou LHD (vertical line) (1989-1990)	0-200	Large pelagic	<i>C. longimanus</i> <i>Thunnus albacares</i> <i>L. Oxyrinchus</i> <i>Thunnus allalunga</i> <i>C. Hippurus</i> <i>R. pretiosus</i> <i>Thyrsites sp.</i> <i>E. bipinnulata</i> <i>K. Pelamis</i>
	GND (1989-1990)	0-20	Large pelagic	
	LTL (1989-1990)			
	LTL, LLD, 2012		Large pelagic	

A technical and economic study by reports the species caught at AFADs with the largest volumes are attributed to yellowfin and albacore Table 24. Other species caught include bonito (unclear what exact species), dolphinfish, and wahoo (*Acanthocybium solandri*).

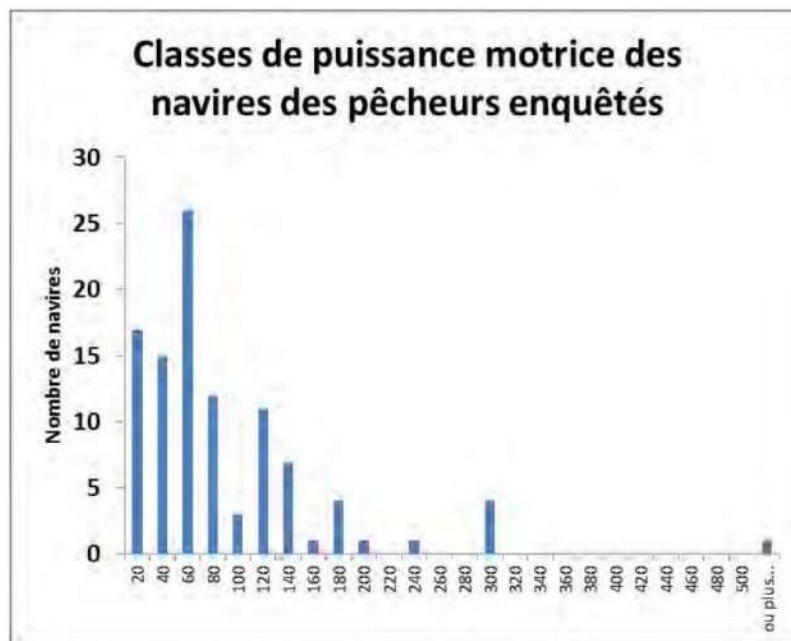
There is additional information suggesting that fishers practiced fishing for small pelagics for the use as livebait to specifically be used on the AFADs. When surveyed by Guyomard et al., (2012), 87% said they used livebait, of which 68% buy and/or fish for themselves (90 %).

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

A 2012 socio-economic study surveyed nearly half the fisher population of La reunion, showing at the time, an aging fisher population (average = 47 years old). The survey highlighted the dependency of the fishers to the FADs, with around 50% of indicating they were indispensable, and further 45 % indicating they were ether important or very important.

The distribution of engine power was also reported by Guyomard et al., (2012) finding the modal engine power to be 60 HP (Horse power), with maximum of 800 HP found for the large recreational angling vessels (Figure 35).

Figure 33. Distribution of vessel engine power (HP) of the fisher surveyed (n=103)



Source: Zanella et al. (2019)

Within the paper by Zanella et al., (2019), socio-economic data from IFREMER data is reported. In it, data between 2010 and 2017 is presented in a series of graphs describing the number of vessels, number and duration of trips and capture volume and value (EUR) both annually and by trip. However, despite the gears referenced (Handline, drifting vertical line, and trolling) being associated with FADs, it is unclear whether the referenced data is data directly attributed to catches from AFADs. They do, however, estimate an indicator for the average CPUE per trip to be 30.8 kg per trip based on data from 2010.

4.3.4.18. Mozambique

In communication with an in-country stakeholder, it was expressed that currently Mozambique does not have any AFADs installed along its coastline. However, they express that there are thoughts in place to deploy them, but are currently at their infancy stage and having to go through aspects including viability studies before they can be implemented.

Historically, a 2011 report mentions a future deployment of 2 AFADs as part of a SWIOF project (Failler, 2011). No further information of these FADs was found.

A website page of MacAlister Elliott and Partners indicates a further three were deployed in 2019 outside of Palma Bay in 300 m of water. This appears to part of a wider programme sponsored by TOTAL, with a 2022 report suggesting that all three remained in position up until publication, and are believed to be successfully aggregating fish, although further UpToDate information is not available (Lima et al., 2022).

4.3.4.19. Oman

The use of AFADs in Omani waters was not identified through this study's systematic literature review. No response was received from an Omani stakeholder despite making several attempts.

4.3.4.20. Pakistan

The use of AFADs in Pakistani waters was not identified through this study's systematic literature review. A stakeholder response stated that Pakistani fishers do not utilise AFADs in their operations but that the Marine Fisheries Department would like to explore the possibility of deploying them on a limited basis for the purpose of research.

4.3.4.21. Seychelles

In correspondence with a relevant Seychelles stakeholder, it was found that AFADS are not currently used in Seychelles waters, but expressed that there are plans to deploy "a few" soon. No further information was provided (SFA, pers comm, 2024).

4.3.4.22. South Africa

In correspondence with a relevant South African stakeholder, it was found that AFADS are not currently used in South African waters. It was expressed the AFADs are not permitted for use within South African fisheries (DFFA, pers comm, 2024).

4.3.4.23. Tanzania

Despite a number of emails, no response was received from a Tanzanian stakeholder. Despite this, this research was able to identify that Tanzania does use AFADs.

Nether the 2024 nor the 2023 Tanzania National report to the IOTC SC has any mention of FADs or FAD use. The 2022 national report to the IOTC does mention FAD use, stating that there are a number of FADs which can be used within the licence period given to a fishing vessel, and that there are additional fees associated with the use of particular FADs (Yahya et al., 2022). However, no indication is given explaining if they are referring to drifting or anchored FADs.

Contemporary data on the use of AFADs in Tanzania is in short supply. Much of the information regarding their use comes from two report papers (Richmond et al., (2006) and Failler et al., (2011).

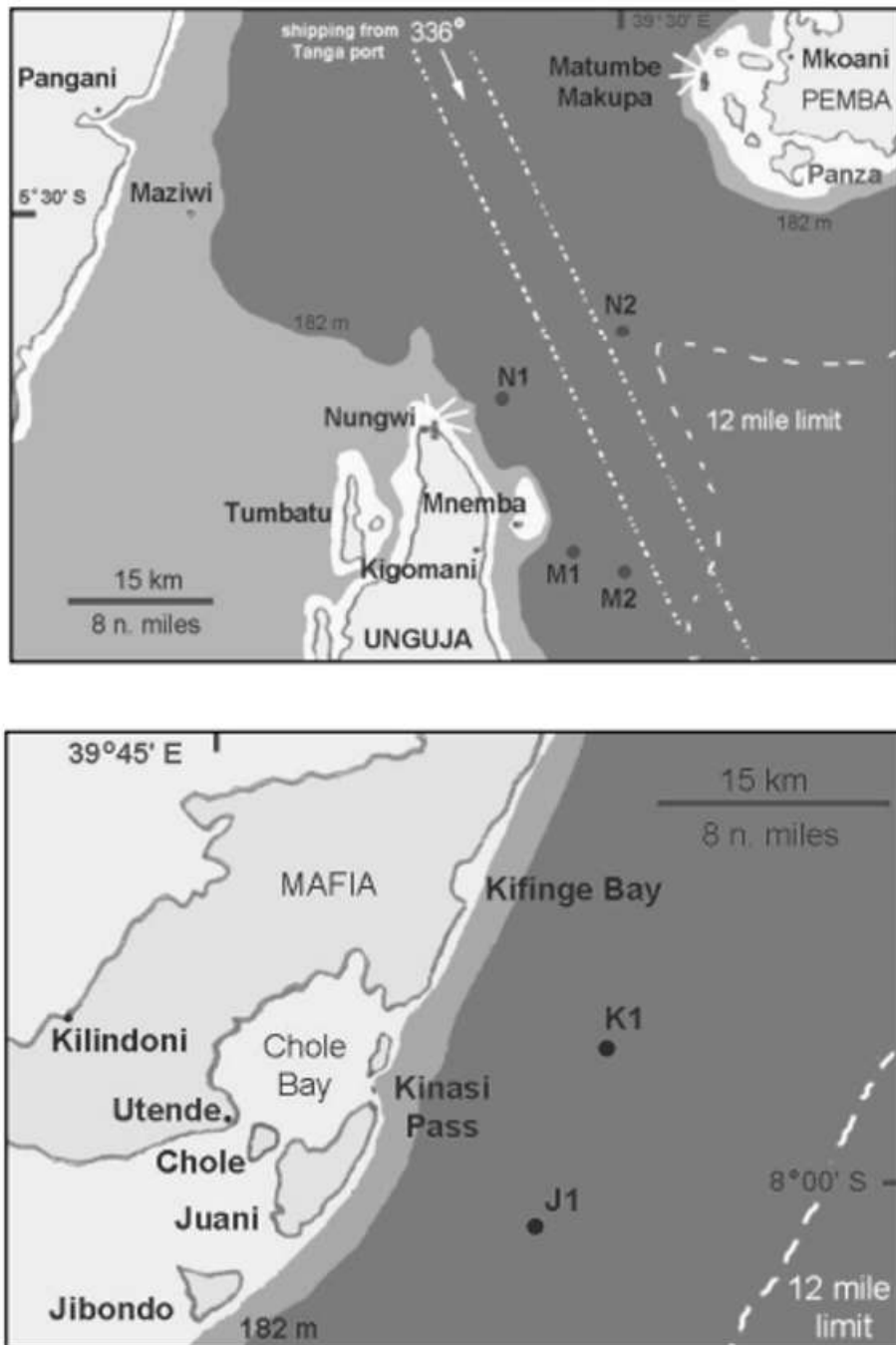
In 2005, 6 AFADs were deployed (Table 25). Four of them were deployed off the coast of Zanzibar (-upper) and 2 off the coast of Mafia Island Figure 36-lower). The initial project did include fisheries monitoring surveys, but were not able to be conducted through a whole year to provide seasonal variation. (Richmond et al., 2006).

Table 25. Names, positions and water depths of Tanzania Fads deployed in March 2005

FAD Name	ID	Lat. new	Long. New	Depth (m)
Nungwi 1	N1	5 ⁰ 41.011'	39 ⁰ 23.791'	300
Nungwi 2	N2	5 ⁰ 37.079'	39 ⁰ 30.055'	650
Matemwe 1	M1	5 ⁰ 50.716'	39 ⁰ 27.570'	400
Matemwe 2	M2	5 ⁰ 52.135'	39 ⁰ 30.794'	650
Kinasi	K1	7 ⁰ 56.330'	39 ⁰ 55.078'	500
Juani	J1	8 ⁰ 02.300'	39 ⁰ 52.570'	530

Source: Failler et al. (2011)

Figure 34. Tanzania FAD locations 2005. Upper – Northern Unguja and southern Pemba island; lower Eastern Mafia Island



Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

With information gathered at the time, Failler et al., (2011) found the main types of gear to be used around the AFADs to be troll lines and midwater longlines.

No information regarding effort or numbers of fishers using AFADs was identified.

Target Species (i.e. Catch)

As mentioned above, fishing trials were performed within the deployment programme, but sampling was limited (Richmond et al. 2006). Tuna species were spotted in the general areas, but none were caught directly at the FADs. Sampling was conducted across at landing sites close to the FADs, but no indication is given if these catches are attributed to the AFADs, or whether there was an increase in landings compared to before their deployment, with the exception of one species – Giant barracuda (*Sphyraena barracuda*) caught at “Nungwi 1 FAD”.

A survey was planned as part of a wider SWIOFP research study to survey pelagic species of Tanzania coast, with plans to survey the AFADs. Unfortunately, the surveys were abandoned as the FADs were lost (Groeneveld et al., 2013)

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

No information was identified through this study regarding the socio-economic background of AFAD fisheries in Tanzania.

4.3.4.24. FAO Area 57: Eastern Indian Ocean

This section presents country profile information for coastal and island States operating within the Eastern Indian Ocean (FAO Area 57). Where data is available, profiles provide an overview of AFAD characteristics, fleet composition and gear types, spatial and temporal deployment trends, and socio-economic dimensions.

AFAD use across Area 57 varies considerably. Some countries have established and relatively well-documented AFAD programmes, while others show limited or no engagement in AFAD deployment. The study identified active AFAD use in the following countries:

- Australia
- Indonesia
- Malaysia
- Thailand
- Timor-Leste

In contrast, the following countries were not found to be currently deploying AFADs in Area 57:

- Sri Lanka

- Seychelles
- Tanzania
- India
- Bangladesh

The country profiles that follow offer further detail on national approaches, available data, and key gaps in knowledge related to AFAD fisheries in this region.

4.3.4.25. Australia

The management of AFADS across Australia are devolved to the territories, each developing and managing their own for the specific needs. Not all Australian territories are found within Area 57, and in-fact only Western Australia, South Australia, Victoria and Tasmania sit within Area 57. A common aspect of AFAD in Australia is that they are deployed specifically to benefit recreational fishers, rather than the commercial sector.

Through reaching out to an Australian stakeholder, data were shared by Department of Primary Industries and Regional Development. These data showed a total of 153 AFADs anchored in throughout Australian waters. Situated at sites with depths ranging between 6 to 306 m (mean = 93 m) and distances from shore ranging from 3 to 15 km.

In Western Australia, AFADs are being used as part of a support package to enhance the West Coast Demersal Scalefish Resource recovery plan. The AFAD programme aims to offer recreational fishers alternative targets, thereby enabling them to shift their catch and target species to facilitate the recovery of heavily exploited demersal stocks.

Based on the designs used in Victoria territory, AFADs are secured to the ocean floor using a standard anchor and tether design consisting of three components: headgear, mooring line, and anchor. The headgear features a highly visible yellow 'Aqua Float 800' buoy fitted with a 'Sealite SL15' LED, visible up to 1-2 nautical miles at night. The mooring line forms a catenary (S-shaped) curve using a combination of chain, sinking nylon line, and floating polypropylene line. This configuration provides slack to withstand ocean swells and currents, preventing the Sarca anchor from dislodging (Womersley & Green, 2022).

Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

Australian fisheries utilising AFADs appear to be primarily designed for and targeted by recreational fishers, with no information available regarding their use in commercial operations.

Target Fishing Grounds (i.e. Spatial temporal variability)

AFADs in Australia are largely situated within 6 – 36 km from the shore in depth ranges of 7 to 300+ metres. Used largely throughout the austral summer month, many of the AFADs are removed over the winter period for maintenance in Western Australia. In contrast, Tasmania's AFADs are left out year-round (although only deployed in 2023).

Target Species (i.e. Catch)

Due to the scale of Australia, species catch characteristics somewhat vary depending on the territory. In Victoria catches are predominantly made up from tuna, including southern bluefin (*Thunnus maccoyii*) and yellowtail Kingfish (*Seriola lalandi*) (Womersley & Green, 2022).

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

Reporting on the socio-economic aspects of AFAD use by recreational fishers is somewhat limited. The territory of Victoria reports that their AFAD programme has been a success, and that schools of Kingfish and tuna are common over the summer months. Characteristics of fuel used, employment numbers and catch value are not available. This is likely this is due to the nature of recreational fisheries, which often lacks the same level of reporting as compared with commercial fisheries.

4.3.4.26. Indonesia

Today, Indonesia is the world's largest tuna producer, generating approximately 1.1 million metric tons of tunas annually. This output represents roughly 15-17% of the total global tuna supply (FAO, 2024).. The use of anchored Fish Aggregating Devices (AFADs) in Indonesia is widespread, with both officially and unofficially devices deployed across Indonesian waters.

Various estimates have been published regarding the number of AFADs. Scott and Lopez (2014), among others, reported 3858 official AFADs, though the accuracy of this classification remains unconfirmed (Proctor et al., 2019). Proctor et al. (2019) suggested a more realistic estimate at the time to be between 5000 and 10000 AFADs. A recent study using satellite imagery from 2020 across three Fishery Management Areas (FMAs 713, 714, and 715) identified 661, 608, and 291 AFADs in these FMAs, respectively (Widodo et al.,

2023. However, these figures are likely underestimates due to imaging limitations in detecting objects smaller than 5 metres.

The characteristics of AFADs in Indonesia are diverse but follow the same general three or four component design consisting of a float, mooring lines, an anchor and often some kind of subsurface fish attractor. Two sub-types of anchored FADs are known to exist – surface and subsurface – although the latter was only first documented in Indonesian waters in 2018 (in conflict with national regulations) (Proctor et al., 2019). The most prevalent sub-type is without a doubt the surface type. Of those, however, three main designs are used:

7. Pontoon style steel cylinders (*ponton*)
8. Bamboo rafts (*rakit*)
9. Large cylinders or blocks of Styrofoam (*gabus*)

The pontoon-style steel cylinder design is straightforward, typically using a steel cylinder approximately 2–3 metres in length and 0.8 metres in diameter, often with a single conical end. At one time, this was the most commonly used AFAD style in Indonesia.

In contrast, the bamboo raft design, or *rakit*, is the most sophisticated style in current use. Many of these rafts incorporate onboard accommodation, allowing custodians to reside on them for extended periods—often weeks or months—which necessitates regular supply deliveries. These rafts are predominantly found in eastern Indonesia and, as of 2019, have not been observed in the western part of the country (Proctor et al., 2019).

The third common style is the *gabus* type, which uses large Styrofoam cylinders or blocks bound with rope or car tires and reinforced with a wooden frame. This style has become the most widely used AFAD design across Indonesia in recent years due to its simplicity and cost-effectiveness (Proctor et al., 2019).

Most AFAD designs share a key feature: the inclusion of "fish attractors". (Widyatmoko, 2018; Proctor et al., 2019 Widodo et al., 2023). Typically made from natural materials like bunches of palm fronds, these attractors are suspended below the surface to create structure around which fish can aggregate. However, Proctor et al. (2019) found that in some cases, synthetic materials, such as plastic-based nets, were used, despite regulations requiring only biodegradable materials.

Anchors are usually made up from 60 – 80 kg concrete block with embedded attachment points. Each block is used in conjunction with others, to create a cluster of blocks, forming a single anchor of around 2 – 3 tonnes.

The material used for mooring lines is usually made of synthetic rope, occasionally with a wire core, with a diameter of 2.5 – 4 cm (Procter et al., 2019). Other, lesser quality, smaller diameter rope is also sometimes used, particularly with the simpler 'gabus' float style. In any case, fishers will use 1.2 – 1.5 times more rope material than the water depth to mitigate damage from oceanographic impacts such as strong current, tide and winds (Widodo et al., 2023).

Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

Tuna fisheries associated with AFADS in Indonesia are diverse in character. The main gear types used include purse seine, pole and line, hand-line, troll and surface fishing using kites and lures (Procter et al., 2019).

A study in the waters of FMA 713–717 found two sizes of purse seine fleets operate there: smaller vessels under 30 GT, referred to as "mini purse-seine" or locally known as "pajeko," and larger purse seine vessels over 30 GT, called "kapal pukat cincin." Similarly, pole and line (PL) vessels operating around FADs are also divided into two main types: smaller vessels under 20 GT, commonly known as 'funae,' and larger vessels over 20 GT, referred to as 'huhate.'

Hand-line, troll-line, and kite fishing are typically carried out by a single vessel type known as multigear vessels, which switch between different fishing gears based on the season, sea conditions, and catch success. These vessels, usually wooden-hulled and ranging in size from 6 to 10 GT, are locally called "penongkol" in northern and southeastern Sulawesi, and "sekoci" in Bali and east Java. These vessels and their fishing methods originated from southern Sulawesi, developed by Bugis fishermen, and have since spread to many regions across the Indonesian archipelago.

Another type of tuna hand-line vessel commonly used in eastern Indonesian waters, particularly in northern Sulawesi, are 'pump boats.' These vessels function as 'mother vessels,' carrying several small boats (sampan) on board during travel to the fishing grounds. In southern Sulawesi and southeastern Sulawesi, some hand-line/troll vessels have adopted this method, often carrying 6 to 8 sampans to catch both large tunas, such as yellowfin (up to 100 kg), and smaller tunas.

Based on port sampling between 2013 and 2016 of four representative Indonesian ports (in regard to gear types and geographic distribution) the majority of the sampled trips were for handline/troll vessels, which are carried out more in the eastern waters (Procter et al., 2019). Purse seine and pole and line was found to be more commonly carried out in the central and western ports, which coincides with where carrier vessels were observed.

Target Fishing Grounds (i.e. Spatial temporal variability)

The spatial and temporal variability of AFADs appears to be diverse. It is generally understood that AFADs are located in coastal areas, situated less than 15 nautical miles from land (Nurdin et al 2012; Widyatmoko, 2018). The distance between AFADs has been the subject of a previous study that looked into three Indonesian Fishery Management Areas (FMA)(FMA 713, 714 and 715). That research found that, on average, AFADs were placed a distance of less than 10 nautical miles, breaching the regulation stated in Minister of MMAF Decree No. 26/Permen KP/2014 on FADs, which requires a minimum distance of 10 nm between each FAD. For example, in each of the three FMAs, the minimum and maximum distances ranged from 0.8 to 33.0 km, 0.4 to 40.0 km and 0.4 to 33.0 km for FMAs 713, 714 and 715, respectively (Widodo et al., 2023).

Target Species (i.e. Catch)

Of the four ports sampled by Procter et al., (2019) over a four-year period, the ports of Padang and Palabuhanratu are the most relevant to the Indian ocean based on their geographies. Sampled catches from handline/troll vessels from these ports find that pelagic species, largely tuna, make up the majority of the catch. These species include: Skipjack, Yellowfin, Striped Marlin, Bigeye tuna, Mahi-mahi, albacore tuna and Frigate/bullet tuna. Across both these ports, it is reported that a substantial proportion of the catch is made up from juvenile yellowfin and bigeye tuna. Across 3 months in 2013 at the Palabuhanratu port, sampling found juvenile yellowfin and bigeye, combined, made up around 60% of the total catch.

Other studies have found similar findings regarding typically caught species. A review by Karama and Matsushita, (2019) found the main targeted species including yellowfin, skipjack mackerel, scads, carangids and sardines.

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

The number of fishers involved in Indonesian AFAD fisheries is not well reported, particularly within the small-scale sector, where tuna fisheries are dominated by small-scale and artisanal vessels (<5 GRT) that account for approximately 90 percent of the total registered tuna vessels (Sunoko & Huang, 2014; Widyatmoko, 2018). This is somewhat a factor of the transient nature of particularly the tuna fisheries, acting as a driver of fisher movement depending on the season and associated fish movement and migrations. Approximately 90% of vessels used troll line in 1979 with that rate reducing to 67% by 2009. Concurrently, longline and pole and line represented 0 and 1%, respectively, in 1979 and increased to 8% and 10% in 2009 (Sunoko & Huang, 2014).

Widyatmoko (2018) found that economics play a strong role in catch composition and are affected by relationships among FAD owners and communities. The study revealed that fishermen adjust their fishing strategy during trips to minimize financial risk, which implies that port sampling will likely be a biased measure of catch rates. Widyatmoko (2018) demonstrated that the use of large numbers of FADs serves as an indicator of low catch rates, with the relationship between FAD visitation patterns and trip length being tied to the underlying economics of the fishery. The research identified complex social relationships that affect FAD use and sharing, which may translate into bias in port sampling, FAD use patterns, and other metrics that are important for fisheries management. These social dynamics among FAD owners and communities were found to influence fishing strategies and catch composition, creating additional complexities in understanding the true socioeconomic impacts of the fishery. Widyatmoko (2018) concluded that the economically driven behavioural adaptations of fishermen suggest that traditional monitoring approaches may not capture the full picture of fishing operations, proposing that an estimator for catch built from FAD visitation and trip length could provide a useful proxy for both stock status and a quality check on logbook or port sampling data.

4.3.4.27. Malaysia

Despite a few emails, no response was received from a Malaysian stakeholder. Despite this, this research was able to identify that Malaysia does use AFAD within their fisheries.

AFADs or “unjang” have been traditionally used in Malaysia for many years with Jani, (2015) citing reports dating back to 1975. The definition of “unjang” in the literature often does not differentiate between those set on the bottom to create artificial reef style structures and those with floating structures. A distinction is made by Ahmad et al., (2004) stating that “unjang” is the widely used term for a variety of fish aggregating devices, including sunk material on the bottom. While “Unjam” refers to the devices set up by the Malaysian Board of Fisheries Development. It’s said that the majority of the traditional style AFADs, made from local, mainly natural materials do not have a long-life expectancy (changed every 6 – 8 weeks) (Ahmad et al., (2004).

Information regarding the number of AFAD in Malaysian waters is not well understood based on the information available. A guide, published by the Department of Fisheries Malaysia and Marine Fishery Resources Development and Management Department, describes 66 AFADs being installed in 2003, with the average cost per AFAD around \$312.5 (Ahmad et al., 2004). No information is provided on the location of these 66 FADS, but studies related to AFADs do include some location data for deployed AFADs (Hasaruddin et al.,

2015; Rosdi et al., 2018). Furthermore, the Fisheries Development Authority of Malaysia (FDAM) installed artificial reefs (unclear if they include AFADs), at over 550 sites across Malaysia by 2010 (Azmi and Yazid 2008). However private individuals and fisher groups have deployed several hundred FADs in various coastal areas of Malaysia during this time. The coastal public waters have been gradually privatized through the construction of FAD or ARs in coastal waters in Malaysia. The number of AFADs is thus currently unknown with no estimate available.

At the time of writing, Ahmad et al., (2004) stated that all the AFADs in the coastal waters of the east coast peninsular of Malaysia are set by the government, but are to be common property of the people. They were introduced as a form of indirect subsidy to enable fishers a fresh supply of fish throughout the year, particularly through the northeast monsoon season.

Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

Minimal information is available regarding the gears, effort and number of fishers utilising AFADs in Malaysia. The 2004 report from the Malaysian government provides a guide on how to make and set AFADs and briefly discusses the type of species caught from them (Ahmad et al., 2004). Fish species caught from the AFADs included: mainly groupers, red snappers, sweetlip, Indian mackerel, Spanish mackerel, barracuda, scads, yellow snapper, nemipterids, trevally, starry trigger fish, dolphin fish and sharks. The species caught is said to be dependent on the gear used. For example, fishers using trolling lines largely caught Spanish mackerel and dolphinfish, while those using handlines caught mostly grouper and snapper. The use of livebait is also suggested. Scientific/Latin names were not reported.

Target Fishing Grounds (i.e. Spatial temporal variability)

The areas in which AFADs are located is poorly documented across Malaysia. However, it is documented that the earlier mentioned 66 FADs installed in 2003 were arranged in clusters with 25 deployed in each location, about 10 m apart.

The study area described by Hasaruddin et al., (2015) shows AFADs deployed in the waters of the East coast of the Malaysia Peninsular, around Bidong Island (Figure 37). The longitudinal and latitudinal positions of these AFADs can be found in Table 26Table 26.

Table 26. Positions of 9 AFADs located around the Island of Bidong, in the waters of the east coast Malaysia

GPS Coordinates of the sampling stations for aggregating devices

<i>Station</i>	<i>Latitude</i>	<i>Longitude</i>
1	5°35'935" N	103°07'309" E
2	5°38'060" N	103°06'364" E
3	5°38'422" N	103°04'062" E
4	5°37'899" N	103°02'870" E
5	5°38'355" N	103°00'952" E
6	5°40'081" N	103°00'471" E
7	5°40'027" N	103°06'322" E
8	5°40'250" N	103°03'896" E
9	5°40'150" N	103°02'408" E

Source: s et al. (2015)

One other study with the locations of AFADs was identified, with 4 “midwater” AFADs described by Rosdi et al., (2018). No description of the area is provided and basic information such as their depths is missing.

Figure 35. AFAD location around the Island of Bidong, in the waters of the east coast Malaysia peninsular

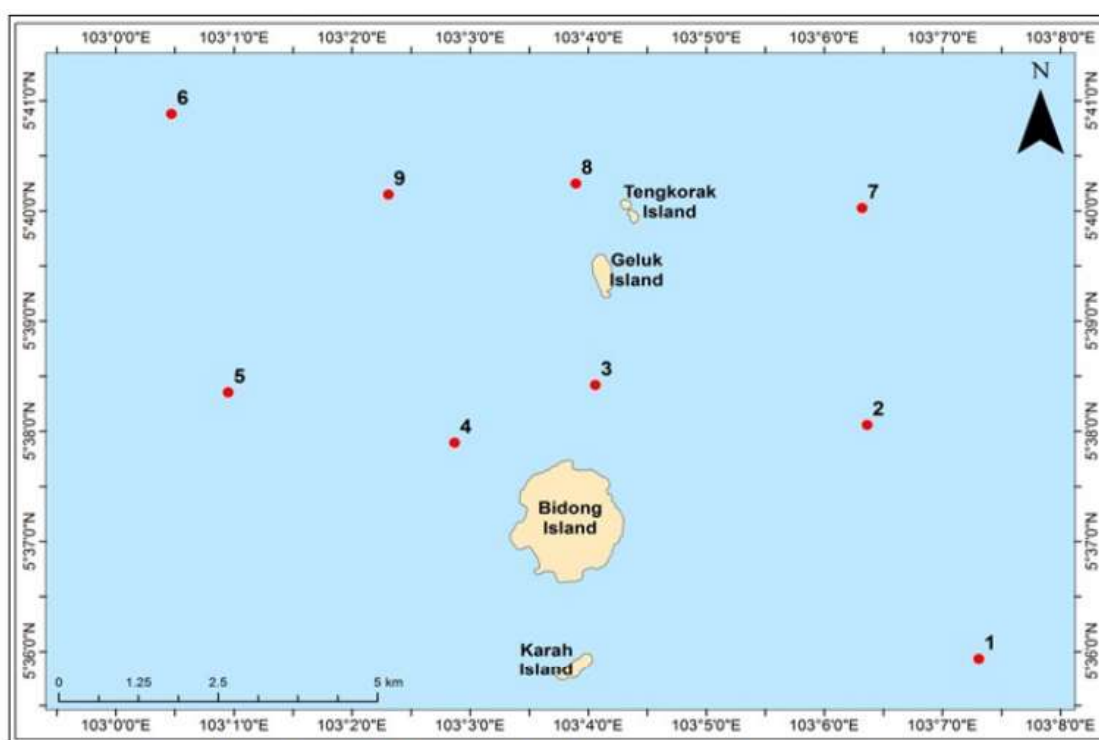


Figure 1. The map of Bidong Island waters shows the location of the study. The locations of the aggregating devices are marked in red (Ibrahim et al 2014).

Source: Hasaruddin et al. (2015)

Table 27. AFAD locations used in a study

Name Of Fads	Types Of Fads	Coordinates
Tukun 1 (T1)	Bottom Fads	N 05° 37 027' E 103° 02 943'
Tukun 2 (T2)	Bottom Fads	N 05° 37 465' E 103° 0 862'
Tukun 3 (T3)	Bottom Fads	N 05° 38 750' E 103° 02 896'
Tukun 4 (T4)	Bottom Fads	N 05° 34.609 E 102° 55. 457'
Unjam 1 (U1)	Midwater Fads	N 05° 40 222' E 103° 06 429'
Unjam 2 (U2)	Midwater Fads	5°40.187 'N 103°6.400 'E
Unjam 3 (U3)	Midwater Fads	5°41.645 'N 103°5.629 'E
Unjam 4 (U4)	Midwater Fads	5°39.106 'N 103°13.701 'E

Source: Rosdi et al. (2018)

Target Species (i.e. Catch)

The most detailed account of the species caught at Malaysian AFADs is by Rosdi et al., (2018). However, this study is somewhat biased by the survey method, as the only gear type used was jigging with metal lures. The study also targeted “bottom FADs” which fall out of the scope of this study. Species caught at the AFADs included pelagic species (*Selaroides leptolepis*, *Scomberomorus commerson*, *Scomberoides commersonnianus*, *Thunnus tonggol*, *Coryphaena hippurus* and *Sphyraena jello*) and demersal species, mainly from the Serranidae family (*Cephalopholis boenack*, *Cephalopholis formosa*, *Cephalopholis argus* and *Epinephelus areolatus*).

Another study found a slightly different composition of species at FADs Hasaruddin et al., (2015). However, this studies aim was to look into the use of AFADs as spawning substate for squids. Regardless, this study notes the presence of a number of species around the AFADs including hard-tail scad (*Megalaspis cordyla*), black kingfish (*Rachycentron canadum*), blackfin scad (*Alepes melanoptera*), Snapper (*Lutjanus lutjanus*), peron’s threadfin bream (*Nemipterus peronii*), areolated grouper (*Epinephelus areolatus*), and white-shouldered whiptail (*Pentapodus bifasciatus*).

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

No information was identified regarding the socio-economic aspects of AFAD fisheries in Malaysia.

4.3.4.28. Sri Lanka

A Sri Lankan stakeholder confirmed that AFADs are not currently used in their waters and have never been used there. However, they mentioned it’s possible they might be used in the future.

4.3.4.29. Timor-Leste

Information on AFAD use in Timor Leste is somewhat limited. Communication with a Timor Leste stakeholder was not possible despite multiple requests. Despite this, this research was able to show that Timor Leste does use AFADs (Tilley et al., 2019; Tilley et al., 2022).

First trailed in 2013, a 2019 study reports 8 AFADs having been deployed in Timor Leste waters in 2016 and 2017 by Timor-Leste's Ministry of Agriculture and Fisheries (MAF) and WorldFish (Table 28). The average lifespan of these AFADs was 11.9 months with 6 having been lost in 2 years.

Table 28. Deployment depth and longevity of artisanal nearshore fish aggregating devices at four community fishing sites in Timor-Leste

TABLE 1 | Deployment depth and longevity of artisanal nearshore fish aggregating devices at four community fishing sites in Timor-Leste.

Site	Depth (m)	Date deployed	Date lost	Duration (months)	Distance from shore (km)
Adara	170	1-Sep-16	Mar-17	7	0.57
	158	29-Jul-17	Apr-18	11	0.45
Vemasse	340	03-Mar-17	Sep-17	6	2.77
	260	03-Mar-17	Mar-18	12	2.35
	250	03-Mar-17	Mar-18	12	1.85
Adarai	65	27-Apr-17	–	18+	2.66
	65	27-Apr-17	–	18+	3.62
Biacou	100	12-May-17	Apr-18	11	1.96
Average				11.9 ± 4.4	2.03

Where no "Date lost" listed, FADs are still in place. Gray shading separates sites.

Source: Tilley et al. (2019)

A 2022 study highlights further AFAD deployments in February and March 2021, but does record how many or their locations (Tilley et al., 2022a). It is also mentioned that the AFADs deployed as part of their study would be open access, except for one site, where the AFADs would be incorporated into existing FAD fishing groups that manage and fish at specific FADS, invest in gear and hold shares of the catch, implying more are present than those reported here.

Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

The most informative paper of the gears used around AFADs in Timor Leste is Tilley et al., (2022). The study took place between 2016 and 2018 and focused on four different ecological zones in Timor Leste's fishing communities (Adara, Adara, Biaco and Vemass), where the eight Fish Aggregating Devices (FADs) previously mentioned were set up. Records from 184 fishers were gathered, across 3277 trips from the four sites. CPUE across the survey period is shown in (Table 29).

Proportional catch data on the specific gears used at the FADs is not shown. Despite this, the main gears at all sites were similar characterised by gillnets and handlines with two sites, Biacou and Vemass, recording the use of a

specialised scoop seine net gear specific for fishing FADs (Tilley et al., 2019a; Tilley et al., 2019b). A short description is given in section 0.

No concrete numbers are available of the number of vessels engaged in AFAD fishing, but most of the fishing in Timor-Leste is conducted by one- or two-person non-motorised wooden outrigger canoes (82%). The remaining 18% consist of larger canoes with “long-tail” outboards (63%) and larger wooden or fibreglass boats with outboard engines (35%) (Tilley et al., 2019b).

Table 29. Catch statistics by landing site of four small scale fishing communities in Timor-Leste

TABLE 2 | General catch statistics by landing site of four small-scale fishing communities in Timor-Leste.

Site	Diversity (Shannon's H)	Evenness (Shannon's J)	VAC [hr/(month × boat)]	Recorded catch (N fishes)	Recorded catch (kg)	Recorded effort (h)	Mean trip time (h)	CPUE [kg/(fisher × hour)]	Motorized vessels	Canoes	Total catch (t)
Adara	1.28	0.37	19.13	19288	6675	2729	2.5	2.78	3	12	28.4
Adarai	0.4	0.13	53.42	32875	3360	3210	3.21	0.97	12	60	44.3
Biacou	1	0.26	46.74	73302	5888	7367	4.32	0.92	41	8	72.5
Vermasse	1.16	0.43	76.24	106626	10761	5669	3.97	0.94	9	23	24.1

Source: Tilley et al. (2019a)

AFAD use was found to have a significant positive effect on productivity, with mean CPUE value of 2.17 kg / fisher x hour for FAD-associated fishing. Both reefs associated fishing and “other” fishing category had much lower values in comparison - 1.2 kg /fisher x hour and 0.8 kg / fisher x hour, respectively. However, disaggregation by site sees these numbers largely driven by two sites (Adara and Vermasse) Table 30.

Table 30. Point estimate (poisson means) of catch rates and 95% confidence bounda from FAD, reef, and other habitats (deep, mangrove and beach) from four small-scale fishing communities in Timor-Leste

TABLE 3 | Point estimates (Poisson means) of catch rates and 95% confidence bounds from FAD, reef, and other habitats (deep, mangrove, and beach) from four small-scale fishing communities in Timor-Leste.

Site	Habitat	CPUE [kg/(fisher × hour)]	CPUE (N individuals/hr)	Success rate	Recorded trips	Recorded catch (N individuals)	Recorded Catch (kg)	Diversity	Evenness
Adara	FAD	2.8(2.66/2.96)	7.99(7.74/8.24)	0.961(0.939/0.975)	485	18480	6413	1.24	0.37
Adara	Other	0.86(0.39/1.91)	3(1.96/4.6)	1(-- / --)	7	163	41	1.05	0.96
Adara	Reef	1.25(0.92/1.7)	3.81(3.19/4.55)	0.875(0.711/0.952)	32	645	220	0.87	0.34
Adarai	FAD	1.16(1.02/1.32)	10.98(10.52/11.46)	0.959(0.919/0.979)	193	10794	1184	0.17	0.07
Adarai	Other	0.87(0.8/0.94)	9.15(8.92/9.38)	0.905(0.88/0.925)	682	22081	2175	0.47	0.16
Biacou	FAD	1.25(1/1.56)	6.92(6.29/7.61)	0.541(0.416/0.661)	61	2610	411	0.82	0.37
Biacou	Other	0.8(0.74/0.87)	12.48(12.22/12.75)	0.62(0.583/0.656)	669	69338	4675	0.75	0.21
Biacou	Reef	1.24(1.03/1.49)	2.28(1.99/2.61)	0.761(0.663/0.837)	92	1354	802	2.48	0.75
Vermasse	FAD	5.27(4.68/5.94)	40.18(38.47/41.95)	1(-- / --)	51	59098	7900	0.08	0.11
Vermasse	Other	0.62(0.57/0.67)	12.29(12.07/12.5)	0.962(0.948/0.972)	1005	47528	2861	1.3	0.48
Total	FAD	2.17(1.84/2.54)	13.7(9.8/19.13)	0.826(0.808/0.974)	790	90962	15908	0.98	0.27
Total	Other	0.8(0.68/0.93)	9.2(6.59/12.85)	0.9(0.758/0.963)	2363	139110	9753	1.34	0.35
Total	Reef	1.21(0.97/1.51)	2.49(1.75/3.53)	0.939(0.83/0.98)	124	1999	1022	2.4	0.69

Poisson means with asymmetric 95% confidence bounds shown in parentheses.

Source: Tilley et al. (2019a)

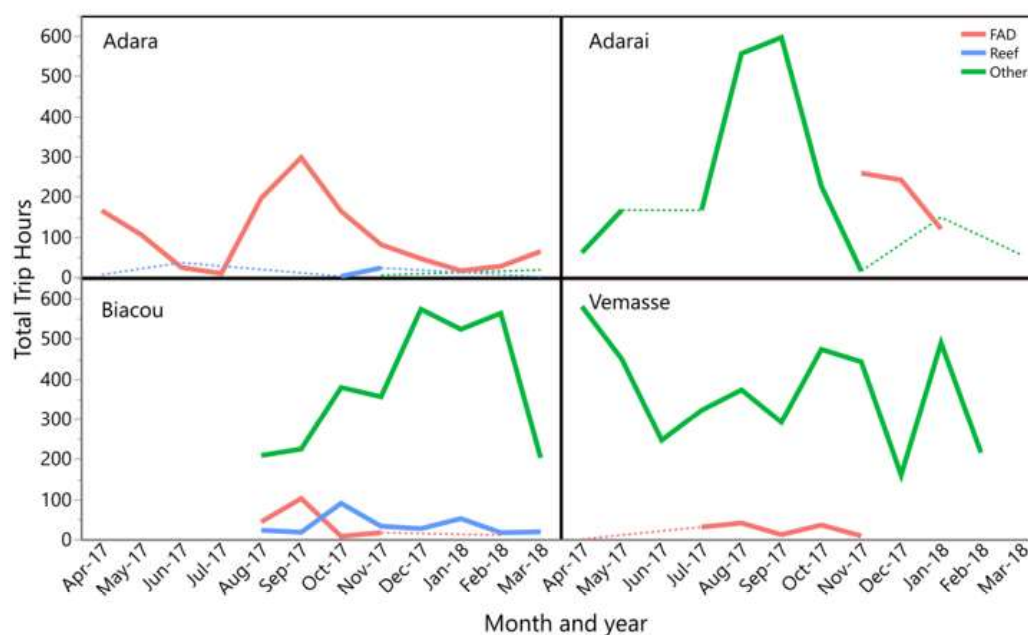
Target Fishing Grounds (i.e. Spatial temporal variability).

No maps or locations of AFADs in Timor Leste water could be identified. However, it appears that AFADs in Timor Leste are located nearshore, rather than offshore. The distances from shore presented in Table 28 show that the maximum distance from shore is 3.6 km, and averages 2.0 km. This is specifically to enable fishers to access them specifically to help alleviate poverty and food security, which is a significant challenge currently.

The study by Tilley et al., (2019a) shows highly seasonal variation in catches across the four sites surveyed. Only Adara, an island to the north of the main Island of Timor Leste, has catches year around, and even then, the catches are seasonal.

Figure 36. The total number of fishing trips for which catch was recorded, by month and habitat at four sites in Timor-Leste

Solid line represents continuous data, connecting dotted lines reflect no data



Source: Tilley et al. (2019a)

Target Species (i.e. Catch)

The 2016 – 2018 study by Tilley et al., 2019a documented 66 species across the whole survey, which included reefs and other habitats. However, the catches at AFADs, across all locations, were dominated by three species, the short-bodied scad (*Rastrelliger brachysoma*), mackerel scad (*Decapterus macarellus*), and sardines (likely a mix of up to five local species, as they are difficult to identify accurately), which comprised 96% of landings. Two of the

landing sites are largely single species fisheries with > 90% of their catches comprised of *R. brachysoma* (99.6% in Adarai) and sardines (92.1% in Biacou). Sardines were only found in catches from mainland sites. The top three species from Adara on Atauro Island *R. brachysoma*, *D. macarellus*, and *Pterocaesio tile* – striped fusilier.

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

Aspects such as fuel and numbers of fishers using AFADs across Timor-Leste was not found. However, it can be calculated that of the 3277 trips surveyed by Tilley et al., (2019a) 790 trips were AFAD associated, representing 24% of trips. A fisher focus group based in Adara stated the largest benefit from using the AFADs was the reduced time to catch enough fish thereby enabling additional time to be dedicated to other livelihoods. The highest catch rates are from Vermasse (Table 31) where catch success on FADs was reportedly sporadic, often catching nothing, and highly seasonal, but on good days the daily catch value could exceed USD \$1000 (almost paying for the FAD costs in one day). The community in Vermasse has been deploying AFADs for a number of years and have created AFAD fishing groups of around 12 people that hold catch shares based on their investment or labour. These groups use a specialised method of using modified scoop-seine net that is deployed around schooling fish aggregating around a light shone down on the AFAD before dawn. The average price of fish in USD/Kg is provided in Table 31.

Table 31. Site base returns on Invest,ent (RoI) in days for nearshore AFADs at Four sites in Timor-Leste

TABLE 4 Site-based Returns on Investment (RoI) in days for nearshore FADs at four sites in Timor-Leste.							
Site	FAD trips/total trips (F)	Total Boats (N)	VAC_{day} (h)	ΔCPUE	Price of fish (\$/kg)	Proportion of catch sold (S)	RoI (in days)
Adara	0.82	15	0.64	1.55	\$1.81	0.37	154
Adarai	0.27	72	1.78	0.29	\$2.19	0.69	82
Biacou	0.21	49	1.56	0.01	\$2.80	0.83	3355
Vermasse	0.52	9*	2.64	4.65	\$2.12	0.59	18

Variables for the calculation of RoI are in bold, following Eq. 3. *In Vermasse only motorboats fished on FADs so canoes were excluded from the calculation of RoI.

Source: Tilley et al. (2019a)

4.3.4.30. Thailand

Despite a number of emails, no response was received from Thai stakeholders. Despite this, this research identified that Thailand does use AFADs.

In 2020, Thailand reported using unspecified "FADs" in a national report to the IOTC Scientific Committee (SC) (Nootmorn et al., 2020), highlighting a legally designated FAD area for purse seine vessels. By 2022, their report to IOTC SC identified "FAD" as one of four segments of their purse seine fleet, noting that this segment sometimes collaborates with light-luring purse seines to use FADs.

The report also specified that vessels deploying AFADs must do so at least 12 nautical miles from shore, as required by their fishing licenses (Nootmorn et al., 2022). In 2024, the only mention of AFADs in their report to the IOTC SC was that they are used to target small pelagic fish (Noranarttragoon et al., 2024).

A number of useful sources were identified (Yingyuad & Chanrachkij, 2010; IOTC SC National reports) However, no indications of the numbers of AFADs being used is reported.

This lack of reporting AFAD numbers is likely to do with the characteristics of the AFADs employed. A 2010 description of the main AFAD types used by the purse seine fleet describes three main types.

The first is a shallow set (20 – 50 m depth) design, made with bamboo rafts, 7 to 20 coconut leaves tied to the anchor line at intervals of 1 – 3 m under the surface, which use fairly light anchor weights (40 – 50 kg) made of stones, or concrete. Often deployed on the fishing trip in sets of 20 – 50 units, the designs are expected to last 2 – 3 months, with fish schools aggregating after 1 – 2 weeks after deployment, sometimes as quick as 3 - 5 days. Another design details similar components, with a smaller bamboo raft design, and fewer coconut leaves tied below in smaller interval. These are used more by small-scale fishers, squid jigging, set at depths 20 – 25 m. In Rayong Province, these are usually deployed in groups of around 5 – 7. The design used in the Andaman sea, is practically the same, however for purse seine fishing at deeper depths in the Gulf of Thailand, a slightly larger design is used that follows the same principles.

An exception to the above-mentioned traditional style AFADs are those mentioned in a Southeast Asian Fisheries Development Center cruise reports from 2010 and 2011 in the Andaman sea (Southeast Asian Fisheries Development Center (SEAFDEC, 2011)). These cruise reports describe deployments of modern style (float raft type and bullet type) AFADS in 2008 and 2010 (Figure 39).

Figure 37. Locations of the surveyed AFADs in the 2011 research cruise by Southeast Asian Fisheries Development Center



As of 2013, there were no regulations determining the use of AFADs in terms of number and the grounds, and as a result the FAD fishery is open access to Thai fishers (Noranarttragoon et al., 2013). Furthermore, several indications of problems related to the AFAD fishery are presented by Noranarttragoon et al., (2013). These issues include changes to the species composition, decline in the mean size of the main species and the large number of juvenile fishes caught, strongly suggesting both growth and recruitment overfishing.

Fleets and Gears (i.e. Flag States, Gear Types, Effort, Fishers)

A 2010 report from the Southeast Asian Fisheries Development Center indicates that monitoring of the purse seine fleet has been in place since 1974. This includes four main categories, one of which is purse seines operated with surrounding FADs (called "Sung" in Thai) (Yingyuad & Chanrachkij, 2010). However, after a reform the countries statistical system in 1984, confusion among fishers registering their gear as ether purse seine or FADs in 1993, there was a steady increase is vessels registering as purse seine, and reporting of AFADs reduced (Yingyuad & Chanrachkij, 2010). In 1982, Thai statistical records show 840 registered purse seiners and used AFADs and luring lights. Since 1993, these categorises have been combined under purse seine, with the number of Thai purse seine vessel at 1058 in 2010 (Noranarttragoon et al., 2013). In 2023, number of Thai purse seines was reported as 218 (Noranarttragoon et al., 2024).

As mentioned above, up until 1993 Thai reporting of AFAD catches was documented. As such, it is reported that the purse seine FAD fishery accounted for the continuously increasing production from 70000 tonnes in 1974 to 390000 tonnes in 1983 (Yingyuad & Chanrachkij, 2010).

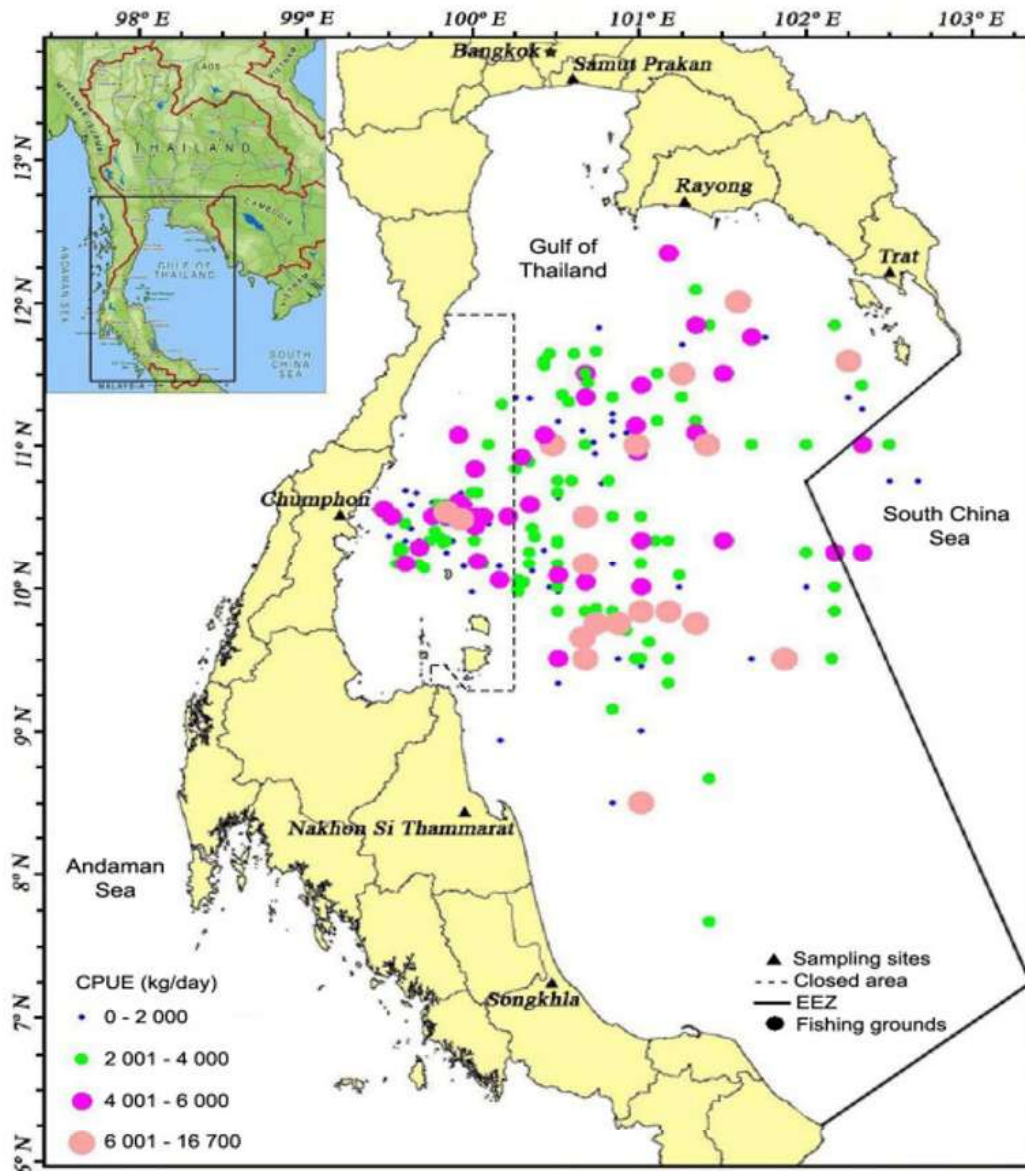
The main gear reference by Yingyuad & Chanrachkij, (2010) that was used around AFADs was the surrounding nets with a purse line (mesh size 25.0-29.9 mm), and is widely used in the Gulf of Thailand and Andaman Sea. This one category has a further three types within it *Uan dam* and *Uan lom sung* and *Uan tang-ke* (two boat purse seine), all of which are mentioned to also fish free school operations. Both *Uan dam* and *Uan lom sung* are described as similar, but no further description of *Uan lom sung*

The *Uan dam* are fished in the day and using lights during the night, from a medium-scale boat (14-26 m in length, 20-700 HP engine) by around 10-30 fishermen. Nets when fishing AFADs are usually 400 – 600 m in length 60- 110 m in depth. *Uan tang-ke* requires several vessels, using a mother boat (16 – 20 m length 100 – 150 HP) and several smaller boats to set the nets. A similar description of the fleet targeting AFADs is provided by Noranarttragoon et al., (2013) who described the Thai purse seine nets associated with using FADs use nets 400 – 900 m in length and 80 - 110m depth, with a mesh size of 25 mm. Vessels are usually 18 – 26 m in length with crews of 20 – 35 people. The vessels usually have a small support boat, as a patrol/security for the FAD and sometimes as an electric generator for those that use a light luring method to aggregate the fish.

Behaviour of fishing vessels is interesting, in that when smaller schools of fish are located at the FAD (ether by sight or sonar), vessels may drag the FAD to another located close by, after which they will drag it quickly away, combining the smaller schools. This step is repeated until a school worth the effort of casting a net is attained. The number of fishing days per trip is mostly three to ten days, depending on volumes caught, with one to five hauls per day, averaging around three.

Effort is estimated by Noranarttragoon et al., (2013) by surveying landings monthly in 2007 from FAD fishing boats (Figure 40).

Figure 38. Sampling sites, fishing grounds and CPUE (kg day⁻¹) of the FAD fishery in the Gulf of Thailand



Source: Noranarttragoon et al. (2013)

Target Fishing Grounds (i.e. Spatial temporal variability)

The AFAD fishery in Thai waters extends to the Gulf of Thailand and Andaman Sea (Yingyuad & Chanrachkij, 2010).

The fishing grounds for purse seines using surrounding nets with a purse line (mesh size 25.0-29.9 mm) are in the eastern and western parts of the Gulf of Thailand, in the inner Gulf, and the southern part of the Andaman Sea.

With estimates from 2007, Noranarttragoon et al., (2013) was able to provide a comparison of the composition of the species associated with the Gulf of Thailand AFAD fishery over time (Table 32).

Table 32. Comparison of species composition and CPUE of the AFAD fishery in the gulf of Thailand

Species/group	Composition (%)		
	1976 ¹	1986 ²	2007
Sub-total pelagic fish	98.7	94.1	88.1
Indian scad	48.9	23.4	23.6
Bigeye scad	19.0	12.6	8.2
Goldstripe sardinella	8.6	3.1	2.7
Indian mackerel	8.3	29.5	25.4
Short mackerel	5.7	0.5	1.8
Yellowtail scad	6.8	11.4	4.8
Yellowstripe scad	0.7	2.5	2.8
Neritic tunas	–	7.5	8.3
Other pelagic fish	0.7	3.6	10.5
Other	1.3	5.9	11.9
Average CPUE (kg day ⁻¹)	–	3 120.6	3 351.4

Notes: ¹ Noopetch 1983; ² Noopetch 1987.

Source: Noranarttragoon et al. (2013)

Target Species (i.e. Catch)

In a 2007 study of the Gulf of Thailand FAD fishery, ports were surveyed monthly for a year (Noranarttragoon et al., (2013). The main species over that time period have been summarised in Table 33. The size range of these species is also reviewed and presented in Table 34.

Table 33. Summary of main species from 2007 monthly AFAD vessel landings. Those under 1% are not shown

Species	Scientific Name	Composition (%)	CPUE (tonnes day ⁻¹)
Indian mackerel	<i>Rastrelliger kanagurta</i>	25.0	0.85
Indian scad	<i>Decapterus russelli</i>	23.6	0.79
Bigeye scad	<i>Selar crumenophthalmus</i>	8.2	0.28
Torpedo scad	<i>Megalaspis cordyla</i>	5.3	0.18
Yellowtail scad	<i>Atule mate</i>	4.8	0.16
Kawakawa	<i>Euthynnus affinis</i>	4.3	0.14
Frigate tuna	<i>Auxis thazard thazard</i>	3.4	0.11
Goldstripe sardinella	<i>Sardinella gibbosa</i>	2.7	0.09
Short mackerel	<i>Rastrelliger brachysoma</i>	1.8	0.06
Rainbow sardine	<i>Dussumieria acuta</i>	1.5	0.05

Source: Noranarttragoon et al. (2013)

Table 34. Review of size ranges of economically important species caught by the FAD fishery in the Gulf of Thailand

Species	Size range (cm)	Mean (cm)	SD (cm)	Size at first maturity (cm)	Reference
Indian mackerel	6.5–24.0	15.0	3.0	M: 20.1, F: 17.1	Krajangdara et al. 2007
Indian scad	6.0–26.5	13.8	2.2	Unsexed: 16.2	Chullasorn and Yusukswad 1978
Bigeye scad	6.5–26.5	15.0	3.3	M: 17.6, F: 18.3	Phuttharaksa et al. 2008
Torpedo scad (*)	4.0–33.5	16.3	6.3	Unsexed: 25.0	Reuben et al. 1992
Yellowtail scad	4.0–28.5	14.2	3.3	M: 21.8, F: 21.2	Premkit et al. 2004
Kawakawa (*)	7.0–41.0	19.0	6.1	Unsexed: 37.5	Klinmuang 1981
Frigate tuna (*)	7.5–45.0	18.7	5.8	Unsexed: 34.1	Klinmuang 1981
Yellowstripe scad	5.0–19.5	10.9	1.8	Unsexed: 13.2	Dwiponggo et al. 1986
Goldstripe sardinella	9.0–21.0	15.4	1.5	F: 13.1	Nasuchon and Rotjanaratana 2000
Short mackerel	5.0–23.5	13.4	3.2	M: 16.5, F: 18.0	Krajangdara et al. 2007
Rainbow sardine	10.0–19.5	17.0	1.3	Unsexed: 14.2	Chullasorn and Martosubroto 1986
Longtail tuna (*)	7.5–34.5	14.8	5.0	Unsexed: 39.6	Klinmuang 1981

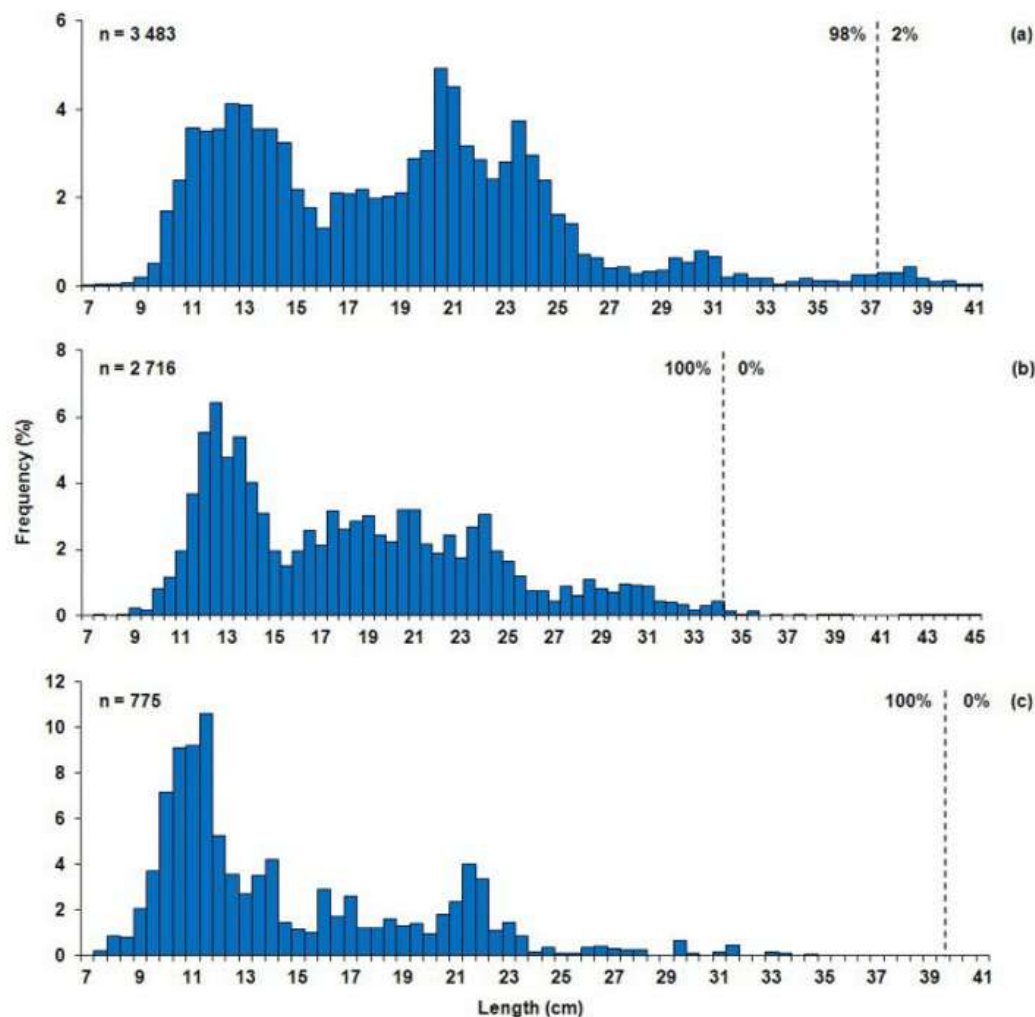
(*) Fork length; M is male and F is female.

Source: Noranarttragoon et al. (2013)

Noranarttragoon et al., (2013) study also presents a length frequency distribution of the three main neritic tunas caught by the Gulf of Thailand FAD fishery. This demonstrates very clearly catches of predominantly undersize Kawakawa, longtail tuna and frigate tuna (Figure 41).

Figure 39. Length (FL) distributions of neritic tunas caught by the FAD fishery in the Gulf of Thailand: (a) Kawakawa, (b) frigate tuna, (c) longtail tuna

Dotted line shows size at first maturity



Source: Noranartragoon et al. (2013)

Cruises from 2010 and 2011 in the Andaman sea surveyed the pelagic fish around AFADs using trolling line, drifting vertical longline, tuna longline and squid jigging, despite being somewhat different to the main characteristics used by the Thai AFAD using fleet segments (SEAFDEC, 2010; SEAFDEC. 2011). The survey was limited in size and conducted few sampling events and thus may not be representative of AFAD catches in the Adaman sea. Catch tables from these surveys are presented in those reports, with the main species being Yellowfin, Swordfish and Pelagic stingray (*Dasyatis violacea*).

Socioeconomics (i.e. Fuel, Gear, Employment, Catch Value)

Other than the variation in the number of vessels throughout the course of the reporting of AFADs in Thai waters mentioned above, no further information was identified on the socio-economic dimensions of fisheries associated with AFADs.

Annex 5: Indonesia Case Study Report

Background of AFADs

Anchored Fish Aggregating Devices (AFADs) have become a significant tool in tuna fisheries, primarily used to attract and concentrate fish, making them easier to catch (Beverly et al., 2012; Karama & Matsushita, 2019). These devices are anchored to the ocean floor and provide a structure that fish, particularly tuna, are drawn to. The use of AFADs has increased globally due to their effectiveness in enhancing tuna catch rates (Moreno et al., 2016). However, the growing reliance on AFADs in tuna fisheries has raised concerns about their potential impacts on tuna behaviour, particularly their migratory patterns and natural schooling behaviour, which could have long-term implications for tuna populations.

One of the critical areas of study involves analyzing how AFADs influence the behaviour of juvenile tuna. Research aims to quantify the extent to which these devices impact juvenile populations, as these younger fish are often more vulnerable to overfishing. The aggregation of juvenile tuna around AFADs can lead to higher catch rates of these immature fish, which might hinder the sustainable management of tuna stocks (Moreno et al., 2016). Understanding these impacts is crucial for developing strategies to mitigate potential negative effects and ensure the sustainability of tuna fisheries.

In addition to biological and ecological considerations, the socio-economic aspects of AFAD fisheries are also important. AFADs contribute to local economies by providing a reliable source of income for fishers (Matsumoto et al., 1981). However, their use can also lead to unintended consequences, such as increasing bycatch of non-tuna species and altering traditional fishing practices. Moreover, the environmental impacts of AFADs on marine and coastal ecosystems, including habitat disruption and pollution, need to be carefully evaluated. A comprehensive analysis of AFADs must consider both their economic benefits and potential ecological costs to ensure a balanced approach to fisheries management.

Objective of the study

- To understand the spatial and temporal distribution of AFADs in Indonesia through data and information collection.
- Provide insights into tuna fisheries employing Anchored Fish Aggregating Devices (AFADs) and analyse the potential implications of these fisheries on tuna behaviour, striving to quantify impacts on juvenile populations wherever feasible. Furthermore, it will delineate the socio-economic

aspects of such fisheries, evaluating the extent to which AFADs contribute to non-tuna targeted fishing activities.

Geographic scope

The number of AFADs in Indonesia is significant due to their impact on both artisanal and industrial fisheries, as well as food security and sustainability. FADs, which are floating objects designed to attract fish, can increase fishing efficiency and catch rates, but their over-deployment can also lead to overfishing and unsustainable fishing practices. AFADs in Indonesia is important because it directly impacts fishing efficiency, food security, the sustainability of fish stocks, and the livelihoods of coastal communities. Effective management of FADs is crucial to ensure that they contribute to sustainable fisheries and do not lead to overfishing or harm the marine environment. Based on last data published by Widodo et al. (2023) and Widyatmoko et al. (2021) also by FAO (2023) it is estimated that number of AFADs installed in Indonesia approximately between 5000 to 10000 units and correspondence to approximately 72% of total tuna catch. Reflect to these figures, it is obviously that this report focused on Indonesia due to number of AFADs installed and tuna volume production associate with AFADs.

Anchored Fish Aggregating Devices (AFADs) are widely utilized in tuna fisheries to attract and concentrate fish, improving catch efficiency. However, their increasing use has raised concerns regarding potential impacts on tuna behaviour, particularly migratory patterns and the vulnerability of juvenile tuna populations to overfishing. Beyond the ecological effects, AFADs also have significant socio-economic implications. While they support fisher incomes, they may also increase bycatch and alter traditional fishing practices. Therefore, a balanced analysis of AFADs is crucial, weighing their economic benefits against the ecological risks, in order to ensure sustainable fisheries management.

Methods

This study employs a systematic literature review method to identify and analyse the current situation regarding the use of anchored fish aggregating devices (AFADs) in Indonesia. This method was chosen as it allows for the retrieval, evaluation, and synthesis of various scientific sources and related documents to obtain a comprehensive understanding (Mengist et al., 2020) of the technical, regulatory, and ecological, social, and economic implications of AFAD utilization in the fishing industry.

Data collection was conducted through a systematic literature search using specific keywords in both Indonesian and English. The keywords used include:

- **Indonesian:** Jumlah AND Rumpon AND Tetap OR Jangkar AND di AND Indonesia

- **English:** Number AND of AND Anchored OR Moored AND AFADs AND FADS AND FAD AND MFAD AND in AND Indonesia

These keywords were designed to encompass various terminologies used in research and policies concerning fish aggregating devices (FADs) in Indonesia, ensuring a broader data coverage. The literature search was systematically performed using the following software and academic databases (Khan et al., 2018):

10. **Publish or Perish Software** – Used to extract metadata from Google Scholar, facilitating the identification and organisation of relevant literature (Harzing, 2010).
11. **Google Scholar** – Utilized as the primary source for academic literature searches, including scientific journals, technical reports, and grey literature such as conference papers and theses.
12. **Web of Science** – Used to obtain peer-reviewed articles with high academic credibility.
13. **Scopus** – Leveraged to acquire references from high-impact journals discussing technical and policy aspects of AFADs.
14. **Reports and official documents from the Indonesian Ministry of Marine Affairs and Fisheries (KKP)** related to the regulation and implementation of AFADs.
15. **Secondary sources**, including online media articles, academic repository system, investigative reports, and news from national and international media discussing policy developments, operational challenges, and impacts of AFADs in the Indonesian fisheries context.

Following data collection, a screening and selection process was carried out to ensure the relevance of publications to the research objectives. This process involved several stages:

16. **Initial selection** based on titles, abstracts, and keywords to identify literature relevant to the research topic.
17. **Evaluation of full-text publications** that passed the initial selection, ensuring the content aligns with the research objectives and meets the inclusion criteria.
18. **Screening based on inclusion and exclusion criteria:**
 - Inclusion Criteria:
 - Publications in English or Indonesian.
 - Articles discussing the use, regulation, or impact of AFADs in Indonesia.

- Studies covering technical, ecological, economic, or social aspects related to AFADs.
- Official reports from the government, international organisations, or non-governmental organisations (NGOs).
- Exclusion Criteria:
 - Publications in the form of letters, editorials, or commentaries that are not research-based.
 - Articles that are not available in full text.
 - Papers that are irrelevant to the topic of AFADs in Indonesia.

After the screening stage, selected publications were analysed in depth to identify patterns in AFAD usage, including technical aspects such as installation, buoy structure, anchoring systems, and materials used. Additionally, this study explores AFAD operational aspects, covering navigation systems, fish-attracting device (FAD) effectiveness, and fishing methods employed around AFADs.

Further analysis was conducted to assess policies and regulations governing AFADs, challenges in implementation and monitoring, and their impact on the fisheries sector, particularly in terms of productivity, catch distribution, and effects on traditional fishermen's welfare. Additionally, this study examines fishing ground locations, types of fishing gear used, and the composition of catches around AFADs.

Results

Regulation of AFADs (International, Regional, National, Local)

Several regulations govern AFADs at the global, regional, national, and local levels.

International Law

- **United Nations Convention on the Law of the Sea (UNCLOS, 1982).** Establishes that coastal states have sovereign rights over their Exclusive Economic Zone (EEZ) (up to 200 nautical miles). Requires states to ensure the conservation and sustainable use of fish stocks, including through FAD regulations.
- **UN Fish Stocks Agreement (1995).** Emphasizes the precautionary approach and ecosystem-based management for highly migratory

species, like tuna. Calls for cooperative management through Regional Fisheries Management Organisations (RFMOs).

- **FAO Code of Conduct for Responsible Fisheries (1995).** Encourages states and fishers to adopt sustainable FAD management practices.
- **FAO Guidelines on the Marking of Fishing Gear (2019).** Suggests marking requirements for gear, including FADs, to reduce ghost fishing and marine debris.
- **Regional Fisheries Management Organisations (RFMOs)**
- **Western and Central Pacific Fisheries Commission (WCPFC).** Requires FAD closures in specific months to reduce juvenile tuna catch. Mandates reporting on FAD use and encourages biodegradable materials. Discusses AFAD placement to prevent conflicts with artisanal fisheries.
- **Indian Ocean Tuna Commission (IOTC).** Limits the number of operational FADs per vessel. Requires tracking and marking of FADs. Discusses AFAD zoning and effects on coastal ecosystems.

National Regulations

- **Government of Indonesia Act No. 31/2004 and No. 45/2009 on Fisheries.** Not specifically regulated for FADs. FADs categorised as fishing equipment
- **Ministry of Marine Affairs and Fisheries (MMAF) Regulation No. 26/2014.** Establishes regulations on anchored and drifting FADs. Requires installation permits (SIPR) for AFADs in Indonesian waters.
- **MMAF Regulation No. 18/2021.** Updates Regulation No. 26/2014. Limits the number of AFADs per vessel based on operational areas.
- **MMAF Decree No. 7/2022.** Allocates AFAD placement across 11 designated Fisheries Management Areas (WPP) in Indonesia.

Provincial and Local Regulations

- **Provincial Regulations** govern FAD placement and ownership, such as: Central Kalimantan Governor Regulation No. 8/2023 on capture fisheries governance; South Sulawesi Provincial Regulation No. 2/2019 on coastal zoning and small islands, and West Sumatra Governor Regulation No. 10/2016 on fisheries business licensing.
- **District Regulations** govern fisheries business permits, including FAD installation, such as South Bangka Regency Regulation No. 17/2012 on fisheries business, Bantul Regency Regulation No. 77/2012 on fisheries

business licensing, and Marine Regency Regulation No. 8/2008 on licensing fees for fisheries businesses.

These regulations collectively ensure the sustainable and responsible use of AFADs in Indonesia, balancing ecological conservation with economic benefits for local fishers.

Comparative study of AFADs data toward regulations

The use of anchored fish aggregating devices (AFADs) has become a primary strategy in fisheries to enhance fishing efficiency, particularly for tuna (Khan et al., 2020). However, its impact on fishery resource sustainability, marine ecosystems, and fisher welfare remains a subject of debate. Regulations governing AFADs have been implemented at various levels, from Regional Fisheries Management Organisations (RFMOs) to national policies in coastal countries.

In a previous study (Hamar & Bone, 2021), fish aggregating devices (FADs) in Buton were found to be distributed in areas 2-10 miles offshore. Based on this data, the installation of FADs must comply with Indonesian regulations, which require a minimum distance of 10 km (approximately 6 miles). Meanwhile, according to the Western and Central Pacific Fisheries Commission (WCPFC), the minimum distance should be 1-5 miles to prevent overfishing. This issue should be evaluated, and re-registration should be conducted to regulate FAD installations in certain waters. Furthermore, some FADs lacked SIPR (Fish Aggregating Device Installation Permit).

A study conducted by Putra et al., (2023) found 288 violations related to capture fisheries activities, including FADs. According to Indonesian regulations, FADs installed in Indonesian waters must have a SIPR. However, some FADs lack this permit, leading to disorderly installations and fishing operations that could result in overfishing (Putra et al., 2023). Although efforts have been made to regulate FADs, the policy implementation has not favored fishers, and law enforcement remains weak.

Another study by Prayitno (2016) found that while some installed FADs met regulatory standards, the high intensity of fishing activities has led to their full utilization. The study reported that fish catches in the Pacitan region have been declining yearly (M. R. Prayitno et al., 2017). If this situation continues without measures to prevent overfishing, the marine environment will deteriorate.

Further, research by (Nurwahidin & Setianto, 2018) highlighted violations by fishers who failed to report their installed FADs. This was due to concerns about disclosing fishing areas to other parties and a lack of socialization regarding FAD regulations. Additionally, inconsistencies exist between international and national regulations on FADs, such as distances between FADs being less than 10 miles and their placement within commercial shipping lanes. According to

the Indonesian Ministerial Regulation on Marine and Fisheries (Permen-KP No. 26 of 2014 on FADs) (Ministry of Maritime Affairs and Fisheries, 2014), Article 12, Paragraph 1d states that the distance between FADs must be at least 10 nautical miles. Moreover, Paragraph 1e states that FADs must not be installed in a way that creates a fence-like (zigzag) pattern, which threatens pelagic fish sustainability, and Paragraph 1c mandates that FAD installations should not interfere with shipping routes. Additionally, some FADs lacked reflectors, despite Permen-KP No. 26 of 2014, Article 17, clearly requiring FAD owners to install reflectors and identification markers.

Violations related to FAD usage have been reported across Indonesia. In a patrol in the Timor Sea, the fisheries surveillance vessel KP Orca 04 from PSDKP discovered numerous illegal FADs operating without permits (Lewokeda, 2019). The same surveillance vessel also secured 20, 8, and 16 illegal FADs in the Sulawesi Sea (WPPNRI 716), near Indonesia's border with the Philippines, in 2019, 2023, and 2024, respectively (Ambarwati, 2023, 2024; Maharani, 2019). Similar cases of unregulated FADs were found in Buton, Wakatobi, and Banda Sea, with improper spacing not in compliance with regulations (Rahman, 2021). If left unregulated, these illegal FADs could contribute to illegal fishing. Hence, offshore FADs must be equipped with identification markers and radar reflectors. The identification markers should contain the owner's name, SIPR number, and coordinates of the FAD placement (latitude and longitude) (Sutrisna, 2024). The Ministry of Marine Affairs and Fisheries continues to conduct socialization and licensing services to address illegal FAD violations, including outreach at the Bitung Oceanic Fishing Port (PPS) as part of FAD regulation efforts (Sayuti, 2024). Additionally, NGOs assist fishers in obtaining FAD installation permits, as seen in Pulau Bisa, North Maluku (Ichi, 2023).

Technical aspects of AFADs in Indonesia

Operational

In Indonesia, Anchored Fish Aggregating Devices (AFADs) have become a primary tool in tuna and pelagic fisheries across various Fisheries Management Areas (WPPs). The use of AFADs plays a strategic role in supporting sustainable fisheries, particularly by increasing fishing efficiency. AFADs help fishers locate fish concentrations more easily, reducing search time, improving catches (Hikmah et al., 2016; Wanimbo et al., 2024b; Widodo, Wilcox, et al., 2023; Widyatmoko et al., 2021), and lowering fuel consumption during fishing operations (Citra et al., 2022; Julius et al., 2023). Furthermore, AFADs contribute to better fisheries resource management by enabling more controlled fishing zones.

The use of AFADs in Indonesia has proven to enhance fisheries productivity, especially for small- and medium-scale fishers. AFADs effectively attract high-value pelagic fish such as tuna, mackerel, and scad, facilitating efficient fishing operations (Dewanti, 2023). Additionally, AFADs provide attachment sites for periphyton, forming part of the marine food chain and creating productive fishing areas (Akbar, 2024). Technological innovations have further improved AFAD efficiency. For example, Badak LNG collaborated with Bogor Agricultural Institute (IPB) to introduce the Electronic Fish Aggregating Device (e-FAD), a portable FAD that emits sound frequencies to attract fish (Imandiar, 2023). The South Sulawesi provincial government has also launched a programme to build artificial reefs to conserve marine ecosystems and promote eco-friendly fishing (Marco, 2024). Additionally, Bulukumba Regency has developed the first prototype “tree-shaped FAD,” incorporating a buoyant system for stability and an anchoring system for secure positioning (Suparman, 2024).

AFADs in Indonesia are generally placed in deep waters, sometimes exceeding 1000 metres in depth and up to 100 km offshore. For example, in Labuhan Lombok, Oeba Kupang, and Bone (WPP 713), AFADs are installed in waters deeper than 1000 metres (Widyatmoko et al., 2021). Meanwhile, in the northern Java Sea and southern Sulawesi Sea (WPP 713), AFADs are placed in shallow (50–200 metres) and deep waters (400–4000 metres) (Khyria, 2019). In Semau and Sawu Sea (WPP 573), AFADs are positioned at depths exceeding 45 metres with a sandy-muddy substrate (Citra et al., 2022).

The operation of AFADs involves three main stages: setting, towing, and hauling. For handline fishing, the setting involves lowering fishing lines, towing consists of dragging lines around the FAD at 2-4 knots, and hauling is performed when fish take the bait (Depari, 2018).

Buoy Structure

The buoy structure of AFADs in Indonesia varies widely, depending on the materials used and the water conditions at the installation site. In general, AFAD buoys are designed to ensure optimal stability and buoyancy, especially in areas with high waves and strong currents. Commonly used buoy types include plastic drums, styrofoam, bamboo rafts, steel pontoons, and fibreglass, each offering advantages in terms of durability, ease of maintenance, and effectiveness under specific sea conditions.

Across various Indonesian waters, buoy structures are adapted to local characteristics. For example, in Belu Regency, East Nusa Tenggara (Mauko & Daga, 2010), buoys are made from plastic drums tied with 16 mm nylon ropes, providing adequate buoyancy and ease of installation and maintenance. Meanwhile, in Jayapura, the buoys are designed with an aerodynamic, bullet-like shape (Yahya & Rahmat, 2017) to reduce water resistance and enhance overall system stability (Wanimbo et al., 2024b). In addition to serving as the

primary flotation device, AFAD buoys also act as location markers for FADs (Julius et al., 2023; Mauko & Daga, 2010; Wanimbo et al., 2024b), making it easier for fishermen to locate fishing areas. Some AFADs are even equipped with radar reflectors to improve visibility (Widyatmoko et al., 2021), particularly in poor weather conditions or busy shipping lanes. With a variety of designs and materials used, AFADs in Indonesia continue to evolve to adapt to diverse marine environmental challenges while enhancing the efficiency and sustainability of FAD-based fisheries.

The structure of fixed FADs installed in the waters of Pacitan (WPP 573) consists of buoys, attractors, mooring lines, and anchors. The FAD buoys are made of styrofoam wrapped in nets and securely tied with ropes. They are block-shaped with dimensions of 1 metre in length, 1 metre in width, and 2 metres in height (Prayitno, 2016). The materials and construction of FADs in Palabuhanratu have been regulated under the Minister of Marine Affairs and Fisheries Regulation No. PER.26/MEN/2014 on FADs. Therefore, fishermen using FADs as fishing aids must comply with the following regulations: the main components of FADs must include (1) Buoys, (2) Attractors made of natural materials, (3) Mooring lines, and (4) Weights for fixed FADs (Depari, 2018).

The buoy structure of FADs in WPP 712 varies depending on the location, such as in Lampung and Banten. FAD buoys in Banten waters use steel plate pontoons as the main flotation device, measuring 305 cm in length, 42.5 cm in height, and 95 cm in diameter. The main rope connecting to the wire has a diameter of 22 mm (Wahju et al., 2009). Meanwhile, in Lampung waters, FAD buoys are made of styrofoam measuring 60 cm x 40 cm, with a main rope length of 10 metres (Alfian et al., 2023).

In WPP 713, the FAD buoy structure in the Makassar Strait and Bone Bay remains relatively traditional. FAD buoys are constructed using bamboo combined with foam, measuring 3 metres (length) x 2 metres (width) x 0.5 metres (height) (Hidayat et al., 2021; Rumpa et al., 2022).

Attractor

The attractors used in AFADs (Anchored Fish Aggregating Devices) in Indonesia play a crucial role in enhancing the effectiveness of these devices as fish aggregation centres. Attractors serve as shelters and food sources for fish, drawing various fish species to the vicinity of AFADs. The materials used for attractors are generally made of natural substances that resemble fish habitats in the wild. The choice of materials varies based on local conditions and target fish species. Coconut, lontar, and palm fronds are the primary choices for fish attractors due to their ability to mimic natural habitats and their abundant availability (Antara News, 2025).

Their use is widespread across different regions, such as in Jeneponto Regency and Belu Regency, East Nusa Tenggara, where these fronds have proven effective in attracting fish to FADs (Hikmah et al., 2016; Mauko & Daga, 2010). In the waters of Buton Regency (FMA 714), the attractors used are slightly different. Local fishermen rely more on old coconut leaves, which are regularly replaced every three days to maintain their attractiveness and prevent decay that could reduce their effectiveness in attracting fish (Suyuti et al., 2018).

The attractors used in FMA 573, such as in Pacitan and Palabuhanratu, are made in various ways. In the waters of Pacitan, FAD attractors designed to draw fish attention are created using coconut leaves tied to a 25-metre-long rope, weighted at the end to keep them submerged (Prayitno, 2016). Meanwhile, FAD owners in Palabuhanratu also utilize coconut leaves as natural attractors. These leaves are chosen because, after being installed for 10–12 days, they encourage the growth of microorganisms that serve as a food source for fish (Depari, 2018).

In FMA 712, such as Lampung and Banten, and FMA 713, such as Bone Bay, FAD attractors also utilize coconut leaves (Rumpa et al., 2022). Fishermen in Banten install approximately 80 coconut leaves, which attract fish through a natural decomposition process involving marine microorganisms (Wahju et al., 2009). In Lampung, the FAD attractors consist of coconut fronds measuring 170 cm in length (Alfian et al., 2023; Yusfiandayani, 2013; Yusfiandayani et al., 2015).

In FMA 571 and 572, particularly in Aceh waters, attractors consist of 50 stalks of coconut and areca palm leaves. These attractors function to lure and gather fish around FADs by mimicking their natural habitat (Hasaruddin et al., 2021). Not only in Aceh waters, but fishermen in the Makassar Strait (FMA 713) also use natural attractors from the Cycadaceae family, such as coconut (*Cocos nucifera*) and nipa palm (*Nypa fruticans*) leaves, which have been proven effective in attracting fish (Hargiyatno et al., 2018; Hidayat et al., 2021).

Meanwhile, in some Aceh waters, the use of ijuk (*Arenga pinnata* fibers) is becoming increasingly popular as a more durable alternative to other materials like coconut or lontar leaves. The natural fibers from aren trees have a coarser and stronger texture, making them more resistant to ocean currents and less likely to degrade underwater. This advantage makes ijuk more efficient, as it reduces the frequency of attractor replacements often required for other materials (Antara News, 2025). Furthermore, a report from Bank Indonesia, in collaboration with local fishermen, indicates that the use of ijuk-based attractors in FADs has become part of a flagship programme aimed at improving FAD effectiveness and supporting the local fishing industry (Antara News, 2025).

In addition to natural materials, innovations in attractor use continue to develop. In some Nusa Tenggara Timur (NTT) Province's waters (Atapupu Beach, Belu Regency), AFADs have been equipped with solar-powered LED lights activated at night to attract fish around FADs (Mauko & Daga, 2010). This lighting has proven effective in attracting fish species that hunt in the dark. The light serves as a visual stimulus that mimics the flicker of plankton or small fish, thereby drawing the attention of pelagic and predatory fish while increasing fishermen's catch rates.

Some AFADs also feature additional attractors, such as nets, raffia strings, or bait bags filled with small fish, specifically designed to lure predators like tuna and skipjack. These innovations further enhance AFADs' role as fish aggregation centers, improving their effectiveness as auxiliary tools in capture fisheries. In the waters around Jayapura (Wanimbo et al., 2024b), the combination of raffia strings and coconut leaves is a preferred choice for attracting both small and large pelagic fish. These materials not only resemble fish habitats but are also easily obtainable and regularly replaceable to maintain their attractiveness.

With the diverse attractor types applied across different regions, AFADs continue to be refined to improve their efficiency and appeal to fish, supporting the sustainability of FAD-based fisheries in Indonesia.

Anchor System

The anchor system on AFADs is designed to ensure that fish aggregating devices (FADs) remain in the desired position, especially in waters with strong currents. This stability is crucial for the FADs to function optimally in attracting fish and providing a fixed reference point for fishermen. The type of anchor used varies depending on water conditions and the depth of the installation site. Common materials include concrete blocks, river stones, cement-filled drums, and steel anchors, with weights adjusted to withstand the pull of currents and wind.

In various Indonesian waters, the anchor system is adapted to specific local needs. For instance, in the Flores Sea, AFADs are moored using 1.5-ton stones to ensure stability in deep waters (Rahmadi & Samu, 2018). In Jayapura waters, AFADs use metal drums filled with a mixture of sand and cement as the main ballast (Yahya & Rahmat, 2017). This combination provides good stability and high durability against strong ocean currents in the region. Meanwhile, in Jenepono waters, the anchoring system is tailored to the calmer water conditions. The anchors used consist of 35 kg river stones, which are effective in maintaining the position of the FADs without requiring large ballast weights (Hikmah et al., 2016). River stones are also chosen due to their abundance and ease of installation.

To ensure the anchor remains connected to the surface buoy, the main rope is made of polypropylene, with lengths varying between 2000 and 5000 metres, depending on the installation depth. This rope is chosen for its high resistance to friction, water pressure, and sun exposure. With a carefully designed anchor system adapted to water conditions, AFADs can function optimally as an effective and sustainable fishing aid.

The anchor rope for FADs in Pacitan waters (WPP 573) is made of polypropylene (PP) or polyethylene (PE) with a diameter ranging from 25–50 mm and a length of approximately 1.2–1.5 times the water depth. The anchor serves as a mooring device to keep the FAD in place and prevent it from drifting. The anchor material is generally made from used drums with a diameter of 1 metre and a height of 1.2 metres, filled with a concrete mixture of sand, stones, and cement. FADs are installed at depths ranging from 1000 to 5500 metres, based on FAD location mapping using a bathymetric map (M. R. E. Prayitno, 2016).

The ballast for FADs in Banten waters consists of a mixture of sand, cement, stones, gravel, and split rock—small, rough, and sharp-edged crushed stones. The main ballast is made of 2-inch diameter reinforced iron equipped with two hillban. Additionally, an attractor ballast is placed at the end of the attractor to keep it vertically upright, made using small buckets as concrete moulds, with two units in total. Intermediate ballast is also used on the main rope to maintain its vertical position, made using large buckets as concrete moulds, with two units in total. The primary ballast placed at the seabed consists of seven units, with a total weight exceeding 1.5 tonnes, or approximately 0.25 tonnes per unit (Wahju et al., 2009). Meanwhile, FADs in Lampung waters utilize ballast made of concrete and natural stone, with weight adjustments based on the buoyancy of the floats used (Alfian et al., 2023). Another commonly used ballast material is concrete, adapted to the depth of the FAD installation area. This type of concrete is commonly used by fishermen in the Makassar Strait, where it is tied to the main rope made of PE (polyethylene) (Hidayat et al., 2021).

Navigation

The navigation of AFADs in Indonesia is still predominantly manual, relying on fishermen's experience in determining the installation location of fish aggregating devices (FADs). In several regions, such as the waters of Jayapura and Buton, Atapupu Beach in East Nusa Tenggara, and the waters of Sorong, West Papua (Mauko & Daga, 2010; Sururi et al., 2022b; Suyuti et al., 2018; Yahya & Rahmat, 2017), the placement of AFADs is largely based on traditional knowledge passed down through generations, without detailed oceanographic calculations. This method is considered effective by local fishermen as it takes into account fish migration routes, ensuring that FADs remain in optimal locations for attracting fish.

However, with the advancement of technology, GPS devices have begun to be used to improve accuracy in determining AFAD installation sites. In some areas, such as Labuhan Lombok, Oeba Kupang, and Bone, fishermen have started utilizing affordable GPS devices as navigation aids (Widyatmoko et al., 2021). GPS usage has also been reported in the waters of Jenepono (Hikmah et al., 2016), helping ensure that FADs remain within range and making it easier for fishermen to relocate previously installed FADs. In addition to GPS, some fishing vessels have been equipped with a Radio Direction Finder (RDF) to detect the presence of FADs (Widodo, Wilcox, et al., 2023), especially if they drift or sink due to unstable sea conditions.

At Tenau Beach, Kupang City, East Nusa Tenggara (Laoda et al., 2022), underwater cameras have been introduced to monitor the effectiveness of bait attractors. This allows fishermen to evaluate how well the AFADs attract fish and make necessary improvements. With the growing adoption of technology in AFAD navigation, it is expected that FAD usage will become more efficient, reducing the risk of losing FADs and enhancing fishermen's catch sustainability.

The use of GPS has become common among FAD fishermen in various Indonesian waters to help determine direction and location toward fishing grounds (Hargiyatno et al., 2018; Wahju et al., 2009; Widodo, Wilcox, et al., 2023). In determining fishing locations around FADs, larger fishing fleets in Indonesia not only rely on GPS but also utilize echosounders as acoustic technology to detect fish presence (Rulianto & Gurning, 2020).

AFADs fishing uses

AFADs play a crucial role in supporting both commercial and small-scale fisheries across various Indonesian waters. These devices not only improve fishing efficiency but also help fishers reduce operational costs, particularly fuel consumption. With AFADs, fishers can go directly to the fishing spot without spending time and resources searching for fish in the open sea. This advantage is particularly evident in Teluk Talengen, North Sulawesi, and Labuhan Lombok, West Nusa Tenggara, where AFADs have become an integral part of local fishing strategies (Julius et al., 2023; Widyatmoko et al., 2021). In Fisheries Management Area (WPP) 713, which includes the Makassar Strait and the Flores Sea (Hikmah et al., 2016; Rahmadi & Samu, 2018), AFADs serve as essential tools for purse seine operations targeting small pelagic fish and neritic tuna. Meanwhile, in Sorong Regency (WPP 715) (Citra et al., 2022; Khan et al., 2020; Sururi et al., 2022b), AFADs are utilized in handline tuna fishing, one of the most environmentally friendly and sustainable fishing methods.

Apart from their role in fisheries, AFADs also contribute to maintaining marine ecosystem balance by helping regulate fishing activities in line with conservation efforts. In Komodo National Park, for instance, AFADs are not only used as fishing devices but also function as markers for conservation zones,

helping fishers understand the permitted operational areas (Khyria, 2019). In Ambon, FADs improve fish catch productivity and ensure the sustainability of fishing activities, as their placement must consider the migration routes of small pelagic fish (Matrutty et al., 2021).

Support for AFAD use is evident in Kupang, NTT, where fishers have welcomed the installation of FADs to enhance their catch and optimize fishing operations (Antara News, 2024). According to a report from Antara News Kupang, fishers hope these FADs will help them reduce operational costs and increase their income. However, while FADs provide benefits in increasing catch rates, they also pose risks as a gateway for illegal fishing. Many reports highlight cases of foreign vessels poaching fish around FADs in Indonesian waters, particularly in border areas such as the Sulawesi Sea, Anambas (Riau Islands), Aru (Maluku), Pieh Island, and Waigeo (West Papua) (Ambarwati, 2023).

The use of AFADs brings various advantages, including enhancing food security by helping fishers meet the growing demand for fish due to population growth and climate change. FADs also support fisheries management by reducing the use of destructive fishing gear and lowering operational costs through reduced fuel consumption. Additionally, fishing around anchored FADs results in minimal bycatch, making it a more environmentally friendly method. FADs also have the potential to be developed in the tourism and recreational fishing sectors, offering an alternative source of income for fishers. From a safety perspective, FADs provide reference points for fishers in emergencies, thereby improving their security at sea (FAO, 2012).

The use of anchored FADs (AFADs) comes with several risks, including high costs, as expenses are needed for materials, surveys, installation, monitoring, and maintenance. Therefore, a cost-benefit analysis is necessary before initiating a FAD programme. Moreover, the lifespan of a FAD varies, with some being lost due to poor design, environmental factors, vandalism, theft, shark bites, or damage caused by fishing gear and vessels. Conflicts among users may also arise if access to FADs is not well-managed. Another risk is the overexploitation of pelagic species that gather around FADs, making it crucial for fishers to collect catch data to support fish stock management. Additionally, placing FADs in inappropriate locations can disrupt sensitive ecosystems, such as conservation areas and habitats vital for protected species (FAO, 2012).

Catches

The types of fish caught around AFADs vary greatly depending on the location of the waters, depth, and fishing gear used. AFADs generally attract a range of pelagic fish species, from small to large, which are the main targets in FAD-based fisheries in Indonesia.

Table 35. Weight (tonnes) of other key species caught in AFADs over time based on literature review.

No	Author	Location	Volume of other species	Volume of other species statistic
1	Soghirun et al. 2024	Bone Bay Waters, South Sulawesi Province	Swordfish Blue marlin Black marlin Dolphinfish/Mahi-mahi Sailfish Blue shark Silky shark Barracuda Wahoo Escolar Tripletail	not available

No	Author	Location	Volume of other species	Volume of other species statistic
2	Alfian et al. 2023	Hurun Bay, Bandar Lampung, Indonesia	Buntal (<i>Tetraodon lineatus</i>) 1 fish Chromis notata 10 fish Lemon damsel (<i>Pomacentrus moluccensis</i>) 688 fish Kepe-kepe (<i>Cheatodon auripes</i>) 5 fish Black damsel (<i>Neoglyphidodon melas</i>) 16 fish Barakuda (<i>Sphyrena</i>) 1 fish Blue devil (<i>Chrysptera cynea</i>) 15 fish Betok hijau (<i>Chiromis vridis</i>) 13 fish Red sea dascllus (<i>Dascyllus</i>) 10 fish Ekor kuning (<i>Caesio cuning</i>) 100 fish Kerapu macan (<i>Cephalopholis boenak</i>) 3 fish Stegastes (<i>Fasciolatus</i>) 18 fish Abudefdud (<i>Pomacentridae</i>) 23 fish Redtail butterflyfish (<i>Chaetodon collare</i>) 3 fish Idola moor (<i>Zanclus cornutus</i>) 7 fish Cheilodipterus macrodon 2 fish Tail-spot wrasse (<i>Halichoeres melanurus</i>) 3 fish Triplepot wresse (<i>Halichoeres trispilus</i>) 3 fish Bluestripe snapper (<i>Lutjanus kasmira</i>) 1 fish Napoleon (<i>Cheilinus undulates</i>) 1 fish Parajulis (<i>Parajulis poecilepterus</i>) 4 fish Briled parrotfish (<i>Scarus frenatus</i>) 2 fish Barred Thicklip (<i>Hemigymnus fasciatus</i>) 7 fish	not available
3	Anggawangsa et al. 2023	Palabuhan ratu, West Java, Indonesia	Indian scad (<i>Decapterus russelli</i>) 2 tonnes	not available
4	Widodo et al 2023	Indian Ocean, Sulawesi Sea, Banda Sea, and Flores Sea.	Small shark Bramidae Mahi-mahi (dolphin fish) Rainbow fish Neritic tuna Scad	not available

No	Author	Location	Volume of other species	Volume of other species statistic
5	Julius et al. 2023	Sangihe waters, North Celebes	Carangoides (famili Carangidae) 49% Decapterus (famili Carangidae) 28% Balistapus (famili Balistidae) 18% Salaria (famili Blennidae) 5% Loligo (famili Loliginidae) 1%	not available
6	Syari et al. 2023	Rebo, Bangka Belitung Province	<i>Neopomacentrus azysron</i> 118 fish <i>Neopomacentrus cyanomos</i> 36 fish <i>Lutjanus vitta</i> 63 fish <i>Lutjanus russeli</i> 14 fish <i>Lutjanus madras</i> 115 fish <i>Epinephelus coioides</i> 11 fish <i>Cephalopholis boenak</i> 11 fish <i>Apoogon endekataenia</i> 40 fish <i>Apogon cavitensis</i> 19 fish <i>Choerodon schoenleinii</i> 3 fish <i>Helichoeres dussumieri</i> 28 fish <i>Helichoeres bicolor</i> 8 fish <i>Diagramma pictum</i> 60 fish <i>Arothron stellatus</i> 12 fish <i>Scolopsis monogramma</i> 31 fish <i>Pentapodus paradiseus</i> 9 fish <i>Taeniura lymma</i> 1 fish <i>Nebrius ferrugineus</i> 3 fish <i>Selaroides leptolepis</i> 220 fish <i>Parachaetodon ocellatus</i> 4 fish <i>Chelmon rostratus</i> 2 fish <i>Monacanthus chinensis</i> 1 fish <i>Cymbacephalus beauforti</i> 6 fish <i>Siganus margaritiferus</i> 5 fish	not available
7	Agustian 2023	Aceh Jaya Province water, Aceh	<i>Caranx ignobilis</i> (giant travelly) 62 fish <i>Pomadasys argyreus</i> (Gerot-gerot) <i>Lutjanus spp.</i> <i>Epinephelus spp.</i> (grouper and tiger grouper) <i>Trichiurus lepturus</i> <i>Valamugil buehanani</i> <i>Siganus vermiculatus</i> <i>Rastrelliger spp.</i> <i>Priacanthus hamrur</i> <i>Atule mate</i> <i>Selaroides leptolepis</i> <i>Scoberomorus guttatus</i>	not available

No	Author	Location	Volume of other species	Volume of other species statistic
8	Radius et al, 2023	Banyak Island waters, Aceh Singkil Province, Aceh	Lane Snapper (<i>Lutjanus decussatus</i>) 25% Kakap Asuan (<i>Lethrinus miniatus</i>) 6.25% Kuwe (<i>Carangoides ignobilis</i>) 12.5% Grouper (<i>Epinephelinae</i>) 6.25% Kerapu Sunuk (<i>Plectropomus leopardus</i>) 6.25% Kerapu Macan (<i>Epinephelus fuscoguttatus</i>) 6.25% Kerapu Kayu (<i>Epinephelus tauvina</i>) 6.25% Talang (<i>Scomberoides tala</i>) 6.25% Sunglir (<i>Elagatis bipinnulata</i>) 6.25%	not available
9	Arnenda & Rochman 2023	Kutaraja, Banda Aceh	Dolphin fish (<i>Coryphaena hippurus</i>) <20% from total catch Shark (<i>Sphyrna</i> spp.) Scad Selar	not available
10	Saifullah & Heriyansah 2023	Pemangkat Sea, Sambas Regency, West Kalimantan	<i>Selaroides leptolepis</i> (Selar Besar / Klarau) 0.17 tonnes Rastrelliger sp. (Kembung) 0.07 tonnes <i>Caranx ignobilis</i> (Kuwe / Mayok) 0.02 tonnes <i>Megalaspis cordyla</i> (Selar Tetengkek) 0.61 tonnes	not available
11	Sugianto et al. 2023	Semaka Bay, Tanggamus Regency, Lampung Province, Indonesia	Alu-alu (<i>Sphyrna jello</i>) 49 fish Ayam-ayaman (<i>Abalistes stellaris</i>) yellowtail (<i>Caesio cuning</i>) Kakap merah (<i>Lutjanus campechanus</i>) Grouper (<i>Epinephelus fuscoguttatus</i>) Kurisi (<i>Nemipterus nematophorus</i>) Giant travelly (<i>Caranx sexfaciatus</i>)	not available
12	Laoda et al. 2022	Kupang City, East Nusa Tenggara Province (NTT)	Yellowtail scad (<i>Selar crumenophthalmus</i>) sardinella (<i>Sardinella</i> spp.) Round scad (<i>Decapterus russeli</i>) Indian mackerel (<i>Rastrelliger kanagurta</i>) squid (<i>Loligo</i> spp.)	not available

No	Author	Location	Volume of other species	Volume of other species statistic
13	Setyohadi et al. 2022	Lancang Island, Kepulauan Seribu, Jakarta	<i>Selaroides leptolepis</i> 38 fish Baby anchovies (<i>Stolephorus</i> sp) 10 fish Barakuda (<i>Sphyrnaidae</i> sp.) 4 fish Kiper (<i>Scatophagus argus</i>) 1 fish Mullet (<i>Mugil</i> sp.) 13 fish Blue swimming crab (<i>Portunus pelagicus</i>) 4 fish Squid (<i>Loligo</i> sp.) 9 fish	not available
14	Sururi et al. 2022	Makbon waters Sorong, West Papua	Salem (small pelagic fish non-tuna) 11 fish	not available
15	Bou 2022	Tenau beach, East Nusa Tenggara	Frigate tuna (<i>Euthynnus affinis</i>) 4.40 tonnes Selar (<i>Selar crumenophthalmus</i>) 2.59 tonnes Sardinella 2.41 tonnes Round scad (<i>Decapterus russeli</i>) 1.57 tonnes Indian mackerel (<i>Rastrelliger kanagurta</i>) 1.4 tonnes squid (<i>Loligo</i> spp) 0.38 tonnes	Frigate tuna 187 tonnes
16	Purnama et al. 2022	East Nusa Tenggara	<i>Decapterus macarellus</i> <i>Rastrelliger kanagurta</i> <i>Caranx sexfasciatus</i>	Not available
17	Paiki & Wanimbo 2020	Jayapura waters, Papua Province	<i>Atule mate</i> 24 fish <i>Caranx caeruleopinnatus</i> – Bobara Tapis 76 fish <i>Caranx tille</i> – Bobara Mata Merah 84 fish <i>Gnathanodon speciosus</i> – Golden Trevally 30 fish <i>Lethrinus xanthurus</i> – Gotila Mulu Tikus 13 fish <i>Lutjanus buccanella</i> – Kakap Merah 47 fish <i>Lutjanus fulvus</i> – Kakap Tambak 23 fish <i>Lutjanus rufolineatus</i> – Badur / Kakap 121 fish <i>Megalaspis cordyla</i> – Selar Tetengkek 48 fish <i>Nemipterus furcosus</i> 174 fish <i>Epinephelus argus</i> – grouper 54 fish <i>Lethrinus harak</i> – Gotila 21 fish <i>Selar boops</i> – Kawalina 183 fish <i>Rastrelliger kanagurta</i> 110 fish	not available

No	Author	Location	Volume of other species	Volume of other species statistic
18	Matrutty 2021	Ambon	<i>Decapterus</i> sp 278 fish <i>Rastrelliger</i> sp 149 fish <i>Selar crumonephthalmus</i> 182 fish <i>Selaroides</i> sp 172 fish	<i>Decapterus</i> sp 926 tonnes <i>Rastrelliger</i> sp 151 tonnes <i>Selaroides</i> sp 136 tonnes (BPS Ambon 2012)
19	Nurlaela et al. 2021	West Sumatera waters, specially around Kepulauan Mentawai Regency	Scad (<i>Decapterus macrosoma</i>) 0.02 tonnes (35%)	not available
20	Hasaruddin et al. 2020	Nagan Raya, Aceh	<i>Sardinella lemuru</i> <i>Rastrelliger kanagurta</i> <i>Selaroides leptolepis</i> <i>Lepturacanthus savala</i> 8 <i>Lutjanus campechanus</i> 1 <i>Rastrelliger brachysoma</i> 1	not available
21	Khyria 2019	Southern Celebes sea	Mackerel Scads Carangids Sardines	not available
22	Zuraidah et al. 2018	West Aceh Waters, Meulaboh – Aceh Province	Round scad 382 fish Yellowtail 285 fish Indian mackerel 83 fish Blue round scad 18 fish yellowfin scad 135 fish Sardinella 75 fish Tamban 26 fish	not available
23	Chaliluddin et al. 2018	Pusong waters, Lhokseumawe City, Aceh Province	Indian mackerel (<i>Rastrelliger</i> sp.) 1.2 tonnes Round scad (<i>Decapterus</i> sp.) 0.35 tonnes Ayam-ayam (<i>Abalistes stellaris</i>) 0.69 tonnes Tegang ekor/Tetengkek (<i>Megalaspis cordyla</i>) 0.3 tonnes Talang (<i>Scomberoides lysan</i>) 0.14 tonnes	not available
24	Kantun et al. 2018	Babana waters, Center Mamuju Regency, West Sulawesi	Indian mackerel (<i>Rastrelliger kanagurta</i>) 428 fish	not available

No	Author	Location	Volume of other species	Volume of other species statistic
25	Jaliadi 2017	Meulaboh waters, Aceh Province	Bullet tuna 167 fish Round scad 382 fish Yellowtail 285 fish Indian mackerel 83 fish Blue round scad 18 fish yellowtail scad 135 fish Sadinella 75 fish Tamban 26 fish	not available
26	Suardi 2017	Luwu, Bone bay	baronang lingkis (<i>Siganus canaliculatus</i>) 519 fish	not available
27	Suardi et al. 2016	Pesisir Uloulo, Bone Bay, Luwu Regency (South Sulawesi)	<i>Siganus canaliculatus</i> (baronang lingkis) 38.99% <i>Caranx</i> sp. (giant travelly) 1,88%	not available
28	Amry et al. 2016	Malabero Beach, Bengkulu City	Selar (<i>Selar crumenophthalmus</i>) 20 kg /tip = 0.462 tons/year Gembolo (<i>Rastrelliger</i> sp.) Bawal hitam (<i>Parastromateus niger</i>) Sarai (<i>Rastrelliger</i> sp.) Indian mackerel (<i>Rastrelliger</i> sp.)	not available
29	Prayitno 2016	Pacitan, East Java	Round scad 383 tonnes Marlin 38.96 tonnes Frigate tuna 367.46 tonnes Pogot 114.21 tonnes Dolphin fish 122.7 tonnes Rainbow runner 66.17 tonnes Squid 58.72 tonnes	not available
30	Hikmah et al. 2016	Jeneponto Regency, South Sulawesi Province, Indonesia	Sardinella: 102 fish Yellowtail scad: 79 fish Round scad: 45 fish Giant travelly: 31 fish Indian mackerel: 23 fish Poni fish: 2 fish Total catch: 284 fish	not available
31	Jeujanen 2016	Kepulauan Kei, Maluku Tenggara	Selar (<i>Selaroides leptolepis</i>) 886.10 tonnes Round scad (<i>Decapterus russelli</i>) 362.10 tonnes Indian mackerel (<i>Rastrelliger brachysoma</i>) 299.37 tonnes Frigate tuna (<i>Auxis thazard</i>) 647.04 tonnes	Frigate tuna 10.10 tonnes (BPS Maluku Tenggara 2023)
32	Hernando et al. 2015	Bengkalis Regency waters, Riau Province, Indonesia.	Gulama (<i>Pseudocienna amovens</i>) 65 fish Pepetek (<i>Equulites leuciscus</i>) Bawal Laut (<i>Stromateus cinereus</i>) Talang (<i>Chorine mustala</i>)	not available

No	Author	Location	Volume of other species	Volume of other species statistic
33	Zikri et al. 2015	Bengkalis Regency waters, Riau Province, Indonesia.	<i>Polynemus tectradactylus</i> 34 fish <i>Chirocentrus dorab</i> <i>Arius</i> sp. <i>Pristigasteride</i> <i>Diodon holocanthus</i>	not available
34	Rahmah 2014	Sendang Biru, Malang	Dolphin fish 0.24 tonnes Marlin 0.13 tonnes Frigate tuna 0.55 tonnes	Frigate tuna 2004.83 tonnes (BPS Malang 2020)
35	Simbolon et al. 2013	South East Maluku Waters	Round scad (<i>Decapterus russelli</i>) 52.957 fish Tenggiri (<i>Scomberomorus commersoni</i>) 573 fish Total volume non-tuna species: 53530 fish	not available
36	Albar 2012	Blanakan Subang, West Java	Round scad 157.3 tonnes Bawal 13.4 tonnes Indian mackerel 19.4 tonnes Selar 16.9 tonnes Sardinella 106.9 tonnes Frigate tuna 28.1 tonnes Squid 25.5 tonnes	Frigate tuna 52.3 tonnes (BPS Subang 2020)

Annex 6: Stakeholder survey

EXPERT SURVEY

Respondent profile

1. Please, indicate the country or area for which you hold best expertise **within the Indian Ocean**

2. Please, indicate the field in which you hold your **main** expertise:

Coral reef research
Fisheries research
Fisheries industry
Environmental management
Fisheries management
Policy
Other (please, specify)

3. Please, indicate the type of organisation you work at:

Academia
Research organisation
(Fishing) industry
Government (local, national, regional) or public administration
Consultancy
NGOs
Other (please, specify)

4. What is your level of experience with AFAD?

High
Medium
Low

Technical inputs – AFAD Characterization

5. Which of these four types of AFADs is currently the most widely used?
Please rank them according to their estimated percentage of use.

	0%	1-20%	21-40%	41-60%	61-80%	81-100%
TRADITIONAL						
GABUS						
RAKIT						
PONTOON						

6. Classify these three types of AFADs according to their deployment distance from the coast. If applicable, more than one option may be valid.

	COASTAL (1-20KM)	OFFSHORE (20-200 KM)
TRADITIONAL		
GABUS		
RAKIT		
PONTOON		

7. Considering that AFADs consist of three parts: a) the raft, b) the attractors, and c) the mooring, please indicate the materials used in their construction:

In the case of the **RAFT**,

	GABUS	RAKIT	PONTOON
Bamboo canes			
Wood			
Styrofoam			
Plastic Coat			
Plastic Net			
Plastic Drum			
Tyres			
Styrene Foam			
Welded Metal Drum			
Others			

8. Considering that AFADs consist of three parts: a) the raft, b) the attractors, and c) the mooring, please indicate the materials used in their construction:

In the case of the **ATTRACTORS**,

	GABUS	RAKIT	PONTOON
Organic ropes (Rattan, Jute,...)			
Palm leaves			
Stones			
Plastic ropes (Polypropylene)			
Swivel/Shackle			
Cement block			
Others			

9. Considering that AFADs consist of three parts: a) the raft, b) the attractors, and c) the mooring, please indicate the materials used in their construction:

In the case of the **MOORING**,

	GABUS	RAKIT	PONTOON
Organic ropes (Rattan, Jute,...)			
Stones			
Wire/Chain rope top			
Wire/Chain rope bottom			
Plastic ropes (Polypropylene)			
Cement block			
Half tyres			
Steel anchore			
Others			

Technical inputs – AFAD use

10. How long does a AFAD last? Please mark with an “X” the time range that best represents its average duration in months.

	0-6 MONTHS	6-12 MONTHS	12-18 MONTHS	18-24 MONTHS	24-30 MONTHS	30-36 MONTHS	>36 MONTHS
GABUS							
RAKIT							
PONTOON							

11. Which part of the AFAD breaks or degrades first? Please mark with an “X” the part or parts that tend to break or degrade first.

	GABUS	RAKIT	PONTOON
RAFT			
ATTRACTORS			
MOORING			
ALL			

12. Are the degraded or broken parts of the FAD usually replaced or repaired?

YES or NO.

13. Please mark with an "X" the parts that are usually replaced or repaired.

	GABUS	RAKIT	PONTOON
RAFT			
ATRACTORS			
MOORING			
ALL			

14. Based on your experience, are the degraded or broken parts usually lost?

YES or NO.

15. Please mark with an "X" the parts that are most frequently lost once they are degraded or broken. If applicable, you may select more than one component for each type of FAD.

	GABUS	RAKIT	PONTOON
RAFT			
ATRACTORS			
MOORING			
ALL			

16. Are the lost parts of the FAD usually recovered?

YES or NO.

Technical inputs – AFAD impacts

17. Recent research indicates that some of the main risks to coral reefs in the Indian Ocean include climate change, coastal development, and "bad" fisheries practices.

Could you please indicate examples of "bad fisheries practices"?

18. As you may know, anchored FADs are used by fishery to catch tuna. Sometimes, these devices get lost at sea. Have you ever seen any drifting, entangled or beached AFAD? If yes, please describe the environment of the place you found the AFAD.

19. Based on your knowledge or observations, please indicate whether the effect of derelict AFADs on

- Fish is: negative – neutral – positive – I don't know
 - o Please, indicate some of these effects
- Coral is: negative – neutral – positive – I don't know
 - o Please, indicate some of these effects
- Environment is: negative – neutral – positive – I don't know
 - o Please, indicate some of these effects
- Ecosystem functioning is: negative – neutral – positive – I don't know
 - o Please, indicate some of these effects

20. Which is the part of the AFAD that you think is responsible of most of the negative impacts (if any) that they can cause?

21. The tuna fishing industry would like to minimize potential negative impact of AFAD. Please, if you have the knowledge, complete the following sentences:

To minimize the impacts of AFADs, the **DESIGN** of AFADs could be improved by

To minimize the impacts of AFADs, the **MATERIALS** used in the AFADs could be improved by

To minimize the impacts of AFADs, the **MANAGEMENT** of AFADs could be improved by

To minimize the impacts of AFADs, ...

Annex 7: RFMO and RFBs contacted and responses

Table 36. Summary of RFMOs / RFBs contacted and responses

RFMO	Email sent (date)	Response	Afads?	Number of Afads	Indication of future FAD application?	Indication of past FAD application?	Comment from responder
CRFM	25/09/2024	None					
FAO	25/09/2024	None					
FFA	25/09/2024	None					
IATTC	25/09/2024	None					
ICCAT	25/09/2024	None					
IOTC	25/09/2024	Yes	Yes	Data in national reports	Yes	Yes	Data held in national reports, for 4 IOTC CPCs but data cannot be released by Secretariat. Contact CPCs direct..
NPFC	25/09/2024	None					
NEAFC	25/09/2024	Yes	No	0	No	No	
NAFO	25/09/2024	Yes	No		No	No	
SEAFO	25/09/2024	Yes	No	0	No	No	ICCAT cover tuna fisheries (and thus the issue of FADs)
SPC	25/09/2024	None					
SRFC	25/09/2024	None					
WCPFC	25/09/2024	None					
WECAFC	25/09/2024	None					

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