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WESTERN CENTRAL ATLANTIC FISHERY COMMISSION (WECAFC)
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Draft Caribbean Regional Management Plan for the Moored Fish Aggregating Device (MFAD) Fishery

Contents

Abbreviations and acronyms

CARIFICO	Caribbean Fisheries Co-management Project
CFMC	Caribbean Fisheries Management Council
CLME	Caribbean Large Marine Ecosystem project
CRFM	Caribbean Regional Fisheries Mechanism
EAF	Ecosystem Approach to Fisheries
ERA	Ecological Risk Analysis
FAO	Food and Agriculture Organization
ICCAT	The International Commission for the Conservation of Atlantic Tunas
IFREMER	French Research Institute for Exploration of the Sea
JICA	Japan International Cooperation Agency
MAGDELESA	Moored fish Aggregating Devices in the Lesser Antilles project
MFAD	Moored Fish Aggregating Device
OSPESCA	Central America Fisheries and Aquaculture Organization
SAP	Strategic Action Plan
WECAFC	Western Central Atlantic Fishery Commission

1. Background

This document presents the Caribbean Regional Management Plan for the Moored Fish Aggregating Device (MFAD) Fishery following the Recommendation of the 3rd meeting of the WECAFC ad hoc Joint Working Group on Development of Sustainable Moored Fish Aggregating Device (MFAD) Fishing in the Lesser Antilles held on April 30th- May 2nd 2019 - Recommendation WECAFC/17/2019/21 (Amendment to Recommendation WECAFC/15/2014/2) - which was endorsed during Seventeenth Session of the Commission held on July 15-18 2019 in Miami, US, and was the basis for the 2019-2020 Programme of Work adopted by the Commission. This Programme sought to increase the knowledge of, and experience with, moored-FADs related fisheries, with the ultimate goal of strengthening regional fisheries management and good-practice approaches for fisheries and aquaculture development. In this context, the development of this document was funded by the European Union through the Food and Agriculture Organization of the United Nations (FAO) and its Western Central Atlantic Fishery Commission (WECAFC).

Since the first exploration of MFAD use in the region in the late 1960's, the number of countries and overseas territories making use of MFADs has gradually increased, particularly in the insular Caribbean (Wilson et al. 2020), opening new revenue opportunities for small-scale fishers but also raising challenges in governance and concerns about the impacts of MFAD fishing on fish stocks shared across the region.

In that regard, considerable effort has been allocated over the last two decades towards describing the MFAD fishery and sharing information on MFADs across the region. Most of the existing detailed information comes from the French Overseas territories (Guadeloupe and Martinique), where MFAD fishing was adopted earlier than in other locations, and through research efforts of IFREMER that started in the 1990's (Reynal et al. 1999). In 2001, recognizing the need to exchange information, practices and experiences in the management and exploitation of large pelagic using MFADs, the WECAFC ad hoc Working Group on the Development of Sustainable Development of MFAD fishing in the Lesser Antilles was established and its first meeting held in Martinique (FAO 2002). Following this meeting, IFREMER conducted the DOLPHIN research project aimed at characterizing fish aggregations around MFADs and describing in considerable detail the MFAD fishery in the French Antilles. The results of this project were shared during the second Working Group meeting that took place in Guadeloupe in 2004 (FAO 2007). This later meeting led to the conception and subsequent development and execution of the MAGDELESA (Moored fish AGgregating DEvices in the LESser Antilles) project by IFREMER between 2011 and 2014, which generated considerable new knowledge on the MFAD fishery (Reynal et al. 2015).

Between 2010 and 2012, JICA and CRFM collaborated to conduct a pilot project in St Lucia and Dominica seeking to improve the capacity of fisheries officers and fishers' organizations to manage pelagic resources exploited using MFADs and increase MFAD productivity by developing skills and capacity to utilize pelagic resources (CRFM/JICA 2012). This project focused on technical aspects of MFAD design, construction, deployment, and maintenance but also sought to set the grounds for a co-management approach to such fisheries in which fishers were expected to increase their participation in decision making but also share a greater responsibility in the provision of fisheries data (CRFM/JICA 2012; CRFM 2013b). These efforts were followed up in 2013 by the implementation of the 5-year Caribbean Fisheries Co-Management (CARIFICO) Project, which sought to further support the development a co-management approach to MFAD fisheries in Dominica and St Lucia and expand its geographic range by including four more countries with significant MFAD fisheries, namely Antigua and Barbuda, St Kitts and Nevis, St Vincent and the Grenadines, and Grenada (CRFM 2014a; CRFM 2014b; CRFM 2017).

Around this time, during the CRFM-JICA CARIFICO/WECAFC-IFREMER MAGDELESA Workshop on FAD Fishery Management in St Vincent in 2013, it was proposed that the Working Group expand to a Joint Working Group with possible participation of JICA, IFREMER, CRFM and WECAFC (CRFM 2013a).

In this very dynamic context, and recognizing the increasing need for coordination, harmonization, and cooperation across the region on issues pertaining to MFAD use, the CRFM facilitated the development of a draft Sub-regional Management Plan for the MFAD fishery for the Eastern Caribbean in 2015 (CRFM 2015a). In 2019, the Joint Working Group met for the third time and its Terms of Reference (ToR) were formalized during the Seventeenth Session of WECAFC that same year. These ToR included the review of the CRFM Sub-Regional Management Plan to adapt it to the broader WECAFC regional setting.

The Caribbean Regional Management Plan for the Moored Fish Aggregating Device (MFAD) Fishery thus seeks to build on the CRFM sub-regional management plan by seeking to (1) expand the geographic scope to include the wider Caribbean (Figure 1), (2) integrate the most recent developments in MFAD fisheries, and (3) provide an update on the current state of the MFAD fishery across the region. The latter was facilitated by a regional online survey on MFAD use across the region that took place between August and October 2021. Respondents from twenty countries/overseas territories with significant MFAD fisheries took part in the survey. These countries/overseas territories were St. Eustatius, Dominica, Bonaire, Haiti, Antigua and Barbuda, Guadeloupe, Martinique, St Lucia, Puerto Rico, Bermuda, Montserrat, St. Vincent and the Grenadines, Florida (USA), Saba, Anguilla, Tobago (Trinidad and Tobago), the Dominican Republic, Curaçao, Cayman Islands, and Grenada. Seventy percent of the respondents were affiliated with national/local fishery and/or coastal management authorities. A detailed review of the state and challenges of the MFAD fishery is given in Appendix I. Details and in-depth findings of the regional survey are given in Appendix II. A summary of the biology, distribution, and exploitation status of fish stocks of species typically caught on MFADs is given in Appendix III.

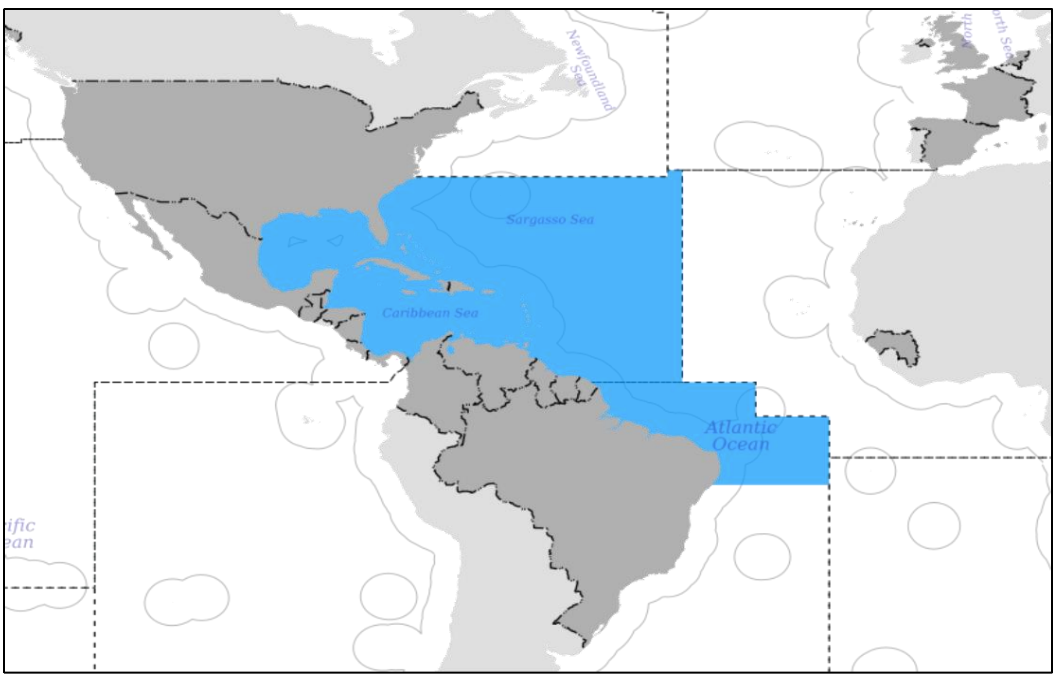

Figure 1. Area of competence of the Western Central Atlantic Fishery Commission (WECAFC)

In addition, the Regional MFAD Fishery Plan is also informed by recent relevant regional policy instruments such the strategy 5B of the Strategic Action Plan (SAP) of the Caribbean Shared Living Marine Resources and Adjacent Regions (CLME) and the 2016 CRFM-OSPESCA-WECAFC Memorandum of Understanding for Interim Coordination on Sustainable Fisheries, The Caribbean Billfish Management and Conservation Plan (Bealey et al. 2019) and ICCAT recommendations.

2. Summary of the state and challenges of the MFAD fishery

A detailed review of the current state of the MFAD fishery across the region and a detailed description of the challenges that it currently faces is given in Appendix I. A summary is given below.

About 6,200+ fishers and 2,700+ fishing vessels are engaged in (full- or part-time) MFAD fishing across the region for mainly commercial and/or subsistence purposes. Nearly all MFAD fishing takes place in the insular states and overseas territories of the Caribbean, where MFAD vessel numbers have remained stable or increased across most locations over the last five years. In contrast, there is comparatively little MFAD fishing taking place in the continental states and overseas territories of the region. There is also currently an estimated total number of 3,600+ MFAD units deployed across the region, with two locations, the Dominican Republic and Guadeloupe, jointly accounting for 86% of all MFADs in the region.

Nearly all (97%) MFADs deployed across the region are privately owned by fishers, even though many locations also support publicly owned MFADs. Both public and private MFADs are typically made of synthetic non-biodegradable materials, but private MFADs are generally considerably less expensive than public ones even though across locations they can also vary markedly in cost and design.

Public MFADs designs generally align with best practices, including the provision of surface markers and features allowing the identification of their origin. In contrast, such best practice considerations are rarely implemented on private MFADs. Overall, private MFADs get lost more often than public MFADs and are also less likely to be recovered once they are lost. On the other hand, they tend to be more quickly replaced than public MFADs, allowing a more continuous access to the pelagic resource. All the aforementioned elements combined suggest that private MFADs represent a significant source of marine litter in the region, albeit patchily distributed, underscoring an important challenge of the fishery and the need for affordable MFAD designs that minimize marine litter.

Fishing on MFADs across the region generally takes place using small-sized (<9 m long) multipurpose vessels (made of wood, fiberglass, or fiberglass and wood) engaged in one-day fishing trips, carrying 2-3 fishers, and equipped with outboard engines. Typical outboard engine power can differ by up to one order of magnitude among locations, although the prevailing engine horsepower across most locations is 100 hp and above. In most locations fishers will generally carry safety signaling equipment, emergency flotation devices, and navigation equipment. In contrast, fishers will generally lack adequate training in safety at sea, alternative means of propulsion, and personal protective gear to handle large fish, highlighting the need for more fisher training. The extent to which large fish typically caught on MFADs are processed onboard to maintain high quality of the landed product (spiked; bled out; gutted; preserved on ice) differs markedly across the region. Moreover, adequate facilities to handle large fish are still lacking in many locations across the region and most of the catch is directly destined to local markets with generally little value added to the landed product.

Fishing techniques on MFADs are largely dominated by the surface (<2 m deep) and sub-surface (2-10 m deep) trolling using baited hooks and artificial lures and deeper drifting droplines using live fish bait such as small tunas. A relatively large number of species are targeted on MFADs, including major tuna species such as yellowfin tuna, bigeye tuna, and skipjack; small tuna species such as blackfin tuna and little tunny; and tuna-like species such as blue marlin, wahoo, and dolphinfish. However, there can be marked differences across islands and within islands (Atlantic vs Caribbean side) as well as seasonally in the relative contribution of these different species to the catch. The environmental factors that drive such spatiotemporal variability in catch composition across the region remain poorly known and require more research. One potentially contributing factor is that in some locations MFAD fishing takes place all year round whereas in other locations it takes place seasonally – these differences in seasonality across the region likely reflect differences in local socio-economic and ecological contexts.

In terms of incidental by-catch, the capture of marine mammals, sea turtles, and sea birds on MFADs appears to be infrequent across the region, possibly because the use of entangling materials such as old nets as MFAD aggregators also seems to be infrequent. In contrast, sharks appear to be comparatively more frequently caught on MFADs, which is expected given the range of hook and line fishing techniques used. That said, actual data on incidental catches on MFADs are notoriously lacking for any of these groups, highlighting the need for improved monitoring.

The stocks of several species targeted on MFADs are currently considered overexploited by ICCAT's most recent stock assessments, including bigeye tuna (stock overfished but not undergoing overfishing), blue marlin (stock overfished and undergoing overfishing), Atlantic white marlin (stock overfished but not undergoing overfishing) and wahoo (stock overfished), whereas other species are considered to have high risk to overfishing, including blackfin tuna, king mackerel and Atlantic Spanish mackerel. This raises the urgent need to carefully monitor landings of species caught on MFADs and to do so in a way that can effectively provide a regionwide view of the state of shared stocks. However, considerable differences still exist among locations in the implementation of fishery statistical systems. Whereas several locations do not systematically collect fishery data, most do have active fishery data collection systems involving the use of standardized data collection forms and nearly all these locations distinguish landings from MFAD fishing from non-MFAD fishing. That said, there is still great need to standardize minimum data requirements across these locations to help establish a harmonized regional database that can inform management more effectively. Moreover, because MFADs tend to aggregate juvenile fish of several tuna species and dolphinfish, catches of these species on MFADs can be numerically dominated by immature fish (even though the total weight of the catch might be dominated by a few large adult individuals). Targeting juvenile tuna on MFADs for commercial purposes raises legitimate concerns about potential negative impacts on stocks; these same concerns are expressed in ICCAT 19-02 Recommendation. Although such recommendation does not directly apply to the small artisanal vessels used in the region, further development of the fishery in the region should give this issue due consideration and, to the extent that it is possible, seek to minimize such effects under the precautionary approach. In the meantime, it further justifies the need for improved monitoring of catches on MFADs and highlights the need for research on natural rates of juvenile mortality of these species in the region.

Furthermore, it is well known that estimates of catch per unit effort on MFADs are not reliable indices of fish population abundance because MFADs are likely to continue to aggregate fish (and thus yield stable catches) even when total fish abundance might be rapidly declining. It is thus necessary to supplement fishery-dependent data from MFADs with fishery-independent data to accurately assess the impacts of MFAD fishing on stocks, which would benefit from regional research programs and monitoring networks where MFADs are being used.

Published reports of MFAD landings are rare because separating MFAD catch data from other types of fishing has only begun recently in most of the locations that monitor fishing trips. The existing data show that variability in MFAD landings across the region spans one to two orders of magnitude; Guadeloupe and the Dominican Republic largely dominate reported landings, with values exceeding 1,000 metric tons per year, in line with the large number of MFADs present in their territories. Recent catches in the order of 1,000 metric tons such as those of the Dominican Republic represent a very small fraction (<3%) of total reported landings (all fishing types combined) for the region. However, disaggregating landing data by species indicates that MFAD fishing can still account for a large fraction of total regional landings for a few specific groups (e.g. blue marlin), highlighting the importance of species-specific monitoring. Yields per MFAD fishing trip can also differ considerably across the region and such variability is likely driven by multiple factors, including the distance of MFADs to fish migration routes and the number of boats that typically simultaneously exploit the same MFAD.

It is generally expected that MFADs will improve fisher livelihoods (via increased revenue and fishing efficiency and reduced fuel consumption), support food security, and decrease fishing pressure in coastal systems. However, data on the socio-economic dimension of the MFAD fishery and on its performance relative to other types of fishing are lacking across the region. The few data that exist do support that, overall, MFAD fishing tangibly improves the livelihoods of fishers. However, these data also support that the magnitude of such improvement depends on local socio-economic and fishing context (e.g. government or NGO subsidies; opportunity costs; competition with fish imports; local markets; distance of MFADs to landing sites), which varies markedly across the region so that in some contexts MFADs might not actually yield the expected economic benefits. Overall, more rigorous data on MFAD economic performance across the region are needed to adequately guide MFAD programs. On the other hand, the rare studies that have assessed the expectation that MFAD fishing will lead to a decrease of fishing pressure in coastal systems have found no support for it, and there seems to be growing awareness across the region about this lack of effect, highlighting the need to better understand how MFAD fishing and coastal fishing interact with each other.

There is evidence that in some locations MFAD fishers tend to be younger and more educated than long-time MFAD fishers and non-MFAD fishers, suggesting that the MFAD fishery is attracting new younger and more educated fishers rather than converting other fishers to MFAD fishing. This is relevant because the younger and more educated fishers are more likely to integrate Information and Communication Technology (ICT) systems into their business and marketing activities and early warning programs for hazards, which is desirable in all fronts.

The introduction of MFADs at a given location usually is done via the implementation of short-term projects funded by government or non-governmental agencies and typically involve the deployment of public MFADs that tend to align with best practices in MFAD design and are consequently relatively expensive to maintain and replace. The general expectation is therefore that the revenues generated by the MFAD fishery will ultimately contribute to support these public MFAD programs in the long run. However, it has been very difficult to create a sustainable funding scheme relying on fisher contributions to maintain public MFADs across the region. Instead, once the fishery is locally adopted, fishers will often prefer to invest in their own low-cost private MFADs, either individually or in groups. Private MFADs are lighter and cheaper and so easier to replace and deploy than public MFADs, which gives fishers greater ability to track the abundance of pelagic resources. They are also more likely to be deployed in locations that minimize their use by other fishers, which leads to higher revenue for the owners, but also to more frequent conflicts with non-owner users of the MFADs in the absence of regulation.

In that regard, there is a pervasive lack of comprehensive MFAD regulation (including MFAD registry and licensing systems) and local MFAD fishery management plans across the region. Furthermore, in those locations where specific pieces of MFAD legislation exist, they are seldom enforced. Finally, there is also evidence that many fishers might be simply unaware of (formal or informal) rules governing public and private MFAD use when such rules exist, pointing also to a problem of ineffective communication and sensitization within and among stakeholders. Such inadequate or inexistent regulatory environment can only lead to increases in the frequency of conflicts among MFAD users. That said, the extent to which conflicts among MFAD users take place appears to vary markedly across locations, possibly reflecting variability in the intensity of local competition for MFAD use. When conflicts do take place, they are mainly driven by local fishers using MFADs that they do not own or by interference between commercial and recreational fishers on MFADs. These local conflicts are generally settled among fishers, particularly in the case of private MFADs as these are often not adequately reported to the local authorities; such conflicts do not generally result in violence, but in some instances, they can lead to theft or acts of vandalism on fishing gear or MFADs. On the other hand, there is evidence that fishers might set or use MFADs in foreign waters of nearby islands, suggesting that IUU fishing involving MFADs might be widespread across the region, further highlighting the urgent need for improved monitoring, control, and surveillance mechanisms.

Finally, it is generally accepted that effective management of the MFAD fishery across the region will require more sharing of responsibilities between government and fishers. Although the actual nature of such arrangements remains to be resolved, it is likely that it will require going beyond simply consulting fishers towards a model where fishers and other fishery stakeholders are more actively engaged in decision making from early in the process. Considerable experience in participatory approaches in the MFAD fishery has been gained in the region over the last 5 years (e.g. CARIFICO project) from which valuable lessons should be drawn. Successfully implementing such approaches is, however, challenging and will require strengthening fisher organizations and improving formal and informal governance frameworks under which the MFAD fishery currently operates. Without effective dialogue between fishers and Fishery authorities, and in the presence of a system that remains unregulated in practice, the scenario that seems to emerge is that of a MFAD fishery based on the establishment of informal individual exclusive territorial-use rights around historical use of MFADs. This scenario seems effective in limiting fishing access to other fishers, but raises serious issues about fairness and equity, and leads to conflicts with those that challenge the informal system. Moreover, in the race for fish, it ultimately results in the deployment of large numbers of low-cost MFADs, which will generally end up as marine litter, and to increased fuel expenses that might outweigh the benefits of increased catches on MFADs.

3. Overall goal and specific objectives of the Plan

The overall objective of this Regional MFAD Fishery Management Plan is to guide the implementation of a set of identified management measures that can be applied at the regional, subregional, national and local levels for the sustainability of large oceanic and coastal pelagic fish stocks while ensuring a healthy MFAD fishery and the improvement of the livelihoods of the people that rely on the fishery.

This Plan is anchored on an ecosystem-based approach to fisheries, seeking to enhance partnerships and collaboration throughout the Wider Caribbean region to improve the long-term governance of MFAD fisheries across the Caribbean. It is meant to be implemented gradually and incrementally and recognizes that progress towards achieving the desired outcomes will differ across the region due to inherent differences in socio-economic and political context. In relation to the latter, the Plan is meant to be adaptive; it recognizes the need to continuously monitor the various components of the system (social, economic, biological, and ecosystem) to assess whether changes in actions and strategies are needed to achieve the desired specific objectives.

As part of the Logical Framework Approach (LFA), this section presents the Logical Framework Matrix (LFM) for the implementation of the Regional MFAD Fishery Management Plan in Table 1. The objectives and activities were identified by integrating those proposed by the sub-regional MFAD fishery management (CRFM 2015a) with the findings of the review of the state and challenges of the fishery (Appendix I). The matrix follows the conventional format, with specific objectives, outputs, activities, indicators, and means of verification to reach the planned outputs. Table 2 presents a tentative timeline for the proposed outputs and activities.

This Regional MFAD Fishery Management Plan was formulated with the following specific objectives:

1. O1- To increase coordination and collaboration between MFAD fishery stakeholders locally and between nations regionally by improving the national and regional governance frameworks for the MFAD fishery;
2. O2 - To increase coordination and collaboration between MFAD fishers and Fishery Authorities locally, and between nations regionally, by improving the collection and integration of fishery-dependent data needed to help determine the population status of target species;
3. O3 - To improve the monitoring, control, and surveillance (MCS) of MFAD fisheries across the region to effectively address IUU fishing;
4. O4 - To improve the sustainable socio-economic performance of MFAD fisheries;
5. O5 - To help assess and mitigate the impacts of MFADs on target and non-target species and ecosystems.

Table 1 – Logical framework for the implementation of the Regional MFAD fishery Management Plan

Overall objective	Outputs	Activities	Indicators	Means of verification	Assumptions
O1 - To increase coordination and collaboration between MFAD fishery stakeholders locally and between nations regionally by improving the national and regional governance frameworks for the MFAD fishery	Legal national/local regulatory framework to support local MFAD management plans are adopted	Draft and adopt into law provisions to support implementation of local/national MFAD management plans	Adopted legislation	Relevant legal documentation (e.g. publication in Gazette)	There is sufficient political will from government
	MFAD fisher groups actively engaged in decision-making	Conduct local/national level consultations and public awareness campaigns	Number and scope of consultations and campaigns	Meeting minutes; media outputs	Active interest of all stakeholders and general public
		Strengthen MFAD fisher groups and other MFAD fishery stakeholders to facilitate effective collective representation	Increase in membership and number of fisherfolk organizations	Meeting minutes and workshop/training sessions with list of participants; legal status documents of organization	Continuous active participation by all stakeholders in decision-making process
		Strengthen multi-stakeholder organizational structures to support effective dialogue among stakeholders	Establishment of multi-stakeholder organization	Meeting minutes and workshop/training sessions with list of participants; legal status documents of organization	Continuous active participation by all stakeholders in decision-making process
		Identify and test co-management arrangements best suited to local context	Co-management arrangements identified	Meeting minutes and workshop sessions with list of participants	There is sufficient political will from government in sharing decision-making; continuous active participation by all stakeholders in decision-making process
	Adaptive local MFAD fishery management plans anchored on EAF approach are developed, harmonized across the region, and effectively implemented	Develop and implement adaptive local/national MFAD management plans that align as much as possible with best practices in EAF	Joint establishment of management plan broad objectives	Meeting/workshop minutes with list of participants; final agreed objective document	Continuous active participation by all stakeholders in decision-making process
			Clear national policy on public versus private (individual vs collective) MFAD use and/or Territorial User Rights for Fishing (TURFs) on MFADs	Meeting/workshop minutes with list of participants; final agreed policy document	Continuous active participation by all stakeholders in decision-making process
			Reached agreement on the rights and duties of all stakeholders during plan implementation	Co-management agreements	Continuous active participation by all stakeholders in decision-making process
			Management plan is approved by all stakeholders	Meeting minutes with list of participants	Continuous active participation by all stakeholders in decision-making process
		Gradually harmonize local/national management plans (and associated regulations) across the region to	Increase in MFAD owner identification markings on MFADs	MFAD design used locally	Stakeholders collaborate to comply with regulations / recommendations

		increasingly align with EAF best practices and the recommendations of relevant management bodies/instruments, including the Caribbean Billfish Management and Conservation Plan, CRFM, OSPESCA and WECAFC and ICCAT	Limits to MFAD numbers	MFAD registry; vessel trajectory maps	Stakeholders collaborate to comply with regulations / recommendations
			Regulation of authorized MFAD fishers	MFAD license numbers; vessel trajectory maps	Stakeholders collaborate to comply with regulations / recommendations
			Sustained reduction over time of juvenile fish (tuna and dolphinfish) landings	Landing data	Stakeholders collaborate to comply with regulations / recommendations
			Sustained reduction (or no increases) over time in landings of regionally overexploited species (e.g. billfishes)	Landing data	Stakeholders collaborate to comply with regulations / recommendations
			Cessation of use of animal entangling materials on MFADs	MFAD design used locally	Stakeholders collaborate to comply with regulations / recommendations
			Increases in use of biodegradable materials in MFADs	MFAD design used locally	Stakeholders collaborate to comply with regulations / recommendations
		Critically evaluate adaptive local/national MFAD management plans across the region within five-year cycles	Number of local management plans reviewed and evaluated	Recommendations and plan amendment documents	Stakeholders collaborate to comply with regulations / recommendations
	Increased participation of countries in regional decision-making	Increased representation in ICCAT of Caribbean countries	Inclusion of countries in ICCAT membership	ICCAT membership certification	There is sufficient political will and funding to support participation
		Increase scientific contributions from MFAD Working Group to relevant ICCAT Working Groups	Meetings between Working Groups; report and data exchanges	Meeting minutes; relevant documentation	Various Working Groups have the resources and time to collaborate

Table 1 – Logical framework for the implementation of the Regional MFAD fishery Management Plan continued

Overall objective	Outputs	Activities	Indicators	Means of verification	Assumptions
O2 - To increase coordination and collaboration between MFAD fishers and Fishery Authorities locally, and between nations regionally, by improving the collection and integration of fishery-dependent data needed to help determine the population status of target species;	Minimum fishery-dependent data requirements are harmonized across the region	Standardize, test, validate, and adopt minimum data requirements and data collection protocols for catch and fishing effort data and biological data for target and non-target species caught on MFADs	Data collection forms and/or fisher logbooks and protocol descriptions are available; national database is operational	Sample data	Fisheries authorities are willing to standardize minimum data requirements and data collection protocols
					Fishers collaborate to provide data
		Test and gradually integrate the use of low-cost electronic data collection tools (Information and Communication Technology) into the fishery data collection process	Operational national electronic database and associated app for mobile devices; electronic national database is operational	Field data collection apps on mobile devices are functional; sample data	Availability of funding and adequately trained staff to maintain and update electronic systems
					Fishers collaborate to provide data
		Train data collectors and fishers on fishing trip data collection (catch and effort and biological) and better species identification	Training sessions	Training session documents and certificates of participation	Funding for training is available and fishers are interested
	Data collection efficiently conducted, and data quickly processed and returned to relevant users	Use Information and Communication Technology (ICT) to return personalized catch and effort summary to fishers in short timeframes	Catch and effort summary function is operational	Personalized electronic summary reports print outs or online dashboards for fishers to access their data	Information and Communication Technology is fully integrated into the data collection process; fishers see considerable value in their personalized catch and effort data
	Fishery-dependent local data collection coverage is expanded and/or refined	Expand spatial and temporal coverage of data collection	Increases in landing sites and temporal coverage	Sample data	Funding to increase sampling coverage is available
	National databases and a regional CRFM-OSPESCA-WECAFC MFAD database are operational	Integrated national and regional databases for catch, fishing effort and biological data and aligned with WECAFC DCRF	National databases ready for regional integration	Framework design of national and integrated regional databases	Availability of adequately trained staff to run national and regional databases

Table 1 – Logical framework for the implementation of the Regional MFAD fishery Management Plan continued

Overall objective	Outputs	Activities	Indicators	Means of verification	Assumptions
O3 - To improve the monitoring, control, and surveillance (MCS) of MFAD fisheries across the region to effectively address IUU fishing	Fishing effort on MFADs and MFAD location mapped	Test and gradually implement the use of Vessel Tracking Systems (VTS) for MFAD motorized vessels (<9 m long)	Operational VTS	Vessel track maps	Availability of funding and adequately trained staff to run VTS database
					In cases of transboundary fishing, countries agree to cooperate with data sharing and enforcement.
					Fishers collaborate to use VTS
	MFAD registry, MFAD fisher licensing, and MFAD vessel registry systems in place	Implement MFAD registry, MFAD marking, MFAD vessel registry, and MFAD fishery licensing systems	MFAD registry, MFAD vessel registry, and MFAD fishing licensing systems operational	Registry and licensing records; license cards available	Availability of funding and adequately trained staff to maintain and update systems
					Fishers collaborate to register MFADs and secure licenses
		Test and gradually implement the use of low-cost electronic data collection tools (Information and Communication Technology) to facilitate time efficient MFAD registry, MFAD vessel registry, and MFAD licensing	Electronic registry and licensing systems operational	Registry and licensing electronic databases; license cards available	Availability of funding and adequately trained staff to maintain and update electronic systems
					Fishers collaborate to electronically register MFADs and secure licenses

Table 1 – Logical framework for the implementation of the Regional MFAD fishery Management Plan continued

Overall objective	Outputs	Activities	Indicators	Means of verification	Assumptions
O4 - To improve the sustainable socio-economic performance of MFAD fisheries	Improved local knowledge of the contribution of MFADs to livelihoods and national economies	Systematically collect relevant economic data of MFAD fishing trips (revenue, expenses, MFAD location) to assess fishing economic performance and variability among MFADs in productivity	Data collection forms and/or fisher logbooks and protocol descriptions are available; national database is operational	Sample data	Availability of funding and adequately trained staff to maintain system
					Fishers collaborate to provide data
		Test and gradually integrate the use of low-cost electronic data collection tools (Information and Communication Technology) into the fishing trip economic data collection process	Operational national electronic database and associated app for mobile devices; electronic national database is operational	Field data collection apps on mobile devices are functional; sample data	Availability of funding and adequately trained staff to maintain and update electronic systems
					Fishers collaborate to provide data
		Train data collectors and fishers on fishing trip economic data collection	Training sessions	Training session documents and certificates of participation	Funding for training is available and fishers are interested
		Use Information and Communication Technology (ICT) to return personalized electronic economic performance summary to fishers in short timeframes	Economic summary function is operational	Personalized summary reports print outs	ICT is fully integrated into the data collection process; fishers see considerable value in their personalized economic performance data
		Conduct household surveys to establish socio-economic baselines for MFAD fishers and assess trends over time	Data collection forms and protocol are available; household database is operational	Sample data	Fishers and other fishery stakeholders collaborate to provide data
	Improved economic returns and working conditions of MFAD fishers	Train MFAD fishers on (1) safety at sea, (2) navigation, (3) MFAD use and fishing techniques, (4) large fish handling and conservation, (5) business management, and (6) ICT systems	Number of training sessions and participants	Training session documents and certificates of participation	Funding for training is available and fishers are interested
		Develop ICT systems with, and for, fishers to increase fishing efficiency and safety at sea	ICT system operational and used by fishers	Fisher reports	Funding for training is available and fishers are interested
		Set guidelines for MFAD vessel minimum requirements and personal protection equipment	Scope and content of guidelines	Guideline documents	Fishers comply with guidelines

		Improve landing facilities and infrastructure to facilitate handling and post-harvest processing of large fish	Number of improved facilities and extent of improvement	Documentation of the works conducted	Funding is available
		Explore export markets and value-added processing for pelagic fish to avoid market gluts	Recommendations of market study	Market study reports	Funding is available
		Test and implement use of satellite-linked echosounder buoys and other electronic equipment on strategically selected MFADs locally to inform cooperating fishers on local fish abundance	Number and location of echosounder buoys	Echosounder data	Funding is available
		Control fish imports to support local fish production	Government policy to control fish imports	Trends in fish import data	There is sufficient political will from government
	Improved long-term persistence of public or public-private partnership MFAD programs	Use MFAD economic performance data to develop a national public and/or public-private partnership MFAD program using best practices MFAD designs and including a contingency plan in case of high MFAD loss due to extreme weather events	National MFAD program proposal	Cost-benefit study; contingency plan document	Funding for proposal is available
		Secure local funding to support MFAD program, including license fees, support from national budget, donors, tax-free concessions, and/or stakeholder contributions	Adequate funding is available	MFAD program financial/banking statements; funding plan document;	Fishers collaborate to secure licenses; other funding sources are available
		Secure regional funding to support MFAD program by integrating MFADs into regional research networks (as observatories)	Adequate funding is available	MFAD program financial/banking statements; funding plan document;	Regional research networks exist and can provide funding
		Implement national MFAD program	Number and lifespan of deployed MFADs	Fisher reports	Funding is available

Table 1 – Logical framework for the implementation of the Regional MFAD fishery Management Plan continued

Overall objectives	Outputs	Activities	Indicators	Means of verification	Assumptions
O5 - To help assess and mitigate the impacts of MFADs on target and non-target species and ecosystems	Improved understanding of how MFAD fishing interacts with coastal/reef fishing	Monitor MFAD fisher fishing activity on MFADs and on coastal/reef habitats	Extent to which MFAD fishers engage in coastal fishing	Catch and effort data on MFADs and coastal/reef fishing; fishing effort maps from VTS data	VTS is operational; fishers collaborate to provide data
	Improved regional understanding of abundance and movement of target and non-target species on MFADs	Partake in research programs implementing use of satellite-linked echosounder buoys and other electronic equipment on strategically selected public MFADs across the region along with tagging studies to generate fishery-independent data on abundance, growth, survivorship and/or movement of selected species.	Regional research network of public MFADs equipped with electronic monitoring equipment	Fishery-independent data on movement, growth, abundance, and/or survivorship of selected species generated to complement fishery-dependent data	Funding is available; expert and local research partners are available
	Improved regional understanding of factors that affect catch composition and fishing yields on MFADs	Inform research programs using fishery-dependent and -independent data to model drivers of catches on MFADs	Models developed	Model output and validation	Funding is available; expert and local research partners are available
		Partake in research to identify fishing techniques and practices that minimize catches of vulnerable fish groups and maximize catches of sustainably exploited fish groups	Fishing techniques and practices used	Catch composition data relative to baselines	Funding is available; expert and local research partners are available
	Improved local MFAD designs to reduce MFAD losses, animal entangling, and marine litter	Partake in research to identify suitable biodegradable and non-entangling materials for MFAD construction	Improved biodegradable materials	Research study reports	Funding is available; expert and local research partners are available
		Partake in research to optimize MFAD designs to minimize both MFAD losses and MFAD costs	Improved MFAD design	MFAD average lifespan	Funding is available; expert and local research partners are available

Table 2 – Tentative timeline for proposed outputs and activities

Overall objective	Outputs	Activities	Timeline
O1	Legal national/local regulatory framework to support local MFAD management plans are adopted	Draft and adopt into law provisions to support implementation of local/national MFAD management plans	1-5 years
	MFAD fisher groups actively engaged in decision-making	Conduct local/national level consultations and public awareness campaigns	1-3 years
		Strengthen MFAD fisher groups and other MFAD fishery stakeholders to facilitate effective collective representation	1-3 years
		Strengthen multi-stakeholder organizational structures to support effective dialogue among stakeholders	1-3 years
		Identify and test co-management arrangements best suited to local context	1-3 years
	Adaptive local MFAD fishery management plans anchored on EAF approach are developed, harmonized across the region, and effectively implemented	Develop and implement adaptive local/national MFAD management plans that align as much as possible with best practices in EAF	1-5 years
		Gradually harmonize local/national management plans (and associated regulations) across the region to increasingly align with EAF best practices and the recommendations of relevant management bodies/instruments, including the Caribbean Billfish Management and Conservation Plan, CRFM, OSPESCA and WECAFC and ICCAT	1-10 years
		Critically evaluate adaptive local/national MFAD management plans across the region within five-year cycles	1-10 years
	Increased participation of countries in regional decision-making	Increased representation in ICCAT of Caribbean countries	1-10 years
		Increase scientific contributions from MFAD Working Group to relevant ICCAT Working Groups	1-10 years
O2	Minimum fishery-dependent data requirements are harmonized across the region	Standardize, test, validate, and adopt minimum data requirements and data collection protocols for catch and fishing effort data and biological data for target and non-target species caught on MFADs	1-3 years
		Test and gradually integrate the use of low-cost electronic data collection tools (Information and Communication Technology) into the fishery data collection process	1-5 years
		Train data collectors and fishers on fishing trip data collection (catch and effort and biological) and better species identification	1-3 years
	Data collection efficiently conducted, and data quickly processed and returned to relevant users	Use Information and Communication Technology (ICT) to return personalized catch and effort summary to fishers in short timeframes	1-5 years
	Fishery-dependent local data collection coverage is expanded and/or refined	Expand spatial and temporal coverage of data collection	1-5 years
	National databases and a regional CRFM-OSPESCA-WECAFC MFAD database are operational	Integrated national and regional databases for catch, fishing effort and biological data and aligned with WECAFC DCRF	1-5 years
O3	Fishing effort on MFADs and MFAD location mapped	Test and gradually implement the use of Vessel Tracking Systems (VTS) for MFAD motorized vessels (<9 m long)	1-5 years
	MFAD registry, MFAD fisher licensing, and MFAD vessel registry systems in place	Implement MFAD registry, MFAD marking, MFAD vessel registry, and MFAD fishery licensing systems	1-3 years
		Test and gradually implement the use of low-cost electronic data collection tools (Information and Communication Technology) to facilitate time efficient MFAD registry, MFAD vessel registry, and MFAD licensing	1-5 years

Table 2 – Tentative timeline for proposed outputs and activities continued

Overall objective	Outputs	Activities	Timeline
O4	Improved local knowledge of the contribution of MFADs to livelihoods and national economies	Systematically collect relevant economic data of MFAD fishing trips (revenue, expenses, MFAD location) to assess fishing economic performance and variability among MFADs in productivity	1-5 years
		Test and gradually integrate the use of low-cost electronic data collection tools (Information and Communication Technology) into the fishing trip economic data collection process	1-5 years
		Train data collectors and fishers on fishing trip economic data collection	1-5 years
		Use Information and Communication Technology (ICT) to return personalized electronic economic performance summary to fishers in short timeframes	1-5 years'
		Conduct household surveys to establish socio-economic baselines for MFAD fishers and assess trends over time	1-5 years
	Improved economic returns and working conditions of MFAD fishers	Train MFAD fishers on (1) safety at sea, (2) navigation, (3) MFAD use and fishing techniques, (4) large fish handling and conservation, (5) business management, and (6) ICT systems	1-3 years
		Develop ICT systems with, and for, fishers to increase fishing efficiency and safety at sea	1-5 years
		Set guidelines for MFAD vessel minimum requirements and personal protection equipment	1-3 years
		Improve landing facilities and infrastructure to facilitate handling and post-harvest processing of large fish	1-5 years
		Explore export markets and value-added processing for pelagic fish to avoid market gluts	1-5 years
		Test and implement use of satellite-linked echosounder buoys and other electronic equipment on strategically selected MFADs locally to inform cooperating fishers on local fish abundance	1-5 years
		Control fish imports to support local fish production	1-5 years
	Improved long-term persistence of public or public-private partnership MFAD programs	Use MFAD economic performance data to develop a national public and/or public-private partnership MFAD program using best practices MFAD designs and including a contingency plan in case of high MFAD loss due to extreme weather events	1-10 years
		Secure local funding to support MFAD program, including license fees, support from national budget, donors, tax-free concessions, and/or stakeholder contributions	1-10 years
		Secure regional funding to support MFAD program by integrating MFADs into regional research networks (as observatories)	1-10 years
		Implement national MFAD program	1-10 years
O5	Improved understanding of how MFAD fishing interacts with coastal/reef fishing	Monitor MFAD fisher fishing activity on MFADs and on coastal/reef habitats	1-5 years
	Improved regional understanding of abundance and movement of target and non-target species on MFADs	Partake in research programs implementing use of satellite-linked echosounder buoys and other electronic equipment on strategically selected public MFADs across the region along with tagging studies to generate fishery-independent biological data	1-5 years
	Improved regional understanding of factors that affect catch composition and fishing yields on MFADs	Inform research programs using fishery-dependent and -independent data to model drivers of catches on MFADs	1-5 years
		Partake in research to identify fishing techniques and practices that minimize catches of vulnerable fish groups and maximize catches of sustainably exploited fish groups	1-5 years
	Improved local MFAD designs to reduce MFAD losses, animal entangling, and marine litter	Partake in research to identify suitable biodegradable and non-entangling materials for MFAD construction	1-3 years
		Partake in research to optimize MFAD designs to minimize both MFAD losses and MFAD costs	1-3 years

4. Practical measures promoting a sustainable MFAD fishery across the region

A list of recommended measures is given below, some of which echo those provided by the CRFM (2015a) sub-regional MFAD plan. These measures are broadly presented in decreasing order of priority in addressing based on the input received during the 2021 MFAD regional survey.

4.1 Strengthen MFAD fisher participation in the management process

Justification: It is increasingly recognized that effective management of the MFAD fishery will require active engagement and participation of fishers in the decision-making process and the sharing of responsibility within the management system. This will be particularly so if the ultimate goal is to establish durable co-management arrangements. The collective representation of fishers' interests will be best achieved via the voice of legally registered fisherfolk groups such as associations or cooperatives. These formal groups are expected to play a fundamental role in defining stakeholder rights and duties within the MFAD fishery, in developing MFAD programs with government, and in identifying and implementing best management practices, including the collection and/or reporting of fishery catches, the elaboration of code of conducts, and the drafting of national MFAD fishery management plans (CRFM/JICA 2011). Building fisher collective capacity for decision-making might require substantial time, commitment, and continued support from national fisheries authorities and other actors wishing to engage fishers.

Implementation advice: Empowering fisherfolk organizations will require identifying leaders, providing technical assistance, building capacity in governance, administration and leadership skills, and fostering fisher engagement and participation in the organizations by providing tangible benefits (Tamura et al. 2018). This process will require time and resources and is unlikely to be achieved via short-term projects; rather, it should be recognized as an integral part of national/local development and food security policies. Moreover, the extent to which these fisher organizations are asked to assume responsibilities in management should be commensurate with their ability and means to effectively to do so (CRFM 2017), which could gradually increase as the organizations strengthen.

4.2 Strengthen Fisher Advisory Committees or similar intersectoral coordinating mechanisms

Justification: Interactive governance of MFAD fisheries is likely to be best operationalized through National Intersectoral Coordinating Mechanisms such as Fishery Advisory Committees (FAC) (Compton et al. 2017). These Fishery Advisory Committees could help integrate and connect sectors and stakeholders with interest in marine ecosystem-based approaches at the national level, including representatives of civil society, NGOs, and the private sector. They could also serve to link governance processes at national and regional scales. These FAC could operationalize all stages of the policy cycle (i.e. data and information, analysis and advice, decision-making, implementation, review and evaluation) of the MFAD fishery management system and process (Tietze and Singh-Renton 2012b; Compton et al. 2017).

Implementation advice: As stated in CRFM (2015a), the current functioning and structure of national Fisheries Advisory Committees (FAC) needs to be revised to assure participation of all fisheries sub-sectors and of stakeholders beyond fisheries that have interest in the marine ecosystem. This revision should ensure that FACs are formally institutionalized and have a clear structure, functioning and mandate, which might require bringing legislation up to date (FAO 2016a). The selection process for FAC members should be made transparent and carried out in close consultation with the groups which are to be represented, strong leaders should be identified, and resources should be allocated to support the adequate functioning of FACs.

4.3 Update legal instruments to support effective (co-)management arrangements and align with best practices

Justification: A recent report of the legal and institutional framework of Caribbean countries, including some with significant MFAD fisheries highlighted that the objectives and scope of fisheries legislation in these countries were generally consistent with the principles of sustainable management (FAO 2016a). It also highlighted that many laws reflected a multi-stakeholder and participatory vision of fisheries governance, aligning with best practices and that most countries in the region had an adequate legal basis for the elaboration of management plans (FAO 2016a). However, the report also outlined that the legal basis for co-management was generally under-developed across the region and that countries differed considerably in their treatment of rights-based approaches such as Territorial User Rights for Fishing (TURF) as well as in their integration of MFAD use in their legislation (FAO 2016a). The latter highlights that more efforts are needed to create an adequate legal and institutional framework to effectively support MFAD fishery management plans, particularly if co-management is the final goal, although the extent to which such efforts are necessary will depend on the country.

Implementation advice: Use existing legal frameworks to identify areas of weakness and address these areas so that the revised frameworks align with the guiding principles of Ecosystem Approach to Fisheries, the precautionary approach, and good governance (transparency, participation, accountability, and nondiscrimination) (Tietze and Singh-Renton 2012b; FAO 2016a). In so doing, create the necessary space to integrate co-management principles and provisions governing MFAD use (Box 1). In the meantime, countries that already have legal provisions for engagement of fisherfolk organizations in fisheries governance should make use of them. Such mechanisms may include designation of local fisheries management areas and Local Fisheries Management Authorities with capacity to make fishing regulations in the local fishery management areas (e.g. Section 18 and 19 of the 1987 Fisheries Act of Dominica).

Box 1. Aspects of MFAD use to consider when developing provisions for legal frameworks and/or management plans for the MFAD fishery. Taken and adapted from CRFM (2015a). See also Annexe 1 of ICCAT (2020a) and the Voluntary Guidelines on the Marking of Fishing Gear (FAO 2019).

- MFAD design, including:
  - Minimum standards ensuring a sufficient mooring weight and an adapted buoy volume to resist currents;
  - Minimum standards for identification and marking of MFADs (e.g. lighting requirements; radar reflectors; visible distance during the night and day) so as to prevent navigational hazards;
  - Prohibition of use of certain materials in MFAD construction, including entangling materials (e.g. old nets).
- Authorization for deployment of MFADs;
- Registration of MFADs;
- MFAD fisher license and license fees;
- Required provision of catch and effort data by MFAD fishers;
- Fishing techniques allowed and/or prohibited on MFADs;
- Rules governing fishing operations near MFADs, including distance from MFAD to which rules apply;
- Responsibilities of (national and community level) organizations in the MFAD fishery, including:
  - Constructing, deploying, maintaining, monitoring and replacing MFADs.
- In addition to the above, additional provisions could be considered in relation to the following:
  - Reporting and disposal of unauthorized MFADs;
  - Reporting of MFAD losses and replacement;
  - Designating areas closed to MFADs (e.g. shipping lanes) and/or where only MFAD fishing is allowed;
  - Designating the maximum total number of MFADs within the authorized areas;
  - Establishing arbitration mechanisms to address cases of conflict;
  - Designating the minimum distance separating moored MFADs;
  - Establishing rules governing commercial versus recreational fishing on MFADs;
  - Specifying the vessel characteristics for MFAD transport and deployment;
  - Prohibiting the transshipment at sea of fish caught on MFADs;
  - Regulating the composition of the catch on MFADs, including minimizing the capture of juveniles and endangered and threatened species including sea turtles;
  - Controlling fishing pressure on nearshore/reef resources by MFAD fishers;
  - Establishing spatiotemporal closures as relevant to avoid by-catch;
  - If applicable, establishing rules governing user access to private and public MFADs;
  - If applicable, designating the maximum number of private MFADs per fisher.

4.4 Explore using Territorial Use Rights for Fishing (TURFs) arrangements for improved MFAD governance

Justification: In locations where a public MFAD program is unlikely to be financially sustainable and/or yield the desired socio-economic benefits in the long run, countries should explore the use of formalized Territorial Use Rights for Fishing (TURF) as part of the management system. Informal TURF use of private MFADs already exist in the region and are largely recognized within fishing communities (FAO 2016b; Gentner et al. 2018; Guyader et al. 2018). Conflicts do arise when those who are excluded from fishing question the legitimacy of these informal systems (Bugeja Said et al. 2021). There thus seems to be an opportunity to build on these informal governance arrangements so as to formalize them in way that could help improve equity in access to MFAD fishing opportunities while controlling fishing effort on MFADs (Sadusky et al. 2018). This potential remains largely unexplored in the region (FAO 2016b).

Implementation advice: Bugeja Said et al. (2021) outline insightful differences and similarities between the MFAD fishery of Malta and Guadeloupe. Both fisheries are similar in that both are characterized by the existence of spatially explicit territorial course-lines within which individual fishers deployed multiple MFADs. A fundamental difference is that in the Malta fishery, the course-lines are transparently and fairly assigned by government to individual fishers on an annual lottery basis within which fishers have exclusive fishing rights. Fishers can swamp territories, but they cannot transfer them through a market nor divide them into subparts. In contrast, in Guadeloupe, most territories are informally created by individual fishers even though provisions exist to secure temporary use of space for MFAD deployment; these provisions are rarely followed or enforced. These informal territories are created on a first come first serve basis and then subsequently indefinitely maintained by the individual fishers themselves, precluding access to fishing grounds to other fishers, particularly younger ones. These informal territories are sold and transferred among fishers, even though there is no legal basis to do so. Neither fishery seeks to control the number of MFADs deployed within these formal or informal territories and neither have clear spatial planning and management policies, which reduce fishing yields and increase interferences with other users, respectively.

The examples by Bugeja Said et al. (2021) provide valuable lessons, particularly for those locations in the Caribbean where the MFAD fishery is still at a relatively early development stage, where it might still be practical and politically sensible to introduce the necessary regulatory changes. These examples highlight that the use of a system of territorial use rights to individual fishers or, preferably, groups of fishers is likely to provide the necessary incentive structure to help maintain the system in the long run with minimum financial investment from government. However, and importantly, such system should be based on assigning access rights for territories in a way that is equitable, inclusive, transparent, and temporary. It should also be carefully informed by spatial planning and set clear limits to MFAD numbers within each territory. Moreover, eligibility to enter the system should be conditioned to the use of MFADs that follow minimum quality standards. The monitoring, control, and surveillance component of these TURF systems, which is always the weakest link, could be facilitated by the integration of low-cost ICT systems into the monitoring system form early on (see Measure 3.8).

4.5 Develop, implement, and harmonize local/national adaptive MFAD fishery management plans

Justification: The management of MFADs in accordance with the principles and best practices identified in this document can be achieved in a number of different ways, including through national or local management plans that address relevant fish stocks and ecosystems. However, very few countries currently have management plans in place for the MFAD fishery. This makes it difficult to rigorously assess whether the policy objectives that MFADs were supposed to facilitate have been objectively achieved and can be supported with data. It also precludes addressing legitimate concerns about the impacts that MFADs can have on shared regional stocks in the current context of open access, undermining the long-term sustainability of the fishery and threatening the livelihoods of fishers, particularly in light of the evidence that some of these stocks are already under heavy regional pressure and some are overexploited (Bealey et al. 2019). Finally, it creates an environment conducive to conflicts among stakeholders. As indicated in CRFM (2015a), it is thus critical and urgent that countries initiate as soon as possible the process of MFAD fishery management plan development and implementation .

Implementation advice: Countries should, as far as practically possible, use existing current legislation to the fullest extent towards implementation of adaptive management plans while in the process of amending current legislation. The plans should be grounded on the principles of EAF and so integrate all fishery stakeholders from the onset. In some locations, national consultations and public awareness campaigns are likely to be needed to increase the engagement and participation of stakeholders. The strengthening fisherfolk organizations and Fisheries Advisory Committees might have to be integrated within the plan development and implementation process itself. In accordance to EAF principles, these plans should be comprehensive and adaptive and go well beyond the establishment codes of conduct aimed at minimizing user conflicts to also help generate local knowledge on the exploitation status of the fish stocks and use current regional knowledge to guide local management measures. These plans should thus, to the extent that is practically possible, and being mindful of context, align with current recommendations of ICCAT for tuna (See Annexe 1 of ICCAT 2020a) and billfishes (ICCAT 2019; ICCAT 2020b) and of other relevant regional (WECAFC) and sub-regional (CRFM, OSPESCA) fishery bodies and relevant instruments such as The Caribbean Billfish Management and Conservation Plan (Bealey et al. 2019), the draft Subregional Fisheries Management Plan for Blackfin Tuna Fisheries in the Eastern Caribbean (Tietze and Singh-Renton 2012a) and FAO's Voluntary Guidelines on the Marking of Fishing Gear (FAO 2019). Such alignment with best practices and sub-regional and regional recommendations - even though some do not directly apply to the small (<9m long) vessels that characterize the MFAD fishery (e.g. ICCAT 2020a) - will contribute to ensure some degree of harmonization across the region, which will be necessary for any management measure to be effective in the long-term. In that regard, WECAFC, in collaboration with CRFM and OSPESCA, through the Interim Coordination Arrangement, could play an important role in reviewing and evaluating local/national management plans across the region and make recommendations towards their gradual harmonization, as appropriate. Ultimately, this iterative process could encourage more countries within the region to join ICCAT as members or cooperating parties.

4.6 Implement MFAD fisher licensing, vessel registry, and MFAD registry systems

Justification: The MFAD fishery is in practice an open access fishery across most locations. It is widely recognized that the fishery should transition to a restricted-access system in due time to ensure the sustainable exploitation of stocks, to optimize fishing yields, and to minimize user conflicts. This will require controlling the number of fishers, vessels and MFADs operating at any given time. As stated in CRFM (2015a), the national authorities should implement a licensing system for MFAD fisheries. Moreover, all vessels exploiting MFADs should be registered and have a registration number. This vessel registration system is needed to identify vessels fishing for large oceanic and coastal pelagics species, track change of ownership, base of operation and use of vessels, and provide information to sub-regional and regional databases. National authorities should also implement a registry and MFAD marking system for deployed MFADs that records data on MFAD location, design, marking, and other characteristics as well as reports of MFAD losses.

Implementation advice: Legislation on MFAD use will likely need to be revised and adopted to support compliance with these systems, as adequate legislation is still lacking in many locations (FAO 2016a). The marking and registration systems for MFADs should closely align with the directives of the Voluntary Guidelines on the Marking of Fishing Gear (FAO 2019) and be harmonized across the region. To minimize administration and bureaucratic delays and so increase likelihood of fisher participation and compliance, Information and Communication Technology (ICT) systems should be explored to facilitate and considerably reduce time frames associated with the granting of licenses and the registration process.

4.7 Harmonize minimum catch and effort and biological data requirements across the region and integrate national data sets into a regional database

Justification: The fish stocks exploited on MFADs are shared regionally (in some cases, the stocks are shared oceanwide) and thus any effective attempt to assess the impact of the MFAD fishery will require the integration of catch and effort and biological data at the regional scale. The latter would be greatly facilitated by standardizing minimum data requirements across countries; failing to do so will add another potentially large source of uncertainty to the assessments or might simply preclude an assessment at the right spatial scale. Data standardization would also allow integration of national/local datasets into a regional shared WECAFC-OSPESCA-CRFM database, which should be used to inform ICCAT.

Implementation advice: Align minimum fishery data requirements with those of the CRFM FAD fishery logbook (CRFM 2015b), which was originally developed in consultation with several Fisheries Departments across the region. The logbook was designed to allow for the collection of refined catch and effort data, cost-benefit data, crude environmental data, and by-catch information, and to align as much as possible with ICCAT requirements. It also considered the level of fish processing onboard, further facilitating harmonization and integration of data across the region. Moreover, to the extent that it is possible, national, sub-regional, and regional databases should align with the WECAFC Data Collection Reference Framework (WECAFC 2019; updated version to be finalized in 2022).

4.8 Integrate low-cost Information and Communication Technology (ICT) into the monitoring system

Justification: The cost of ICT systems is rapidly going down and will likely continue to do so over the next decade. There are three fundamental ways by which ICT systems could help improve MFAD fishery management. First, the use of electronic survey forms on mobile devices (tablets, smartphones) connected to cellular and/or satellite networks that automatically store the data in electronic databases can dramatically speed up the fishery data collection, data handling, data quality assessment and data analysis, with near-real time capabilities in some contexts. This means that the time gap between the provision of raw data by fishers and the return of processed activity summary outputs (e.g. catch and effort data, cost-benefit data) to them could be minimized to the point where such summaries could become operationally useful to them. This also raises the potential for such summary outputs to be personalized and confidential for each individual fisher, which should increase the incentive to collaborate with data provision. Second, the use of Vessel Tracking Systems for small boats (< 9 m length) can provide high-resolution tracking of effort and landings and increase safety at sea (if connected in real-time with satellite networks). This vessel tracking technology can also help reveal the location of individual MFADs used (e.g. Widyatmoko et al. 2021) and thus dramatically improve the monitoring, control, and surveillance (MCS) system of the MFAD network. Coupling VTS with electronic data collection systems has been shown to be a powerful way of obtaining high-resolution catch documentation in a traditionally data-poor context (e.g. Tilley et al. 2020). Third, fisher-oriented mobile phone applications, WhatsApp messaging groups, and/or VHF handsets could tangibly enhance fisher safety at sea, enhance communications at sea and onshore, and improve cost and time efficiency as well as fishing efficiency for fishers (Babu 2020).

Implementation advice: There are countries within the region such as Dominica that are already effectively using ICT systems for fishery monitoring with little external support – Their experience should be shared across the region. It will also be critical to establish monitoring systems where the data generated by fishers are co-owned by them to foster transparency and accountability and to empower fishers in the decision-making process. This implies that the implementation of ICT systems should integrate from the beginning mechanisms and data sharing agreements that allow fishers to co-own and access their data and protect them against data misuse or manipulation. This might imply in some cases establishing confidentiality agreements that protect the identity of individual fishers (e.g. requirement for summary reports and fishing effort maps to be provided in an aggregated form). Finally, to build ICT capacity in fishers in a way that can effectively improve their livelihoods and reduce their vulnerabilities, they need to be integrated from early in the development of the context-appropriate ICT solutions that are meant to help them to ensure that their needs are adequately satisfied (Mallalieu 2020).

4.9 Improve MFAD fisher training

Justification: The data presented in the review of the state and challenges of the MFAD fishery (Appendix I) strongly support the need for more fisher training in all areas surrounding the use of MFADs, including safety at sea, navigation, MFAD use and fishing techniques, large fish handling and conservation (Eugène et al. 2015), business management, and use of ICT systems. Such training should lead to greater working conditions and safety at sea, a higher quality of fish landings, and a better financial performance of MFAD fishers. Importantly, such training could also facilitate diversification of resource use on MFADs by introducing fishing techniques and practices that allow targeting species that are currently underexploited around MFADs.

Implementation advice: Develop a multi-lingual professional training course with modular packages addressing all key areas of MFAD fishing, supported with video footage (e.g. Youtube videos) to enhance the learning experience. It will also be important to promote fisher exchanges among locations within the region, but also between regions with a longer tradition of MFAD fishing such as the Pacific to share experiences, knowledge, and best practices in MFAD use and governance.

4.10 Improve post-harvest and infrastructure support

Justification: Raising Sanitary and Phytosanitary (SPS) standards of fish caught on MFADs will be particularly important to overcome market gluts during periods of high fish abundance (Diaz et al. 2002) and/or the competition with fish imports (Mathieu et al. 2014) by opening opportunities to engage new markets, either as added-valued processed products, eco-labeled products, and/or as exports. In this case, improved fisher training in fish handling and conservation should be accompanied with the improvement of post-harvest infrastructure and facilities to adequately accommodate large fish, which remain deficient across many locations in the region.

Implementation advice: Conduct marketing studies and engage relevant actors within the private sector to assess potential to develop Public-Private Partnerships supporting post-harvest infrastructure improvements and added-value processing and product differentiation.

4.11 Improve MFAD designs to minimize marine litter

Justification: Public MFADs are generally designed to minimize MFAD loss rates, which entails a relatively high cost per unit, whereas individual private MFADs are generally designed to minimize costs, which tends to lead to high MFAD losses. From the perspective of minimizing marine littering, it is highly desirable that when MFAD units are lost they are recovered quickly. Alternatively, if recovery is not possible or practical, then it is highly desirable that the units are made of biodegradable materials. The use of biodegradable materials is receiving increased research attention in the purse seine tuna fishery making use of drifting FADs (Moreno et al. 2016b; Lopez et al. 2019), where it has been integrated into policy recommendations (ICCAT 2020a). In the Caribbean, the use of light MFADs entirely made of biodegradable materials can be justified if MFAD fishing were to be highly seasonal, as in the Mediterranean dolphinfish fishery (Morales-Nin et al. 2000) and this appeared to be the case in many locations in the region. However, if MFADs are to be used all year long, as it is the case in other locations, then the emphasis might be on maximizing MFAD lifespan and on recovering the units when these get lost, which should position MFAD design towards the heavy and semi-heavy end of the range and involve the use of highly durable synthetic materials. Best practices in MFAD construction and materials aimed at maximizing lifespan now exist for the region (Gervain et al. 2015) and descriptions of MFAD designs currently used in other regions are also publicly available (Sokimi et al. 2020 and references therein). The challenge remains to integrate such existing knowledge into designs that offer the longest lifespan (and chances of recovery when lost) at a cost that can be sustainably absorbed by MFAD programs, which often rely in short-term projects for funding to support the relatively high cost of public MFADs. The latter also needs to recognize that the physical environment in which MFADs are deployed (depth, currents, wave exposure, storm frequency, shipping traffic) will differ among locations so that the optimal design will depend on location. For example, due to high shipping traffic around Puerto Rico, subsurface MFADs are currently being deployed in greater frequency than surface MFADs due to past issues with surface MFAD shipstrikes. Finally, it is important to highlight that accurate data on MFAD lifespan are scarce because of the widespread lack of regular monitoring and/or loss reporting so that much more is known about the few MFADs that remain than about the many that were lost. The latter makes it very difficult to link MFAD design to prevailing (and extreme) local environmental conditions to inform MFAD design process.

Implementation advice: Countries/locations that experience similar prevailing physical conditions should consider joining efforts to support research collaborations into improving the cost-effectiveness of local MFAD designs and exploring that of new ones (e.g. subsurface MFADs: Schneider et al. 2021) in a carefully controlled monitoring setting so that drivers of MFAD losses are adequately identified. Moreover, establishing a regional database of deployed and lost MFADs that includes detailed info on MFAD design and prevailing physical conditions would provide important insights into what is a durable MFAD design. In addition to that, the use of satellited-linked GPS units is becoming increasingly affordable and might now represent only a small fraction of the MFAD total cost. Thus, systematically integrating solar-powered GPS buoys into the surface component of MFADs, as it is typically done for drifting FADs in the purse-seine tuna fishery, will help maximize recovery when they get lost, potentially also allowing the re-use of MFAD materials (Sinopoli et al. 2020). Furthermore, research should also take place on those locations where shorter lived light MFADs made of biodegradable materials might be preferred; such research should draw from the traditional knowledge in MFAD materials (Morales-Nin et al. 2000) and those currently being explored for drifting FADs (Moreno et al. 2018a; Moreno et al. 2018b; Lopez et al. 2019; Wang et al. 2021), while also being mindful that such materials need to be locally available and affordable. These alternative biodegradable materials should be actively promoted over non-biodegradable ones. For any of these efforts to be successful in the long run, it will be critical to involve fishers into MFAD design development from early on. Finally, irrespective of MFAD type, the use of animal entangling materials such as old nets in any part of the MFAD design should be explicitly prohibited across the region.

4.12 Explore public-private partnerships (PPP) to support long-term MFAD use that complies with best practices

Justification: As stated in CRFM (2015a), an MFAD fishery characterized by open access using very high densities of short-lived, non-biodegradable, and privately and individually funded MFADs threatens the long-term socio-ecological sustainability of the MFAD fishery and should be discouraged across the region. On the other hand, it has been challenging to maintain publicly funded MFAD programs in the region, although the implementation of comprehensive MFAD management plans might help alleviate this problem. In this context, establishing formal Public-Private Partnerships (PPP) in the MFAD fishery could help achieve the sought socio-economic objectives in the long run while promoting best practices in MFAD use, but these joint ventures remain largely unexplored in the region. Here, PPP are defined as "*a cooperative venture between the public and private sectors, built on the expertise of each partner that best meets clearly defined public needs for services or infrastructure through the transfer between partners of resources, risks and rewards*" (Weirowski and Hall 2008). PPPs can provide a range of opportunities that include improving access to national and international markets, improving food safety and quality, developing niche markets, improving infrastructure, improving financial services, facilitating technology development and research, and improving information and communication (Weirowski and Hall 2008). All these areas are highly relevant to the MFAD fishery.

Implementation advice: The exact nature and objective of any PPP will obviously depend on the socio-economic, political, and organizational context and specific partners involved from both the public sector (government, development banks, NGOs, research institutions) and the private sector (fisher associations or cooperatives, fish processors, microcredit institutions, traders, consultants), which will vary across locations. In the Caribbean, the financing of small-scale ventures in local processing and marketing is a big challenge in most fisheries (Khan et al. 2019). This is also the case in the MFAD fishery, which would benefit from added-value processing (e.g. filleting, smoking) and product differentiation (e.g. eco labeling) and marketing in those locations where the fishery is managed sustainably. This might require initial investment in infrastructure (e.g. expansion of cold facilities), financial support (e.g. micro-credits) and technical support (e.g. training; marketing studies) that could be facilitated by government or/and its associate donors. The MFAD fishery would also benefit from long-lived MFAD designs, which could be supported by government via the provision of technical support and tax-free concessions on high-quality materials and/or equipment (e.g. GPS buoys) for MFADs to fisher groups acting as partners. In any case, it is highly desirable that PPPs are designed so as to favor self-organization of stakeholder groups (e.g. fisher cooperatives or associations) and that their implementation is contingent on the use of best practices through the entire value chain of the MFAD fishery, including the pre-harvest (sustainably exploited species), harvest (fishing and MFAD designs), and post-harvest (processing and marketing) stages.

4.13 Integrate local MFAD networks into regional research programs to inform management

Justification: Biological research is required on multiple topics to help assess and mitigate the impacts of MFADs on target and non-target species and ecosystems, such as the characterization of size and species composition of aggregations and catches on MFADs, movements between MFADs and other habitats and areas, growth, and changes in abundance over time. Moreover, it is well known that Catch per Unit Effort (CPUE) on FADs is not a reliable measure of relative abundance of exploited fish stocks because fish can continue to aggregate on MFADs, and so result in stable CPUE on MFADs, even though their total population abundance might be rapidly declining (Ehrhardt et al. 2017). Detailed fishery-dependent data (catch and effort; biological) from MFADs are still needed to help assess how much biomass is removed by MFAD fishing and to better understand the range of spatiotemporal environmental factors that influence catch composition (species and fish sizes) on MFADs. However, these fishery-dependent data will need to be complemented with fishery-independent data from MFADs to provide a reliable picture of the impact of MFADs on fish stocks (Moreno et al. 2016a). Moreover, there are non-target species caught on MFADs that also need to be considered when assessing MFAD impacts, but for which there are little fishery-dependent data available (Moreno et al. 2016a). In that regard, MFADs can be equipped with satellited-linked buoys integrating ICT systems such as echosounders, hydrophones, underwater and surface cameras, and acoustic receivers, which jointly provide an multisensory observatory of target and non-target animal communities associated with MFADs (Moreno et al. 2016a; Merten et al. 2018). By equipping strategically located MFADs with these ICT systems, the spatiotemporal coverage of fishery-independent data collection could be greatly expanded in the region. Importantly, coupled with tagging studies, these electronically equipped MFAD networks can be used to derive fishery-independent indices of population abundance of key target species, at least over some larger scales (Capello et al. 2016). They could also facilitate research on mortality rates of selected species (e.g. juvenile tuna). Moreover, they could provide valuable data to assess the expected effects of climate change on the abundance and distribution of large pelagic fish stocks and associated fisheries in the region (Monnereau and Oxenford 2017; Oxenford and Monnereau 2017; Cheung et al. 2019a; Cheung et al. 2019b).

Implementation advice: With current estimates of 3,500+ MFADs in the WECAFC region there is great potential to expand the spatial coverage of electronic monitoring of target and non-target species using MFADs. This would dramatically improve our capacity to monitor the abundance of these species over a range of relevant spatiotemporal scales to supplement fishery-dependent data (e.g. Orúe et al. 2020) and help assess the impacts of MFADs on stocks and other components of the ecosystem. This type of research is already very active in the purse-seine tuna fishery of the Indo-Pacific making use of drifting FADs (Forget et al. 2015; Capello et al. 2016; Lopez et al. 2016; Moreno et al. 2016a; Lopez et al. 2017a; Lopez et al. 2017b; Boyra et al. 2019; Orúe et al. 2019; Orue et al. 2019; Baidai et al. 2020; Orúe et al. 2020; Santiago et al. 2020). Much of that technical experience, knowledge, and recent technology existing in the Indo-Pacific is likely to be directly transferable to MFADs in the Wider Caribbean region. It would thus be important to develop a long-term regional research program supported by a network of strategically located MFADs acting as observatories across the region in collaboration with relevant research groups (from within and outside the region) and WECAFC/CRFM/OSPESCA and ICCAT scientific divisions. Finally, these MFAD observatories could also be used to inform fishers about the local abundance of those target species that are being sustainably exploited so to increase fishing efficiency (Bell et al. 2018), which could foster strengthened partnerships between fishers and research programs.

5. Adaptative management mechanisms for implementing and reviewing the Plan

The Interim Coordination Arrangement (ICM) for Sustainable Fisheries developed under the CLME+ project in collaboration with WECAFC, CRFM and OSPESCA provides a useful framework for the implementation of the Plan. It is proposed that, at the national level, national governments are responsible for implementing and reviewing the Plan to provide recommendations and findings that will be submitted to their respective sub-regional fishery bodies, i.e. OSPESCA or CRFM. If a country is not a member of either organization, it will submit these outputs directly to WECAFC. In turn, OSPESCA and CRFM will review and evaluate the contributions from their member countries and generate findings and recommendations for submission to WECAFC. The WECAFC will liase with the WECAFC / IFREMER / CRFM / OSPESCA Joint Working Group on MFADs, and other relevant working groups, including the WECAFC / CRFM / OSPESCA / IFREMER / CFMC Joint WG on Fisheries Data and Statistics and the WECAFC / OSPESCA / CRFM / CFMC Joint WG on Recreational Fisheries.

Amendments to the regional Plan are to be made at the level of WECAFC and then passed on to the member countries for their implementation. At the national level, fisheries authorities in coordination with key stakeholders and Fishery Advisory Committees (or similar) will be responsible for implementing the Plan and its amendments. At the sub-regional level, OSPESCA and CRFM will be responsible for coordinating and monitoring the Plan's implementation whereas at the regional level the responsibility will be taken on by WECAFC.

At the regional level, WECAFC will also liase with ICCAT via the establishment of a Memorandum of Understanding (MoU) or similar arrangement, as recommended by the subregional MFAD fishery management plan (CRFM 2015a) following Tietze and Singh-Renton (2012b). Since WECAFC and ICCAT are both subsidiaries of FAO, WECAFC could seek assistance from FAO headquarters in the preparation of the MoU (Tietze and Singh-Renton 2012b).

Moreover, development agencies, financial institutions, and government and non-governmental agencies investing in the implementation of activities under the Plan should also independently monitor and evaluate the impact of their financial contributions on the expected outcomes.

A review of progress should be conducted on a bi-annual basis by the WECAFC in conjunction with the Joint MFAD Working group. A first evaluation of activities and outcomes under each specific objective should be conducted after five years of the Plan being adopted before a major amendment to the Plan is to be conducted.

The financial resources to implement the Plan will be obtained mainly at the national level, with support from bilateral and multilateral donors and collaborators.

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Appendix I - Review of the state and challenges of the Moored Fish Aggregating Device (MFAD) Fishery in the WECAFC region

Contents

Abbreviations and acronyms

CARIFICO	Caribbean Fisheries Co-management Project
CFMC	Caribbean Fisheries Management Council
CLME	Caribbean Large Marine Ecosystem project
CRFM	Caribbean Regional Fisheries Mechanism
DFAD	Drifting Fish Aggregating Device
ERA	Ecological Risk Analysis
FAO	Food and Agriculture Organization
ICCAT	The International Commission for the Conservation of Atlantic Tunas
IFREMER	French Research Institute for Exploration of the Sea
JICA	Japan International Cooperation Agency
MAGDELESA	Moored fish Aggregating Devices in the Lesser Antilles project
MFAD	Moored Fish Aggregating Device
NAFCOOP	National Association of Fisherfolk Cooperatives
OSPESCA	Central America Fisheries and Aquaculture Organization
SAP	Strategic Action Plan
WECAFC	Western Central Atlantic Fishery Commission

7. Preface

This document presents a review of the current state and challenges of the MFAD fishery across the WECAFC region to support the development of the Caribbean Regional Management Plan for the Moored Fish Aggregating Device (MFAD) Fishery, following the Recommendation of the 3rd meeting of the WECAFC ad hoc Joint Working Group on Development of Sustainable Moored Fish Aggregating Device (MFAD) Fishing in the Lesser Antilles held on April 30th- May 2nd 2019 - Recommendation WECAFC/17/2019/21 (Amendment to Recommendation WECAFC/15/2014/2) - which was endorsed during Seventeenth Session of the Commission held on July 15-18 2019 in Miami, US, and was the basis for the 2019-2020 Programme of Work adopted by the Commission. This Programme sought to increase the knowledge of, and experience with, moored-FADs related fisheries, with the ultimate goal of strengthening regional fisheries management and good-practice approaches for fisheries and aquaculture development. The development of this document was funded by the European Union through the Food and Agriculture Organization of the United Nations (FAO) and its Western Central Atlantic Fishery Commission (WECAFC).

This review builds on that of the CRFM sub-regional management plan (CRFM 2015a) by seeking to expand the geographic scope to include the wider Caribbean region and update on the current state of the MFAD fishery across the region. It is the result of a desk review, interviews with several key informants, and a regional online survey on MFAD use across the region that took place between August and October 2021. Respondents from twenty countries/overseas territories with significant MFAD fisheries took part in the survey. These countries/overseas territories were St. Eustatius, Dominica, Bonaire, Haiti, Antigua and Barbuda, Guadeloupe, Martinique, St Lucia, Puerto Rico, Bermuda, Montserrat, St. Vincent and the Grenadines, Florida (USA), Saba, Anguilla, Tobago (Trinidad and Tobago), the Dominican Republic, Curaçao, Cayman Islands, and Grenada. Seventy percent of the respondents were affiliated with national/local fishery and/or coastal management authorities. Respondents were also asked to rank a series of challenges and issues of the MFAD fishery - most of which had been previously identified by the CRFM sub-regional management plan - based on urgency in addressing to help identify regional priorities. Details and in-depth findings of the regional survey are given in Appendix II. A summary of the biology, distribution, and exploitation status of fish stocks of species typically caught on MFADs is given in Appendix III.

8. State of the MFAD fishery

8.1. Fish Aggregating Devices (FAD)

Observations that some fish tend to associate with natural or man-made floating objects and that such behavior can be used by fishers to facilitate fish detection and capture go back thousands of years ago (Castro et al. 2002; Taquet 2013). This associative behavior is observed in many taxonomically diverse fish species (Castro et al. 2002), although the physical distance at which such association takes place will differ markedly (from several cm to several km) among species and even among different life stages of the same species (e.g. small juveniles versus large adults) (Castro et al. 2002). A number of non-mutually exclusive biological hypotheses have been put forward to explain why fish associate with floating objects (Freon and Dagorn 2000; Castro et al. 2002). These include floating objects protecting against predators (the *shelter* hypothesis), acting as indicators of high food availability (the *indicator-log* hypothesis) and increasing encounter rates with other similar fishes (the *meeting point* hypothesis), with the general recognition that the support for any given hypothesis will depend largely on the life stage and/or species of interest (Freon and Dagorn 2000; Castro et al. 2002; Ehrhardt et al. 2017b). Whatever the biological explanation, fishers in the warm seas have historically capitalized on this fish behavior by building floating objects and placing them in the sea to fish under (or near) them (Castro et al. 2002; Taquet 2013)

8.2. Defining a Moored Fish Aggregating Device (MFAD)

A moored Fish Aggregating Device (MFAD) is hereby defined as any man-assembled structure composed of surface (or subsurface) buoyant components attached to an anchoring system resting on the sea bottom, which is primarily designed and deployed to attract fish to facilitate their capture. This definition excludes oil rig platforms (Franks 2000) as well as other anchored man-made objects deployed in the sea for other purposes (e.g. oceanographic data buoys (Silva et al. 2021)) even though such structures also both attract fish and can sustain important fisheries.

This definition excludes the practice of shadow fishing using boats (Arocha 2019) and fisheries making use of drifting Fish Aggregating Devices (DFAD), including the flying fish fishery in the eastern Caribbean (Gomes et al. 1998) for which there is already a management plan (CRFM 2014c) and the industrial purse-seine fishery that accounts for most tuna catches worldwide (Taquet 2013); the latter in particular operates in a very different socioeconomic, technological, governance and management context from most MFAD fisheries globally (Taquet 2013).

8.3. Historical overview of the MFAD fishery in the Wider Caribbean

The most comprehensive accounts of the development of the MFAD fishery in the Caribbean are given by (Reynal et al. 1999; Reynal et al. 2002) and are briefly summarized in CRFM (2015a). One of the earliest official records of the use of MFADs in the insular Caribbean region dates from the 1968-1971 period and took place in the context of exploratory fishing activities under the Caribbean Fishery Development Project funded by the UNDP/FAO (Wolf 1974; Wolf and Rathjen 1974). This experience yielded unimpressive results due to the very short lifespan of the rudimentary MFAD designs used and small aggregations within that time frame. Around the same time exploratory work linking MFAD design to aggregating properties was being conducted in the Pacific coast of Costa Rica (Hunter and Mitchell 1968), in the Gulf of Mexico (Panama City, USA) (Klima and Wickham 1971), and further north in South Carolina (Hammond et al. 1977, cited in de Sylva 1982) . In a review of MFAD use, de Sylva (1982) was among the first to specifically highlight the potential of MFADs for the Caribbean in a public fisheries forum (34th Gulf and Caribbean Fisheries Institute conference) in 1980. Subsequently, in 1983, fishery officers of the Eastern Caribbean identified FAD use and training as one of top priorities for their region (McIntosh 1984). The use MFADs was at that time viewed as a means of reducing fish imports in the Eastern Caribbean to satisfy the increasing local demand for fish products, given that coastal resources were already heavily exploited in many small island states, whereas pelagic resources were underexploited (Reynal et al. 2002). In the 1980s the use MFADs continued to be explored across the insular Caribbean, including in Martinique, St Kitts, Guadeloupe, Dominica, Grenada, Haiti, US Virgin Islands, Puerto Rico, and Cuba (McIntosh 1984; Reynal et al. 1999 and references therein), as well as in the eastern USA (Rountree 1989; Stephan and Lindquist 1989). Much of the research focus at the time was on the aggregating properties of different MFAD designs generally deployed at relatively shallow depths and short distances from the coast (Reynal et al. 2002).

In the late 1980s and throughout the 1990s, the introduction of drifting droplines with live bait (in addition, to surface trolling) around MFADs and the deployment of MFADs in deeper waters (and further away from the coastline) in the French Antilles allowed specifically targeting large oceanic pelagics such as large yellowfin tuna and billfishes and resulted in tangible increases in fishing yields (Reynal et al. 2002). This change in fishing strategy around MFADs helped initiate a steady increase in the number of locations across the region adopting the use of MFADs to present times (See Fig 1 in Wilson et al. 2020).

8.4. Current MFAD use across the region

The 2021 MFAD regional survey (hereafter referred to as the MFAD Survey; Appendix II), combined with interviews with key informants, and a review of the literature jointly yield a snapshot of the current state of the MFAD fishery across the WECAFC region. Twenty-six locations across the region have a significant MFAD fishery. Nearly all these locations (92%) are Caribbean islands, in line with the historical development of the MFAD fishery in the region. The only two continental locations with a significant MFAD fishery are northeast Brazil and northwest Florida. However, in Brazil, the use of MFADs to target tuna is being gradually replaced by the practice of shadow fishing since the 2010's, and so MFADs appear to be rapidly disappearing (Marco Bailon, pers. com.) whereas, in Florida, the number of MFADs is very small (Table 1). Overall, these results highlight that the MFAD fishery remains mainly confined to the insular Caribbean, as previously documented (CRFM 2015a).

There is currently an estimated total number of 3,600+ MFADs deployed across the region (Table 1), in line with previous estimates (Wilson et al. 2020). In that regard, two locations, the Dominican Republic and Guadeloupe, jointly account for 86% of all MFADs in the region. There is also an estimated total number of 7,200+ fishers and 3,200+ vessels engaged in MFAD fishing either full- or part-time across the region (Table 1). Excluding Florida, the only location where MFADs mainly support recreational fishing (Appendix II), yields a revised estimate of 6,200+ fishers and 2,700+ vessels engaged in MFAD fishing across the region mainly for commercial and/or subsistence purposes. The MFAD survey indicates that in nearly all locations trends in MFAD vessel numbers have remained stable or increased over the last five years (Appendix II). These estimates and trends support an important role of MFAD fishing in sustaining fishers' livelihoods and food security in the insular Caribbean region.

8.5. Objectives of the MFAD fishery

The MFAD Survey indicated that current objectives to support MFADs remain consistent with historical objectives in the region (See Table 5 in CRFM 2015a), namely improving fisher livelihoods (via increased revenue and fishing efficiency and reduced fuel consumption), supporting food security, and decreasing fishing pressure in coastal systems (Table 2). Interesting, objectives about improving co-management and social cohesion among fishers have gained prominence over the last few years relative to the objectives outlined by the desk review in CRFM (2015a), likely as a result of recent efforts to improve co-management approaches in the region (Tamura et al. 2018) (Table 2).

Table 1 – List of WECAFC countries (and/or their overseas territories) and whether they currently have a significant MFAD fishery; for those that do (grey shading), estimates of numbers of public and private MFADs as well as MFAD fishers and vessels (full- and part-time) are provided. NA- No data available

Country / Territory	MFAD fishery	Public MFADs	Private MFADs	MFAD boats	MFAD fishers	Comments / Sources
Anguilla (British OT)	Yes	0	25	15	15	More MFADs to be deployed after the hurricane season
Antigua and Barbuda	Yes	8	20	15	35	Six public MFADs to be deployed in 2022; about 40-80 illegal private MFADs set by foreign vessels
Aruba (Dutch Caribbean)	No	-	-	-	-	
Bahamas	No	-	-	-	-	There is one MFAD, but it is used exclusively for research
Barbados	Yes	1	0	NA	NA	A total of 17 public MFADs to be soon deployed
Belize	No	-	-	-	-	
Bermuda (British OT)	Yes	1	0	5-25	5-75	One additional public MFAD to be re-deployed after being lost
Bonaire (Dutch Caribbean)	Yes	6	1	20	20	
Brazil	Yes	0	NA	NA	NA	The use of MFADs has declined considerably in the last decade; very few boats now use MFADs.
British Virgin Islands (British OS)	NA	NA	NA	NA	NA	
Cayman Islands (British OT)	Yes	0	2	-	-	
Colombia	No	-	-	-	-	
Costa Rica	No	-	-	-	-	
Cuba	No	-	-	-	-	
Curacao (Dutch Caribbean)	Yes	0	20	10-15	10-15	
Dominica	Yes	2	20	300	600	
Dominican Republic (south coast)	Yes	0	2500	1250	2500	
Grenada	Yes	0	3	70	140	Four to five MFADs present at any given time
Guadeloupe (French OT)	Yes	<30	600	218	387	Estimates from 2008 (public) and 2012 (private) - current numbers are probably higher
Guatemala	No	-	-	-	-	
Guyana	No	-	-	-	-	
Haïti (southeast department)	Yes	6	3	250	1500	This is an estimate for about 150 km of coastline; there are more MFADs along the rest of 1,700 km of Haitian coastline.
Honduras	No	-	-	-	-	
Jamaica	No	-	-	-	-	
Martinique (French OT)	Yes	4	20-25	220	377	
Mexico	No	-	-	-	-	
Montserrat (British OT)	Yes	4	0	8	25	Six MFADs were recently lost
Nicaragua	No	-	-	-	-	
Panama	No	-	-	-	-	
Puerto Rico (USA OT)	Yes	11	10	-	-	
Saba (Dutch Caribbean)	Yes	0	15-20	12	22	
Saint Kitts and Nevis	Yes	0	100	75	100	50% of MFADs in Nevis and 50% in St Kitts
Saint Lucia	Yes	8-10	0	200-250	450-500	
Saint Vincent and the Grenadines	Yes	6	0	50	100	
Sint Eustatius (Dutch Caribbean)	Yes	1	5	6	6	Two MFADs were recently lost
Sint Marteen (Dutch Caribbean)	Yes	0	2	20	NA	Source: Wilson et al. (2020)
St Barthelemy (French OT)	Yes	0	100	22	NA	Source: Wilson et al. (2020)
St Martin (French OT)	NA	NA	NA	NA	NA	
State of Florida (USA)	Yes	8	0	500+	1000+	MFADs located off Destin - Fort Walton Beach
Suriname	No	-	-	-	-	
Trinidad and Tobago	Yes	0	100	-	60-80	Only Tobago has MFADs
Turks and Caicos (British OT)	No	-	-	-	-	
US Virgin Islands (USA OT)	Yes	4	0	20	NA	Source: https://coastalanglermag.com/usvi-fish-aggregating-device-fad-program/
Venezuela	No	-	-	-	-	

Table 2. Frequency of citation of high-level objectives to support a MFAD fishery by respondents from 20 territories/countries with MFAD fisheries. The list of objectives was based on CRFM (2015).

High level objective	Citation frequency
To increase fisher revenue	18
To increase fishing efficiency for fishers	17
To decrease coastal or nearshore fishing pressure	16
To increase local availability of fish products	15
To reduce fuel consumption	14
To support food security	14
To reduce fish imports	10
To promote social cohesion and collaboration among fishers	9
To promote co-management	8
To reduce competition among fishers in resources/fishing grounds	7
To generate new added value products	5
To increase employment	5
To encourage fishers to remain within territorial waters	4
To increase safety at sea	4
To support or develop a charter/sports fishing market	4
To conduct research on pelagic species biology and/or fishing techniques	4
To increase fish exports	3
To reduce conflicts between fishers and other users of the sea (e.g. shipping, tourism)	3
To decrease physical demands of fishing	2
To control or reduce use of private MFADs	1

8.6. Fishing vessels and safety at sea

Most vessels making use of MFADs in the region are small-sized (<9 m long) multipurpose vessels (made of wood, fiberglass, or fiberglass and wood) equipped with outboard engines engaged in one-day fishing trips (CRFM 2015a). Moreover, the MFAD Survey indicated that (1) in half of these locations MFAD vessels were generally decked, (2) in most of these locations MFAD vessels were typically equipped with ice boxes, whereas (3) only in a few of these locations MFAD vessels were equipped with winches (Appendix II). Typical outboard engine power can differ by up to one order of magnitude among locations (e.g. 15-18 hp in Haiti (Vallès 2016) vs 176 hp (on average) in Guadeloupe (Guyader et al. 2018)), although the prevailing engine horse power across most locations is 100 hp and above (Appendix II). Most crew sizes engaged in MFAD fishing involve 2-3 fishers (Appendix II)(CRFM 2015a).

The MFAD Survey indicated that in the majority (≥50%) of locations most fishers (1) had safety signaling equipment, (2) had emergency flotation devices, and (3) had navigation equipment; however, (4) they were not trained in safety at sea, (5) did not have alternative means of propulsion in their vessels, and (6) did not wear personal protective gear to handle large fish (Fig 1).

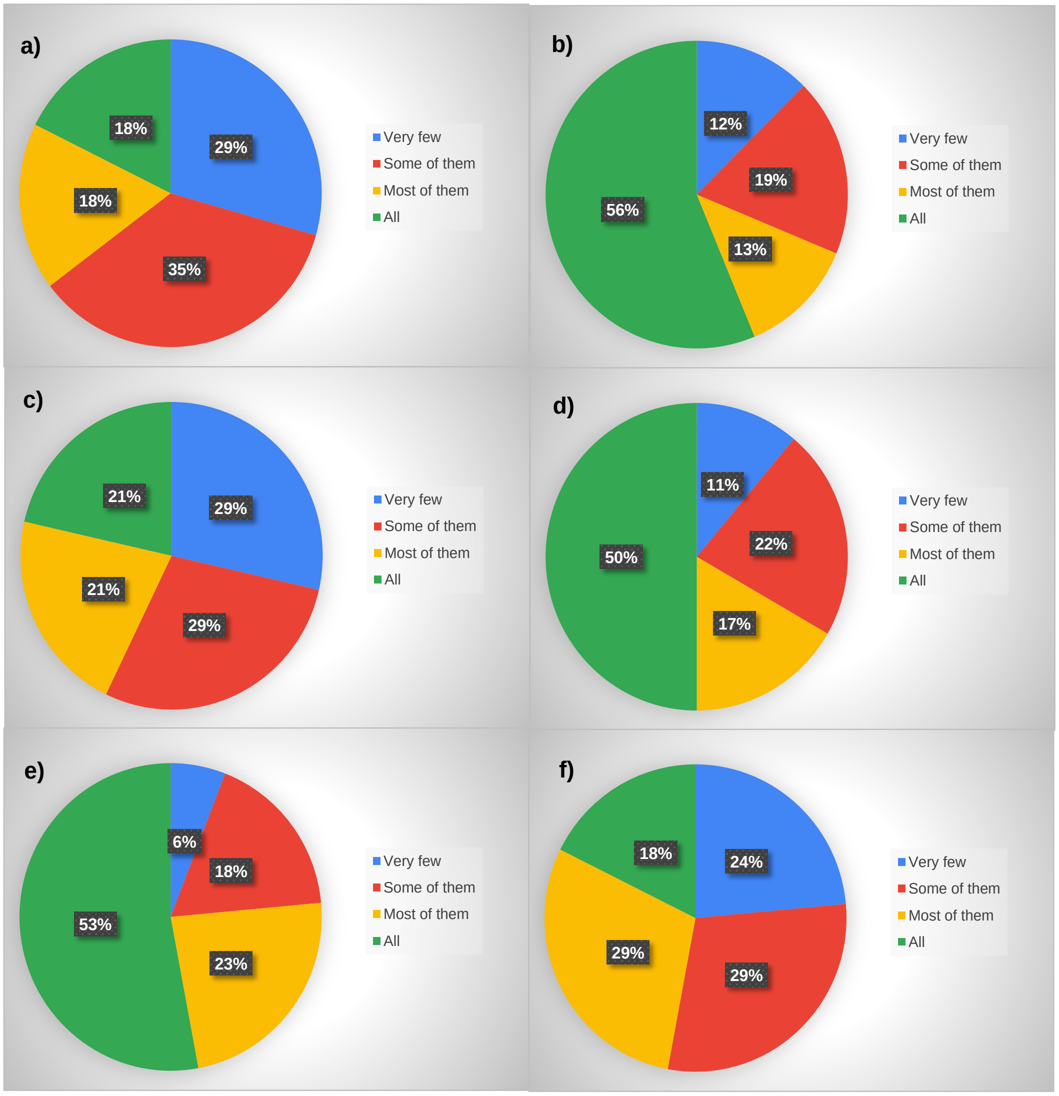

Figure 1 – Safety at sea conditions for MFAD fishers as percentage of responses across 20 territories indicating the number of fishers in their respective locations that a) are trained in safety at sea, b) have safety signaling equipment (e.g. VHF / radio-telephone, torch, flares, mirror, air horn, etc), c) have alternative means of propulsion (e.g. oars, sail rigs, auxiliary engine), d) have emergency flotation devices (e.g. floats, life-jackets, large plastic containers), e) have navigation equipment (e.g. compass, GPS), and f) have personal protective gear to handle large fish (e.g. noose, boots, gloves).

8.7. Fish handling on board and post-harvest facilities

The MFAD Survey indicated that the extent to which large fish typically caught on MFADs are processed onboard (spiked; bled out; gutted; preserved on ice) differs markedly across the region (Fig 2a-d). This variability in fish handling and conservation practices likely reflects a combination of factors including the degree to which domestic markets impose (or not) quality standards (Gentner et al. 2018), duration of fishing trips, local availability of ice, and whether fishers are trained in fish handling.

As indicated in CRFM (2015a), the landing sites for MFAD catches are typically part of the larger pool of landing sites for pelagic species. Following FAO (2004) these can be assigned to three categories: (1) a beach with no or minimum makeshift facilities, (2) a developed small landing site with some government-provided facilities such as covered working areas, water supply, lighting, gear sheds, and (3) a developed complex including a building, office space, freezers and jetty. In that regard, the MFAD Survey supports that in many locations across the region adequate facilities to handle large fish are still lacking (Fig 2e). This is consistent with a recent study by Montes et al. (2017), which found that most fishers (including MFAD fishers) in each of five insular Caribbean countries were not openly satisfied with the services and facilities of the landing sites they had access to, with the degree of overall dissatisfaction varying markedly among countries.

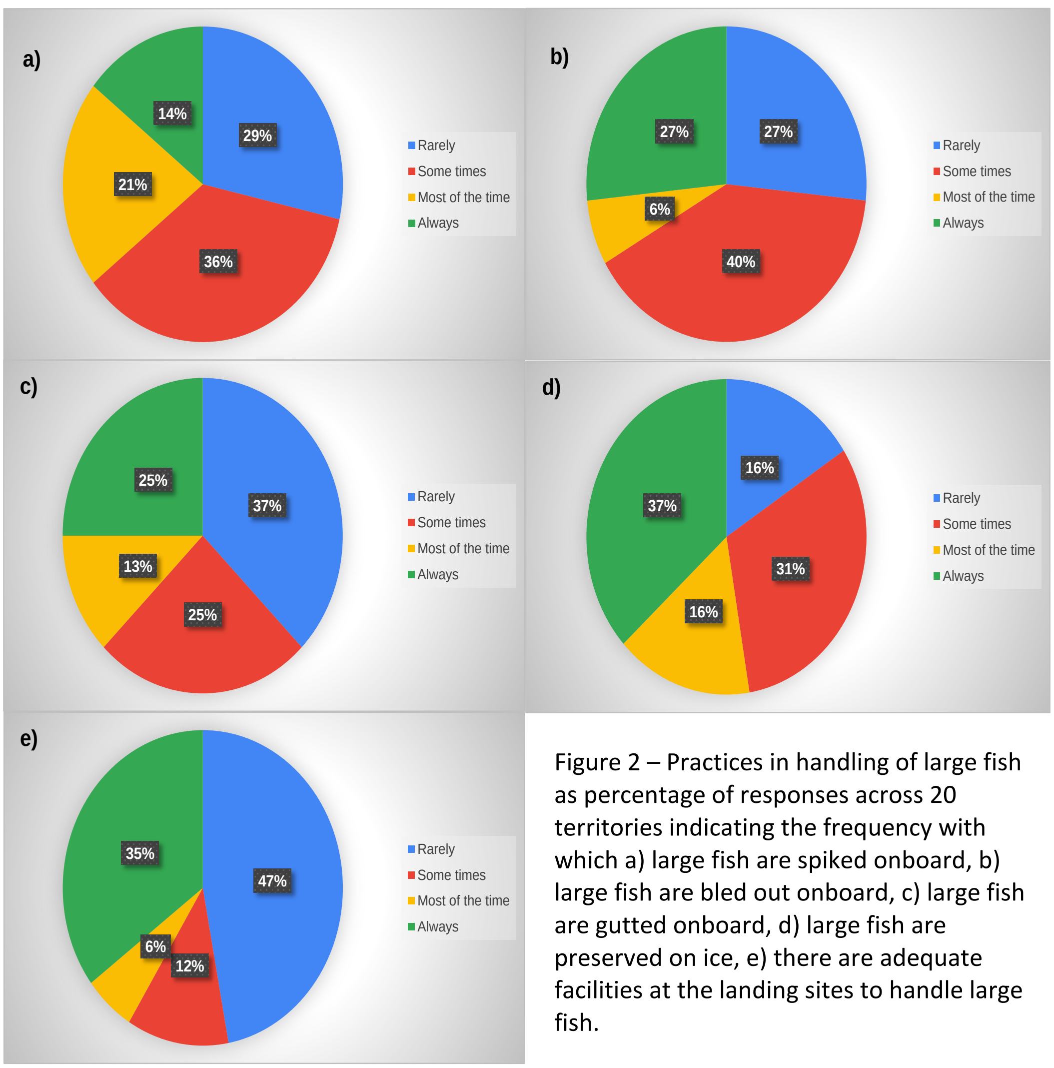

Figure 2 – Practices in handling of large fish as percentage of responses across 20 territories indicating the frequency with which a) large fish are spiked onboard, b) large fish are bled out onboard, c) large fish are gutted onboard, d) large fish are preserved on ice, e) there are adequate facilities at the landing sites to handle large fish.

8.8. MFAD design, cost, and lifespan

A MFAD is typically made up of six distinct components: (1) the surface float component (typically made up of string of buoys or floats or a single spar buoy), (2) an aggregator component aimed at attracting fish (e.g. tarpaulins, plastic strips, coconut leaves), (3) a mooring line (which can be made of a diverse range of materials including polypropylene, polyester, nylon, cable rope, banana string, telephone wire), (4) a mooring component (typically made up of concrete blocks or barrels, sand bags, old engines), (5) a surface marker to minimize collision with boats (typically including a flag, a radar reflector, a light, mast), and (6) the joining elements (shackles, thimbles, knots, swivels) (Fig 3 and 4).

Depending on their dimensions, design complexity, and materials, MFADs can be classified as heavy, semi-heavy or light, although in reality designs will vary along a continuum (Dempster and Taquet 2004). All three types of MFAD designs can be found in the region (CRFM 2015a). Heavy MFADs generally have a single large buoy made of steel, PVC, or composite material as surface component (Dempster and Taquet 2004; Gervain et al. 2015). This component is generally designed to remain on the surface even in the face of strong currents (Fig 3d; except in the case of subsurface MFADs – Fig 3c). The mooring line is typically made of different sections of high-diameter and high-quality materials that fulfill different functions with the ultimate goal of minimizing the risk io rupture of the mooring line (Gervain et al. 2015). The line segment just below the surface component is typically made of sinking material (e.g. chain, cable, polyester, polyamide) to ensure that it never reaches the surface in periods of low currents. The first section of this line (e.g. first 50m-200 m) will also be physically reinforced to resist fish bites and cuts by fishing lines. The line segment coming from the anchoring component is typically made of floating material (e.g. polypropylene, polyethylene) to ensure that the line does not drag on the sea floor during periods of low currents (Gervain et al. 2015). Due their size and high buoyancy, heavy MFADs often require large anchoring components (e.g. one or several large concrete blocks) and thus their safe transport and deployment typically requires larger vessels than those typically used by MFAD fishers.

Semi-heavy MFADs are smaller and have a surface component made out of a string of resistant buoys that sink with the currents and return to the surface after immersion (Fig 3a,b) (Dempster and Taquet 2004); the more expensive models might also have a mooring line with sections also made of markedly different materials to minimize the risk of rupture. If the mooring line is entirely made of floating line (e.g. polysteel), ballasts can be attached to the line to prevent it from reaching the surface under low currents (Fig 3b).

At the other end of the continuum are the light MFADs, which generally have a relatively small surface component made of a string of cheap locally available floats (e.g. plastic drums, cans, recycled floats/buoys) that will tend to sink under strong currents and are likely to implode during prolonged immersion (Fig 4); the surface component will be generally attached to the anchoring component often via a single low-diameter cheap line made of whatever material is locally available (e.g. banana string, polyethylene). Light MFADs often lack surface markers specifically designed to avoid collisions with boats (e.g. flags; radar reflectors). The anchoring components of semi-heavy and light MFADs are relatively small and light (e.g. concrete blocks, old engines, sand bags), which allows fishers to transport and deploy MFADs themselves using their small vessels (Fig 3a, b and Fig 4). CRFM (2015a) and references therein provide a review of the evolution of MFAD designs in the Caribbean region. MFAD designs from the French Antilles first, and subsequently from the FAD Pilot project of Dominica (CRFM/JICA 2012) have been particularly influential in driving MFAD design in other locations in the region (FAO 2007; CRFM 2015a; Defoe 2020).

A major ecological concern surrounding the use of MFAD is the loss of the units, which are often made nearly entirely of non-biodegradable materials, thus contributing to marine litter. Such losses can also threaten the economic viability of the fishery. MFADs can be lost in various ways including when (1) the upper part goes adrift because of rupture of the mooring line, (2) the whole MFAD sinks after implosion or destruction of surface buoys or floats, and (3) the whole MFAD goes adrift due to insufficient anchor weight or because the sea bottom is too steep (Gervain et al. 2015). The surface component remains the most vulnerable part of the MFAD. Potential causes of loss are diverse and include excessive strain by swells and waves, damage by collision with boats, buoy/float implosion due to submersion under strong currents, mooring line cut by fishing lines or fish bites, tangling with drifting objects, inadequate mooring line design, incorrect assembly of components, incorrect MFAD deployment, vandalism, and lack of maintenance (Gervain et al. 2015).

Best practices in MFAD design and materials to minimize MFAD losses have been documented (Gervain et al. 2015) and include, among others, sufficient anchoring weight in relation to the mooring lines and the system of buoys; correct night and day markings to prevent boat collisions; sufficient buoyancy of the floating component to prevent buoy submersion and implosion under strong currents; extra protection against cuts by fishing lines and fish bites of the mooring line below the surface; presence of a sinking mooring line below the floating component and a floating mooring line above the anchoring component to prevent the line from floating to the surface or dragging on the sea bottom, respectively, when there is no current (CRFM 2013a; Gervain et al. 2015). Most of these features are found on heavy MFAD models and are lost progressively as models transition through semi-heavy designs to the light ones.

Greater investments in materials and design should lead to a greater life span of the MFAD unit (Gervain et al. 2015). The MFAD Survey highlighted that, relative to private MFADs, public MFADs are more likely to be equipped with surface markers, a sinking line below the floating component, a floating line above the mooring component, and a large concrete block as mooring component (Appendix II). Thus, public MFADs across the region are more likely to align with best practices in MFAD design. As expected, the MFAD Survey also confirmed that public MFADs are also more likely to last several years after deployment than private MFADs, with the latter most frequently having about one year of lifespan (Appendix II). The MFAD Survey also indicated that public MFADs more frequently fell into the cost bracket exceeding USD 8,000 per unit across the region, whereas private MFADs more frequently fall into the USD 1,000-2,000 bracket (e.g. USD 1,000-1,800 in Dominica; Defoe 2020). However, depending on location, materials and depth of deployment, some private MFADs can largely exceed that bracket (up to USD 5,000 in Guadeloupe; Guyader et al. 2018) but also so go well below (USD 100-150 in the Dominican Republic; Gentner et al. 2018) (Fig 4). On the other hand, the MFAD Survey also indicated that private MFADs are more likely to be replaced within just a few months when lost than public MFADs, with the latter more likely to be replaced within a year (Appendix II). In contrast, public MFADs are much more likely to be recovered when lost than private MFADs (Appendix II). The MFAD Survey also found that two thirds of locations with public MFADs reported that the MFAD units had clear markings allowing owner identification; when it came to locations with private MFADs, only half of these locations reported that the MFAD units had clear markings allowing owner identification (Appendix II).

The MFAD Survey indicated that tarpaulins and plastic strips are the most frequently used types of aggregator materials for both private and public MFADs, although in a few locations potentially animal entangling materials such as old nets are still being used (Appendix II). Storm events were most frequently cited as causes of MFAD losses for both MFAD types, followed closely by mooring lines being cut by boats (Appendix II). The MFAD Survey also supported differences between private and public MFADs in depth of deployment, with public MFADs more frequently deployed between 501-1000 m and private ones between 1001-2000 m (Appendix II). The latter likely reflects efforts by fishers to deploy private MFADs further away from the coastline to maximize catches of large oceanic pelagics while minimizing the chances of other fishers fishing on their MFADs (Guyader et al. 2013; Guyader et al. 2018), although it cannot be discarded that these differences might be confounded by the varying bathymetry across locations.

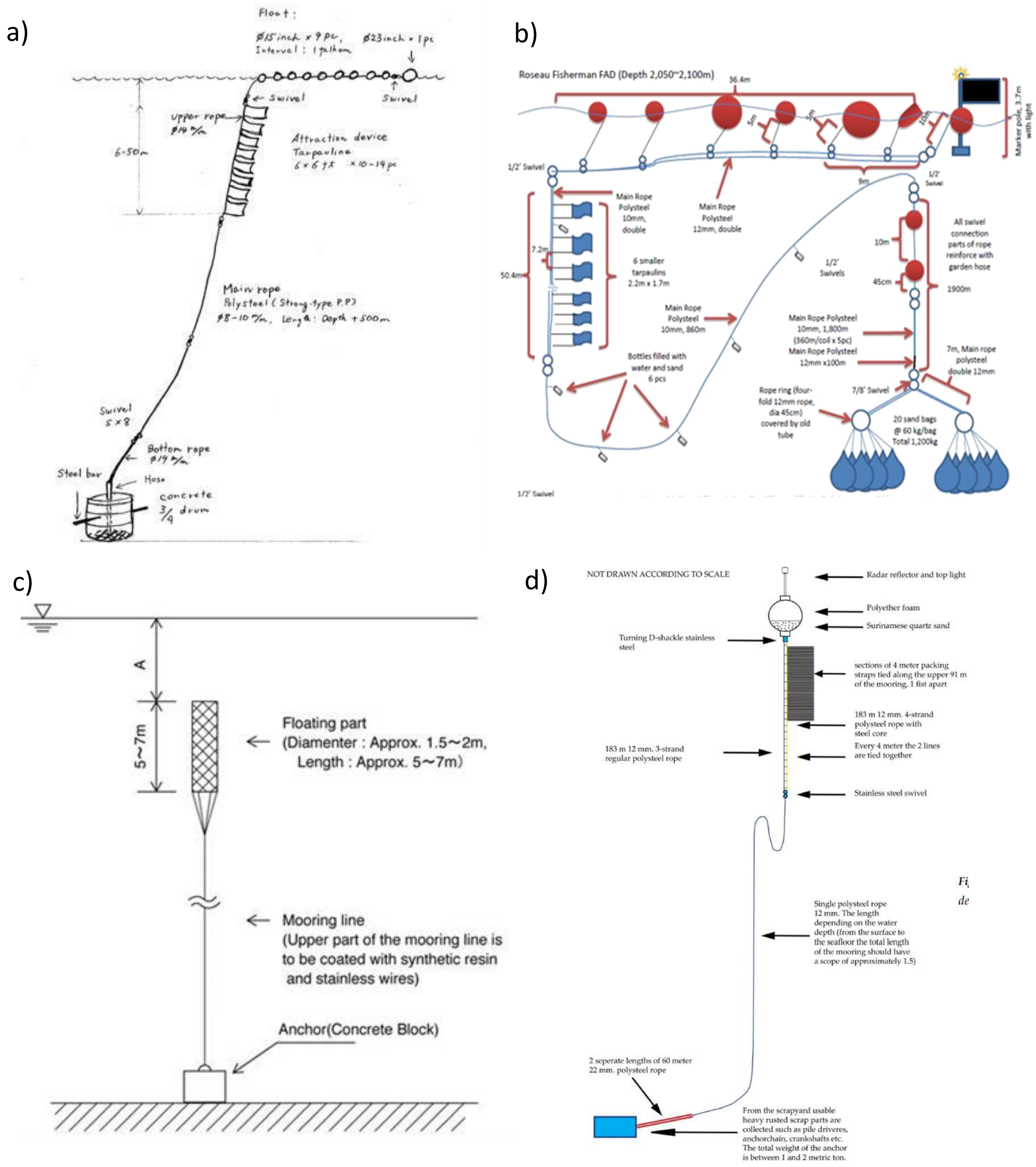

Figure 3 – Diversity of MFAD designs including (a) a semi-heavy traditional MFAD from Dominica, (b) an improved semi-heavy MFAD from Dominica, (c) a heavy "mega" MFAD from Dominica, and (d) a heavy MFAD from Curacao. Sources are Defoe (2020) for Dominica and Dilrosun Faisal (unpublished) for Curacao

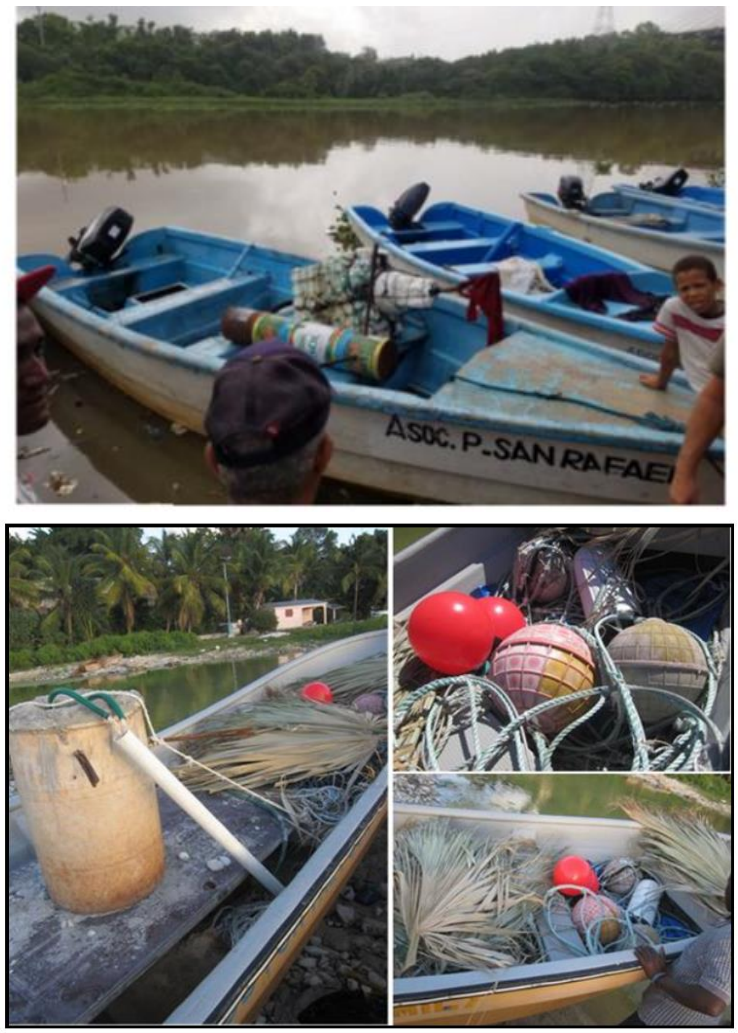

Figure 4. Anchor and floating components for light MFADs ready for deployment in (a) the Dominican Republic and (b) Haiti. Taken from Gertner et al. (2018) and Vallès (2015)

8.9. Fishing techniques, target species and sizes, and variability in catch composition

The MFAD Survey found that fishing near MFADs across the region takes place mainly within 100 m from the MFAD during daylight hours; fishing techniques are largely dominated by the surface (<2 m deep) and sub-surface (2-10 m deep) trolling and drifting droplines using live small pelagic species (e.g. flyingfish) and small-bodied tuna species (e.g. skipjack) as bait as well as artificial lures, as previously reported (CRFM 2015a). When specifically targeting large individuals of large oceanic pelagics such as yellowfin tuna and marlin, fishers will generally troll near the MFAD using artificial lures to capture small-bodied tuna species (e.g. bonito) or juveniles of large-bodied tunas (e.g. yellowfin tuna), which tend to aggregate near the surface (Doray et al. 2007) (Fig 5), and will subsequently use these as live bait in drifting droplines operating a greater depths (Guillou and Lagin 1997; Sidman et al. 2015; Gentner et al. 2018; Defoe 2020). Wahoo and dolphinfish are often targeted using surface and sub-surface trolling with baited hooks or artificial lures (Guillou and Lagin 1997) as well as with handlines with baited hooks (Defoe 2020).

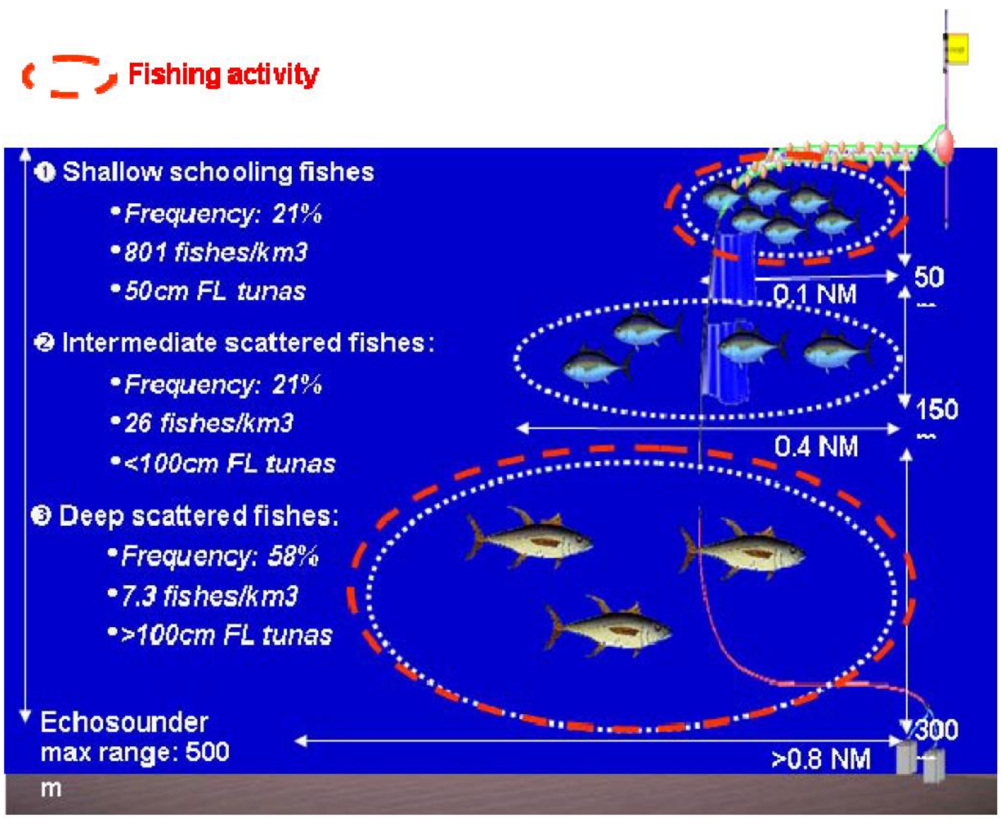

Figure 5. Changes in the species and size of tuna associated with a MFAD along the depth gradient. Taken from Doray (2007)

A great diversity of oceanic and coastal pelagic species associates with MFADs and thus MFAD fishery landings often include multiple species. The MFAD Survey found that eight species accounted for ¾ of frequency of reporting. These include, by decreasing order of importance, yellowfin tuna, wahoo, blackfin tuna, blue marlin, skipjack, bigeye tuna, dolphinfish, and little tunny (Fig 6). These species overlap largely with the most abundant species reported in long-term (≥1 year) fishery landing data from MFADs across the region, including the Lesser Antilles (Fig 7 and Table 3) or Greater Antilles (Fig 8a; Table 4).

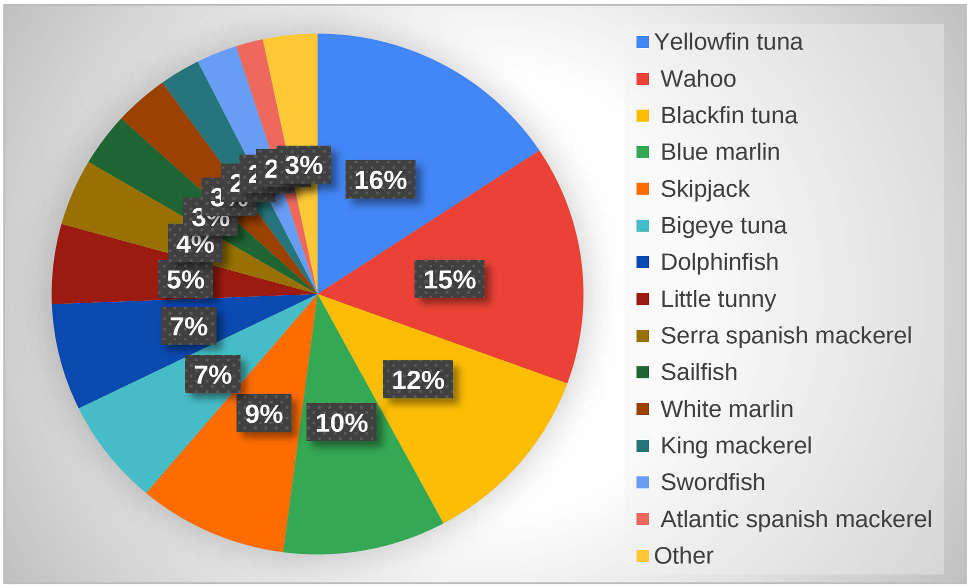

Figure 6. The most frequently reported target species on MFADs across 20 territories.

Table 3 - Top five fish groups caught on MFADs over ≥ 1 year in five islands in the Eastern Caribbean. Taken from CRFM (2015a).

Top groups	Grenada	St Vincent and The Grenadines	Martinique	Dominica	Guadeloupe
1	Blackfin tuna	Blue marlin	Blue marlin	Yellowfin tuna	Yellowfin tuna
2	Yellowfin tuna	Yellowfin tuna	Yellowfin tuna	Dolphinfish	Dolphinfish
3	Cavalli	Blackfin tuna	Little tunny	Skipjack	Little tunny
4	Dolphinfish	Dolphinfish	Blackfin tuna	Blackfin tuna	Blue marlin
5	Rainbow runner	Skipjack	Dolphinfish	Sharks	Rainbow runner

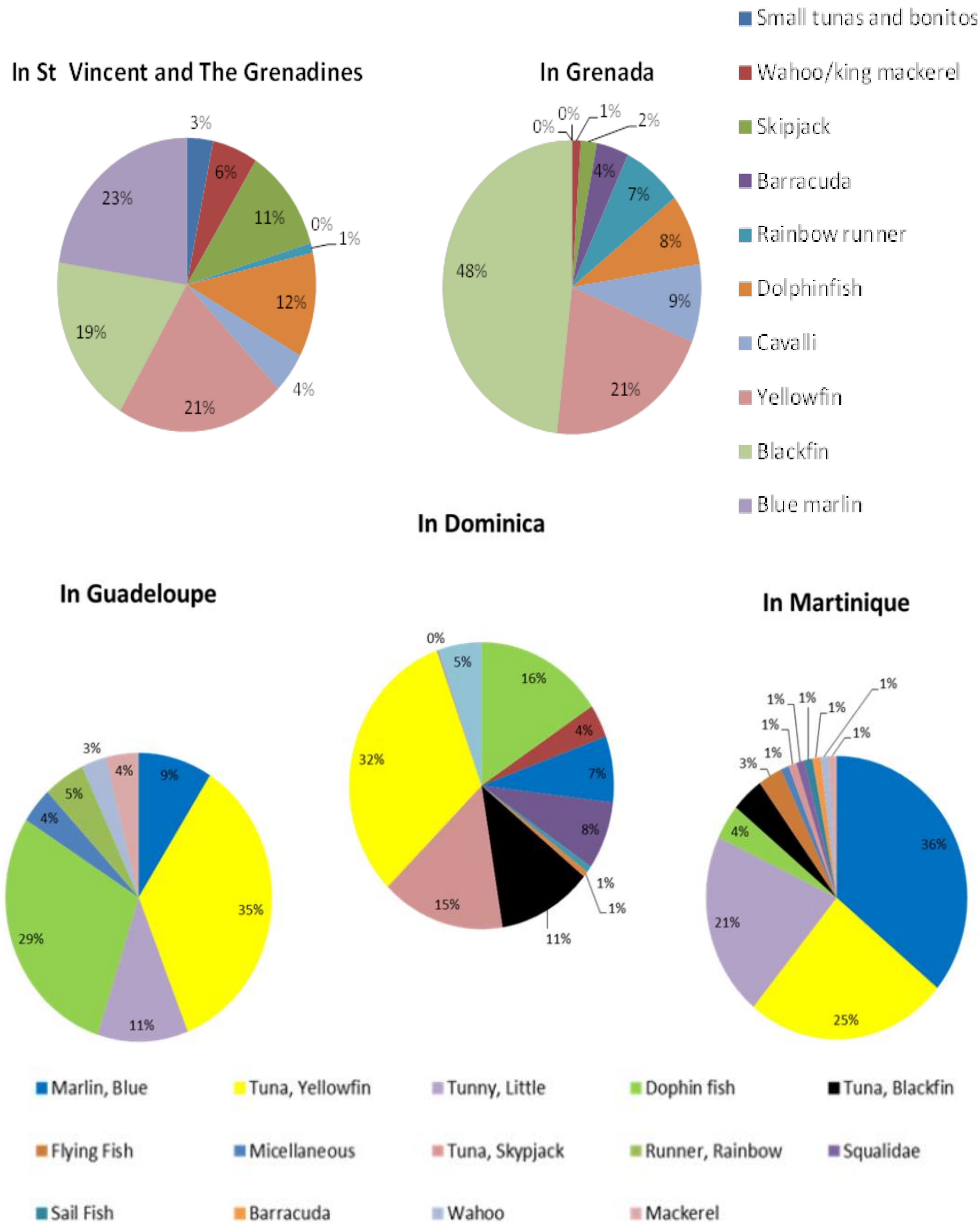

Figure 7. Catch composition over ≥ 1 year from MFADs in five different islands of the eastern Caribbean. Adapted from (CRFM 2015a) based on CRFM (2013b) and Mathieu et al. (2014)

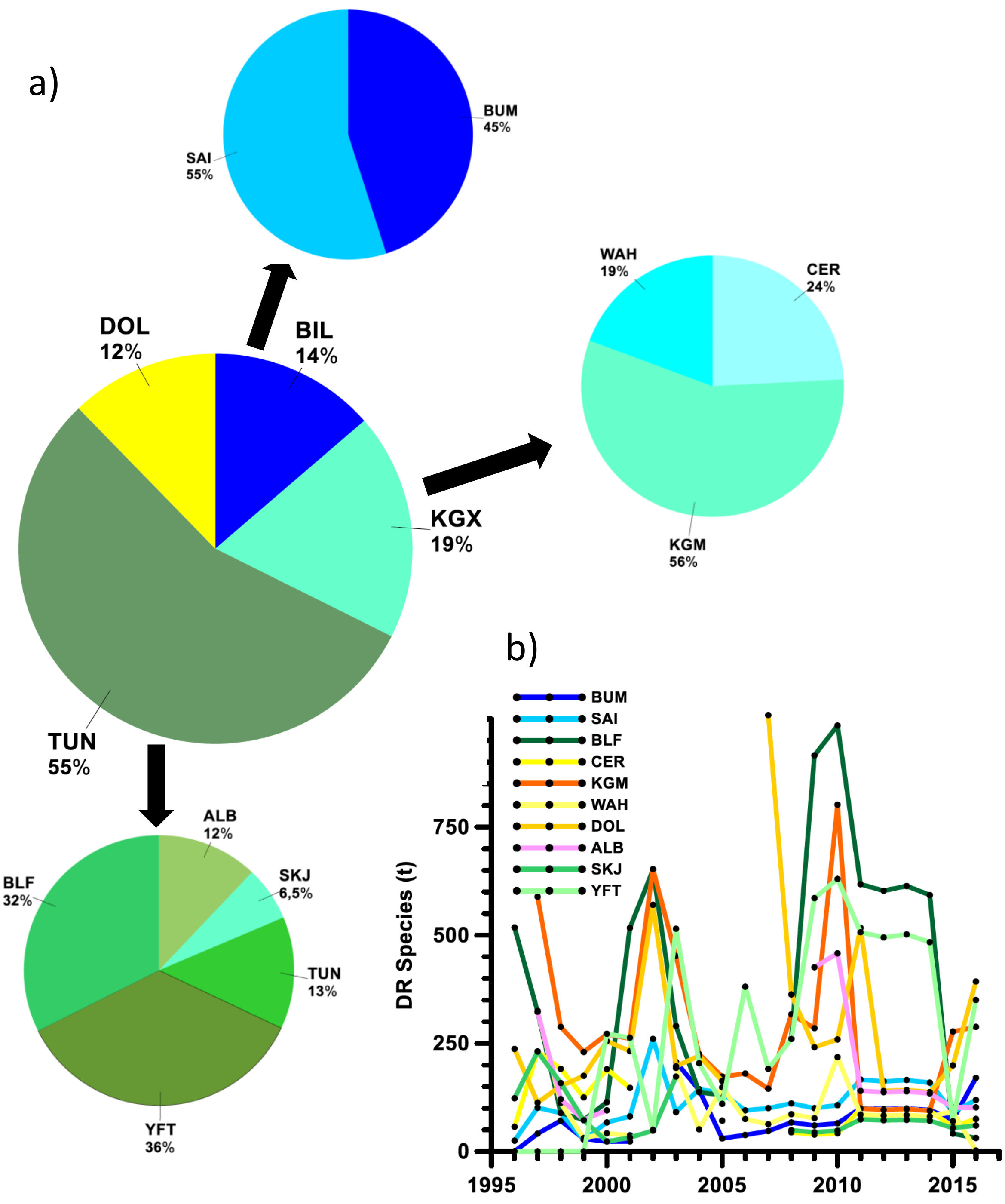

Figure 8. Landing composition of large pelagics in the Dominican Republic (a) broken down by relative abundance for the 2014-2016 period, and (b) by yearly landings between 1996 and 2016. These landing data come mainly from the use of MFADs in the south of the island. ALB- Albacore tuna; BIL – Billfish; BLF- Blackfin tuna; BUM- Blue marlin; CER - Cero mackerel; DOL – Dolphinfish; KGM- King Mackerel; KGX – Kingfishes; SAI- Sailfish; SKJ – Skipjack; TUN - other tunas; WAH -Wahoo; YFT - Yellowfin tuna. Taken and adapted from Arocha (2019).

Table 4. Average landing composition of large pelagics in the Dominican Republic for which data are available over the 2015-2019 period and corresponding percentage of total reported landings (all fishing types combined) in the region that they represent. These landing data come mainly from the use of MFADs in the south of the island. Taken from Arocha (2021)

Species	Metric tons per year	% of total reported landings for the region
Yellowfin tuna	220.4	0.7
Skipjack	40.4	0.8
Albacore	267.2	6.4
Blackfin tuna	23.0	1.9
Blue marlin	155.4	19.5
Sailfish	117.4	7.4
Dolphinfish	391.8	10.3
Wahoo	19.2	2.5
King mackerel	286.8	3.0
Cero	48.2	24.3
Total	**1569.8**	**2.8**

It is important to highlight that tuna aggregations around MFADs will tend to have greater proportions of juveniles relative to adults than free-swimming schools of tuna (Fonteneau et al. 2000; Dagorn et al. 2013). Moreover, MFADs allow targeting all year-round species that were traditionally fished only during certain periods of the year coinciding with the passage of their adult migrations such as dolphinfish (Guillou and Lagin 1997). These two factors ultimately result in catches around MFADs of specific fish groups that are often dominated by pre-mature individuals (Doray and Reynal 2002). These fish groups include notably yellowfin tuna, blackfin tuna and dolphinfish (but not blue marlin; Fig 9). The targeting of pre-mature individuals for commercial purposes around MFADs raises legitimate concerns about their potential to lead to growth overfishing and recruitment overfishing (Fonteneau et al. 2000; Dagorn et al. 2013; MRAG 2017), particularly given the lack of data on juvenile mortality and growth rates for some of these groups in the region. Although the MFAD Survey indicated that in two thirds of the locations small fish (<2kg) generally made less than 25% of the catch (Appendix II), even at such low levels juveniles are still likely to numerically dominate the catch (Reynal et al. 2002). Moreover, the use of juvenile tuna as bait is rarely quantified as part of the catch, highlighting an area for improved monitoring.

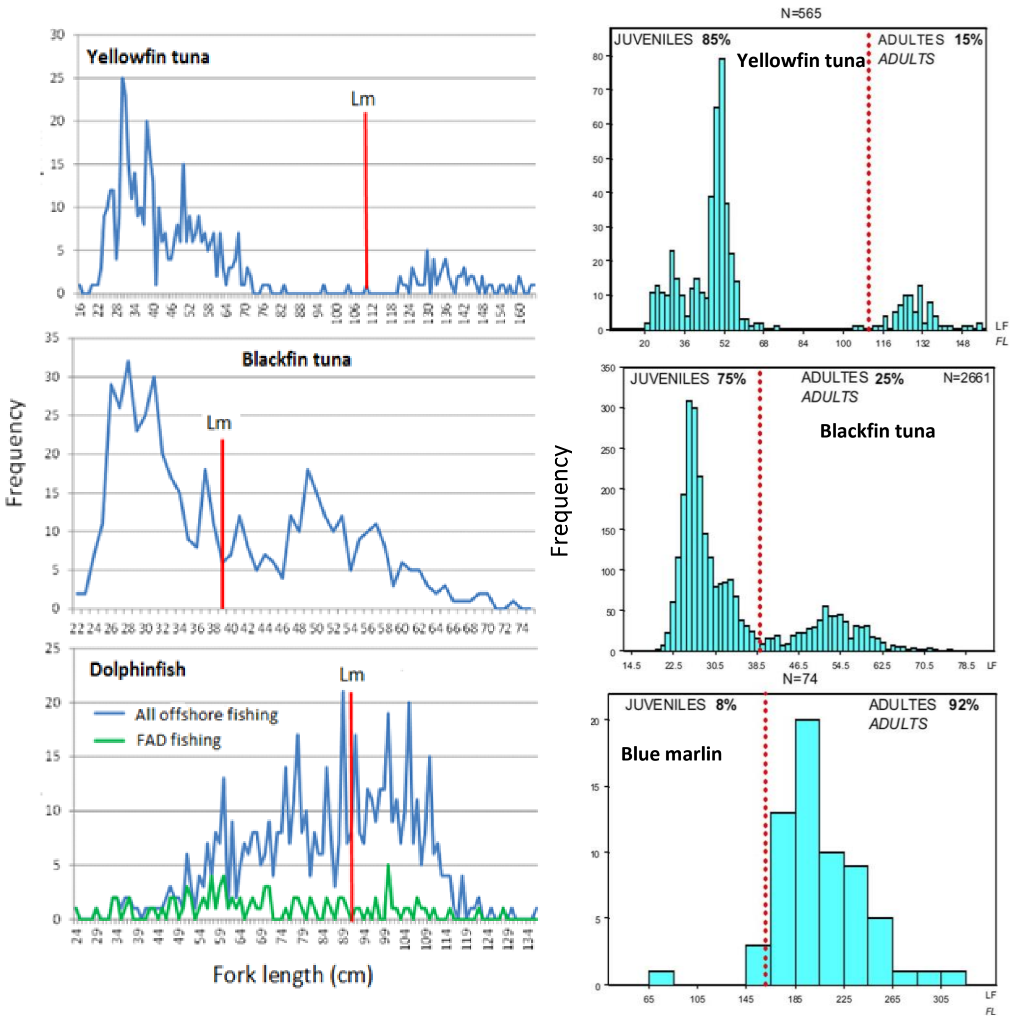

Figure 9 - Size-frequency distributions of fish caught around MFADs in Martinique (left panels) between 2008 and 2013 and (right panels) between 1998 and 2001. Vertical red lines indicate length at maturity (Lm). Taken and adapted from CRFM (2015a) and Doray et al. (2002).

Beyond the fishing techniques employed for MFAD fishing, which species dominate MFAD catches will differ in space and time over a range of scales. A review of variability in catch composition on MFADs in the region and underlying factors is given in CRFM (2015a); there are differences in catch composition within islands (Atlantic vs Caribbean side) and among islands (with no clear latitudinal pattern) as well as between night and day, among months (seasonal), and among consecutive years in the same location. Such differences are driven by a combination of (1) factors influencing the likelihood of target species encountering MFADs such as proximity to migration routes (e.g. distance from shore) and the seasonality of such migrations, (2) factors influencing the aggregation dynamics of such species once they encounter the MFADs (e.g. residence time, depth re-distribution over the dial cycle), and (3) factors potentially affecting fish catchability on MFADs (e.g. bait availability; sea conditions) (CRFM 2015a and references therein).

The MFAD Survey also supported differences across locations in seasonality of MFAD use. Fifteen locations reported seasonality in MFAD fishing, whereas five reported a lack thereof. There is direct evidence supporting both scenarios. Pooling data across the fifteen locations suggested a broad regional seasonal pattern for MFAD fishing between May and November (Appendix II), which broadly aligns with that documented in some locations for some years such as Martinique (2009,2010) and Guadeloupe (2008, 2010) (Mathieu et al. 2014). Other locations certainly seem to fish on MFADs all year round as it was the case of Dominica in 2008-2010 period (Mathieu et al. 2014). Such differences across the region in seasonality of MFAD use likely reflect the interplay of very different factors. For example, the MFAD Survey indicated that the four most frequently cited reasons for seasonality in MFAD use were, by decreasing order of importance, abundance of target species, market demand for fish, low revenue from other fishing activities, and good sea conditions for offshore fishing. These results suggest that the economic incentives for MFAD fishing and environmental and ecological conditions within which MFAD fishers operate differ markedly across the region.

In terms of incidental by-catch, the MFAD Survey suggested that the capture of marine mammals, sea turtles, and sea birds on MFADs was infrequent across the region, possibly because the use of entangling materials such as old nets as aggregators appeared to only take place in a few locations (Appendix II). In contrast, incidental by-catch of sharks on MFADs was reported to occur more frequently across the region, with sharks being one of the most frequently reported non-target fish species caught on MFADs (Appendix II).

8.10. MFAD total landings, number of fishing trips and yields per fishing trip

Long-term monitoring of fishing trip landings exists in many locations across the region. However, published reports of MFAD landings are rare because unambiguously separating MFAD catch data from other types of fishing has only started to be implemented more recently (CRFM 2015a). Table 5 shows the most recent yearly estimates of MFAD landings from the studies compiled by CRFM (2015a) along with a recent study from Dominica. Data from the Dominican Republic are given in Fig 8b and Table 4. These data show that MFAD landings vary by one to two orders of magnitude across the region, with Guadeloupe and the Dominican Republic largely dominating yearly reported landings with estimates exceeding 1,000 tons per year.

Table 5. Yearly estimates of fish landings from MFAD across the region

Location	Yearly estimate (metric tons)	Temporal coverage	Number of MFADs	Source
Grenada	22	Aug 2012- Jul 2013	1	CRFM (2013b)
St Vincent	5	Aug 2012 - Nov 2013	2	CRFM (2013b)
Haiti (southeast)	43	Jun 2013- Aug 2014	6-7	Vallès (2015)
Guadeloupe	1090	2008	400	Guyader et al. (2011)
Martinique	311	2009; 2010	12	Reynal et al. (2011)
Dominica	91	1994-2014	Multiple	Defoe (2020)[1]

[1-]Note that estimates for Dominica might include some offshore fishing of large pelagics without using MFADs

It is important to provide a regional perspective of the contribution of MFAD landings to total reported landings (all fishery types combined). In that regard, it is informative to use data from the Dominican Republic as reference, since this is likely the largest single contributor to MFAD landings in the region (Table 4 and 5) and the data available are likely to mainly reflect MFAD fishing (Arocha 2019). Data over the 2015-2019 period indicate a relatively small contribution to total reported landings with an estimate of 2.8% when all species are combined (Table 4). However, there is considerable variability in such contributions when data are broken down by target species, with landings of several important tuna species (yellowfin, skipjack, blackfin) accounting for very small fractions of total landings (<2%; Table 4) whereas other species such as blue marlin and cero accounted for large contributions (≥19.5%; Table 4), highlighting the importance of species-specific monitoring and perspective.

There is also a pervasive lack of data across the region on fishing effort on MFADs (e.g. fishing trips) as well as landings per fishing trip. In Guadeloupe, Guyader et al. (2013) most recently estimated 12,000 fishing trips to MFADs in 2008 for yields of approximately 100 kg per fishing trip. In Martinique, Reynal et al. (2015) more recently estimated a yearly number of fishing trips of 6,500 between 2009 and 2012 with a drop to about 4,350 trips in 2013, with yields varying between 55 kg and 85 kg per fishing trip. In Dominica, Sidman et al. (2014) found that yields per fishing trip varied between 56 kg and 118 kg during a short-term study in 2012. More recently in Dominica, Defoe (2020) used historical landing records between 1994 and 2014 to estimate between 2,000 and 5,000 yearly trips to MFADs and between 7 kg and 39 kg (average: 23 kg) of fish landed per fishing trip, although such estimates might include some non-MFAD fishing of large pelagics. In south Haiti, a short-term (two-week) study in 2015 estimated landings per fishing of 18 kg (Vallès 2015), whereas a longer-term (2007-2014) study found a median estimate of 29 kg per fishing trip (Vallès 2018). Data on total number of fishing trips to MFADs in Haiti were not available (Vallès 2018).

The above studies highlight that yields per fishing trip to MFADs can differ considerably across the region. Interestingly, the MFAD Survey found that most locations reported yields per fishing trip exceeding 76 kg, but a few locations did report values less than 50 kg (Appendix II), capturing the full range of values provided by the above studies. However, the limited geographic range and number of studies with published MFAD landing data still precludes a rigorous regional analysis of fishing efficiency on MFADs. Such analysis will also require more precise information on MFAD numbers and location as well as on total fishing effort on individual MFADs. For example, Sidman et al. (2014) found that yields per fishing trip halved with the doubling of the number of boats using the same MFAD (from 2 to 4 boats). Similarly, Reynal et al. (2015) found that catches per fishing trip on MFADs deployed away from the coast (>24 nautical miles) were three times higher than on MFADs close to the coast (<12 nautical miles), partly because fewer fishers exploited the distant MFADs (3-8 vessels per MFAD close to the coast vs 2-6 further away). Thus, estimates of MFAD density and of the degree of MFAD fisher concentration on MFADs are needed to adequately assess drivers of fishing efficiency on MFADs. In that regard, the MFAD Survey indicated that in one third of locations MFADs were often being simultaneously used by more than five fishing vessels (Appendix II), suggesting a potential dilution of individual fishing yields per boat.

8.11. Socio-economic aspects of the MFAD fishery

In terms of age demographics, in the context of a JICA/CARIFICO project, Montes et al. (2019) interviewed 316 fishers across five countries (St Kitts and Nevis, Grenada, St Lucia, Dominica, St Vincent and the Grenadines) with significant MFAD fisheries and found that their ages spanned a wide range (from late teens to early 70s), with an overall average of 41 years. In terms of basic education, the vast majority of fishers had either primary or secondary education, although the extent to which fishers had completed secondary education differing across countries (Montes et al. 2017). Interestingly, Montes et al. (2019) also found that recent MFAD fishers tended to be younger and more educated (i.e. a higher proportion with secondary education) than long-time MFAD fishers and non-MFAD users, suggesting that the MFAD fishery is attracting new younger and more educated fishers rather than converting other fishers to MFAD fishing (Montes et al. 2019). Similarly, Guyader et al. (2013) and Mathieu et al. (2014) found that fishers investing in MFAD fishing in Guadeloupe tended to be younger. The MFAD Survey aligned with these findings, with most frequently cited age groups for MFAD fishers across the region ranging between 30 and 50 years old and evidence that in one quarter of locations MFAD fishers appeared to be younger (Appendix II). This is relevant because the younger and more educated fishers are more likely to integrate Information and Communication Technology (ICT) systems into their business and marketing activities and early warning programs for hazards (Khan et al. 2019), which is desirable in all fronts.

Data on the socio-economic dimension of the MFAD fishery and on its performance relative to other types of fishing are lacking (CRFM 2015a). In the context of the aforementioned JICA/CARIFICO project, Montes et al. (2019) compared the perceived and self-reported livelihood assets (natural, physical, financial, social and human) among fishers who did not use MFADs and those who were long-time (<6 years) and recent (1-5 years) MFAD users. Overall, fishers who used MFADs reported higher levels for all livelihood assets than those who did not (Fig 10), supporting that MFAD fishing improves fisher livelihoods.

In Guadeloupe, Guyader et al. (2013) provided the most detailed comparative economic analysis to date of MFAD fishing and other types of fishing; they found that MFAD yielded higher economic performance than coastal fishing, provided that trip duration (much longer for MFAD fishing) was not seen as an opportunity cost (Figure 11 a, b). They pointed out to the role of increases in state aid available to MFAD fishers (via vessel subsidies), which might have contributed to promote the growth of the MFAD fishery (Guyader et al. 2013). They also argued that current MFAD fishing strategies (visitation of multiple distant MFADs in a trip) and high, unregulated, private MFAD numbers likely lower the economic performance of the fishery in Guadeloupe (Guyader et al. 2013).

In southeast Haiti, where there are very few opportunity costs for fishers, daily fishing trips on MFADs yield higher median profits than most types of coastal fishing (Fig 11 c), and this was particularly the case when MFADs were close to the landing sites (Vallès 2018). However, this remains a system where capital costs (vessels, MFAD units, gear, engines) have been heavily subsided by aid projects (Macías 2014) and remain to be integrated into the economic analysis. There is thus urgent need for cost-benefit studies of the MFAD fishery that comprehensively take into account local socio-economic contexts.

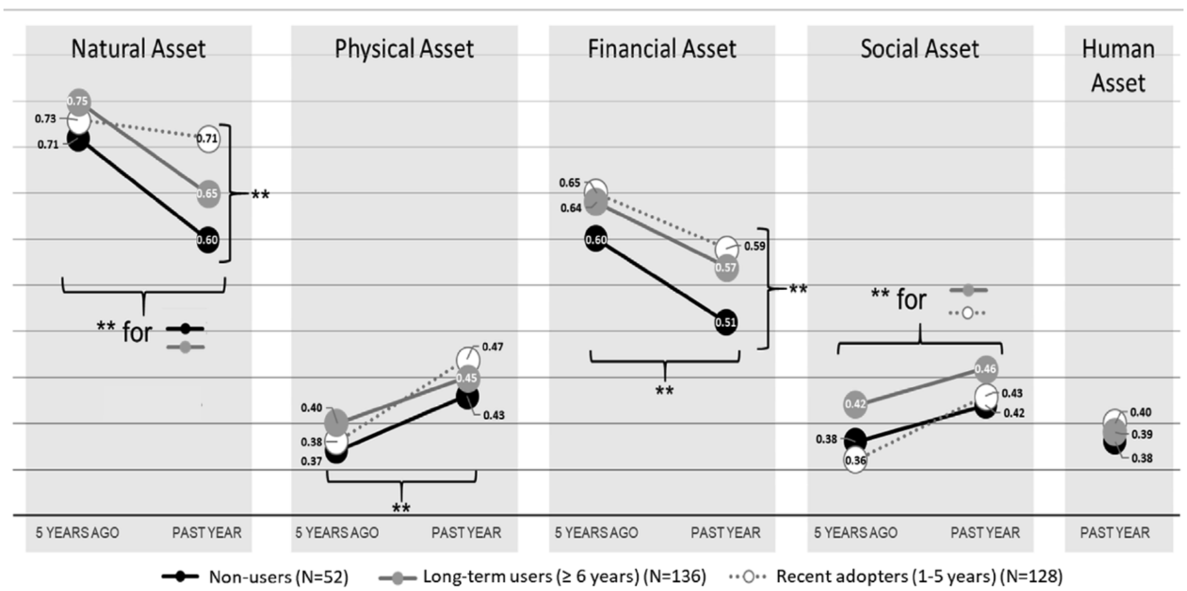

Figure 10 - Livelihood asset mean scores (natural, physical, financial, social, human) of non-MFAD users, long-term MFAD users, and recent MFAD users and across five English-speaking countries in the Caribbean over two time periods (5-years ago vs past year). Taken from Montes et al. (2019).

The MFAD Survey supported that socio-economic context differed markedly across locations in the region in ways that could affect the economic performance of the MFAD fishery, including the proportion of MFAD fishers that (1) are full-time fishers, (2) have jobs outside fishing, (3) practice other types of fishing, (4) own their own boats, (5) have access to credit lines, (6) are subsidized by government, (7) are trained in small business management, and (8) have access to training on MFAD use (Figure 12). With regard to the latter, in the context of the five-country JICA/CARIFICO project, Montes et al. (2017) highlighted that less than half of the fishers interviewed had participated in any type of training, although there were marked differences again among countries (Figure 13).

Overall, these findings combined point to considerable differences across the region in socioeconomic contexts within which the MFAD fisheries operate. This likely helps explain differences across locations in the extent to which the MFAD fishery has developed over time (Mathieu et al. 2014).

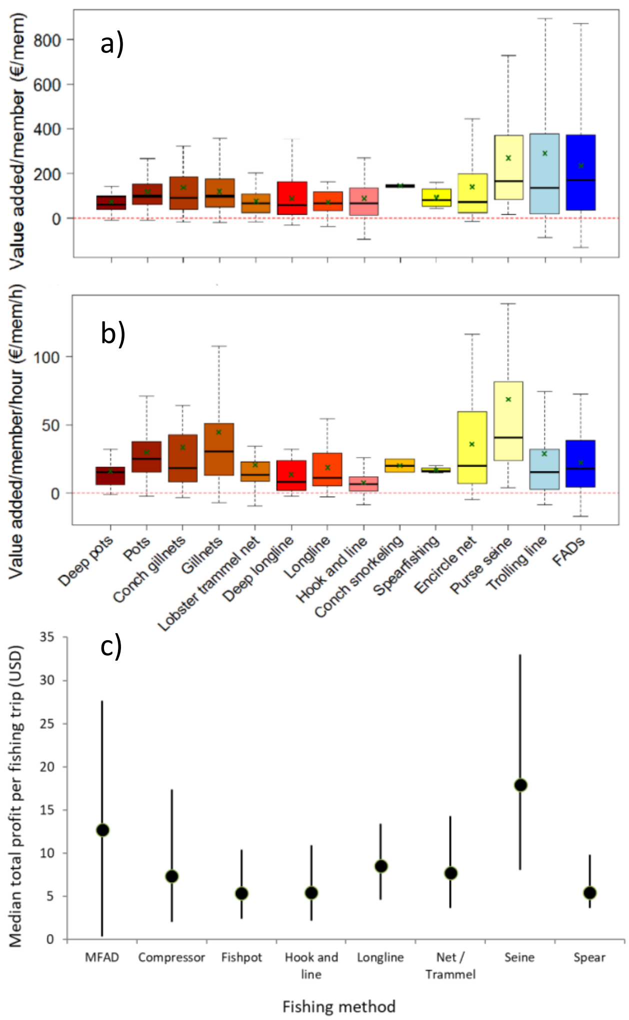

Figure 11. Comparison of fishing trip economic performance between MFAD fishing and other types of fishing in (a and c) Guadeloupe (in Euros) for each crew member (a) before and (b) after accounting for time spent at sea and in (c) southeast Haiti (USD) for a fishing trip (but not accounting for crew size or time spent at sea). Data for Guadeloupe

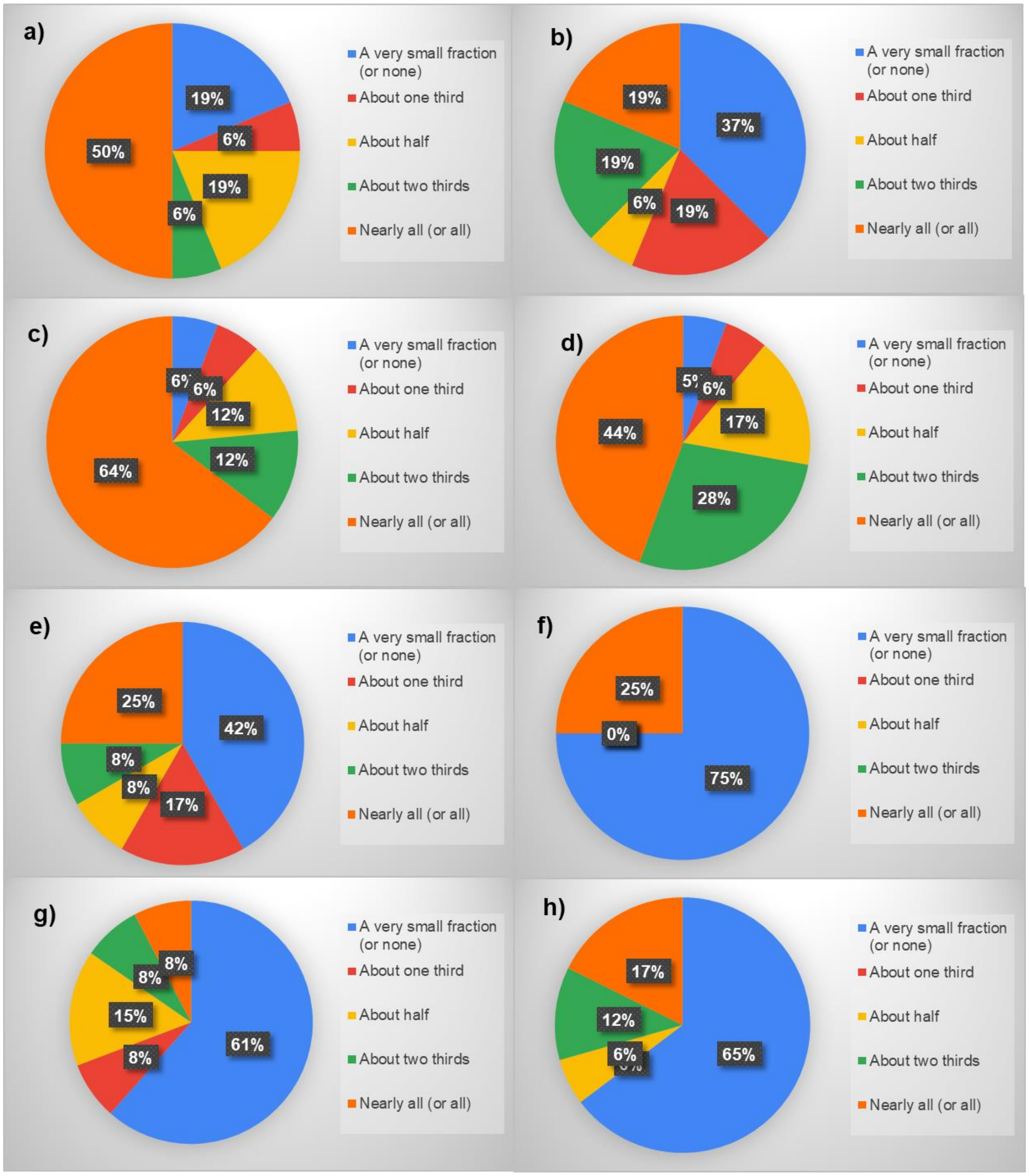

Figure 12 – Frequency of responses across 20 territories/countries quantifying the proportion of MFAD fishers that a) are full time fishers, b) also have jobs outside fishing, c) also practice other types of fishing, d) own their own boats, e) have easy access to credit lines, f) are subsidized in any way by government or non-government entities, g) are trained in small business management, and h) have access to training on MFAD use.

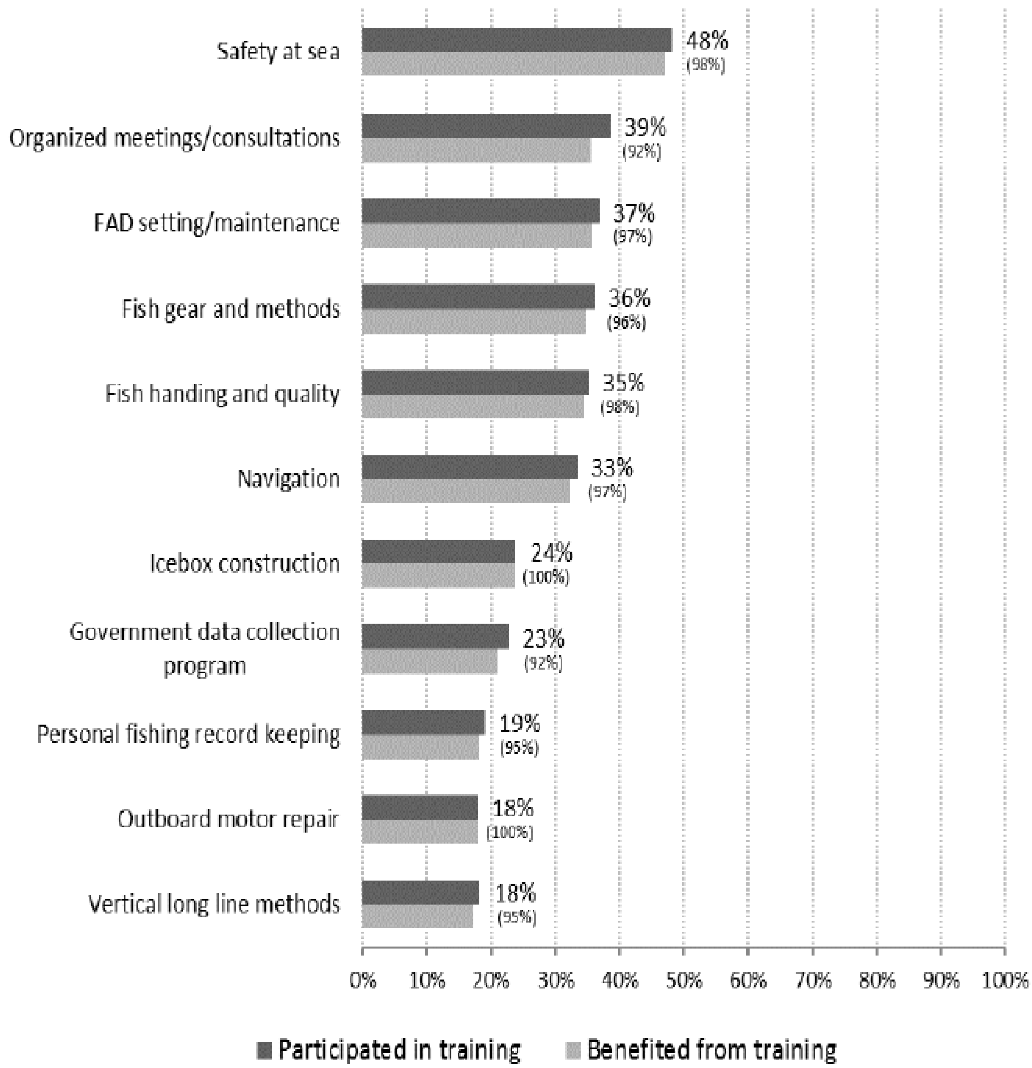

Figure 13. Percentage of fishers across five English-speaking countries that have received training in various topics concerning marine fishing and percentage of fishers how felt they benefitted from such training. Taken from Montes et al. (2017)

8.12. MFAD management systems

8.12.1. Private versus public MFADs

As pointed out in the CRFM (2015a) sub-regional plan, the introduction of MFADs at a given location usually is done via the implementation of short-term fishery development projects funded by government or non-governmental agencies (See Table 9 in CRFM 2015a) and typically involve the deployment of public MFADs that tend to align with best practices in MFAD design and are consequently relatively expensive to maintain in the long-term even with government support. The general expectation is therefore that the revenues generated by the MFAD fishery will ultimately contribute to support the maintenance and replacement of these public MFADs when the projects' funding runs out. However, it has been notoriously difficult to create a sustainable funding scheme relying on fisher contributions to maintain public MFADs across the region (e.g. Defoe 2020). Instead, once the fishery is locally adopted, fishers will prefer to invest in their own private MFADs, either individually or by forming groups to fund private collective MFADs. Private MFADs are often suboptimal from a design perspective but are also much cheaper and easier to replace and deploy than public MFADs, which gives fishers greater ability to track the abundance of pelagic resources; importantly, they are also less likely to be detected and thus used by other fishers, which leads to higher revenue for the owners, but also to more frequent conflicts with non-owner users of the MFADs. Table 6 provides a comprehensive summary of the diverse implications of having public versus private MFADs for the management of the fishery as documented in the CRFM (2015a) sub-regional plan.

As shown in Table 1, the extent to which the MFADs deployed at a given location can be considered private versus public differs markedly across the region. Across 25 locations for which information on the number of private and public MFADs was available, 28% of these locations only had public MFADs (e.g. Barbados), 40% only had private MFADs (e.g. Tobago), and the 32% remainder of locations had both MFAD types (e.g. Antigua and Barbuda) (Table 1). However, in terms of absolute MFAD numbers deployed across the region, the vast majority (97%) are private MFADs (Table 1).

The MFAD Survey also revealed that in most locations (57%) where private MFADs existed, these were owned by individual fishers, whereas only in about one third of locations (29%) private MFADs were collectively owned by groups of fishers. In the few remainder locations (14%) private MFADs could be owned by individual fishers or groups of fishers. Among those locations where MFADs could be owned by individual fishers, two locations (Guadeloupe and the Dominican Republic) reported 11-15 MFADs per fishers, followed by Anguilla with 6-10 MFADs, Saba with 2-5 MFADs, and Dominica, Antigua & Barbuda and Martinique with only 1 MFAD per fisher.

Table 6. Relative comparison between public (funded by government or non-government agencies for collective and inclusive use) and individual private (funded by an individual fisher for his/her intended exclusive use) MFADs of attributes relevant to the management and economic performance of the MFAD fishery. Attributes for private collective FADs (i.e. owned by a group of fishers) will typically lie somewhere in the middle. Taken (and minimally adapted) from CRFM (2015).

Attributes	Public FAD	Private individual FAD
Benefits and costs	**Benefits shared by all fishers; minimal costs to fishers**	**Costs and benefits borne by a single fisher**
FAD design	**Expensive, but highly visible and longer-lived FAD units:** o More regular fishing activity	**Inexpensive, inconspicuous, shorter-lived FAD units:** o More irregular fishing activity due to frequent FAD loss and/or immersion
FAD maintenance	**Highly dependent on public fund availability:** o Low fisher's engagement in FAD maintenance	**FAD maintenance and replacement mainly dependent on fisher's funds:** o High fisher's engagement in FAD maintenance

and replacement	○ Slow replacement time ○ Lower long-term financial sustainability	○ Fast replacement time ○ Higher long-term financial sustainability: self-financing
Ratio of number of FADs to number of fishers	**High number of fishers per FAD unit:** ○ Low overall FAD density in EEZ ○ Low overall yields per fishing trip ○ Fishing gear used must be compatible with presence of other users	**Multiple FAD units per fisher:** ○ High overall FAD density within EEZ ○ Possible dilution of fish aggregating effects ○ Visits to multiple FADs in a fishing trip o High overall yields per fishing trip o Fishing gear used can be incompatible with presence of other users
Distance to shore	**Nearshore deployment (<10 nm):** o High unauthorized recreational fishing on FADs o High safety at sea ○ High vessel and engine size not required ○ Low fuel costs ○ High amounts of coastal pelagics (e.g. blackfin tuna)	**Offshore deployment (>20 nm) and secrecy in deployment:** o Low unauthorized recreational fishing on FADs o Low safety at sea o High engine and vessel size required ○ High fuel costs ○ High amounts of oceanic pelagics (e.g.yellowfin tuna)
Levels of enforcement of regulations	**High levels of regulation enforcement:** ○ Low interference with shipping ○ Low levels of conflicts over FAD use: ▪ Cut-off and entanglement of fishing lines ○ No illegal FAD fishing in foreign waters	**Low levels of regulation enforcement:** ○ High interference with shipping ○ High levels of conflicts over FAD use: ▪ Between FAD owner vs non-owners ▪ Between FAD fishers and other fisheries (e.g. long-lines, recreational) ○ High illegal FAD fishing in foreign waters

8.12.2. MFAD regulation

As pointed out by the CRFM (2015a) sub-regional plan and more recently by Wilson et al. (2020), the proliferation of private MFADs has very likely been favored by a pervasive lack of comprehensive MFAD regulation across the region. Moreover, in those instances where specific pieces of MFAD formal regulation exist (see Table 10 in CRFM 2015a), they appear to be seldom enforced (e.g. Guyader et al. 2017; Montes et al. 2017). There is also evidence that that many fishers might be simply unaware of rules governing public and private MFAD use when such rules exist (Montes et al. 2017), pointing also to a problem of ineffective communication and sensitization within and among stakeholders.

The lack of a comprehensive and well-enforced regulatory framework for MFADs across the region is particularly well illustrated by the findings of the MFAD Survey. Out of 21 aspects of MFAD use that are amenable to regulation, only four aspects had specific pieces of regulation that were enforced in 50% or more of the locations surveyed (Table 7). These four aspects were (1) the requirement to provide catch and effort data, (2) penalties for breaching regulations, (3) rules about how MFADs need to be marked to avoid collisions at sea, and (4) rules about where MFADs can be deployed (Table 7). In contrast, the remainder 14 aspects of MFAD use were not the subject of any regulation or rule in most of the locations (Table 7). Many of these aspects were relevant to the fishery impacts on various components of the ecosystem (e.g. MFAD loss reporting; MFAD materials; seasonal closures; target species/sizes; fishing techniques) (Table 7). Moreover, the MFAD Survey also revealed that only 2 of 20 locations (Grenada and St Lucia) currently had a local MFAD management plan (Appendix II). These results are highly consistent with a recent study highlighting that Caribbean countries differ markedly in the legal provisions surrounding MFAD use (FAO 2016a).

Table 7 – Percentage of respondent territories/countries that fall into one of three categories of rule/regulation on 21 aspects of MFADs and MFAD fishing. The 21 aspects are ranked (from top to bottom of the table) by order of decreasing percentage in the category of regulations and rule that exit and are also enforced.

Rule / regulation	**Regulations or informal rules exist AND enforced**	**Regulations or informal rules exist BUT rarely enforced**	**Regulations or informal rules DO NOT exist**
Requiring provision of catch and effort data	58%	11%	32%
Penalties for breaching rules/regulations	53%	11%	37%
How MFADs need to be marked for boat traffic (e.g. light, radar reflector)	53%	16%	32%
Where MFADs can (or cannot) be deployed	50%	11%	39%
Requiring MFAD registration	47%	26%	26%
Who can set MFADs (and how)	47%	32%	21%
Governing who has priority to fish on MFADs (e.g. MFAD owner; commercial vs recreational fishers)	40%	10%	50%
How to apply for permission to set MFADs	40%	40%	20%
How MFADs need to be marked for ownership tracing (e.g. registration #)	33%	11%	56%
Requiring users to have a MFAD fishing licence	29%	18%	53%
Requiring MFAD loss reporting	28%	0%	72%
The distance from a MFAD subject to the regulation (e.g. 1 km radius)	28%	17%	56%
What fishing techniques are (or are not) allowed (e.g. prohibition of certain gears)	25%	15%	60%
How to fish when multiple boats use same MFAD (e.g. clockwise boat movement)	25%	30%	45%
Prohibition of certain MFAD materials	22%	11%	67%
Which fish species/sizes can (or cannot) be targeted	20%	10%	70%
Informing the general public about MFAD location (e.g. press release)	17%	22%	61%
When is fishing allowed (e.g. night vs day fishing; seasonal closures)	5%	0%	95%
Standards for MFAD buoy volume and mooring weight	5%	5%	89%
Minimum distance between MFADs	5%	5%	89%
Maximum MFAD densities allowed	5%	5%	89%

8.12.3. Conflicts on MFADs

A lack of adequately enforced regulatory framework should increase the likelihood of conflicts among MFAD users, which has been an aspect of the MFAD fishery that has attracted particular attention (Gentner et al. 2018; Guyader et al. 2018; Sadusky et al. 2018; Defoe 2020; Wilson et al. 2020). Interestingly, the MFAD Survey suggested that conflicts among MFAD users and acts of vandalism involving MFADs were infrequent across most locations in the region (from once a year or less to a few times a year). Nonetheless, a few locations such as Guadeloupe and Dominica, did report considerably higher frequencies, with conflicts occurring on a weekly basis (Appendix II). In the absence of actual data, these results should be interpreted with caution as conflict frequency estimates will depend on several factors that are likely to vary across the region, including the number MFAD fishers and the likelihood of conflict reporting. That said, the survey did reveal that, when conflicts took place, they were mainly driven by local fishers using MFADs that they did not own or by interference between commercial and recreational fishers on MFADs, which are two well-established reasons (Angelelli and Reynal 2007; Ramdine 2007; Gentner et al. 2018; Guyader et al. 2018). These local conflicts are generally settled among fishers, particularly in the case of private MFADs as these are often note adequately reported to the local authorities; such conflicts do not generally result in violence, but in some instances they can lead to theft or acts of vandalism on fishing gear or MFADs (Ramdine 2007). More instructive is perhaps that half the locations participating in the MFAD Survey reported that foreign fishers from nearby islands illegally set MFADs on their local waters or illegally fished on local MFADs, supporting that IUU fishing involving MFADs is widespread across the region (Appendix II).

8.12.4. MFAD monitoring

The baseline Study on the Formulation of a Master Plan for Sustainable Use for Fisheries Resources for the Coastal Community Development in the Caribbean (CRFM/JICA 2012), which included 13 CARICOM countries, identified the generation and handling of fisheries statistics as an issue that needed much improvement across the Caribbean region. This study also recognized that the fishery statistical systems at that time differed markedly across the region in development and implementation and underscored the need for a regional database for the region (CRFM/JICA 2012).

Follow-up work recognized the need to (1) distinguish data from fishing trips to MFADs from other fishing activities during data collection, (2) to align minimum data requirements with those of ICATT's Recommendations on a Multi-annual Conservation and Management Program for Bigeye and Yellowfin tunas and in relation to ICCAT's Guidelines for Preparation of FAD management plans, and (3) to standardize data requirements and collection methods as much as possible across locations (Barnwell 2014; Mohammed and Masters 2014; Masters and Mohammed 2015; Mohammed 2015; Mohammed and Masters 2015). Such efforts culminated with the development of a MFAD logbook by the CRFM that is yet to be adopted by the different countries (CRFM 2015b). More recently, it has been recommended that such standardization across the region aligns as much as possible with the WECAFC Data Collection Reference Framework (WECAFC 2019a; WECAFC 2019b)

However, the MFAD Survey supports that considerable differences still exist among locations in the implementation of fishery statistical systems. For example, one quarter of the locations surveyed did not systematically collect fishery data. The rest of locations did have active fishery data collection systems involving the use of standardized data collection forms and nearly all these locations explicitly distinguished landings from MFAD fishing from non-MFAD fishing.

Table 8 summarizes the types of data currently collected across locations with systematic fishery data collection systems involving MFADs. More than ¾ of locations collect data on (1) time spent fishing, (2) number of fishers on boat, (3) fishing techniques used, (4) total weight landed, and (5) total weight landed by species (Table 8). In contrast, only half of these locations provided data on the number of fishing lines used, an important metric to refine fishing effort (Table 8). Even fewer locations recorded the location/identity of the MFAD used or fuel consumption expenses, which are necessary to understand potential variability in profits from MFAD use (Table 8). Because MFADs facilitate the exploitation of shared stocks across the region, more efforts are needed towards standardization of data requirements to facilitate regional data integration.

Table 8. Percentage of territories/countries (out of 15) that collect data on 12 variables from fishing trips to MFADs

Variable	Yes	Some times	No
MFAD ID or location	38%	23%	38%
Time spent fishing	87%	13%	0%
Time spent travelling	43%	14%	43%
Number of fishers on boat	87%	7%	7%
Fishing techniques used	93%	7%	0%
Number of fishing lines in the water	50%	17%	33%
Total weight landed	93%	7%	0%
Weight landed by species	86%	14%	0%
Fuel consumption and other expenses	36%	29%	36%
Estimate of revenue from sale	64%	7%	29%
Number of fish landed	47%	27%	27%
Number of fish landed by species	47%	33%	20%

8.12.5. MFAD co-management

It is now widely recognized that effective management of the MFAD fishery in most locations across the region will require more sharing of responsibilities between government and fishers (FAO 2002b). Although the actual nature of such arrangements remains to be resolved, to be truly effective it will likely have to go well beyond being simply instructing or consulting fishers, to actively include the fishers and other fishery stakeholders in the decision making (cooperative, advisory, informative models) (Sen and Raakjaer Nielsen 1996).

Defoe (2020) describes efforts in developing a co-management strategy for the MFAD fishery in Dominica. There, the rapid development of the MFAD fishery in the 1990's and early 2000's prompted a series of national consultations between the Fisheries Division and fishery stakeholders to improve management of the MFAD fishery. The formation of the National Association of Fisherfolk Cooperatives (NAFCOOP) in 2008, the umbrella association regrouping all registered fisher cooperatives in the island, provided an unprecedented opportunity to initiate a process of formal collaboration with MFAD fisher groups towards improved management. The proposed arrangement sought to hand over to NAFCOOP authority for the construction, deployment, maintenance, and fee collection of public MFADs. This arrangement was facilitated under The Fisheries Act no11 of 1987 (18), which makes provision for a fisher association to undertake functions aimed at managing local fisheries. The Fisheries Division and NAFCOOP also initiated a process of national consultations with stakeholders and legal experts to draft regulations for the MFAD fishery. In 2011 the draft MFAD fishery regulations were submitted for formal adoption into law, which is yet to be achieved. At that time, a MFAD fishery management initiative including deployment of public MFADs and advocated voluntary compliance of fishers with the draft regulations was initiated. Defoe (2020) states that this initiative, which relied on voluntary compliance, received little fisher support overall. Nonetheless, Defoe (2020) points out that such efforts did help tangibly reduce MFAD user conflicts.

In 2008, the Secretariats of CRFM, CARICOM and JICA, signed the implementation of The Study on the Formulation of a Master Plan for Sustainable Use for Fisheries Resources for the Coastal Community Development in the Caribbean (CRFM/JICA 2012). This study covered 13 CARICOM countries and aimed to offer options for "*a comprehensive resource management approach in the Caribbean region that may include limited entry to coastal fisheries, diversification of the fisheries, and the promotion of the optimal* *use of fisheries resources with cooperation between government and communities*". This study led to the execution of a pilot project on the MFAD fishery in two countries, St Lucia and Dominica, with the aim of (1) improving the capacity of fisheries officers and fishers' organizations to manage pelagic resources exploited using MFADs and, (2) increasing the productivity of the MFAD fishery by developing skills and capacity to utilize pelagic resources. This pilot project focused primarily on technical aspects of MFAD design, construction, deployment, and maintenance as well as on a co-management approach to such fisheries in which fishers were expected to increase their participation in decision making but also share a greater responsibility in the provision of fisheries data.

Based on the experience of the MFAD pilot project component of the Master Plan Study, the 5-year Caribbean Fisheries Co-Management (CARIFICO) Project followed up in 2013. It aimed to further develop a co-management approach to MFAD fisheries for each participating country. This project expanded to include five countries with MFAD fisheries, Antigua and Barbuda, St Kitts and Nevis, Dominica, St Lucia, St Vincent and the Grenadines and Grenada. A key co-management output of this project was the development of a logbook system to be filled by fishers, as part of their responsibility to help monitor the MFAD fishery. At the time small groups of fishers in several beneficiary countries were participating voluntarily into data collection using these logbooks through the CARIFICO project.

In Dominica, with the Fisheries Division and NAFCOOP as partners, the CARIFICO project also aimed at helping transition the MFAD fishery from an open-access fishery to a restricted-access one governed by regulations and requiring the purchase of a license fee (Defoe 2020). This fee was also meant to provide the necessary funding to allow NAFCOOP to maintain and replace public MFADs, of which many were also deployed under the CARIFICO project with the collaboration of fishers. However, the licensing scheme continued to receive little voluntary support from fishers in spite of frequent consultations and public awareness campaigns, highlighting the difficulties of obtaining the buy-in from fishers in the absence of formal legislation (Defoe 2020). Thus, to a large degree, the lack of legal recognition of NAFCOOP as the national authority governing MFAD use has prevented it from securing adequate funding to strengthen institutionally and carry out its mandate in Dominica (Defoe 2020).

These recent experiences in co-management in the region have left a wealth of information and undoubtedly provided valuable lessons for future co-management efforts (CRFM/JICA 2011; CRFM 2012c; CRFM 2012b; CRFM 2012a; CRFM/JICA 2012; CRFM 2013e; CRFM 2013b; CRFM 2014b; Sidman et al. 2014; Sidman et al. 2015; CRFM 2017; Montes et al. 2017; Tamura et al. 2018; Montes et al. 2019; Defoe 2020). They have also likely contributed to guide the way forward. For example, in Greenville, Grenada, a local MFAD organization collects a levy per weight of fish landed to maintain a network of five MFADs and also enforces MFAD ownership via an internal licensing system and data collection; this provides a model of MFAD fishery co-management system based on community-owned rights (private collective MFADs) that could be refined locally (CRFM 2014b; Gentner et al. 2018) and perhaps exported elsewhere.

In the absence of effective dialogue between fishers and government authorities and in the presence of a system that remains open access in practice, the scenario that seems to emerge is that of a MFAD fishery based on the establishment of informal individual exclusive territorial-use rights around historical use of MFADs, as is the case of Guadeloupe (Guyader et al. 2018; Bugeja Said et al. 2021) (Fig 14) and the Dominican Republic (Gentner et al. 2018). Such scenario seems effective in limiting access to other fishers but raises serious issues about fairness and equity, leads to conflicts with those that challenge the informal system, and ultimately does not preclude the deployment of large numbers of MFADs in the race for fish (Gentner et al. 2018; Guyader et al. 2018; Bugeja Said et al. 2021).

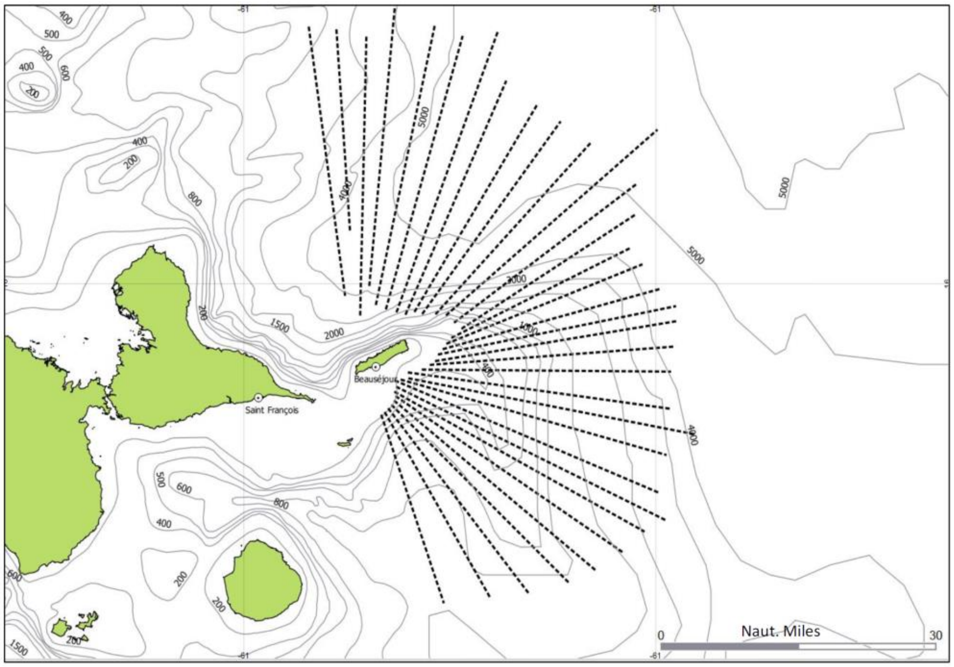

Figure 14. Informal territories of MFAD fishers in the Island of La Désirade (Guadeloupe) in 2014. Each line represents a fishing territory belonging to a MFAD fisher, with multiple MDAs deployed along the line.

9. Exploitation status of stocks

Arocha (2021) provides a summary of stock exploitation status and associated fisheries for large oceanic and coastal pelagic species typically caught on MFADs across the wider Caribbean region. A list of the species of interest and most recent stock assessments is given in Table 9. Following Arocha (2021), these species are divided into four groups, namely major tunas, small tunas, tuna-like species, and large pelagics. Additional information on stock exploitation status, management advice, biology, distribution and fisheries for these species based on Carpenter (2002) and Arocha (2021) is given in Appendix III.

Based on the most recent stock assessments for the four major tunas, namely yellowfin tuna, skipjack, bigeye tuna and albacore, only the stock assessment of bigeye tuna indicated that this stock was overfished but not undergoing overfishing (Table 9; Appendix III). The stock assessments for the other three species concluded that they were not overfished and not undergoing overfishing (Table 9; Appendix III).

It is worth pointing out that recommended management measures for bigeye tuna (and yellowfin) apply exclusively to semi-industrial and industrial fishing operations using large vessels (≥20 m long), which include purse-seine boats and bait-boats making use of drifting FADs (ICCAT 2020b). These measures do not directly apply to the small (<9 m long) vessels making use of MFADs in the Caribbean region. However, it is important that the region aligns, to the extent that it is practically possible, with ICCAT recommendations of improving the monitoring of catches on MFADs and developing and implementing MFAD fishery management plans (CRFM 2015a). Moreover, targeting juvenile tuna on MFADs for commercial purposes raises legitimate concerns about potential negative impacts on stocks; these same concerns are expressed in ICCAT 19-02 Recommendation. Further development of the fishery in the region should thus give this issue due consideration and, in addition to ensure adequate monitoring, it should seek to minimize such effects to the extent that it is possible under a precautionary approach.

In 2016, an Ecological Risk Assessment (ERA) was applied to a several small tunas from the north Atlantic by the SCRS-Small Tunas Group, which included blackfin tuna, little tunny, frigate tuna, bullet tuna, and Atlantic bonito. These species have historically been neglected in stock assessments, despite their importance for the small-scale fisheries of the region (Pons et al. 2019b). The ERA concluded that blackfin tuna had the highest risk of overfishing of the group (Table 9; Appendix III). However, qualitative evaluation of landing data from four Caribbean islands in 2012 by the CRFM's Working Group in Large Pelagics found no evidence of stock depletion or this species (Tietze and Singh-Renton 2012). The ERA also concluded that bullet tuna and Atlantic bonito had low risk of overfishing, whereas frigate tuna and little tunny had moderate risk of overfishing (Table 9; Appendix III). However, for little tunny, a more recent assessment in 2019 for the northwest Atlantic supported that the stock was not overfished (Pons et al. 2019b).

In relation to the tuna-like species, recent stock assessments warrant particular concern for three species: blue marlin, Atlantic white marlin, and wahoo. For blue marlin, the 2018 full stock assessment concluded that the Atlantic stock was overfished and undergoing overfishing, whereas for Atlantic white marlin, the 2019 full stock assessment concluded that the stock was overfished but not undergoing overfishing (Table 9; Appendix III). For wahoo, a 2019 stock assessment in the northwest Atlantic supported that the stock was overfished (Table 9; Appendix III).

In contrast, the 2017 stock assessment for swordfish in the North Atlantic supported that the stock was not overfished and was not undergoing overfishing (Table 9; Appendix III). For western Atlantic sailfish, the evidence available in 2016 also supported that the stock was unlikely to be overfished or undergoing overfishing, even though stock assessment models at the time could not conclude on stock status due to large uncertainty (Table 9; Appendix III)(Arocha 2021). For common dolphinfish, the most recent stock assessment was conducted in 2010 and found no evidence of stock declines at the time (Table 9; Appendix III). No assessments have been conducted for spearfishes as individual species (Table 9; Appendix III).

An Ecological Risk Analysis (ERA) for the species caught by longline and purse seine fisheries in the north Atlantic, which included king mackerel, Atlantic Spanish mackerel, serra Spanish mackerel and cero, was conducted in 2016 and showed marked differences among these *Scomberomorus* species. The assessment concluded that king mackerel and Atlantic Spanish mackerel exhibited high risk of being overfished, whereas cero and serra Spanish mackerel showed low and moderate risk of being overfished, respectively (Table 9; Appendix III). However, for the stock units of king mackerel and Atlantic Spanish mackerel that are managed by the US in the Gulf of Mexico and southeastern USA, the most recent assessments (2013 and 2014) indicated that these stocks were not overfished and not undergoing overfishing (see references in Arocha 2021).

Table 9. Most recent ICCAT (or ICCAT affiliated or CRFM) stock exploitation status assessments for major tunas, small tunas, tuna-like species, and large pelagics typically captured using MFADs. Adapted from Arocha (2021).

Common name	**Scientific name**	**Stock unit**	**ICCAT (or CRFM)**			
			Assessment Year	**Overfished**	**Overfishing**	**Ref.**
Major tunas						
Yellowfin tuna	*Thunnus albacares*	Atlantic	2019	NO	NO	ICCAT (2020c)
Skipjack tuna	*Katsuwonus pelamis*	West Atlantic	2014	NO	NO	ICCAT (2015)
Albacore	*Thunnus alalunga*	North Atlantic	2020	NO	NO	ICCAT (2021a)
Bigeye tuna	*Thunnus obesus*	Atlantic	2021	YES	NO	ICCAT (2021b)
Small tunas						
Blackfin tuna	*Thunnus atlanticus*	North Atlantic	2016	-	Vulnerability : High	ICCAT (2017b)
Little tunny	*Euthynnus alletteratus*	NW Atlantic	2016/2019	NO	Vulnerability : Moderate	ICCAT (2017b) Pons et al. (2019b)
Frigate tuna	*Auxis thazard*	NW Atlantic	2016	-	Vulnerability : Moderate	ICCAT (2017b)
Bullet tuna	*Auxis rochei*	NW Atlantic	2016	-	Vulnerability : Low	ICCAT (2017b)
Atlantic bonito	*Sarda sarda*	NW Atlantic	2016	-	Vulnerability : Low	ICCAT (2017b)
Tuna-like species						
Swordfish	*Xiphias gladius*	North Atlantic	2017	NO	NO	ICCAT (2020c)
Atlantic sailfish	*Istiophorus albicans*	West Atlantic	2016	Not likely	Not likely	ICCAT (2017a)
Blue Marlin	*Makaira nigricans*	Atlantic	2018	YES	YES	ICCAT (2019)
Atlantic white marlin	*Tetrapturus albidus*	Atlantic	2019	YES	NO	ICCAT (2019)
Longbill spearfish	*Tetrapturus pfluegeri*	West Atlantic	Not assessed	-	-	-
Roundscale spearfish	*Tetrapturus georgii*	Not defined	Not assessed	-	-	-
Common dolphinfish	*Coryphaena hippurus*	NW Atlantic	2010	No evidence to suggest stock is declining		CRFM (2010)
Wahoo	*Acanthocybium solandri*	NW Atlantic	2019	YES	-	Pons et al. (2019a) Pons et al. (2019b)
Large pelagics						
King mackerel	*Scomberomorus cavalla*	North Atlantic	2016	-	Vulnerability: High	ICCAT (2017b)
Atlantic Spanish mackerel	*Scomberomorus maculatus*	North Atlantic	2016	-	Vulnerability: High	ICCAT (2017b)
Serra Spanish mackerel	*Scomberomorus brasiliensis*	North Atlantic	2016	-	Vulnerability: Moderate	ICCAT (2017b)
Cero	*Scomberomorus regalis*	North Atlantic	2016	-	Vulnerability: Low	ICCAT (2017b)

10.Challenges of the MFAD fishery

The challenges to the MFAD fishery identified by the CRFM (2015a) plan remain highly relevant for the Wider Caribbean region and are therefore revisited and described in Table 10. Moreover, during the MFAD Survey, key informants were asked to score these challenges based on their severity and the urgency with which they felt they needed to be addressed in their respective locations using a scale of 1 (very low priority) to 4 (high priority) (Tables 11 to 14). Issues with high scores are here interpreted as those that are largely shared across many locations in the region, whereas issues with low scores will be those that are particularly important in some locations, but not so much in others. As in the CRFM (2015a) subregional plan, these challenges are allocated into four broad categories, namely governance, socio-economic, biological, and ecosystem (Table 10).

Table 10 – List of challenges of the MFAD fishery in the WECAFC region

Area	Challenge	Description	Consequences
Governance	Inexistent/inadequate local capacity to enforce regulations	Even when regulations exist, they tend to be rarely enforced by the relevant authorities due to limited human resources and low prioritization of MFAD-related issues (see Section 2.12.2)	Lack of penalties for those who breach regulations discourages compliance by the rest of stakeholders
	Weak organization of MFAD fisher groups	Limited organization of fishers in groups, cooperatives, or associations. When such groups exist, they might not be cohesive enough nor sufficiently well trained nor funded to be capable of effectively representing their collective interests. Whatever fisher organizational structure is best suited for the local context, it will still require strong leadership and substantial investment in capacity building in local governance to effectively defend fishers' collective interests.	Any attempt to successfully co-manage the MFAD fishery, including setting regulations and ensuring compliance, will require active participation of MFAD fishers in the process. Weak organization of fishers in groups will preclude an effective integration and participation of fishers and other stakeholders in decision making, which is critical for the development of local management plans and any other co-management arrangement.
	Inexistent or poor data collection systems	Several countries do not have data collection systems in place to monitor fishing trips on MFADs. Of the countries that do have data collection systems in place: • Few capture data on all relevant aspects of economic performance of MFADs (e.g. fuel costs) (See Section 2.12.4); • Few capture refined data on fishing effort (e.g. number of fishing lines) (See Section 2.12.4) and in some cases landing data might not be disaggregated by species (Barnwell 2014; Mohammed 2015; Arocha 2019); • Few locations engage in systematic collection of biological data of target species (individual fish length and weight frequencies, maturity stage, gonad weight) (Barnwell 2014; Mohammed 2015; Arocha 2019).	Socio-economic consequences: MFAD fishing can result in quite variable fishing yields, high fuel costs, and dilution of fishing yields due to multiple fishers using the same MFADs (See Socio-Economic aspects of MFADs section). Lack of economic data on MFAD fishing trips precludes assessing whether MFAD programs will be profitable enough to tangibly benefit fishers while ensuring maintenance, repairs and replacement of MFADs in the long-term. Biological consequences: Lack of accurate catch and effort and biological data precludes adequately assessing the impact of the MFAD fishery on stocks, which threatens the sustainability of the fishery.

	Inexistent/inadequate local MFAD management plans	Very few locations have local management plans for the MFAD fishery (see Section 2.12.2). These plans are necessary to establish rules and/or codes of conduct agreed upon by the key stakeholders as well as to clarify the rights and responsibilities of each stakeholder group within the fishery. Moreover, it is important that, to the extent that it is possible, local management plans are harmonized across the region and aligned with ICCAT recommendations for the management and conservation of tuna and tuna-like species	A lack of local management plans will likely lead to excessive deployment of MFAD numbers, dilution of fishing yields, increases in marine litter due to MFAD losses, increases in user conflicts, lack of control, surveillance and monitoring, and increases in biologically unsustainable fishing practices.
	Inexistent/inadequate local MFAD regulation	Lack of comprehensive regulation for MFAD use; where pieces of regulation exist, they do not consider the biological (e.g. minimum size for target species) or ecosystem (e.g. use of biodegradable materials) dimension of the fishery (See Section 2.12.2) (FAO 2016a). Also, there is a general lack of provisions for area-based user rights approaches such as Territorial User Rights for Fishing (TURFs), which are particularly amenable to MFAD fishing (FAO 2016a; FAO 2016b; Sadusky et al. 2018). Moreover, there is great need to implement systems for MFAD marking that allow identifying the owners when these gest lost; to the extent that it is possible, these systems be should harmonized across the region and align with the Voluntary Guidelines on the Marking of Fishing Gear (FAO 2019).	A legal framework to support development and implementation of local MFAD management plans under an ecosystem-based approach to fisheries is necessary to increase acceptance and compliance of stakeholders. A lack of such framework undermines the legitimacy of any measure.
	Inexistent/inadequate representation in ICCAT	A considerable number of WECAFC countries/territories with significant MFAD fisheries are not contracting parties to ICCAT, including Antigua and Barbuda, Dominica, the Dominican Republic, Haiti, St Kitt and Nevis, St Lucia, and the islands of the Dutch Caribbean (except Curacao).	As stated in CRFM (2011), "… *A main problem is that many countries of the Caribbean, often SIDS, presently take only a small proportion of the catch of species managed by ICCAT. These countries may, by virtue of the size and productivity of their EEZs, be entitled to a larger share, but lack the technical capacity or the financial resources to participate in ICCAT where their case would be made*". This also results in a reduced ability to defend collective interests regarding the exploitation of tuna and tuna-like species in the region.
	Weak governance structure across stakeholder groups	Organizational structures that integrate diverse stakeholder groups from various sectors such Fishery Advisory Councils could facilitate dialogue among stakeholders and oversee the implementation of local management plans (Compton et al. 2017). However, such structures need to be first adequately strengthened and funded and given clear mandates (CRFM 2015a).	The degree of trust and cooperation between government agencies (Fishery Authorities) and fishers is likely to vary across the region. Moreover, the ecosystem-based approach to fisheries requires the participation of a wide range of stakeholders into decision-making. Establishing multi-stakeholder multi-sectoral organizations might be critical to facilitate national dialogue and rebuilding of trust among key stakeholder groups.
	Illegal, Unreported, Unregulated (IUU) fishing	IUU fishing might currently take place across most locations in the region at various levels: • First, several locations do not have fishery data collection systems in place to monitor MFAD landings (Section 2.12.4), so their catches go largely unreported;	IUU fishing precludes adequately assessing the impact of the MFAD fishery on stocks and might lead to quota overruns .

		• Second, even in locations where data are routinely collected, there still might be issues precluding an effective disaggregation of data by species (inadequate data collection forms; problems identifying species) (Arocha 2019); • Third, in many locations the fishery remains open access in practice with little enforcement of existing regulations; • Fourth, the wide use of drifting drop lines with live bait implies that baitfish are commonly captured around MFADs. These captures, which often include small pelagic fishes but also small-bodied or juvenile tuna (Section 2.9), are rarely reported as part of the catch; • Fifth, the MFAD Survey indicated that in half the locations, foreign fishers illegally came to local waters to fish MFADs, supporting that illegal transboundary fishing is widespread (Appendix II). On the other hand, by-catch discards are rare in MFAD fishery across the region.	
	Inexistent/inadequate sharing of info/data on MFADs across region	The lack of harmonization and standardization of data collection systems across locations hinders the ability to share data across the region and thus the ability to meaningfully inform management decisions at the regional scale. In the insular Caribbean, CRFM, IFREMER, JICA and WECAFC have played a particularly important role in facilitating data sharing across member states over the last two decades through various projects, open libraries, ad hoc workshops, and via the WECAFC Working Group of sustainable use of MFADs in the Lesser Antilles (FAO 2002a; FAO 2002b; FAO 2007; CRFM/JICA 2012; CRFM 2013e; CRFM 2013b; CRFM 2013c; CRFM 2013d; CRFM 2014a; CRFM 2014b; CRFM 2015c; CRFM 2017). However, it is widely recognized that there is need for greater integration of data across the region, including the development of a common regional database for CRFM, OSPESCA and WECFAC members. The Caribbean Anchored Fish Aggregating Devices website (CARAFAD)[1] hosted by IFREMER has attempted to fill some of this gap. It hosts the reported position of some MFADs across the region and provides access to a valuable collection of research papers on MFADs. However, it is still are the early stages of development and the MFAD Survey indicated that very few of the key informants surveyed knew of its existence (Appendix II).	Lack of integration and standardization across the region in data collection systems leads to the need for additional resources and processing steps for data integration. Combining datasets obtained using different methodologies, data requirements, and protocols raises uncertainty in regional stock assessments.

[1]https://wwz.ifremer.fr/carafad/FAD-location

	Inexistent/insufficient MFAD fisher participation in decision making	The integration of MFAD fishers into the decision-making process remains a challenge in many locations.	Co-management arrangements are not possible without sufficient fisher participation.
	Transboundary fishing	The MFAD Survey indicated that in half the locations, foreign fishers illegally came to local waters to fish MFADs suggesting that illegal transboundary fishing is widespread (Appendix II).	See IUU fishing
	Uncontrolled/excessive proliferation of MFADs	A lack of policy/regulation setting limits to total MFAD numbers in national waters or setting private MFAD quotas for individual fishers can lead to high densities of private MFADs in the race for fish.	Beyond the legitimate concerns about the impact on fish stocks that increases on MFAD numbers and fishing effort would raise, such increases would also likely lead to the dilution fishing yields, higher fuel consumption when visiting multiple MFADs, higher levels of marine littering as MFADs are increasingly lost and replaced, and escalation of conflicts among fishers due to the diminishing available fishing space.
Socio-economic	High fuel consumption and costs	Visits to multiple MFADs during the same trip and deployment of private MFADs increasingly away from coast to minimize interference with other MFADs or competition with other fishers will increase fuel costs (Guyader et al. 2018). Fuel costs represent the single largest expense during a fishing trip (Doray et al. 2002)	MFAD fishing might not always yield sufficient catches to offset increases in fuel costs, which is generally the biggest trip expense. For example, in southeast Haiti, Vallès (2018) found that economic returns of MFAD fishing at twelve landing sites tended to be higher overall than those of coastal fishing. However, he also found that this effect was largely driven by data from the sites that were closest to the MFADs partly because of lower fuel consumption. Data from the sites that were further away from MFADs did not show any improvement in economic returns when fishing on MFADs and at one of such sites, MFAD fishing resulted in net economic losses (Vallès 2018).
	Inexistent/inadequate fisher training in business management	Higher inherent variability of catches on MFADs and possibly greater capital investment in MFAD fishing (bigger vessels, MFAD materials) and fuel consumption as more MFADs are deployed require careful accounting and analyses of revenue and expenses (e.g. Guyader et al. 2013). Yet, many private MFAD fishers are not adequately trained to conduct such financial tasks (see Section 2.11)	MFAD fishing might be practiced and even promoted in local contexts where it is not cost-beneficial for fishers in the long-term or does not lead to the desired policy outcomes.
	Inexistent/inadequate systems for repair and maintenance of deployed MFADs	Public MFADs are often deployed on an ad hoc basis as funds become available (e.g.. via short-term projects or donations); such funding is rarely integrated into part of the country's national budget expenditure.	This precludes an appropriate development of the MFAD fishery using public MFADs (as it often takes too long to replace them when they get lost) and encourages the multiplication of private MFADs.
	Inadequate commercialization circuits for target species	In most locations, catches from MFADs are destined to domestic short-chain fish markets where large pelagic fish might have lower market value than more traditional coastal or reef species (e.g. Doray and Reynal 2002; Gentner et al. 2018; Vallès 2018) and with limited value addition opportunities and product differentiation.	Low economic returns per unit weight for MFAD fishers compared to other types of fishing.

	Low capacity to replace lost MFADs	Public MFAD funding has historically relied on short-lived projects for initial construction and deployment and on the collection of user fees for their subsequent MFAD maintenance and replacement. MFAD funding is rarely integrated into part of the country's national budget expenditure. Generating sufficient funds from user fees to maintain MFAD programs has been difficult to achieve in practice, in some instances because these depended on fishers' voluntary contributions in the absence of formal regulations (e.g. Defoe 2020).	This precludes an appropriate development of the MFAD fishery using public MFADs (as it often takes too long to replace them when they get lost) and encourages the multiplication of private MFADs.
	Impact of Sargassum on fish abundance around MFADs	The abundance of Sargassum rafts seasonally moving through the Caribbean has dramatically increased since 2011. Sargassum rafts act as natural fish aggregating objects.	High abundance of Sargassum rafts might reduce the abundance of fish aggregating around MFADs, ultimately reducing fishing yields (Monnereau and Oxenford 2017).
	Lack of adequate facilities/infrastructure to handle large pelagics	Large pelagic fish require additional conservation space and special pieces of equipment to be handled (e.g. scales; trollies) in a way that maximizes product quality. Such facilities are lacking in many landing sites across the region (Section 2.7)	This sets a limit to the quality of the landed product, which might be acceptable for local markets. However, this lack of infrastructure needs addressing if the fishery seeks to generate greater revenue by targeting exports or by post-harvest processing to add value and create product differentiation.
	Inadequate MFAD designs for local context	A MFAD design represents a marriage between unit cost and lifespan, whereby bigger costs tend to lead to longer lifespans. Private MFAD fishers, who generally have limited buying power, will prioritize a strategy of minimizing costs, even if this means shorter lifespans (see Section 2.8). There is thus great need to improve MFAD designs to minimize losses while at the same time minimizing costs, which is challenging. The use of sub-surface MFADs is being explored in the region (e.g. St Lucia) as a means of reducing losses. On the other hand, the use of biodegradable MFADs remains largely unexplored.	A strategy of minimizing costs at the expense of lifespan leads to high levels of MFAD losses and replacement thus to high levels of marine littering if the MFAD units are not made of biodegradable materials, which is generally the case in the region. It will also contribute to promote having multiple MFADs deployed at any given time to ensure that at least some are available.
	Lack of safety at sea (MFAD deploying and fishing)	Fishers use small vessels to deploy MFADs and to fish around them. The risk of vessel capsizing increases when the anchoring components are transported and launched using such small vessels. During fishing, limited space on the vessel increases the chances of the fisher getting entangled on an active fishing line. Moreover, bringing large fish into the boat by hand also poses a risk of injury during lifting and handling of the catch. Finally, fishers might deploy MFADs at increasingly greater distances from shore to avoid competition with other fishers, potentially exceeding the statutory operating limits for small vessels.	Death and/or serious injury can occur; loss at sea

	Lack of access of MFAD fishers to training	Widespread lack of training of MFAD fishers on a number of areas relevant to navigation and fishing (Section 2.11).	Reduced safety at sea, suboptimal working conditions, and lower diversity and quality of landed products
	Poorly equipped boats for MFAD fishing	Boats in many locations are equipped with iceboxes, but few are equipped with winches facilitating bringing large fish on board (Section 2.6). In some locations, boats might not be equipped with bait tanks to keep bait alive.	Lack of winches might pose an injury risk while bring large fish on board; lack of iceboxes will the quality of landed products; lack of bait tanks might limit the diversity of target fish and/or increase the time spent fishing for bait on the MFAD.
	Competition with fish imports	Fish imports can lead to a reduction of sale price of fish if the supply exceeds demand (e.g. Mathieu et al. 2014).	Reduction of economic returns per unit weight of fish; difficulty in selling the catch.
	Fluctuating or low prices for target species	Market gluts associated with seasonality of MFAD fishing and markets destined primarily for local consumption.	If large pelagics are destined for the local market, seasonal increases in abundance of fish might lower the value of the catch or preclude its sale (e.g. Diaz et al. 2002).
	Low or highly variable catches on MFADs	Higher inherent variability of catches on MFADs (compared to other types of fishing) due to fish aggregation dynamics on MFADs. For example, Vallès (2016) monitored MFAD landings in south Haiti and found that about ¼ of fishing trips returned to the port with no catch. Although it is important to highlight that such study was carried out during the low MFAD season, it still highlights the economically risky nature of MFAD fishing.	Fishing trips to MFADs might not yield enough catches to offset expenses. This might also promote fishing for juvenile tunas and other non-target baitfish to help offset costs.
	Conflicts with other sea users (e.g. shipping)	Lack of regulation might lead to the deployment of MFADs in areas of heavy boat traffic or in areas that are amenable to other uses of the sea (e.g. whale watching)	Collision of boats with MFADs, leading to damage and MFAD losses, and elevation of conflicts among stakeholders.
	Conflicts between local and foreign MFAD fishers	Foreign fishers illegally fishing MFADs on local waters or local fishers fishing MFADs that foreign fishers set on local waters (Section 2.12.3)	Escalation in conflicts potentially leading to acts of vandalism and even violence. Resolving such issues will require cooperation between concerned countries/territories.
	Conflicts between local commercial MFAD fishers	Fishers fishing on MFADs from other fishers or interfering with each other while fishing the same MFAD (Angelelli and Reynal 2007; Ramdine 2007) (Section 2.12.3).	These conflicts are generally settled among fishers, but if left unresolved they could lead to acts of vandalism and even violence.
	Conflicts between local commercial vs recreational MFAD fishers	Recreational fishers fishing MFADs from commercial fishers (Angelelli and Reynal 2007; Ramdine 2007; Gentner et al. 2018) (Section 2.12.3)	These conflicts are generally settled among fishers, but if left unresolved they could lead to acts of vandalism and even violence.

Biological	Fishing of juvenile fish (e.g. yellowfins) for commercial purposes	Juvenile tuna of several large tuna species (yellowfin, bigeye) and juveniles of tuna-associated species such as dolphinfish tend to aggregate around MFADs, which facilitates their capture. Fishers across the region use small-bodied tunas (bonitos) and juvenile of large-bodied tunas (e.g.yellowfin) as live bait in drop lines targeting large tuna and billfishes (Section 2.9). However, fishers might also specifically target juvenile tuna and dolphinfish around MFADs for commercial purposes. Even though fishing techniques currently used on MFADs are highly selective, there is great need to refine those techniques so that catches of the most vulnerable species/groups are minimized and those of least concern are maximized, while still providing good economic returns to fishers. This purpose has received some attention in the region (Diaz and Gervain 2007; Dromer et al. 2015; Sidman et al. 2015), but more work is needed.	The use of juvenile tuna as live bait is contentious given that relatively small numbers are used on a fishing trip and juveniles might experience high natural mortality rates at that size anyway (e.g. Hampton and Fournier 1999). On the other hand, specifically targeting immature fish (tuna, dolphinfish) for commercial purposes should be carefully monitored as this is more likely to lead to growth overfishing (and potentially recruitment overfishing) (Fonteneau et al. 2000). Because data on natural mortality rates of juvenile tuna are lacking (Fonteneau et al. 2000), the use of juvenile tuna for commercial purposes should be minimized to the extent that it is possible under the precautionary approach.
	Intense targeting of regionally overexploited species (e.g. blue marlin)	Catches on MFADs typically include multiple species (See 2.9). Some of these species currently are considered overexploited or might be in the process of stock recovery. There is great concern that the MFAD fishery might further negatively impact some of these stocks. In particular, the regional stock of blue marlin is currently considered overfished and undergoing overfishing (See Section 3). This species is particularly amenable to be caught near MFADs and it is currently being (and has historically been) targeted by MFAD fishers across the region (Bealey et al. 2019). Even though fishing techniques currently used on MFADs are highly selective, there is great need to refine those techniques so that catches of the most vulnerable species/groups are minimized and those of least concern are maximized, while still providing good economic returns to fishers. This purpose has received some attention in the region (Diaz and Gervain 2007; Dromer et al. 2015; Sidman et al. 2015), but more work is needed.	Continued high levels of fishing of blue marlin, whether as target species or by-catch, and underreporting of catches across the region undermines the potential for the stock to recover. There is urgent need to better understand spatiotemporal variability in species composition on MFADs - which will depend on location - to minimize impacts of MFAD fishing on vulnerable species (Reynal et al. 2002).
	Disruption of fish migrations	It has been proposed that MFADs might act as ecological traps and interfere with the habitat selection instincts of migratory fish by attracting them and retaining them into poor quality habitat. However, this phenomenon is very difficult to test and the various studies that have attempted to do so have found conflicting results (Dagorn et al. 2013).	Diverting and retaining large oceanic fish into poor quality habitat (e.g. with fewer feeding opportunities; Hallier and Gaertner 2008)) should ultimately reduce their growth, condition, fecundity and/or survivorship.

	Hyperstability in catch and effort estimates*	Estimates of catch per unit effort on MFADs are not reliable indices of population abundance because MFADs are likely to continue to aggregate fish (and thus yield stable catches) even when total fish abundance might be rapidly declining (Ehrhardt et al. 2017a)	Since catch per unit effort on MFADs cannot be reliably and solely used as index of population abundance, it is critical to develop fishery-independent abundance estimates to complement fishery-dependent ones (Moreno et al. 2016a).
Ecosystem	Insufficient reduction of fishing pressure on coastal/reef resources	MFADs have been historically promoted in the region as a means of reducing fishing pressure on coastal/reef resources. However, the few studies in the region that have examined this proposition have not found support for it (Mathieu et al. 2014; Defoe 2020). This aligns with the finding that across most locations, most MFAD fishers continue to practice other types of fishing (Section 2.11).	High levels of fishing pressure on coastal/reef resources might be maintained by multipurpose fishers who can switch between MFAD fishing and coastal fishing, with coastal fishing generally providing lower, but more stable, yields. Thus, if the goal is to reduce coastal fishing pressure, MFAD programs need to be accompanied of effective regulation limiting fishing effort on coastal/reef resources by MFAD fishers.
	High levels of marine littering via MFAD losses	MFAD designs in the region mainly incorporate a diversity of non-biodegradable synthetic materials. Moreover, each MFAD requires that an anchoring component is deployed on the sea floor. Finally, most private MFADs, which account for the vast majority of MFADs in the region, get lost within a year of deployment and are quickly replaced, but very few of the lost ones are ever recovered (Section 2.8). On the other hand, efforts are currently being undertaken in the drifting FAD fishery for tuna to integrate biodegradable materials into FAD construction in terms of research (Moreno et al. 2016b; Lopez et al. 2019) and legislation (ICCAT 2020a). However, similar efforts are yet to be undertaken for the small-scale MFAD fisheries of the WECAFC region.	Most MFAD materials ultimately enter the ocean as marine litter. If these materials include entangling components such as old nets, lost MFADs could engage in *ghost fishing* and/or damage reef and nearshore habitats (Balderson and Martin 2015). The impact of the anchoring component on the sea bottom will depend on the type of surrounding substrate and on whether the mooring line attached to the anchoring component sinks or floats; this is an area of MFAD use that has received little attention (Sinopoli et al. 2020).
	High catches of non-target species (e.g. sea turtles)	Many non-target species might be occasionally captured on MFADs. If MFADs have entangling materials, marine mammals, sea birds and sea turtles might get entangled and drown. The MFAD Survey suggested that catches of marine mammals, sea birds and sea turtles occurred rarely (Section 2.9), but this remains largely undocumented in a rigorous manner.	If substantial incidental by-catch takes place on MFADs, this could threaten the recovery of species that are currently considered threatened or endangered such as sea turtles.

10.1. Governance challenges

During the MFAD Survey, challenges associated with the systems of governance of MFADs in Table 10 scored the highest across the region in terms of urgency of addressing, with an overall mean score per challenge of 2.6 on average per challenge. Table 11 ranks the individual challenges based on their perceived priority.

High ranking challenges (≥59% of respondents scored medium to high priority) were those pertaining to the inadequate or inexistent regulatory backdrop within which the MFAD fishery currently operates across most locations in the region, including **inadequate or inexistent regulations and management plans** as well as **inadequate or inexistent capacity to enforce regulations** when the latter exist (Table 11). This is consistent with the lack of a comprehensive and harmonized regulation framework (Section 2.12.2) and the lack of local management plans across locations previously reported. Moreover, **weak organizational structure of MFAD fishers** also ranked high across the region (Table 11).

With lower but still relatively high ranks came a second group of challenges (45-55% of respondents scored medium to high priority) that included the **lack of representation in ICCAT**, **weakness in inter-sectoral organizational structures** integrating a broad range of local stakeholder groups to facilitate dialogue and transparent decision-making such as Fishery Advisory Committees, **inexistent or poor data collection systems** (biological, economical), **illegal, unreported and unregulated (IUU)** fishing, **inexistent/inadequate sharing of info/data on MFADs across region,** and **inexistent or insufficient participation of MFAD fishers** in the decision-making process (Table 11).

The lower rank challenges (<30% of respondents scored medium to high priority) were **transboundary fishing** and **uncontrolled and excessive proliferation of private MFADs**, likely because these issues are likely to be more location-specific (Table 11).

Table 11. Governance challenges of the MFAD fishery and associated priority score breakdown

Governance challenge	Mean score (1 to 4)	Percentage of respondents				
		High priority	Medium priority	Low priority	Very low priority	Not known
Inexistent/inadequate local capacity to enforce regulations	3.1	55%	23%	5%	18%	0%
Weak organization of MFAD fisher groups	3.1	50%	14%	23%	9%	5%
Inexistent/inadequate local MFAD management plans	2.9	41%	18%	18%	18%	5%
Inexistent/inadequate local MFAD regulation	2.8	50%	9%	5%	32%	5%
Inexistent/inadequate representation in ICCAT	2.7	27%	27%	9%	23%	14%
Weak governance structure across stakeholder groups	2.7	32%	23%	27%	18%	0%
Inexistent or poor data collection systems (biological, economical)	2.6	32%	23%	14%	27%	5%
IUU fishing	2.6	23%	27%	5%	27%	18%
Inexistent/inadequate sharing of info/data on MFADs across region	2.4	18%	27%	23%	27%	0%
Inexistent / insufficient MFAD fisher participation in decision-making	2.3	14%	36%	18%	32%	0%
Transboundary fishing	1.9	14%	14%	14%	45%	14%
Uncontrolled/excessive proliferation of MFADs	1.9	14%	9%	27%	45%	5%

10.2. Socio-economic challenges

The socio-economic challenges in Table 10 came second overall in terms of perceived urgency in addressing, with an overall mean score per challenge of 2.3 on average per challenge. However, this component exhibited considerable heterogeneity in scores across the region, which is expected given that the socio-economic and ecological context in which the MFAD fishery operates also differs markedly across the region (Section 2.11). Table 12 ranks the challenges based on their perceived priority.

The highest-ranking challenges (≥64% of respondents scored medium to high priority) were those pertaining to **high levels of fuel consumption** and the **lack of training of fishers in business management**, followed by the **inadequate commercialization circuits for target species** (59% of respondents scored medium to high priority) (Table 12).

With lower ranks came a second group of challenges (45-55% of respondents scored medium to high priority), which included **inexistent/inadequate systems for repair and maintenance of deployed MFADs** and **low capacity to replace lost MFADs**, along with **lack of adequate facilities/infrastructure to handle large pelagics**, **lack of access of MAD fishers to training**, **competition with fish imports**, and **poorly equipped boats for MFAD fishing** (Table 12).

With even lower ranks (35-45% of respondents scored medium to high priority) came a group of challenges that included **inadequate MFAD designs for local context**, **lack of safety at sea**, **low or highly variable catches on MFADs**, and **fluctuating or low prices for target species** (Table 12).

The lowest ranking group (<35% of respondents scored medium to high priority) included challenges associated with conflicts among users, including **conflicts between local and foreign MFAD fishers**, **conflicts between local commercial MFAD fishers**, **conflicts between local commercial vs recreational MFAD fishers**, and **conflicts between MFAD fisher and other sea users** (Table 12).

Finally, one potential challenge, the **impact of Sargassum on fish abundance on MFADs** stood out because of the lack of clear prioritization score, precluding any straightforward allocation to any of the aforementioned groups (Table 12).

Table 12. Socio-economic challenges of the MFAD fishery and associated priority score breakdown

Socio-economic challenge	Mean score (1 to 4)	Percentage of respondents				
		High priority	Medium priority	Low priority	Very low priority	Not known
High fuel consumption and costs	3.0	45%	18%	18%	14%	5%
Inexistent/inadequate fisher training in business management	3.0	41%	27%	5%	18%	9%
Inexistent/inadequate systems for repair and maintenance of deployed MFADs	2.7	36%	14%	18%	23%	9%
Low capacity to replace lost MFADs	2.6	36%	9%	14%	32%	9%
Inadequate commercialization circuits for target species	2.5	18%	41%	0%	32%	9%
Impact of Sargassum on fish abundance around MFADs	2.4	18%	18%	14%	23%	18%
Lack of adequate facilities/infrastructure to handle large pelagics	2.4	32%	14%	14%	36%	5%
Lack of access of MFAD fishers to training	2.3	18%	36%	0%	41%	5%
Inadequate MFAD designs for local context	2.3	27%	14%	23%	36%	0%
Competition with fish imports	2.3	27%	23%	0%	50%	0%
Poorly equipped boats for MFAD fishing	2.2	18%	32%	5%	45%	0%
Lack of safety at sea (MFAD deploying and fishing)	2.2	18%	27%	14%	41%	0%
Low or highly variable catches on MFADs	2.1	14%	18%	18%	36%	14%
Fluctuating or low prices for target species	2.1	18%	18%	9%	45%	9%

Conflicts between local and foreign MFAD fishers	2.0	23%	5%	23%	45%	5%
Conflicts between local commercial MFAD fishers	1.9	23%	5%	9%	59%	5%
Conflicts between local commercial vs recreational MFAD fishers	1.9	5%	23%	18%	45%	9%
Conflicts with other sea users (e.g. shipping)	1.5	5%	9%	14%	64%	9%

10.3. Biological challenges

The biological challenges in Table 10 came third overall in terms of perceived urgency in addressing, with an overall mean score per challenge of 2.0 on average per challenge. Table 13 ranks the challenges based on their perceived priority.

With only three challenges identified, **fishing of juvenile fish for commercial purposes** ranked highest but with only a moderate score (45% of respondents scoring medium to high priority), followed by **intense targeting of regionally-overexploited species** with a relatively low score (32% of respondents scoring medium to high priority) and **disruption of fish migrations** with an even lower score (18% of respondents scoring medium to high priority), although the latter had particularly high levels of unknown (36% of respondents) (Table 13).

Table 13. Biological challenges of the MFAD fishery and associated priority score breakdown

Biological challenge	Mean score (1 to 4)	Percentage of respondents				
		High priority	Medium priority	Low priority	Very low priority	Not known
Fishing of juvenile fish (e.g. yellowfins) for commercial purposes	2.3	14%	32%	5%	36%	14%
Intense targeting of regionally-overexploited species (e.g. blue marlin)	2.1	14%	18%	23%	36%	9%
Disruption of fish migrations	1.7	0%	18%	9%	36%	36%

10.4. Ecosystem challenges

Overall, ecosystem challenges in Table 10 came also third overall in terms of perceived urgency in addressing, tying with the biological challenges with an overall mean score per challenge of 2.0 on average per challenge. Table 14 ranks the challenges based on their perceived priority.

With only three challenges identified, **insufficient reduction of fishing pressure on coastal/reef resources** ranked highest with relatively high score (50% of respondents scoring medium to high priority), followed by **high levels of marine littering via MFAD losses** with a relatively low score (23% of respondents scored medium to high priority) and **high catches of non-target species** with an even lower score (only 5% of respondents scored medium to high priority) (Table 14).

Table 14. Ecosystem challenges of the MFAD fishery and associated priority score breakdown

Ecosystem challenge	Mean score (1 to 4)	Percentage of respondents				
		High priority	Medium priority	Low priority	Very low priority	Not known
Insufficient reduction of fishing pressure on coastal/reef resources	2.6	27%	23%	14%	23%	14%
High levels of marine littering via MFAD losses	2.1	18%	5%	32%	32%	14%
High catches of non-target species (e.g. sea turtles)	1.3	5%	0%	9%	77%	9%

10.5. Summary

Overall, the governance challenges scored highest in terms of perceived priority, underscoring a regionwide consensus on the urgent need to strengthen governance and regulation frameworks and the organizational capacity of stakeholders. This certainly reflects that effectively addressing these challenges is required in order to help resolve many of those operating in the socio-economic, biological and ecosystem dimensions. The fact that there was also considerable regionwide agreement on the importance of addressing high fuel consumption and lack of training of fishers in business management suggests that MFADs might not always yield the expected economic benefits. There is therefore a need for better assessment of the economic performance of MFADs and its drivers and this should be accompanied with building the necessary capacity in fishers to make decisions that will ensure sustained profits. Finally, biological and ecosystem challenges came last, suggesting a greater diversity in the perceived importance of these challenges across the region. The exception was the recognition that MFAD fishing might not necessarily lead to a reduction in coastal fishing pressure. Overall, the lower ranking of biological and ecosystem challenges might reflect differences in ecological context and in the relative importance of MFAD fishing at the local scale. However, it might also reflect a pervasive lack of data across the region to adequately inform these issues, which can only be adequately addressed via improved monitoring of the MFAD fishery.

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Appendix II – Preliminary Results of the Caribbean Regional Moored Fish Aggregating Device (MFAD) Survey

Contents

Executive Summary

In the context of the project entitled "Support to the Secretariat of WECAFC in implementing targeted actions of the 2019-2020 Workplan on improved regional fisheries governance", an online survey was conducted between August and October 2021 to assess the current state of the MFAD fishery across states and overseas territories engaged in MFAD fishing within the WECAFC region. The survey acquired information on broad management objectives to support MFAD fishing, MFAD unit numbers (both public and private) and MFAD fishing fleets, features of the MFAD units being currently deployed (design, materials, life span, cost), characteristics of MFAD vessels, MFAD regulation, fishing techniques and target species on MFADs, incidental by-catch on MFADs, MFAD fishing trip characteristics, safety at sea, large pelagic fish handling practices, MFAD fisheries monitoring, and current challenges of the MFAD fishery. Twenty states/overseas territories participated in the survey; 71% of respondents were affiliated with fisheries departments or other relevant government agencies, 19% of respondents were affiliated with research institutions, and 10% of respondents were affiliated with conservation NGOs.

The survey revealed that MFAD use is mainly confined to island states and overseas territories, with at least 78% of such locations in the region confirming using MFADs. In contrast, most continental states (85%) did not make use of MFADs and those which did either had an MFAD fishery that was gradually disappearing (Brazil) or a very limited use of MFADs (Florida, USA). The most frequently cited objectives to support MFAD fishing were improving fisher livelihoods (increased revenue and fishing efficiency and reduced fuel consumption), supporting food security and local availability of fish products, and decreasing fishing pressure in coastal systems.

There are currently more than 3,600 MFAD units deployed across the WECAFC region and nearly all (97%) are privately owned. Two locations, the Dominican Republic and Guadeloupe, account for 86% of all MFADs. Two other locations, St Kitts & Nevis and Tobago, account for an additional 6% of all MFADs. In general, respondents felt that the total number of public and private MFADs in their locations were low to adequate, except for Guadeloupe in relation to private MFADs, whose levels were deemed too high.

There are currently more than 3,100 vessels and 7,200 fishers (full- and part-time) currently making use of MFADs across the surveyed locations (2,600+ vessels and 6,200+ fishers if we exclude the recreational fishery of Florida). Two thirds of survey responses (76%) categorized their MFAD fishery as either commercial, subsistence, or subsistence and commercial to similar extents. The single biggest contributor in terms of both vessels and fishers is the Dominican Republic, although Haiti, Dominica, and St Lucia also have important MFAD fisher populations. Vessels using MFADs across the region are typically small (<9m), equipped with outboard engines and iceboxes. Nearly half the locations indicated an increase in the number of vessels using MFADs over the last five years, with only a small fraction indicating a decrease.

The survey points to differences between public and private MFADs in design, cost, and life expectancy across locations. Relative to private MFADs, public MFADs are more likely to be equipped with surface markers, a sinking line below the floating component, a floating line above the mooring component, and a large concrete block as mooring component. Thus, public MFADs across the region are more likely to align with best practices in MFAD design. Public MFADs are also more likely to last several years after deployment than private MFADs and are also more likely to be recovered when lost than private MFADs. Such greater investment in design also explains the survey finding that public MFADs more often reach costs exceeding USD 8,000 per unit than private MFADs (which are most often in the USD 1,000-2,000 bracket). Tarpaulines and plastic strips are the most frequently used types of aggregator materials for both private and public MFADs, whereas in a few locations (≤23%) potentially entangling materials such as old nets are still being used. Storm events were most frequently cited as causes of MFAD losses for both MFAD types, followed closely by mooring lines being cut by boats. When lost, private MFADs are more likely to be replaced within just a few months than public MFADs, with the latter more likely to be replaced within a year. The survey also found that two thirds of locations with public MFADs reported that the MFAD units had clear markings allowing owner identification. In contrast, when it came to locations with private MFADs, only half of these locations reported that the MFAD units had clear markings allowing owner identification. There also appear to be differences between private and public MFADs in depth of deployment, with public MFADs more frequently deployed between 501-1000 m and private ones between 1001-2000 m, but these differences might be confounded by the varying bathymetry of the different locations.

The survey supported a wide-spread deficiency in regulations governing the use of MFADs. Out of 21 aspects of MFAD use potentially subject to regulation, only four, namely (1) requiring provision of catch and effort data, (2) penalties for breaching regulations, (3) how MFADs need to be marked to avoid collisions at sea, and (4) where MFADs can (or cannot) be deployed, were subject to regulations or rules that were actually enforced in at least half the locations. In contrast, 14 aspects (out of 21) of MFAD use with direct relevance to the ecosystem dimension of the fishery (e.g. MFAD loss reporting; MFAD materials; target species/sizes) were not the subject of any regulation or rule in most of the locations. Finally, only a few locations had MFAD management plan.

The survey supported that conflicts among MFAD users and acts of vandalism involving MFADs were infrequent across most locations in the region (from once a year or less to a few times a year). However, some locations, notably Guadeloupe and Dominica, did report considerably higher conflict frequencies than the rest of the region (once a week). When conflicts took place, they were mainly driven by local fishers using MFADs that they did not own or by interference between commercial and recreational fishers on MFADs. Moreover, half the locations reported that foreign fishers from nearby islands illegally set MFADs on their local waters or illegally fished on local MFADs, supporting some level of IUU fishing.

The survey supported seasonality in MFAD use across the region: two thirds of the locations identified months of higher MFAD fishing activity. Combining the responses suggests a broad seasonal peak period for MFAD fishing between May and October across the region, although such finding requires caution in interpretation given the large distances among locations and the multi-species nature of the MFAD fishery. Seasonal abundance of target species was the most frequently cited reason to explain such seasonality.

Surface (<2 m) and sub-surface (2-10 m) trolling and drifting dropline with live bait were the most frequently cited fishing techniques on MFADs across the region. Fishing most frequently took place during daylight hours, within 100 m of the MFAD, at relatively shallow (<10m) depths, using live small pelagics or live small-bodied tunas as bait. The five most frequently cited target species across the region were, by decreasing order of importance, yellowfin tuna, wahoo, blackfin tuna, blue marlin and skipjack. Two thirds of the locations indicated that small fish (<2kg) made up less than 25% of the typical catch.

The survey supported that incidental by-catch on MFADs of marine mammals, sea turtles, and sea birds was infrequent (once a year or less) across the region, whereas that of sharks was higher. The majority (67%) of locations indicated that sharks were one of the most frequently caught non-target fish species.

The survey revealed that two-thirds of locations are engaged in systematic fishery data collection that include MFAD fishing trips and these locations use standardized forms for data collection. One third of locations did not engage in systematic data collection involving MFADs. At least 80% of the locations engaged in fishery data collection explicitly distinguish between MFAD fishing and other types of fishing. Fishing trip data requirements vary across locations. Most locations collect information on time spent fishing, number of fishers, fishing techniques, total weight landed, total weight landed by species, and fishing trip revenue. In contrast, few locations collect information on MFAD ID and location, time spent travelling, fuel consumption, or number of fishing lines used. Sampling coverage of fishing trips across most of these locations varied between 25% and 75%. Most of these locations indicated that the data collected was used to inform policy and stakeholders on an annual frequency basis.

In terms of safety at sea, the survey yielded mixed results. In the majority of locations most fishers possessed safety signaling equipment, emergency flotation devices and navigation equipment, but were not trained in safety at sea, did not have alternative means of propulsion in their vessels, nor wear personal protective gear to handle large fish. Nearly all locations indicated that accidents at sea while deploying MFADs or fishing on MFADs were rare.

In terms of the handling of large fish onboard, the survey suggests considerable differences across the region regarding onboard practices (spiking, gutting, bleeding out, ice use), with most locations failing to consistently adhere to best practices. The survey also highlights considerable differences in the region regarding access to adequate facilities to handle large fish.

Only 12 locations provided additional information on the characteristics of fishing trips to MFADs, highlighting the lack of data in this aspect of the fishery. Nearly all locations reported fishing trips lasting less than 5 hours. Most locations reported catches exceeding 76 kg, with a modal fuel consumption of 101-200 liters.

The survey also pointed to substantial differences among locations in the socio-economic context surrounding MFAD fishers. In half the locations, nearly all MFAD fishers are full time fishers, whereas in the rest of locations the fractions of fishers who are full time varies substantially depending on location. Whereas in most locations few fishers have jobs outside fishing, there remains a significant fraction (38%) of locations, where most or all fishers do have jobs outside fishing. Similarly, whereas in most locations few fishers receive any support from government or non-governmental agencies or have access to credit lines, in at least one quarter of locations most fishers do receive such types of support. In most of locations very few fishers are trained in small business management or have access to training on MFAD use, although in relation to the latter more than one quarter of locations do provide such access to most fishers. On the other hand, in nearly three quarters of locations most fishers own their boats. Finally, the most frequently cited age for MFAD fishers across locations was between 31 to 50 years, with most locations indicating no age difference between MFAD fishers and other fishers.

Importantly, in two thirds of locations, most fishers continue to practice other types of fishing, suggesting widespread links between MFAD fishing and coastal fisheries across locations.

The survey also queried about the degree of shared responsibility between government and fishers on various aspects of MFAD management. It revealed considerable differences across locations in the extent that government and fishers work together on at least some aspects of MFAD management, highlighting the potential for the transferability of lessons learned between locations.

Finally, the survey asked respondents to prioritize a list of issues typically associated with MFAD fishing. The issues consistently perceived as high priority across the region were: the weak MFAD management and governance structures, including inexistent or inadequate local capacity to enforce regulations; weak organization of MFAD fisher groups; and inexistent or inadequate local MFAD management plans and regulations. Another perceived high priority was the lack of fisher training in business management. Importantly, other widely shared concerns included the fuel consumption costs and fishing pressure on nearshore/coastal resources, bringing into question widely accepted assumptions about MFAD fisheries. Finally, under this general background of poor management systems, there still appeared to be considerable variability across the region in the scoring of priorities, highlighting that some important challenges will be location specific.

Background

The WECAFC Secretariat is currently executing an EU-funded project titled "Support to the Secretariat of WECAFC in implementing targeted actions of the 2019-2020 Workplan on improved regional fisheries governance" which aimed among others at improving the management MFADs in the Wider Caribbean by drafting a WECAFC regional MFAD fishery management plan.

Initial enquiries quickly revealed that most WECAFC countries and overseas territories supporting significant MFAD fisheries in the region are island states/territories supporting small-scale artisanal fisheries using small sized vessels (<9m length) (see also Results). This implies that any WECAFC regional plan would necessarily overlap almost entirely in both geographic scope and fisheries characteristics with the CRFM (2015) MFAD fisheries management plan for the Eastern Caribbean[2]. Because the latter was purely based on a desk study and given the fluidity of MFAD projects in the region, it was then deemed appropriate to conduct a region-wide comprehensive survey to update the current state of knowledge about the MFAD fishery across the region. The WECAFC MFAD management plan would then build on the CRFM (2015) document by adding the key results of the region-wide survey and by seeking to integrate the most recent relevant work in the region (notably the outputs of the CARIFICO and Caribbean Billfish projects that came after 2015) and elsewhere (notably work by the Pacific Community (SPC)).

This survey would seek to inform about all relevant dimensions of the MFAD fishery, including among others (1) broad management objectives to support a MFAD fishery across the region, (2) MFAD numbers (both public and private) and MFAD fishing fleets, (3) features of the MFAD units being currently deployed (design, materials, life span, cost), (4) characteristics of vessels, (5) regulation, (6) fishing techniques and target species, (7) incidental by-catch, (8) fishing trip characteristics, (9) safety at sea, (10) fish handling practices, and (11) monitoring. The survey concludes by listing the management challenges/issues identified in the CRFM (2015) document and requesting that informants identify which ones are the most pressing in their local context.

Survey details

Survey period: August 2021 – Oct 2021 (Last survey received on Oct 5th)

Participant territories/ countries: St. Eustatius; Dominica; Bonaire; Haiti (southeast department only); Antigua and Barbuda; Guadeloupe; Martinique; St Lucia; Puerto Rico; Bermuda; Montserrat; St. Vincent and the Grenadines; Florida; Saba; Anguilla; Tobago; Dominican Republic; Curaçao; Cayman Islands; Grenada. In total, 20 countries/overseas territories participated.

Respondents: Fisheries department and coastal management department affiliations (71%), environmental NGO affiliation (10%; WWF-NL and Saba Conservation Foundation) and Research affiliations (19%; IFREMER, Beyond Our Shores Foundation, Caribbean Netherlands Science Institute). In some locations, fisher representatives were also consulted by the person filling the survey.

Responses: One single response per territory/country. In some instances, several key informants coordinated to jointly fill in the same survey form. In situations where more than one person independently filled the survey (Puerto Rico), results were reconciled between surveys to yield a single

[2] CRFM (2015) 2015 Draft Sub-Regional Management Plan for FAD Fisheries in the Eastern Caribbean (Stakeholder Working Document). CRFM Technical & Advisory Document 2015/ 05

response for each question. One of the conservation NGO respondents (Bonaire) filled the survey in close communication with, and on behalf of, fishers. All respondents had experience with MFADs in their respective locations.

Link to survey: https://forms.gle/B8a9Vmdg63qGLhhG6

Analyses: Percentages and proportions shown throughout the document are calculated out of the total number of answers after excluding answers where the respondents indicated “I do not know”.

Results

MFAD numbers across the region

Table 1 – Overview of MFAD numbers (public vs private) across the WCAFC region. Blue shading indicates locations with regular presence of MFADs. These data were supplemented with additional correspondence with key informants

Type	Location	Are there MFADs?	Public	Private	Comments
Continental	Belize	No	-	-	
Continental	Brazil	Yes	0	NA	Important point: the MFAD fishery is in now in decline and being replaced by boat shadow fishing; very few boats currently use MFADs
Continental	Colombia	No	-	-	
Continental	Costa Rica	No	-	-	
Continental	Guatemala	No	-	-	
Continental	Guyana	No	-	-	
Continental	Honduras	No	-	-	
Continental	Mexico	No	-	-	
Continental	Nicaragua	No	-	-	
Continental	Panama	No	-	-	
Continental	Suriname	No	-	-	
Continental	United States (Florida)	Yes	8	0	
Continental	Venezuela. R	No	-	-	
Insular	Anguilla	Yes	0	~25	There will be more deployed after the hurricane season has passed which will be in September, October time.
Insular	Antigua and Barbuda	Yes	8	20	6 public ones will be deployed in 2022 AND between 40-80 illegal private MFADs are currently set by foreign vessels in local waters
Insular	Aruba	No	-	-	-
Insular	Bahamas	Yes	1	0	Used exclusively for research;
Insular	Barbados	Yes	1	0	A total of 17 public MFADs to be soon deployed
Insular	Bermuda	Yes	1	0	Another public MFAD lost its surface component and is to be replaced
Insular	Bonaire	Yes	0	1	6 public ones are planned for the near future
Insular	Cayman islands	Yes	-	2	-
Insular	Cuba	No	-	-	-
Insular	Curacao	Yes	0	20	-
Insular	The Commonwealth of Dominica	Yes	2	20	Most public were lost during the passage of hurricane Maria in 2017. Since, government focus has been on restoration of fisheries infrastructure, fishers’ assets and services negatively impacted by the hurricane. Focus on deployment of public FADs will resume when services such as fish storage, adequate ice production and marketing is fully restored by 2022. Fishers continue to deploy private MFADs as necessary or to replace lost ones.
Insular	Dominican Republic	Yes	0	2500	Rough estimate; most MFADs are in the Caribbean (south) coast
Insular	Grenada	Yes	0	3	4-5 private MFADs typically present at any given time
Insular	Guadeloupe	Yes	< 30	600	30 public ones since 2008, but most now lost. 600 is estimate for 2012, number probably higher currently
Insular	Haiti	Yes	6	3	Estimate for the southeast of island only
Insular	Jamaica	No	-	-	To note that the NGO Food for the Poor has established "Fishing villages" in Jamaica - In Haiti these projects involved deployment of MFADs

Insular	Martinique	Yes	4	20-25	There will be 8 public ones in 2022 - Private MFAD are not declared by fishers so number given is an estimate
Insular	Montserrat	Yes	4	0	Six were recently lost
Insular	Puerto Rico	Yes	11	10	Permits for 8 surface FADs, two submerged FADs and two clusters submerged FADs to be depoyed soon; Private MFADs are illegally set
Insular	Saba	Yes	0	15-20	Estimate
Insular	Saint Kitts and Nevis	Yes	0	100	50% of MFADs in Nevis and 50% in St Kitts
Insular	Saint Lucia	Yes	8-10	0	Note that private MFADs in St Lucia are considered public - everyone has access.
Insular	Saint Vincent and the Grenadines	Yes	6	0	-
Insular	Sint Eustatius	Yes	1	~5	2 FADs were lost
Insular	Sint Marteen	NA	NA	NA	-
Insular	St Barthelemy	NA	NA	NA	-
Insular	St Martin	Yes			-
Insular	Tobago	Yes	0	~100	-
Insular	Turks and Caicos	No	-	-	-
Insular	Virgin Islands, British	NA	NA	NA	-
Insular	Virgin Islands, US	Yes	4	0	https://coastalanglermag.com/usvi-fish-aggregating-device-fad-program/

Key findings :

- 3,600+ MFADs currently deployed
- MFAD use is very strongly associated with island countries or territories, with 78% of such locations confirming using MFADs. Little use of MFADs in the continental region (only 15% of states), although some locations (Panama) have expressed interest in MFADs in the near future to support recreational fishing.
- Most island locations have small or moderate numbers of MFADs. The exceptions are the Dominican Republic and Guadeloupe, with 86% of all MFAD numbers, followed by St Kitts and Nevis and Tobago with an additional 6% of total numbers.
- Most MFAD fishing in the Dominican Republic takes place in the south (Caribbean side) of the island.
- 97% of all MFADs are private (i.e. fully funded by private individuals or groups for their intended main use)
- Although private MFADs account for 97% off all MFADs deployed (Table 1), locations possessing both private and public MFADs represent the single largest fraction (45%) of locations, followed by those having only private MFADs (35%), with locations with only public MFADs coming last (20%).
- Of those locations possessing private MFADs, 57% indicated that MFADs were owned mainly by individual fishers (e.g. Guadeloupe), 26% indicated that MFADs were owned mainly by groups of fishers (e.g. Grenada), and the remainder 14% indicated that MFADs ownership was similarly distributed between individual fishers and groups of fishers (including the Dominican Republic).
- Southeast Brazil used private MFAD in the 80’s, 90’s and early 2000’s for pole and line fishing (skipjack) with boats > 20 m in length – However, since 2010 MFADs have been rapidly replaced by the technique of boat “shadow fishing” for large tuna (yellowfin) by smaller vessels (12-15 m). It thus appears the MFADs are no longer used in significant numbers along most of the Brazilian coastline.

High level objectives driving MFAD fisheries

Table 2. Frequency of citation of high-level objectives to support a MFAD fishery by respondents from 20 territories/countries with MFAD fisheries. The list of objectives was based on CRFM (2015).

High level objective	Citation frequency
To increase fisher revenue	18
To increase fishing efficiency for fishers	17
To decrease coastal or nearshore fishing pressure	16
To increase local availability of fish products	15
To reduce fuel consumption	14
To support food security	14
To reduce fish imports	10
To promote social cohesion and collaboration among fishers	9
To promote co-management	8
To reduce competition among fishers in resources/fishing grounds	7
To generate new added value products	5
To increase employment	5
To encourage fishers to remain within territorial waters	4
To increase safety at sea	4
To support or develop a charter/sports fishing market	4
To conduct research on pelagic species biology and/or fishing techniques	4
To increase fish exports	3
To reduce conflicts between fishers and other users of the sea (e.g. shipping, tourism)	3
To decrease physical demands of fishing	2
To control or reduce use of private MFADs	1

Key findings:

The most frequently cited objectives remain consistent with historical objectives in the region (see CRFM (2015)), (1) namely improving fisher livelihoods (via increased revenue and fishing efficiency and reduced fuel consumption), (2) supporting food security, and (3) decreasing fishing pressure in coastal systems.

Interesting, objectives about improving co-management and social cohesion among fishers and conducting research have gained prominence over the last few years relative to the objectives outlined by the desk review in CRFM (2015).

Local perception of adequacy of MFAD numbers

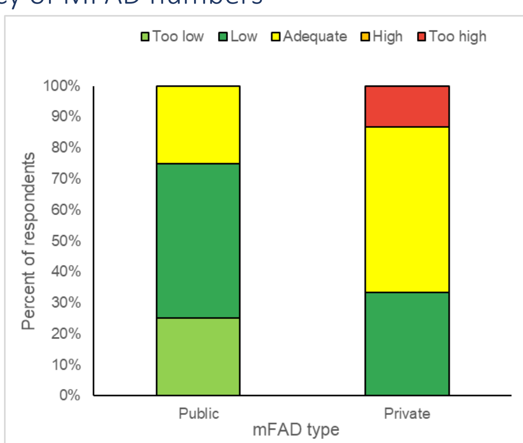

Figure 1. Percent of responses in relation to the adequacy of the number of MFADs in a given location

Key findings:

- In general, respondents felt the total number of MFADs in their locations were between low to adequate, except for Guadeloupe in relation to private MFADs, whose levels were too high.

Components of the MFAD design

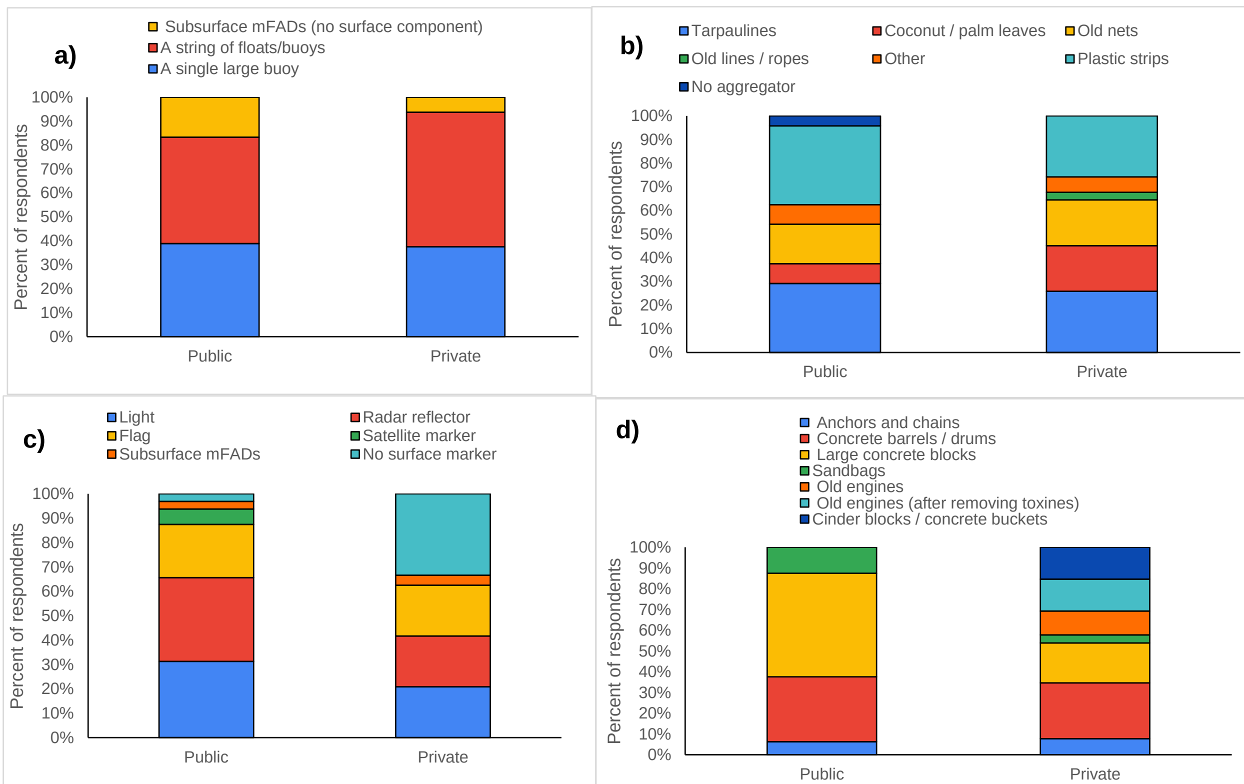

Figure 2 – Frequency of responses for public versus private MFADs in relation to materials used to build MFADs including a) surface components; b) aggregators; c) marking components and; d) anchoring components.

Key findings:

- A string of floats or buoys was the most frequently cited floating component for both public (44%) and private (56%) MFADs.
- The most obvious differences in materials between public and private MFADs involved the MFAD marking component and the anchoring component. A 33% of the respondents indicated that private MFADs did not have any marking component versus only 3% for public MFADs (Fig 2c). Moreover, large concrete blocks were more frequently cited as anchoring components for public MFADs, whereas a greater diversity of materials was cited for private MFAD (Fig 2d).
- Potentially entangling materials like old nets were cited in 16% and 23% of the responses for public and private MFADs, respectively (Fig 2b).
- Moreover:
  - 67% and 50% of respondents indicated that public and private MFADs, respectively, had an ID tag or marking allowing identifying the owner.

- 82% of respondents indicated that public MFADs were designed with both a sinking line under the surface component and a floating line over the mooring component, consistent with best practices. These percentages were lower for private MFADs, with 50% and 64% of respondents indicating the presence of a sinking and floating line, respectively.
- The majority of respondents indicated that public (60%) and private (70%) MFADs were designed to have the first part of the mooring line below the surface component specifically protected from fishing cuts, which is consistent with best practices.

MFAD cost and losses

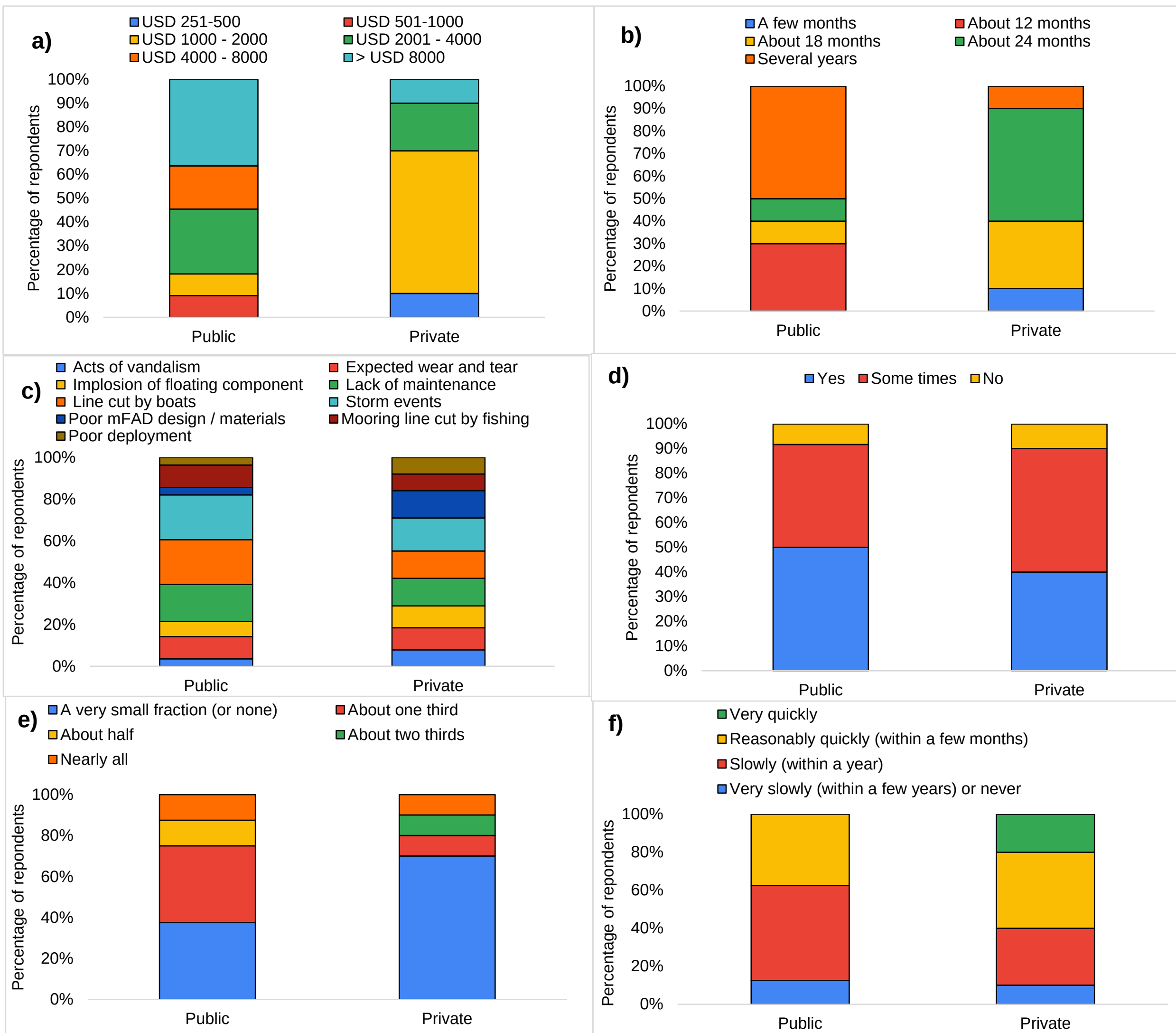

Figure 3 – Frequency of responses for public versus private MFADs in relation to a) MFAD cost (materials and assemblage); b) MFAD life span; c) cause of MFAD loss; d) whether areas of heavy boat traffic are avoided during MFAD deployment; e) fraction of MFADs that are recovered; and f) speed at which lost MFADs are replaced.

Key findings:

- There are considerable differences in costs between the public and private MFADs, with the greatest proportion of responses citing >USD 8,000 for public MFADs versus only USD 1,000-2,000 for private ones (Fig 3 a).

- There are also differences in life span between private and public MFADs, with the greatest proportion of responses citing several years for public MFADs versus 2 years for private ones (Fig 3b).
- Storm events were most frequently cited as causes of MFAD losses for both MFAD types, followed closely by mooring lines being cut by boats and lack of maintenance (Fig 3c). For private MFADs, the use of poor designs and/or materials was also frequently cited (Fig 3c).
- For both types of MFADs, areas of heavy boat traffic tended to be avoided (Fig 3d).
- There are considerable differences between public and private MFAD in the fractions of lost MFADs that are recovered, with the greatest proportion of responses citing nearly half for public MFADs versus a very small fraction (or none) for private ones (Fig 3 a).
- There are also considerable differences between public and private MFAD in the time that it takes to replace them when they get lost, with the greatest proportion of responses citing slowly (within a year) for public MFADs versus reasonably quickly (within a few months) for private ones (Fig 3 f).

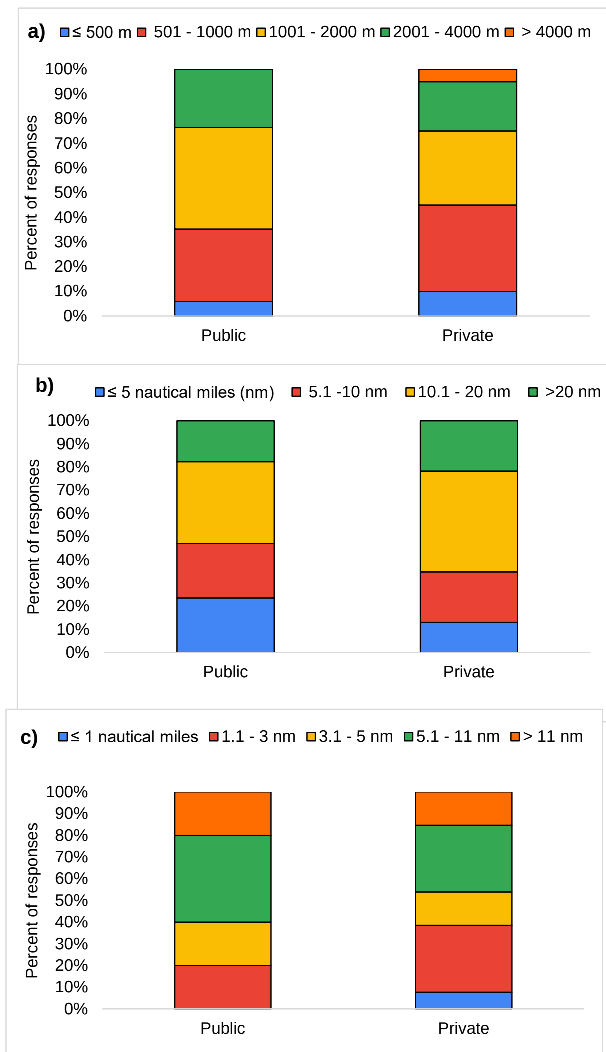

Fig 4 - Frequency of responses for public versus private MFADs in relation to a) depth of deployment); b) distance from coastline; and c) distance between MFADs.

Key findings:

- There are differences in depth of deployment between public and private MFADs, with the greatest proportion of responses citing 1001-2000m for public MFADs versus 501-1000m for private ones (Fig 4 a).
- In contrast, the most frequently cited distance from the coastline is 10.1-20km for both public and private MFADs (Fig 4b).
- There are differences in distances separating MFADs, with the greatest proportion of responses citing 5.1-11km for public MFADs versus only 1.1-3km for private ones (Fig 4 a).
- Obviously, the results above might be confounded by broad differences in depth and coastal characteristics among locations as in some locations there are only public or private MFADs.

Number of MFAD vessels and fishers

Table 3 – Summary of number of MFAD boats and MFAD fishers (full- and part-time) operating in the surveyed territories/countries.

Territory (or country)	Active MFAD boats (full- and part time)	Active MFAD fishers (full and part-time)
Anguilla	15	15
Antigua and Barbuda	15	35
Bermuda	5-25 expected	1 - 3 fishers per vessel expected
Bonaire	~20	~20
Cayman Islands	-	-
Curaçao	10-15	10-15
Dominica	300	600
Florida	500+	1000+
Grenada	70	~ 140
Guadeloupe	218	387
Haiti (southeast only)	250	1500
Martinique	220	377
Montserrat	8	25
Puerto Rico	-	-
Republica Dominicana	1250 (500 full time)	2500 (~1000 full time)
Saba	12	22
St Lucia	200-250	450-500
St. Eustatius	6	6
St. Vincent and the Grenadines	50	100
Tobago	-	60-80

Key findings:

- 3,100+ vessels currently fish on MFADs across surveyed locations (2,600+ vessels excluding Florida)
- 7,200+ fishers currently fish on MFADs across surveyed locations either full- or part-time (6,200+ fishers excluding Florida)
- The single biggest contributor in terms of both vessels and fishers is the Dominican Republic.

- Across the insular Caribbean, Haiti, Dominica, and St Lucia also have important MFAD fisher populations.

Type of MFAD fishery, number of fishers per vessel, numbers of boats per MFAD, and perception of degree of fishing effort on MFADs

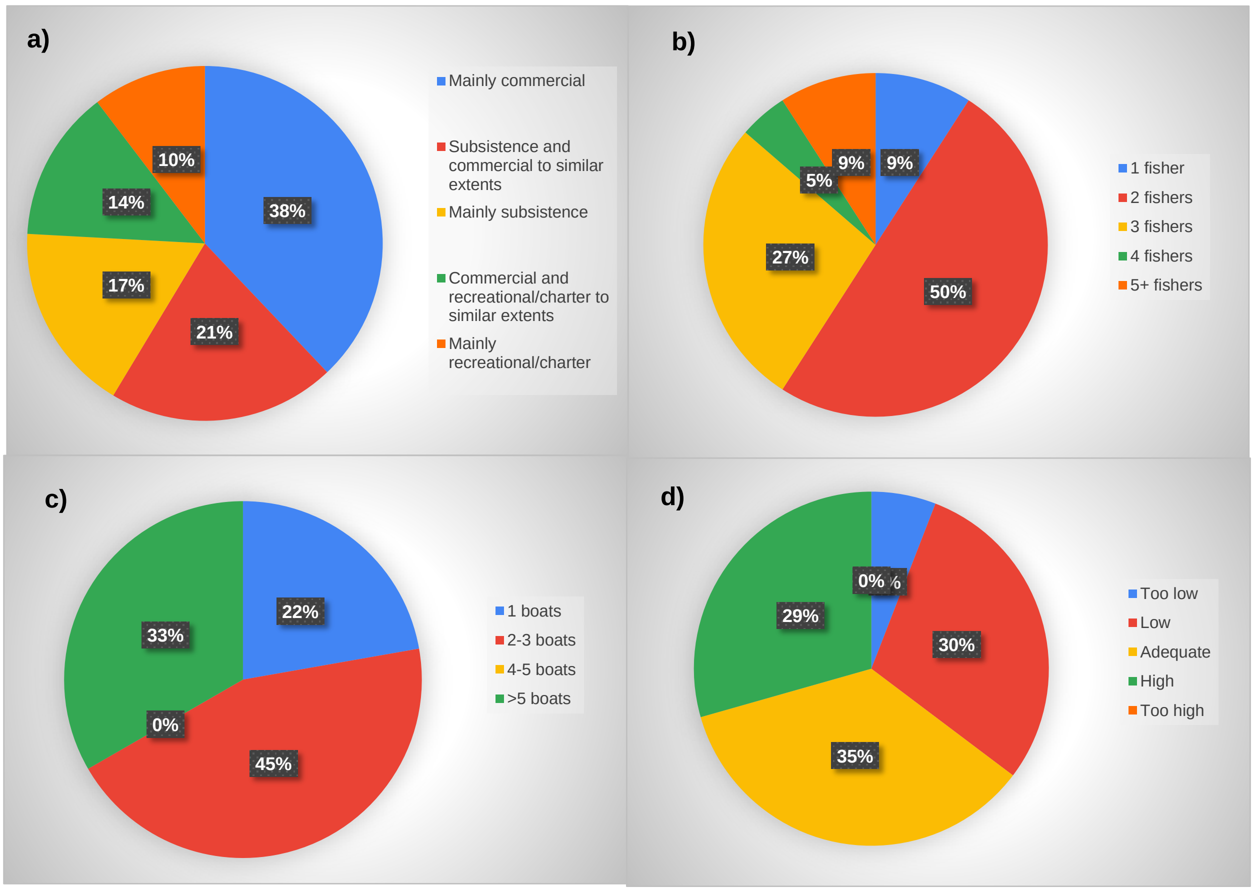

Figure 5. Characteristics of the MFAD fishery in terms of a) main fishing purpose and b) number of fishers per boat, c) number of boats per MFAD and d) perception of intensity of fishing effort.

Key findings

- Nearly 60% of respondents across locations categorized their MFAD fishery as either mainly commercial or as subsistence and commercial to similar extents (Fig 5a). Only one respondent (Florida) categorized its MFAD fishery as mainly recreational/charter.
- Most (77%) respondents indicated that vessels fishing on MFAD typically had either 2 or 3 fishers per vessel (Fig 5b).
- The most frequently cited response in terms of the number of boats fishing around a MFAD at the same time was 2-3 boats (45%), followed by >5 boats (33%) (Fig 5c).
- The most frequently cited perception of fishing effort on MFADs was that it was adequate, followed by either low or high to similar extents (Fig 5d).

- In terms of trends over the last five years in the number of boats fishing on MFADs, 11% of respondents indicated a decrease, 42% indicated no change, and 47% indicated an increase in numbers (data not shown).

Seasonality of MFAD fishing

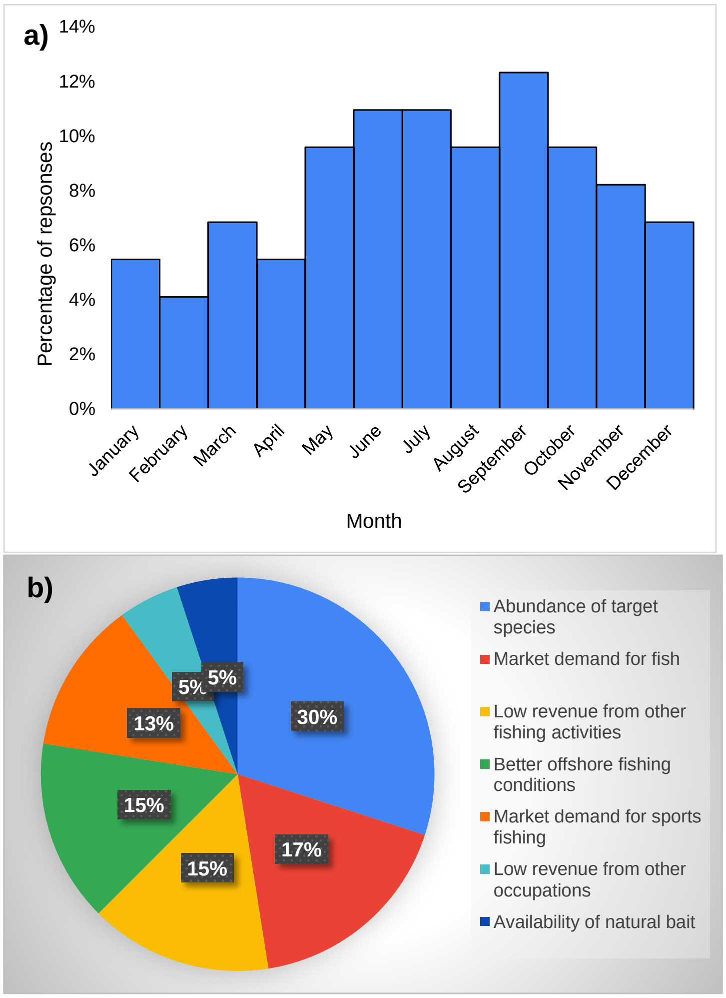

Figure 6 – Seasonality in MFAD fishing as a) frequency of citation of peak months for MFAD fishing and b) reasons as to why MFAD fishing is seasonal.

Key findings:

- Five locations stated that all months were similar when it comes down to MFAD fishing.
- The responses of the rest of the locations supported a peak period for MFAD fishing between May and October (Figure 6), although such finding requires caution in interpretation given the large distances among locations and the multi-species nature of the MFAD fishery.
- Seasonal abundance of target species was by far the most frequently cited (30%) reason to explain seasonality of MFAD fishing.

Characteristics of fishing vessels on MFADs

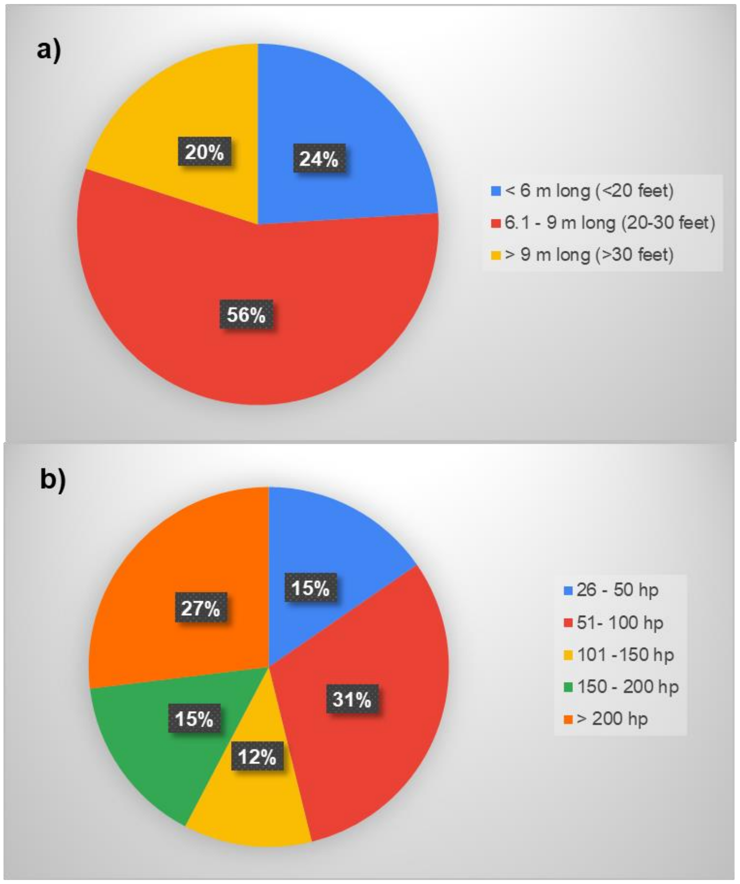

Figure 7 – Characteristics of fishing vessels on MFADs as a) boat length and b) outboard horsepower.

Key findings:

- The majority of the respondents (56%) indicated that boats fishing on MFADs are 6.1-9m long; this category was followed by that of smaller boats (24%) (Fig 7a).
- All respondents cited outboard engines as the main means of propulsion for MFAD fishing, whereas 20% of respondents also indicated inboard engines (data not shown).
- In terms of the horsepower of the outboard engines, the most frequently cited category across respondents was 51-100 hp, followed by that of >200 hp (Fig 7b).
- 85% of respondents indicated that boats fishing on MFAD were equipped with iceboxes; 75% of respondents indicated that boats were not equipped with winches; 50% of respondents indicated that boats were undecked (data not shown).

Regulation of MFADs

Table 4 – Percentage of respondent territories/countries that fall into one of three categories of rule/regulation on 21 aspects of MFADs and MFAD fishing. The 21 aspects are ranked (from top to bottom of the table) by order of decreasing percentage in the category of regulations and rule that exit and are also enforced.

Rule / regulation	Regulations or informal rules exist AND enforced	Regulations or informal rules exist BUT rarely enforced	Regulations or informal rules DO NOT exist
Requiring provision of catch and effort data	58%	11%	32%
Penalties for breaching rules/regulations	53%	11%	37%
How MFADs need to be marked for boat traffic (e.g. light, radar reflector)	53%	16%	32%
Where MFADs can (or cannot) be deployed	50%	11%	39%
Requiring MFAD registration	47%	26%	26%
Who can set MFADs (and how)	47%	32%	21%
Governing who has priority to fish on MFADs (e.g. MFAD owner; commercial vs recreational fishers)	40%	10%	50%
How to apply for permission to set MFADs	40%	40%	20%
How MFADs need to be marked for ownership tracing (e.g. registration #)	33%	11%	56%
Requiring users to have a MFAD fishing licence	29%	18%	53%
Requiring MFAD loss reporting	28%	0%	72%
The distance from a MFAD subject to the regulation (e.g. 1 km radius)	28%	17%	56%
What fishing techniques are (or are not) allowed (e.g. prohibition of certain gears)	25%	15%	60%
How to fish when multiple boats use same MFAD (e.g. clockwise boat movement)	25%	30%	45%
Prohibition of certain MFAD materials	22%	11%	67%
Which fish species/sizes can (or cannot) be targeted	20%	10%	70%
Informing the general public about MFAD location (e.g. press release)	17%	22%	61%
When is fishing allowed (e.g. night vs day fishing; seasonal closures)	5%	0%	95%
Standards for MFAD buoy volume and mooring weight	5%	5%	89%
Minimum distance between MFADs	5%	5%	89%
Maximum MFAD densities allowed	5%	5%	89%

Key findings:

- Only four aspects (out of 21) of the management of MFADs, namely (1) requiring provision of catch and effort data, (2) penalties for breaching regulations, (3) how MFADs need to be marked to avoid collisions at sea, and (4) where MFADs can (or cannot) be deployed, were subject to regulations or rules that were enforced by 50%-58% of the participating territories/countries.
- In contrast, 14 aspects (out of 21) of the management of MFADs, some of which concerned the ecosystem dimension of the fishery (MFAD materials; target species and sizes; MFAD loss reporting) were not the subject of any regulation or rule in most (≥50%) of the participating territories/countries.
- Importantly, only a few locations had a MFAD management plan (Grenada, St Lucia, Bonaire; data not shown); one location (Bermuda) had developed a plan for MFAD monitoring.

Conflicts between MFAD users

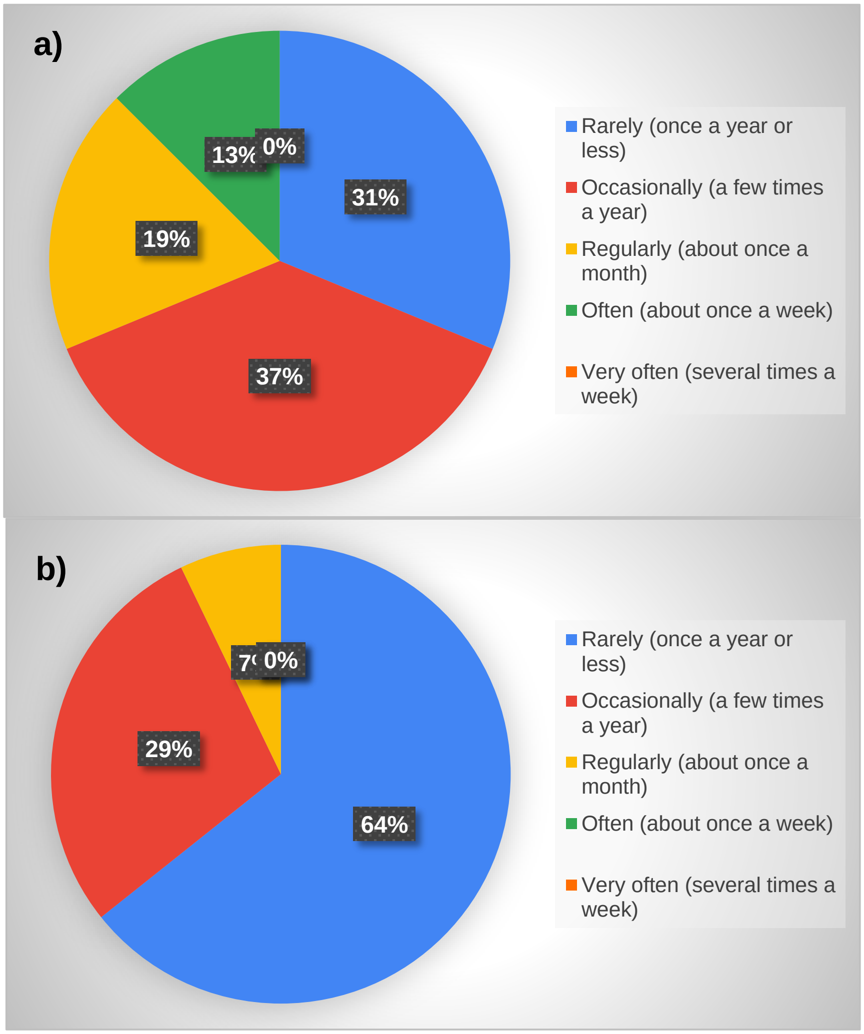

Figure 8. Conflicts among fishers as a) frequency with which conflicts among MFAD fishers occur and b) frequency with which acts of vandalism on MFADs occur.

Table 4. Percentage of responses that fell into different conflict sources

Source of conflict	Percentage
Local fishers fishing on MFADs for which they do not contribute to cover costs	27%
Interference between local commercial and recreational fishers using the same MFAD	20%
Competition between local commercial fishers differing in fishing capacity (e.g. small vs large boats)	13%
Foreign fishers fishing on MFADs in local waters	13%
Interference between local commercial fishers using the same MFAD (e.g. fishing line entaglement)	10%
Different fishing methods interfering with other methods.	3%

Foreign fishers fishing on MFADs in local waters	3%
Anchoring on the MFADs	3%
Interference between MFAD fishers and other users of the sea (e.g. shipping)	3%
Local fishers fishing on MFADs in foreign waters	3%

Key findings:

- The most cited frequency of conflicts among fishers across locations was occasionally (a few times a year), followed by rarely (once a year or less) (Fig 8a). Five territories/countries reported higher frequencies; these were Guadeloupe and Dominica (once a week), followed by Tobago, Curacao, St Lucia (once a month).
- The most cited frequency of acts of vandalism across locations was rarely (once a year or less), followed by occasionally (a few times a year) (Fig 8b).
- When conflicts occurred, the most cited source of conflict was fishers fishing on MFAD for which they do not contribute to cover costs, followed by conflicts between commercial and recreational fishers on MFADs (Table 4).
- Finally, 50% of respondents indicated that foreign fishers illegally set MFADs on their local waters or illegally fished on local MFADs (data not shown).

Fishing techniques on MFADs

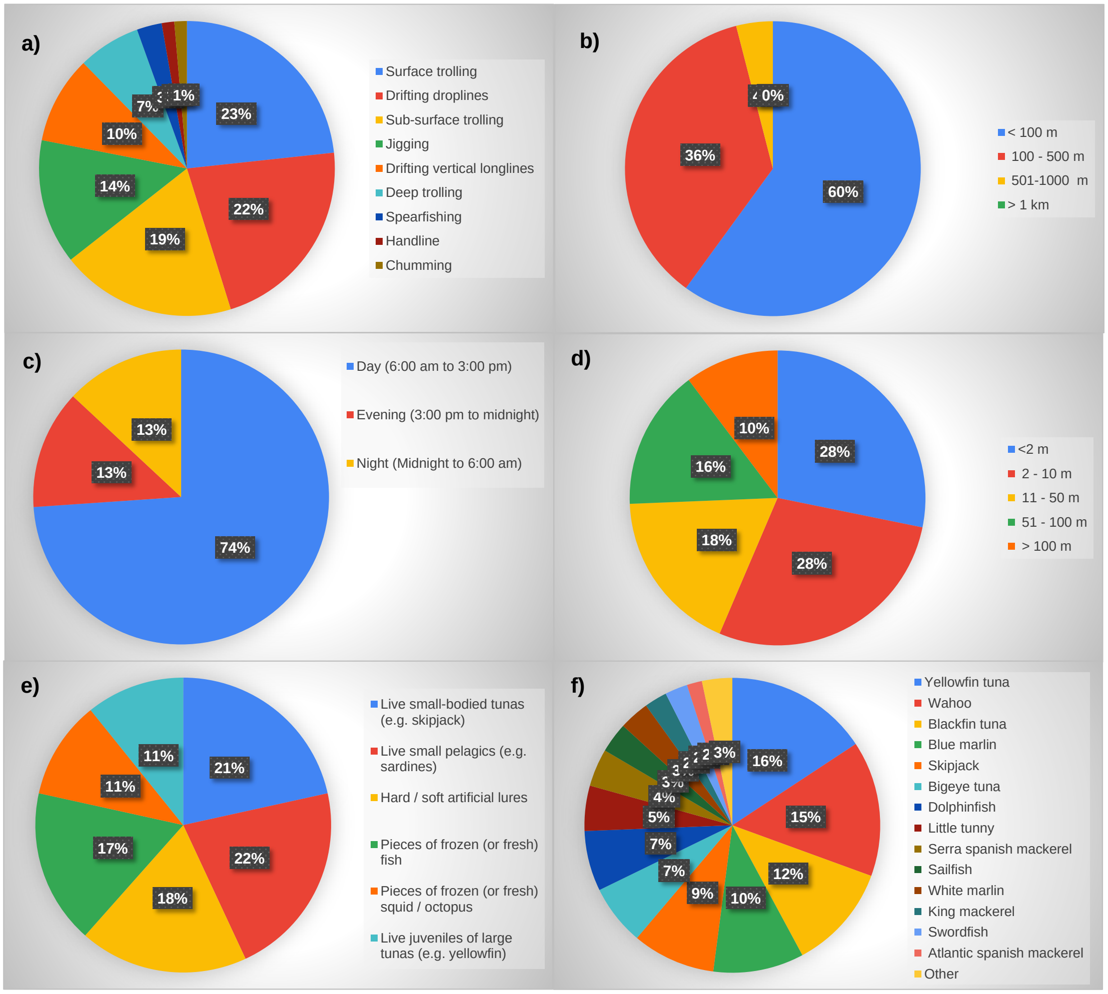

Figure 9 - Fishing on MFADs shown as a) fishing techniques, b) fishing distance from the MFAD, c) time of day for MFAD fishing, d) depth of fishing, e) type of bait, and f) target species.

Key findings:

- Surface (<2m deep) trolling was the most frequently cited fishing technique, closely followed by drifting dropline with live bait, and sub-surface (2-10 m deep) trolling (Fig 9a).
- The most cited fishing distance from a MFAD was <100m (Fig 9b), supporting that fishing in most locations took place very close to the MFAD.
- The most cited time of day for MFAD fishing was overwhelmingly during the day (Fig 9d).
- The most cited fishing depths were the <2 m and 2-10 m intervals, with similar frequencies, in line with surface and sub-surface trolling being very frequently used techniques on MFADs (Fig 9a).
- The most cited bait types were live small pelagics (e.g. sardines, pilchards, flyingfish and similar) followed closely by live small-bodied tunas (e.g. skipjacks, mackerels, scads, little tunnies, etc). In third place came the use of artificial lures (e.g. octupus, poppers).
- The most cited target species were, by decreasing order of importance, yellowfin tuna, wahoo, blackfin tuna, blue marlin and skipjack, which jointly accounted for most (>50%) of the citations.

- The proportion of catch that was made up of small fish (<2kg in individual weight) that was most frequently cited was <25% (67% of responses), followed by 25-50% (27%) and >50% (7%) (data not shown).

Incidental by-catch

Table 5. Percentage of responses seeking to categorize the frequency of incidental catch on MFADs of four animal groups

Animal group	Rarely (once a year or less)	Occasionaly (a few times a year)	Regulalry (about once a month)	Often (about once a week)	Very often (several times a week)
Marine mammals	100%	0%	0%	0%	0%
Sea turtles	100%	0%	0%	0%	0%
Sea birds	89%	11%	0%	0%	0%
Sharks	50%	38%	0%	0%	13%

Key findings:

- This section was optional depending on availability of information locally. Only nine locations proceeded to answer this section.
- The most cited frequency of incidental catch was rarely (once a year or less) for all animal groups, although for sharks the occasionally category was also reasonably highly cited (Table 5).
- 75% of respondents indicated that, compared to target species, catches of non-target fish species occurred rarely, whereas the remainder 25% of respondents indicated that it occurred at frequently as targeted ones (data not shown).
- Sharks were identified as one of the most frequently caught non-target fish species (66.7% of respondents; data not shown).

Monitoring of fishing trips

Table 6. Percentage of territories/countries (out of 15) that collect data on 12 variables from fishing trips to MFADs

Variable	Yes	Some times	No
MFAD ID or location	38%	23%	38%
Time spent fishing	87%	13%	0%
Time spent travelling	43%	14%	43%
Number of fishers on boat	87%	7%	7%
Fishing techniques used	93%	7%	0%
Number of fishing lines in the water	50%	17%	33%
Total weight landed	93%	7%	0%
Weight landed by species	86%	14%	0%
Fuel consumption and other expenses	36%	29%	36%
Estimate of revenue from sale	64%	7%	29%
Number of fish landed	47%	27%	27%
Number of fish landed by species	47%	33%	20%

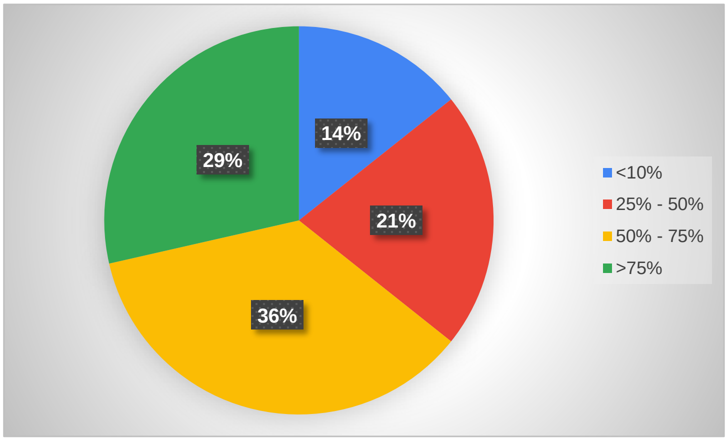

Figure 10 – Sampling coverage of the total number of fishing trips to MFADs during fishery data collection

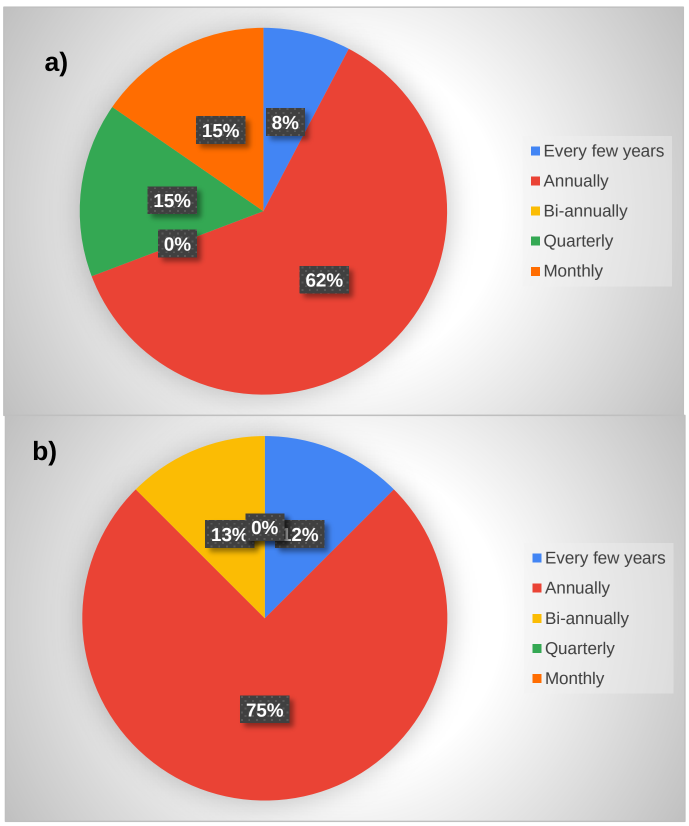

Figure 11 – Frequency with which fishery data are used to a) inform policy, and b) inform fishers and other stakeholders

Key findings:

- 15 of the 20 of the participating countries/territories (75%) are engaged in fishery data collection involving MFAD fishing trips, and these countries use a standardized form for data collection.

- At least 80% of these 15 countries explicitly distinguish between MFAD fishing and other types of fishing during data collection.
- Variables that are well represented (a "Yes" in >75% of respondents) across locations/territories during data collection are (1) time spent fishing, (2) number of fishers on boat, (3) fishing techniques used, (4) total weight landed, and (5) total weight landed by species. Variables that are poorly represented (a "Yes" in < 38% of respondents) are MFAD ID or location and fuel consumption expenses (Table 6).
- The most cited sampling coverage of fishing trips to MFADs was 50-75%, which was listed by 36% of the respondents (Fig 10). This sampling coverage was followed by the 25-50% category, with 21% (Fig 10).
- Across locations, the most cited frequency with which fishery data were used to inform policy (62% of respondents; Fig 11a) and fishers and other stakeholders (75% of respondents; Fig 11b) was annually.

Safety at sea

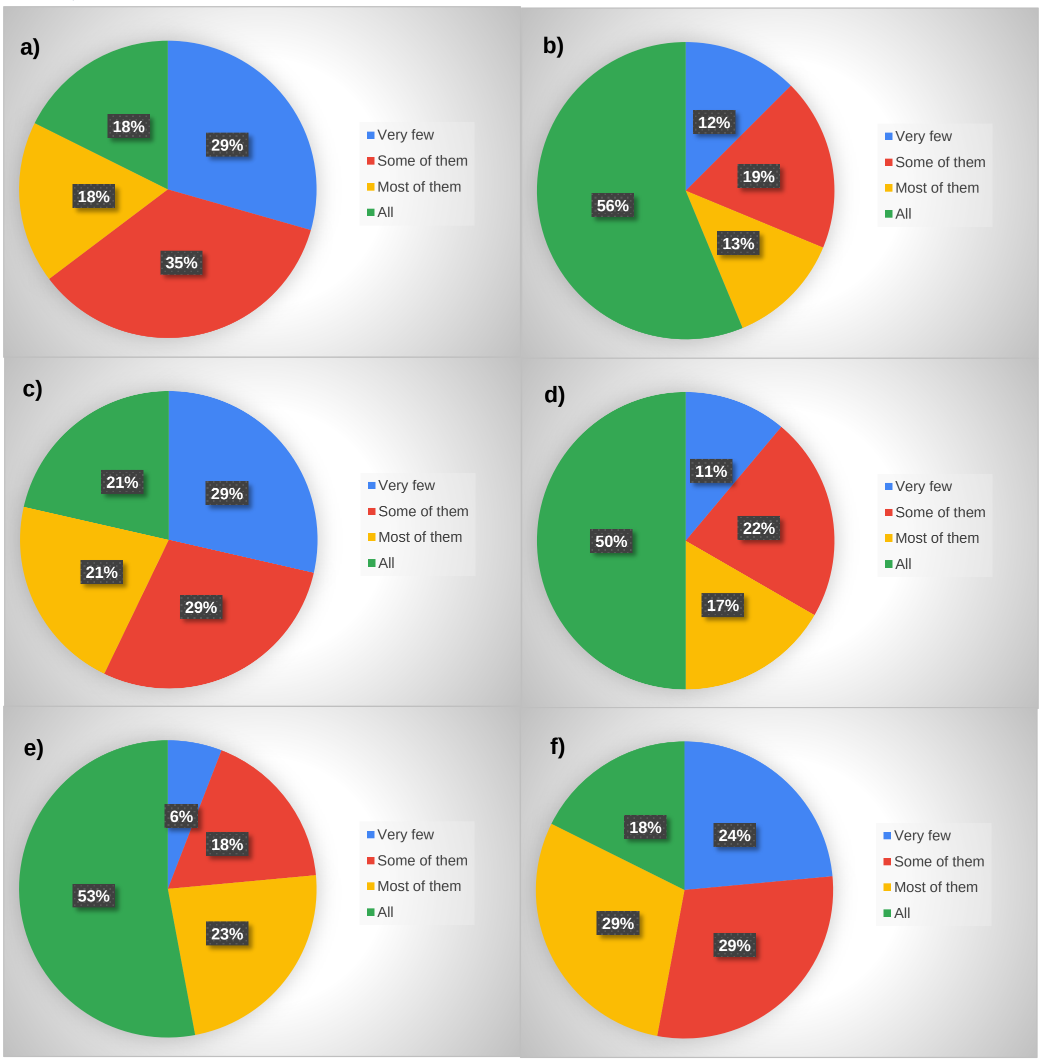

Figure 12 – Safety at sea conditions for MFAD fishers based on a) training in safety at sea, b) having safety signaling equipment (e.g. VHF / radio-telephone, torch, flares, mirror, air horn, etc), c) having alternative means of propulsion (e.g. oars, sail rigs, auxiliary engine), d) having emergency flotation devices (e.g. floats, life-jackets, large plastic

containers), e) having navigation equipment (e.g. compass, GPS), and f) having personal protective gear to handle large fish (e.g. noose, boots, gloves).

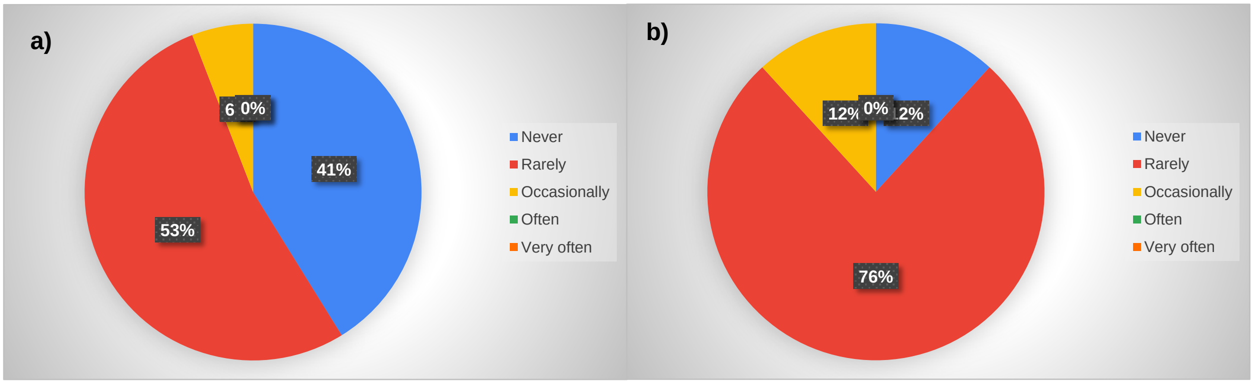

Figure 13 – Accidents at sea while a) deploying MFADs and b) fishing on MFADs

Key findings:

- The most cited number of fishers across the territories/countries that have training in safety at sea was "*some of them*", followed by "*very few*", with 35% and 29% of respondents, respectively (Fig 12a).
- The most cited number of fishers across the territories/countries that have safety signaling equipment was by far "*all*", with 56% of locations (Fig 12b)
- The most cited numbers of fishers across the territories/countries that have alternative means of propulsion are "s*ome of them*" and "*very few*", with 29% of respondents each (Fig 12c).
- The most cited number of fishers across the territories/countries that have emergency flotation devices is by far "*all*", with 50% of locations (Fig 12d)
- The most cited number of fishers across the territories/countries that have navigation equipment is by far "*all*", with 53% of locations (Fig 12e)
- The most cited numbers of fishers across the territories/countries that have personal protective gear are "s*ome of them*" and "*most of them*", with 29% of respondents each (Fig 12f), followed by "*very few*" with 24%.
- Overall, in the majority (≥50%) of locations most fishers (1) had safety signaling equipment, (2) had emergency flotation devices, and (3) had navigation equipment; however, (4) they were not trained in safety at sea, (5) did not have alternative means of propulsion in their vessels, and (6) did not wear personal protective gear to handle large fish.
- Finally, the most cited frequency at which accidents happen at sea while deploying MFADs (Fig 13a) or fishing on MFADs (Fig 13b) was "*rarely*".

Fish handling at sea

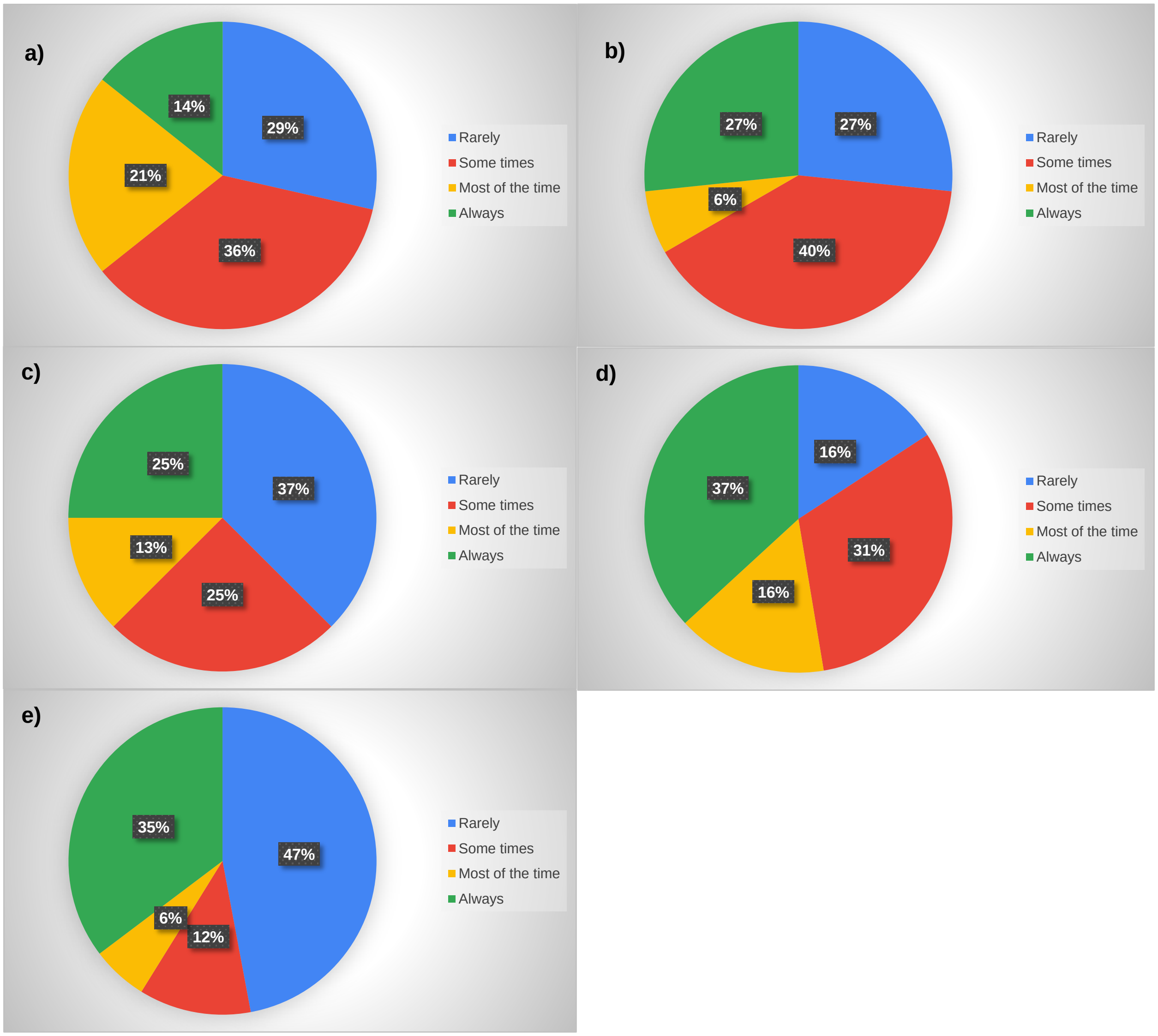

Figure 14 – Practices in handling of large fish as the frequency across territories/countries with which a) fish are spiked onboard, b) fish are bleed out onboard, c) fish are gutted onboard, d) fish are preserved in ice, e) there are adequate facilities at the landing sites to handle large fish.

Key findings

- The most cited frequency across territories/countries with which fishers spiked fish onboard was “sometimes” (36% of respondents), followed by “rarely” (29%) (Fig 14a).
- The most cited frequency across territories/countries with which fishers bled fish out onboard was “sometimes” (40% of respondents), followed by “rarely” (27%) (Fig 14b).
- The most cited frequency across territories/countries with which fishers gut fish onboard was “rarely” (37% of respondents), followed by “sometimes” (25%) and “always” (25%) (Fig 14c).
- The most cited frequency across territories/countries with which fishers preserved fish in ice onboard was “always” (37% of respondents), followed by “sometimes” (31%) (Fig 14d).

- If we consider the spiking, gutting and bleeding out of large fish onboard as best practices, then the survey supports that in most locations fishers are not consistently adhering to them. The exception is the use of ice onboard, which appears to happen most of the time (or always) across most locations, although in a very substantial fraction of locations (47%) it is only used sometimes or less. Overall, the survey suggests considerable heterogeneity across the region in these onboard practices (Fig 14a-d).
- Finally, the most cited frequency across territories/countries with adequate facilities to handle large fish were available "rarely" (47% of respondents), followed by "always" (35%) (Fig 14e), highlighting again strong differences among locations.

Fishing trip characteristics

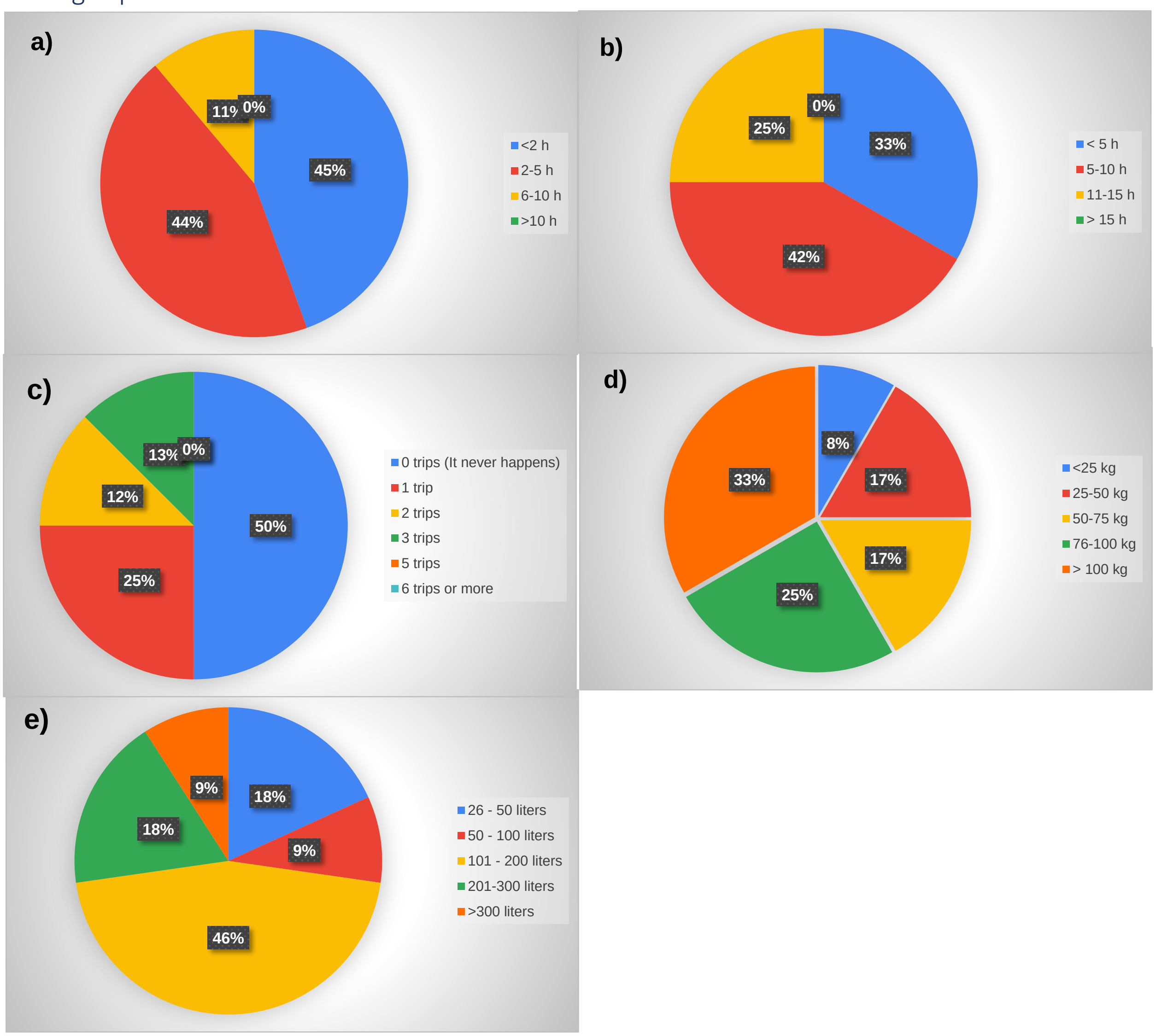

Figure 15 - Fishing trip characteristics as a function of a) time spent fishing, b) fishing trip duration, c) number of trips (out of 10) with zero catch during peak MFAD season, d) most common landed weight from fishing trip during peak MFAD seasons, e) most common fuel consumption during MFAD fishing trip.

Key findings

- This section was optional depending on availability of information locally. Only 12 locations proceeded to answer this section.
- The most cited time spent fishing across territories/countries was <2 h (46%), followed closely by 2-5 hours (44%) (Fig 15a).
- The most cited duration of a fishing trip across territories/countries was 2-5 h (42%), followed by <2 h (33%) (Fig 15b).
- The most cited number of trips with zero catch (out of 10) across territories/countries during peak MFAD season was 0 trips, which accounted alone for half the records (Fig 15c).
- The most cited number landed weight from MFAD fishing across territories/countries during peak MFAD season was >100 kg (33% of respondents), followed by 76-100 kg (25% of respondents) (Fig 15d).
- The most cited number fuel volume consumption from MFAD fishing across territories/countries was 101-200 liters (46% of respondents) (Fig 15e).

Socio-economic factors associated with MFAD fishers

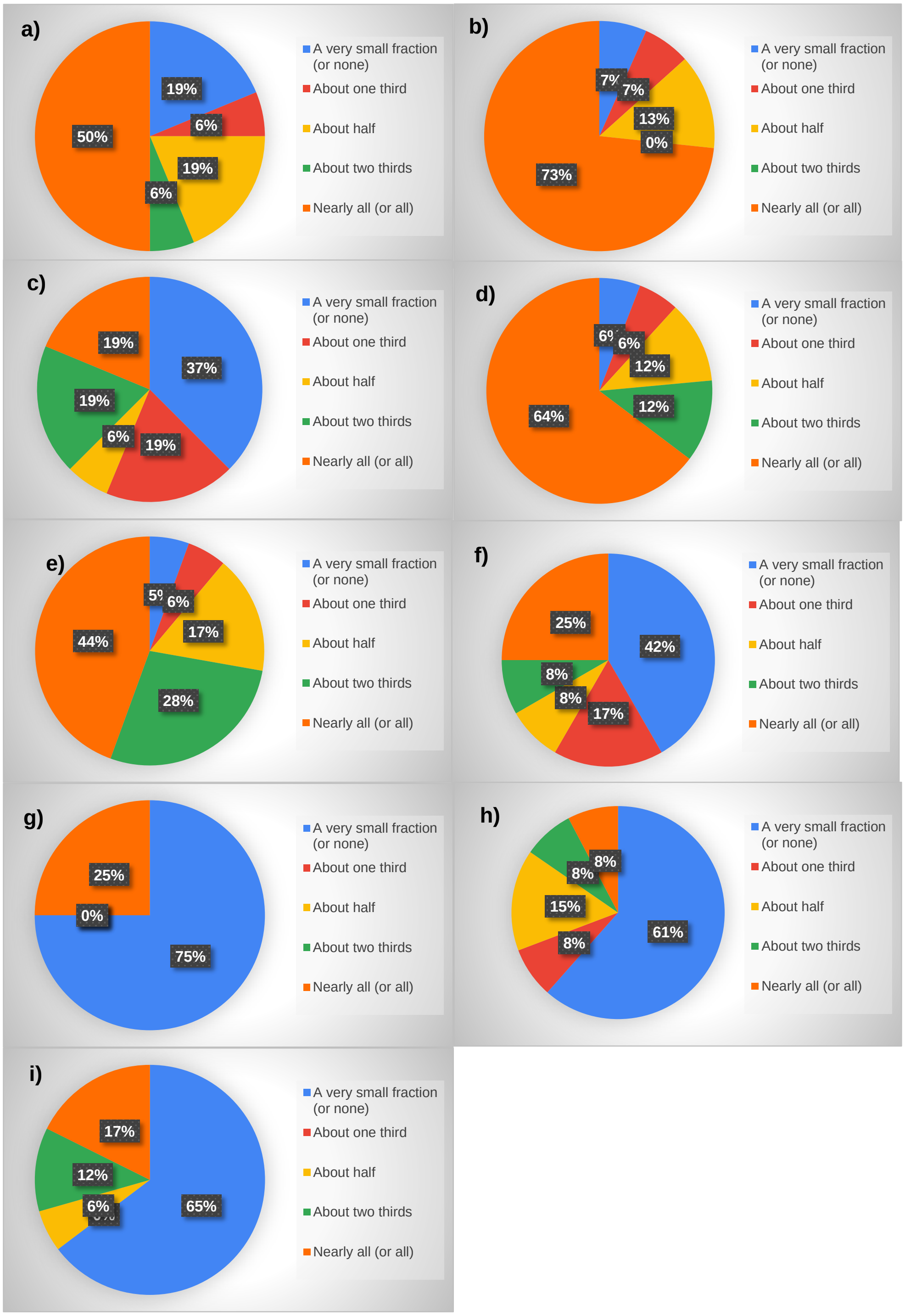

Figure 16 - Socio-economic factors associated with MFAD fishers across territories/countries as proportion of fishers that a) are full time fishers, b) used to fish before MFADs were introduced, c) also have jobs outside fishing, d) also practice other types of fishing, e) own their own boats, f) have easy access to credit lines, g) are subsidized in any way by government or non-government entities, h) are trained in small business management, and j) have access to training on MFAD use.

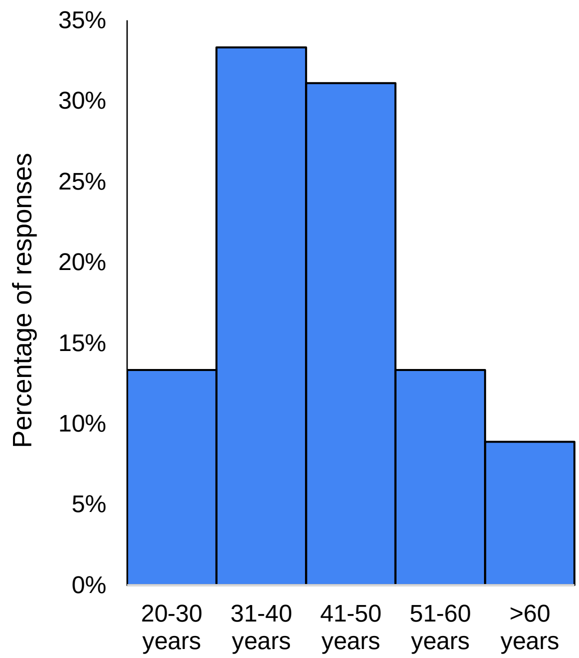

Figure 17 – Size-frequency distribution of ages of MFAD fishers across territories/countries across the region.

Key findings:

- 50% of locations indicated that MFAD fishers are full time fishers, for the rest of locations the situation was very diverse (Fig 16a)
- 75% of locations indicated that fishers used to fish before MFADs were introduced (Fig 16b).
- 37% of locations indicated that a very small fraction of fishers had jobs outside fishing, and this was followed by 19% of locations indicating that only about 1/3 of fishers had jobs outside fishing (Fig 16c). However, there remains a significant fraction (38%) of locations, where either most or all fishers do have jobs outside fishing (Fig 16c).
- 64% of locations indicated that nearly all fishers practiced other types of fishing, but with contrasting patterns across locations (Fig 16d). For example, comments in the survey indicated that in the Dominican Republic, MFAD fishers were highly professionalized and very few practiced other types of fishing, whereas in Guadeloupe, nearly all fishers practiced other types of fishing. Alternative types of fishing included pots (fish, lobster), nets, hand lines, and seines
- 44% of locations indicated that fishers owned their own boats and gear, which was followed by 28% of locations indicating that about two thirds of fishers owned their own boat and gear (Fig 16e).
- There were contrasting findings across locations in terms of access to credit lines, whereas 42% of locations reported that only a small fraction of fishers had access to credit, 25% of locations reported the opposite, with nearly all fishers having access to credit (Fig 16f).
- Similarly, although 75% of locations reported that only a small fraction of fishers was subsidized by government or non-government entities, 25% of locations reported the opposite, with nearly all fishers being subsidized (Fig 16g).
- In the majority of locations (61%) fishers were not trained in business management (Fig 16h)

- In the majority of locations (65%), fishers did not have readily access to MFAD training, although this was the opposite in 17% of locations (Fig 16i).
- The most frequently cited age groups for MFAD fishers across locations was the 31 to 50 years groups (Fig 17).
- 29% of locations reported that MFAD fishers tended to be younger than other types of fishers, whereas 65% indicated that there was no difference in age (data not shown).

Sharing of responsibility between government and fishers

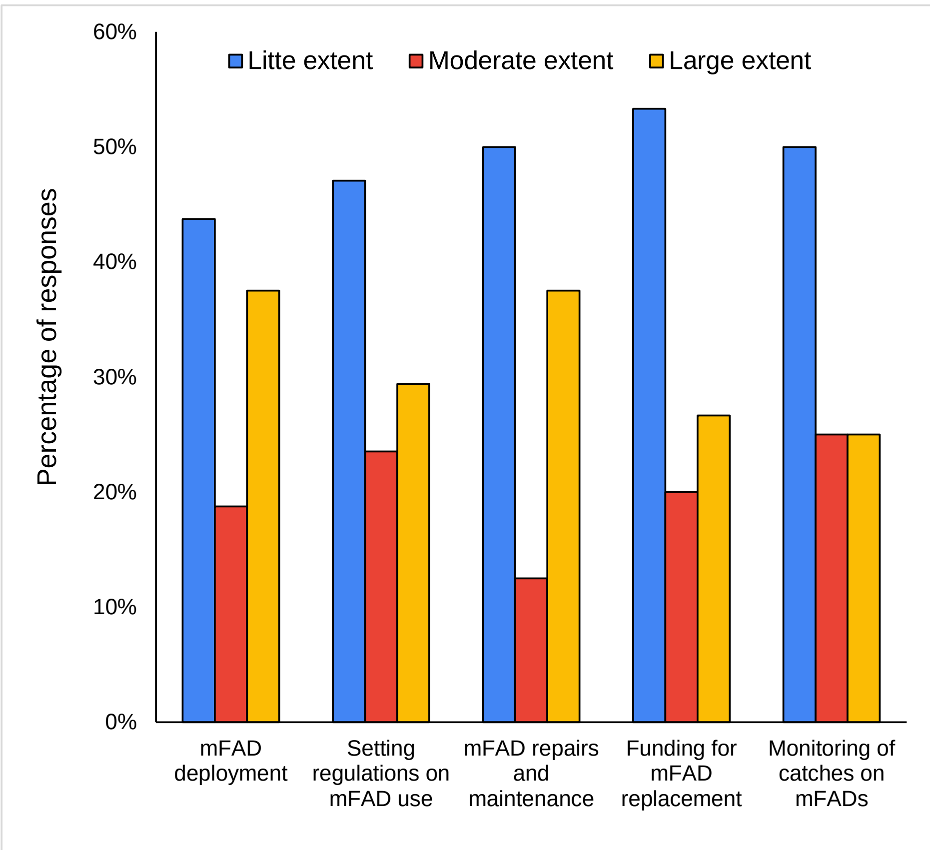

Figure 18 – Degree to which fishers and government share responsibility in various aspects of MFAD management

Key findings:

- Overall, between 44% and 53% of locations indicated that there was little sharing of responsibility between fishers and government when it came to MFAD deployment, setting regulations on MFAD use, MFAD repairs, MFAD funding and monitoring of catches on MFADs.
- However, another 29% and 38% of locations did indicate a large extent of shared responsibility in at least some aspects of management, namely MFAD deployment, setting regulations and MFAD repairs and maintenance.
- Thus, there appears to be substantial differences across locations in the extent that government and fishers work together for at least some aspects of MFAD management, highlighting the potential for the transferability of lessons learned between locations.

Familiarity with CRFM MFAD manuals and CARAFAD

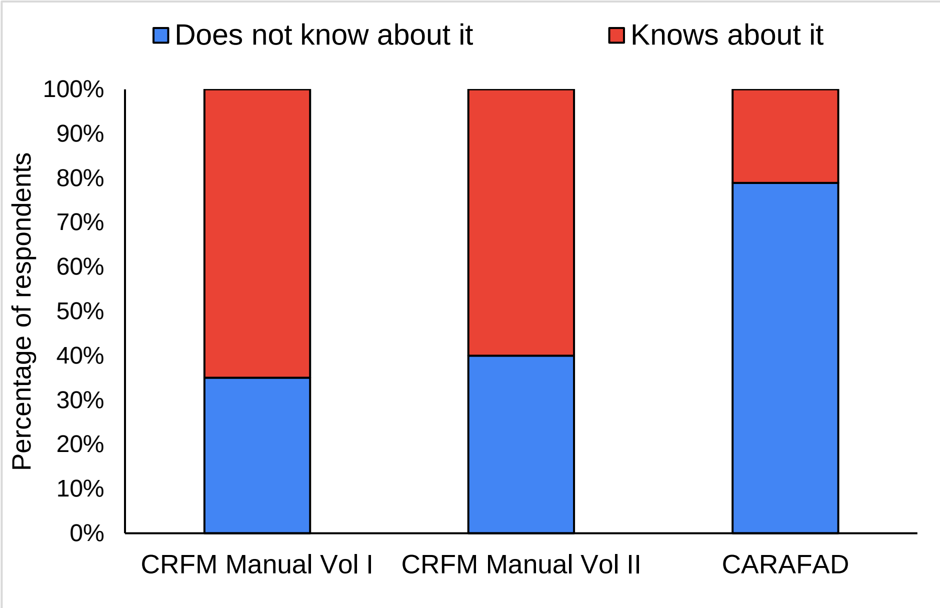

Figure 19 – Percentage of respondents that know about the CRFM Manual Volumes I (FAD design, construction, and deployment) and II (Maintaining good quality of FAD-caught fish) and about the Caribbean Anchored Fish Aggregating Devices (CARAFAD) website hosted by IFREMER (https://wwz.ifremer.fr/carafad/).

Key findings:

- Most respondents (≥60%) knew about the CRFM manuals, but very few respondents (21%) knew about the CARAFAD website. Interestingly, the respondent from the only Spanish-speaking location (the Dominican Republic) did not know about any of these outputs.
- All those respondents who commented on the manuals (40% of respondents) found them useful.

Prioritizing issues and challenges in MFAD management

Table 7. Degree of urgency in addressing management challenges as indicated by the 20 territories/countries across the region. Higher values (red) indicate higher urgency and consistency across locations. The issues were largely based on issues identified in the CRFM (2015) plan

Territory (or country)	Severity / urgency score
Inexistent/inadequate local capacity to enforce regulations	3.1
High fuel consumption and costs	3.1
Weak organization of mFAD fisher groups	3.1
Inexistent/inadequate fisher training in business management	3.0
Inexistent/inadequate local mFAD management plans	2.8
Inexistent/inadequate local mFAD regulation	2.7
Inexistent/inadequate representation in ICCAT	2.7
Insufficient reduction of fishing pressure on coastal/reef resources	2.7
Weak governance structure across stakeholder groups	2.6
Inexistent/inadequate systems for repair and maintenance of deployed mFAI	2.6
Inexistent or poor data collection systems (biological, economical)	2.6
IUU fishing	2.5
Inadequate commercialisation circuits for target species	2.5
Low capacity to replace lost mFADs	2.4
Impact of Sargassum on fish abundance around mFADs	2.4
Lack of adequate facilities/infrastructure to handle large pelagics	2.4
Inexistent/inadequate sharing of info/data on mFADs across region	2.4
Inadequate mFAD designs for local context	2.3
Lack of safety at sea (mFAD deploying and fishing)	2.3
Fishing of juvenile fish (e.g. yellowfins) for commercial purposes	2.3
Lack of access of mFAD fishers to training	2.3
Poorly equipped boats for mFAD fishing	2.3
Inexistent/insufficient mFAD fisher participation in decision making	2.2
Competition with fish imports	2.2
Fluctuating or low prices for target species	2.1
High levels of marine littering via mFAD losses	2.1
Low or highly variable catches on mFADs	2.0
Conflicts between local and foreign mFAD fishers	2.0
Intense targeting of regionally-overexploited species (e.g. blue marlin)	1.9
Transboundary fishing	1.8
Conflicts between local commercial mFAD fishers	1.8
Uncontrolled/excessive proliferation of mFADs	1.8
Conflicts between local commercial vs recreational mFAD fishers	1.7
Disruption of fish migrations	1.7
Conflicts with other sea users (e.g. shipping)	1.4
High catches of non-target species (e.g. sea turtles)	1.3

Table 8. Heatmap of urgency scores in addressing issues surrounding the MFAD fishery across 20 territories/countries. Red values indicate higher urgency.

Territory (or country)	Inexistent/inadequate local capacity to enforce regulations	High fuel consumption and costs	Weak organization of mFAD fisher groups	Inexistent/inadequate fisher training in business management	Inexistent/inadequate local mFAD management plans	Inexistent/inadequate local mFAD regulation	Inexistent/inadequate representation in ICCAT	Insufficient reduction of fishing pressure on coastal/reef resources	Weak governance structure across stakeholder groups	Inexistent/inadequate systems for repair and maintenance of deployed mFADs	Inexistent or poor data collection systems (biological, economical)	IUU fishing	Inadequate commercialisation circuits for target species	Low capacity to replace lost mFADs	Impact of Sargassum on fish abundance around mFADs	Lack of adequate facilities/infrastructure to handle large pelagics	Inexistent/inadequate sharing of info/data on mFADs across region	Inadequate mFAD designs for local context	Lack of safety at sea (mFAD deploying and fishing)	Fishing of juvenile fish (e.g. yellowfins) for commercial purposes	Lack of access of mFAD fishers to training	Poorly equipped boats for mFAD fishing	Inexistent/insufficient mFAD fisher participation in decision making	Competition with fish imports	Fluctuating or low prices for target species	High levels of marine littering via mFAD losses	Low or highly variable catches on mFADs	Conflicts between local and foreign mFAD fishers	Intense targeting of regionally-overexploited species (e.g. blue marlin)	Transboundary fishing	Conflicts between local commercial mFAD fishers	Uncontrolled/excessive proliferation of mFADs	Conflicts between local commercial vs recreational mFAD fishers	Disruption of fish migrations	Conflicts with other sea users (e.g. shipping)	High catches of non-target species (e.g. sea turtles)
Tobago	4	4	3	3	4	4	3	3	3	3	3	4	3	3	4	3	3	4	4	4	3	4	3	3	3	2	3	2	3	3	3	3	1	3	1	4
Bonaire	4	3	4	4			3	4	4	3	4	4	1	1		4	4	2	3	4	3	3	2	1	4			4	4	4	4		2	3		1
Dominica	4	4	4	4	4	4	3	4	3	3	2	3	3	4	2	4	2	2	2	3	3	3	3	3	3	3	3	4	4	3	4	2	1	2	1	1
Guadeloupe	4	4	4	4	4	4	3	3	4	4	1	3	3	4	3	2	3	4	3	1	3	3	3	3	2	4	1	2	1	2	4	4	3	3	2	1
St. Eustatius	4	4	4	3	4	4	3	4	4	4	4	3	1	2	3	3	4	3	3	3	4	4	3	3	1	2	4		2	3	1	2	1		1	2
Anguilla	4	4	4	3	3	3	4	3	4	2	4		3	1	2	4	3	2	3	2	3	2	4	4	3	2	2	4	1	2	4	3	2	3	1	2
Montserrat	4	4	4	4	4	4	1	1	4	4	4	4	1	4	4	4	1	4	4	3	4	4	3	1	1	4	3	1	1	1	1	1	1		3	1
Haiti (southeast)	4	2	2	4	4	4	4	1	3	2	4		4	4	1	4	4	1	3	3	3	3	2	4	2	4	2	3	2		2	4	1	2	1	1
Republica Dominicana	2	4	2	4	4	4	4	2	2	1	1	1	4	1	3	4	1	3	4	1	4	4	2	4	4	1	4	2	2	1	1	2	3	1	1	1
Puerto Rico	3.5	1.5	3	2.5	3.5	3.5	4	4	2.5	4	3.5	3	1	4		1	3	2.5	1.5	4	2	1	2.5	2.5	1	3	1.5	1.5	3	1	1.5	2	2	1	3	1
Curaçao	1	4	4	4	4	4	4	4	3	4	4	1	1	4	1	1	3	2	1	1	1	1	4	3	1	1	3	1	1	1	1	1	1	1	1	1
Martinique	1	4	4	2	3	1	2	4	2	4	1	1	3	4	2	3	1	1	4	3	1	3	1	1	1	2	1	2	3	1	1	2	3	1	1	1
Grenada	4	4	1	3	1	4	4	1	1	1	1	1	4	1	4	1	3	2	1	3	1	1	3	1	4	1	1	1	1	2	1	1	1		1	1
St Lucia	3	3	3	3	1	1	3	1	2	2	1	3	3	2	4	2	3	1	1	3	3	1	1	1	1	1	1	1	1	1	1	1	3	1	3	1
St. Vincent and the Grenadines	3	1	4	4	2	1	1	3	4	2	2	2	3	2	1	1	1	1	3	1	1	3	3	1	3	1	1	1	1	1	1	1	1	1	1	1
Antigua and Barbuda	4	3	3	1	2	1	1	1	1	1	3	4	3	1	1	1	1	1	1	1	1	1	1	4	1	2	1	4	2	4	1	1	1	1	1	1
Saba	4	2	1	1	2	2	1	3	1		2	4	3			1	2	4	1	1	1	1	1	1	1	2	1	1		1	1	1	2		2	1
Florida	1	2	2	1	2	1	2	2	2	1	3	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	3	1	1	1
Bermuda	3		2		1	1	1		1		1	1				2	1	4	1		1	1	1	1		1		1		1		1				
Cayman Islands	1	1			1	1			2	1				1		1	2	1	1	1		1	1	1				1	1		1	1	1		1	1

Key findings:

- The most frequently identified high-priority issues across the region involved weak MFAD management and governance structures, including inexistent or inadequate local capacity to enforce regulations, weak organization of MFAD groups, and inexistent or inadequate local MFAD management plans and regulations (Table 7). Another important priority across the region was the lack of fisher training in business management, which speaks to the economic dimension of MFAD fishing (Table 7). Other high-priority concerns bring into question some of the widely accepted assumptions about MFAD fisheries, namely that they lead to a reduction in fuel consumption costs and that they lead to a reduction in fishing pressure on nearshore/coastal resources (Table 7). All the above issues should be considered regional priorities based on their region-wide recognition.
- Under this general background of poor management systems, there still appeared to be considerable variability across the region in the scoring of priorities. Indeed, the heatmap (Table 8) broadly separated the locations in two halves. The first half included locations that tended to assign a high priority score to most issues (Table 8: first 10 territories/countries from top to bottom) and the second half included locations that either generally assigned low priority scores to most issues or only assigned high priority scores to a much smaller sub-set of issues (Table 8: last 10 territories/countries from top to bottom). This highlights that some important challenges will be location-specific such the adequacy or existence of fishery data collection systems and will require a more refined understanding of local context and likely more resources to solve.
- Finally, the territories/countries that scored most issues as high priority (Table 8: first 10 territories/countries from top to bottom) include those with some of the highest number of MFADs and/or MFAD fisher populations (e.g. Dominican Republic, Guadeloupe, Haiti, Dominica), supporting the need to prioritize efforts at these specific locations.

Conclusion

The survey has confirmed that MFADs are widely used across the insular Caribbean, with temporal trends over the last five years indicating stable or increasing MFAD numbers. With estimates of 3,600+ deployed MFADs across the region, the data presented corroborate the recent findings by Wilson et al. (2020). Moreover, estimates of 6,200+ fishers and 2,600+ vessels engaged in subsistence and/or commercial MFAD fishing across the region support that MFADs are contributing significantly to improve fisher livelihoods and food security in the insular Caribbean (Montes et al. 2017; Vallès 2018; Montes et al. 2019; Defoe 2020), as they do in other regions (Sharp 2011; Albert et al. 2014; Sharp 2014; Albert et al. 2015; Tilley et al. 2019).

From a governance perspective, the survey corroborates the lack of comprehensive MFAD fishery management systems and regulations across the region and reveals a heterogenous regulatory landscape, in line with previous reports (FAO 2007; CRFM 2015; Wilson et al. 2020). Moreover, these deficiencies in management systems and regulations were consistently perceived as high priority across most locations. Where regulations exist, they tend to focus on aspects of governing MFAD registration, MFAD location and who has access to MFADs. In contrast, little attention has been given to governing other important aspects of MFAD use such as limits to MFAD numbers, standards and materials for MFAD construction, MFAD loss reporting, fishing techniques and target fish species and/or sizes on MFADs, and potential seasonal closures on MFADs. These regulation gaps will need to be addressed if the ultimate goal is to harmonize efforts with those of the larger-scale pelagic fleets targeting the same species (e.g. yellowfin tuna) in the region (ICCAT 2020). Overall, these findings highlight the urgent need to develop comprehensive local MFAD management plans across the region (CRFM 2015; Sadusky et al. 2018). Such management plans should obviously be informed by existing formal or informal governance structures (e.g. Guyader et al. 2018; Bugeja Said et al. 2021). They should also further help reduce potential conflicts among MFAD users, even though the survey suggested that such conflicts tend to be infrequent in most, but not all, locations. These local MFAD management plans should integrate adequate fishery data collection systems to assess whether socio-economic management objectives are being achieved while ensuring the long-term sustainable exploitation of the stocks. In that regard, the survey highlighted that most locations are engaged in some form of standardized fishery data collection involving MFADs, but that there is considerable discrepancy in data requirements across locations, bringing to light previous efforts to standardize data collection systems across the region to ensure adequate management of regional straddling fish stocks (Barnwell 2014; Mohammed 2015). Importantly, the survey also reveals a very heterogenous socio-economic and governance landscape across the region within which the MFAD fisheries operate. Depending on location, fishers might occupy very different positions along a continuum of access to private funding, subsidies and training, job opportunities outside fishing, engagement in coastal fishing, and sharing of responsibility with government agencies on MFAD governance. These conditions will also need to be carefully and further mapped and understood when developing local MFAD management plans.

The survey has also confirmed that the distribution of MFAD across the region remains highly patchy, with a few locations (namely the Dominican Republic and Guadeloupe) accounting for the vast majority of deployed units. From an ecological perspective, the impact of such patchy MFAD distribution on the movement of straddling stocks is unknown since we lack the understanding of the scales at which such stocks respond to the presence of islands and MFADs within island shelves (Kleiber and Hampton 1994; Dagorn et al. 2007; Sinopoli et al. 2019) in the region. In contrast, it is clearer that marine litter derived from lost MFADs (e.g. concrete blocks, tarpaulins, etc) might be substantial and will likely mirror such patchy distribution (Sinopoli et al. 2020), particularly given the fact that nearly all MFADs in the region are private and thus more prone to be lost and replaced (but not recovered) within a year after deployment, as suggested by the survey. These private MFADs are also less likely to have clear marking identifying owners, which goes against the best practices set by the Voluntary Guidelines on the Marking of Fishing Gear (FAO 2019). The ecological significance of such marine litter will depend on the types of habitats MFAD are deployed in and on the extent that MFAD designs integrate non-biodegradable materials (Sinopoli et al. 2020), which in the Caribbean is likely to be substantial. In contrast, the survey did not support that incidental by-catch of marine mammals, sea birds, and sea turtles on MFADs was a frequent nor wide-spread problem in the region. This might be partially explained by the fact that the use of entangling materials as aggregators appears to take place in only a few locations, but it might also reflect a lack of data on these animal groups. However, the fact that sharks were found to be caught more frequently as by-catch than these other groups, which is expected given the fishing techniques used, lends some credibility to these findings, at least in relative terms. Similarly, the finding that small fish (<2kg) appeared to make up less than 25% of the typical catch in most locations suggests that impacts on juvenile fish (Morgan 2011; CRFM 2015) might be less widespread than previously thought. However, great caution is needed in interpreting these findings in the absence of actual biological data, the multi-species nature of the MFAD fishery, and the fact that even though juveniles might represent less than 25% of the catch in most locations, they are still likely to dominate catches numerically (Reynal et al. 2002). In contrast, the fact that blue marlin was within the five most cited target species across the region, consistent with independent catch reports for this species throughout the insular Caribbean (CRFM 2015; Arocha 2021), continues to warrant particular attention given the current overfished status of the stock (Arocha 2021). Finally, and importantly, examination of the priority issues consistently identified across the region suggests that MFADs have not led to a tangible and wide-spread reduction in fishing pressure on coastal resources. This is further supported by the finding that most MFAD fishers continue to practice other types of fishing across most locations. These two lines of evidence, combined with the few available empirical studies in the region (Mathieu et al. 2014; Defoe 2020), bring into question the widely accepted assumption that MFAD programmes on their own will led to a reduction in fishing pressure on overexploited coastal resources.

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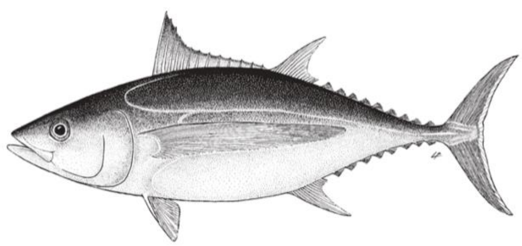
Appendix III – Biology, distribution, fishery status, and most recent stock assessment status of large oceanic and coastal pelagic species typically targeted on Moored Fish Aggregating Devices (MFADs) in the Wider Caribbean

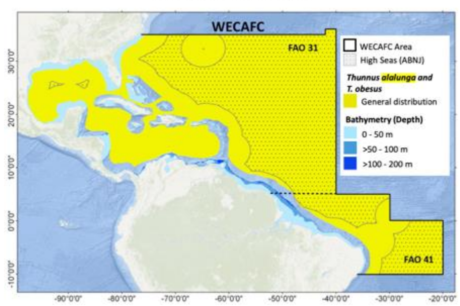
The information below provides a summary of the biology, distribution, fishery status, and most recent stock assessment status for major tunas (yellowfin, skipjack, albacore, bigeye), small tunas (blackfin, little tunny, frigate and bullet tuna, Atlantic bonito), tuna-like species (billfishes, swordfish, dolphinfish) and large pelagics (mackerels) based on Arocha (2021) and Carpenter (2002). All species drawings are taken from Carpenter (2002) and all species distribution maps are taken from Arocha (2021)

Major tunas

Albacore
Thunnus alalunga



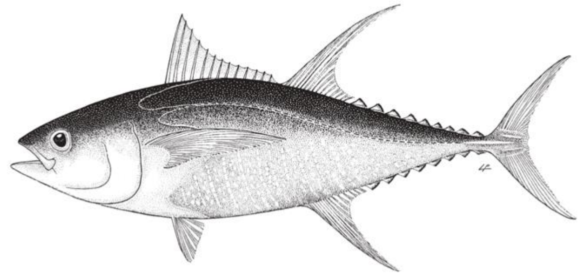
Biology and distribution:
Species characterized by an elongated fusiform body with extraordinarily long pectoral fins. Back colored a metallic dark blue, with a whitish belly and a faint blue band running along the sides. With an average fork length of 100 cm largest specimens can attain up to 120 cm and weight up to 40 kg. Except for the Gulf of Mexico, this species is pervasive in the Western Central Atlantic, from south New England trough the Caribbean Sea to southern Brazil in temperatures ranging from 17 to 21°C. It feeds on fish, cephalopods, and pelagic crustaceans.



Fishery status:
- Mainly caught as bycatch of the tropical tunas.
- 55% of the reported catch is from Taiwan operating in the high seas of the WECAFC region.
- In the Dominican Republic the landed catch is likely from MFADs.

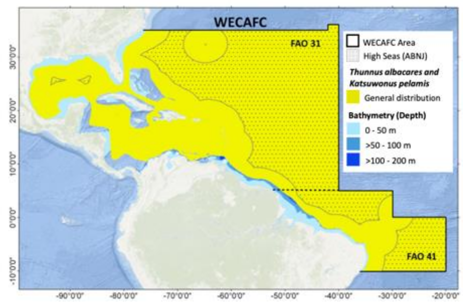
Stock status:
- Reference: ICCAT (2021a)
- Intermediate abundance level.
- Not overfished nor undergoing overfishing.
- No or low fishing mortality.
- Recommended TAC of 37801 t.

Yellowfin tuna
Thunnus albacares



Biology and distribution:

Species characterized by an elongated fusiform body slightly compressed laterally with elongated dorsal and anal fins. Back colored a metallic dark blue, changing through yellow to silver on the belly. With an average fork length of 150 cm largest specimens can attain up to 195 cm and weight up to 176 kg. Distributed throughout the WECAFC region this open-water pelagic and oceanic pantropical species is found above and below the thermocline in waters with temperatures above 18°C. It feeds on fish, cephalopods, and crustaceans. Genomic studies suggest the presence of two distinct genetic populations in the eastern and western Atlantic respectively.



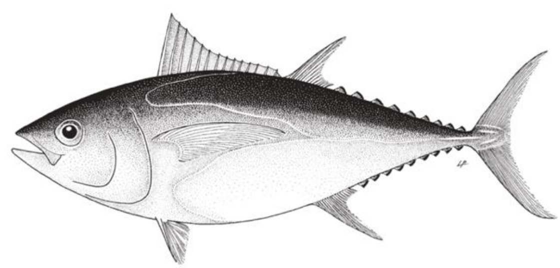
Fishery status:

- Highest reported landings over 25000 t (2015-2019);
- Since 1990 caught mostly by pole-and-line Baitboat and purse seine.
- Over 45% of the reported catch is from Brazil followed by Venezuela and Bolivia with over 11% and Suriname with over 10%. [Period 2015-2019]

Stock status:

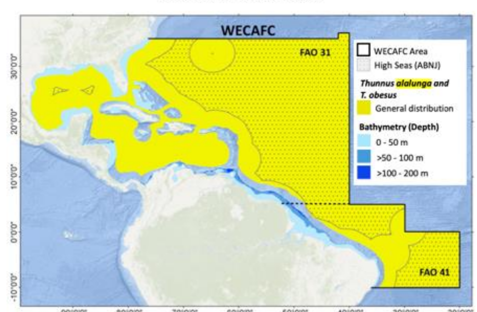
- Reference: ICCAT (2020)
- Intermediate abundance level.
- Not overfished nor undergoing overfishing.
- Moderate fishing mortality.
- Atlantic wide recommended TAC of 100000 t.

Bigeye tuna
Thunnus obesus



Biology and distribution:

Species characterized by a robust fusiform body with moderately long pectoral fins. Back colored a metallic dark blue, with both lower sides and belly whitish. Its average fork length is 180 cm with largest specimens attaining up to 236 cm and weighting up to 197 kg. Although the bigeye tuna is more abundant in the Southern Caribbean Sea and the High Sea within the region it is widely distributed throughout the Atlantic Ocean. This pelagic oceanic species feeds on fish, crustaceans, and cephalopods.



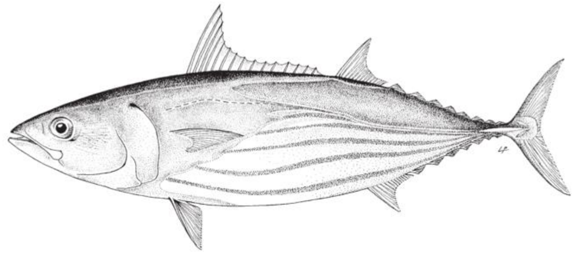
Fishery status:

- Mainly caught by longline gear.
- Reported landings over 10000 t (2015-2019).
- Over 54% of the reported catch is from Brazil followed Japan and China with over 12% and 8% respectively. [Period 2015-2019]

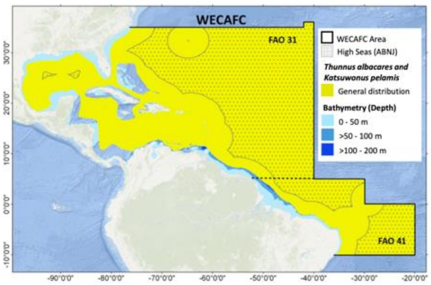
Stock status:

- Reference: ICCAT (2021b)
- Low abundance level.
- Was overfished but not undergoing overfishing.
- High fishing mortality.
- Maximum Sustainable Yield 86833 t.

Skipjack tuna
Katsuwonus pelamis



Biology and distribution:
Species characterized by a fusiform, elongate, and rounded body with short pectoral fins. Back colored a dark purplish blue, with 4 to 6longitudinal dark bands running along the sides.The average fork length is 80 cm with larger specimens attaining up to 100 cm and weighting up to 20.5 kg. Widely distributed in tropical and subtropical seas this open-water pelagic and oceanic species is found at depths of 260 m and temperatures between 20 and 30 °C. It feeds on crustaceans, fish, and cephalopods.

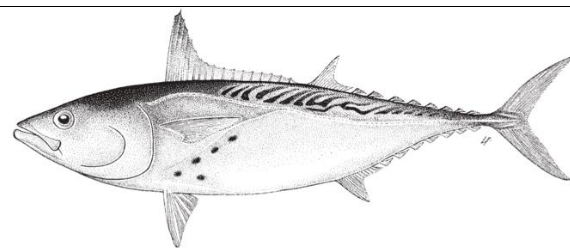


Fishery status:
- Since 1990 caught mostly by Baitboat, pole-and-line and purse seine.
- Over 48% of the reported catch is from Brazil followed by Venezuela and Bolivia with over 33% and Suriname with over 4%. [Period 2015-2019]

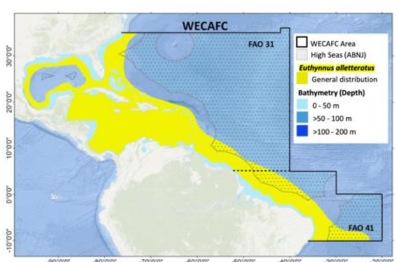
Stock status:
- Reference: ICCAT (2015)
- Not overfished nor undergoing overfishing.
- Maximum Sustainable Yield 30000 - 32000 t.

Small tunas

Little tunny
Euthynnus alletteratus



Biology and distribution:
Species characterized by a compact torpedo body shape with the anterior spines on the dorsal fin much higher than those midway. Its back is dark blue with a stripe pattern that does not extend forward beyond the middle of the first dorsal fin. The average fork length is 75 cm with larger specimens attaining up to 100 cm and weighting in average 6 kg and up to 15.9 kg. Found mainly on the continental shelf, this epipelagic species is widespread in the region from New England south to Victoria Island, Brazil including Bermuda. It is also found in the eastern Atlantic and the Mediterranean but rare north of the Iberian Peninsula. It feeds on
squids, pelagic crustaceans and small fish (clupeoids).



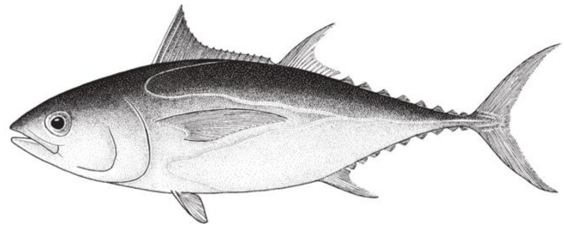
Fishery status:
- Mostly caught by small scale fisheries using trammel nets from Colombia.
- Over 70% of the reported catch is from Colombia followed by the USA with over 21% and ST

Stock status:
- Reference: ICCAT (2017b)
- Not overfished with moderate vulnerability to overfishing.

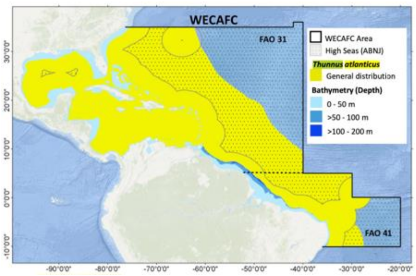
Vincent and the Grenadines with over 4%. [Period 2015-2019]

- Using data limited assessment methods indicated an above stock status not overfished (Pons, Kell, et al., 2019).

Blackfin tuna
Thunnus atlanticus



Biology and distribution:



Smaller tuna species characterized by a compact torpedo body shape slightly compressed laterally with moderately long pectoral fins. Back colored a metallic dark blue, with grey and white belly. The average fork length is 72 cm with larger specimens attaining up to 89 cm and weighting up to 20 kg. Found only in the western Atlantic limited for the most part to the WECACF region. A warm-water species, its distribution is likely limited by the 20 °C isotherm. Spawning occurs offshore in the Florida Current and potentially also in the Gulf of Mexico and Caribbean Sea. It is often found in large mixed schools with skipjack tuna. It feeds on fishes, shrimps, squids, amphipods, and crustaceans.

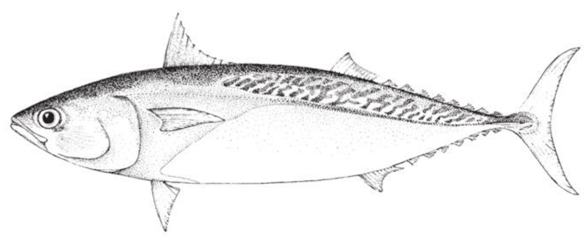
Fishery status:

- Mostly caught FADs (Grenada and Saint Lucia) and pole-and-line and purse seine (Cuba and Venezuela).
- Second most landed catch among the small tuna species (1242 t) with Cuba, Saint Lucia and Grenada reporting over 68, 9, and 8 % catch respectively. [Period 2015-2019]

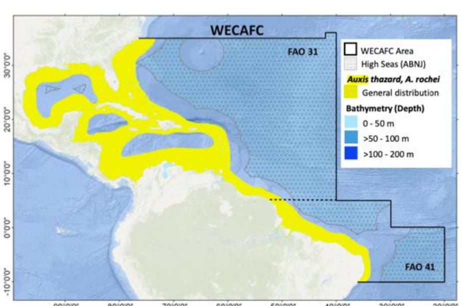
Stock status:

- Reference: ICCAT (2017b)
- Despite no current overfishing an Ecological Risk Assessment found blackfin in the high vulnerability to overfishing category, suggesting an increasing trend of annual landings and a call for caution.

Frigate tuna
Auxis thazard thazard



Biology and distribution:



Species characterized by a robust, elongate, rounded body with two dorsal fins separated by a large interspace and short pectoral fins. Its back is bluish green with numerous dark vertical stripes on the sides that extend below the lateral line. With an average fork length of 40 cm larger specimens can attain up to 50 cm and weight up to 1.72 kg. Although thought to be widely distributed throughout the Western Central Atlantic, two species have recently been recognized, *A. rochei* and *A. thazard*, and their exact respective distribution is yet to be determined. It feeds on squid, small fish, and planktonic crustaceans and stomatopods larvae.

Fishery status:

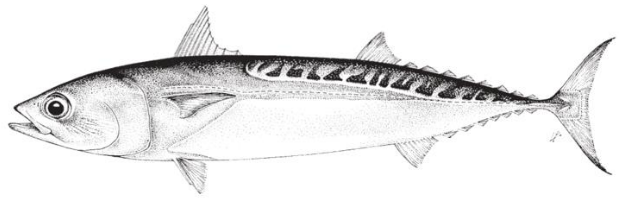
- Mostly caught by small scale fisheries with beach seines, drift nets, purse seine and by trolling.

Stock status:

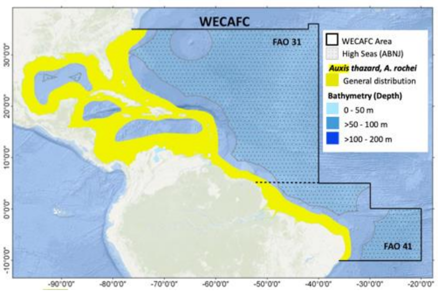
- Reference: ICCAT (2017b)

- Over 96 % of the reported catch is from Belize followed by Bermuda with over 3 %.
- Reported catch for both *A. rochei* and *A. thazard* is from Venezuela and Bolivia with over 73 % followed by Colombia with over 25 %. [Period 2015-2019]
- Ecological Risk Assessment indicated moderate vulnerability to overfishing.

Bullet tuna
Auxis rochei rochei



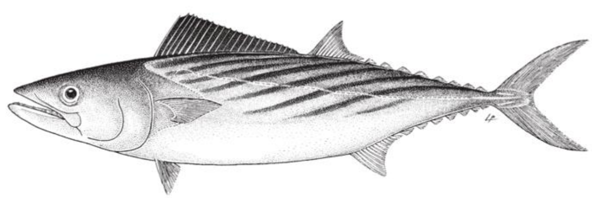
Biology and distribution:
Species characterized by a robust, elongate, rounded body with two dorsal fins separated by a large interspace and short pectoral fins. Its back is bluish to purple with 15 or more wide nearly vertical dark bars limited to the scaleless area. With an average fork length of 35 cm larger specimens can attain up to 40 cm. Although thought to be widely distributed throughout the Western Central Atlantic, two species have recently been recognized, *A. rochei* and *A. thazard*, and their exact respective distribution is yet to be determined. It feeds on small fishes, crustaceans, and megalops and stomatopods larvae.



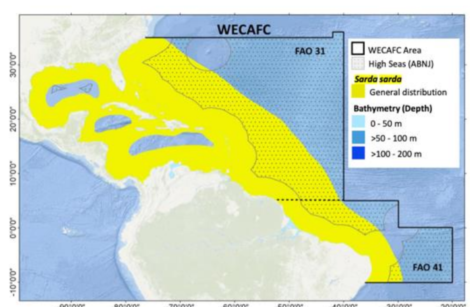
Fishery status:
- Mostly caught by small scale fisheries from Venezuela using trammel nets.
- Reported catch for both *A. rochei* and *A. thazard* is from Venezuela and Bolivia with over 73 % followed by Colombia with over 25 %. [Period 2015-2019]

Stock status:
- Reference: ICCAT (2017b)
- Ecological Risk Assessment indicated low vulnerability to overfishing.

Atlantic bonito
Sarda sarda



Biology and distribution:
Species characterized by a small narrow body (compared to large tunas) with a long first dorsal fin. Steel-blue back and upper-sides with 5 to 11 slightly oblique stripes that run from the back forward and downward. The average fork length is 50 cm weighting 2 kg with larger specimens attaining up to 85 cm and weighting up to 5 kg. This pelagic migratory species occurs along the tropical and temperate coasts of the Atlantic Ocean. It has been recorded from the USA east coast (except Miami and the Florida Keys), the Gulf of Mexico and Colombia and the Gulf of Cariaço in Venezuela. It is absent from most of the Caribbean Sea. It mostly feeds on small clupeoids, gadoids, and mackerels.



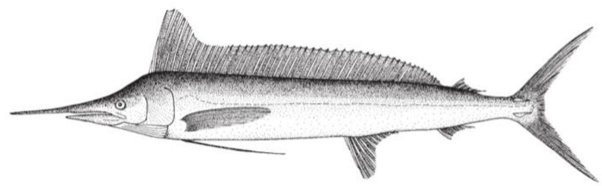
Fishery status:
- Highest landed average catch (2015-2019) of 3380 t Most reported by Mexico (98 %).

Stock status:
- Reference: ICCAT (2017b)

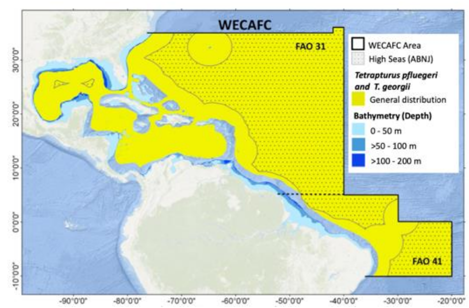
- Caught mainly by trammel nets used for the mackerel fishery.
- Ecological Risk Assessment indicated low vulnerability to overfishing.

Tuna-like species

Longbill spearfish
Tetrapturus pfluegeri



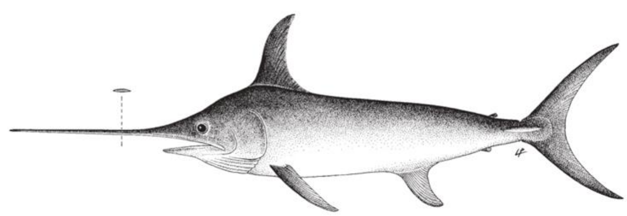
Biology and distribution:
Species characterized by an elongated greatly compressed body with a first dorsal fin with a high initial crest that is lobed as opposed to pointed and runs moderately high throughout its length. Upper jaw prolonged into a slender, round in cross-section spear. The average fork length is 2 m with larger specimens attaining up to 2.5 m. Mostly found in off-shore waters it is a highly migratory species found along the tropical and subtropical waters of the Atlantic Ocean commonly above the thermocline. It feeds on diverse crustaceans, cephalopods, and fishes.



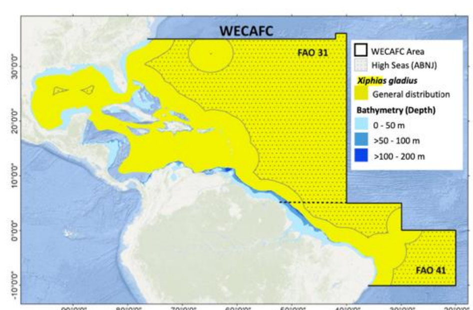
Fishery status:
- Highest reported catch is from St. Vincent and the Grenadines (61.5 %), followed by Venezuela and Bolivia (32.0 %), Mexico and Spain (over 3 % and 2 % respectively). [Period 2015-2019]
- Over 93 % of the landed catches are from commercial bycatch of the main target species (yellowfin tuna).
- Landed catches are from both the WECAFC high seas (St. Vincent and the Grenadines and Spain) and within the WECAFC exclusive economic zone.

Stock status:
- No ICCAT assessment available.

Swordfish
Xiphias gladius



Biology and distribution:
Species characterized by a robust rounded body in cross-section with two short dorsal fins of which the first one is highly pronounced and curved as compared to the second one. Bill prolonged into a long, flattened, and sword-like shape. The average fork length is 2.2 m with larger specimens attaining up to 4.5 m. Found in tropical and temperate waters, this is a highly migratory, aggressive, and solitary species that aggregates occasionally. It feeds on pelagic squids, fishes (schooling), and pelagic crustaceans.



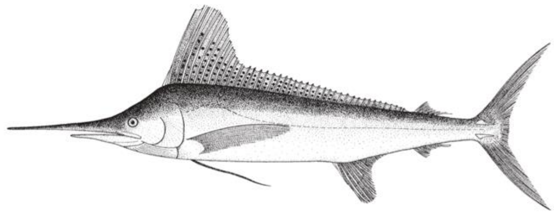
Fishery status:
- Highest reported catch is from Spain (55.7 %), followed by USA (32.1 %), and St Vincent and the Grenadines (over 2 %). [Period 2015-2019]

Stock status:
- Reference: ICCAT (2020)
- Species not overfished nor undergoing overfishing.

Specialized pelagic longline fishery by setting longline at dusk, and dishing during the night.

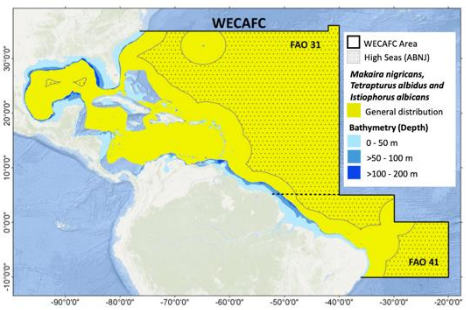
- Moderate fishing mortality.
- Intermediate abundance of stock
- Recommended TAC 13200 t.

Atlantic white marlin
Tetrapturus albidus



Biology and distribution:

Species characterized by an elongated compressed body with a first dorsal fin with a high initial crest that is lobed as opposed to pointed and runs along most of the back. Upper jaw prolonged into a slender, round in cross-section spear. The average fork length is 2.5 m with larger specimens attaining up to 3 m. Highly migratory, it is found along the tropical and subtropical waters of the Atlantic Ocean usually above the thermocline. It is densely present off Florida, in the Caribbean Sea, and along the Brazilian coast to Argentina. It feeds on cephalopods, fishes, and crustaceans.



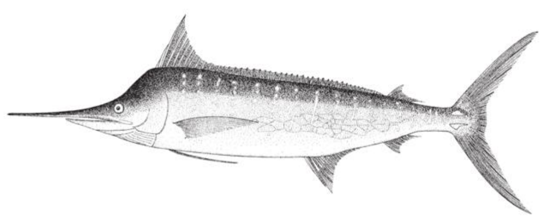
Fishery status:

- Highest reported catch is from Venezuela and Bolivia (52.7 %), followed by Costa Rica (18.9 %), Mexico and Barbados (over 9 % and 5 % respectively). [Period 2015-2019]
- Mostly caught as bycatch of the tuna directed fisheries (over 50 %), from the artisanal drift gillnet fishery and the Venezuelan Artisanal Off-Shore longline fleet. No data has been reported from the latter since 2015. Barbados and Grenada's catch is mostly using longline gear. In the south of la Española, reports of catches are from troll and baited drop-line associated with MFADs from small scale fisheries.

Stock status:

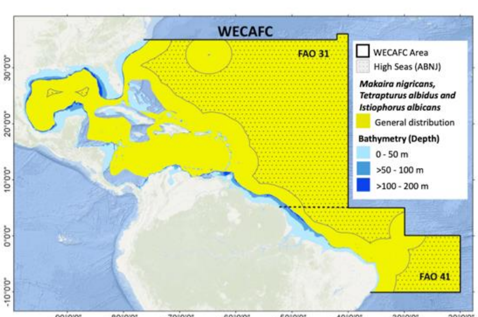
- Reference: ICCAT (2017a)
- Species overfished but not undergoing overfishing.
- High fishing mortality.
- Intermediate abundance of stock
- Recommended TAC 400 t.

Atlantic blue marlin
Makaira nigricans



Biology and distribution:

Species characterized by an elongated slightly compressed body with a first dorsal fin with a high initial crest that steeps down and runs along most of the back. The upper jaw is prolonged into a slender, round in cross-section spear. The average fork length is 3.5 m with larger specimens attaining up to 4 m. This epipelagic oceanic highly migratory species occurs along the tropical and subtropical open waters of the Atlantic Ocean above the thermocline. It is densely present in the Caribbean Sea, the Gulf of Mexico and in the Brazil Current. It feeds on diverse cephalopods, fishes, and crustaceans.



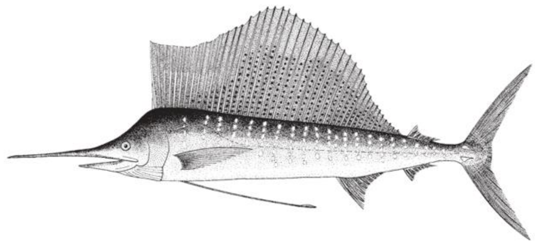
Fishery status:

Stock status:

- Highest reported catch is from Dominican Republic (19.4 %), France (17.61 %), followed by Venezuela and Bolivia (17.59 %) and Saint Lucia (over 11 %). [Period 2015-2019]
- The 2000 stock assessment led to the implementation of the Atlantic wide management actions by ICCAT limiting the catch and recommending catch and release for all tuna fisheries.
- Mostly caught as bycatch of yellowfin longline fisheries and small-scale fisheries using MFADs as attractants and line gear to catch the fish. Within the exclusive economic zone caught by rod and real (Bermuda and USA Est coast)

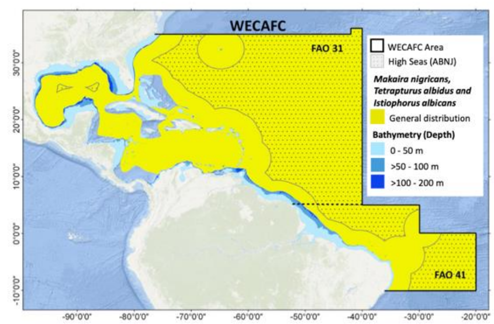
- Reference: ICCAT (2019)
- Species overfished and undergoing overfishing.
- High fishing mortality.
- Low abundance of stock
- Maximum Sustainable Yield estimated 3001 t.
- Recommended TAC 2000 t.

Atlantic sailfish
Istiophorus albicans



Biology and distribution:

Species characterized by an elongated laterally compressed body with a sail-like first dorsal fin and the upper jaw prolonged into a slender, round in cross-section spear. The average fork length is 2.5 m with larger specimens attaining up to 3 m. This epipelagic highly migratory species occurs along the tropical and subtropical waters of the Atlantic Ocean on coastal and oceanic areas above the thermocline. It is densely present in the Caribbean Sea and the Gulf of Mexico. It mostly feeds on cephalopods, fishes, and crustaceans.



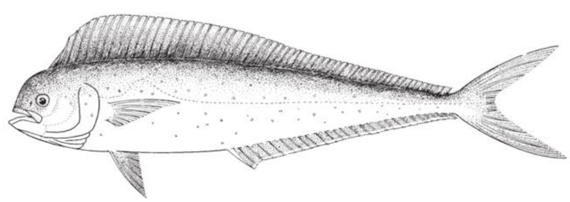
Fishery status:

- Highest reported catch from Suriname (25.8 %), Venezuela and Bolivia (25.2 %), and Panama (15.8 %). [Period 2015-2019]
- Caught mostly by longline gear and as bycatch of yellowfin tuna, but also from MFADS (Dominican Republic) by trolling and from the artisanal drift gillnet fishery in Venezuela. In USAs' exclusive economic zone mostly caught by the sports fishery.
- Lack of reporting by the VAOS fleet on sailfish removal prevents knowing the impact in total removals.

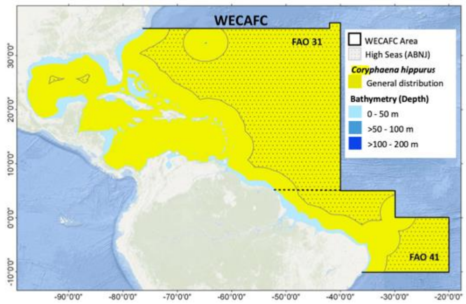
Stock status:

- Reference: ICCAT (2017a)
- Not likely overfished or undergoing overfishing.
- No or low fishing mortality.
- Intermediate abundance of stock.
- Maximum Sustainable Yield between 1438 t and 1636 t.

Common dolphinfish
Coryphaena hippurus



Biology and distribution:
Species characterized by long and compressed body with a slightly convex head profile and a single dorsal fin that runs from above the eye to the caudal fin. The average fork length 100 cm with larger specimens attaining up to 200 cm and weighting up to 39.9 kg. Found in open water this pelagic species is widely distributed throughout the area and worldwide in the tropical and subtropical seas. It breeds in the open sea and feeds predominantly on epipelagic fishes but also on squids and crustaceans.

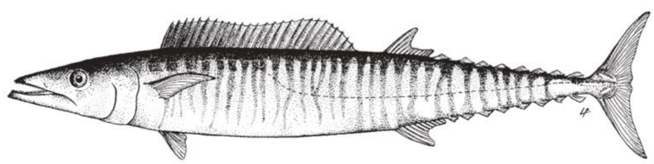


Fishery status:
- The highest reported catch is from France (20.2 %), followed by Venezuela and Bolivia (20.1 %), Saint Lucia (11.1 %) and Dominican Republic (over 10 %). [Period 2015-2019]
- Important fishery resource across the region
- Directed fisheries are from small scale and recreational fisheries with a limited proportion resulting from commercial bycatch (tuna longline fishery).
- Over 57 % of the landed catch come from the MFAD fishery of EU France (Martinique and Guadalupe), Saint Lucia, Dominican Republic, Dominica, and Grenada with hand-line gear.

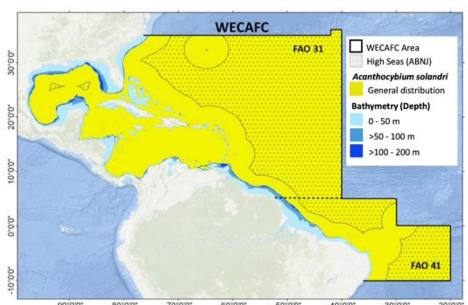
Stock status:
- Not under ICCAT.
- Reference: CRFM (2010)
- A 2010 stock assessment from eastern Caribbean indicated no decline.
- Single panmictic population (Merten, Schizas, Craig, Appeldoorn, & Hammond, 2015)

Large pelagics

Wahoo
Acanthocybium solandri



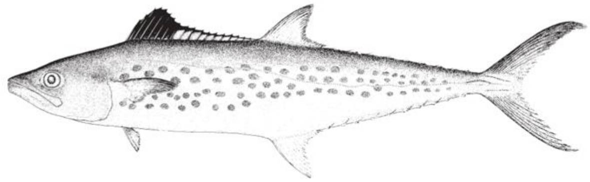
Biology and distribution:
Species characterized by a long fusiform compressed body with an elongated snout. Presence of two dorsal fins and 9 dorsal and anal finlets. The average fork length 170 cm with larger specimens attaining up to 210 cm and weighing up to 71.89 kg. Found offshore this epipelagic species is widely distributed throughout the Caribbean area and particularly along the north-western coast of Cuba. Spawning extends over a long part of the year, and feeds predominantly on epipelagic fishes but also on squids.



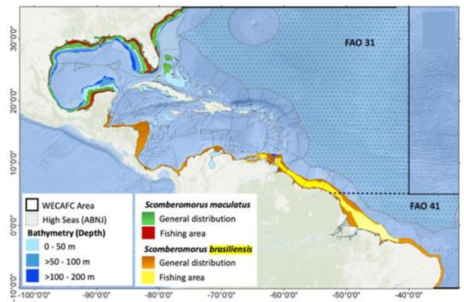
Fishery status:
- Highest reported catch is from Suriname (24.2 %), followed by Saint Lucia (14.4 %), Bermuda (11.2 %), and Panama (over 8 %). [Period 2015-2019]
- Not part of a fishery but caught seasonally in the region when present in areas of large pelagic target species. Mostly caught by countries within in the region – Important resource for small islands developing states.
- Wahoo is primarily caught by trolling and longline gear

Stock status:
- Reference: Pons, Kell, et al. (2019) Pons, F., Fredou, and Mourato (2019)
- Data-limited assessment methods indicated that the stock is overfished and that a length-based models should be applied in the future
- Single stock structure (Constantine, 2002)

Serra-Spanish mackerel
Scomberomorus brasiliensis



Biology and distribution:



Species characterized by a long and strongly compressed body with a snout much shorter than the rest of the head and barely separated dorsal fins. Its sides are silvery with characteristic several rows of yellow to bronze spots that increase in number as the size increases. The average fork length 65 cm with larger specimens attaining up to 125 cm. its distribution is limited to the western North Atlantic from Yucatán and Belize south to Rio Grande de Sul, Brazil. It's an epipelagic, neritic species found often in estuaries and coastal areas for which spawning takes place over longer seasons in estuaries. It feeds small fishes, penaeid shrimps and squids.

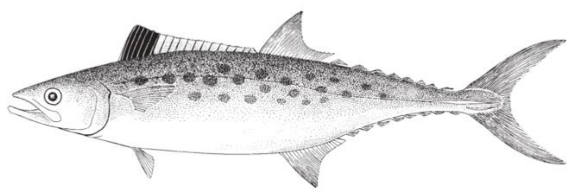
Fishery status:

- Most of the catches are by Venezuela and Bolivia (46.52 %), Trinidad and Tobago (29.68 %) and Guyana (22.49 %). [Period 2015-2019]
- Important large coastal pelagic resource, with potential masking of true removal numbers due to incomplete reporting.

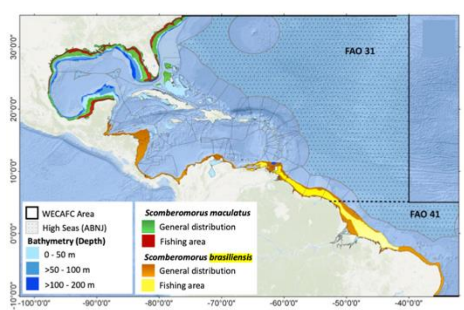
Stock status:

- Reference: ICCAT (2017b)
- Moderate vulnerability to undergoing overfishing
- Composed of three stock units: two in the southeastern Caribbean and one in northeastern Brazil (Gold, Jobity, Sailiant, & Renshaw, 2010)

Atlantic Spanish mackerel
Scomberomorus maculatus



Biology and distribution:



Species characterized by a long and strongly compressed body with a snout much shorter than the rest of the head, barely separated dorsal fins and 8 - 9 dorsal and anal finlets. Its sides are silvery with about three rows of oblong yellow to bronze spots. The average fork length 50 cm with larger specimens attaining up to 70 cm. its distribution is limited to the western North Atlantic from the northern limit of the WECAFC region to the Yucatán Peninsula and northern Cuba. Spawning takes place in the northern Gulf of Mexico and the southeastern of USA. It's an epipelagic, neritic species found often in estuaries and coastal areas. It feeds on small fishes, particularly sardines and anchovies.

Fishery status:

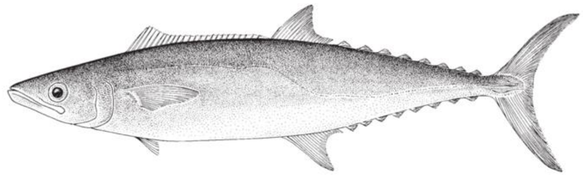
- Highest reported catch is from Mexico (over 86 %), followed by USA (13.36 %). [Period 2015-2019]

Stock status:

- Reference: ICCAT (2017b)
- High vulnerability to undergoing overfishing.

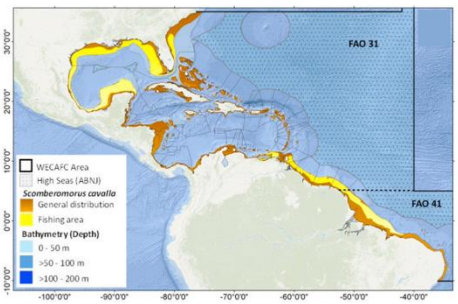
- Caught with bottom gillnet and trolling by Mexico, while cast nets, gillnets and hook-and-line gear are used by USA.
- Single intermingling genetic stock (Buonaccorsi, Starkey, & Graves, 2001)
- Southeastern stock unit not considered overfished in 2013 (SEDAR, 2013)

King mackerel
Scomberomorus cavalla



Biology and distribution:

Species characterized by a long and strongly compressed body with a snout much shorter than the rest of the head, barely separated dorsal fins, 8 – 9 dorsal finlets and 9 – 10 anal finlets. Its sides are silvery. The average fork length 70 cm with larger specimens attaining up to 150 cm and weighting 36 to 45 kg. It is widely distributed throughout both coasts of Florida, the Antilles and the northern coast of South America down to Rio de Janeiro. Epipelagic species, oceandromous and common in outer reef areas that can be solitary or in small groups, and spawns mostly in the Gulf of Mexico, the Caribbean Sea and northeastern Brazil. It feeds primarily on small fishes.



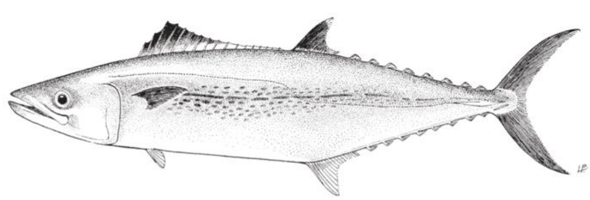
Fishery status:

- Most of the catches are by Mexico (63.1 %), followed by USA (19.2 %), Venezuela and Bolivia (7.27 %) and Trinidad and Tobago (4.18 %). [Period 2015-2019]
- Important large pelagic resource for mid- and long-range artisanal fleet. True removal numbers might be masked due to recent incomplete reports on landed catch from northeastern Venezuela and Trinidad and Tobago.
- Caught by trolling with live bait in Venezuela, handline, gillnets are used mostly by USA, and MFADs by the Dominican Republic.

Stock status:

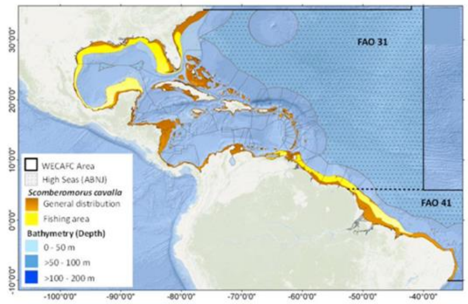
- Reference: ICCAT (2017b)
- High vulnerability to undergoing overfishing.
- Composed of four stock units; two in the Gulf of Mexico (Although not genetically different). One northeastern of Venezuela and Trinidad through Suriname and one northeastern Brazil (Gold et al., 2010; Hogarth & Martin, 2006; Marcano, Lárez, & Carrión, 1998; Nóbrega & Lessa, 2009).
- Gulf of Mexico and Southeastern stocks not considered overfished in 2014 (SEDAR, 2014a, 2014b)

Cero
Scomberomorus regalis



Biology and distribution:

Species characterized by a long and strongly compressed body with a snout much shorter than the rest of the head, barely separated dorsal fins, 8 – 9 dorsal and anal finlets. Its sides are silvery with a midlateral row of stripes of different length and small yellow spots above and below the stripes. The average fork length 45 cm with larger specimens attaining up to 80 cm and weighting up to 7.76 kg. Occurring solitary or in small groups, it is found from the coast of Massachusetts, through Bahamas and West Indies to Brazil. Epipelagic species, oceandromous and common in outer reef areas it feeds primarily on small fishes, particularly sardines anchovies and silversides.



Fishery status:

- Most of the catches are by Venezuela and Bolivia (70.2 %), followed by Dominican Republic (24.3 %), and Puerto Rico (3.8 %). [Period 2015-2019]
- Around the Venezuelan off-shore area it is mostly caught with handline gear, while MFADs are used in Dominican Republic using hand-line gear by trolling and live bait.

Stock status:

- Reference: ICCAT (2017b)
- Low vulnerability to undergoing overfishing.
- No available information on stock structure.

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