Artisanal and industrial FADs: A question of scale

Tahiti conference reviews current FAD use and technology

Foreword

Since ancient times, fishers have known about the natural tendency of pelagic fish such as tunas, mahi mahi, sharks and marlins to gather around floating objects. Beginning in the early 1980s, fish aggregating devices (FADs) have gradually become essential and preferred tools for tuna fishing around the world. This technique is used at two very different scales.

In coastal areas, local fishers moor FADs on the sea bottom in depths of 50–2,500 metres in order to encourage tuna to gather not too far offshore, where small artisanal fishing vessels can catch them. At that scale, anchored FADs are an excellent fisheries management tool that allows fishing effort to be moved away from coasts, where resources are both limited and fragile, towards the open ocean where tuna resources are not as sensitive at such scales.

In the open ocean, tuna purse-seine operators profit from large pelagic fishes' propensity to aggregate; they do so by fishing around FADs that have been deliberately set adrift for fishing purposes, and which are monitored at large geographic scales by electronic tracking beacons. One purse-seine operator can have up to 100 drifting FADs (dFADs) equipped in this way. Therefore, catches by industrial fleets can reach tens or even hundreds of thousands of tonnes in a single area of the ocean. These dFADs are tools that may be considered to be "too" efficient but getting rid of them would strike a heavy blow to the world's tuna canning industry. In fact, the volume of catches around these dFADs (by all types of fishing combined) accounts for about 1.8 million tonnes, or 43%, of the 4.2 million tonnes for the three main tuna species worldwide. It has been suggested that purse-seine fishing around dFADs is leading to catches of small, undersized bigeye tuna (*Thunnus obesus*) and yellowfin tuna (*T. albacares*), unwanted bycatch such as mahi mahi (or dolphinfish, *Coryphaena hippurus*) and wahoo (*Acanthocybium solandri*), and species that are extremely sensitive ecologically such as sharks and sea turtles.

It was against this backdrop that the French Research Institute for the Exploitation of the Sea (IFREMER), French Polynesia's Ministry of Marine Resources, the Secretariat of the Pacific Community (SPC) and the French Institute of Research for Development (IRD) together decided to hold an international conference on "Tuna Fisheries and FADs" to review the use of this particularly effective tool for worldwide harvests of large pelagics, in particular tuna and related species.

The conference (held in Tahiti in November 2011) was attended by nearly 150 participants from 40 countries and 3 oceans and the Mediterranean Sea. The most original aspect of this conference was that it brought fishers, managers and scientists together around a common theme. Three and a half days of the meeting were devoted to scientific presentations divided into five different theme-based sessions.

- Session 1:
  Artisanal fisheries and anchored FADs
- Session 2:
  Industrial fisheries using anchored or dFADs
- Session 3:
  Understanding aggregation
- Session 4:
  Ecosystem impacts of FADs
- Session 5:
  Socioeconomic impacts of FADs

The final two days featured four round table discussions led by expert panels (four to five experts for each discussion), interacting directly with all participants and guided by the priority issues below:

- Round table 1:
  Anchored-FAD design and technology: Durability and effectiveness
- Round table 2:
  Socioeconomic impact and management of regional FAD programmes
- Round table 3:
  dFADs: How to manage this very effective tool
- Roundtable 4:
  Research on the double topic of anchored and dFADs

The summaries presented below — written by the expert groups and rapporteurs — shed new light on the development of anchored FADs and dFADs. The summaries present proposals and recommendations from different groups (i.e. fishers, managers, scientists) directly involved in current fishing practices, and help identify research issues and priorities pertaining to FADs, which are of particular importance for the future of tuna resources and fisheries.

Round table syntheses

Round table 1.

Balancing anchored FAD design for costs, longevity and aggregation efficiency

Expert panel: Marc Taquet (IFREMER, Chair — *Marc.Taquet@ifremer.fr*), Michel Blanc (SPC, rapporteur), Kim Holland (University of Hawaii, rapporteur), Paul Gervain (PLK Marine), David Itano (Pelagic Fisheries Research Program, Hawaii), William Sokimi (SPC), Mainui Tanetoa (Direction des Ressources Marines, French Polynesia).

General overview of discussion

Because different types of FADs can be used for different purposes such as artisanal and subsistence fishing for food security, sportfishing, and industrial-scale harvesting, there is a need to codify FAD terminology. The most basic distinction is the difference between anchored FADs and the dFADs used in industrial fisheries. For anchored FADs, there is an existing terminology used by SPC:

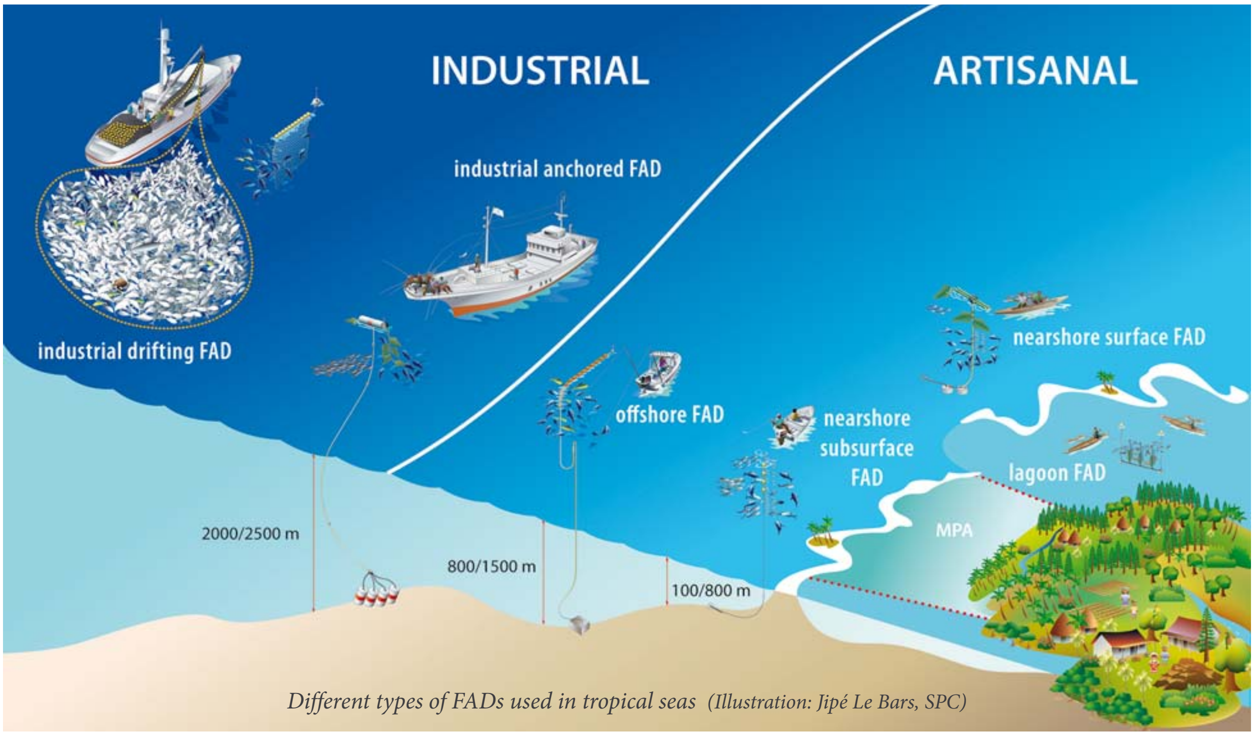
- lagoon FAD (surface and subsurface) — Used primarily to support artisanal and subsistence fisheries.
- nearshore FAD (surface and subsurface) — Typical maximum depth is 500 m. Used to support subsistence, artisanal and sportfishing activities.
- offshore FAD (currently all surface). Typical maximum depth is 2,000 m. Used to support artisanal, sportfishing and industrial fishing of various scales.

The term "Indian Ocean design" was frequently used during discussions. This design generally refers to a FAD constructed with light- to medium-weight mooring lines and a surface flotation section comprising a string of small and medium floats that lay on the ocean surface.

Different types of user groups must be considered when deciding where to locate FADs. The requirements of subsistence fishers using canoes or small motorized vessels are different than those of modern sport fishers and commercial fleets. Similarly, the type of FAD used (and its constituent components) depend on the capabilities of local agencies to fund and deploy the FADs.

For lagoon and nearshore FADs, there is an emerging trend toward the deployment of subsurface designs. These FADs are increasingly used in conjunction with the establishment of marine protected areas (MPAs) as part of community-based resource management programmes.

There have been significant advances in the design of FAD systems and in the types of materials and components used to construct FADs. These advances have resulted in increased longevity of FADs. There may



Different types of FADs used in tropical seas *(Illustration: Jipé Le Bars, SPC)* be a need for an updated technical manual to assist user groups in designing and deploying FADs tailored to specific locations and user groups. Importantly, the design and deployment strategies for FADs are dependent on the size and reliability of funding available for the project.

Specific items discussed

Materials. There have been significant advances in materials and engineering for all types of FADs, and the general trend has been to reduce the number of components (e.g. shackles, swivels) in mooring systems. This reduces cost and the number of weak links in the system, and increases longevity. In the Maldives and the Caribbean, nylon or polypropylene ropes with a steel wire core have proven to be successful in providing secure mooring systems that resist damage from fish bites and fishing gear. New synthetic ropes made of Kevlar-type materials are also showing promise as mooring systems for FADs.

In general, heavy anchors such as cement blocks are used, although lighter anchoring systems (e.g. grapnels, engine blocks) are also used, especially for nearshore and lagoon FADs. Lighter anchors are beneficial for a number of reasons, including reduced cost and ease of deployment from small vessels. However, several analyses from different regions indicate that insufficient anchor weight was responsible for FAD loss.

Stainless steel components are not necessary and may even be detrimental, although they are used successfully in some places (e.g. Maldives) for certain functions (e.g. mooring attachment points).

For lagoon FADs, biodegradable and recycled components are frequently used.

Maintenance. There are differences in opinion regarding the need for maintenance programmes. For properly designed systems (using, for example, spherical buoys and adequately large anchors) with long life spans, maintenance may not be necessary or cost effective. Systems with global positioning system (GPS) transmitters, which allow "real time" monitoring of a FAD's position, facilitate recovery when a FAD goes adrift and, thereby, minimise regular maintenance costs. On the other hand, FADs using the Indian Ocean design require regular and thorough maintenance of surface components.

Aggregators. For nearshore and offshore FADs, the use of aggregators[1] is generally favoured by fishers although there are no empirical scientific data to support their effectiveness. Generally, larger surface areas tend to be more effective than smaller ones. Aggregators may increase drag, and this should be considered in designing long-lasting FADs. Using aggregators as separate components (e.g. double-headed FAD, Indian Ocean style, Maldives style) may be preferable to placing aggregators on the mooring line.


Maldives (top) and Indian Ocean (bottom) artisanal FADs. On the Maldives FAD, aggregators are attached to the array of small buoys floating on surface, not to the main mooring line

Electronics. There is increasing use of sonar buoys to give real time estimates of fish abundance at FADs, and GPS receivers and transmitters are being used to monitor whether or not FADs are on station and when they break loose. There is a need for an updated technical manual for FAD construction and deployment technologies.

Data collection. For all types of FADs, the strengthening of data collection systems (biological, engineering, socioeconomic) is essential to quantifying the generally accepted positive impacts of FAD programmes. These data are crucial to securing sustainable funding for national FAD programmes.

Lagoon FADs. There is an increasing demand for FADs in lagoons and other sheltered inshore waters. This is especially true in rural areas where they can be used in combination with MPAs and to enhance food security and to re-direct fishing effort away from benthic and epibenthic reef fishes to small pelagic species. However, the effectiveness of these FADs may be site specific — sandy bottom lagoons are good locations. Lagoon FADs are cheap and can be made of several designs from a variety of recycled and biodegradable materials.

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[1] Aggregators are appendages made of loose netting, mussel ropes or coconut fronds, attached below the raft, which are supposed to increase the FAD's attractiveness.

Nearshore FADs. Nearshore FADs are useful for addressing a number of contemporary issues (e.g. food security, promotion of sportfishing and related businesses, support of small-scale commercial fishing). They can also be effective in preserving coral reef biodiversity by shifting fishing effort away from reef fish species to more resilient pelagic species.

There is a need to conduct a comparative study (life span vs cost) of several nearshore FAD designs that have recently been used. Most designs are typically inexpensive (i.e. less than USD 2,000).

Subsurface designs are gaining momentum and are being increasingly used in several countries. Advantages include reduction of vandalism, suitability for areas of heavy maritime traffic, and longer lifespan due to reduced wear and tear. They are usually less expensive than surface designs for similar depths. There may be limitations of deployment depth for subsurface FADs beyond which the "cons" outweigh the "pros". For example, deployment in deep water requires very high precision, which in turn requires appropriate vessels and equipment, as well as expertise.

Fishers initially tend to be negative about subsurface FADs so there is a need for education, the use of surface marker buoys to assist in finding the FAD (at least in the beginning), and research into the aggregation success of subsurface FADs. There are existing examples of successful deployments at depths up to 500 m (Tonga, Fiji), although questions persist regarding the types of fish these FADs attract (e.g. mahi mahi) and the maximum depth they can be deployed accurately. This needs future research. Because their precise locations may not be known to all fishers, subsurface FADs may be vulnerable to being fouled by longline gear.

Offshore FADs. Offshore anchored FADs support industrial, artisanal and sportfishing activities that use a wide variety of motorized vessels. The mooring line is usually the most expensive component, so cost-effectiveness depends on balancing the depth (usually related to distance offshore) with the capabilities of the user group.

There are significant deployment challenges for subsurface FADs in deep water, and consequently, to date, all offshore FADs use surface floats. Use of steel core rope or cable is appropriate for at least the uppermost sections of the mooring, and this is replacing conventional rope in some instances. There is a trend to reduce the number of elements (e.g. swivels) on the mooring line.

Although "boat-shaped" floats are used and have some advantages (e.g. ease of construction, housings for instruments), mechanical analysis suggests that spheres are best shape for most purposes. Double-headed systems seem effective in aggregating fish and in extending FAD life. However, regular maintenance operations are required.

Recommendations and points of agreement

- Anchored FADs are a cost-effective way of redirecting fishing effort from nearshore benthic fish species to more resilient pelagic fisheries. These FADs are useful for food security and for promotion of economic activities such as sportfishing.
- Data collection is vital to promoting financial and political support for FADs.
- Subsurface FADs have many positive aspects (including lower costs) and are becoming increasingly popular.
- Reducing the number of components in the mooring system increases FAD longevity.
- There is a need for a new technical manual describing modern FAD technology.

FAD maintenance may require acrobatic skills. Changing the buoy light, Hawaii (Image: David Itano)

Round table 2

Socioeconomic impacts and management of domestic FAD programmes

Expert panel: Marc Taquet (IFREMER, Chair — *Marc.Taquet@ifremer.fr*), Beatriz Morales-Nin (Mediterranean Institute for Advanced Studies (IMEDEA)/University of the Balearic Islands (UIB)/Consejo Superior de Investigaciones Científicas (CSIC), rapporteur), René Galzin (Centre de Recherche Insulaire et Observatoire de l'Environnement (Criobe)/Centre national de la recherche scientifique (CNRS)/École Pratique des Hautes Études (EPHE), rapporteur), Olivier Guyader (IFREMER), David Itano (PFRP), Lionel Reynal (IFREMER), Michael Sharp (SPC), Stephen Yen Kai Sun (Direction des Ressources Marines, French Polynesia).

Purposes, objectives and drivers of domestic anchored FAD programmes

Socioeconomic, environmental and political drivers were identified as the primary motivations for the launching of domestic FAD programmes. Although anchored FADs have been used since ancient times, the review of case studies shows that many anchored FAD programmes have been developed recently, beginning in the early 1980s. The objectives of these programmes vary, but there are some common themes. One of their main objectives is to increase fishing efficiency through increased catch per unit of effort (CPUE), and a reduction in fishing costs, primarily due to a reduction in searching time. Expected benefits are improved earnings and increased food security of high quality, and ciguatera-free protein for local communities. In some cases, programmes have aimed at reducing country dependence on seafood imports and, in a limited number of cases, allowed for the development of exports. Safety-at-sea issues are also considered to be an important benefit of coastal FAD programmes, especially for small-scale fleets with limited range. In other cases, anchored FADs have been set for recreational fishing or charter-tourism development. And, anchored FADs are sometimes used for scientific monitoring of marine ecosystems.

When environmental and resource aspects are considered, anchored FADs are considered to be a tool to reduce fishing pressure on coastal ecosystems via enabling the transfer of fishing effort from coastal fish to pelagic fish. Coastal FADs are increasingly highlighted as offering alternative fishing opportunities that can protect reef and lagoon and demersal environments (i.e. MPA establishment). FADs can also relieve fishing pressure on coastal environments that have been degraded by pollution, ciguatera contamination, invasive species and climate change.

On political and institutional levels, anchored FADs have also been seen as a way to reduce conflicts between neighbouring countries by reducing incentives for fishermen to follow the movement of target species into foreign exclusive economic zones. The group also noted that FADs have a cultural dimension and can become a mechanism to improve and foster the organisation of fishing communities and cooperatives and fishery management efforts.

Interactions, conflicts and access regulation

The review of case studies shows that the main users of anchored FADs are small-scale fishers who mainly use hook-and-line gear. However, industrial-scale fisheries operating large commercial vessels using other techniques (e.g. purse-seine) are operational in some regions, particularly in the western Pacific. Recreational fishing may benefit from anchored FADs installed for commercial purposes and vice versa; some FADs, however, are maintained for the benefit of only one fishing sector.

Conflicts and interactions between individual fishermen and/or FAD user groups were recognized as a significant issue in some areas that needs to be mitigated by an outside, impartial organization that can facilitate communication and management efforts. Due to the international scope of the conference, a wide range of access regulation arrangements to anchored FADs was noted, including preferential access (FAD licenses and permits, territorial use rights, catch limits) to commercial fishermen or other user groups; and restrictions on fishing gear types. This was considered to be a positive proposal to manage user conflict. Currently, many FAD fisheries are open access, which may significantly reduce the benefits of such management measures, or the programmes themselves.

It was recognized that access issues are complex and need to be addressed at the local level, and cannot be standardized across all regions. General guidelines could be developed at a global scale, with inputs from all user groups. These guidelines could lead to the development of voluntary domestic codes of conduct for responsible anchored FAD fishing in order to minimize conflicts and interactions between users. Guidelines to minimize conflict while fishing on FADs should be developed through input from all user groups into a voluntary code of conduct for responsible FAD fishers wherever FADs are deployed and widely distributed.

Management of FAD density and interactions in coastal areas

The management of anchored FAD density emerged as one of the most important issues to be considered in relation to resource utilization and conflict resolution. The optimal number and density of anchored FADs in a given fishery is difficult or impossible to determine given the diversity of contexts (e.g. target species, gear type), but evidence from several studies indicates that "more" is not necessarily "better". Excessively high FAD density can lead to tangling of mooring lines, aggregation interaction or competition between neighbouring FADs, especially when FAD setting is unregulated. The problem with FAD overcapacity is high FAD programme costs in combination with a loss in local productivity and catchability due to FAD competition and/or interaction (diminishing marginal returns). Conversely, the number of FADs in a given area can be regarded as insufficient where individual FADs act as separate units with no overall benefit from the combined aggregative effect of the entire FAD array, which can occur when the FAD programme is not fully funded or well planned.

The number of permitted FADs in a given area is a key management concern, which must be determined by carefully planned scientific studies and can not be separated from the issue of access regulation. It was noted that the development of management measures must include stakeholder input from all sectors to ensure that management measures are accepted and enforceable.

FAD management should be strongly linked to broader marine spatial planning mechanisms to avoid potential interactions that can seriously impact anchored FADs (submarine cables, shipping lanes, protected species habitats, tourism and development). Inadequate planning and regulation may result in significant user-group conflicts. Even if some FADs are constructed with biodegradable materials, the impacts of their loss — especially on coastal, coral reef and sea floor habitats — must be more clearly assessed and anticipated.

When large-scale fisheries exist that are not compatible with anchored FAD moorings or small-scale fisheries, they may have to be separated by regulation. This has occurred in some regions where large-scale tuna longline and purse-seine gear has been excluded from coastal waters where anchored FADs are maintained for the benefit of small-scale fishers. Studies indicate that a physical separation of gear types can also reduce interaction and competition issues.

Funding and maintenance

The group noted the need to promote long-term sustainable FAD funding in all contexts. Long-term budget allocation must incorporate FAD maintenance, replacement or recuperation when lost, data collection, training and management. Evidence from existing programmes indicates that FAD programmes need to explore innovative avenues for continued funding that may include fees from user groups, funds derived from fishery permits or violations, external private funding, core government infrastructure budget, fishery development funds, and taxes levied on fishing gear.

Private sector funding, maintenance and management of FAD programmes was identified as an ideal scenario, however it is recognised that this may result in user conflict. With good cooperation and governance, private sector funding is deemed appropriate, however if this fails, public sector funding and management of FAD programmes would be required.

Maintenance and renewal frequency and cost data are required to establish optimal maintenance routines and FAD designs.

Some case studies revealed that the longevity of anchored FADs is greatly improved with frequent maintenance. Increased FAD longevity has significant implications on cost and benefits of FADs, and further research is required in the design of FADs, deployment site, and maintenance frequency, to improve the life of an anchored FAD.

Monitoring and data collection

The need to define minimum requirements to obtain high quality data with an acceptable level of uncertainty was recognized, which would then be used to establish data collection and monitoring protocols. It was noted that monitoring and data collection systems must be designed and established with the fishing community well before the first FAD is deployed. Sampling methodologies could be carried out to generalize the results at a more global scale. Moreover, the use of standardized forms for catch and effort reporting are required to facilitate information comparisons, especially in the case of shared resources. Minimum requirements include long-term robust catch and effort surveys for different gear types, and socioeconomic data collection (from vessels and households to supply chain of fish products) for cost-benefit analysis. The importance of agencies to actively pursue the collection and verification of high quality data useful for CPUE and socioeconomic analyses was recognized.

In addition to developing data collection and monitoring protocol, economic studies are required to understand the impact that FADs have on the domestic fisheries, including the socioeconomic costs and benefits of anchored FADs and research into longer lasting FAD designs.

Research is needed to determine the direct and indirect socioeconomic costs and benefits of anchored FADs, and to improve the efficacy of FAD development initiatives and promote best practice to achieve socioeconomic objectives.

Round Table 3:
dFAD: How to manage this very efficient fishing tool?

Expert panel: Marc Taquet (IFREMER, Chair — *Marc.Taquet@ifremer.fr*), John D. Filmalter (South African Institute for Aquatic Biodiversity (SAIAB), rapporteur), David Itano (PFRP, rapporteur), Laurent Dagorn (IRD), Alain Fonteneau (IRD emeritus), Michel Gougon (Organisation de Producteurs de Thon congelé - ORTHONGEL), Patrice Guillotreau (Université de Nantes), Martin Hall (Inter-American Tropical Tuna Commission - IATTC), Juan Pedro Monteagudo (Organización de Productores Asociados de Grandes Atuneros Congeladores - OPAGAC).

Positive and negative impacts of FADs

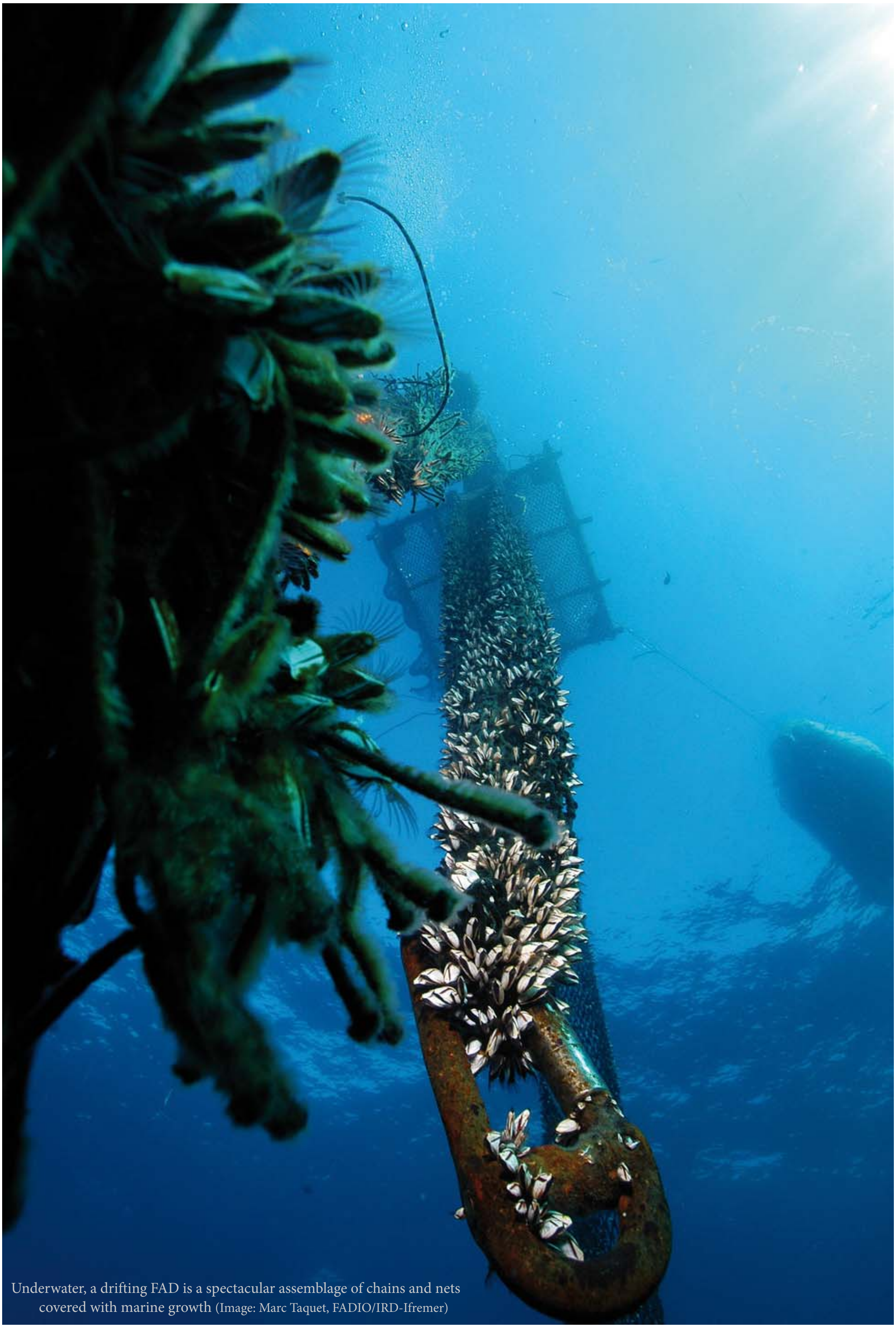
The efficiency of purse-seine fleets in all tropical oceans has improved, with drifting FAD (dFAD) and floating object sets now responsible for over half of the global tuna production. Their use has vastly improved the economic viability of tuna seining through reduced fuel and operational costs, and has allowed successful fishing in previously unexploitable fishing grounds and in areas and seasons when unassociated schools are unavailable. Sonar-equipped GPS locating buoys, coordination with supply vessels and an ample supply of dFADs work to virtually eliminate “zero catch” days resulting in high annual production. Given high and rising fuel costs, the utilization of dFAD technology was recognized as a necessary aspect of tuna production for the global canning industry.

Unfortunately, the unconstrained use of this very efficient fishing tool has resulted in negative impacts to target and non-target resources. Increased dFAD use can lead to large increases in fishing mortality of juvenile yellowfin and bigeye that contributes to growth overfishing. Bycatch levels of sets on floating objects — including dFADs — of oceanic sharks (primarily silky (*Carcharhinus falciformis*) and oceanic white tip (*C. longimanus*)), marine turtles, istiophorid billfish and certain pelagic bony fish (mahi mahi, wahoo, rainbow runner, etc.) are higher than for any other purse seine set type.

Drifting FADs are often constructed of surplus purse seine netting and usually have a panel of net suspended below the raft or float to a depth of 15 meters or more. This webbing can entangle FAD associated animals, including species of particular concern such as marine turtles, cetaceans and oceanic sharks. Lost or abandoned dFADs become marine debris and can impact coral reefs or end up in coastal areas and cast up on beaches.

While expansion of fishing grounds can help to distribute exploitation over a broader area, it is theorized that previously unexploited areas may represent natural reserves or “stock sinks” that help to replenish heavily exploited areas. Drifting objects tend to aggregate particular species or life stages that can contribute to differential exploitation with negative ecological impact.

On surface, a drifting FAD is a simple bamboo raft equipped with a radio beacon (Image: Marc Taquet, FADIO/IRD-Ifremer)



Underwater, a drifting FAD is a spectacular assemblage of chains and nets covered with marine growth (Image: Marc Taquet, FADIO/IRD-Ifremer)

Finally, dFADs in areas of high-speed directional drift may transport fauna away from normal areas and habitats, possibly to less favourable areas.

Data gaps and need for additional information

Significant data gaps and information needs were noted that must be improved to allow for the effective management of global purse-seine fisheries. More and higher quality data on dFADs and dFAD fishing operations are necessary for management purposes.

Basic technical data are needed on:

- the number of unique dFADs used per trip per boat, with comparisons between different fleets;
- the total number of active dFADs in a fishery (in the water with actively monitored electronic device attached); and
- dFAD trajectories throughout a fishery region.

The manner in which dFADs are constructed, deployed and fished by fleet type, and in comparison between different oceans, needs to be better recorded and understood by scientists and managers. These parameters are highly technical, requiring close collaboration and understanding of the fisheries and should, at a minimum, include:

- details of dFAD construction type, materials and depth;
- dFAD fishing techniques by fleet and region;
- use of technological adaptations to enhance aggregation (e.g. use of light, bait, depth of appendage, colour and type of streamers);
- characterization of dFAD use during fishing trips (i.e. numbers of dFADs set on or available that were previously deployed, appropriated, lost, recovered, or converted, log to dFAD); and
- documentation of changes in fishing gear and dFAD fishing practices over time.

Significant data gaps were also recognized in relation to the ecological impacts of dFAD use, including the need to understand "population dynamics" and trajectories of dFADs in relation to tuna and bycatch resources. Drifting FADs can be viewed and studied as a dynamic population of floating objects that are born (seeded), mature (aggregate species), migrate (drift) and die (sink, drift ashore, are recovered or stolen). Better information on all these processes is necessary for management purposes.

More and higher quality data on bycatch entanglement, species-specific bycatch levels, discard levels, fate of discards, and the broader ecological significance of bycatch and discard removals from the pelagic ecosystem need to be collected and processed.

Science and industry research initiatives to address these needs

The purse-seine industry has taken the initiative to study and promote ways to reduce the negative impacts of dFADs on the ecosystem. Specific projects were noted, including those that explored the use of sonar GPS buoys, echo sounders and sonar equipment to improve pre-catch estimation and selectivity for better targeting and bycatch reduction. The industry has also been involved in the testing of dFADs designed to minimize entanglement of sea turtles and other bycatch species. Some purse-seine companies have self-imposed FAD management plans, limited annual FAD usage per vessel per year, and are working on a declaration for responsible dFAD use (due in 2013).

Scientific research programmes that work collaboratively with industry were noted as a highly desirable and efficient approach because they allow experiments to take place on the high seas within the fishery under realistic commercial conditions, often using purse-seine vessels rather than research vessels. Further collaborative research was encouraged. Completed and ongoing projects of note included:

- FADIO (Fish Aggregating Devices as Instrumented Observatories of pelagic ecosystems),
- MADE (Mitigating ADverse Ecological impacts of open ocean fisheries),
- ISSF (International Seafood Sustainability Foundation),
- Purse Seine Bycatch Mitigation Project, and
- Skippers Workshops (to gain information from fishermen experienced in FAD fishing).

FAD management options

The meeting noted several ways to manage dFADs to mitigate their impact on target and bycatch stocks and their influence on the pelagic environment. These included the well-known mix of input and output controls, the most basic of which would be a control on the total number of vessels in a fishery and the number of dFADs deployed. The urgent need for the development and adoption of FAD Management Plans that are standardized across fleets and regions was recognized.

Management of input controls attempts to maintain or reduce fishing effort by controlling some aspect of the fishery that contributes to total fishing effort, such as a limit on the:

- number, type and capacity of vessels in the fishery;
- numbers of dFADs deployed (e.g. per boat, trip, year, fleet, area);
- number of electronic buoys allowed per fleet or fishery; and/or
- number of FAD sets allocated to a fishery sector.

Mechanisms to reduce vessel or fishing efficiency can also be imposed, such as a limitation on net size and depth, restrictions on the time of set, a limit on the underwater depth of a FAD, and a ban on the use of lights. There was strong support for banning FAD supply vessels that greatly increase the effective effort of a purse-seine operation. Time and area closures can also be applied to a fishery on a permanent, seasonal or variable (time or area) basis.

Output controls attempt to control effort by establishing a maximum level of catch, generally through the establishment of a total allowable catch (TAC). In this case, a TAC could be set for species or sizes of particular concern (such as juvenile bigeye and yellowfin tuna less than 60 cm). A TAC can be vessel-specific or by fleet, region, year or fishery.

A number of technological or economically driven initiatives to reduce dFAD impacts were discussed, including altering FAD design, changes in fishing methods, and bycatch marketing. Technical solutions could include the:

- design and promotion of non-entangling and/or biodegradable dFADs;
- development of fishing methods and practices to reduce impacts on undesirable catch, especially oceanic sharks and tuna of undesirable size;
- better utilization of finfish bycatch (e.g. mahi mahi, wahoo, rainbow runner) through vessel storage modification, freezer technology and market development;
- development and testing of release gear and techniques (e.g. sorting grids, use of large mesh, release chutes, modified brailing); and the
- testing of bycatch release techniques and gear from the net and vessel, and determining survival rates of released bycatch.

The development and adoption of FAD management plans was considered to be a key element towards effective regional management of dFADs. Currently, efforts are in place to adopt FAD management plans and some regional fishery management organizations (RFMOs) are requiring this of each member. However, the potential benefit of these plans is greatly reduced by the fact that RFMOs have not yet agreed on the data fields and information required for science and effective management. It was recognized that FAD management plans should be adopted by all fishing entities and should require vessels to report the number and fate of deployed and fished dFADs per trip. Management plans should also include:

- a ban on the use of FAD supply vessels;
- clarification on the role of observers in relation to data collection vs. Monitoring, control and surveillance; and
- information that identifies the ownership and responsibility of lost or abandoned dFADs.

It was recognized that the use of dFADs has greatly increased the economic viability and potential yield from tuna fisheries worldwide, and that it is not reasonable to abandon this highly efficient tool. Drifting FADs and their electronic marking buoys should be considered as individual units of fishing gear that must be managed to preserve the viability of pelagic ecosystems and sustainable tuna fisheries.


Dense aggregation under a drifting FAD
(Image: Marc Taquet, FADIO/IRD-Ifremer)

Round table 4

Research priorities on anchored and drifting FADs

Expert panel: Marc Taquet (IFREMER, Chair — *Marc.Taquet@ifremer.fr*), Alain Fonteneau (IRD emeritus, rapporteur), Fabien Forget (Rhodes University, rapporteur), Laurent Dagorn (IRD), Martin Hall (IATTC), Kim Holland (University of Hawaii), Jean-Claude Gaertner (Université de Polynésie française), René Galzin (Criobe/CNRS/EPHE).

The following recommendations were endorsed by the meeting:

Scientific use of FADs — Develop and improve scientific FADs equipped with a wide range of monitoring and recording equipment (e.g. scientific sounders, underwater cameras, recording of sound and environmental parameters, new tags). These scientific FADs should be actively used in scientific programmes designed and implemented in full cooperation with industry. These FADs should be also used in selected areas of particular significance, for instance in the Mozambique Channel (dFADs) or in areas of dense anchored FAD use (i.e. Papua New Guinea), as well as after any moratorium on dFAD use.

Basic fishery data — Improve data on size and species composition from all purse-seine effort for target and bycatch species, and incorporate new technology such as the electronic monitoring of fishing operations. There is a need to better understand the behaviour of target and bycatch species on dFADs to improve selectivity using a variety of methods including tagging, tracking, acoustics and video gear.

Drifting FAD moratoria — Restrict fishing areas and/or implement spatiotemporal moratoriums on FADs (by RFMOs) in conjunction with scientific research to monitor the dynamics of tuna associated with dFADs before, during and after using scientific FADs, research vessels or fishing vessels in the moratorium strata.

Feeding studies — Conduct comparative stomach content analyses on tunas caught in free and FAD-associated schools in different parts of the world. The results are of key importance to evaluating the impact of dFADs on the pelagic ecosystem, understanding interactions between species (i.e. tuna natural mortalities), and quantifying diversity in offshore pelagic areas.

Environmental impact of FADs — Reduce (to nearly zero) environmental pollution due to lost dFADs (sunk or drifting onto reefs or coasts), in agreement with the MARPOL convention[2] incorporating provisions that stipulate the responsibility for damage and impacts of lost or abandoned FADs. Biodegradable and non-entangling FADs should be developed by scientists and fishermen, and the universal use of these FADs should be developed as soon as possible by all purse-seine operators using dFADs at sea.

Bycatch reduction — Find methods to pre-estimate aggregation composition (bycatch to target species ratio), to reduce encirclement and mortality of bycatch and to study the survival rate of discards and released bycatch with a special focus on oceanic sharks and undersized tuna.

Industry collaboration — That the industry fully cooperates with scientists by sharing data (acoustic, FAD positions, FAD drift tracks) with the aim to understand the dynamics of dFADs and their impacts on ecosystems. There is a need to understand how many dFADs are in use by area, fleet and season which is far easier to determine with industry support.

Comparative research — Conduct comparative studies (between oceans and regions) on anchored FADs and dFADs. These studies are essential to better understanding biological, oceanographic and ecological mechanisms and processes related to FADs. A possibility would be the creation of an online network of FAD scientists to foster communication and collaboration.

FAD mooring designs — Design anchored FADs that have longer life spans in order to optimize investments, and develop subsurface FAD technology for deep offshore areas.

Socioeconomic studies — Monitor the biological (catch per species and size, fishing effort) and economical (price of catch, operative costs) variables that are required to evaluate the impact of FADs on resources, and analyse socioeconomic gains. This basic information is important for obtaining funds for anchored FAD deployment programmes. Standard sampling methods for data collection should be developed and used. Research should also focus on the analysis of fisheries dynamics and on the impact of FAD management measures, especially access regulation, and funding schemes.

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[2] The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It was adopted in 1973 at the International Maritime Organization (IMO).