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Fish Aggregating Devices: What next?

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Introduction

In keeping with the objectives of the workshop, this address will summarize the management related knowledge on FADs to determine which questions have already been answered and where to direct our next efforts. It will draw on the extensive body of information, published or otherwise (non-exhaustive list enclosed) to review and compare the major results, details of which will be covered in depth during the following presentations and discussions, to lay the ground work for future research and activities.

There is a lot of information out there and if we want to assess its usefulness, we first have to determine which questions it might answer. Let's thus begin by looking at what we need to know to deploy FADs successfully.

What do we need to know?

Why do we deploy FADs in the first place? Presumably, to capitalize on the tendency pelagic fishes have to associate with floating objects. We assume that artificial floatsam will have the same effect, thereby increasing the fishing opportunities (likelihood of encounter) and reducing searching time. Ultimately, we expect that it will increase fishing success and total catch.

What might be our concerns then, when we plan to implant FADs in an area? Four immediately come to mind:

- 1. Will it work (and where)?
 - Will it aggregate fish
 - Will it increase CPUE and total catch
- 2. How much increase can we expect?
- 3. What effects will it have on the resource and other fisheries?
- 4. How much will it cost (will it be worth it)?

Are there enough elements in our collective experiences to address these questions?

What do we know already?

A lot of the information about FADs is empirical: the rafts are moored, activity is monitored and inferences are drawn from observations. This makes for difficult comparisons because the methods are not standardized (fishing or collection). However, we can see some stricking similarities and for lack of more accurate information, start to derive some general principles. 1. Will it work (and where)?

We shall not go over the traditional exposé about the association of pelagic fishes with floatsams: it has been observed many times and it is well documented albeit not fully explained... Instead, we will look at the effectiveness of FADs at, for lack of a better word, "attracting" fish.

a) Do pelagic fish associate with FADs?

There are many instances of significant catches at FADs, sometimes to the extent of sustaining commercial purse seining operations, but some FADs have also been resolutely unproductive. The answer to our first question thus seems to be a resounding YES... but!

What can we learn from these combined experiences that could help us define some of the criteria for what it takes to make a "good" FAD? The most important consideration appears to be its location. Although so far we only dispose of empirical evidence, certain "rules" to which there are obviously exceptions, begin to emerge:

In general, FADs have been shown to be more successful in areas of higher productivity. Obviously, if fish associate with FADs, the more fish there are, the greater the potential there is for the FADs to be used. The "tuna holes", sea mounts and banks have been suggested as the more evident locations. Other remarkable features in ocean conditions or bottom topography can also be used to identify areas of enriched current convections conducive to fish occurence. This habitat enhancement attribute thus seems determinent in FAD productivity.

Depth has also been cited as being instrumental in the productivity of a FAD, and the 1000m isobath often described as the shallower limit. That is to say that more FADs have been productive in the deeper than in the shallower waters. This assessment however seems to be function of the yields of tuna and large pelagics which are more prominent offshore. If we are not concerned with the size or composition of the catch (e.g. for subsistence/local production), shallower moorings have proved to be equally effective at attracting small tunas, scombrids and other coastal pelagics.

The evidence for locating FADs in relation to "competing" habitat tends to indicate that distance is instrumental. Unfortunately, as with the other criteria, there is no experimental data to tell us what it is. It appears that FADs are more successful as you move offshore (land or reef), save for the couple of instances when FADs in proximity of small islands were particularly productive. If we return to the arguments presented for the other criteria, these observations may only be the physical expression of other influences: depth is generally

greater away from shore and islands create productive current vortices. Similarly, there has been some speculation about the optimal distance between rafts, in an attempt to increase the chances of encounter without scattering the fish between the devices. Purse seiners have derived their own rules which vary between 4 and 12 miles but that may only reflect peculiarities of this type of operation. Sonic tracking has shown that tuna are very aware of these structures and capable of keeping a "home range" of several miles which would be consistent with the commercial wisdom. Again, the variations may only reflect the productivity of the overall resource.

Other factors such as the size of the float/raft or the presence and type of appendages seem to influence the overall productivity of the rafts. The circumstantial evidence indicates that larger is better although most authors put more emphasis on the importance of the underwater structures. For equal surfaces, the tent shape seems to work better. Finally, although natural fibers (fronds) are quicker to be colonized, because of their very short lifespan, they are not superior to the nylon strapping material in the long run.

We can therefore conclude that aside from the unavoidable exception, if we locate FADs at suitable depth and away from the coast in areas of known productivity, they will attract fish. But will they help catch more fish?

b) Do FADs increase the fishing success and overall catch?

Considering only the productive FADs, there is a large body of evidence to prove that the overall fishing success is improved. It is true for most gears (trolling, pole and line, handlining, vertical longlining and purse seining) but not all species. The majority of the increase is due to much greater catches, in number, of skipjack and yellowfin. So much so that even with a smaller average size, the overall CPUE is still greater than in open water.

The evidence for other species is more divided especially regarding Mahimahi. There has been cases for both greater and fewer numbers of greater or lesser average sizes at FADs. Wahoo on the other hand seem to be consistently fewer at the rafts. For either species however, the distance to shore/reef could have been instrumental in their association with a particular FAD. One is more oceanic and less inclined to visit shallower areas, whereas the other dwels more around reef areas and do not often venture miles offshore.

Once believed to be a source of supplementary bait, FADs do not seem to sustain large catches of baitfish. The best harvest strategy is described for midwater FADs and daily cropping is reported to yield greater amounts than total harvest every few days but no significant quantities are caught repeatedly.

An increase in CPUE is attributable to greater occurence or a change in catchability. In the case of trolling it is evidenced by fewer instances of 0 catches/trip together with an increase in the number caught. For pole and line, it is perceived through a more frugal use of bait allowing longer trips. For handline and vertical LL, it not only creates more opportunities but also increases the occurence of deep swimming tunas. As for purse seine, it changes the catchability and availability, putting the operation within reach of the smaller units.

The overall total catch will be influenced in so far as the fishing habits have been modified. In other words, the effort directed at FADs would not have otherwise be exerted. In Hawaii for instance, it induced more people to engage in fishing and those who already fished to take more trips. As stated before, the operation of small seiners has been made possible by the deployment of FADs and contributing significantly to the total landings in those countries. In Polynesia on the other hand, because free floating objects and bait schools are more productive and apparently abundant, the influence of FADs has not been felt in the overall catches. Finally there are instances where, although effort had only been redirected, because CPUE at the rafts was significantly higher, overall landings did show an increase.

The rational for deploying FADs for commercial, artisanal or recreational purposes thus seems to have been founded: it does increase success rates and total catch. However, to manage a FAD fishery and plan its development, we have to know how much we can expect...

2. How much fish can we harvest from a FAD?

The overall catch will depend on the efficiency of the fishing gear but it will also be function of the dynamics of aggregation under the raft. We thus need to know how the "crop" is going to be harvested and what does it represent: is the aggregation proportional to the abundance in open waters? what are the mechanisms governing the exchanges between the raft and the population at large?

We have seen previously that productivity is variable and strongly associated with the occurence of large pelagics. What other information do we have on species composition and abundance?

Depending on the geographical location and type of FAD, between 20 an 40 species have been reported to occur under the rafts. Up to 70 percent of these species have been classified as resident. That is to say that they are not subject to wide fluctuations in abundance due to the departure or arrival of many individuals. Their recruitment observed over a span of 20-60 days has been described as increasing exponentially first with the occurence of many small individual and then larger predators. individuals. The recruitment rate to some mid-water

FADs has been consistently estimated between 0.5 and 5 tonnes/day reaching a total biomass of up to 25 tonnes.

Non-residents, mostly tuna, comprise the greatest part of the biomass. Yet, because of the transient nature of their association, they cause large fluctuations in the aggregation. Commercial records report catches of tuna at the rafts varying between 1 and 220 tonnes which give an indication of potential yield. The average catch per set of purse seiners operating around FADs varies between 11 and 35 tonnes, harvesting the rafts every 10-30 days. This would correspond to a potential yield of 11-105 tonnes/month, all latitudes, areas and seasons combined... Estimates of the initial size of the aggregation by using the depletion method are possible for successive sets on the same device. It is difficult however to differentiate partial from total removal in the data and thus separate harvest from recruitment. Because there are observations of several schools at the same raft, this method seems only applicable for documented cases.

Overall productivity also has to be considered together with the holding capacity to get a better idea of turnover and throughput. Again it probably depends on geographic location and/or time of year. We have circumstancial evidence from consecutive sightings at the same FAD over time that tuna will remain with a particular raft, but whether it is the same concentration in every occasion remains to be documented. In general, yellowfin have shown a greater tendency than skipjack to remain around FADs and their residence time is often estimated at several weeks compared to only one or two for skipjack. A dietary change by yellowfin to utilize the FAD specific forage base has been suggested as the reason for the stronger association.

On the other hand, Skipjack tend to arrive first followed by yellowfin. They have been observed to arrive any time between 1 and 60 days after their last occurrence, recruitment being more discrete than continuous.

The growing body of information about the behavior of tuna under the FADs does not offer much light on the subject. Daily patterns of activity of tuna (skipjack and yellowfin) studied by sonic tracking showed that besides their stong "homing" behavior previously mentioned, tunas tend to move away from the rafts at night and return at dawn. Observations of the daily patterns of recruitment to midwater FADs showed the same tendencies, with the maximum concentrations occurring at midday. The movement of fish around offshore buoys depicted by echo-integration on the other hand show a biomass continously decreasing during the day and rebuilding at night. Commercial fishing would tend to corroborate the later evidence since seiners fish before daybreak (although the influence of their attracting lights could offset that of the darkness) and pole and line boats follow the concentrations away from the rafts at daybreak. However inconclusive, this evidence should at least warn us of the strong fluctuations in relative abundance which make the use of catch statistics very difficult.

It is difficult to be categoric about the productivity of FADs in the light of the evidence available. FADs, appropriately located, will attract tuna (since it is their greatest output) in proportion to their local and seasonal abundance and will thus contribute to an enhancement of the existing fishery... but to what extent? Because this attraction depends on the population at large, we also need to consider the potential interactions with other fisheries.

3. what potential impact will it have on existing fisheries and associated stocks?

There are obviously different sorts of impacts: economic and biologic. The former will be addressed in the next section and we shall concentrate here on the biological implications of deploying FADs. We have seen that FADs can be used to enhance the habitat and increase fishing opportunities but will it also alter the existing fisheries? We then need to know what is the overall abundance of the resource, what part of it is accessible at FADs and how will its removal affect the population at large and hence fishing.

What effects can we possibly worry about? That the extensive removal of fish at FADs 1) reduces the availability in open waters creating a competition between gears/interests or 2) reduces the overall abundance, entailing lower catches. Again, different gears will have different effects.

The only available evidence comes from the well publicized case of the Philippines. Because of the tendency smaller fish have to associate with FADs, there has been a disproportion of young tunas caught in this fishery, leading biologists to diagnose growth overfishing. There are no data however to evaluate the status of the fishery or relative abundance in the open waters and we can only speculate on the potential interactions with another gear. Purse seine ventures can harvest a significant proportion of the crop residing at a FAD and could conceivably, depending on the mechanism of recruitment, reduce the neighbouring stocks. In the worst situation, the only concentrations left might be at the FADs which would be particularly misleading because the catch statistics would not show a real decline in CPUE since apparent abundance would be seemingly stable.

The potential impact on another gear competing for the same fish, would probably depend on the relative efficiencies and target species: if it is less efficient at catching fish, the competition will be detrimental to the operation. In the Philippines however, artisanal fishermen policing a company's rafts for the right to fish under them, find the competition viable either because of the number of rafts (more opportunities) or because they are able to catch the deep swimming tunas that are not always accessible to the purse seiners.

It is debatable whether artisanal operations such as trolling or handlining and vertical longlining would make enough of an impact on the resource to influence the population at

large. Particularly if the deployment of FADs did modify the fishing habits: if rafts compete with other habitats, and fishermen redirect their effort to FADs, they would be catching fish that they would otherwise have caught elsewhere.

We can thus conclude that only the intensive use of purse seining around FADs could potentially have a detrimental effect on the overall resource and that only this depletion would affect the other gears or fisheries. These consequences are important when considering the cost effectiveness of FADs and how to optimize their exploitation.

4. Are the FADs cost effective?

Our perception of cost effectiveness will ultimately depend on the objectives of the programme. Our expectations will not be the same if we are thinking in terms of development (creating an incentive), enhancement (creating new opportunities) or optimum yields. It all boils down to the cost of the devices in relation to their productivity or the return obtained on the investment and the most effective gears are thus more cost effective.

a) The commercial fisheries

By the nature of their operations, commercial fishermen will make a more efficient use of the FADs. Most prominent in this category are the purse seiners. It seems that it is the the most efficient gear to use in conjunction with the aggregators and several specific fisheries have evolved to exploit this advantage. Their break even performance has been reported to be around 150-200 tonnes a month at fairly low cannery prices, and in one instance 25% was allocated for the construction/deployment/maintenance of the rafts. The reported number of rafts to operate (sustain) one vessel varies around 30, which if we take an average cost of US\$4,000 would take only about 170 tonnes at US\$700 to pay for. Profitability thus has to be considered more in terms of whether the resource and its greater availability at rafts will sustain the vessel beyond its break even threshold since in the costs of the rafts will be absorbed almost immediately.

Modeling exercises, looking at the long range accrued benefits to the fishery argued that at the maximum sustainable yield, there is little if any profit. The scenarios consider a fleet of vessels competing for, thus affecting, the same resource and profitability for the overall fishery drops with CPUE. There seems also to be different strategies whether you manage the fishery for maximum economic return or to maximize catch.

The discussion so far emphasized the purse seine fishery, mainly because there are fewer

evidence for other gears. Following the same principles, we would need to know how many rafts would be needed to sustain on vessel of each gear to estimate what the rent will be and if it can be born with the increase in profitability resulting from fishing at FADs.

b) The recreational fisheries

The assessment of recreational fisheries is somewhat different. The estimate of the benefits is indeed more tenuous since the rent is not charged to the fishermen. There has been two main approaches based on the savings incurred to the operators (fuel costs) or the willingness to pay the rent. The evidence in a particular case shows very marginal profits at best. Recreational fishermen seem to be willing to pay just slightly more than it cost to install and maintain the FADs and the perceived savings in fuel were negated by longer trips, having more focal points to explore.

The benefits accrued to a charter fleet were also shown to be minimal. Because of the nature of a charter, committed to half or full day trips, there was no marked reduction in fuel expanses. Similarly, because it is an open entry fishery, small profit gains are quickly dissipated amongst new arrivals. The economic fall outs on the tourist industry were not however taken into consideration when they probably constitute the greatest hidden benefit.

c) The artisanal fisheries

Artisanal fisheries are similar to recreational fisheries in as much as they both are marginal exploiters compared to commercial operations. Their accrued benefits will thus be considerably less and can only be measured in terms of increases over what they would have gained in other activities. This situation is however only relevant as long as the prices are not affected by the increased landings. The question is thus to determine if the net gain occurring from the difference in CPUE between productive FADs and other areas is significant enough to pay for the rent. The evidence thus far is divided, probably because it all depends on the amount of effort that can be exerted which may be limited when it comes to trolling. That is to say that for trolling, the difference with other fishing grounds is so slight that the amount of effort needed to produce the amount of catch to pay the rent is often prohibitive.

The cost effectiveness is much more favorable when ancillary gears are also taken into account (handlining, vertical longlining)

d) The subsistence fisheries

It is questionable whether cost effectiveness should even be considered for subsistence fisheries where protein production may be the first objective. In that case, the price difference with imported goods should be taken into account.

From the evidence presented, we begin to see that cost effectiveness may be different depending first on the type of exploitation and second on the objectives of the project.

So, What do we need to do next?

From this very general exposé which only attemps to summarize some of the more striking evidence of past research and observations, we should now attempt to determine what our remaining needs are and how to meet them.

We have seen that location is the single most important factor in FAD productivy and several guidelines for deployment are beginning to emerge. It is also apparent that the ultimate productivity will be function of the abundance of tuna in the area and that we can expect geographical and seasonal variation.

 \mathbf{Q} : Should we dispense more energy on the question of location?

- \mathbf{Q} : Is it necessary to take a much more scientific approach to the depth/productivity relationship?
- \mathbf{Q} : Are we satisfyed by the empirical approach?
- \mathbf{Q} : Will the experimental approach give much more definite answers?

As far as measuring the productivity, we know that the extreme situation of commercial purse seining will probably be limited by operational constraints (No. rafts accessible/day).

- Q : Is it really necessary to evaluate the potential for other fisheries which will only be cropping the aggregations?
- \mathbf{Q} : Do we need to know how much effort we can direct on a FAD and can we estimate it?

 \mathbf{Q} : is productivity the issue for artisanal fishermen?

The measure of productivity is important in terms of the resource at large and the potential impact of payao fishing, especially with purse seine. The Philippine experience should caution us somewhat to the liberal development of the fishery.

 \mathbf{Q} : Is there any risk of local depletion, growth or recruitment overfishing?

 \mathbf{Q} : How do we measure it or monitor it?

 \mathbf{Q} : Or is it more important to measure interactions with other fisheries/gears?

Finally, we should ask ourselves:

 \mathbf{Q} : Can these quiestions be addressed individually at a National level?

 \mathbf{Q} : Do they need to be addressed collectively at the regional level?

 \mathbf{Q} : Should we not be attempting to standardize information gathering to allow future comparisons?

Conclusion

A lot of the information is available to plan FAD deployment. Collective experiences have brought much light to the subject and we now need to decide if the empirical approach is

satisfactory, in which case we still might want to standardize our data collection to facilitate generalizations, or if specific questions would be better answered experimentally. Let's now see some regional cases in details.

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