Ecological Trap Hypothesis’ of FADs

Literature Review

October 2020 – Key Traceability

Purpose: This literature review has been conducted according to the FIP workplan, available here. Specifically, this task is part of IPG 7 – Ecosystem impact of FADs, where it was assessed in the pre-assessment that further information is required to understand the Fish Aggregation Device (FAD) impacts on the fishery and the wider ‘ecological trap hypothesis.’ The work will go towards evidence and knowledge-based fishery management, such as FAD management plans for the fishery that consider findings in this literature review.

Scope: Review current literature surrounding the ‘ecological trap hypothesis’ of FADs on behaviour, feeding and migration of key elements of the ecosystem, including ETP sharks, indication of other potential impacts of FADs on key elements of the ecosystem.

What are Ecological Traps?

Ecological traps are situations in which rapid environmental change leads organisms to prefer to settle in poor-quality habitats. The concept stems from the idea that organisms that are actively selecting habitat must rely on environmental cues to help them identify high-quality habitat and the concept was introduced in 1972 by Dwernychuk and Boag and many studies suggest that the ecological trap may be widespread because of anthropogenic habitat change (Schlaepfer et al., 2002; Battin, 2004 and Robertson and Hutto, 2006). If either the habitat quality or the cue changes so that one does not reliably indicate the other, organisms may be lured into poor-quality habitat (Battin, 2004). The concept is an inherently behavioral phenomenon of individuals (Robertson and Hutto, 2006). Despite being a behavioural mechanism, ecological traps can have far-reaching population consequences for species with large dispersal capabilities (Lamb et al., 2017) with these errors made in judging habitat quality possibly leading to population declines or extinction. These poor selections are also not limited to habitat selection but may occur in any behavioural context such as predator avoidance, mate selection or foraging site selection (Schlaepfer et al., 2002). This paper will review current literature surrounding the ‘ecological trap hypothesis’ of FADs on behaviour, feeding and migration of key elements of the ecosystem, including endangered, threatened and protected (ETP) shark species, indication of other potential impacts of FADs on key elements of the ecosystem to enable us to better advise the fishery currently in a Fishery Improvement Project.

What are Fish Aggregating Devices?

Fish Aggregating Devices are a permanent, semi-permanent or temporary structure or device made from any material and used to lure fish to then be fished on, usually using purse seine nets (FAO, 2005). Fish generally congregate under floating devices in two steps: Firstly small fish are attracted to floating objects for a myriad of possible reasons such as reduced swell for safety or increased productivity (Castro et al., 2002; Freon and Dagorn, 2000; Hall, 1992) which secondly attracts larger fish that prey on the former small fish. Castro et al. (2002) found records of 333 species belonging to

96 families that, at some time, has been observed associated with floating structures. However, when considering only species that are commonly found around drifting floating objects in tropical waters, this number drops to between 30 and 40 species (Romanov, 2002; Taquet et al., 2007). This aggregation could sometimes be at a distance from the FAD and in many cases the aggregation happens across the whole water column attracting a range of species depending on depth (FAO, 2005). This aggregation could take roughly two to four weeks for larger fish such as tuna and tuna-like species and increases the amount of tunas in one place. At the start of the 1990s, long distance purse seiners began constructing and deploying large numbers of FADs to increase their catch of tropical tunas: the amount of tropical tuna captured around both FADs and logs represents a very large portion of the total annual catch in each ocean (Dagorn et al., in press). Most FADs consist of a raft with nets hanging below and are equipped with positioning buoys to allow them to be located remotely (Moreno et al., 2007). The introduction of FADs has seen a marked increase in catch, in the last 30 years more than 50% of the catch from purse seine vessels in the western Indian Ocean has come from sets on floating objects (more than 75% in 2009) (Dagorn et al., in press), and therefore a reciprocated dramatic increase in the total number of floating objects. Since the introduction of FADs, the number of objects has at least doubled in most locations and in some regions such as around Somalia the increase is as high as 20 or 40 times (Dagorn et al., 2013). This clearly represents a change in the floating object environment, a key element of the natural habitats of tropical tunas as well as other species that associate with floating objects.

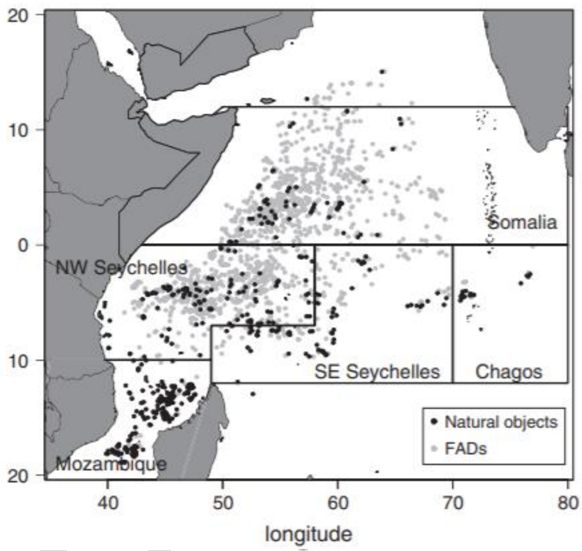

Figure 1 - Map representing all FADs and logs recorded by observers during 2007 and 2008, in the Western Indian Ocean with indication of the geographical strata used in the analysis (Dagorn et al., 2013).

FADs and the Ecological Trap Hypothesis

With FADs the ecological trap hypothesis is that small tunas and the various species found in association with drifting FADs (such as "mahi -mahi", rainbow runner, wahoo, etc.) may be biologically trapped by such a strong association (Marsac et al., 2000). These FADs may significantly alter movement where populations follow a drifting FAD with populations being artificially transferred to less favourable parts of the ocean when following FADs (Marsac et al., 2000). Obviously natural floating objects (e.g., logs) have always been a component of the habitat of tropical tunas but these are likely to be beneficial and not act as an ecological trap due to these tending to accumulate in convergence areas with richer foraging areas (Marsac et al., 2000).

The deployment of FADs in the ocean could modify this environment in two ways. First, FADs can be deployed in or drift into areas where there previously were no logs. In this way FADs can create new areas with floating objects. Secondly, FAD deployments can increase the number of floating objects in areas that already had logs (even at very low densities) (Dagorn et al., 2010 and 2013). It has also been observed that the use of FADs often alters the exploitation of the resources with more juvenile stocks of fish being taken when fishing around the FADs. The association of tunas with any floating object may then be a result of an evolutionary process where tunas use these indicators to find or stay in contact with rich waters. Following this hypothesis, FADs could act as ecological traps because tunas could be misled by FADs (Marsac et al., 2000; Hallier and Gaertner, 2008). If FADs drive the associated fauna to biologically poor areas (a change in their migration routes) or prevents them from leaving a poor area, this could have detrimental effects on their biology (e.g., growth) (Dagorn et al., 2010). This hypothesis is mainly based on the idea that FADs occupy areas where logs are not found. Dagorn et al. in 2013 found that the processes for FADs to drive tunas to new areas, and possible consequences of such movements on the biology of individuals, could occur at scales smaller than 2°x2° with logs and FADs occupying different 1°x1° quadrats but similar 5°x5° areas. In addition, further work is needed to understand the impacts FADs have on how long tuna remain in these areas compared to one another.

In the example of Atlantic skipjack, the ICCAT International Skipjack Year Programme, in the early eighties, revealed seasonal migrations from the Guinea Gulf to the more productive areas of Senegal (to the north) and Angola (to the south). If juvenile tunas remain trapped in the equatorial network of FADs, they may show less migrations to the productive coastal areas which were an important component of their evolutionary and recent life cycle. In comparisons of fish plumpness and growth rate between free school and drifting FAD (dFAD)-associated tunas for skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*) caught in the Atlantic and Indian Oceans significant differences were observed, with those associated with drifting FADs being reduced and therefore less healthy than those in free schools (Hallier and Gaertner, 2008). This difference in growth rate and condition could be the consequence of altered feeding patterns as those on FADs eat less than those in free schools. Significant changes in displacement and migratory direction were observed in the presence of dFADs proving that they act as super stimuli causing tunas to make inappropriate habitat selection (Hallier and Gaertner, 2008).

Similar consequences might be expected for some species of the fauna which are associated to the FADs among tunas, such as mahi-mahi, rainbow runner, wahoo and some species of sharks (Marsac et al., 2000).

Potential Solutions

Much of the concern surrounding FAD fishing stems from uncertainty around their ecological impacts. In order to quantitatively assess the impact of FADs and to consider potential management options, it is necessary to generate more data on how, where and why they are used. It is very apparent that to further understand this issue, the flow of data needs to greatly improve. Observer programmes need to continually improve and they must maintain 100% observer coverage to continually monitor potential changes in this distribution (Dagorn et al., 2013).

Fishers currently do not report all floating objects they encounter in logbooks, and only report the objects which they set. To assess the changes due to the deployment of FADs, it is essential to start to collect information on all objects found in the ocean. It is noteworthy that if fishers could note in a rigorous manner all floating objects they encounter (indicating the type of the object, date, time and location), acting as observers of the ocean, the amount of data would increase considerably (Dagorn et al., 2013).

Additional knowledge, collected through tracking buoys, on the locations of instrumented floating objects would be beneficial if it could be shared in a delayed database to address the sensitivity of the data, would serve the scientific purpose without affecting the real-time efficiency of the skippers (Dagorn et al., 2013). Conventional tagging of small tunas in the FAD fishery area would allow a comparison of the migration pattern with the historical tagging programmes (International Skipjack Year Programme), a comparison of growth rates by area and the assessment of the fidelity of tunas to FADs, in the short and medium terms (Marsac et al., 2000). In addition to this, acoustic telemetry has enabled scientists to provide information on the time spent by tunas around FADs and in arrays of anchored FADs (Ohta and Kakuma, 2005; Dagorn et al., 2007; Mitsunaga et al., 2012; Robert et al., 2012). However, it is difficult to obtain such estimates for drifting FADs, as this would require equipping all drifting FADs in an area with automated acoustic receivers, which is obviously tough to organise (Dagorn et al., 2013). However, we feel pilot projects led by the RFMO are a viable option and we would endeavour to provide any resources from a fishery.

Additional research programmes led by the RFMO should include:

- Biological analyses to address the trophic ecology of tunas between those associated to FADs for a significant amount of time, and the rather resident populations in forage-rich areas. These analyses, using stable isotope ratios of carbon and nitrogen, can be complemented by the estimation of condition factors based on the chemical characteristics of the tuna flesh. Such conditions factors should be compared between FAD-associated and free-school tunas.
- Changes in size composition of the catches in the FAD fishery area, between historical and recent periods.
- Stomach contents of large predators (billfish, sharks, large tunas) taken under FADs to understand biological attractions (Marsac et al. 2000)

However, we must understand there are other forces at play such as the free distribution theory (which is not addressed in this paper) (Fretwell and Lucas, 1970) and ecological trap hypothesis is not the only factor in play.

Next Steps

As a fishery within a Fishery Improvement Project, we endeavour to make sure our fishing practices are as sustainable as possible. This naturally means understanding fully how the fishery can impact the ecosystem and contribute to the trap hypothesis. The findings of this brief review must be used to inform the creation of future FAD management policies.

As a FIP, we shall:

- Advocate for continual improvement to observer programmes to ensure data is collected and the programme continually advances.
- Improve skippers reporting of floating objects, regardless of their interaction with them.
- Push for locational data to be shared with RFMOs in a sensitive nature to build a data base to fully map the ecological trap hypothesis with regard to tuna fisheries.
- Advocate for a tagging and acoustic telemetry pilot study.
- Advocate for biological based studies to understand the ecology and biological differences between tunas found in free schools and on FADs.
- Have a strong FAD management plan in place that removes FADs from being in the water for too long through a FAD recovery scheme.
- Improve reporting in the fishery to understand exact amounts of FADs deployed.

Conclusion

Overall, it is apparent that FADs do have a major impact on the behaviour of tunas and can play a detrimental role by acting as an ecological trap. This trap holds or moves tuna to poor habitat areas reducing the strength of the population through this inappropriate selection. As a fishery we use FADs in our operation to improve the catch of tuna, and endeavour to do so in a sustainable manner and therefore we must be aware of the impacts they have on the ecosystem and the potential traps they could make so management measures can be implemented

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