Report of the ISSF Workshop on FADs as Ecological Traps

29-31 January 2014 – Sète, France

Summary

There is currently inadequate scientific information to conclude if deployments of fish-aggregating devices (FADs) induce adverse impacts on tropical tunas, and thus function as "ecological traps." This workshop was structured with the following three sections: 1) potential changes in habitat due to FADs, 2) effects of FADs on tuna behavior and movements (by retaining them or by carrying them into locations that were not part of their original migratory patterns), and 3) effects of FADs on the biology of tunas through changes in diet, growth, reproductive success, etc.

Natural floating objects (e.g. logs, branches, etc.) have always been components of the habitat of tunas, with densities varying by area and season. In the recent years, fishers have deployed a large number of FADs in the ocean and it is essential to evaluate the degree to which this FAD deployment practice has changed the habitat of tunas (as opposed to natural floating objects) in each oceanic region and during each season. A first step in this process requires the estimation of the densities of floating objects within the habitat of tropical tunas, including distances between adjacent floating objects, and compare data for natural logs with data for all types of floating objects within the same spatial strata.

Some data tend to show that FADs may modify the large-scale movement behavior of tunas, but it is not yet possible to identify whether FADs are the main factor responsible for these changes, or if they are also due to environmental factors. There is limited scientific information on the processes involved with the associative behavior of tropical tunas, which impairs our ability to assess whether FADs can impact the large-scale movements of tunas. The commonalities and differences between anchored and drifting FADs in terms of behavioral responses were underlined and should be considered in the design of the future experiments.

Differences in the condition factors of tunas in free-swimming schools and those associated with floating objects have been observed, but with opposing results depending on the areas investigated. Therefore it remains uncertain if or how FADs may affect the biology of tunas, and a more accurate assessment of condition would be necessary.

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Major gaps in our knowledge on this topic were identified during the workshop. Research dedicated to investigate this topic is needed if one wants to assess whether the deployments of FADs adversely affects the ecology of tunas.

Introduction

A 2.5 day workshop (WS) was organised in Sète, France, to review the current knowledge on the effects of FADs on the biology and ecology of tunas, commonly referred to as the "ecological trap hypothesis". There are two related questions: do FADs change the behavior, biology or ecology of tunas, and does this change have positive or negative impacts on tuna survival or reproduction? Specific aims were:

- to evaluate data and results of the effects of FADs (drifting and anchored) on tunas, and assess whether or not FADs act as an ecological trap for tunas
- to conduct a gap analysis
- to prioritize future research
- to evaluate the feasibility to prepare a paper to be published in a peer-reviewed journal

The WS was endorsed and funded by the International Seafood Sustainability Foundation (ISSF) and hosted by the *Centre de Recherche Halieutique Mediterranéenne et Tropicale* in Sète.

Twenty-three participants attended this workshop:

Participant	Institute, Country	Participant	Institute, Country
Laurent Dagorn	IRD, France	Jean-Louis Deneubourg	ULB, Belgium
Frédéric Ménard	IRD, France	Gregory Sempo	ULB, Belgium
Alain Fonteneau	IRD, France	Manuela Capello	ULB, Belgium
Francis Marsac	IRD, France	David Itano	NOAA, USA
Daniel Gaertner	IRD, France	Kim Holland	UH, USA
Hervé Demarcq	IRD, France	Jeff Muir	UH, USA
David Kaplan	IRD, France	Kurt Schaefer	IATTC, USA
Alexandra Mauffroy	IRD, France	Martin Hall	IATTC, USA

Liliana Pascuali	IRD, France	Francesca Forrestal	ISSF, USA
Gala Moreno	AZTI, Spain	John Filmalter	IRD, South Africa
Hilario Murua	AZTI, Spain	Fabien Forget	IRD, Mauritius
Jon Lopez	Spain		

Definition of an ecological trap

The ecological trap concept was first proposed about 40 years ago in the terrestrial ecology community. An ecological trap occurs when a habitat becomes unsuitable (e.g., degraded by human activities) for a given organism, but the original cues that the animal was using as a proxy for selecting the habitat persist, misleading the organism into behaving as though the habitat patch is still suitable[1]. The cause of an ecological trap can only be a change in the habitat (usually anthropogenic changes).

Ideally, the behavior and condition of the organism should be compared before and after the habitat change. Unfortunately, this is rarely possible due to the lack of an historic baseline.

Background

FADs undoubtedly increase the catchability of tunas and the efficiency in purse seine fisheries for tropical tunas around the world.

Marsac et al. (2000)[2] was the first paper to suggest an hypothesis stating that FADs, (man-made floating objects deployed to aid in the capture of tunas), may change the migration patterns and the biology of tropical tunas. Since then, numerous studies have been conducted on this topic, with contrasting results. The workshop gathered together a group of tuna scientists, with expertise on this topic, to present relevant information, and discuss our current level of understanding on this topic.

The list of presentations is given in Annex 1 (agenda of the workshop).

Habitat

Tunas have lived for thousands of years in habitats with natural floating objects. The natural floating objects were mostly parts of trees and branches carried by rivers to the ocean. Human activities (logging, coastal development, shipping, etc.) have affected the number of floating objects encountered by the tunas. Some of these trends may have resulted in steady increases (marine debris, shipping); others such as logging may have increased and then decreased because of deforestation. There are also environmental changes that affect the production and movement of floating objects (floods, El Nino events, tsunamis) so the system has always been in a dynamic condition. In the recent years, the large increase of the number of FADs used by fishers raises the question of the impacts of this practice on the habitat. It is essential to assess to what extent FADs have

[1] See Schlaepfer et al. 2002 and Battin 2004

[2] Marsac, F., A. Fonteneau, et al. (2000). Drifting FADs used in tuna fisheries: an ecological trap? Le Gall J.-Y., Cayré P. and Taquet M. (eds.), Pêche thonière et dispositifs de concentration de poissons, Ed. Ifremer, Actes de colloques. no. 28, pp. 537-552.

changed the habitat of tunas, relative to an environment only containing natural floating objects (logs). Some tuna regional fisheries management organizations (TRFMOs) have defined a FAD as a "floating object encountered and modified, or built and deployed, by fishers to attract fishes, and usually with a device to facilitate its relocation". For the particular question addressed here, FADs only refer to man-made floating objects built and deployed by fishers (usually bamboo rafts) and not to all floating objects equipped with a satellite buoy. The two other categories of floating objects are natural objects (logs) and marine pollution.

Main recommendations were:

- Two main parameters must be estimated to assess changes due to drifting FADs: densities of objects, and distance between objects (nearest neighbor), both being closely related. These parameters depend strongly on the dynamics of the DAD population. These dynamic in turn depend upon the rates at which FADs are added or removed from the ocean, as well as their movements between areas. For every oceanic region and season, it is important to compare these parameters for natural floating objects (e.g. logs, whether equipped or not with buoys) and for all types together (natural and artificial).
- For arrays of anchored FADs, densities of FADs and distance between FADs should also be measured.
- Fishery statistics are not the best source of data to investigate this issue. Observer information, however, could be used as observers record all objects encountered by the purse seine vessel during a trip (with a set or not) and, thus, densities of objects and distances between them could be estimated form those data (it should be noted that this could lead to an over-estimation due to multiple observations of a same object).
- But observer data are limited to areas covered by purse seiners, while it is known that FADs and logs can drift outside fishing regions. Other remote sensing methods including high definition satellite derived images or drones equipped with LIDAR and/or cameras should be explored.
- Complete trajectories of all floating objects equipped with satellite buoys, monitored by fishing fleets, should be provided to scientists, along with information on types of objects, as they would greatly improve our understanding of these processes and estimates. The studies of drift patterns should shed light on the distributions, drifting speed, and distances covered by the FADs.

Behavior

FADs may effect large-scale movements of tunas in the following two ways : they could cause tunas to relocate to new areas or they could increase residence times in some areas. Ideally, the best approach would be to compare the large scale movement patterns of tunas before and after the period of large scale deployment of FADs. But suitable data does not appear to be available for this purpose.

The main objective should be to further evaluate the mechanisms which influence large scale tuna movements, including the impacts of floating objects and their environment.

Main conclusions and recommendations were:

- Some conventional tagging results showed different patterns in the location of recaptures by school type (free vs associated). In the absence of more detailed information, it is not possible to assess if these differences are the results of tunas following FADs (so called "misled tunas") or tunas responding to other cues.
- It is therefore essential to understand the behavioral processes involved in the association of tunas with floating objects (anchored and drifting FADs), and how these are affected by abiotic and biotic conditions.
- How FADs are colonized as well as how fish leave the FAD are behavioral processes essential in understanding the drivers of tuna associative behavior and thus the potential effect of FADs on tuna ecology. The echo-sounder buoys utilized by fishers can provide information on collective behavior of fish from colonization to decolonization over varying time scales. However acoustic data obtained from these buoys require careful processing and validation before meaningful indices of relative abundance can be generated.
- Variables characterizing the movement behavior of tunas in a network of floating objects are the residence time at floating objects and time elapsed between two association events. From these data, it is possible to measure the percentage of time tunas spend associated with floating objects.
- To measure residence time and absence time, scientists can use acoustic tags, but acoustic receivers should cover all floating objects of the studied area. This has only been possible in arrays of anchored FADs (Hawaii, Maldives, Mauritius) and it has not been possible on drifting floating objects due to the nature of drifting networks. Because bigeye tuna exhibit different vertical behavior patterns when associated or non-associated with floating objects, archival tags have been used to assess residence times at and between floating objects, without the need to instrument all objects. There is also potential for using this method with yellowfin tuna but requires further validation studies by ocean regions.
- These behavioral variables can be influenced by various factors including: fish size and condition, the density of floating objects (or distances between objects), the number of associated conspecifics and tuna density in the area, the biotic environment (prey abundance and presence of predators).
- Particular experiments must be conducted to measure these variables together, in order to fit existing models. Then, once these processes are better understood, scientists could use these models to perform simulations in order to assess the effects of higher densities of floating objects on the movements and behavior of tunas.
- FADs can also affect schooling behavior, which can a wide range of consequences on the biology and the movements of tunas. Studies, particular those following a modeling approach, should be promoted to investigate the consequences of changes in the densities of floating objects on tuna school sizes.

Biology

Some of the important biological impacts on tuna populations to be considered include feeding, growth, reproduction and natural mortality. One hypothesis is that new zones of floating objects created by drifting FADs (if any) are not necessarily favorable for tuna feeding. Another hypothesis is that massive deployment of FADs may increase food competition in areas by increasing local abundance of competitors on limited forage resources. Investigations were based on feeding indices (diet composition, fullness index, rates of empty stomachs), condition factors (plumpness, lipids, measures of water content), and tagging data (natural mortality).

Main conclusions and recommendations were:

- Available results indicate that differences in the condition between tunas in free-swimming schools and associated with drifting floating objects have been observed, with some opposite patterns.
- Different variables were used to measure the condition factor of tunas, e.g. thorax girth and BIA - Bio Impedance Analysis (Phase angle and composition index). However more data are needed to relate simple indicators of body condition to biochemical composition and energy content. Indeed, it is noteworthy that a fish with a sub-standard condition does not automatically imply that this fish is in a bad condition. Does lower condition cause decline in growth production? Would lower available energy reserves reduce allocation for reproduction?
- Therefore, experiments on captive tuna must be conducted to understand the temporal scale of evolution of different condition factors in order to be able to compare these data with behavioral data (time spent by tunas at and away from FADs) and see if differences in condition factors can be explained by the behavior.
- Studies should investigate whether different indices could provide a better information on the possible effects of association on the long-term biology of tunas.
- At the same time, collection of data at sea (free-swimming school vs. floating object schools) should be continued, but specific protocols must be rigorously followed: significant number of fish sampled by set (> 30), identical measurement procedures, comparison between free-swimming and associated schools made on samples collected in a restricted area over a relatively short time period.

Conclusions

No conclusions were reached with respect to whether FADs act or not as ecological traps for tunas. However, the group agreed that the ecological trap term, although inspiring, has been misleading due to its negative connotation and, thus, that it would be desirable to abandon this term and focus on investigating the "**effects of FADs on the biology and ecology of tunas**".

The group agreed that a dedicated research project is needed in order to assess the effects of FADs on the ecology of tropical tunas, and determine whether these effects may become detrimental to the populations. Research should be conducted in every ocean as effects of FADs could vary depending on the properties of each ecosystem. The project should encompass ambitious technological developments (e.g. 'metabolic' tags, drones), experiments on captive fish and obviously fieldwork, as well as a range of modeling approaches.

The group considered that this workshop was a major step forward and recommended that the group continues to interact, either electronically or by meetings, to regularly circulate new knowledge, plan new research and look for funding opportunities.

Annex 1

Agenda

ISSF Workshop on FADs as Ecological Traps, 27 – 29 January 2014

1. **Welcoming and introduction (Monday 0900-1000/1030)**
2. **Present data, discuss results, identify research priorities**

Habitat/Environment (Monday 1000/1100 – Monday 1530)

- A. Fonteneau: The FAD environment
- L. Dagorn: How much do Fish Aggregating Devices (FADs) modify the floating object environment in the ocean?
- JD Filmalter: Estimates of the number of FADs in the IO
- D. Kaplan: Drifts of FADs in the IO and AO
- L. Pascuali: Relationships between FADs and the environment in the IO and EPO

Gap analysis, synthesis and perspectives

Movement (Monday 1600 – Tuesday 1030/1230)

- D. Gaertner: Effects of FADs on tuna movements, from conventional tagging
- L. Dagorn: Residency times of tunas at FADs
- K. Schaefer: Movements and behavior of tunas in the equatorial EPO and CPO relative to drifting FADs
- G. Sempo: Impact of increasing deployment of artificial floating objects on the spatial distribution of social fish species
- J. Lopez: Diel behavior of tunas around DFADs as assessed by echo-sounder buoys

Gap analysis, synthesis and perspectives

Biology (Tuesday 1100/1400 – Tuesday 1730)

- F. Ménard: Trophic ecology of FAD-associated tunas
- D. Gaertner: Effects of FADs on the condition factors of tunas
- L. Dagorn: Comparison of condition factors of skipjack tuna (Katsuwonus pelamis) associated or not with floating objects in an area known to be naturally enriched with logs
- H. Murua: Lipids classes and condition factor of yellowfin and skipjack tuna associated and non associated with floating objects in the IO
- F. Forget: Condition factors of skipjack tuna associated and non associated with floating objects in the WCPO

Gap analysis, synthesis and perspectives

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3. **Synthesis: prioritizing objectives and tasks (Wednesday 1000-1230)**