Colonization patterns of fish on fish aggregation devices (FADs)

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The Island School · Cape Eleuthera Institute

Introduction

What is a FAD?

Fig. 1A. A low-tech, nearshore fish aggregation device (FAD) using bamboo floats and palm fronds (the 'aggregator'). *Photo by WWF, Soloman Islands*

In the open ocean, fish are known to attract towards naturally occurring structures. It is thought that this association provides grazing, shelter, and a meeting point for breeding (Davies *et al*. 2014). Examples of natural structures include uprooted trees, palm fronds, and seaweed.

Small fisheries have exploited this relationship to improve local fishing success (Fig. 1A & 1B). In recent years, commercial fishers have also created larger man-made structures known as **fish aggregation devices** (FADs) to mimic this natural association. There are two different types of FADs: a drifting FAD and an anchored FAD. An anchored FAD is tied down to the bottom of the ocean floor and a drifting FAD is free floating, carried along by the current.

Fig. 1B. The underside of a nearshore FAD *Photo by Wade Fairey/WorldFish, Soloman Islands*

Why are FADs important?

Fig. 2. An example of potential bycatch, a loggerhead turtle (*Caretta caretta*), on a FAD in the East Pacific Ocean. *Photo by Alex Hofford, Greenpeace*

While certain fisheries depend on FADs, there is limited research investigating how the presence and harvesting of fish on FADs influences existing populations, and the time it takes for different types of pelagic (open ocean) fish to colonize FADs (Moreno *et al*. 2016). There is also limited management of FADs which can lead to over-exploitation of species as well as a risk of bycatch (Fig. 2) due to non-selective fishing methods.

Aims

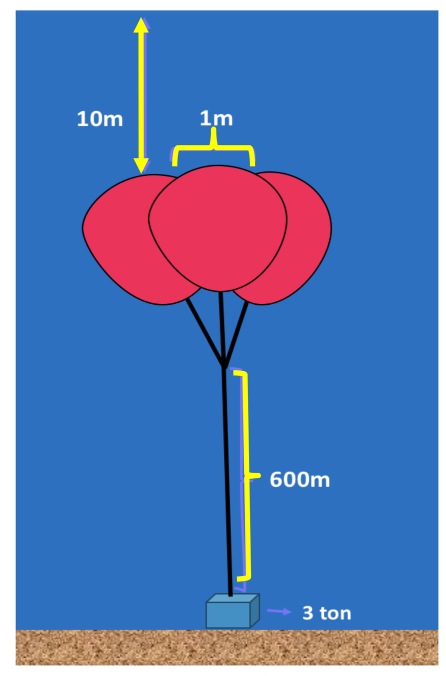

Fig. 3. The structure of a FAD deployed by the Cape Eleuthera Institute in the Northern Exuma Sound

1. The broader aim of this five-year project is to improve management and regulation of FADs with the additional goal of using FADs as conservation tools.
2. During the Island School 2018 spring semester, our aim was to assess the colonization cycles of fish aggregating on FADs. This includes calculating the abundance (number of fish) and species richness (number of different types of pelagic fish present) present on the FADs.

Study Site

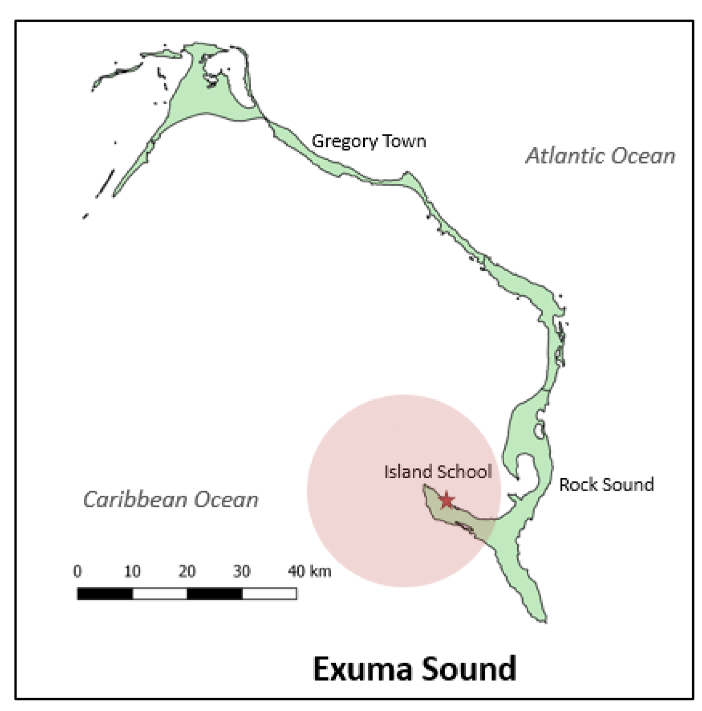

Fig 4. FADs are deployed in the Northern Exuma Sound, near to the Island School campus

The Cape Eleuthera Institute (CEI) deployed two-off shore, sub-surface anchored FADs along the nearby continental shelf at depths ranging from 500 – 800 m in the North Exuma Sound, off of Southern Eleuthera in The Bahamas (Fig. 4, in the approximate area of the Island School indicated by the red circle).

FADs were deployed as part of a research class with the Fall 2017 Island School class.

Methodology

Fieldwork

We used a combination of snorkel and video surveys in order to assess the number and species of pelagic fish present on the two FADs:

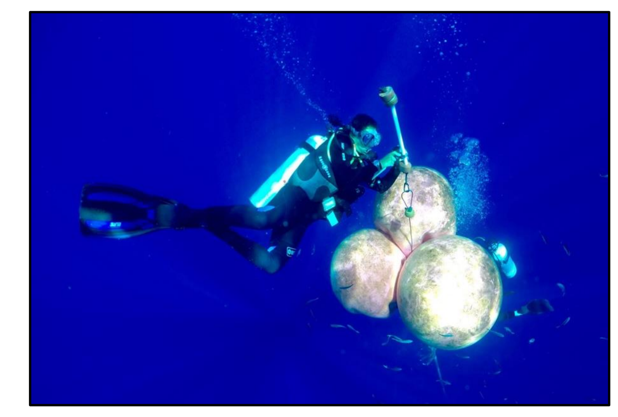

Fig. 5A. Project Advisor ,Olivia Eisenbach, deploying a camera on one of the CEI FADs in the Exuma Sound for a video survey

1. Video surveys
A single GoPro camera was deployed at each FAD by clipping the camera and attached floatation device into a specially designed swivel mount. The camera was attached by CEI staff and left to record a video continuously for 90 minutes (Fig. 5A). The aim was to capture two video surveys, one on each FAD, each week.

Fig. 5B. FAD class students, Wyatt Balderson and Ben Easton, carrying out a snorkel survey at one of the FADs

2. Snorkel surveys
Island School students carried out 50 meter snorkel transects in four cardinal directions (north, south, east, west) while working in pairs to record the species present and their abundance (Fig. 5B) on dive slates. Although it was not always possible, the aim was to conduct a snorkel survey on each FAD every week.

Statistics

After carrying out surveys, this semester's data was combined with that collected during the previous semester (August 2017 to February 2018). From this data, **species abundance** and **species richness** was calculated. Species abundance describes the numbers of the different species that are present and species richness describes the total number of different species that are present.

The **Simpsons diversity index,** an index is on a scale from 0 – 1, was calculated and used to assess whether there is an overall dominant species present on the FAD during each month.

Results

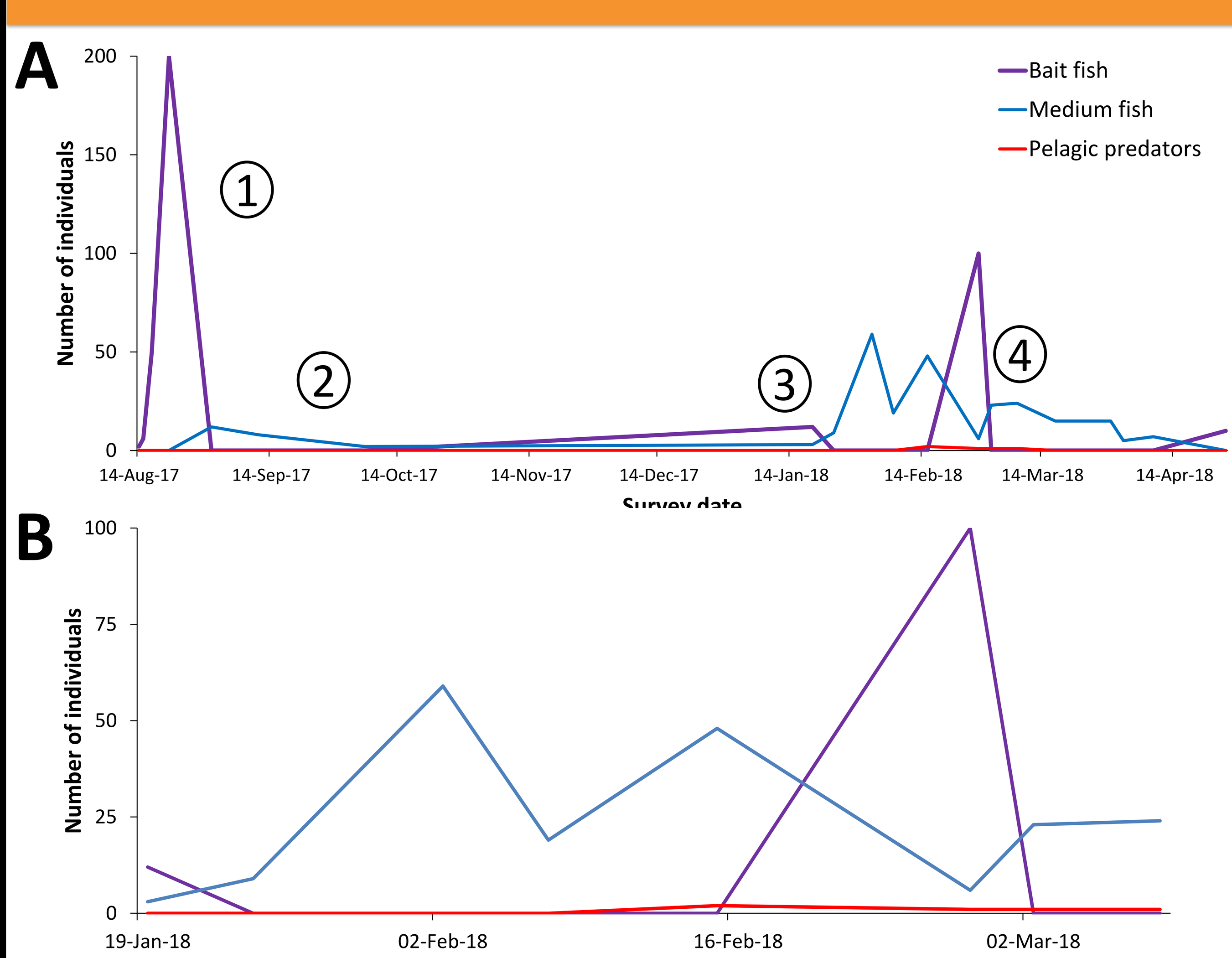

Fig. 6. A. The abundance of pelagic fish on FAD 1 from the 14th of August 2017 to the 14th of April 2018. Three different data groups present in graph: bait fish (2 centimeters or smaller), medium sized fish (Alcamo Jacks, Bar Jacks, Rainbow Runners), and pelagic predators (sharks, mahi mahi, and Wahoo). B. A sub-section of Fig. 6A focused on data collected from mid-January to early-March. There is a clear predator-pray relationship trend in this specific section of data. For example, on February 16, a pelagic predator (Galapagos shark) was present on the FAD. Its presence was followed by a decrease in medium fish, followed then by an increase of bait fish

In order to investigate the colonization cycles (the time taken for different types of fish to appear) a graph was plotted using data from both semesters (Fig. 6A). This graph is representing the following trends:

① August – early September 2017
- 200% Increase of bait fish

② September 2017 – early January 2018
- Low abundance of all pelagic fish due to cyclical predation or seasonal/temperature change

③ Mid January 2018
- Small increase in baitfish followed by 33% increase of medium fish

④ February 2018
- 100% increase in bait fish followed by spike of medium fish
- One pelagic predator seen on FAD 1 on February 16, 2018

Table 1. Summary table for data collected from August 2017 to April 2018 on one of the FADs. Month describes the month data was collected, no. of surveys combines the number of video and snorkel surveys carried out per month, total species abundance describes the total number of individuals, species richness is the total number of different species seen on the FAD for that month. Simpsons diversity index (D) was calculated using Equation 1 (below) and is an index of 0 – 1 which indicates whether a dominant species is present for that month. Dominant species describes the most abundant species for that given month across all surveys. Bait fish describes all pelagic fish < 5 cm

Month	No. of surveys (video + snorkel)	Total Species abundance (n)	Species richness	Simpsons diversity index (D)	Dominant species
August	5	270	3	0.91	Bait fish
September	1	8	2	0.57	Almaco jack
October	1	2	1	1	Almaco jack
November	0	n/a	n/a	n/a	n/a
December	0	n/a	n/a	n/a	n/a
January	2	24	3	0.44	Bait fish
February	4	235	6	0.29	Bait fish
March	4	79	5	0.57	Rainbow runner
April	2	12	1	1	Rainbow runner

$$D = \sum \frac{n(n-1)}{N(N-1)}$$

Equation 1. The Simpsons diversity index (*D*), where *n* is the total species abundance for a given month, and *N* is the total number of fish in all species. Produces a value between 0 and 1.

In August 2017, the calculated Simpsons diversity index was 0.91 (Table 1) which indicates a dominants species was present. In contrast, February of 2018, the Simpsons diversity index was 0.29 which indicates that there was not a clear dominant species. The final column suggests the cyclical predation on our FAD. It starts with small bait fish followed by larger predators, in this case these predators are the Almaco jacks and rainbow runners.

Discussion

A trend of cyclical predation has been observed from our data, meaning that as the small baitfish aggregate on the FADs, medium sized fish will then follow, consuming the small baitfish and causing the medium sized fish population to increase. This trend ultimately leads to the appearance of larger pelagic predators. This pattern is expected to continue for the duration of this five year research project.

Fig. 7. A mahi mahi (*Coryphaena hippurus)* sighted during one of our FAD video surveys

Looking at the trends in our data, a distinctive pattern can be seen in the species abundance and richness as colonization occurs. Factors that could have affected our observed results include time, depending on the time of day, there may be different fish as some fish may be more active during the night. Also water temperatures and season may be related to migration, and therefore affect what species we see. Weather is another factor that could have altered our data. Wind, swell, and currents could affect our data and prevent us from collecting data. Additionally, there are many abiotic factors which altered our data and did not allow us to conduct surveys. The fish around our FADs may have been scared off by the sounds of our motor boat or the presence of the snorkelers. There was also a large fishing tournament in the area, which could have taken various species of fish away from the FADs.

Conclusion

The data collected on the FADs over the last eight months has allowed us to further understand the colonization of FADs, and how species richness and abundance changes over time. The colonization on our FADs are shown by small baitfish, followed by medium sized fish that eat those bait fish, and, ultimately, pelagic predators that eat the medium sized fish. This also suggests a cyclical predation on our FADs. However, not enough data has been collected to make a definite claim about the cyclical colonization patterns. Our work is part of a five year project, and, in the future, aims to provide a better idea of cyclical colonization patterns on FADs.

There are multiple ways to continue and enhance our research in this project:

- Continue our surveys: Conducting more surveys more frequently to collect more data
- Deploying additional FADs: More data can be collected from a variety of different locations with different factors (depth, temperature, current, weather, proximity to shore etc.)
- Tagging fish: we could use tagging to collect data on the movement patterns of migratory pelagic fish such as mahi mahi. This would allow us to assess whether they travel between our FADs and whether they occupy our FADs for an extended period of time

We hope that the data collected during this project will allow us to help inform policy and ensure sustainable fishing practices in the future.

Acknowledgements

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