Preliminary findings of AFAD research project in the Maldives

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Abstract

Anchored fish aggregating devices (AFADs) are widely used in the Maldives tuna fishery since its deployment began in the early 1980s. There are a total of 55 AFADs in the Maldives. The associative behavioral patterns of tuna has not yet been studied on a large scale at AFADs in the Maldives. This research project attempts to study behavior of two important commercial species of tuna, *Katsuwonus pelamis and Thunnus albacares,* in the Maldivian AFADs array. Echosounders buoys are used to study the biomass under the AFADs. Acoustic and conventional tagging is conducted to investigate the movement of tuna among the AFADs but also movement to Drifting FADs (DFADs) and free schools. Fisher interviews are conducted to gather local ecological knowledge on the AFAD fishery in the Maldives. Preliminary findings indicate that there is no apparent movements of tuna between AFAD in the Maldives. Preliminary investigation of Echosounder buoy data suggests that biomass at neighboring AFADs can vary in size and that there is no clear East to West gradient in biomass across the Maldives. The combination of echosounder buoy and acoustic tagging data suggest that there is a continuous turnover of fish at FADs. Additional experiments are planned for 2018 in order to increase current datasets.

Introduction

Maldivian tuna fishers have been catching tuna in the Indian Ocean for several centuries (Anderson, 2009). Tuna fishery is the main fishery in the Maldives and tuna is the main source of protein for the people living in the Maldives. Tuna is also the main export from the Maldives. Since Maldives heavily depend on the tuna fishery for employment and also for food security, Maldives has worked hard to improve its catches while at the same time ensuring the sustainability of the tuna resources. To ensure that the Maldivian pole-and-line tuna fishers has easy access to tuna schools, the government of Maldives has deployed 55 anchored fish aggregating devices (AFADs) throughout the Maldives (MOFA, 2017).

Floating structures in the marine environment are known to attract pelagic fish in large numbers (Kingsford, 1993; Castro et al., 2002) and, traditionally, Maldivian tuna fishers have been fishing at various types of floating objects drifting in the coastal waters of Maldives for centuries.

Deployment of AFADs in the Maldives began in the early 1980s (Naeem and Latheefa, 1994) and although AFADs are widely used in the Maldives by the tuna fishers few studies were conducted to understand the behavior of tuna around the AFADs in the Maldives or to understand the tuna fishery associated with the AFADs (e.g., Govinden et al. 2013). This initiative is an effort to better understand the behaviour of two species of tuna, skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*) within the AFADs array in the Maldives.

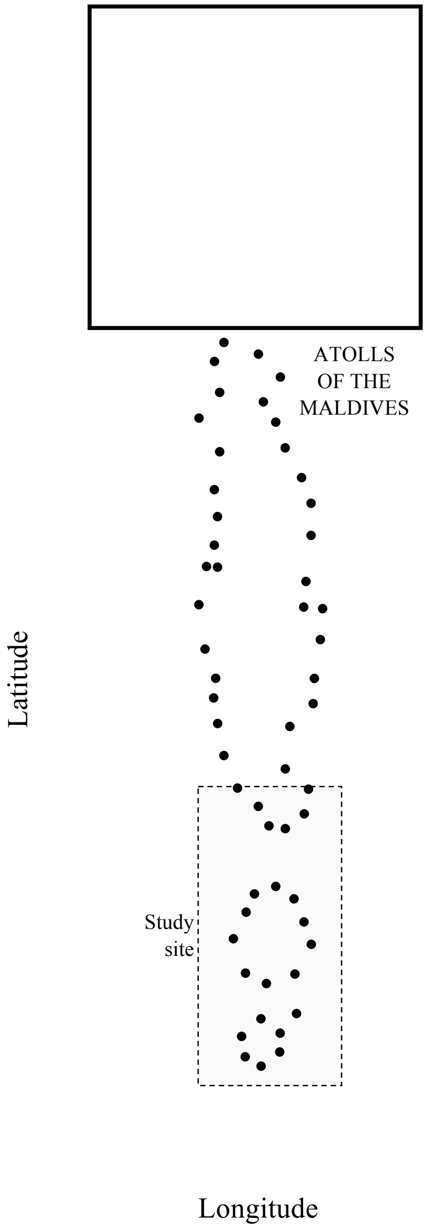

Figure 1: AFADs deployed outside the Maldives atolls and the study site in the south of Maldives. [• AFADs]

Method

Study site

The Maldivian AFADs are located in coastal waters at depths ranging from 2000m to 3000m, anchored on the outside of the atolls. This study was carried out around AFADs in the south of the Maldives, between 2°N to and 1°S and between 72.5°E and 74.0°E. This part of the Maldives has wide channels between the atolls. Most of the Maldives pole-and-line tuna catches come from this region and more than 50% of the Maldives commercial pole-and-line fleet is based in this region.

Local Ecological Knowledge

A questionnaire was designed to gather local ecological knowledge (LEK) on the spatio-temporal patterns of tuna aggregations at AFADs across the Maldives. Among the 30 fishers interviewed (21 boat captains, 5 deputy boat captains and 4 crew members), 21 of them always fished in the study site while the other 9 fishers mainly fished outside the study site. The interviews were conducted from December 2016 to June 2017. The questionnaire was implemented for all 30 fishers in their island of residence or on the fishing vessel they work on.

Acoustic and conventional tagging

In February 2017, 18 AFADs were equipped with VR2W (Vemco, Amarix Ltd., Canada**)** receivers (Figure 2). The VR2Ws were fixed to the mooring rope of the AFAD between 12 m and 15 m deep. Due to severe weather condition it was not possible to attach VR2Ws at AFAD 1, 8, 15 and AFAD 16 and 18 were lost when the experiment began. AFAD 15 was deployed in April, about one month after the acoustic tagging was completed and was thereafter instrumented.

Both acoustic and conventional tagging was conducted during March and April of 2017. Acoustic tagging was carried out at two AFADs (9 and 10) on the east side of Gaafu atoll (Figure 2) between 9th and 16th of March. The distance between the two AFADs was 40 km. A total of 39 tuna were released (Table 1). The selected size class for tagging was set between 35 cm and 60 cm. Although the target was to release about 90 acoustic tagged tuna in the study site over a short period of time (one week), this was not possible due to poor livebait availability and poor tuna fishing. The tagging was done on a chartered pole-and-line fishing vessel. The fish caught by pole-and-line were gently placed on the tagging table which was kept at the back of the vessel just a few feet from the fisherman.

Table 1: Acoustic tagged tuna released

AFAD	SKJ	YFT	TOTAL
AFAD 9	5	8	13
AFAD 10	14	12	26

Conventional tagging was carried out at AFADs, DFAD and free swimming schools (FS) (Table 2). All conventional tagging was carried out on a pole-and-line fishing vessel between 9th March and 26th April. A total of 714 skipjack (SKJ) and 604 yellowfin (YFT) tuna were tagged and released in the study area (Table 2,Figure 2).

Table 2: Conventional tagging summary

SCHOOL	SKJ	YFT	TOTAL
AFADs	327	216	543
DFAD	101	102	203
FS	286	300	586

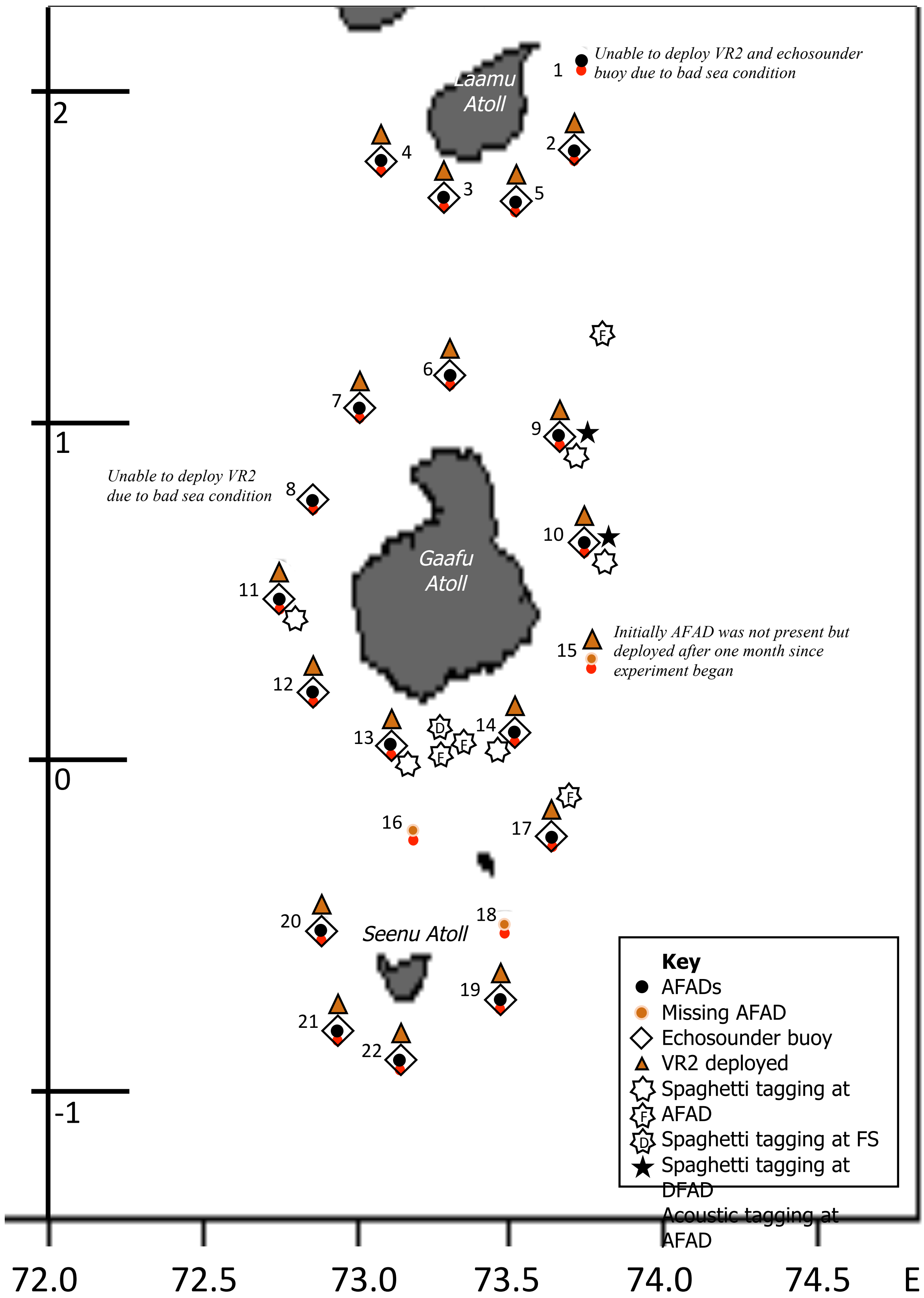

Figure 2:Map of the study site indicating the instrumented FAD array and tagging locations

Echosounder buoys at AFADs

Echosounder buoys (Marine Instruments, model M3I and M3+) were deployed at the AFADs (Figure 2). All AFADs , with the exception AFAD 1, were equipped with echosounder buoys in February 2017 (Figure 2). Information from the echosounder buoys received via satellite were recorded at designated computer at Marine Research Centre (MRC) of the Ministry of Fisheries and Agriculture (MOFA) in the Maldives. Data from the echosounder buoys were compared with the information provided by fishers operating at the respective AFADs during that day.

Results

The results presented here are preliminary finding from the various research activities conducted during this study.

Local Ecological Knowledge (LEK)

Throughout the year some fishing activities take place at almost all the AFADs in the study site. However, the questionnaires revealed that the fishing declines during the SW monsoon.

Most fishermen said that during **NE monsoon fish are more abundant at the FADs located on the east side** and during **SW monsoon** fish are more abundant at the FADs on **west side of Maldives.** Some fishers in the study site acknowledged that there is no clear distribution of tuna in the south of Maldives as tuna can be caught at AFADs on all sides of the atolls during both monsoons.

More than 85% of fishers agreed that some AFADs always attract more tuna and that tuna aggregations are typically more persistent at such AFADs. Similary, 90% agreed that there are some FADs that tend to attract less tuna due to strong currents. 23% of the fishers acknowledged that the tuna sometimes spend more than 10 days at the AFADs but the remaining 73 % said that tuna spends less than 10 days (40% of the fishers said that tuna stay for 3 to 6 days while another 37% fishers said 7 to 10 days). All fishers said that the catchability is always high during dawn while few also said catchability do increase in the late afternoon. 40% of the fishers believe that the association range of tuna with AFADs is up to 2 miles while 57% believe it is up to 5 miles.

Acoustic Tagging

Acoustic tagging – Total Residence Time (TRT)

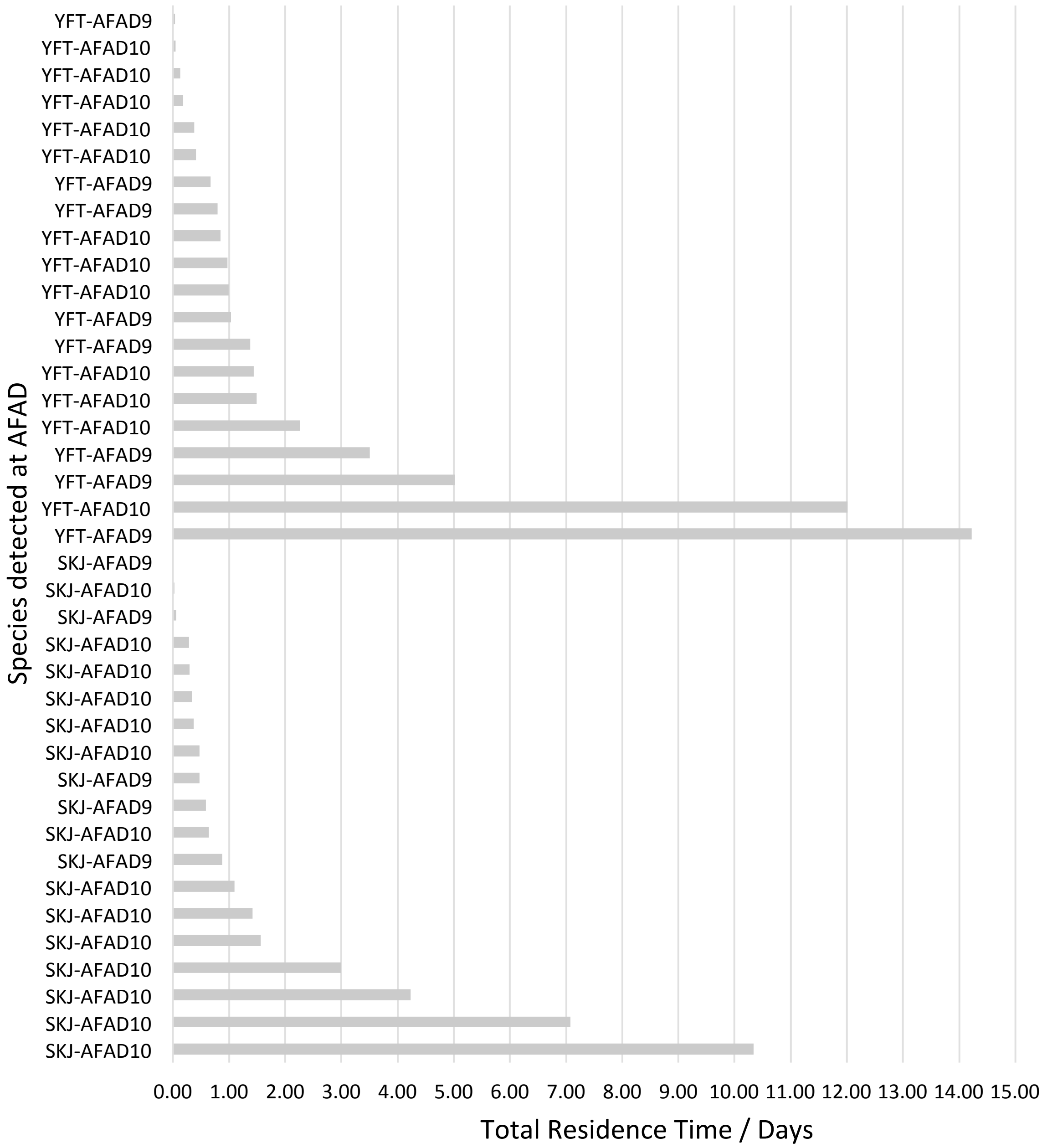

Figure 3: Total residence time of skipjack (SKJ) and yellowfin (YFT) tagged at AFAD 9 and AFAD 10.

Total Residence Time (TRT) was calculated considering the time lapse between the first and the last detection. Of the 13 tunas (5 SKJ and 8 YFT) released at AFAD 9 only 5 yellowfin tunas were detected after 24 hours. All other detections were less than a day. At AFAD 10, 7 skipjacks and 5 yellowfin tunas were detected after 24 hours. There was no detections observed at any other AFADs as no movements between AFADs were recorded in this study

. Two YFTs s the longest TRT (12 and 14.2 days) at both AFADs (Figure 3). The average TRTs were 1.4 days for SKJ and 2.25 days for YFT.

Conventional tagging

Table 3:Summary of conventional tagging recaptures and the different school types.

Recapture

Releases	Same AFAD	DFAD	Free School	Different AFAD
Same AFAD	42	0	0	1
DFAD	0	15	3	0
Free School	0	0	21	1

Of the 1332 tags released, only 82 tags were recovered – 39 SKJ and 43 YFT. 42 tagged tunas were recaptured at the same AFAD where they were released. Only one tagged tuna (released at AFAD 9) was caught at an AFAD different from where it was released (recaptured at AFAD 19). More than 75% of the recaptures occurred within 5 days of release (Figure 4). Only one tag was reported after 50 days since its release.

Days at liberty

Figure 4: Most of the recaptures were within 5 days of release.

Biomass of tuna at AFADs

Biomass using echosounder buoys was measured b between 15 m to 70 m at the 18 AFADs,. Biomass was not constant during the observation period and both AFADs where the acoustic tagging took place had fish during tagging although it was difficult to catch them (due to bait issues). It was also observed that the fish tagged with acoustic tags left the AFADs while a biomass was still detected at the AFAD. Echosounder data from all the AFADs needs further analysis and validation with information provided by fishers fishing at the AFADs.

Discussion

Local Ecological Knowledge (LEK)

AFADs are widely used across the Maldives for tuna fishing (Anderson et al., 1996). Since its deployment began in the early 1980s Maldivian tuna fishers have been fishing around AFADs. Through experience fishers are very aware that floating object attract tuna and have fished around them. These aggregations can be observed around both natural drifting objects and artificial structures floating on the surface of the ocean that are anchored or drifting (Dempster and Taquet, 2004). These include rafts (Heyerdahl, 1950), fish cages in coastal waters (Dempster et al., 2002; Boyra et al., 2004), fish aggregation devices (FADs) (Higashi, 1994) and many other structures like oil platforms (Franks, 2000) found in the open sea. Tropical tuna like skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), and bigeye tuna (*Thunnua obesus*) are often caught near floating objects (Hallier and Gaertner, 2008).

Experience fishers have made several observations on the behavior of tuna around AFADs. They have observed that some AFADs are more successful in attracting tuna than others and there is seasonal variation in the abundance of tuna around AFADs. Aggregations vary seasonally depending on the size and maturity of fish (Hunter and Mitchell, 1967; Castro et al., 2002) and oceanographic conditions of the assemblages (Moreno et al., 2007). For most fishers, the associative radius of tuna ranges between three to five miles. Acoustic tracking experiments around AFADs in other parts of the world have shown tuna can be associated with AFADs from a distance of several miles (Girard et al., 2004).

Fishers also believe that current, prey and the sea surface temperature affects the aggregations. Strong currents, changes in temperature and rough sea conditions can influence the behaviour of the fish (Dempster and Kingsford, 2003) as well as the enitre aggregation (Moreno et al., 2007). Fishes' believe that the catchability of tuna is best as from dawn to the early morning hours and is also good in the late afternoon . Several fishers believed that tuna tend stay at the fads for about 3 to 6 days before they move on.

Tagging

In several studies conducted in other parts of the world acoustically tagged tuna have been observed making several movements to adjacent AFADs (Dagorn et al. 2007; Mitsunaga et al. 2012; Robert et al. 2012). However, in this study, no such movement of the acoustically tagged SKJ or YFT was observed. A similar result was obtained in a study conducted in 2008 and 2009 in the central part of the Maldives (Govinden et al., 2013). Another interesting observation is that all the tagged tuna did not leave the fads at once. This pattern was also observed by Govinden et al., 2013 and Dagorn, et al. 2007.

Since intensive fishing was taking place at the same schools where conventional tagging was carried out the conventional tagged fish were recaptured rapidly . More than 75% of the reported recaptures were within 5 days of release. Only about 6% of the tagged tuna were recaptured. Initial findings from the reports by the fishers show no significant movement between fish at AFADs and other schools. Only one tagged tuna (released at AFAD 9) was caught at an AFAD different from where it was released (recaptured at AFAD 19). This fish was recaptured after 50 days.

Tuna aggregations at AFADs

Initial biomass observation using echosounder buoys showed that the biomass at the AFADs were not constant which is also the similar to the information obtained during LEK survey with fishers. In addition it was also observed that fish tend to leave the FADs in batches which is similar to the information obtained from acoustic tagging and also from fishers. Data from the echosounder buoys needs to be further analysed..

Additional field activities will be conducted in the latter part of 2017 and during the first six months of 2018 to better understand the behavior of tuna in the.

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