PROJECT REPORT

Linking conservation and livelihoods in Lakshadweep's fisheries: Long-term monitoring of the live-bait pole and line tuna fishery

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Summary

Lakshadweep's coral reef atolls, rich in social, cultural and ecological heritage and home to over 70,000 people, are highly dependent on their natural resources for biological, geological and economic integrity. Their traditional live-bait pole and line tuna fishery targets resilient oceanic tunas with the use of planktivorous reef and lagoon live-baits in a low-impact manner that helps reduce fishing pressure on its sensitive coral reefs. Sustaining and promoting this fishery is not only important to preserve fisher livelihoods but is also an important way of reducing local impacts on the coral reefs upon which these islands depend. The objective of our study in the Lakshadweep Islands is to fill data gaps regarding the live- bait pole and line fishery via researcher and community-based methods. So far our work has focused on the islands of Kadmat, Kavaratti, Agatti and Minicoy as they represent an increasing gradient in fishing pressure. In the past season, we also conducted preliminary trips to the islands of Suheli and Kalpeni. Our researcher based baitfish assessments up till April, 2015 have shown a decline in the abundance of most baitfish groups, but drivers of population variability remain unclear.

Spatial expansion of the bait fishery raises questions with regards to the sustainability of this fishery. Fishers have often voiced concerns regarding external fishing pressure, declining stocks, limited fuel supply, ice supply and market connectivity. Improving the status of the pole and line fishermen in Lakshadweep involves restricting external fishing pressure, improving island connectivity and market chains. Infrastructure and policy improvements should go hand in hand with improvements in monitoring and management of the fishery. Despite these growing challenges, traditional baitfish practices in Minicoy have been re-strengthened and renewed with the start of the 2015-2016 fishing season, making a case for their adoption in the rest of the islands. Our community-based catch monitoring programme aids data generation via low-cost methods while promoting participatory decision-making, a tool necessary for successful resource management action. Fisher generated data is revealing specific spatial and temporal trends in tuna landings, baitfish use, and the dependence on FADs. Preliminary surveys show that community members are open to improvements in markets and sustainable seafood certifications, if higher price premiums are guaranteed.

Introduction

Lakshadweep's live-bait pole and line tuna fishery targets resilient oceanic skipjack tuna (*Katsuwonus pelamis*) using lagoon and reef planktivores as live-bait. A best-practice fishery this harvest technique has minimal habitat impact and minimal by-catch and targets fast growing, early maturing species. This fishery helps divert fishing pressure off biologically and ecologically sensitive coral reef species such as groupers, snappers, sharks and parrotfish. Strengthening and sustaining the pole and line fishery via improvements in monitoring, management and markets is essential for protecting Lakshadweep's reefs, their ecological, social and cultural value.

Ecologically sustainable pole and line tuna fisheries can help buffer a shift to the financially lucrative but ecologically deleterious reef fisheries if better markets were available for Lakshadweep tuna. Sustainable seafood certifications and ecolabels can help access better markets and price premiums, but for Lakshadweep, one still requires further research, improvements in monitoring and management to ensure sustainability. Fishery related knowledge gaps include the current social, ecological and economic status of the fishery, trends in baitfish and tuna populations, unsustainable development, prevailing commodity chains and market linkages.

This project aims at understanding the fishery dynamics through research (scientist-lead and community-based), low-cost high-volume ways of monitoring, and collaborative improvements in management and markets. The four main objectives of our study are to:

1. Assess baitfish populations along a gradient of fishing pressure and environmental parameters to determine the role of anthropogenic factors in limiting planktivore abundance.
2. Establish cost-effective community-based fishery monitoring program that covers aspects pertinent to fisherfolk and vital for fisheries management. Understand traditional pole and line tuna fishery management practices and their historical and current context.
3. Assess the current Lakshadweep tuna commodity chain to understand the feasibility and value of a sustainable seafood certification.

Methods

Our project focused on the islands of Kadmat, Kavaratti, Agatti and Minicoy as they represent an increasing gradient in fishing pressure. But as we progress we intend to include other islands of the Lakshadweep archipelago in our documentation such as Suheli and Kalpeni. Eventually, we intend to extend our studies to all of Lakshadweep's fished islands. Methods used to study the ecological, social and economic aspects of the fishery were consistent between sampling years and islands. Our field season overlaps the fishing season and thus is from September 15th to May 15th, avoiding the annual SW monsoon.

1. Ecological assessment of baitfish populations

Lagoon surveys: Lagoons were divided into a 500 m x 500 m grid, with each grid cell representing a sample site. Sites were randomly selected from the grid to constitute at least 10% of the lagoon area. For each site, 50m transects were swum to observe the small free-swimming clupeids (sprats, local name – *hondeli* or *manya challa* and *rahi*) and atherinids (local name - *phitham* or *madam challa*); average sample size ranged between 10-16 transects. Pomacentrids (local name - *nila mahi* or *pachha challa*) and apogons (local name - *bodi*) that associate with coral boulders were enumerated using point counts and standardized for comparison using the average length and width dimensions of the coral boulder. Baitfish species, size and number were recorded for each survey type; transect and point counts. Supplementary data on lagoon bottom type, presence of seagrass and sea turtles were also recorded. Due to limited funds, in the 2014-2015 season, we conducted lagoon surveys in the islands of Kavaratti, Minicoy and Suheli, only (Table 1).

Table 1. Island-wise snorkeling-based lagoon surveys conducted each fishing season indicating survey month and number of sites sampled.

ISLAND	2012-2013	2013-2014	2014-2015
Agatti	Mar (11)	Sep (11), Nov (11), Jan (11), Apr (11)	-
Kadmat	Feb (15)	Feb (15)	-
Kavaratti	Mar (5)	Nov (4), Jan (4), Apr (4)	Jan (4)
Minicoy	Mar (9)	Nov (7)	Apr (4)
Suheli	-	-	Jan (2)

Reef surveys: On the reef, we conducted 60 minute timed random swims, at depths ranging between 6-12 m, using SCUBA, and visually documented all planktivorous apogonids (cardinal fish, local name – *bodi*), atherinids (silver sides, local name – *phitham* or *madam challa*), caesionids (fusiliers, local name – *muguram, dandi, garetta, baichalla, pachha challa*), clupeids (sprats, local name – *hondeli* or *manya challa* and *rahi*), pomacentrids (damselfish, local name – *nila mahi, pachha challa*), and serranids (anthias, local name – *bureki*) along with size, species and number. In each island, we sampled 10 sites (5 on the Eastern side and 5 on the Western side) for two seasons, 2012-2013 and 2013-2014. In Minicoy, we were only able to sample 5 sites in the 2012-2013 season. Due to limited time and funds, our 2014-2015 reef survey was restricted to the island of Kavaratti and two preliminary site surveys of Suheli (Table 2).

Table 2. Island-wise SCUBA-based reef surveys conducted each fishing season indicating survey month and number of sites sampled.

ISLAND	2012-2013	2013-2014	2014-2015
Agatti	Mar-Apr (10)	Apr (10)	-
Kadmat	Dec-Jan-Feb (10)	Feb (10)	-
Kavaratti	Mar (10)	Oct (1), Feb (10), May (1)	Jan (6), Apr (4)
Minicoy	Mar (5)	-	-
Suheli	-	-	Jan (2)

2. Assessment of Fisher Perspectives

During our first two seasons (2012-2013 and 2013-2014) semi-structured interviews were conducted, in Agatti, Kadmat, Kavaratti and Minicoy, to assess current and historical tuna and baitfish fishery trends, understand fisher perspectives regarding factors responsible for ongoing catch changes, document the main challenges faced by fishers and gauge interest in community-based monitoring of baitfish and tuna resources. In the 2014 - 2015 field season, we conducted general interviews of fishing communities in the island of Kalpeni and Suheli as well. Since 2014 we have also made significant progress in profiling the traditional live- bait management practices of Minicoy and community dynamics.

3. Community-based Catch Monitoring Program (CBCM)

Given the dearth of data on the pole and line fishery and the lack of fisher participation in research and conservation action, we initiated a community-based catch monitoring programme in January 2014 in the islands of Agatti, Kadmat and Kavaratti. In January 2015, the programme was expanded to the island of Minicoy. The data sheets utilized in the CBCM program, designed with the help of fishers from Agatti and Kavaratti, help provide species level details on tuna and baitfish catch and effort, along with information on Fish Aggregating Device (FAD) use, weather, wind and external fishing pressure (Figure 1). Data is collected from fishing boats on a regular basis after which it is entered in excel and analyzed.

Analyzed results of the monitoring are shared back with the community along with the detailed records for each boat.

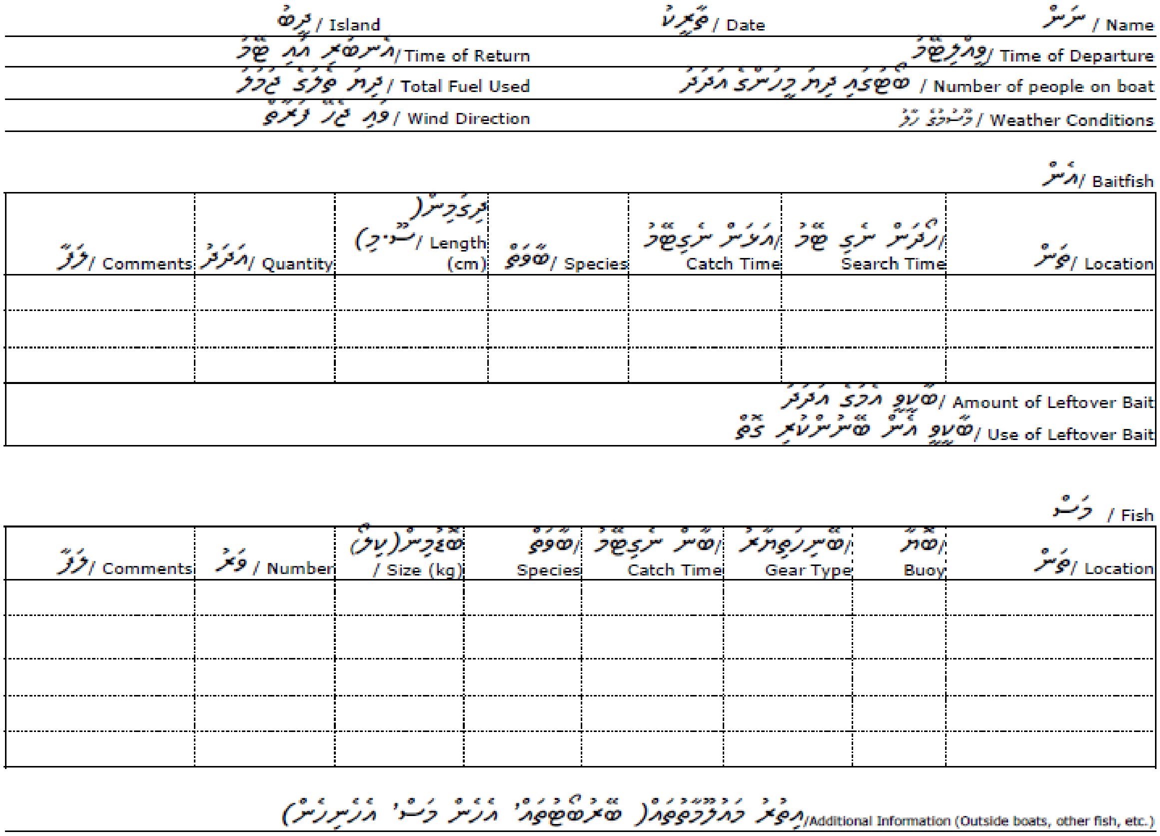

Figure 1. Sample data sheet used in the community-based catch monitoring programme in Minicoy.

Table 3. Records of community-based catch monitoring programme initiated in the islands of Agatti, Kadmat, Kavaratti and Minicoy.

ISLAND	START DATE	TOTAL # OF BOOKS ISSUED	TOTAL # OF BOOKS UTILIZED	TOTAL # OF BOATS RECORDING TO DATE
Agatti	Jan 2014	26	18 (69%)	11 (42%)
Kadmat	Feb 2014	4	3 (75%)	3 (75%)
Kavaratti	Jan 2014	16	9 (56%)	4 (25%)
Minicoy	Oct 2014	13	8 (62%)	6 (46%)

In order to improve participation, we initially used incentives such as gift vouchers to boats with greatest participation. We developed a 2015 and 2016 calendar to help promote the participating boats, the community-based catch monitoring programme and Lakshadweep's unique tuna fishery. In the coming season we are looking to streamline data flow and acquisition to increase participation.

4. Assessment of fishery market dynamics

In the 2014-2015 season, we conducted detailed interviews of pole and line tuna marketing agents to better understand the fishery market dynamics. Semi-structured interviews were loosely divided into nine sections which provided information on the general perceptions, history of the trade, production costs, transportation and fate of *maas* after leaving the islands, price establishment, business structure, trade regulations, management and issues faced by the traders.

Results & Discussion

1. Baitfish ecology

In the 2014-2015 season, we focused our ecological monitoring efforts on the island of Kavaratti as it consistently recorded the highest planktivore densities on reefs (Figure 2) and lagoons (Figure 3) in the 2012-2013 season. We also conducted some supplementary lagoon and reef surveys in Minicoy and Suheli. Presented here are the highlights of the past three years of in-water baitfish sampling.

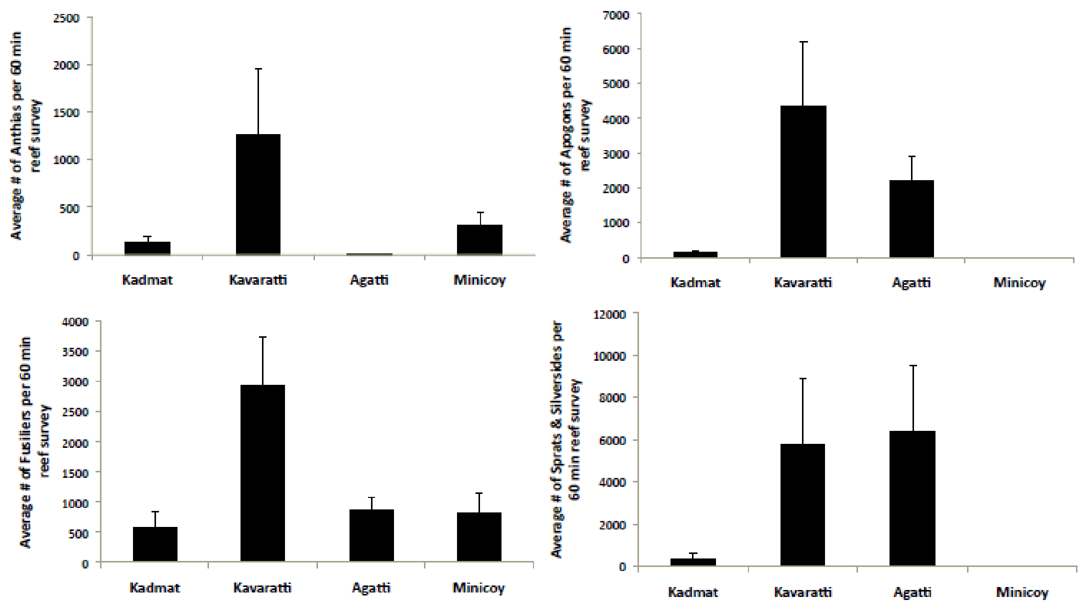

Figure 2. Average densities of anthias (*bureki*), apogons (*bodi*), fusiliers (*muguram*), sprats and silversides (*hondeli, rahi* and *madam challa*) observed on reefs of Kadmat, Kavaratti, Agatti and Minicoy in the 2012-2013 season. Islands arranged in order of increasing fishing pressure. Error bars indicate ±1 S.E.

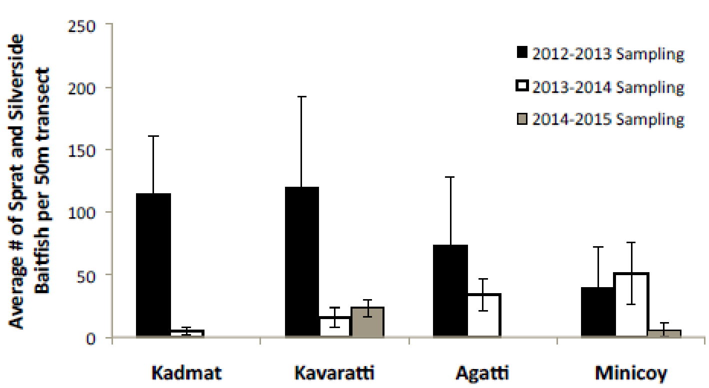

Figure 3. Average annual densities of sprat and silverside baitfish (*hondeli*, *rahi* and *madam challa*) observed in snorkeling based 50 meter lagoon transects. Agatti & Kadmat were not sampled in the 2014-2015 season. Islands arranged in order of increasing fishing pressure. Error bars indicate ±1 S.E.

High levels of variability are evident in the dataset, and this is probably due to the high spatial and temporal patchiness of planktivore populations (Figure 2 - 6). Despite the variability some clear spatial (inter-island), and temporal (inter-annual) trends are evident on the surveyed reefs and lagoons (Figure 2 - 4). It is important to note that we also found much greater planktivore densities on the eastern reefs than on the west.

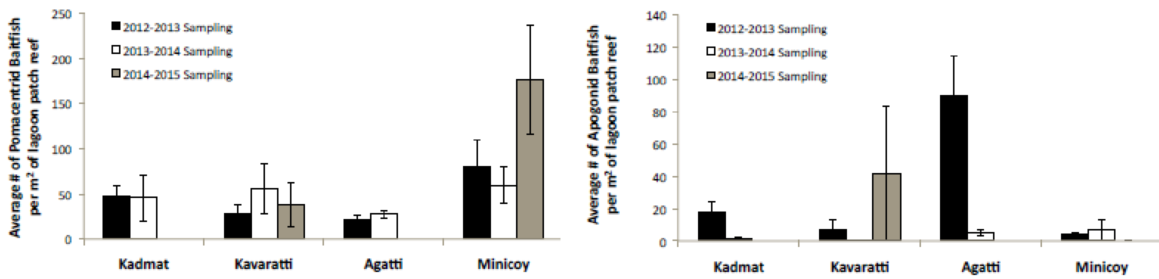

Figure 4. Average annual densities of pomacentrid (local name - *Nila mahi*, Scientific name - *Chromis viridis* and *Pomacentrus pavo*) and apogonid baitfish (*bodi*) observed in snorkeling-based point counts. Agatti & Kadmat were not sampled in the 2014-2015 season. Islands arranged in order of increasing fishing pressure. Error bars indicate ±1 S.E.

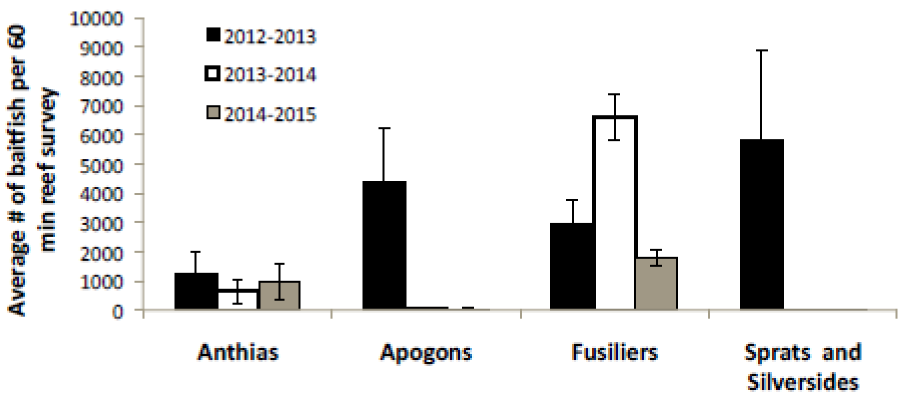

Figure 5. Average densities of anthias (*bureki*), apogons (*bodi*), fusiliers (*muguram*), sprats and silversides (*hondeli*, *rahi*, or *madam challa*) observed on Kavaratti reefs in the 2012-2013, 2013-2014 and 2014-2015 seasons. Error bars indicate ±1 S.E.

Declines in baitfish populations are evident in the lagoons (Figure 3 & 4) and reefs (Figure 5). The disappearance of baitfish groups such as apogons and sprats in Kavaratti reefs during the 2013-2014 and 2014-2015 seasons warrants further research (Figure 5). Given the reliance of fishing community on remote reefs for baitfish supply we were able to include Suheli in the 2014-2015 sampling season. Separating the lagoon sprat and silverside data by monthly surveys reveals a decline in all islands, and highest densities in Suheli (Figure 6). The time of baitfish sampling, tide cycle, wind etc. can influence abundance estimates, further research is required to tease apart environmental variability from anthropogenic causes.

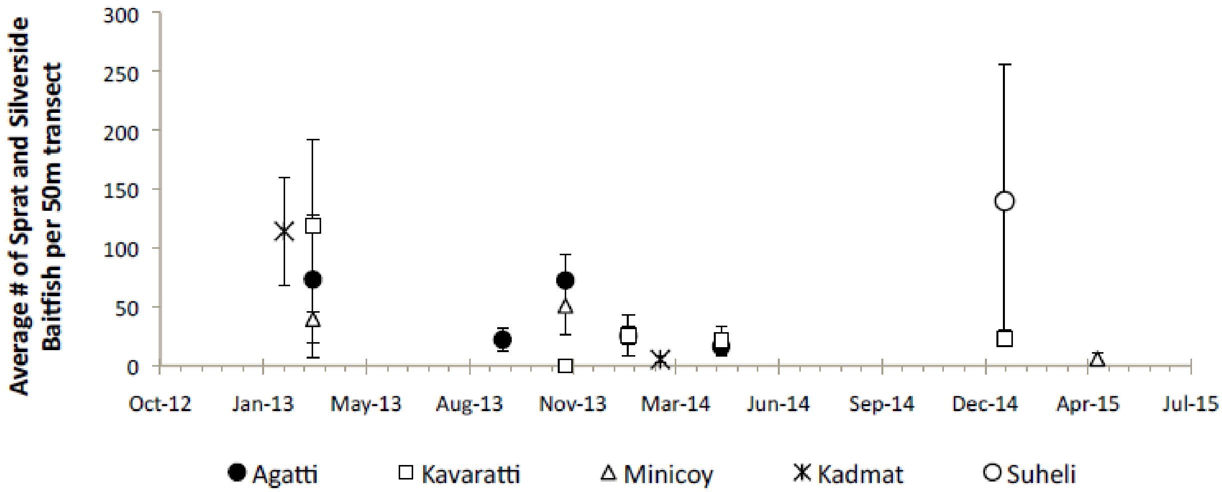

Figure 6. Average densities of sprat and silverside baitfish (*hondeli, rahi* and *madam challa*) observed in snorkeling based 50 meter lagoon transects. Error bars indicate ±1 S.E.

Using supplementary data to understand environmental links with baitfish population, we found a weak positive association between sprat and silverside baitfish (*hondeli, rahi* and *madam challa*) densities and sea grass occurrence (Figure 7). Fishers consider wind to be a strong predictor of baitfish abundance but a preliminary analysis with wind data sampled at the Agatti airport did not show any significant relationships (Figure 8). Analysis against wind derivatives, tide cycles and currents could prove otherwise.

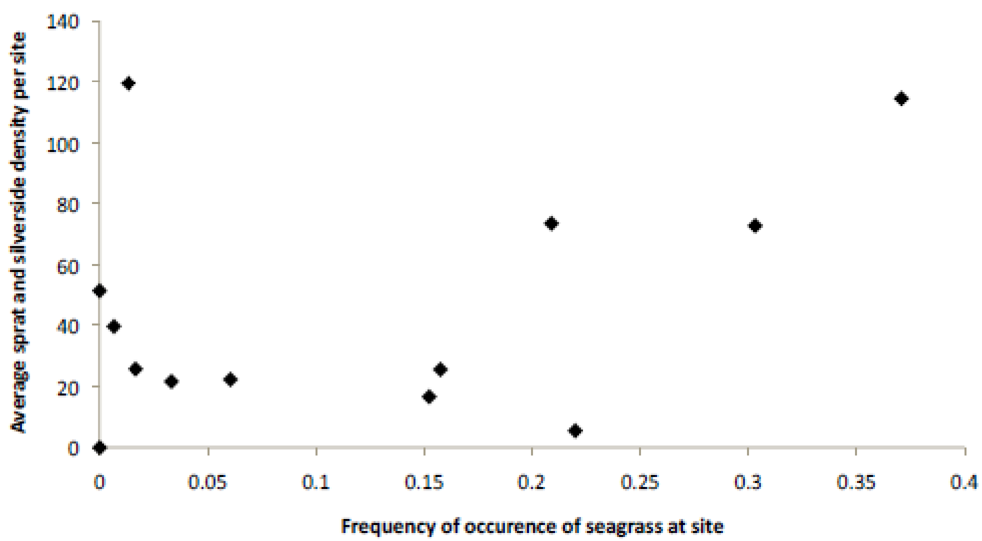

Figure 7. Average densities of sprat and silverside baitfish (*hondeli, rahi* and *madam challa*) in relation to occurrence of seagrass.

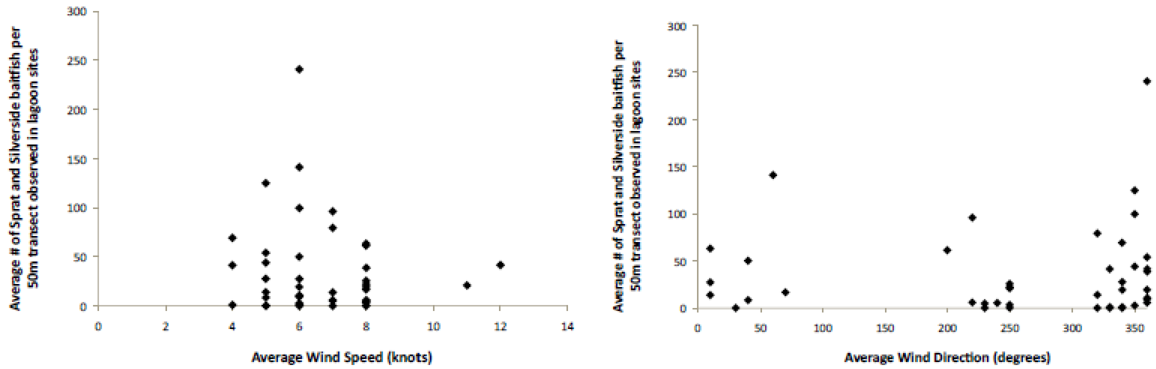

Figure 8. Average number of sprat and silverside baitfish (*hondeli*, *rahi* and *madam challa*) per 50 meter transect observed in lagoon sites in relation to prevailing wind speed and wind direction. Wind data obtained from Meterological station at Agatti airport.

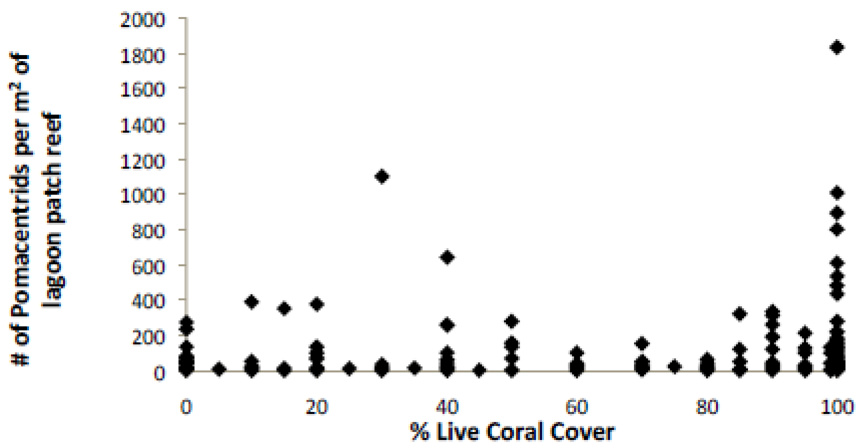

Figure 9. Average densities of pomacentrid (local name - *Nila mahi*, Scientific name - *Chromis viridis* and *Pomacentrus pavo*) in relation to live coral cover.

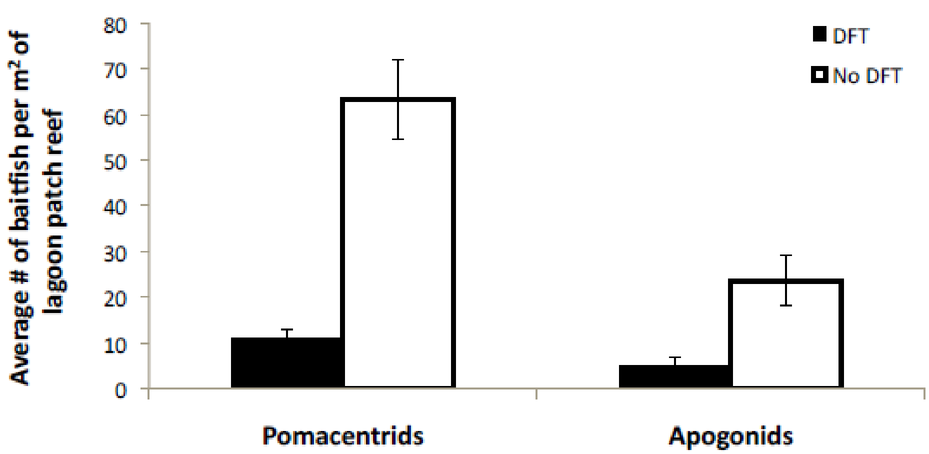

Figure 10. Average densities of pomacentrid (local name - *Nila mahi*, Scientific name - *Chromis viridis* and *Pomacentrus pavo*) and apogonid baitfish (*bodi*) found within Damsel Fish Territories (DFT) and outside of them (No DFT).

Coral associating pomacentrids and apogons however show a different relation with benthic habitat. Pomacentrid abundance was higher with quadrats containing higher live coral cover (Figure 9), and as expected both pomacentrid and apogon abundance was greater in coral quadrats free of territorial damselfish (Figure 10). Increase in lagoon territorial damselfish can have delirious consequences for coral associating baitfish varieties.

2. Social and cultural aspects of Lakshadweep's pole and line fisheries

During the first two years of our project, we conducted semi-structured interviews of fisherfolk in Agatti, Kadmat, Kavaratti and Minicoy. Our surveys have helped document fisher perspectives regarding the state of their live-bait pole and line tuna fishery (Figure 11). Most fisherfolk felt there has been an increase in the amount of time spent fishing and distance travelled for fishing, and a decrease in the tuna catch and size (kg) (Figure 11).

Trends in the bait fishery were less obvious, with majority of the community indicating no change in live-bait availability (Figure 11). Our surveys have also helped reveal fisher perspectives regarding factors that affect tuna and baitfish resources as well as areas of improvement (Figure 12).

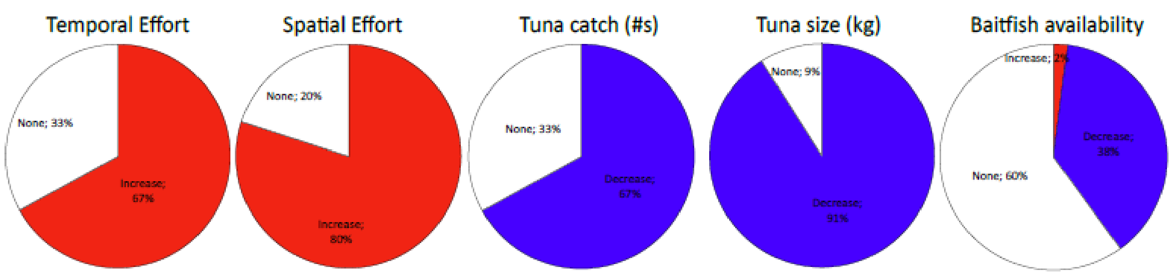

Figure 11. Fisher perspectives regarding decadal changes in temporal fishing effort, spatial fishing effort, tuna catch #s, tuna size (kg) and baitfish availability. Data represented here was acquired from active experienced pole and line fishermen in the islands of Agatti, Kadmat, Kavaratti and Minicoy between 2012-2014. Red indicates increase, blue indicates decrease and white indicates no change.

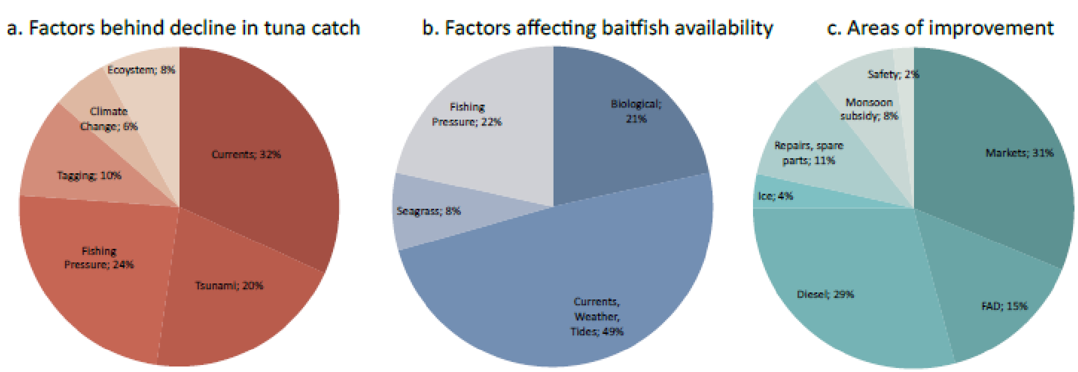

Figure 12. Fisher perspectives regarding a. Factors that cause a decline in tuna catch, b. Factors that affect baitfish availability and c. Areas that require improvement either on behalf of the Fisheries Department or private operators. Data represented here was acquired from active experienced pole and line fishermen in the islands of Agatti, Kadmat, Kavaratti and Minicoy between 2012-2014.

In the 2014-2015, season we were also able to visit the island of Kalpeni and Suheli. Fishery related concerns in Kalpeni were similar to those we encountered in Agatti, Kadmat, Kavaratti and Minicoy. Kalpeni's greatest concerns were regarding the rising number of green sea turtles in their lagoon and the dwindling sea grass beds, which were still much more abundant than those found in the other islands. Interestingly, sailfish, were the one main species being caught in Kalpeni at the time of our visit (October 2014). Another fisher interviewed raised concerns regarding the aquaculture operations in the Kalpeni lagoon.

In January of 2015 we documented the use of Suheli Island as a remote fishing location. Our interviews revealed detailed names of areas in the lagoon that are critical to bait fishing, as well as locations on the reef that most likely were important reef fishing grounds before pole and line tuna fishing was introduced to this region. Most boats from Kavaratti have boat sheds on Suheli's Cheriyakara Island that are either owned by them or leased from other people from Kavaratti. Boat sheds are well equipped with solar powered lighting, storage, kitchen and sleeping utilities. Fishermen spend up to a month at a time camping at Suheli's Cheriyakara Island, fishing in the lagoon and surrounding seas where nearby FADs provide good catch of skipjack tuna. The tuna catch is converted to the dried product, *maas*, at Suheli itself and then transported back to Kavaratti for sale. We observed over 40 boat sheds, of which 4 were operational during the 4 days that we were present. Our interviewees revealed no perceived change in local baitfish populations, sprats were always available in good numbers and fishers seldom turn to other baitfish varieties to meet their needs for the pole and line fishery. Fishermen, however, have been noticing significant changes in beach accretion and erosion. Similar remote fishing operations also exist for Perumal Par, Cheriyapani and Veliyapani.

Our work over the past three years has also lead to a better understanding of the dynamics of the traditional management systems of Minicoy. The pole and line tuna fishery is considered to be over 2000 years old in Minicoy (Key Informant: K.G. Mohammed, Minicoy local, personal communication). Being an age-old traditional fishery, there are many customary management systems linked to it. Given below are accounts of the main traditional baitfish management practices followed in Minicoy.

1. *Magao* or Individual boat-owned coral boulders for *bodi* (apogon) baitfish: *Magaos* act as apogon banks for individual boats in Minicoy. At the beginning of the fishing season boat owners are allowed to select individual coral boulders for their exclusive use within the lagoon (interviews with key informants and fisherfolk; Hoon et al. 2003; Sivadas and Wesley, 2006). All other unclaimed coral boulders are open access. The selection period is open for 3 days and after selection; each boat selected coral boulder is approved by the fisheries *jamad*, union (Hoon et al. 2003). Once established boats aren't allowed to change their *magaos* until the following season (interviews with key informants and fisherfolk, Hoon et al. 2003). Additionally, Minicoy locals also have specific terms for various areas in the lagoon and reefs (documented by V.Hoon and through our community-based programme), such definitions are a boon for resource monitoring.
2. Closed season for Bait fishing: Minicoy locals follow a traditional calendar called *nakai* and the seasons listed in this calendar inform them about weather patterns, sea conditions, fish and coral reef ecology. Bait fishing is prohibited during monsoon

months (May through August). And based on local knowledge of *bodi* (apogon) spawning, traditional laws have prohibited the use of apogon baitfish until mid-November (interviews with key informants and fisherfolk). *Bodi* fishing is not allowed from May through mid-November (Hoon et al. 2003).

3. Baitfish catch quantification: In Minicoy, fishermen have well defined terms for the measure of baitfish catch volumes / weights (Interviews with key informants & from the community-based catch monitoring programme). These terms are species specific and can be quantified as the fish are being caught. For example, a full box (consisting of two separate sections) of *hondeli* and *rahi* (*Spratelloides* species) is made up of 2 *vaigans*, and 3 *foras* make up a vaigan. A *fora* may be equivalent to one defined scoop of the bait net haul. Similar terms such as *fothigan* and *inguri* exist for *bodi* and *muguram* (1 *fothigan* = 2 *inguri*, 5-6 *inguri* = 1 full box). Not well researched, there is no clear documentation of what the individual terms mean in terms of weight, volume or number of fish, but these are extensively and consistently used throughout the island. Understanding Minicoy's baitfish catch quantification system and its applicability has the potential to help improve baitfish monitoring throughout the islands.
4. Use of *labari*: *Labari* or in-water baitfish holding tanks are a common sight in the Minicoy lagoon. These are simple fabrications made of PVC, nets and metal plates, capable of floating in the lagoon and permitting water exchange. Fishing boats often save leftover baitfish in the *labari* for use over subsequent days, thereby reducing wastage. This practice is however not a customary management system but it helps reduce pressure on the baitfish stock. Only other Lakshadweep Island where we have seen this practiced in considerable levels is the island of Kavaratti.
5. Avoiding use of certain species: Minicoy locals are very against the use of certain baitfish varieties like *gumbala* (clupeid) and *phitham* (silver sides). They find that these varieties are harmful to the tuna and will avoid using them unless extremely desperate (interviews with key informants and fisherfolk).
6. Restrictions on use of nets: Minicoy has customary policies restricting the use of nets in certain parts of the lagoons or reef (interviews with key informants and fisherfolk). The exact spatial location of this restriction is unclear some stating it to be in harbor areas (Hoon et al. 2003) while others claim it's on offshore areas of the reef (Sivadas & Wesley, 2006).

Other than those listed above, the Minicoy community also does annual post-monsoon cleaning of the *Neru Magu* channel, an important waterway for fishing boats (interviews with key informants and fisherfolk; Hoon et al. 2003; Sivadas and Wesley, 2006). Traditionally, Minicoy also selects a local pilot or *Arrakutty*, who is in charge of all shipping and fishing related decisions including the opening of the *bodi* season, channel cleaning etc.

We found that during the 2014-2015 season there had been a lot of unrest amongst fisheries *jamad* (union) individuals leading to a split and abandonment of traditional management practices. This season, 2015-2016, we have found that Minicoy is a new *Arrakutty*, and the community has reviewed its customary laws including the *Neru magu* cleaning, *magao* use and temporal baitfishing bans. Understanding the dynamics of Minicoy's customary systems can be very helpful to the fisheries development and conservation in the rest of islands.

3. COMMUNITY-BASED CATCH MONITORING PROGRAMME

The community-based catch monitoring (CBCM) programme was begun in January of 2014 in Agatti, Kavaratti and Kadmat. And in January of 2015, the programme was expanded to include Minicoy. Each boat is issued a catch monitoring book, usually one or two fishers from each boat take charge of daily catch monitoring. The level of involvement in the programme has fluctuated since its start and by the end of the second season (i.e. May 2015), 41% of the boats that enrolled in the programme have remained active (Table 3).

Data is processed and returned to participants and boat owners in the form of daily, monthly and seasonal statistics of daily catch and effort. These reports detail an individual boats time spent fishing, fuel usage, tuna catch species, size and number, and use of FADs. Data on non-fishing days is also collected in this programme in order to understand the reasons for not fishing, and these tend to be mostly due to holidays, poor weather, lack of diesel, engine problems etc. (Figure 13).

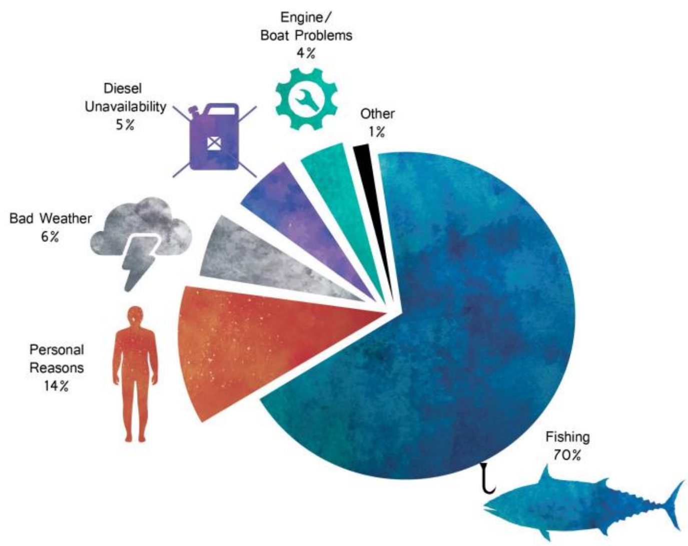

Figure 13. Overall proportion of days spend fishing and not fishing along with reasons for not fishing for all community-based catch monitoring data generated in Lakshadweep since 2014. (Infographic designed by Mohavi Mohandas)

The programme generated detailed daily records of fishing (Figure 14). Unfortunately, due to varying levels of participation and consistency in recording, limited boats show daily overlap between islands.

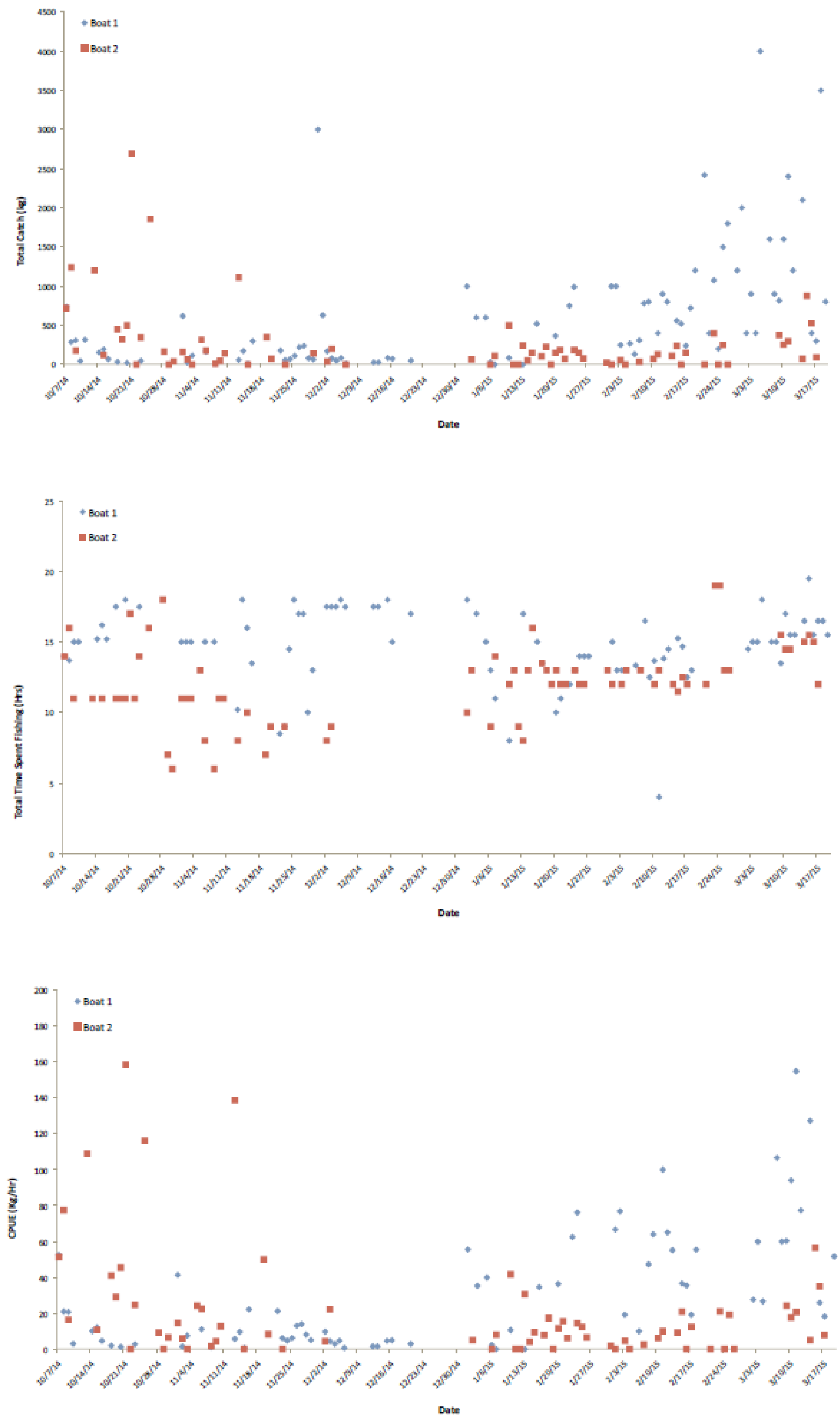

Figure 14. Daily total catch (kg), time (hrs) and catch per unit effort (kg/hr) for two Agatti boats involved in the community-based catch monitoring programme during the 2014-2015 fishing season

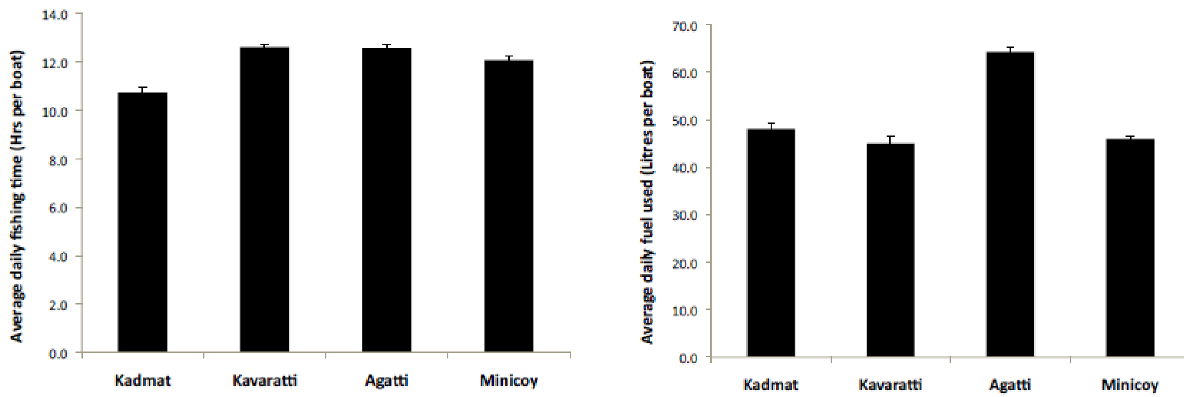

Figure 15. Average daily fishing effort in terms of daily fishing time (hrs) and fuel used (liters). Islands arranged in order of increasing fishing pressure. Error bars indicate ±1 S.E.

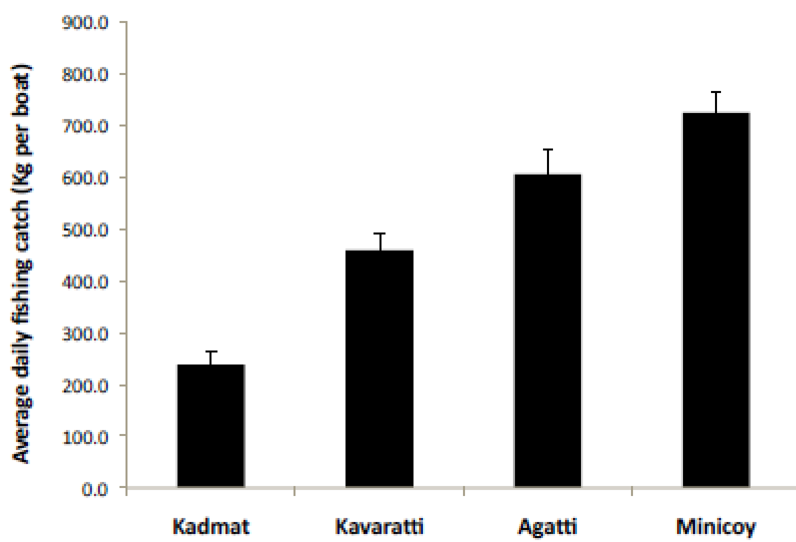

Figure 16. Average daily fish catch (total weight of catch per boat per day). Islands arranged in order of increasing fishing pressure. Error bars indicate ±1 S.E.

Using daily records of catch, effort, species, sizes, FAD use etc., we were able to view general fisheries and island level trends. Islands with more number of boats and people engaged in the pole and line tuna fishery (Agatti and Minicoy) also tend to spend greater amount of time and fuel fishing and also catch greater total weight of fish (Figure 15 & 16). Community-based daily catch records also enable us to calculate island-wise tuna catch composition as a function of total weight of fish caught per island (Figure 17). In the instances when fishers have failed to indicate tuna species, those records have been left out of the catch composition assessment (Figure 17). Interestingly Kavaratti lands the highest proportion of yellowfin tuna, indicating an opportunity for developing markets for higher value tuna.

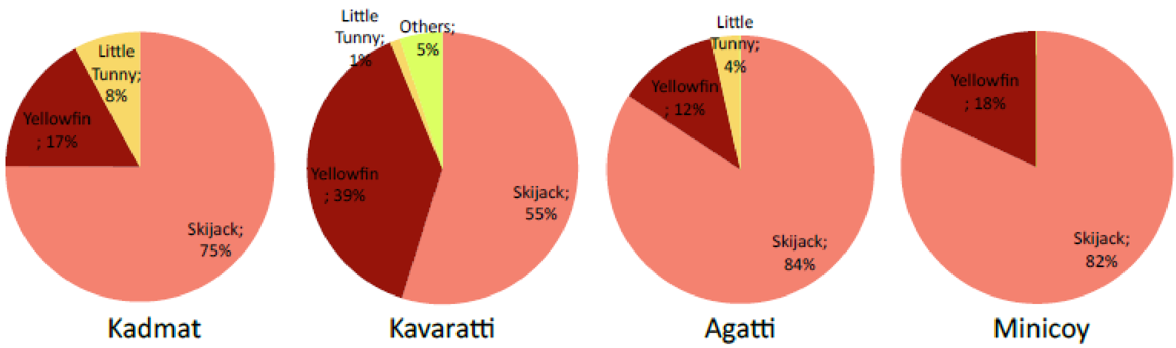

Figure 17. Island-wise tuna species catch composition in proportion of total weight caught.

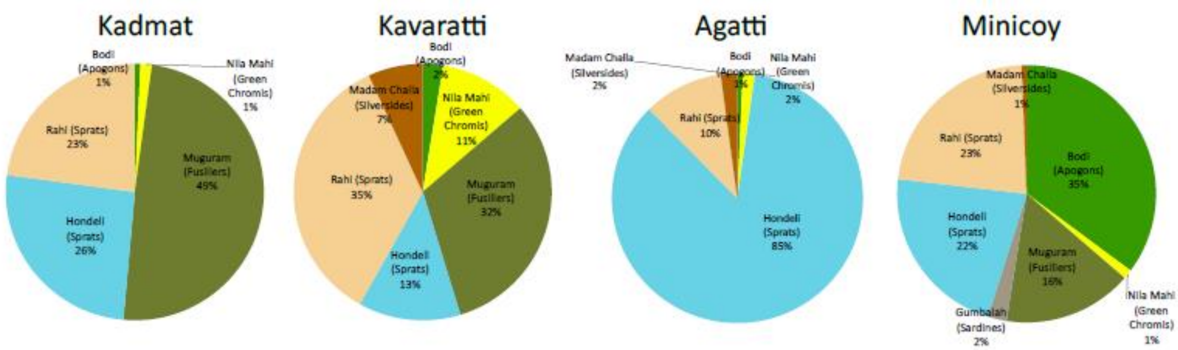

Figure 18. Proportion of baitfish use per island calculated as a function of baitfish varieties used per day per island.

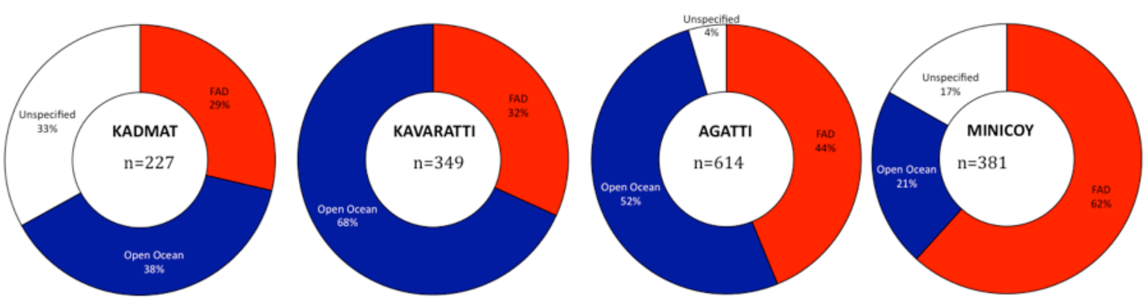

Figure 19. Proportion of days fished at buoy (red), open ocean (blue) and unspecified (white) sorted by islands in order of increasing fishing pressure.

Fisher generated records are also revealing island specific differences in baitfish utilization, with higher diversity of baitfish used in Minicoy and Kavaratti, while the diversity was the least in Agatti where the relied predominantly on one species of baitfish (Figure 18). Such reliance on single species baitfish may be damaging in the long-term. Given the detailed nature of the records, one was also able to compare the efficiency of tuna catch in numbers and size when different varieties of baitfish were used. Greatest number of skipjack tuna was caught when sprats (*hondeli* and *rahi*) were used. The use of larger baitfish like fusiliers (*muguram*) resulted in larger skipjack catch. Yellowfin catch was most numerous when apogons (*bodi*) and sprats (*hondeli*) were used, but greater size of yellowfin were caught when pomacentrids (*nila mahi*) and fusiliers (*muguram)* were used.

There may be an over harvest of baitfish as indicated by the proportion of times that baitfish were left over (either discarded at sea - 21% or saved for the next day – 25%). Understanding the minimum amount of baitfish needed for a successful tuna fishing day may help conserve baitfish stocks.

Given the high demand for FADs by fisherfolk in the Lakshadweep Islands, using the community generated dataset we conducted an analysis of the value of FADs in reducing effort and improving catch. With increasing fishing pressure, fisher spent an increasing proportion of time at FADs or data buoys than at the open ocean (Figure 19). Fishing at buoys (FADs) or data buoys often resulted in a marginal reduction in fishing time and also a slight reduction in amount of fuel spent (Figure 20).

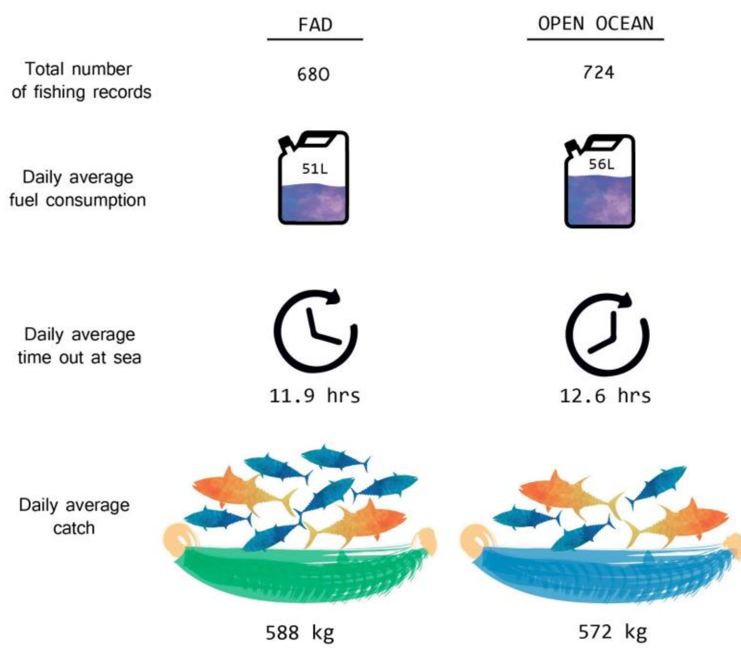

Figure 20. Fishing effort and catch at in terms of average time spent fishing (hrs), fuel used (liters) and average catch (kg) for fishing at buoys and open ocean. Data pooled from all four islands. Error bars indicate ±1 S.E. (Infographic designed by Mohavi Mohandas)

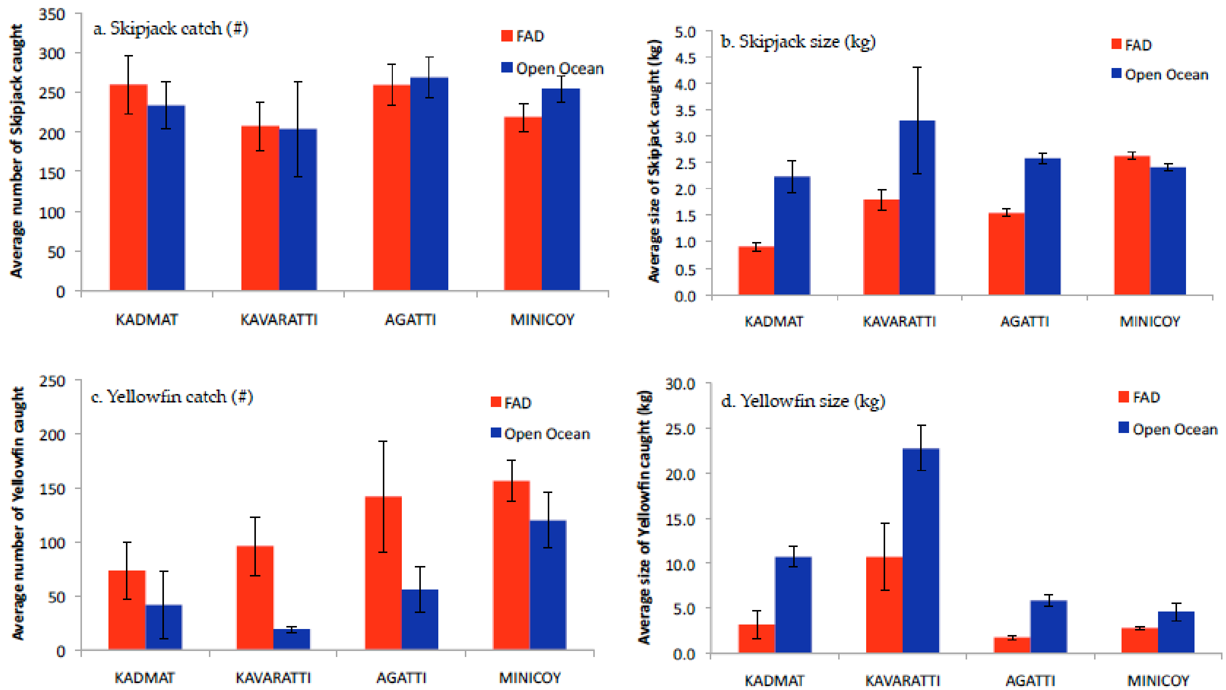

Figure 21. Island-wise average skipjack and yellowfin catch (#) and size (kg) at buoys and open ocean. Islands arranged in order of increasing fishing pressure. Error bars indicate ±1 S.E.

The total catch per unit time and fuel spent is marginally higher for FADs or data buoys than in the open ocean (Figure 20). Skipjack catch numbers are also relatively similar between buoys and open ocean (Figure 21a), but for some islands the size of the skipjack caught is much smaller at FADs (Figure 21b), and in some cases (e.g. Kadmat) it is below the skipjack size at maturity (1.7kg, Fromentin & Fonteneau, 2001). Yellowfin on the other hand were caught in greater numbers at buoys (Figure 21c), and individuals being smaller at buoys than open ocean (Figure 21d). It should be remarked that on average, most of the yellowfin caught in Lakshadweep are below the size at first maturity reported for yellowfin tuna (25kg, Fromentin & Fonteneau, 2001) and should be a cause of concern to fishers and managers.

The community-based catch monitoring data provides a wealth of information related to the pole and line tuna fishery that was previously unavailable. Detailed records of the spatial location of fisheries and information on catch at FADs vs. open ocean can help us understand skipjack spatial dynamics (Table 4 & 5). Although yet to be analysed these variables can help us identify productive parts of the ocean and their seasonality (Table 4 & 5).

Table 4. Average catch (kg) and total number of fishing operations at each of the buoys found around Minicoy for community-based catch monitoring boats recording between 2014-2015.

BUOY	Average catch (kg)	Total number of fishing operations
East Buoy	532.7	192
North Buoy	463.97	38
Panchayat Buoy	706.3	20

Table 4. Average catch (kg) and total number of fishing operations at various directions and 3-20nm away from Minicoy for community-based catch monitoring boats recording between 2014-2015.

DIRECTION	Average catch (kg)	Total number of fishing operations
N	451.7	14
NE	601.7	33
NW	422.4	15
SE	354	7
SW	486	5
W	83.4	4

The community-based catch monitoring programme also enables fishers to record other fishing activity. Fishers often feel threatened by fishing boats from the mainland and they find them to be responsible for declines in local tuna catch. Apart from mainland boats, fishers also often cite over capacity as a significant issue in their islands. Few accounts of occurrence of mainland boats and excessive competition with local vessels have been shown and we are still in the process of analyzing this data (Figure 22).

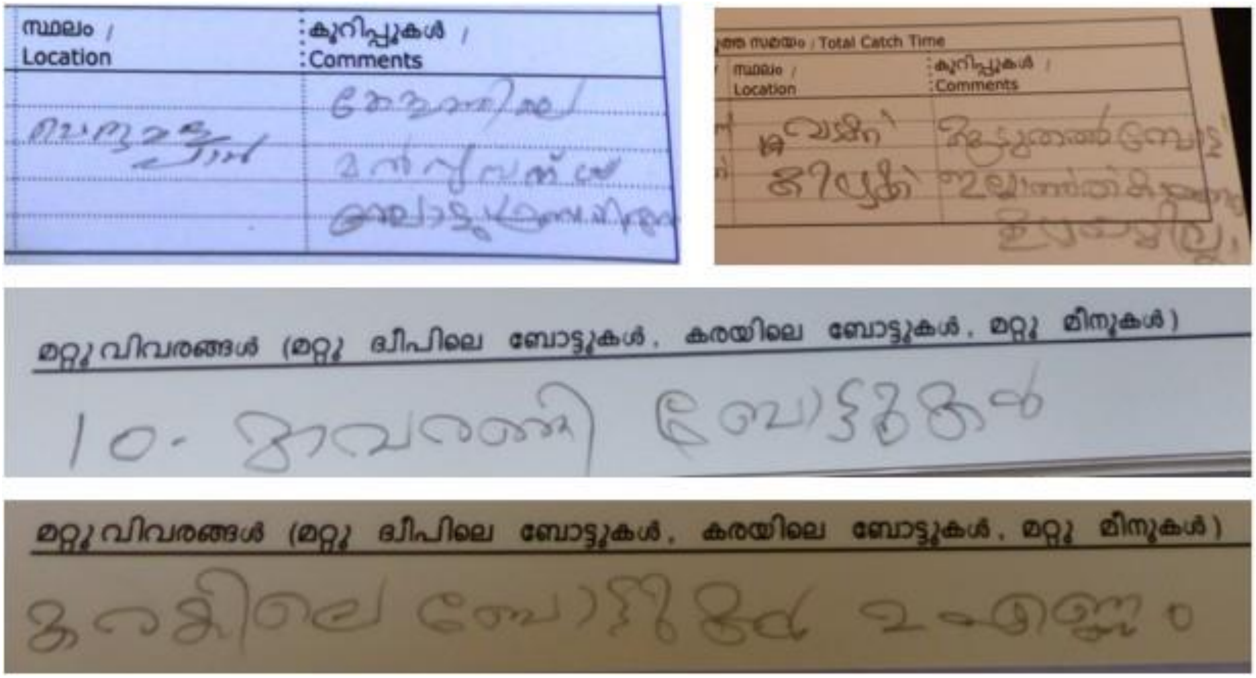

Figure 22. Notes from catch monitoring records detail occurrence of mainland boats as well as high level of competition from local vessels (between January 2014 – May 2015).

4. FISHERY MARKET DYNAMICS

A majority of the tuna in Lakshadweep is exported as *maas* (>70-80%, key informant interviews). The major actors involved in the value chain and the trade route for *maas* are local fishermen from the Lakshadweep Islands, traders / agents from Lakshadweep / Mangalore / Kochi / Beypore, exporters / wholesalers from Tuticorin, wholesalers, retailers and consumers from Sri Lanka and other countries (Figure 23). The interview survey revealed that most traders are unclear about the fate and rate of *maas* once they trade it to the next person. Based on our interviews, Sri Lanka appears to be the largest market for *maas*, but smaller markets in Singapore and mainland India are believed to exist.

Traders noted that lack of infrastructure support (storage facilities, ice plants etc), increasing competition with mainland producers and rising costs are hampering their profitability. Traders and agents seem open to changing the tuna product that is exported as long as the adequate commodity chain that ensures profits and traceability is established. Most fishers also agree that the main problem with the pole and line tuna fishery is the markets and not the catch or production.

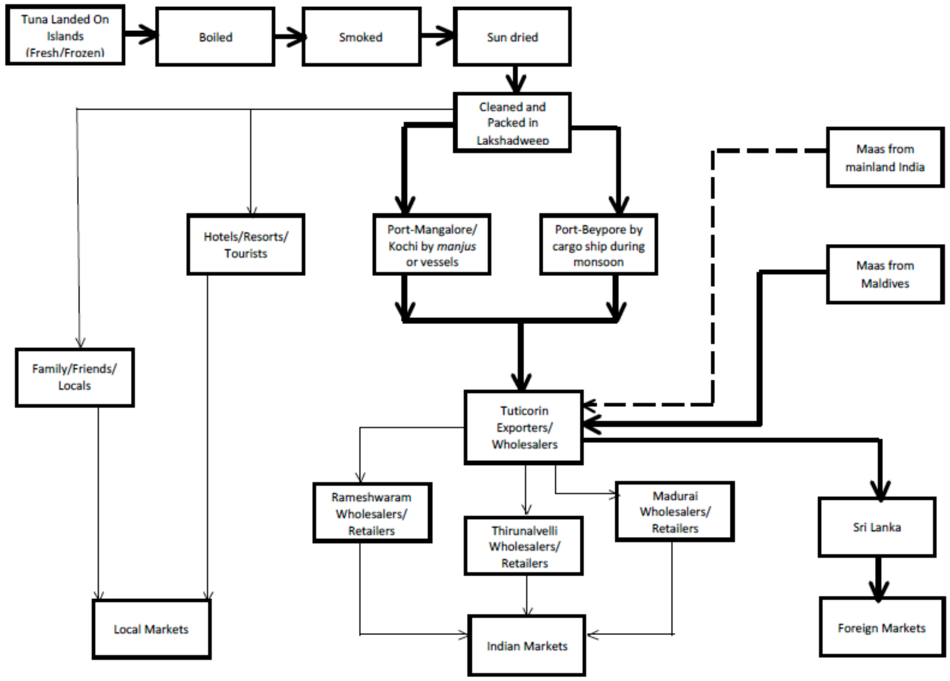

Figure 23. Commodity chain of the Lakshadweep tuna fishery based on semi-structured interviews of Lakshadweep *maas* agents conducted during the 2014-2015 season.

Conclusion

Sustainability of the pole and line tuna fishery is highly dependent on how well its resources are managed. Traditionally, the fishery that originated from the Maldives and Minicoy has utilized a wide variety of baitfish species. Unfortunately, today the major fishing islands like Agatti focus mostly on targeting sprats (*Spratelloides delicatulus* or *hondeli* or *manya challa* and *Spratelloides gracilis* or *rahi*) as indicated by interviews and the community-based catch monitoring programme. More importantly, *S. delicatulus* is often targeted at the time of spawning, a period when fish become relatively inactive, making the harvest of large numbers much easier (source: fisher interviews and personal observations). Our in-water surveys and fisher interviews have indicated a serial depletion of sprats in heavily fished islands, and only the remote islands like Suheli still tend to have fishery viable populations. Additionally, recent interactions in November of 2015 with Agatti fisherfolk indicate that when fishers are unable to find baitfish in Agatti or Bangaram lagoon, they often travel to Perumal Par for live-bait. These declines should be a cause for concern for fishers, managers and scientists. Expansion of pole and line fishing grounds to remote islands, banks and reefs like Suheli, Perumal Par, Veliyapani and Cheriyapani should be monitored as these islands may be the last commercially viable populations of certain baitfish species in the coming years. There is a requirement to standardize participatory baitfish monitoring and management plan that can be used across islands to record and manage baitfish catch. The traditional management systems of Minicoy maybe key to baitfish monitoring and management problems across the islands. Our work has helped identify their practices but further research is required to document them in detail and test their applicability in the rest of the archipelago.

As indicated by our community-based catch monitoring program, the tuna fishery is also undergoing rapid development especially regarding the use of FADs. These structures help marginally by increasing the catch per unit effort, but their ecological impact due to the landing of undersized individuals should be carefully considered. In the coming year, we plan to take on an extensive study of FAD related fisheries dynamics to understand its ecological and economic costs and benefits.

The community-based catch monitoring programme offers a means of monitoring remote islands with minimal cost. Our progress in Agatti, Kadmat, Kavaratti and Minicoy indicates the ability and willingness of fishing community members to contribute to resource monitoring and management. In the following months, we hope to improve the community-based catch monitoring protocol in order to increase participation and data generation.

Such efforts add value to this best practice fishery and could be used as a way for marketing the Lakshadweep product to eco-conscious consumers. A proper documentation of the sustainability of the fish stock, effectiveness of monitoring and management strategies is required to draw conclusions regarding the sustainable nature of this fishery. Improving market returns, rather than fishing capacity, for Lakshadweep’s tuna is vital to the longevity of this traditional fishery.

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