The Artisanal Reef Fishery on Agatti Island, Union Territory of Lakshadweep, India

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ABSTRACT

The main features and characteristics of the subsistence reef fishery in Agatti island, Union Territory of Lakshadweep, India, are described based on information obtained through participatory fish catch monitoring over one and a half years in 2006-7. The overall catch per unit effort (CPUE) recorded was 1.66±0.07 kg per person per day (± standard error of the mean), based on data from 3030 fishing events. Considerable variation in CPUE was observed in particular between gears, but also between landing zones and to some extent time of year. The total annual catch from the reef fishery was estimated at over 56 metric tons, harvested from a lagoon area of 12 km^2. Almost half of this total catch is obtained from the 2% of the catches larger than 20kg, much of it using the more indiscriminate gears available on the island such as large-scale dragnets (local name bala fadal). While the data does not support conclusive statements on the sustainability of the fishery it is clear that the importance of the reef fishery for the local population as a source of household income and food remains high, and growth in exploitation seems likely in view of the demographic structure of the island as well as a developing reef fishery for export markets. Some recommendations are provided with respect to the management challenge this poses.

INTRODUCTION

Agatti island is the westernmost island in the Indian Union Territory (UT) of Lakshadweep, located at 10º 51' N and 72º E (Dept. of Planning and Statistics 2000). The island has an area of 2.7 km^2, and is surrounded by 12 km^2 of lagoon and 14.4 km^2 of reef flat (Bahuguna and Nayak 1994), lying in a roughly north to south direction. The lagoon surrounding the island is wider and deeper on the western than on the eastern side (Fig. 1). The local population of 7072 (Dept of Planning and Statistics, 2002) resides in the wider northern section of the island (see also Hoon et al. 2002, Hoon and Tamelander 2005). The traditional fishing and land rights of Agatti islanders

Obura, D.O., Tamelander, J., & Linden, O. (Eds) (2008). Ten years after bleaching - facing the consequences of climate change in the Indian Ocean.CORDIO Status Report 2008. Coastal Oceans Research and Development in the Indian Ocean/Sida-SAREC. Mombasa. http//:www.cordioea.org

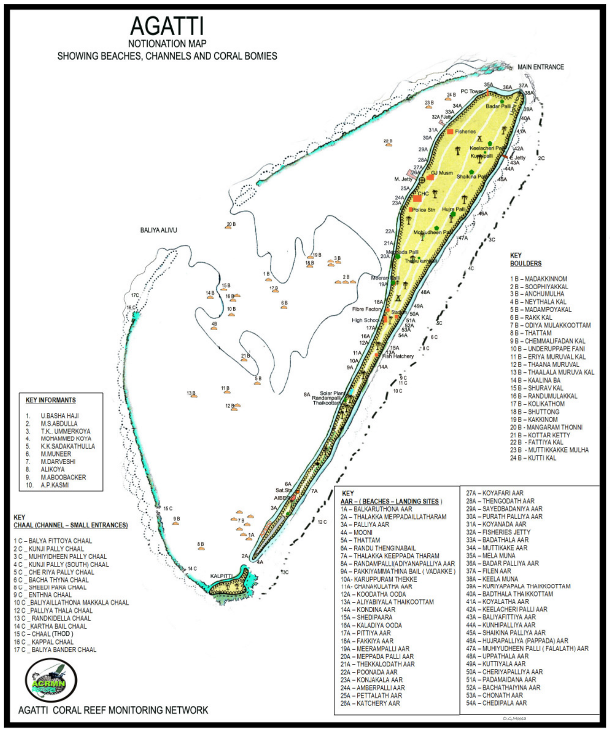

Figure 1. Map of Agatti island and the surrounding lagoon, with important fishing and landing sites. The map has been prepared through consultation with fishers and elders on the island.

also include the Bangaram lagoon, which encompasses the small islands Bangaram, Tinnakara and Parelli's, and a sunken reef Perumal Par (Hoon 2002).

Previous studies conducted on Agatti have described the island and its territories in terms of demography, socio-economic status of the islanders, as well as their use of the coral reef resources and fishing methods (Dept. of Fisheries 1990, Hoon et al. 2002, Hoon 2003, Hoon et al. 2005, Hoon and Tamlander 2005). The islanders remain highly dependent on natural resources. The main income for Agatti is the hook-and-line tuna fishery, a major export industry. The tuna landings in Agatti are the highest in Lakshadweep and consisted of 30% to 38% of the entire tuna catch of Lakshadweep (Dept of Planning and Statistics 2002). However, at the household-level the reliance on the reef fishery and gleaning for protein and income is high. Twenty percent of the households on Agatti report reef fishery and gleaning as their main occupation, and 90% of the protein intake of the poor households comes from reef fishing and gleaning (Hoon 2003). Further, sand, rubble and coral boulders remain important construction materials (e.g. Hoon 2003 and Hoon and Tamelander 2005). Tourism is a growing industry, with resorts catering for both domestic and international tourists established on Agatti and Bangaram. A further resort is planned on Tinnakara, and a second air carrier started daily flights to Agatti in April 2007.

The high reliance on natural resources in combination with the high density of the island population places significant strain on the local environment and, together with natural perturbations and global climate change, poses a significant management challenge. However, as has been noted previously, formal management and gathering of resource use data has focused on larger scale and commercially more significant activities, such as the export-oriented pole-and-line tuna fishery, while little attention has been paid to subsistence and small scale activities that nevertheless are of immense importance for the local population (e.g. Hoon and Tamelander 2005). This has left a gap in the environmental and resource management of Agatti, but also a divide between local populations and the knowledge they possess on the one hand, and management authorities on the other.

There is considerable uncertainty regarding the sustainability of resource use in Agatti, as well as apparent inconsistencies between opinions voiced and trends observed. The many conflicting views and opinions on status and trends of the availability of reef resources and utilization patterns means there is an obvious risk for increased conflict over resource use and access. In the absence of quantitative data, past studies have estimated reef resource use based on numbers of resource users and estimated catch size and composition according to fisher/gleaner perceptions, rather than on actual harvest data (e.g. Hoon and Tamelander 2005).

To address this a participatory study was initiated to quantify and characterize in greater detail the artisanal reef fishery and other reef resource use on Agatti island. Results from one and a half years of catch monitoring of the reef fishery are presented herein, and recommendations made with respect to management implications of the findings as well as further needs for quantitative study of the reef fishery.

MATERIAL AND METHODS

Data collection was carried out through a community based monitoring programme, building on the existing resource use monitoring team on the island described by Hoon and Tamelander (2005).

A new catch monitoring protocol was developed and introduced through a consultative process with the monitoring team, consisting of data recorders (women and men from the island fishing community) as well as a data manager. A workshop was also organized to train the monitoring team, including a number of local fishers.

The sampling protocol builds on low-intensity sampling throughout the year, with catches recorded for 10 continuous days, 6 times a year. The data recorders focus on one landing zone each (although they can cover multiple zones when the need arises) (Fig. 2).

For each catch the following variables were recorded: date; name of data recorder; landing zone; name of fisher; number of fishers; cloud cover (clear, cloudy, rain); wind conditions (low, medium, high); approximate start and end times for fishing operation; fishing activity/gear used; mesh size (if net is used); boat type (if boat is used); fishing site (one to three sites visited in order of importance); total number of fish caught; number of species in the catch; total weight of the catch. Further, for each species in the catch the following was recorded: number of fish, estimated size range and average size in cm; and average weight per fish. An ID number was automatically assigned to each catch event.

Local terminology has been used as much as possible, to ensure the methods and data are more

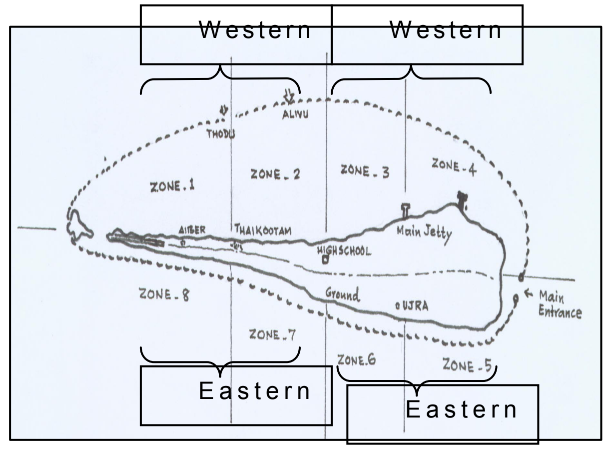

Figure 2. Landing zones on Agatti island (from Hoon and Tamelander 2005).

accessible to the local population, and to better utilize their knowledge of their environment. Consequently fish species are recorded using local names. A total of 113 distinct local taxa have been identified through the catch monitoring. Some of these refer to individual species, while others include two or more species, an entire fish family, and in some cases, fish from different families. A definition list was created grouping local taxa under 40 'family groups', building on scientific definitions, however also taking into consideration how species are defined locally, which is influenced by food and commercial value of the fish as well as how it is caught (Table 1). Results presented in this paper are summarized based on these family groups.

Fishing activities or gears used are also recorded in local terminology. The gears are briefly characterized in Table 2. More detailed descriptions and characterizations can be found e.g. in Hoon and Tamelander 2005.

Although on occasion caught in the reef fishery, incidental catches of tuna have been excluded from this analysis as they are largely pelagic, the main target of a semi-industrialized fishery, and catches are recorded through Fisheries Department data. However, pelagic fish that are frequently found in reef areas and caught through reef fishing operations have been included, such as seer, dorado and mackerels.

Table 1. Reef fish. Local names and taxonomic definition (sharks, rays and tuna as well as two unverified local names not included).

Fish group	Local taxa	Fish group	Local taxa
angelfish	shabadu kallam	milkfish	ilimeen, kuruthola, manabalkody
baitfish	bella chala, bodhi, chala, manja chala , pacha chala, rahiya	mojarra	furachi
barracudas	kolas	morays	malanji
billfish	kudirameen, ola meen	mullets	thidira
box fish	thomp	parrotfish	chandi, feesom
butterfly fish	fakikadiya	pufferfish	chemaniyam
damselfish	kally, kurichil, lattom, mamban, thukiyam	rabbitfish	oram
dorado	habnoose, shaameen	sea chubs	funji, kalkuratty, poonchi
emperor	auran metty, fallam metty, fonthom metty, kannam metty, kilukkom, kulakkathi, manjam, metty, pulli metty	seerfish	ayakura
flying fish	farava	snapper	chemmali, fulariyam, karim karavalli, phuleriyum
fusiliers	baichala	sole	lammam
garfish	keram, oola	squirrel and soldierfish	kallaalam, kankaduvam, pherunganny
goatfish	kalmanakam, manakkam	stone fish	pehchan
gobies	mandiyam	surgeonfish	barifad, fala, karukkam, naithala, nilalam, varipad
grouper	arkolichammmam, chammam, pulli chammam	sweetlips	kotha
halfbeak	mural	threadfin	mookam
jacks and trevallies	cheemkanni, fankuluval, faradam kuluval, fiyada, keri machan, kulluval, madathala	triggerfish	falli, karatty
lizardfish	balaka	wrasse	balala, njaala, thokka
mackerel	bangada		

The island has been divided into four main landing zones (for a discussion see Hoon and Tamelander 2005) that represent an overall aggregate of fishing sites within each zone (Fig 1 and 2).

Results presented here are based on a total of 3030 fish catches recorded during one and a half years between September 2005 and May 2007. Results are presented as total catch and catch per unit effort (CPUE) expressed as kg fish caught per man-day by gear, landing zone, and month. Based on monitoring data on the average daily fishing effort by gear, estimates of total annual catch have been made. Most commonly caught species, gear selectivity and size of the fish caught have been calculated based on species composition of the catches.

RESULTS

Gear Use

Gear use around the island is largely determined by hydrography and how the gear is operated, as well as

Table 2. Fishing activities/gears used on Agatti.

Local Name	Description
bala adiyal	Shore seine, used mainly in the western lagoon
bala attal	Purse seine, used inside the lagoons around the island
bala fadal	Large drag net involving 15-30 people, operated in both eastern and western lagoons
bala idal	Gillnet set in the lagoon
cast net	Small mesh castnet used mainly from the shore and frequently opportunistically, around the island
hand line	Baited hook and line, used opportunistically around the island, frequently from boats during transport or in association with other fishing activities
kalmoodal	"Boulder trap" – a net set around a coral boulder which is then agitated using rods to drive out fish. Not commonly used
kurakkal	Light and spear or sword. Not commonly used, only practised in shallow water
rod and line	Baited hook and line, used opportunistically around the island and mainly from the shore
shal kakal	Gillnet set in reef channels, used mainly during the monsoon and at spring tide. Not commonly used

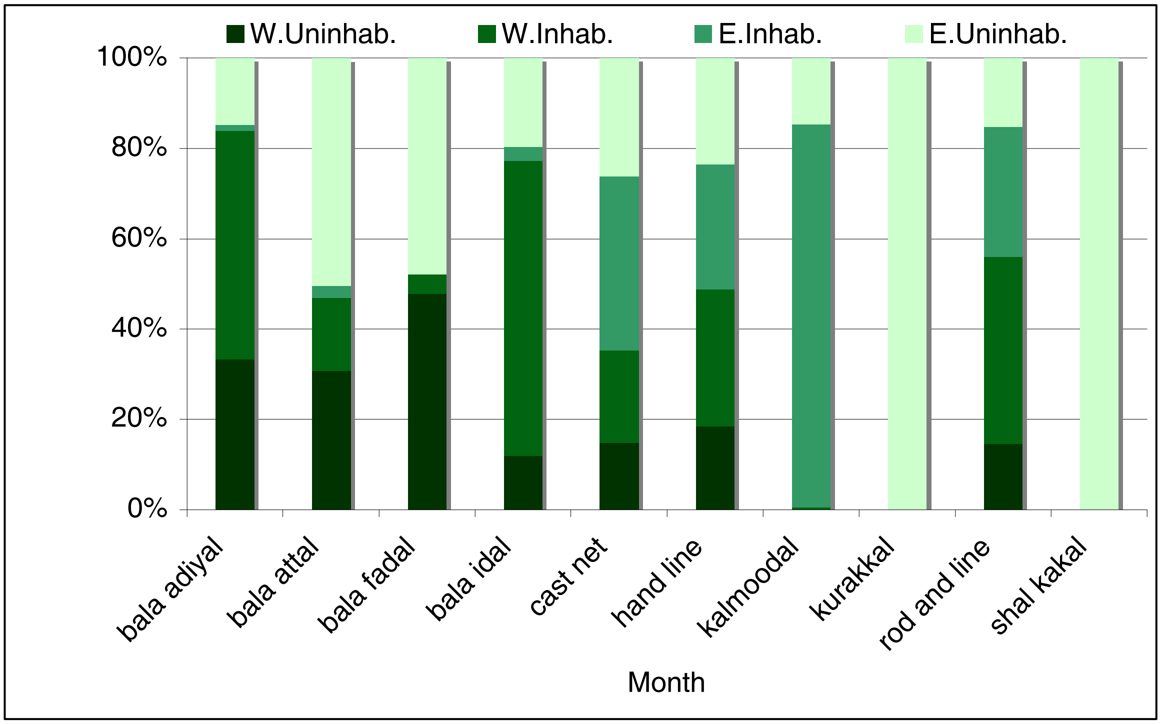

Figure 3. Gear use by fishing/landing zone expressed as % of total number of recorded fishing operations in each zone.

by habitat and availability of target species. Purse and dragnet operations such as bala attal and bala fadal are carried out mainly in the uninhabited section due to ease of operations – there are fewer boats, and less traffic and disturbance. The simpler gears operated mainly by one person are used on an opportunistic

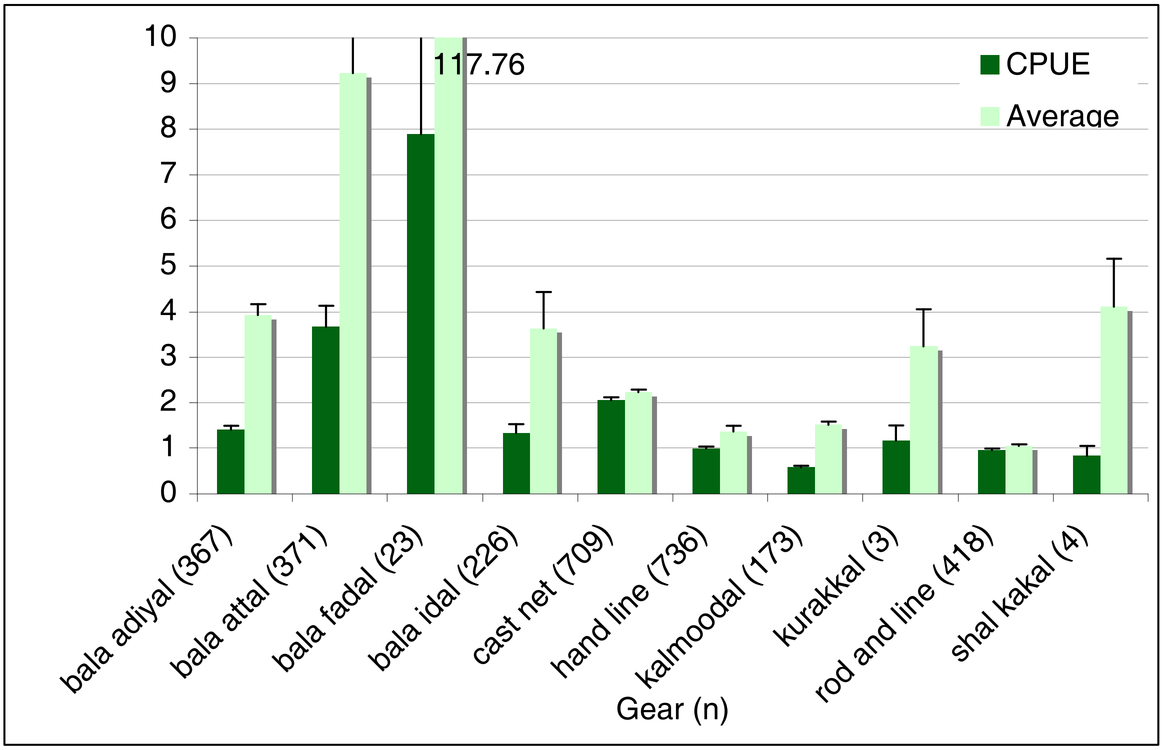

Figure 4. Catch per unit effort (CPUE) and average catch per operation by gear (number of records in brackets). The error bars indicate standard error of the mean (SEM).

basis both from shore and small crafts, rather evenly in the zones around the island. This includes cast nets, hand lines and rod and line (Fig. 3).

Bala adiyal and bala idal, shore seines and bottom set gillnets, are used primarily in the western lagoon. The bala adiyal nets can be walked out from the beach, which has a suitable profile, and areas of coral boulders can be avoided. Bala idal is used significantly more in the inhabited section of the island to allow easy and quick access to check for fish (this compares well with Hoon and Tamelander 2005). Suitable reef channels for shal kakal occur mainly on the eastern reef.

Bala fadal (large drag net) has traditionally been used only in the broad western lagoon, where the operation commonly involves two boats and up to 30 people. A change in activities noted since 2004 is that a modified form of bala fadal has been introduced in the eastern lagoon, whereby 8-15 team members walk out nets to enclose around ½ km of the lagoon and then drag it to the shore. Bala fadal is used almost exclusively in the uninhabited part of the island.

The 'traditional' fishing methods kalmoodal and kurakkal (trapping fish over boulders and spearing fish at night using a torch) are practiced only in the shallow eastern lagoon, which is accessible on foot even at high tide – the water depth remains less than 2 m. These methods are mainly used for recreation. This is reflected in the low sample size, as operations are relatively rare.

CPUE

The overall Catch Per Unit Effort (CPUE) recorded, expressed as catch in kg per person per day, was 1.66±0.07 (average from 3030 fishing events ± standard error of the mean).

CPUE varied considerably between fishing gears, and was notably higher for bala fadal and bala attal

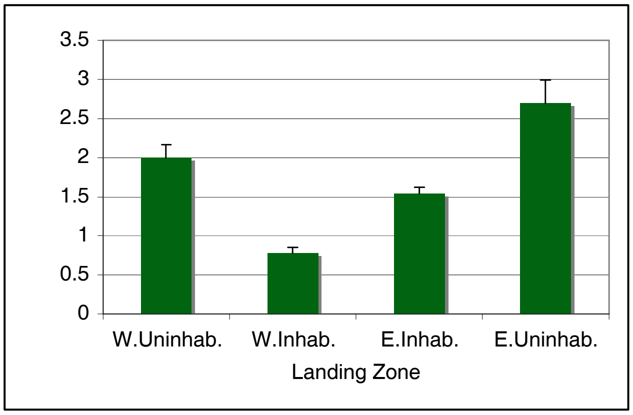

Figure 5a. Average CPUE (±standard error of the mean) by landing zone.

(Fig 4). Due to the nature of these gears – drag net and purse seine - they require several people for their operation but also ensure a lot of fish is caught. The standard error of the mean (SEM) illustrates a higher variability in catch size especially in bala fadal and to some extent bala attal (the sample size is sufficiently large). The large SEM in bala fadal is due to the considerable difference in operation (see comment above), catch and CPUE between the two bala fadal varieties. The larger operations in the western lagoon yielded higher total catches as well as CPUE, was 11.25±4.53 based on 12 recorded operations, compared with 4.21±1.60 based on 11 recorded operation in the eastern lagoon (Fig.s 4 and 5). All but one operation took place in the uninhabited section of the island.

The overall CPUE varies somewhat between landing zones; most notably the CPUE is low in the inhabited section of the western lagoon – less than half of that in the uninhabited section of the western lagoon, and less than a third of that in the uninhabited section of the eastern lagoon. This is due to lower CPUE than in the uninhabited section for e.g. bala adiyal, idal and fadal, as well as cast net, hand line and rod and line, and perhaps more significantly, lower CPUE than in the eastern lagoon for bala adiyal, bala idal, cast net, hand line and rod and line (Fig. 5).

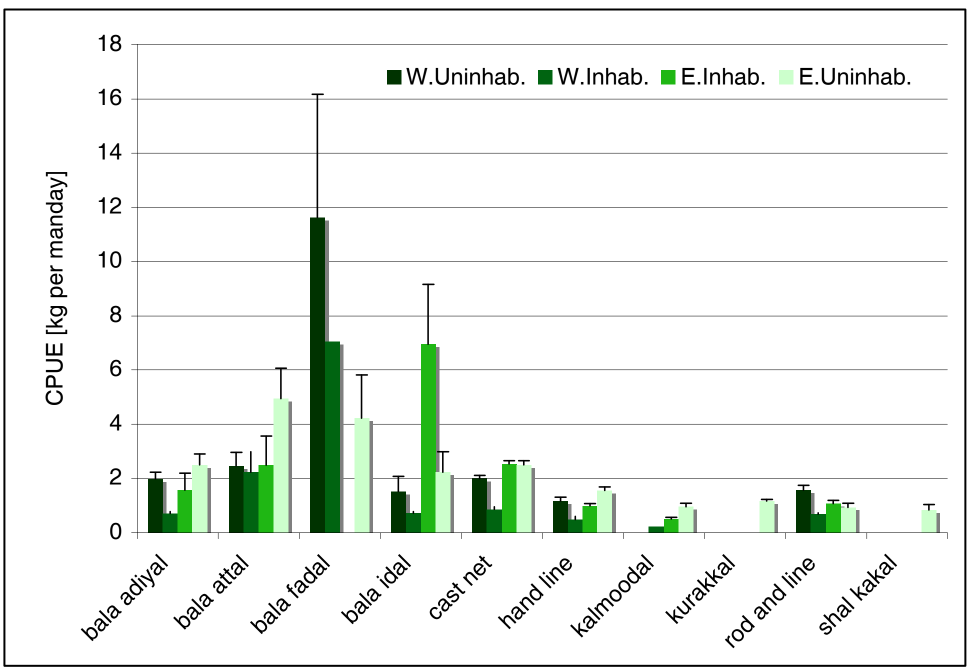

Figure 5b. Average CPUE (±standard error of the mean) by gear and zone.

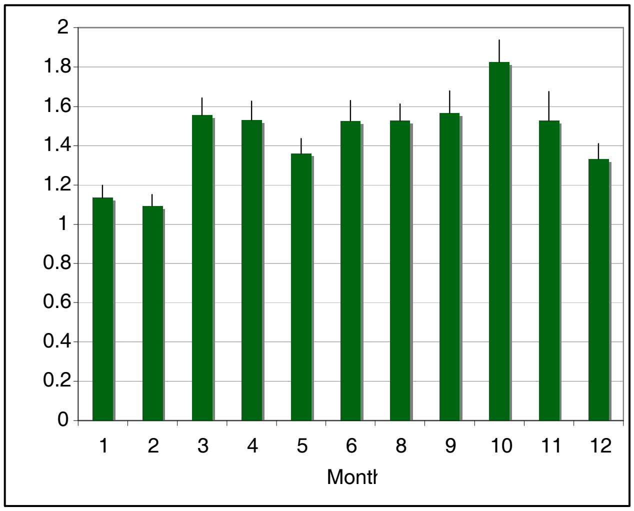

Figure 6. Average CPUE by month (±standard error of the mean).

CPUE also varied over time (Fig. 6), with average CPUE of around 1.55 kg per person per day in March and April, June to September and in November. It was notably lower between December and February and in May, and somewhat higher in October.

Total Catch

Using the CPUE obtained from the catch data and estimates of gear use frequency, the total annual reef fishery catch in Agatti has been estimated at 56 metric tonnes (Table 3). Bala attal and bala fadal catches together constitute over 50% of the estimated total, with bala attal catches of over 16 tonnes making up 29% of the total catch. Other gears with a significant proportion of the total catch, bala adiyal, cast net, hand line, bala idal and rod and line, range between 10.3% of the total for bala idal and 5.5% for rod and line. Kamoodal, kurakkal and shal kakal catches together make up less than 3% of the total catch.

Catch Weights

To compare the relative contribution of catches of different size toward the total weight of fish caught, individual catches recorded were divided into nine classes based on catch weight (<0.5kg; 0.5-1kg; 1-5kg; 5-10kg; 10-20kg; 20-50kg; 50-100kg; 100-500kg and >500kg). Over 90% of the catches were smaller than 5kg, and together constitute just over a third of the total catch recorded. Fifty one percent of all catches recorded fall within the 1-5 kg category, making up

Table 3. Total catch by gear. Average CPUE and average number of fishers involved in gear operations are based on catch data records, number of fishing events per year is estimated based on census data. The estimated total annual catch in kg is calculated based on CPUE and gear use data. The error margin of the estimated total annual catch is calculated based on the standard error of the mean in CPUE and number of people operating gears.

Gear	Avg CPUE	Avg # people	# of Events	Total catch	Error Margin
bala adiyal	1.40	2.64	1560	5,779.47	462.16
bala attal	3.67	2.37	1872	16,306.89	2,183.16
bala fadal	7.89	15.29	100	12,056.28	3,879.77
bala idal	1.32	2.38	1248	3,941.45	671.31
cast net	2.06	1.03	2496	5,300.45	155.86
hand line	0.99	1.09	4680	5,063.10	289.91
kalmoodal	0.58	3.06	624	1,102.96	154.30
kurakkal	1.17	3.00	104	364.00	104.69
rod and line	0.95	1.03	3120	3,074.42	161.96
shal kakal	0.83	5.15	20	85.36	60.87
TOTAL	1.70	2.08	15824	55,955.54	3,129.23

Table 4. Fish taxa occurring in more than 20 catches (number of recorded catches; average catch per fishing event in kg; total weight recorded in the catch monitoring data in kg; and estimated annual total weight caught in kg).

Species	Count	Avg Catch Weight	Tot Weight Recorded	Est. Annual Total
Jacks/Trevallies	2057	1.16	2,386.01	12,756.9
Garfish	110	17.81	1,959.08	10,474.3
Goatfish	980	1.49	1,463.10	7,822.5
Surgeonfish	556	1.47	817.43	4,370.4
Emperor	779	0.98	766.22	4,096.6
Mojarra	751	0.85	635.79	3,399.3
Halfbeak	159	2.26	360.01	1,924.8
Grouper	467	0.67	314.01	1,678.9
Snapper	387	0.67	260.60	1,393.3
Baitfish	34	3.92	133.35	713.0
Parrotfish	169	0.79	133.11	711.7
Threadfin	253	0.50	125.66	671.8
Triggerfish	95	1.31	124.01	663.0
Fusiliers	34	3.48	118.43	633.2
Mackerel	58	1.98	114.59	612.6
Wrasse	120	0.95	113.61	607.4
Sea Chubs	79	1.40	110.51	590.8
Squirrel/Soldierfish	171	0.37	63.14	337.6
Damselfish	24	1.53	36.65	195.9
Barracudas	60	0.55	32.77	175.2
Rabbitfish	19	0.58	10.94	58.5
Lizardfish	28	0.36	10.21	54.6

30% of the total catch. By comparison, 35 catches over 50kg, constituting only 1.2% of the total number of catches, make up 42.4 % of the total catch by weight. Catches over 20kg constitute 1.9% of the total number of catches, but make up 48.3% of the total catch by weight.

Species Caught and Gear Selectivity

An analysis of the fish catch composition (Table 4) shows that five families (or species groups), jacks and trevallies, garfish, goatfish, surgeonfish and emperor made up over 70% of the estimated total annual catch. Jacks and trevallies occurred in almost 30% of all catches. The average catch weight is particularly high in garfish, halfbeaks and baitfish, largely due to the fact that they frequently form large schools that can be trapped using various nets. Garfish in particular exhibits a much higher average catch due to occasional catches of 50kg to over 300kg. Based on reports from fishermen it is assumed these are regular occurrences. As illustrated in Table 5, three to five species groups usually constitute more than 70% of the catch.

DISCUSSION

CPUE

The CPUE for cast net recorded in the catch data was higher than what fishers have reported through interviews (see Hoon and Tamelander 2005). This is to some extent a function of the nature of the fishery

Table 5. Gear selectivity. Species groups constituting more than 5% of the total catch weight, by gear (selected gears).

Species	bala adiyal	bala attal	bala fadal	bala idal	cast net	hand line	rod-line
Jacks/Trevallies	30.7	18.7	8.2	10.6	43.1	13.6	71
Garfish		44.4		35.3			
Goatfish	21.6	19.1		13.1	19.7		
Emperor	6		20.9	6.4		16.7	
Surgeonfish			34		6.6		
Grouper						18.8	11
Mojarra	10.2	5.7			13.1		
Snapper						19.1	
Billfish				12.8		5.7	
Halfbeak	8.4		5				
Seerfish						13.2	
Triggerfish			6.1				
Mackerel	5.3						
Other	17.9	12.1	25.7	21.8	17.5	13	18

and the fish catch sampling strategy. Castnet is an opportunistic gear and may be used on a whim. If fish are being caught the fisher may continue until content with the catch, whereas many times when catches are small or none at all the activity is not continued for long, and not always reported as a "fishing activity". The effect is that the catch monitoring method may overestimate the CPUE for castnet somewhat.

The difference in CPUE and total catch per event in the gears mainly operated by one person, such as cast net, hand line and rod and line, can be explained by the fact that the activities at times are carried out by two people together, and catches may at such times be pooled. This is the case especially for hand line, which is often used from boats in connection with netting operations.

The differences in CPUE between the landing zones reflects the intense pressure on the western inhabited section of the island – the proximity to human populations makes fishery access easy, and the lower CPUE may reflect resource depletion due to over fishing. However, it is also likely that environmental degradation contributes to resource depletion. The inhabited section of the western lagoon contains two busy jetties, a coir processing plant, and receives a large part of the sewage seepage from the island community, which are likely to affect fish habitat and communities.

The island is subject to monsoonal weather patterns, with a 'fair season' between November and March, a 'rough season' between May and September, and 'transition seasons' in October and April. The CPUE variations over time reflect this seasonality to some extent. The reef and lagoon fishery is more intense during the rough season, when the weather is unsuitable for hook-and-line tuna fishing. During the fair season, when more fishers spend more time in the hook-and-line tuna fishery, the CPUE of the reef fishery is lower. May, being the month with generally the roughest sea conditions, showed a somewhat lower CPUE than during the remainder of the rough season. The high CPUE in October was due to large catches using bala attal and bala adiyal. It is unclear if and how fish behaviour in response to temperature and weather patterns factors in.

The low number of records of kurakkal and shal kakal show the gears are rarely used, and further conclusions regarding these gears based on the data gathered are speculative and must be made with caution.

Total Catch

The total annual catch, estimated at 56 metric tonnes between 2006 May 2007, is lower than the 100 tonnes estimated and reported by Hoon and Tamlander, 2005. In part this reflects inconsistencies in the bala idal catch, which was reported to be almost 10 times higher in 2003-2004. Other significant differences were found in the estimated total catch of bala fadal and bala attal, which showed larger total catches than previously reported, due to a higher frequency of use and higher CPUE using bala fadal, and a higher CPUE using bala attal. Bala adiyal showed a much smaller catch than previously reported, the differences primarily due to lower CPUE and use-frequency.

While some of these differences are due to differences in monitoring methods (estimates through fisher interviews compared with quantitative catch monitoring), it is clear that it also reflects changes in fishing on the island and is possibly indicative of changes in the environment. For example, a new type of bala fadal operation has been introduced, and data on daily fishing effort (unpublished) indicate a decline in fishing operations in the recent couple of years. Further, through consultations and awareness workshops organized on the island fishers have indicated that fish catch is declining and fish composition in the catch is changing.

The method presented herein can be particularly valuable for tracking trends in the fishery CPUE and total catch if carried out continuously or at least at regular intervals. It can also complement perception data on catches and gear use gathered using Participatory Rapid Assessments (PRA).

Catch Composition, Gear Selectivity and Catch Size

Catch composition and gear selectivity indicate that the fishing methods used are somewhat selective. However, many species groups are made up of different local taxa: emperors contains 9 different local taxa, jacks and trevallies 7, snappers 4, groupers 3, and goatfishes 2 respectively (see Table 1), and a single catch may contain several different species of from each group. However, a closer look at individual catches shows that average number of species within each species group per catch event is relatively low. The species groups most commonly represented by more than one species in individual catches are jacks and trevallies, emperors and surgeonfish, and to a slightly lesser extent groupers and goatfish. The average number of species per species group and catch is under 1.5 for all species groups.

In spite of the preference for specific fish and the fact that fishing gears are developed and used with this in mind, it is also obvious that the quantity of fish caught matters, which leads to a situation where some of the more popular gears are optimized for a large catch rather than catch exclusivity. The number of species groups that each constitute less than 5% of the total catch by weight for a given gear, and perhaps more importantly, their combined weight as a % of the total catch, give an indication of how selective a fishing gear is. Using these criteria the least selective gears appear to be bala adiyal and bala fadal; 26 different species groups and 37 local taxa were recorded in bala adiyal operations, with 20 different species groups constituting 17.9% of the total catch. In bala fadal, where the total number of species groups and local taxa recorded are lower (23 and 35 respectively), the 'bycatch', 18 different species groups, makes up over one quarter of all catch. Also in bala idal over one fifth of the catch is made up of minor species groups. This mirrors statements by local fishers that many of the nets are designed and used with catch quantity rather than specificity in mind.

By contrast, over 80% of bala attal catches are made up of only three species groups – garfish, goatfish and jacks and trevallies – and the minor constituents of the catch, although rather diverse at 20 species groups, make up only 12.1% by weight. While cast net has the highest number of species caught with any gear (38 local taxa) jacks and trevallies, goatfish and mojarras make up over 75% of the total catch by weight. Hand line seems to have a broader spectrum of target species, but a lower bycatch. Six fish groups constitute 87% of the catch, the remainder is made up of only 13 species groups. It is noteworthy that the results presented herein differ somewhat from what was reported by Hoon et al 2002. This supports the perception among fishers that catch composition has gradually changed over the past five years.

Similar to many other small-scale subsistence reef fisheries there is very little discarded bycatch in the Agatti reef fishery. Although certain species are preferred there are uses for almost all species.

One striking feature of the reef fishery on Agatti is the proportion of the total reef fish landing caught in a comparatively low number of large catches. It is worth noting that the large catches are landed using the more indiscriminate and possibly more destructive fishing techniques, notably bala fadal. There is a need study in more detail how the different fishing gears impact the resource and the health of the ecosystem, as well as the socioeconomic and cultural aspects of their use, as this will have bearing on management decisions regarding the reef fishery. However, it does seem clear that regulations on the unselective and potentially destructive bala fadal would be more feasible to institute and have a larger impact than attempts to regulate minor gears that according to the data presented here are less likely to deplete the fishery resource and would appear less likely damage the ecosystem.

Fishing Sites vs Landing Zones

When fish catch is recorded fishers note down sites visited, 1-3 sites in descending order by quantity of fish caught at each site (subjective ranking by the fisher). In all, over 70 fishing sites have been recorded in the catch data, including coral boulders, reef channels and specific spots on the shore (many of these are indicated on the map in Figure 1). However, this number is approximate as sites have not been checked for duplicate names/synonyms, and they have been georeferenced only to some extent. It is clear though, that sites can have rather different spatial definitions, some referring to a coral boulder or even one side of the coral boulder, an area of only a few square meters, whereas others are more broad, such as "the bar area", which denotes the outer reef crest and slope around the island. It is clear that the gear used also has implications for the definition of a fishing "site". Thus in this study catch has been reported by four landing zones rather than actual fishing sites. Since a large part of the catch is landed in the zone nearest and most convenient with respect to the fishing site, the landing zones provide an acceptable approximation of catch by site cluster. Hoon and Tamelander (2005) provide a justification for this approach, in the absence of site-specific analysis of catch. However, it should be noted that catch from especially boat-operated gears may be landed where the boats are usually moored (primarily the western inhabited zone) rather than in the closest zone, which may affect the accuracy of the fishing intensity data presented. The overall patterns are believed to be correct, however.

Local and Scientific Taxonomy

While many local names for fish match scientific fish species, and some local fish group names seem to largely match scientific families, analysis of catch data presents a number of obstacles in relation to terminology and taxonomy. Most notably, the local names used are not systematic with respect to scientific/taxonomic level – some fish are described only by a family-level name, others by very species-specific ones or even referring to juveniles of a certain species. This reflects the relative importance of specific species to islanders and their lives, as well as the local understanding of functional categories.

An example of this is the much greater taxonomic detail in local names referring to baitfish than other small fishes, due to the importance of the tuna hook-and-line fishery that uses large quantities of baitfish and distinguishes between species. It is important to note, however, the baitfish group includes fusiliers as well as damselfish and possibly also e.g. small serranids, gobies and blennies. The species presented as damselfish in this study are thus damselfish that are not used as tuna bait. Similarly, several of the main target food fish species are classified in detail, e.g.

jacks and trevallies and emperors. Lack of taxonomic detail is observed with respect to fish species that obviously occur around the island but do not constitute important or preferred catch, such as rabbit fish, for which only two local names were encountered.

A further issue is that local terminology is not always used consistently, and a fish, for which a local name that refers to a single species may exist, may be recorded using the name of the fish group to which it belongs. For example, a white-blotch rock cod may be recorded simply as a grouper, i.e. 'chammam' (the family-based species groups used in this study), or using the more specific 'pulli chammam'. Some local names also lack clear distinctions or have overlaps, e.g. in relation to emperors and snappers, where several local names refer to specific species and others may refer to groups that include both emperor and snapper species.

While the local taxonomy approach taken in this study might create a 'bias' for some species or species groups, it is reflective of local conditions. The benefit of using local terminology, making the data collection as well as results more immediately locally applicable, by far outweighs the disadvantages, many of which can be dealt with.

On the whole the level at which local names have been aggregated is considered appropriate for the purposes of this study – to characterize the reef fishery in much greater detail than has been done to date, and quantify the fishing effort and fish catch. The accuracy of the taxonomic system used is viewed as sufficient (after all, more often than not local taxonomy does match the scientific) to also make statements regarding the relative importance of major food fish families and the total harvest. One development that could be useful in this regard would be to ensure species are always recorded to species level, or at least lowest possible taxonomic level. However it must be recognized that the local terminology is rather flexible in nature and varies even from person to person (for example, 262 different names and/or spellings of names occur in the catch data, which correspond to 113 distinct local names), and many fish lack species names. Another approach could be to analyse catch based on a combination of taxonomic and trophic groups. For either of these to be feasible highly detailed and currently not available information on local taxonomy is needed.

Sustainability of the Fishery

It has been reported that the reef fishery in the Lakshadweep decreased in response to the introduction in the 1970s of the tuna hook-and-line fishery (Arthur 2005), and further speculated that this may have contributed to a greater capacity of the reefs of the area to recover from the devastating mass bleaching in 1998 (Arthur 2007, Arthur 2000). However, there are indications of an increased reef fishery for local consumption, and perhaps more worryingly, for export to South East Asia, targeting high value fish such as groupers and snappers. This poses a management challenge as it can be an opportunity for sustained income or lead to temporary but high profits and a rapid decline and collapse in key fish populations (Murty 2002), as has been seen around the region. Management and conservation of the fisheries resource of Agatti must be formulated and implemented in a way that sees to the needs of the many people who depend on reef resources for protein and subsistence. This requires the involvement of local stakeholders as well as Fisheries department and non-governmental organisations, but the task is complex in the context of a rapidly changing global economic and social environment.

While CPUE analysis can yield an abundance of information about a fishery, including changes and trends over time, there is some doubt with regards to whether CPUE in itself can provide adequate information on changes in fishery resource status or provide indications of resource degradation early enough for management responses to be timely and meaningful. Because fishers are skilled and actively seek out places where fish are likely to be found it is possible fish population decline will not be seen as a significant change in CPUE until populations are near total collapse. Thus CPUE trends over time should not be used alone, but rather complemented by other surveys, importantly resource status surveys, which for reef fish can be carried out with relative ease using standard fish under water visual census methods (e.g. English et al. 1998).

Such resource and environmental status surveys have been initiated on Agatti. Members of the local community were trained in modified and somewhat simplified fish UVC and benthic assessment techniques, focusing on indicator species, resource species and important fishing areas identified by fishers. Early results are promising, with e.g. good correlation between (primarily corallivorous) butterfly fish and coral cover observed. However, additional training and field practice are needed for results to be sufficiently reliable. If allowed to continue the ecological survey data will provide an important complement to fish catch and other resource use data in the formulation and implementation of reef resource management.

Resource Conflict

Hoon and Tamelander (2005) reported little resource use conflict on Agatti island, except a divide between formal management authorities and local resource users, a situation that continues unchanged. However, should reef health and fish populations deteriorate, as a result of natural perturbations, due to increase in fishing for local consumption, or due to an uncontrolled expansion of the lucrative export oriented fishery for high value reef fish – perhaps the most worrying prospect at this time – the situation of relatively moderate resource use conflict is likely to change. A proactive management approach needs to be taken to address this in a way that ensures fair resource access and sees to local needs both in terms of conservation and development.

It is also notable that there has been a lot of speculation among local fishers regarding a high abundance and density of green turtles in the Western lagoon of Agatti, in particular in the inhabited section. The turtles are frequently cited as a cause for damaged fishing gear, and there are many reports of nets being torn, especially close to the shore and more so in the inhabited section of the lagoon. In addition turtles are often blamed for reduced catches not only through loss of gear but also altering the environment and reducing fish stocks. Preliminary results from a survey of the occurrence of green turtle in the western lagoon seems to corroborate some of the observations made by local fishers. The turtle densities are significantly higher in the area where local fishers experience the highest frequency of damage to their fishing gear (unpubl., surveys by NCF, CARESS and CORDIO in December 2005). While this does not provide evidence of negative impact of turtles on the fishery resource, it clearly reflects that there is some cause for the situation to be viewed as a conflict by the local fishing community.

There is also, as noted by Hoon and Tamelander 2005, a potential for conflict in relation to the reef resource uses that are technically illegal or regulated, but carried out without controls, such as the harvest of building materials, ornamental fish and other scheduled species (Lakshadweep Gazzette 2001a,b). Harvesting of sand, rubble and coral boulders for construction, as well as octopus and seashell collection, has been monitored as part of the fish catch monitoring programme, but results are not included herein and will be presented separately.

Catch Monitoring and Estimates from Fisher Interviews

The fish catch monitoring method presented herein can if carried out continuously or at regular intervals be particularly valuable for tracking trends in the fishery, and it is expected to provide more accurate estimates on CPUE and total catch than estimates based on interviews and perceptions. However, it is clear that the perceptions of fishers provide valuable, usually highly accurate information that can complement quantitative catch monitoring. This has also been observed during turtle and sea grass mapping surveys of the Agatti western lagoon where perceptions of turtle and sea grass distribution among islanders mirror maps created based on scientific survey data. This validates Participatory Rapid Assessment (PRA) as a quick and fairly accurate technique for obtaining data where none exists and where skills and funding are not available to carry out lengthy and time consuming scientific studies.

RECOMMENDATIONS

In view of the results presented herein, as well as other reports and surveys from the area (including e.g. Arthur 2000, 2005, 2007, and Hoon and Tamelander 2005), the following recommendations are made. Although made specifically with respect to Agatti, most recommendations apply to other islands in the Lakshadweep as well.

A more proactive approach to engaging local populations and resource users in formulating and implementing management policies for the area, and ensuring that this is based on best available scientific findings, is needed from management authorities;

The information available on state of the environment and resource use in the area needs to be synthesized in an appropriate format for supporting management decisions, and data gaps need to be filled through additional surveys and regular monitoring, most notably with respect to resource status and environmental health;

The sustainability of the current fishing effort needs to be determined through sufficient reef health and fish population monitoring, in combination with resource use and socioeconomic monitoring. Management responses e.g. gear restrictions and spatial or temporal closures need to be considered. The idea of a community managed no-take zone has been floated in Agatti and has been well received by fishers;

Importantly, there is a need to pay particular attention to regulation and precautionary management of the export fishery, especially concerning vulnerable and easily over exploited species such as groupers, bumphead parrotfish and napoleon wrasse. This includes setting regulations, establishing quotas, and carrying out enforcement through patrols as well as control of export;

It is also important to note that while there is a regulatory framework on natural resource use it is frequently not enforced coherently and consistently – some laws are broken on a daily basis, others never. A new approach with clearer and more consistent policies as well as and more public engagement is required;

The management interventions recommended should also include an increased focus on development of alternative or supplemental livelihoods for the people of Agatti and the Lakshadweep as a whole, to reduce natural resource dependence and stress on natural resources, and to diversify the local economy and making it more resilient to change.

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