Participatory Fisheries Stock Assessment

Project R7947

Fieldwork Report 1: Zanzibar 2003

UK Department for International Development

Fisheries Management Science Programme

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1 Introduction

The Participatory Fisheries Stock Assessment project R7947 (PFSA) forms part of the Marine Resource Assessment Group's (MRAG) Fisheries Management Science Programme (FMSP) and is funded by the Department for International Development (DfID). The PFSA project aims to provide information to fisheries managers in the form of a scientific advisory based on a participatory interview technique, existing/archival data, and data that can be collected rapidly in the field. The method is flexible and enables scientific advisories to be produced for a variety of fisheries. This report summarises fieldwork undertaken in Zanzibar (Tanzania) during the initial trials of the method.

The field trials of the methodology were conducted in partnership with the Institute of Marine Science (IMS) and the Department of Fisheries. This phase of the project continued the development of the PFSA technique as a method for conducting rapid stock assessments, empowering local stakeholders and management facilitators. During the fieldwork the interview technique was tested and improved, and the validity and relevance of other sources of data evaluated. This report describes the work undertaken and provides a summary of the data collected as well as the scientific advisories developed for two study sites.

Objectives of the fieldwork:

- Develop the interview technique;
- Conduct trials of the PFSA interview technique in at least two fisheries to allow proper assessment of the methodology, and collect data for use in software development and testing;
- Carry out depletion experiments in at least two fisheries to provide catch and effort based parameters to use in the software trials;
- Identify and collate any archival data which may be available and incorporated as part of the rapid assessment;
- Conduct other data collection which may be applicable within the rapid framework of PFSA.
- Produce stock assessments in the form of scientific advisories for each trial.

2 Study Area

2.1 Location

Located off the coast of mainland Tanzania between 4-6.50ºS latitude and 39-40ºE longitude, Zanzibar comprises the two islands of Zanzibar Island (Unguja) and Pemba and over 50 offshore islets, most of which are uninhabited (figure 1). The two main islands have a combined land area of 2300 km2 (Unguja 1400km^2; Pemba 900km^2) and a population of just over 1 million (Ali & Sulaiman, 2002). Due to its proximity to the equator, Zanzibar experiences a warm tropical climate throughout the year. Temperatures average 25º C, but can reach extremes of 39º C during the hottest periods of the year. August is the coolest month, with temperatures peaking in February. Zanzibar is also subjected to two distinct monsoon periods during March-June and September-November when the islands receive most of the annual rainfall.

Figure1. A regional map showing the location of the islands of Zanzibar (Unguja) and Pemba, north-east of Dar es Salaam (Tanzania).

2.1.1 Fieldwork location

PFSA counterparts at the Institute of Marine Science (IMS) identified the coral reef fishery of the Kizimkazi region at the southern end of Zanzibar (Unguja Island), off the east coast of Tanzania, for the initial trials of the PFSA technique (figure 2). Within the area there are three villages, representing the major stakeholders for the fisheries in the region and which this project involved in the field trials: Dimbani, Mkunguni, and Mtende (figure 3). The field sites also fall within the boundaries of the Menai Bay Conservation Area which was listed as a multiple-use management area in 1997, and the Department of Fisheries was keen for the PFSA project to work within the area to facilitate an increase in co-management.

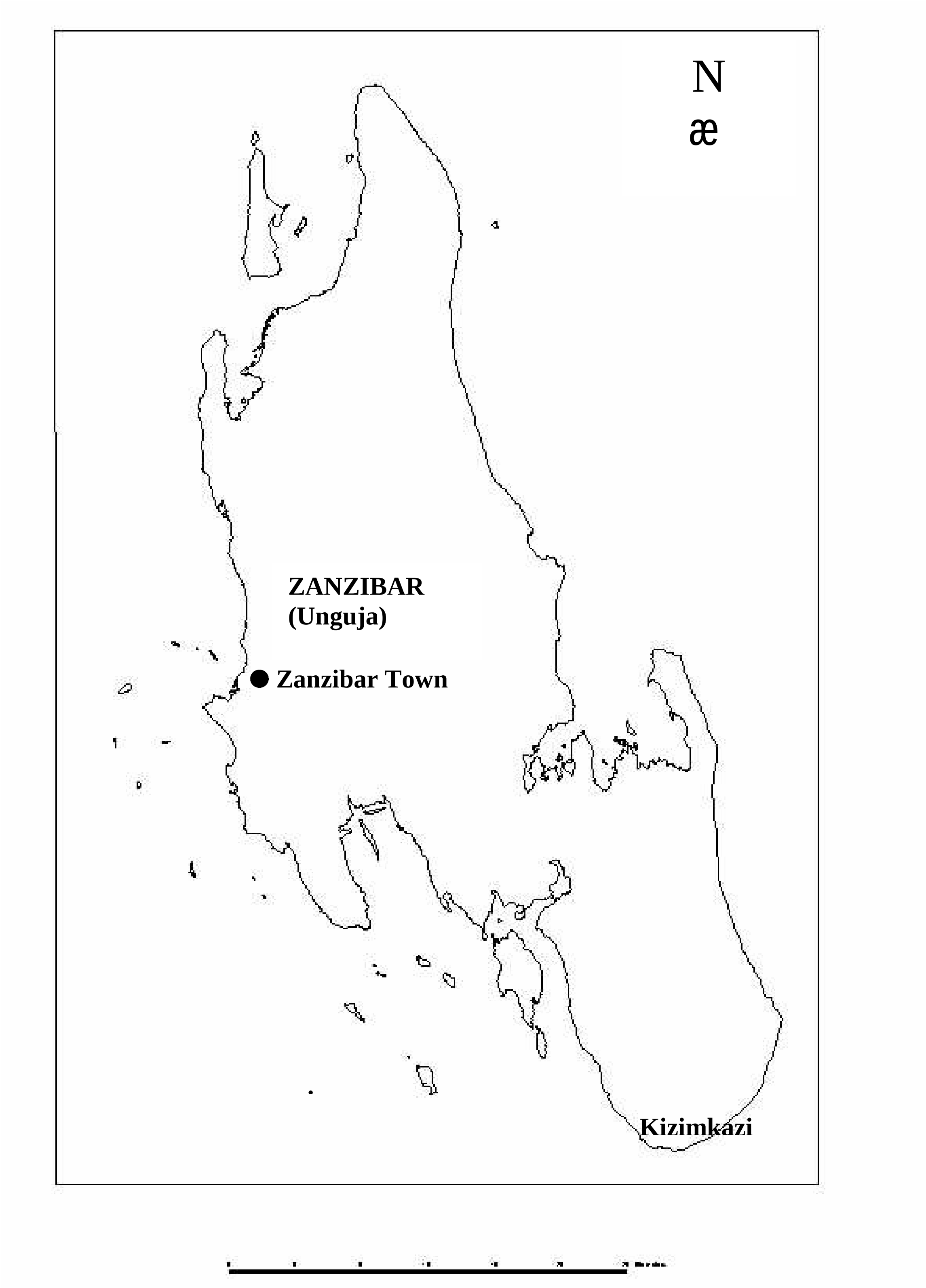

Figure 2. A map of Zanzibar Island showing the Kizimkazi region where the PFSA trials were undertaken. (Map provided by the Institute of Marine Science, Zanzibar)

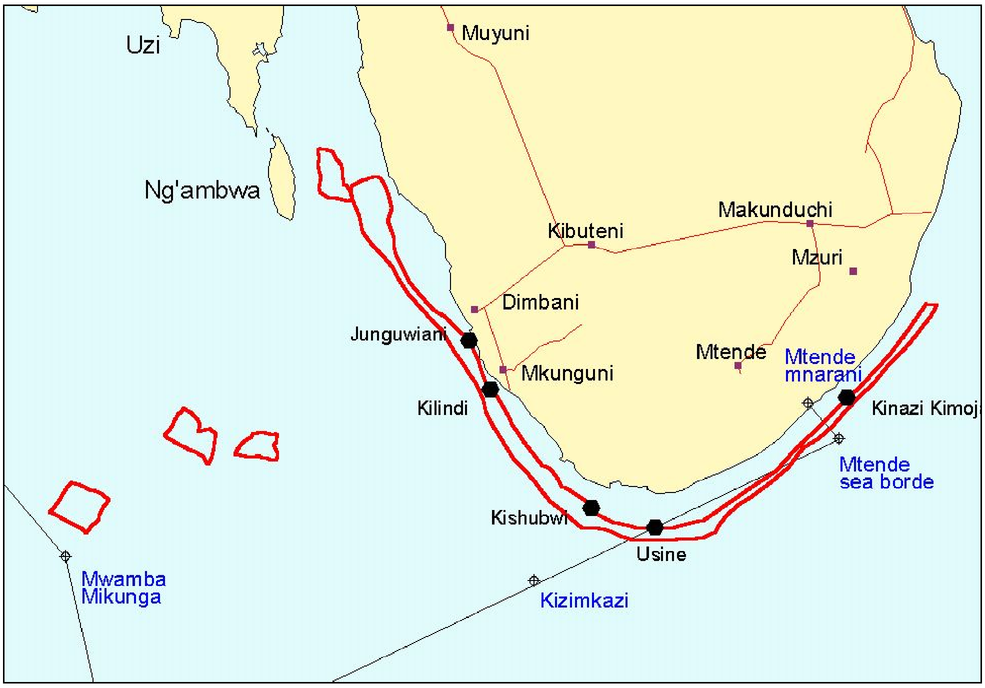

Figure 3. A map of the settlements in Kizimkazi and of reef areas visited during the course of the field trials. Map prepared by the Institute of Marine Science. (Outlined areas indicate reef area identified during the trials. Black line indicates the boundary of the Menai Bay Conservation Area).

2.2 Fisheries

In Zanzibar 90% of the fishing industry is artisanal and is important for providing income (local and foreign) and employment to a large number of fishers and fishery related workers. Fisher families form part of the poorest and most disadvantaged communities in Zanzibar. Approximately 23,000 fishers and 2,500 fish traders are dependent on the industry (Suleiman, 2002). Total employment in the fisheries related sector is estimated at approximately 14% of the population (FAO 1995). The GDP generated by fishing is low (4-10%), but importantly fishing remains the major source of dietary protein providing approximately 20kg/person per year.

Fisheries in the Kizimkazi region are diverse and typical of those found in Zanzibar. These include reef, small and large pelagic species, as well as a variety of invertebrates. The reef fishery gears include the use of hook and line fishing for species of *Serranidae*, *Lethrinidae*, *Lutjanidae* and *Balistidae*, and baited fish traps (locally known as Dema traps) for *Acanthuridae*, *Siganidae* and *Haemulidae*. Spear-fishing and free diving are also common techniques for catching reef fish and octopus (*Octopus cyaneus*), whilst squid (*Sepioteuthis lessoniana*) are caught using jigs. Some destructive fishing practices do take place in the area, though these are usually conducted illegally by fishermen from other areas of Zanzibar and mainland Tanzania. Dynamite fishing and seine nets have caused damage to some reef areas. The former is no longer practised, whilst seine netting is still unfortunately relatively common. Anchor damage is also readily visible in some areas. Offshore and deep water fisheries use gill nets and long-lines for tuna, shark, deep water snappers (*Lutjanus sebae*), and large serranids (*Epinephelus* *lanceolatus*). More valuable fish species, and octopus and squid are sold to local buyers and in fish markets in Zanzibar town, whilst less desirable reef species are kept for local consumption.

The need for increased management of marine resources, particularly in coastal fisheries in the region is widely recognised. One of the specific needs is to inform decision makers through the collection of scientific data and apply this information through more widespread management practices (Suleiman, 2002). The PFSA technique provides a method for meeting these information requirements in a wide variety of fisheries and could rapidly increase the potential for applied stakeholder management strategies in the region.

3 Fieldwork and Data Collection

Summary of work undertaken:

- The interview technique was developed by IMS and PFSA consultants;
- The PFSA interview technique was trialled in three stakeholder communities;
- Two fishery depletion experiments were conducted in two separate locations; (an offshore platform reef; an inshore fringing reef);
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- Mark and re-capture data were collected in conjunction with the fringing reef depletion;
- Monitoring and abundance data were collected using an Underwater Visual Census (UVC) technique;
- Training of local counterparts from the Institute of Marine Science and the Department of Fisheries was provided. This included the interview, species identification, depletion experimental design, mark and re-capture studies, UVC monitoring work and data storage mechanisms;
- The small pelagic fishery was identified for assessment using the PFSA technique, and the assessment is currently being conducted by IMS;
- The octopus fishery was investigated for application of the PFSA method. Data collection techniques were investigated during the course of the project.

Table 1. A summary of the two PFSA trials undertaken in the Kizimkazi region of Zanzibar.

Trial 1: Dimbani	Trial 2: Mkunguni and Mtende
1. Introductory meeting 2. PFSA Interviews 3. Site selection surveys 4. Experiment meeting 5. Depletion Experiment 6. Data analysis/advisory preparation 7. Presentation of advisory	1. Introductory meeting 2. PFSA Interviews 3. Site selection surveys 4. Baseline surveys, monitoring sites 5. Initial UVC surveys 6. Fisher meeting 7. Tagging and UVC data collection 8. Depletion study and UVC surveys 9. Post-experiment UVC surveys 10. Data analysis/advisory preparation 11. Presentation of advisory

The majority of the field testing and data collection was undertaken during two separate field trials in the study area. The first was undertaken in-conjunction with the village of Dimbani, and the second with the two neighbouring villages of Mkunguni and Mtende (figure 2). Each of the field trials consisted of the initial village meetings, PFSA interviews, and a depletion experiment. Additional data collection was included in the second field trial including Underwater Visual Census (UVC) and a mark and recapture programme. These methods of population assessment were included to test the value of other data within the framework of the PFSA technique and its applicability to the software that has been developed. A summary of each trial is shown in table1. The main outputs from the data collection undertaken are the two scientific advisories prepared based on the two trials conducted. These are provided in later sections of this report.

3.1 Interviews

The PFSA interview consists of two sections a) stock assessment and b) preference based questionnaire. The PFSA technique is described further in annex 1 and the interview provided. This section summarises the data collected during the interview phase of each trial.

3.1.1 Data Collection

The interviews were conducted by a working group from IMS who worked closely in developing the interview technique with the PFSA consultants (table 2). Initial interviews were used to test the technique and make improvements where necessary. Subsequently data was collected using the updated version of the questionnaire. The interviews were conducted in each of the three villages during the trial. To aid data collection key informants were identified in each community. These included beach recorders (associated with the Department of Fisheries and the Menai Bay Conservation Area), who were responsible for collecting frame survey data in each community, and village representatives where necessary. The Dimbani interviews were undertaken during February, whilst the interviews in Mkunguni and Mtende took place between April and June. The number of interviews are summarised in table 3.

Table 2. Summary of PFSA project members and their affiliations.

Name:	Affiliation:
Dr Narriman Jiddawi	IMS Research Fellow
Mr Omar Amir	IMS (MSc student)
Mr Saleh Yahya	IMS (MSc student)
Mr Hamad Khatib	Department of Fisheries
Mr Mohammed Sulieman	Department of Fisheries
Mr Rashid Juma	IMS (MSc student)
Mr Oliver Taylor	UK consultant
Dr Paul Medley	UK consultant

Table 3. Summary of interviews undertaken in the study area in three settlements for the stock assessment (a) and preference sections (b).

	a) Stock Assessment	b) Preference
Dimbani (Trial 1)	43	19
Mkunguni (Trial 2)	35	34
Mtende (Trial 2)	14	14
Total	92	67

3.2 Fishing Experiments

3.2.1 Rationale

Controlled overfishing strategies have been proposed as one way of better locating maximum sustainable yield (MSY) conditions and potential target reference points (TRP). Depletion methods have been widely used in fisheries assessments, providing valuable information relating to targeted stocks (Caddy & Mahon, 1995). The technique involves directly reducing a population of fish through fishing to provide parameters for estimating stock size. There are many useful references which deal with depletion techniques (Leslie & Davis, 1939; Ricker, 1975; Hilborn and Walters, 1992; King, 1995; Jennings *et al*, 2001).

Short term, the rate of reduction in abundance of a population of fish is determined by the catch rate and the overall population size. Depletion methods use this relationship between catch rate and abundance to predict the overall size (Jennings *et al*, 2001). The technique is most useful if the population is closed (isolated in some way). The better depletion experiments involve isolated stocks (such as lake environments, offshore platform reefs, atolls etc.) where the effects of fish movement (immigration and emigration) are less likely to affect the stock under consideration. However, it is not always possible or desirable to target isolated stocks. Under these conditions good experimental design can help reduce the inaccuracies that are introduced by added variables. Keeping experiments short reduces the amount of movement related uncertainty and eliminates population factors such as recruitment to the stock (Leslie & Davis, 1939).

Biological traits of the stock under consideration will also have an influence on the data collected, and thus the final assessment. Different species have differing catchabilities depending on the gear used, life stage and behaviour exhibited. In hook and line fisheries some species locate baits more readily than others, may bite more boldly, and as a result exhibit a higher catchability. In multi-species fisheries there may be a series of species specific interactions with behaviour towards baits and the relative abundances of species within a community affecting catch rates. These interactions are dynamic and may change during the course of an experiment as more bold species are disproportionately reduced during the early part of the experiment. Models and methods for accounting for such variation can be found in other reference material (Polovina, 1986).

When conducting a depletion experiment it is important that the stock size is sufficiently reduced, otherwise assessments of overall stock size will be incorrect. Two of the most important considerations for stock assessors are the effort (fishing effort) applied during the experiment, and the size of the area utilised by the experiment. If the effort applied is too low, the time period for the fishing too short, or the experiment area (and thus the population of reef fish) is simply too large in the experimental design, then a sufficient depletion won't be achieved and an assessment will not be accurate. Small scale experiments can provide good stock parameter information, and need not require exhaustive funds.

3.2.2 Experiment Preparation

The two experiments were conducted with local fishers and using their traditional gears. The depletion experiments were introduced to the local communities through pre-arranged meetings following local protocol and the input of key informants. The concept and worth of the information was explained in detail by IMS project members based on technical advice provided by UK consultants. Fishers were also consulted to determine the location of reef areas that were suitable for the experiment. The locations identified were those with low fishing effort to represent unexploited stocks as closely as possible. The locations were then visited and baseline surveys undertaken using scuba and manta tow techniques to assess the suitability of the sites. The fishing areas were recorded using GPS, and mapping data for area estimates are shown in annex 2.

3.2.3 Reef Locations

i) Experiment 1: *Mwamba mwenpa* (Dimbani experiment):

This is an offshore platform reef situated 5 km west of the village Dimbani. The reef is a 600m x 500m ellipsoid with bathymetry between 15 and 20m on the reef surface, sloping to a maximum of 35m in the surrounding seafloor. The habitat is characterised by patchy coral cover surrounded by rubble and sand areas. The fish community is diverse and many commercially exploitable species are evident. The reef is rarely fished by local communities because of the distance involved, although some illegal fishing does take place by boats visiting the area from the mainland.

ii) Experiment 2: *Kishubwi-Usine* (Mkunguni and Mtende experiment)

This is an extensive fringing reef, characterised by a broad lagoon and back-reef, sloping quickly to a depth of 9m from the reef crest. The gradient is shallow and the slope descends gradually from 6m to 18m over a distance of 50m to 100m metres before descending more rapidly to a maximum of 40m. The habitat consists of a mixture of sea-grass and patchy hard and soft coral cover in northern most areas. Further south the habitat improves with a higher percentage cover of both soft and hard coral and more diverse and abundant fish assemblages. (This may be due to the increasing distance from coastal settlements and a subsequent reduction in fishing related impacts.) The depletion experiment was conducted in an area approximately 800m X 100m between Kishubwi and Usine as shown in figure 3.

3.2.4 Experimental Design: Depletions

The Mwamba mwenpa (Dimbani) depletion was conducted over an eight day period. The Kishubwi-Usine (Mkunguni/Mtende) depletion took place over nine days. In both experiments the majority of fishermen used hook and line fishing. Some Dema traps were also included in the first experiment as this is a common method used in the fishery. The species caught by this method were recorded separately. Four families (*Serranidae*, *Lethrinidae*, *Balistidae* and *Mullidae*) dominated the hook and line catches in both experiments, whilst *Siganidae*, *Acanthuridae* and *Scaridae* were abundant in the trap returns of the first trial. A full species list is shown in annex 3. The number of fishers involved in the two depletions is shown in table 4. The catches of the two depletions are summarised in table 5.

Table 4. Number of fishers involved on each day of the depletion experiments.

Day	1	2	3	4	5	6	7	8	9
Dimbani	56	56	55	55	55	58	55	55	-
Mkunguni/Mtende	21	33	44	39	49	53	50	47	47

Table 5. Summary of the species and family composition of the two depletion experiments.

Depletion	Reef name	Number of species	Number of families
1 Dimbani (offshore)	*Mwamba mwenpa*	130	31
2 Mkunguni/Mtende (fringing reef)	*Kishubwi-Usine*	105	26
Total		168	35

In each experiment the fishermen were provided with log books to record time out, time in, and the duration of the fishing period. All catches were returned to the weighing stations established by the project for identification, individual fork-length measurements and species weights. This data was recorded on data forms (annex 4.1) and then entered into spreadsheets by the IMS work group. Species identification was aided by the UK consultants, and standard FAO guides and Lieske and Myers 2001.

3.2.5 Summary data

The targeted populations were successfully depleted during each experiment. During the Dimbani offshore reef depletion CPUE decreased over the course of the experiment period and was reduced by two-thirds by day 7 of the trial. Initial catches were considerably larger than those recorded later in the experiment and this is reflected by the decline in the rate of increase of cumulative catch (table 6), and the relationship between CPUE and cumulative catch (figure 4).

Table 6 shows the summary data of the depletion experiment at Mwamba mwenpa reef during the Dimbani field trial of the PFSA technique.

Day	Effort (person h^{-1})	Catch (kg)	CPUE (kg/h^{-1})	Cumulative Catch
1	128.00	311.35	2.43	311.35
2	116.50	210.31	1.81	521.66
3	109.50	181.70	1.65	703.36
4	116.50	227.10	1.95	930.46
5	109.50	207.95	1.90	1138.41
6	98.33	76.30	0.76	1214.71
7	89.00	66.00	0.74	1280.71
8	91.50	111.70	1.22	1392.41

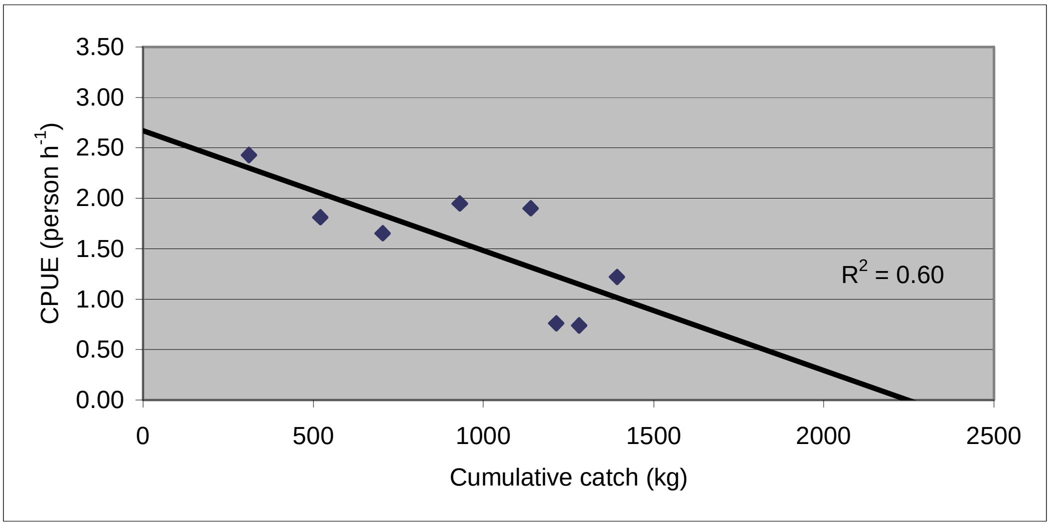

Figure 4 shows Catch per Unit Effort (CPUE) against cumulative catch from data collected during the Dimbani depletion experiment at Mwamba mwenpa reef.

Using the Leslie and Davis (1939) depletion method, the initial yield can be predicted from the information collected during the depletion experiment (table 7). In this instance the initial biomass of reef fish targeted by hook and line fishing could be in the order of 12.4 g $m^{-2}$with the whole reef area yielding up to 2470 kg's of fish in this fishery.

Table 7. The initial biomass calculation for reef fish targeted by hook and line fishing from Mwamba mwenpa reef based on calculations from the depletion experiment conducted during the field trial.

Y-intercept	Regression slope	N1=a/-(b)	Reef Area Estimate	Biomass
a	b	Kg	m2	g/m^{-2}
2.61	-0.0011	2469.28	199000	12.41

The depletion of the target stock was less obvious during the 2nd experiment on the reef of Kishubwi-Usine (Table 8). Effort and catches were less consistent during this experiment due to bad weather during the first three days of the experiment. This resulted in reduced CPUE. Conditions improved on day 4 and this is reflected by the higher effort exerted (as more fishers reached the fishing grounds), and higher catches and associated CPUE. Over the course of the remaining days of the experiment CPUE declined indicating that the applied effort was successfully depleting the target population (figure 5).

Table 8. Summary data for all species collected during the 2nd depletion experiment at Kishubwi-Usine Reef.

Day	Effort (person h-1)	Catch (kg)	CPUE (kg/h^{-1})	Cumulative Catch (kg)
1	57.33	21.11	0.37	21.11
2	97.50	59.40	0.61	80.51
3	142.25	90.60	0.64	171.11
4	98.00	143.39	1.46	314.50
5	161.00	246.04	1.53	560.54
6	105.50	88.09	0.83	648.63
7	173.00	83.70	0.48	732.33
8	161.00	108.57	0.67	840.90
9	130.75	73.26	0.56	914.16

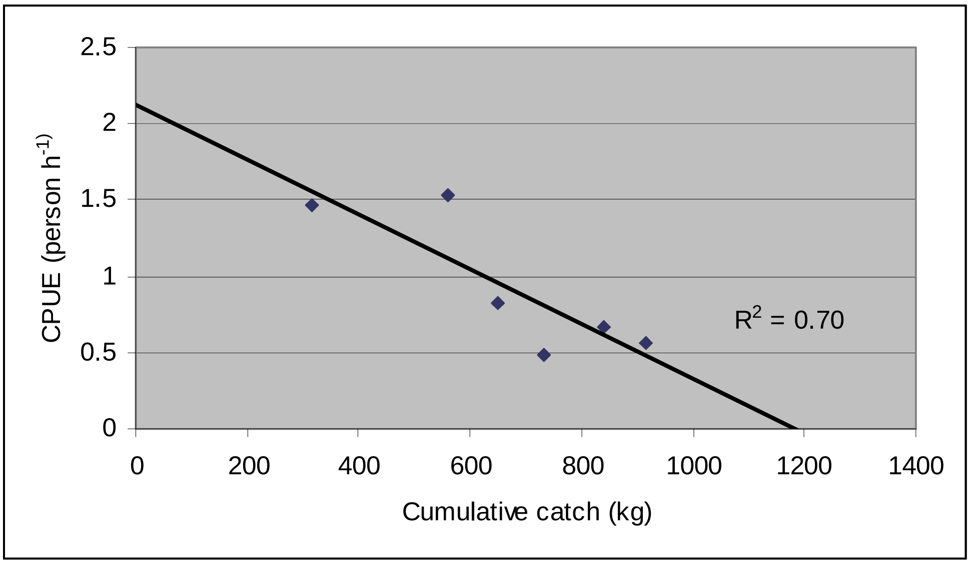

Figure 5. Catch per unit effort (CPUE) against cumulative catch during the Mkunguni/Mtende depletion experiment at Kushubwi-Usine fringing reef. Data represents days 4-9 of the experiment.

Table 9. The initial biomass calculation for reef fish from Kishubwi-Usine reef based on calculations from the depletion experiment conducted during the field trial. (Data from day 4 –9 of the experiment).

Y-intercept	Regression slope	N1=a/-(b)	Reef Area Estimate	Biomass
a	b	Kg	m^2	g/m^{-2}
2.12	-0.0018	1182	80000	14.75

Calculations of biomass (table 9) from the data shown here for the second depletion experiment are likely to be much more inaccurate if using the method applied previously. The data presented in figure 5 suggests a total yield of approximately 1200 kg's from the experiment area based on hook and line fishing. But this discounts catches from the initial 3 days of the experiment which were adversely affected by weather. This estimate is also based on a rough area estimate for the size of the fishing experiment area. More accurate data is currently being compiled by IMS. However, this data set will still provide valuable parameter estimates within the PFSA software, particularly for multi-species analysis, based on length-frequency and species-weight information collected.

3.3 Mark and Recapture Studies

3.3.1 Rationale

The use of mark and recapture techniques in the PFSA experimental design was investigated during the second field trial. Mark and recapture methods have been used for terrestrial and freshwater population estimates but they are also applicable in marine environments despite problems associated with fisheries scale and fish behaviour (Jennings *et al*, 2001). They are best used in confined populations or where the target is relatively sedentary. The technique can be applied to coral reef fish populations where many species exhibit limited home ranges, and where the tagging phase is relatively short. In this instance the experimental design aimed to tag fish within the area designated for the depletion experiment, maximising returns.

3.3.2 Methods

Once the fishing area for the depletion experiment had been selected and demarcated, an intensive tagging programme was conducted for 8 days within the area (see annex 5). Project staff were trained to tag fish with Algaecide-treated, numbered anchor tags. These were then used to mark fish caught from a local vessel using hooks and line by four fishermen employed from the local community (Mkunguni). Each fish was revived in sea-water, tagged in the dorsal region and returned after a subsequent revival period. During the tagging phase 566 fish from 35 different species were marked and released within the boundaries of the fishing area. For each capture the species name, fork length and tag number were recorded (see annex 6). The data is summarised in table 9.

Table 9. Summary of the tagging data collected during the experiment. Two species (*Sufflamen fraenatus* and *Lethrinus borbonicus*) dominated the catches. The most commonly recorded species are shown here.

Family	Species	Tagged	Mean size (cm)	Range (cm)	Standard Error	No. Tag Returns	Return %
Serranidae	*Cephalopholis nigripinnis*	14	17.0	15.1-19.5	0.50	0	0.0
Lethrinidae	*Gymnocranius grandoculis*	20	19.67	14.5-27	0.91	0	0.0
Lethrinidae	*Lethrinus borbonicus*	132	18.2	13.3-24.0	0.14	8	6.0
Lethrinidae	*Lethrinus rubrioperculatus*	40	19.5	13.3-31.7	0.52	10	25.6
Mullidae	*Parapeneus macronema*	47	15.96	13.2-18.2	0.16	3	6.5
Balistidae	*Sufflamen chrysopterus*	27	16.17	14.4-18.0	0.19	4	14.3
Balistidae	*Sufflamen fraenatus*	220	15.8	13.2-20.2	0.09	28	12.8
	All Species	566	13.2	43.5	0.14	54	9.5

During the re-capture phase (the depletion experiment) relatively high return rates were apparent for three species: *Lethrinus rubrioperculatus*, *Sufflamen chrysopterus* and *Sufflamen fraenatus*. This may reflect the high catchability of these species by hook and line fishing and aspects of their behaviour. The two triggerfish in particular may exhibit small home ranges and low migratory behaviour making them more susceptible to re-capture as they boldly approach baited hooks. The data collected during this phase of the experiment will be used in further assessment of the PFSA software.

An estimate of the target stock size can be produced from the information obtained from the mark and recapture study. A simple method relies on the number of fish in the capture sample, which is marked and released. Then subsequently the number of fish removed during a fishing period and the number of marked individuals returned in the catch.

$$N = \frac{n_1 \ n_2}{m_2}$$

Using the formula for population estimates first used by Petersen (1896), where N is the estimated population size, n_1 is the number of fish marked at first capture, n_2 is the number of fish caught during second capture, and m_2 is the number returned in the second capture, which are marked.

There are a number of assumptions made when using this method. These include the population is closed (no immigration or emigration), all fish have the same probability of being caught, catchability does not change after marking, no marks are lost between sampling and no marks go unrecorded in the second sample.

Table 10. Summary of the population size of hook and line targets within the fishing experiment area based on tag returns during the mark-recapture study.

Marked	Recaptured	Total catch	Population size
566	54	5395	56548

The mark and recapture data could also be used for estimating the population sizes of individual species for inclusion in multi-species assessments.

3.4 Underwater Visual Census (UVC)

During the second experiment reef fish populations and species composition were also assessed using an Underwater Visual Census (UVC), using similar methods to Gaudian *et al,* 1995. Six permanent monitoring stations were established in the study area: two within the fishing area for the depletion experiment and two on either side of the experiment area. The transects were 200 x 10m belt transects and were permanently marked using GPS locations (annex 2), surface buoys, and lengths of coconut rope at the start and end of each transect. The transects were spaced at 200m intervals at a depth of 7-10m depending on tidal state, and set perpendicular to the reef slope gradient. The number of replicates and phases of the survey are summarised in table 11. It is apparent from the data that sample sizes vary according to transect despite the aim of the original experimental design to stratify the sampling among the sites, resulting from logistical constraints encountered during the fieldwork.

Table 11. The number of replicates completed at each of the PM sites in four phases of the experiment: Before, during, immediately after, and one month after the experiment. (* Denotes PM sites within the fishing area.)

	PT1	PT2	PT3*	PT4*	PT5	PT6
Before	3	3	6	9	6	10
During	8	4	9	11	8	12
After	3	3	4	7	6	4
>1 Month	-	-	10	12	-	-

The monitoring stations were surveyed at random where possible (see constraints) and transects conducted by two pairs of divers, each recording the target species within the transect boundaries. The UVC assessed reef fish populations before, during, and after the depletion experiment, and was also used to monitor subsequent recovery rates (which is on-going). Recovery data for PT3 and 4 have been collected by IMS staff for 4 additional months using funds from the PFSA project and methodology introduced during the fieldwork. Fish marked during the tagging phase of the experiment were also recorded.

3.4.1 UVC Species

The data collection focused on the principle targets of hook and line fishing identified during the first depletion experiment: *Serranidae* (22 species), *Lethrinidae* (14 species), *Lutjanidae* (10 species), *Balistidae* (13), *Haemulidae* (5) and one species of *Labridae* (*Cheilinus undulatus*). Of these, 54 species were observed during the UVC surveys. Other families were also present in the catches (such as *Mullidae* and *Holocentridae*) though these were excluded from the UVC survey data collection as they were abundant and detrimental to the data collection of more desirable species, or too cryptic to assess accurately using the UVC technique. A full list of the surveyed species is shown in annex 3.

3.4.2 UVC Data collection and Analysis

Summary data and analysis is presented here based on species recorded during the UVC surveys which were present during the depletion catches. Data collection was conducted at each of the 6 permanent monitoring stations, though most survey effort was focused on the two sites within the fishing experiment area (PT 3 & 4). Additional data was collected to monitor the recovery of the target populations at these two stations, accounting for the larger sample sizes and extended time frame of the data presented. Data is presented for each of the experiment phases defined earlier: before, during, immediately after and >1 month. The fishing experiment took place between the 27th of April and the 5th of May. Data for PT3 and PT4 are presented here. Similar data for the permanent monitoring stations outside of the fishing area are shown in annex 7.

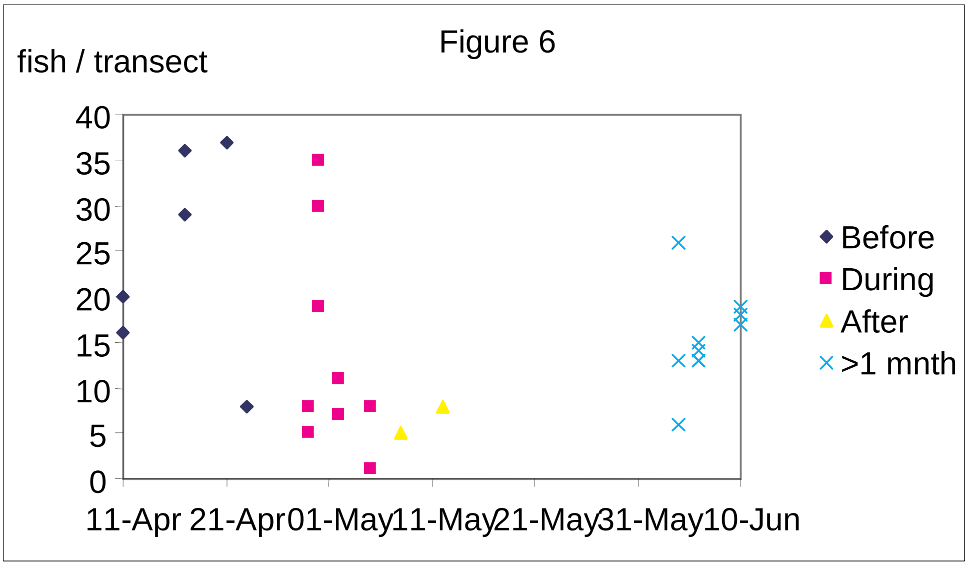

Figure 6. Summary data for station PT3 established within the depletion experiment area during the study. Replicates were conducted for four separate experiment phases: before, during, immediately after and more than 1 month after the fishing period. Sample size, n=29. There is an indication of declining target abundance over the course of the experiment, with considerable recovery in the follow up surveys.

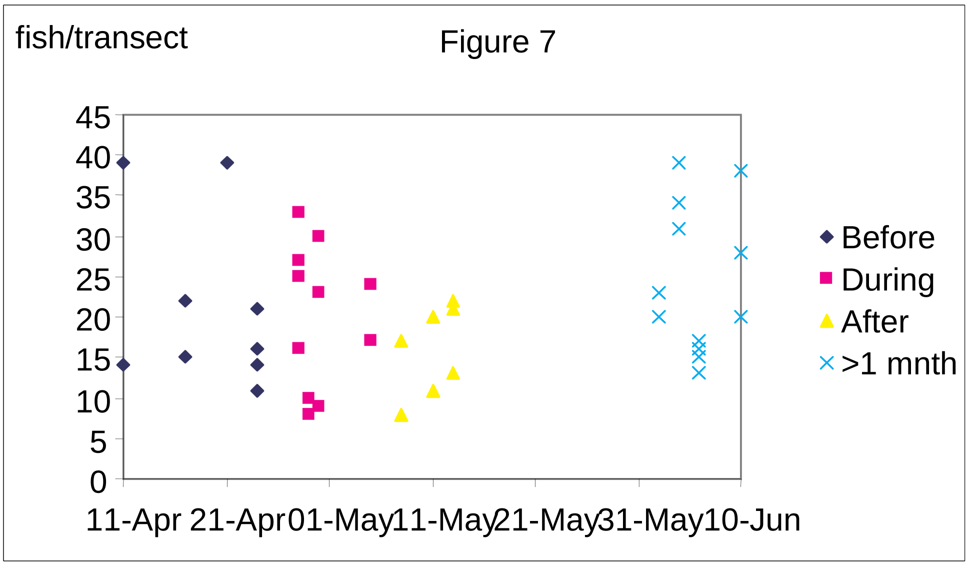

Figure 7. Summary data for station PT4 established within the depletion experiment area during the study. Replicates were conducted for four separate time periods: before, during, immediately after and more than 1 month after the fishing period. Sample size, n=39. There is indication of declining target abundance associated with the fishing experiment, though not as markedly as in PT3. The data suggests that there was a rapid recovery of abundance once the fishing period ended.

Analysis of the data from the two monitoring sites within the fishing experiment area (table 12) shows that the abundance of target species was reduced by the fishing experiment in both of the permanent monitoring stations.

Table 12. Summary of mean abundance of hook and line target species recorded during the UVC monitoring at two sites within the fishing experiment area. Sample sizes (N), abundance indices, standard errors and ranges are shown.

	Before	During	After	>1 Month
PT3				
N=	6	10	3	10
Mean	0.0138	0.0074	0.0048	0.0134
SE +/-	0.0033	0.0013	0.0028	0.0018
Range	0.0220	0.0103	0.0035	0.019
PT4				
N=	9	11	7	12
Mean	0.0113	0.0085	0.0094	0.0145
SE +/-	0.0018	0.0013	0.0010	0.0015
Range	0.0150	0.0130	0.0075	0.0200

In PT3 mean abundance was reduced from 0.014 fish m^{-2} before the fishing began to 0.005 fish m^{-2} when the station was resurveyed immediately after the depletion experiment. When the station was resurveyed for the initial recovery monitoring 1 month after the experiment the mean abundance of targets had increased to 0.013 fish m^{-2}, suggesting that the targeted populations had recovered in abundance.

In PT4 mean abundance was reduced from 0.011 fish m^{-2} before the fishing experiment was conducted, to 0.009 fish m^{-2} when the station was resurveyed immediately after the depletion phase indicating that the stock was successfully depleted. When the station was resurveyed to monitor initial recovery the mean abundance of targeted species had increased to 0.015 fish m^{-2}, exceeding the population size suggested by the surveys undertaken before the depletion phase.

Table 13. Summary of regression analysis data for all target species at each of the permanent monitoring stations established during the fieldwork. Trends for increasing (+) or decreasing (-) abundance from data collected before, during and after the experiment are shown. No data from >1 month after the experiment were used in this analysis. R^2 values for the regression, as well as standard error values and sample sizes (N) are included.

	PT1	PT2	PT3	PT4	PT5	PT6
Trend	- ve	+ ve	- ve	- ve	+ ve	None
R2	0.41	0.33	0.39	0.01	0.27	0
SE +/-	32.87	17.62	10.24	8.83	72.40	195.27
N	14	10	19	27	20	24

Declines in abundance due to fishing mortality are supported by the regression analysis at PT3, but less apparent at PT4. The remaining sites outside of the area suggest a mixture of increasing and decreasing abundances. Further analysis may aid in identifying trends, though it is likely that the sample size and aspects of training involved in the study will have an effect on the data sets. For example, it is apparent from the data that semi-cryptic species (genus *Cephalopholis*) which were abundant in the surveys at PT6, but were initially overlooked by surveyors during initial training, but were subsequently recorded in increasing number once the observers became familiar with the technique.

Other observations from the data suggest that balistids (triggerfish) were the most obviously depleted family, with a high catchability, within the experiment area. One species in particular (*Sufflamen fraenatus*) was abundant in the initial surveys within the fishing area but virtually absent after, and over the course of subsequent monitoring. There is considerable scope for further analysis of the data set, especially at a species level. The species specific data will provide valuable parameter estimates when applying the multi-species model incorporated in the PFSA technique.

The relatively rapid recovery observed at both stations is probably an effect of immigration of fish from areas surrounding the fishing experiment area. Recovery data collection has continued at both of the monitoring stations established by the project. This work has been undertaken by IMS project staff using funds supplied by the PFSA project. Further analysis of the data will be undertaken, though the primary purpose of the information obtained by the UVC programme is to provide indices for use in the PFSA software. Habitat mapping has also been undertaken by the IMS project members and this will be used to develop more accurate assessments of target abundances once the information is made available.

Overall the data collection supports the fishing experiment evidence that the populations were depleted during the experiment. However, the indices for population estimates produced by the assessments are low, and if expanded based on reef area estimates then they produce an abundance estimate likely to be well short of the actual number of targeted fish that are typically found on the reef in the study area. This is due in part to the inability of the survey team to include all species that were recorded in the catches in the UVC assessment. Some families such as H*olocentridae*, *Mullidae* and some *Labridae* were very abundant within the fishing experiment area and this was reflected in the catches. However, due to cryptic behaviour or super abundance they were not included in the data collection as this would have been to the detriment of data collection focusing on more valuable species, and the training aspect of the work undertaken.

3.4.3 Monitoring Reef Recovery

The site of the Mkunguni/Mtende experiment has been resurveyed to monitor recovery rates of the depleted reef area. This resurveying has been undertaken on a monthly basis over a course of three days and four researchers included in each period. The surveys have focused on the two permanent monitoring sites within the depletion area to minimise field costs whilst maximising data production (PT3, PT4). This data will be made available by IMS on completion of the recovery study data collection.

3.5 Octopus Stock Assessment

The Octopus (*Octopus* cyaneus) was also identified as a fishery that could be assessed using the PFSA technique. Interview data relating to this fishery was not obtained during the trials presented here, but could be quickly collated by IMS representatives. However, some fieldwork was conducted to determine the suitability of the fishery for assessment, and what other field based data collection could be undertaken to enhance management predictions. Three octopus fishers were employed on separate occasions to demonstrate fishing techniques involved, and to provide some background information on the fishery in the region.

3.6 Small Pelagic Fishery Stock Assessment

The small pelagic fishery was of particular interest to managers in Zanzibar as no stock assessment had been previously undertaken and fishers had expressed concern that catches had declined considerably over preceding years. Thus the PFSA technique was seen as a technique which would quickly produce a much needed assessment.

A stock assessment is currently underway at the main fishery landing site (Malindi) in Zanzibar town. PFSA interview data has been collected by IMS following the same methodology used in other stock assessments. This data collection is on-going and should be completed by October 2003. An advisory will then be produced based on the interviews and catch effort data provided by IMS. It is intended that IMS will undertake the full assessment using the software under the supervision of a project consultant.

4 Kizimkazi-Dimbani Offshore Reef Advisory

4.1 State of Stocks

The current state of the stock is unknown, although the balance of probabilities suggests overexploitation. This assessment depends upon interview information as there is no other data on the unexploited state. Given that fishing has been going on for generations, this information is not reliable but more a statement of expectation.

4.2 Management Advice

The current assessment indicates too little is known about the unexploited state and productivity of the stock to be sure of the appropriate level of fishing. The main aim should be to determine whether catch rates can be improved for fishers by lowering fishing effort. This would reduce the work as well as catch initially. The assessment suggests no more that 25% decrease would be acceptable at this stage. Fishers would need to agree and co-operate to achieve this.

As the key issue is uncertainty, adaptive management should focus on active control and gaining more information about the fishing and potential yield. Any change in effort should be accompanied by careful monitoring of the result.

A monitored closed area would be particularly useful, not only to obtain an estimate of the unexploited stock size, but also the rate of recovery.

4.3 Stock Assessments

The baseline assessment is a logistic population model representing reef biomass projected forward from parameter probability distributions for the 4 parameters. The parameters are derived from interviews and a fishing experiment. Two parameters, the recovery rate and unexploited biomass, are very poorly estimated as they rely on the interview data alone. Simulations assess the outcome of different controls while taking account of the uncertainty. All assessments indicate a decrease in fishing effort would be advisable.

The baseline assessment suggests a 25% decrease in effort would produce more preferred conditions in the fishery. A 15% decrease in effort would reduce the chance of long term overfishing to 10%. A 15% decrease would represent the smallest recommended decrease with the current limit control parameters.

If only interview data is used, the assessment is much less certain. In particular, the limit control falls below the target, suggesting the risks of higher controls are much larger as there is greater uncertainty. The target control remains unchanged, largely as it is driven by the fisher preference and the predicted change in catch rates is poorly known whether the experiment is used or not. This might only be addressed by monitoring the recovery of a reef.

Closing a reef to fishing is not likely to produce much benefit to fishers, although it would reduce risks of overfishing. Depriving fishers of a fishing area without controlling effort would make fishing more intensive on other reefs. A smaller reduction in effort with an area closure might be the best option in both improving the state of the fishery and providing necessary information for management.

Current effort is 200 boat days a month. The limit state and limit probability are 50% and 10% respectively.

Scenario	Control Type	Current Control	Current State Probability	Target Control	Limit Control
Baseline	Effort	200	0.516	150.00	170.61
Interview Only	Effort	200	0.505	149.12	85.63
Baseline	Closed Area	0	0.526	0.00	0.05
Interviews Only	Closed Area	0	0.505	0.02	0.29

4.4 Special Comments

The model results had to be scaled to the whole fishery. The experiment was conducted on a single reef (out of 13) and the total effort applied in the fishery was estimated from the information from fishers. Both these estimates need to be updated as soon as possible and the assessment run again. This is not expected to change the assessment qualitatively, but it is possible that the limit and target effort rates will change.

5 Mtende Fringing Reef Advisory

5.1 State of Stocks

The current state of the stock is unknown, as the unexploited state of the reef is unknown. This assessment depends upon interview information as there is no other data on the unexploited state. Given that fishing has been going on for generations, interview information is not reliable but more a statement of expectation.

5.2 Management Advice

The current assessment indicates too little is known about the unexploited state and productivity of the stock to be sure of the appropriate level of fishing. There is no evidence for overfishing, however, and the target indicates the fishing effort should remain as it is while additional information on the state of the stock is obtained.

If effort is controlled and kept to the current level, the population size may still change. It is hoped that catch rates will increase. Catch rates should be monitored to see whether the fishery is at equilibrium or whether there is long term change.

A closed area is recommended for this fishery. The assessment indicates that there is sufficient chance that catch rates will increase with a closed area as make such a control worth while. The closed area should be a refuge for about 5-10% of the stock. It is important that the closed area be monitored before and during closure, and after re-opening, if appropriate. If the area did not benefit the fishery, it could be opened again in future.

5.3 Stock Assessments

The baseline assessment is a logistic population model representing reef biomass projected forward from parameter probability distributions for the 4 parameters. The parameters are derived from interviews and a fishing experiment. Two parameters, the recovery rate and unexploited biomass, are poorly estimated as they rely on the interview data alone. Simulations assess the outcome of different controls while taking account of the uncertainty.

The assessments indicate fishing effort should remain at the current level until more information comes available. However, the level of uncertainty favours a closed area control which would protect the stock and improve its status. A monitored closed area would provide very valuable information for the stock assessment.

If only interview data is used, the assessment is much less certain. Although the effort limit control still falls below the target when using the experiment data, the additional information has allowed it to increase. This demonstrates the value of information in reducing risks. The target control remains relatively unchanged.

Current effort is 400 boat days a month. The limit state and limit probability are 50% and 10% respectively. The index was based on additional UVC data.

Scenario	Control Type	Current Control	Current State Probability	Target Control	Limit Control
Baseline	Effort	400	0.483	413.33	296.41
Baseline no index	Effort	400	0.541	413.33	299.97
No experiment	Effort	400	0.638	426.66	148.65
New Effort 400	Closed Area	0	0.541	0.04	0.09
New Effort 600	Closed Area	0	0.541	0.13	0.17

5.4 Special Comments

The model results still have to be scaled to the whole fishery. This information is required urgently before management action can be taken.

The tagging data was not used in this assessment, but could be incorporated at a later date. The UVC data made little difference to the assessment. The variability in counts was most likely due to fish movement. The effective fishing area is probably large and so a larger scale experiment would probably be required to obtain a clear depletion.

6 Presentations

Following the data collection and initial analysis, an important component of the trial phase of the PFSA project (and co-management in general) was the dissemination of information back to the stakeholders involved in the trials. Once the interviews and experiments were completed presentations were made to the fishers of each community:

Aim of the PFSA approach:

1. Highlight the need for some form of management;
2. Identify what potential management options are available;
3. Set up community based monitoring of any management strategies applied;
4. Ensure involvement of scientific advisory (IMS);
5. Develop a simple management plan.

Each presentation was arranged by IMS through key informants within each community. Presentation materials and supporting explanations were prepared by the PFSA work group and subsequently presented by IMS with technical support provided by the PFSA consultants.

What was presented?

1. Fishery prior opinion based on stock assessment interviews;
2. Preference data collected during the interviews;
3. Data collected during the fishing experiment and UVC where collected;
4. Combined opinion based on the prior data and the scientific information collected by the experiment;
5. Discussion on the benefits of better management and possible management scenarios which may be adopted by the stakeholders and incorporated in any future management planning.

7 Comments on the Stock Assessments Methods

7.1 Biomass Assessment

Experiments were shown to be potentially very useful. Even in the simple way they were used here, they were Informative compared to interviews. More could be made of the information they collect. The tagging data requires further analysis, but could give a much better estimate of the effective fishable biomass than other methods, although it would be expensive to carry out routinely. Size frequency requires models which can be included in the current assessment.

The second experiment as well as suffering greater logistical problems, also was much more heavily affected by immigration. During more extensive diving surveys, it was found populations of fish were distributed in a complex manner, not along a simple reef edge. This site appears more complex than would be desirable in looking at immigration and emigration, and further development of this method would require a simpler alternative site.

Gear may need to be a subject of management control. However, it is not clear how to model gear selectivity without introducing considerably more parameters into an already heavily parameterised model. Simple gear models should be introduced, as experiments might be designed very easily to test which of two or more gears might have better selectivity for a multispecies stock. Multi-species yield-per-recruit would be ideal for this.

It would be most informative to monitor a closed area during recovery. The area should be large enough to protect a resident population. The relative increase in density and the rate at which asymptotic density is reached over 5-10 years would be very valuable.

Fishers are generally focused on immigration as the process which regenerates their stock. Similarly, the experiment may well monitor depletion and recovery of a reef based on an immigration-emigration process. This is a fast process compared to birth, death and growth rates, which fisheries scientists usually assume are dominant in a fishery. Given a significant proportion of the stock is unexploited, an immigration-emigration model may well be better for assessment than one based on biology. Advice based on such a model could improve the state of the fishery even if biological overfishing is not occurring. This is probably true for the local octopus fishery. The problem would be that as a fishery develops and new areas come under exploitation, biological overfishing might then occur. A stock assessment based purely on fish movement would fail to account for this.

7.2 Multispecies Assessment

A multispecies assessment was conducted on the emperor (genus *Lethrinus*) guild, which make a significant proportion of the catches (see Multispecies_Lethrinus_Model.PFA). This was done to test out a general approach for constructing prior probabilities (described in the help file) based on data from the Fishbase. The method was applied uncritically in the sense that all parameters from Fishbase were used. In many cases estimates appeared questionable, and might be rejected in a final version of the stock assessment. It is likely that considerably more data would be needed and additional models need to be developed before such multispecies assessments become routine.

A multispecies assessment is much more demanding than a single biomass assessment. The number of parameters is large, so getting adequate information on each parameter is difficult. However, certain types of information, most notably size frequencies, could be used to estimate several parameters needed for the growth curve. Most notably they would be useful to estimate the age at recruitment and the length-weight conversion exponent. The two other critical parameters, the growth and natural mortality rates, would require more sophisticated length-frequency analyses to estimate.

As results depend purely on priors constructed from Fishbase, they were too uncertain to provide useful advice compared to the logistic model. The assessment suggested that fishing mortality was much too high and considerable gains would be made by reducing effort. To reduce risks to the limit level, effort had to be all but eliminated.

As well as uncertainty over Fishbase estimates, splitting the catch data into separate species catches greatly increased the error. In contrast to single species fits, the multispecies model was able to fit these data and provide reasonable estimates of fishing mortality. However, the error was still very great, and combined with other parameter uncertainty, left the assessment of much lower quality than the single biomass assessment.

Multispecies assessments will always be difficult on coral reefs. The numbers of species means the numbers of parameters will be high. Breaking parameters down into smaller groups, building empirical relationships between parameters within groups and developing more models, particularly ones able to use size frequency, will make this approach ultimately viable even in the most diverse fisheries. What will probably turn out most useful is to build hierarchical models that, depending on the available information, are able to break down biomass production models into increasingly finely divided groups.

8 Constraints

The trials identified several constraints that affected the experiments undertaken. Those encountered were associated with the logistics of working in the field and affected only the second experiment in Mkunguni and Mtende:

8.1 Seasonality and Weather

The fieldwork was undertaken in a location that is exposed to strong wave action during certain seasons. Unfortunately the timing of the fieldwork coincided with the on-set of the southeast monsoon which strengthened during the course of the fieldwork. The rough seas associated with this event had a negative effect on the project in several areas:

8.1.1 Depletion Experiment

Catch rates were reduced during the opening two days of the Kizimkazi-Mkunguni/Mtende experimen. Additionally, strong currents are associated with the SE monsoon and these also reduced catch rates by lifting hook and bait off the seabed.

8.1.2 Mark and Re-capture

The wave action and currents associated with SE monsoon also affected the mark and recapture study. The tagging was to be undertaken immediately prior to the depletion experiment to maximise returns. However, unsuitable weather conditions delayed the depletion phase by seven days. This allowed for greater dispersal of tagged fish and may have contributed to lower return rates from the fishing area. These conditions also made the tagging more difficult and may have reduced catch rates.

8.1.3 UVC Surveys

The UVC study was also affected. Rough seas made for difficult survey conditions affecting the monitoring work undertaken before, during and after the depletion phase. This directly affected the number of replicates completed, and also how the replicates were dispersed amongst the permanent stations. Two sites in particular experienced stronger wave action, overly strong current conditions, and poor visibility during most of the experiment.

8.1.4 Recommendations

Seasonal conditions should be considered before beginning PFSA data collection. The first experiment was not affected by seasonal constraints as it was undertaken at the end of the north-east monsoon. However the south-east monsoon begins in March and was in full effect during the second experiment. This resulted in reduced data collection and more strenuous working conditions than necessary. More emphasis on site selection may have reduced these constraints. Selecting a site in a more northerly location would have eased working conditions, and though this wasn’t possible during the trials it would be a valuable consideration during future PFSA work.

8.2 Other Constraints

8.2.1 Site Selection

The trial also identified the experiment area as an important component of the technique and the overall success of the rapid nature of the method. The reef area chosen for the Mkunguni/Mtende experiment was typical of the fishery, however, the nature of the fringing reef complicated experimental design due to the width and gradient of the reef slope. The slope was very gradual over a distance of several hundred metres in some locations. This made locating the permanent transects more difficult, and where limited stations can be sampled it resulted in a smaller percentage of the whole reef area being included in the surveys. This situation was unavoidable in this particular instance, but other PFSA experiments should aim to include areas which are accessible and easily surveyed where possible.

8.2.2 UVC/Mark-Recapture

During the UVC surveys, tagged fish were recorded during the surveys. During the course of the surveys few tagged fish were observed, and invariably these were *Sufflamen fraenatus* which is a visible and unwary species. However, very few other species were recorded through visual observation. Some species could not be approached closely as a result of their behaviour, or observations were limited because of poor visibility. This was most evident in *Lethrinus borbonicus* which is considered a key species to fishers in this fishery. A considerable number of this species were tagged during the trial but none were recorded during the UVC's. This may be due to high migration as few tags were returned during the depletion phase.

8.2.3 UVC Data

The UVC data collected during the trial was not as conclusive as originally hoped for at the outset of the experiment. Problems associated with adverse seasonal conditions have already been discussed. In addition the lack of training time available before the experiment made data collection more difficult. The study utilised the skills of IMS and fisheries staff, however, some staff were relatively inexperienced or had not conducted UVC surveys for a considerable length of time. As such the emphasis during the experiment was not only to collect data but provide useful training to IMS staff so that they may use the skills in future projects.

8.2.4 Observed catches

Based on a previous depletion experiment conducted in the area, it was expected that *Lutjanus fulviflamma* would be common in the catches and during the UVC surveys (Gaudian *et al*, 1994). In the former instance, very few individuals of this species were captured during the tagging phase or during the actual depletion, despite evidence from the UVC surveys that this species was very abundant within the boundaries of the fishing experiment area. Seasonality and behaviour were suggested as causes for this anomaly. Local fishers also expected to catch higher numbers of this species.

8.2.5 Recommendations

Site selection need not be a constraint to the PFSA technique. Data collection during the second experiment would have been more straightforward had the project not faced the unnecessary complication of seasonal and weather constraints. If the experiment had been undertaken during the north-east monsoon UVC site location and the actual survey dives would have been considerably less complex. Factoring in seasonal considerations is highly recommended within future PFSA work, allowing data collection to be maximised. Alternatively, if IMS conduct their own PFSA projects as is hoped, then surveys could have focused on interview data collection in difficult seasons, or on other areas of coast.

9 Evaluation of Data Collection

9.1 Interviews

The development of the interview technique was less complex than originally envisaged at the conception stage of the project. There were initial concerns of how to obtain accurate scientific data for stock assessment from fishers using a questionnaire approach, especially through misinterpretation of the questions. Of most concern was the preference section of the questionnaire designed to develop probabilities of fisher opinion based on a range of management/fishery scenarios. These initial fears appear to have been unfounded, or any points of concern quickly addressed during the field testing. The IMS input into the development of the interview technique was substantial and a large number of trial questionnaires were completed allowing potentially complex questions such as those designed to develop discount rates for individual fishers to be rapidly improved.

9.2 Fishing Depletion Experiments

The fishing depletion experiments conducted were successful on several fronts, and despite the financial outlay from project budgets, are deemed a very valuable tool when conducting PFSA studies. The technique is rapid and allowed for the collection of large data sets based on catch and effort data for producing parameter estimates for use in the software. The experiments also provided a very useful method for involving fishers in the PFSA project, and subsequently a basis for facilitators to discuss the effects of fishing pressure on the fishery using information the fishers had been directly exposed to. This additional participation was very beneficial to the project as a whole, developing considerable discussion and increasing interest in the project and its purpose at forums arranged within each stakeholder community. Only where time-series catch and effort data, or other data which can be used for developing the necessary parameter estimates are available are they likely to be unnecessary.

9.3 Mark and Recapture Studies

The use of tagging data was less successful during the project field trials. In part this is due to some of the logistical constraints imposed by bad weather conditions and a subsequent delay between the tagging phase of the experiment and the fishing experiment period. The study area also increased the likelihood of considerable dispersion of tagged individuals and thus reduced the proportion of returns. If the trial had been conducted on an isolated offshore reef or atoll then returns may have been higher.

One of the aims of the tagging phase was to develop data on immigration and emigration rates within the fringing reef fishery. During the UVC surveys tagged individuals were recorded based on transect location (inside and outside the fishing area). However, very few tagged individuals were observed and those that were encountered were typically one species of balistids (triggerfish) which are easily approached. Other species which could not be approached closely, particularly lethrinids which are arguable the most important family within the reef fishery, and so tags could not be observed.

Further analysis of the data is required, but considering the drawbacks encountered, the additional time involved for undertaking the tagging, and extra costs incurred through boat hire and fisher employment, the final assessment must be that tagging trials do not appear to be an effective method for inclusion in PFSA assessments unless funding is sufficient.

9.4 UVC Monitoring

The UVC technique utilised during the project is a widely used approach for collecting population data. The methods and skills can be quickly learnt and applied relatively easily in the field in most instances. During the trials a number of constraints affected the project, reducing the scope of the initial experimental design. However, if trained expertise is available then the technique can provide useful additional data for inclusion in PFSA assessments depending on a number of considerations: Data collection can be relatively straight forward depending on the location of the study area, the distances which need to be travelled and the availability of staff and equipment. Where these factors are not detrimental to the planned assessment then UVC monitoring can be utilised. However, UVC may not be suitable where the conditions are difficult (i.e. rough seas, deep reef areas, strong currents etc), or where funding is restrictive. The area assessed during the field trials was not ideal within the framework of the current trials, but it did highlight some of the considerations when conducting PFSA work.

10 Conclusions

The field trials undertaken were very successful in developing the PFSA technique, which has proved to be adaptable and practical in the field. It was demonstrated that the combination of techniques can acquire data applicable to carrying out rapid stock assessments. The technique was applied thoroughly and successfully by the Institute of Marine Science and the Department of Fisheries staff who worked on the project, providing a means of stock assessment in Zanzibar that was previously unavailable, and where previous stock management has been limited. The fact that the data collection was relatively uncomplicated despite this being the developmental stage of the project suggests that future assessments would be more rapid and the technique could go along way to providing valuable stock assessments to the regions. This is supported by the Institute of Marine Science’s continued use of the PFSA technique since the end of the fieldwork period. Currently IMS are conducting PFSA interviews for the assessment of the small pelagic fishers, recovery monitoring work for the previous experiments and are looking to begin working in other fisheries in Zanzibar. The potential exists for the Institute to form a centre of excellence for conducting stock assessments in the region given additional funds and technical support.

11 Further Work

11.1 Data Analysis

Large data sets have been collected during the course of the Zanzibar field trials. To date most analysis has incorporated the interview data and catch/effort data produced during the course of the depletion experiments and these have formed the basis of the scientific fishery advisories which form part of the project output. Other data collected during the UVC surveys and tagging stages of the project have yet to be fully analysed within the PFSA software.

11.2 Small Pelagic Fishery

Interview data collection will continue until the end of October and then be submitted for use in the assessment software.

11.3 Data Collation

Data sets currently being accrued by IMS for the recovery monitoring work in Mkunguni and Mtende, and the small pelagic fishery stock assessment, need to be made available for inclusion in the PFSA analysis.

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Annexes