Frontier Madagascar Environmental Research

REPORT 11

Fin-fish resource use

Artisanal fisheries of Beheloka

Frontier-Madagascar
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Woods-Ballard, A.J., Chiaroni, L.D., & Fanning, E. (eds)

Frontier-Madagascar

University of Toliara
The Marine Sciences Institute
Madagascar

The Society for Environmental Exploration
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Frontier-Madagascar
Madagascar, the fourth largest Island on the planet is renowned for its high biological and ecological diversity, characterised by its high abundance of endemic species. Madagascar is one of the poorest nations in the world and very dependent on the resources the natural environment provides. As a result conservation and development work is of paramount importance as efforts are made to preserve an environment under pressure from non-sustainable exploitation. Frontier Madagascar is in the process of carrying out baseline survey work in the southwest coastal region of Madagascar in an effort to provide biological and resource utilisation data for the preparation of sustainable management initiatives for the region.

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The Institute Halieautique et des Sciences Marines (IHSM) is part of the University of Toliara, in Madagascar. IHSM is a university centre of learning in the field of marine sciences and runs courses for both undergraduate and postgraduate students. IHSM also provides consultations to government institutions, NGOs and individuals.

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The Society for Environmental Exploration and The Institute Halieautique et des Sciences Marines (IHSM), part of the University of Toliara have been conducting collaborative research into environmental issues since 2000 under the title of Frontier Madagascar. Frontier Madagascar conducts research into biological diversity and resource utilisation of both marine and coastal terrestrial environments, of which one component is the Frontier Madagascar/Darwin Initiative: Madagascar Marine Biodiversity Training Program. Since October 2001 the initiative has been working with local stakeholders within the marine environment to promote sustainable resource use through training and education.

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EXECUTIVE SUMMARY

The fishing village of Beheloka is situated in Southwest Madagascar 60km south of Toliara. In Southwest Madagascar the fishing methods are generally traditional (using non-motorised pirogues and traditional gears) as opposed to artisanal. However, fishers are becoming increasingly commercial with the number of pirogues increasing.

Fishing is managed within the region and regulated by national laws requiring government issued licenses for fishing from motor pirogues that specify gears and catch quotas. The fishery of Beheloka is here described as a developing artisanal fishery, which unlike he larger fisheries in the Toliara region still use traditional gears.

This report details the findings of a short-term rapid assessment of the fin-fish fishing of Beheloka which took place from February 2002-August 2002. This is an important area of study, as the fishing becomes more commercial.

Fishing production was assessed through two independent visual censuses, where total numbers of fishers were noted in categories according to their activity and numbers of people on the pirogue. Underwater visual census of fin-fish resources were carried out using SCUBA involving rapid habitat assessments and the census of fish species.

The findings of this report suggest that the fin-fishers of Beholoka are being moderately impacted. Although the system appears healthy in terms of larger fish abundance, the relatively recent regular fishing has yet to greatly impact the reef. As larger fish are more fecund than smaller ones, it is suggests that in order to prevent further degradation of this reef community, a suitable community-based management plan could be implemented.

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This report is the culmination of the co-operation, hard work and expertise of many people. In particular acknowledgements are due to the following:

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INTRODUCTION

This report concerns the findings of a short-term rapid assessment of the fin-fish fishery of Beheloka, Southwest Madagascar. Due to this lack of historical exploitation the Behelokan fishery is relatively unimpacted. It is an important area for study as the fishery becomes more commercial.

Southwest Madagascar, the Toliara region

Madagascar is the fourth largest island in the world. It has an area of 590,000km^2 with a population of approximately 15million people increasing at a rate of 3.2% per year. There have been various estimates of the length of Madagascar's coast and reefs, of 4,500-6,000km of coastline and 1,400-3,540km of coral reef (Cooke *et al.* 2000, Billé and Mermet 2002 and Gabrie *et al.* 2000). In the southwest region, coral reefs reach from Androka in the south to just south of Morondava (Gabrie *et al.* 2000).

Fisheries of South West Madagascar

Fishing methods are generally traditional (using non-motorised pirogues and traditional gears) as opposed to artisanal. In 1994, 55% of Madagascar's fisheries production was from these methods (Gabrie *et al.* 2000). Generally multiple species are targeted using multiple fishing technologies. Individual catches are relatively low though there is mounting evidence that this can have a major impact on the ecology of coral reefs. The use of destructive fishing practices such as poison and dynamite fishing are rare (Vasseur *et al.* 1988 and Cooke *et al.* 2000), however the use of purse seinnes, fine mesh beach seinnes, and reef flat trampling are commonplace. Pirogue fishing is becoming less selective and more destructive, with numbers of pirogues increasing from 10,000 in 1980 to 22,000 in 1995 (ICRI 1996) while gleaning pressure is intensifying and the total number of fishers has doubled in the last 20 years (Billé and Mermet 2002).

Regional Fisheries Management

There are a number of Malagasy laws concerning fisheries, however integrated coastal zone management is only recently becoming effective in scattered areas. There are only four marine protected areas within the country, two of which at the time of writing are community managed with policies based on local traditions (*dina*). The two community based schemes of Nosy Tanikely (Nosy Be) and Nosy Ve are managed by local organisations, whereas the government manages the Biosphere reserve of Mananara Nord and Tampolo, Cap Masoala and Tanjona making up part of the Masoala national park under the Association Nationale pour la Gestion des Aires Protégées (ANGAP) (Cooke *et al.* 2000). The region around Anakao and Nosy Ve has been proposed as a biosphere reserve for some time now, most recently a report by the Cellule Environnement Marin et Côtier and the Office National pour l'Environnement (2001) outlines the proposed completion of designation of the reserve. This will give the area increased protection at a government level. At an international level, Madagascar is a signatory of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1975) (CITES) and the Nairobi convention concerned with management, development and conservation of the East African Coastal Zone. Fishing is regulated to a small degree by national laws requiring, for example, government issued licences for fishing from motor pirogues specifying gears and catch quotas. Importantly, this means fishing is no longer a free activity (Beurier 1982). Regulations are difficult or impossible to enforce however, due to the remote nature of most fishing communities (Billé and Mermet 2002).

Beheloka and the Vezo Sara

Situated 60km south of Toliara, the reef opposite Beheloka is a fringing reef with spur and buttress zone as described by Yonge (1963). It is a section of a larger fringing reef 100km long by 500m to 3.5km wide reaching from Lanivato in the south to the Onilahy river. The tides are of a semidiurnal type with a tidal range of 0.9m minimum (neap tides) and 2.8m maximum (spring tides). The reef crest was between 4m and 8m beneath chart datum, with floor depths of 12-24m. The village of Beheloka (see Figure 1) is split into two *fokotany* (or zones) Beheloka Bas and Beheloka Haut. Beheloka Haut is inhabited by around 800 members of the Tanalana ethnic group; predominantly farmers, they rarely venture into the marine environment. Approximately 550 members of the Vezo Sara (Tatangirafeno 2002) inhabit Beheloka Bas. The Vezo were traditionally seafaring nomads (Koechlin 1975), settling Beheloka Bas in the late 1940's. The local belief is that the resources are inexhaustible (Raberinary 2002). However even fishers from this recently settled village have reported dropping yields (Pers. obs.).

Fishery of Beheloka

At present the main commercial industries of the Vezo in Beheloka are the fishing of squid and octopus (collected by the Companie de Pêche Frigorifique de Toliara, COPEFRITO), the harvesting of algae (collected by BIOMAD) and the gleaning of sea cucumbers (collected by Zanatany, MOTC and Mirindra). The fishery of Beheloka is here described as a developing artisanal fishery as it is providing for more than subsistence living, with small-scale commercial exploitation occurring. Unlike larger fisheries in the Southwest such as that of Toliara, gears used are still mainly traditional (lines, spears and nets) with no motors being used and one spear gun. The fishing of Beheloka is highly seasonal, and is summarised in Table 1).

Table 1 Seasonal activities of the Vezo ethnic group, Southwest Madagascar (adapted from Koechlin 1975 with observations from 2002).

Season	Period	Activities
Litsaky (Rainy season)	Dec-March	Village work fish when they can for mullets, mojarras and jacks
Fara rano (End of rainy season)	April –May	Collection of seafood at low tides. Spear fishing for octopus and fish. Collection of sea urchins and sea cucumbers, construction of pirogues (*laka*)
Asotsy (Cold season)	Jun-Sep	Fishing further afield, accumulation of surplus food (lasts longer in cooler weather), night fishing during full moon. More diving for seafood e.g. sea cucumbers but not urchins. Other activities as in *faro rano*
Faosa (Transitional season)	Oct-Dec	Fishing as during *asotsy* but includes urchin collection. Exchange goods with farmers

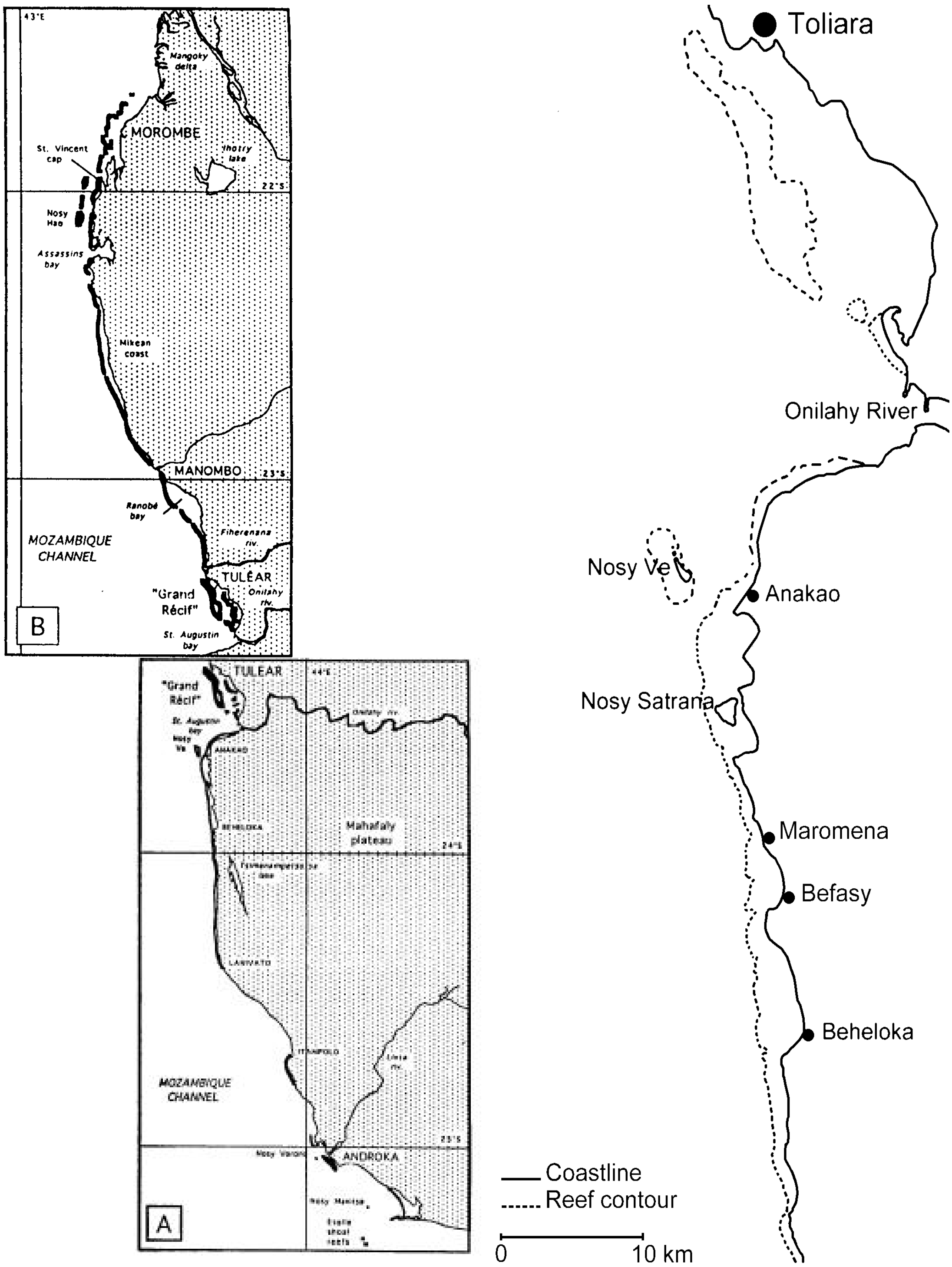


Figure 1 Maps of Southwest Madagascar (adapted from Gabrie *et al.* 2000, and Hemery G. pers. comm.).

METHODOLOGY

Fishery production

Fishery production was assessed through direct questioning and catch measurement at the single landing site on the Beheloka beach. This was conducted during the months of June and August 2002. Throughout the year, fishing habits vary to include the seasonal fishing of anchovy and sardine etc. (Koechlin, 1975) however, production from these stocks was ignored through their exclusions during questionnaires as they are not typically reef associated fish. Fishermen were questioned as to fishing gear used, time spent at sea that day and where possible, each catch was weighed by family. Overall catches included cephalopods, holothurians and gastropods, however for the purposes of this study only reef-associated fin-fish catches are analysed.

Fisheries effort

Fisheries effort was assessed through two fishery independent visual censuses. The censuses lasted for 1 lunar cycle/ 28days and were conducted from 4th February 2002 to 3rd March 2002 and 23rd May 2002 to 19th June 2002.

Each census consisted of watches from 06:00 to 18:00 everyday, with 15minute survey intervals. At each 15minute interval, total numbers of fishers were noted down in categories according to their activity and number of people on the pirogue. Categories noted were: rowing, line fishing, net fishing, spear fishing and sailing, for one, two, or three people on the pirogue (any more than this number were not considered to be contributing further to fishing effort). These data were analysed to produce effort data for each fishing type, which was related to fisheries production data.

Seasonal fishing of anchovy and sardine etc. was not included in the data as the majority was carried out at night, with the single daytime episode being excluded.

Underwater Visual Census of fin-fish resources

The seaward face of the Beheloka reef was censused using SCUBA. Eight sites mid reef (approx. 12m below chart datum) were surveyed approximately 200m apart, giving a general overview of the reef area commonly fished. With all sites an initial rapid habitat assessment was conducted. A course was swum from the base of the reef floor to the crest. At each 4m depth interval (i.e. 20m, 16m, 12m etc.) notes were made on broad habitat topography and complexity, reef type and live coral cover.

Fish species censused were those commonly targeted by traditional and artisanal fishers in the region (Ocean Consultant, 2000), namely members of the Lethrinidae, Lutjanidae, Labridae, Serranidae, Mullidae, Siganidae, Haemulidae, Balistidae, and Acanthuridae.
Families associated with the outer reef column such as Carangidae and Caesionidae, although desirable catches were not censused, due to their association with the outer reef column, outside the area surveyed (Chabenet *et al.* 1997). Families with cryptic daytime behaviour such as Holocentridae were not censused, as UVC methods have been shown to seriously under-sample these individuals (Sale and Sharp 1983).

Due to the steep slope of the reef face in many areas, a physical line transect were inappropriate. Instead an approximation was made in a similar manner to Watson and Ormond (1994). Surveyors swam at constant speed (10m/min) and depths for 25 minutes, following the contour of the reef in one direction, giving a total transect length of 250m. Target fin-fish densities and estimated lengths were recorded. Four replicate fish surveys were carried out at each site. A minimum fish length of 10cm was used as a cut off, to avoid the counting non-adults. Length estimation was trained and checked using the methods described in Darwall and Dulvy 1996.

RESULTS

Fisheries Study

Catch per Unit Effort

Catch per unit effort (CPUE) estimates were worked out by adding together the total weight of fish caught (kg) by method and dividing by the total number of hours and fishers, giving a measure in kg fisher^{-1} hour^{-1} gear^{-1}. The data were also analysed to kg fisher^{-1} trip^{-1} gear^{-1} and kg trip^{-1} gear^{-1} for comparison with other studies. Multiple gears were often used, in these cases, spear and net fishing and spear and line fishing, the weight of fish caught was used to work out the net and line CPUEs respectively. This is due to the inefficiency of spear fishing for fish.

Catch data from 127 pirogues were taken during the months of June and August. The data were pooled as statistical analysis showed no significant difference relating to time compared with catch per day, or catch per hour (Mann-Whitney U Test, exact 2-tailed sig. $P>0.05$).

Table 2: Average CPUE (kg fish/hour/person)

Number of samples	**Fish (kg)**	Fishing Method	Sd
82	0.033	Spear	0.137
31	1.385	Net including fish section of net and spear	0.973
14	0.546	Line including fish section of line and spear	0.328

Catch from one spear gun fisherman was also weighed, and CPUE enumerated (1.625kg/fisher/hour for a spear gun). This data were discounted as unrepresentative, as it was the only spear gun presently being used in the village.

Table 3: Total fishing effort in fisher hours

Fishing effort in fisher hours	Phase	
	June	**August**
Spear	1092.28	1605.94
Net including fish section of net and spear	1011.92	2344.85
Line including fish section of line and spear	415.40	2454.01
Spear from unknown	617.78	420.41
Net from unknown	461.70	571.09
Line from unknown	161.92	592.71

Travel time is integral in the CPUE data, and not represented in the calculations in Table 3. To obtain the most accurate estimates of resource use travel time was included in the calculations. Total travel time recorded was split proportionally between the four fishing types. The “Unknown fishing” category was also split proportionally between the three other fishing types. This requires the assumption that the travel undertaken by the fishers is roughly equal between the gear types. This is not unreasonable, given that the locations fished using the different methods were interspersed along the same stretch of reef, with tide often the determining factor in gear choice, rather than location (Frontier-Madagascar, unpublished data).

In order to assess total fin-fish resource use, the CPUE data and effort census data are combined.

Table 4: Resource use

Fisher hours * kg/fisher/hour	June	August
Spear	36.07	53.03
Net including fish section of net and spear	1401.61	3247.86
Line including fish section of line and spear	226.97	1340.82
Spear from unknown	20.40	13.88
Net from unknown	639.50	791.02
Line from unknown	88.47	323.85
Total resource use in kg of fin-fish	**2413.01**	**5770.45**

For comparison with other studies, daily CPUE's of each gear type were also worked out for the fin-fish fishery (Table 5).

Table 5: Daily CPUE (kg fish/day/person) by gear type

Number of samples	Fish (kg)	Fishing Method	Sd
82	0.159	Spear	0.676
31	5.347	Net including fish section of net and spear	5.540
14	2.986	Line including fish section of line and spear	2.456

11.892kg per net per day sd 13.838

Estimate of fin-fish standing stock: Underwater visual census

Mean abundance per 1,000m^2 was calculated using the results for abundance of the families surveyed. Estimates of individual fish biomass were calculated with the equation; Biomass = Constant x Length^{exponent} (Watson and Ormond, 1994). Data for the mass and length relationships of the dominant species in the area were obtained from sources in the public domain (Fishbase, 2002). Average fish biomass by family per hectare was calculated using individual fish biomass estimates with counts for each size class. For the purposes of the calculations, the length used was the middle value of each size class range i.e. 35cm for the 35-40 size class range.

Statistical Analysis

Non-parametric methods of analysis were used, as the data displayed heterogeneity of variance that was not removed by data transformation. Large count variances are typical of visual census techniques, and may represent diver error as well as variation due to shoals or individuals crossing and potentially re-crossing the transect area (Watson and Ormond 1994). Kruskal Wallis H tests were performed on both abundance and biomass, with site and broad habitat type as determining factors.

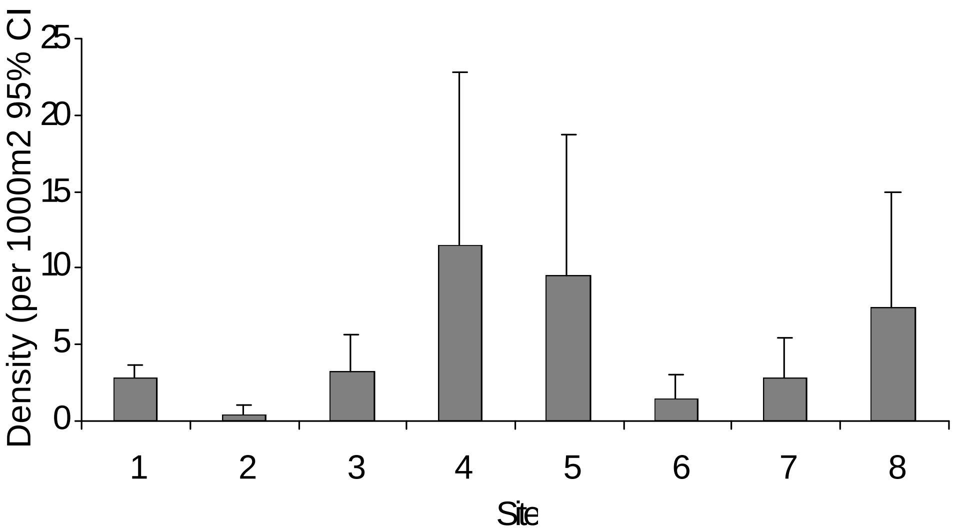
Table 6: Results of Statistical Tests.

Measured Variable	Habitat type		Site	
	H	P	H	P
Fish wet weight (kg/ 1,000m²)				
Acanthuridae	0.57	Ns	4.77	Ns
Balistidae	7.76	**	12.30	Ns
Labridae	0.01	Ns	7.08	Ns
Lethrinidae	3.18	Ns	15.04	Ns
Lutjanidae	0.02	Ns	8.13	Ns
Mullidae	0.70	Ns	9.25	Ns
Scaridae	0.66	Ns	11.53	Ns
Serranidae	2.01	Ns	4.26	Ns
Siganidae	1.66	Ns	8.56	Ns
Fish density (per 1,000m²)				
Acanthuridae	0.13	Ns	6.34	Ns
Balistidae	10.79	**	17.50	**
Labridae	0.49	Ns	7.11	Ns
Lethrinidae	1.64	Ns	11.93	Ns
Lutjanidae	0.39	Ns	9.59	Ns
Mullidae	0.06	Ns	11.70	Ns
Scaridae	1.95	Ns	11.51	Ns
Serranidae	5.84	*	9.21	Ns
Siganidae	0.29	Ns	5.71	Ns

Kruskal Wallis H test on measured variables for density and biomass. Test compares Reef habitat type (Wall vs. Slope) and location along reef (Site). Given are H values and asymptotic levels of significance, where NS =not significant, * = $p< 0.05$, ** = < 0.01.

When the site data were analysed there was no significant difference between the sites surveyed in either abundance or overall biomass, except the family Balistidae, which showed significant differences between sites in abundance (see Figure 2). This could not be explained by any spatial relationship between the sites.

Figure 2: Graph of Balistidae density by site



When divided by reef topography into two broad categories, sloping reef and reef wall, significant differences occurred in the abundance's of the families Balistidae and Serranidae. Significantly higher values for both abundance (see Figure 3) and biomass (see Figure 4) were associated with reef slopes as opposed to reef walls.

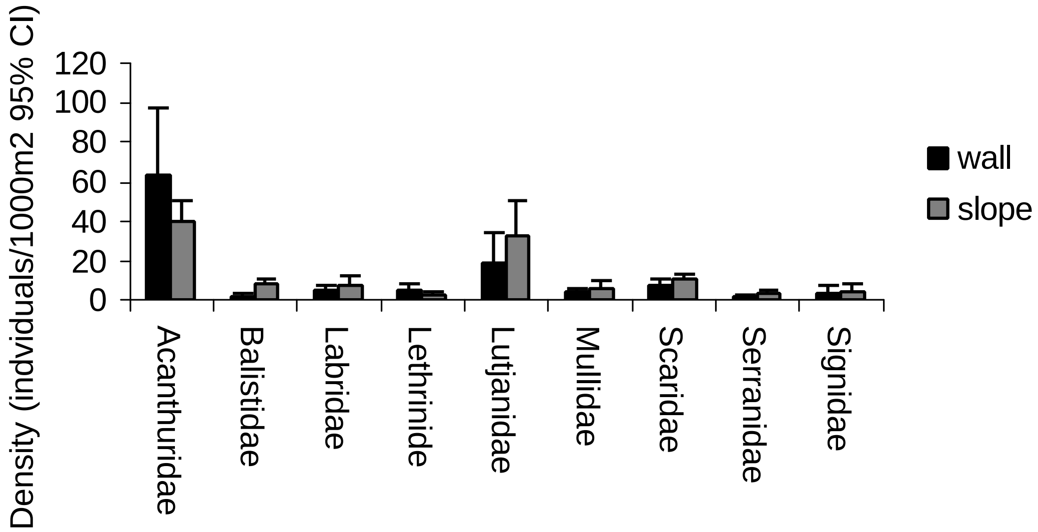


Figure 3: Average density by general reef morphology

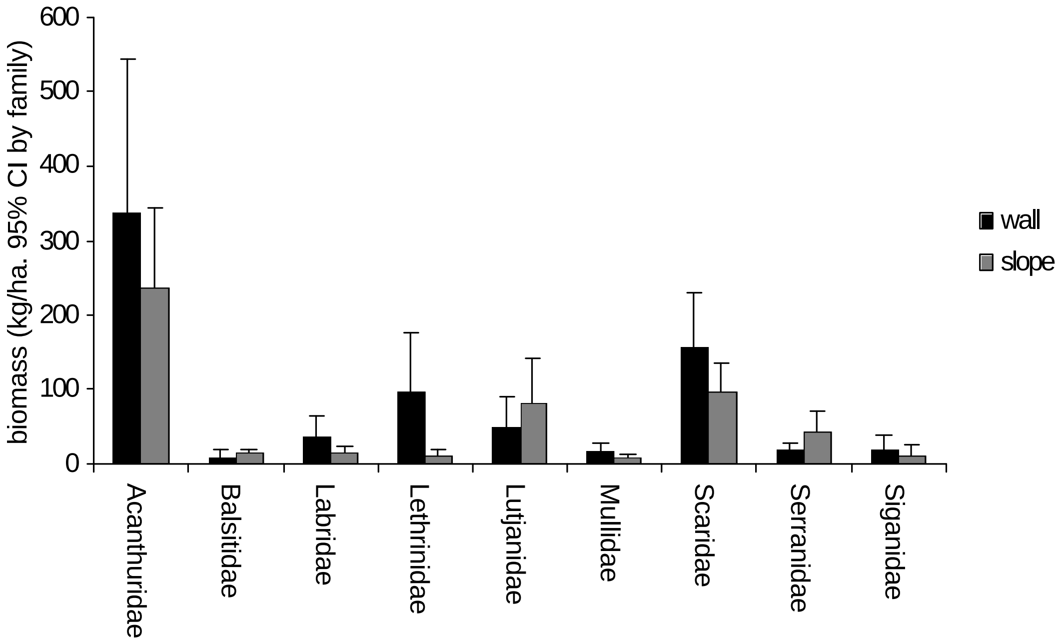


Figure 4: Average estimated biomass by general reef morphology

The data were combined (see Figure 5), to give an overall estimated biomass for the reef associated fin-fish of 640 kg/ hectare ± 170 kg (95% CI). As mentioned before, this is most probably an underestimate due to the limitations of the underwater visual census technique.

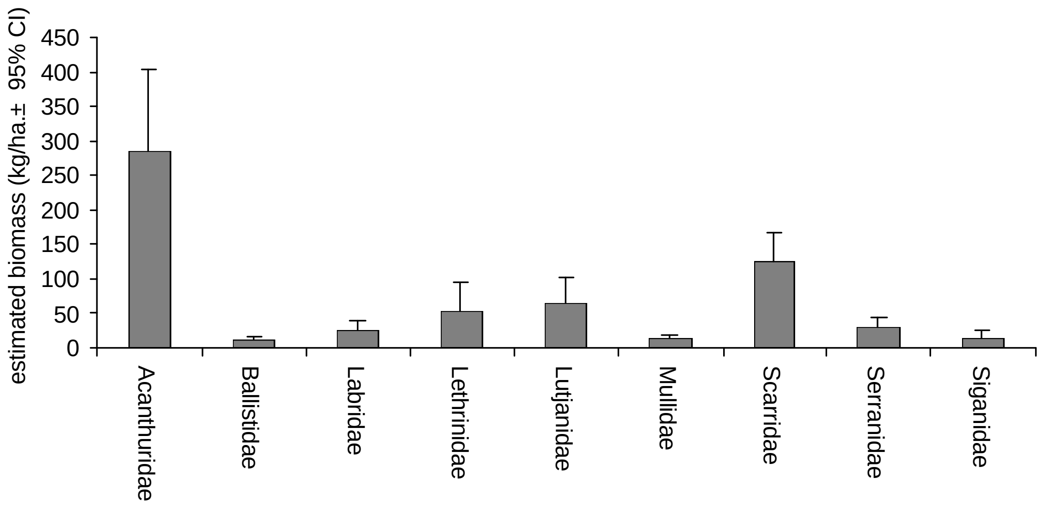


Figure 5: Estimated biomass of seaward face of Beheloka reef.

DISCUSSION

CPUE data

The majority of differences in fishing effort and therefore resource use between the two sampling periods are accounted for by the large amounts of anchovy and sardine fishing nocturnally during January and February. Catch data from these pirogues were excluded as these fish were fished for at night. These are pelagic seasonal migrants and beyond the scope of this study, relating catch to stocks of reef associated fin-fish. Artisanal fisheries by their very nature are seasonal, and this needs to be taken into account in any study of fishing effort/ catch. A summary of results from various studies allows comparison of the data collected in this study (see Figure 6, Figure 7 and Figure 8).

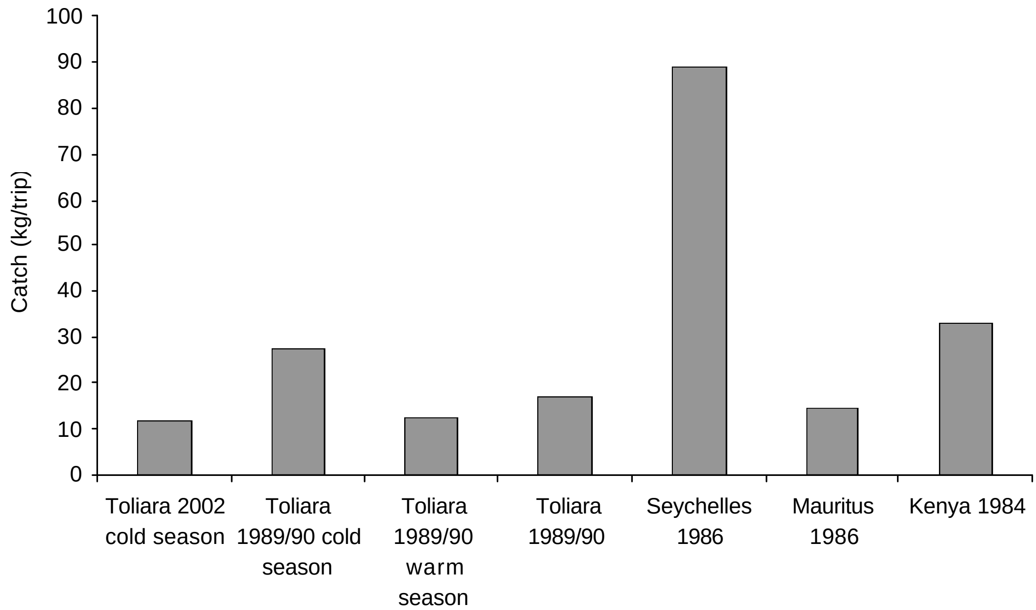


Figure 6 Comparative for gillnet fisheries in the western Indian Ocean (kg/trip) (Laroche and Ramananarivo 1995, Sanders *et al*.1988).

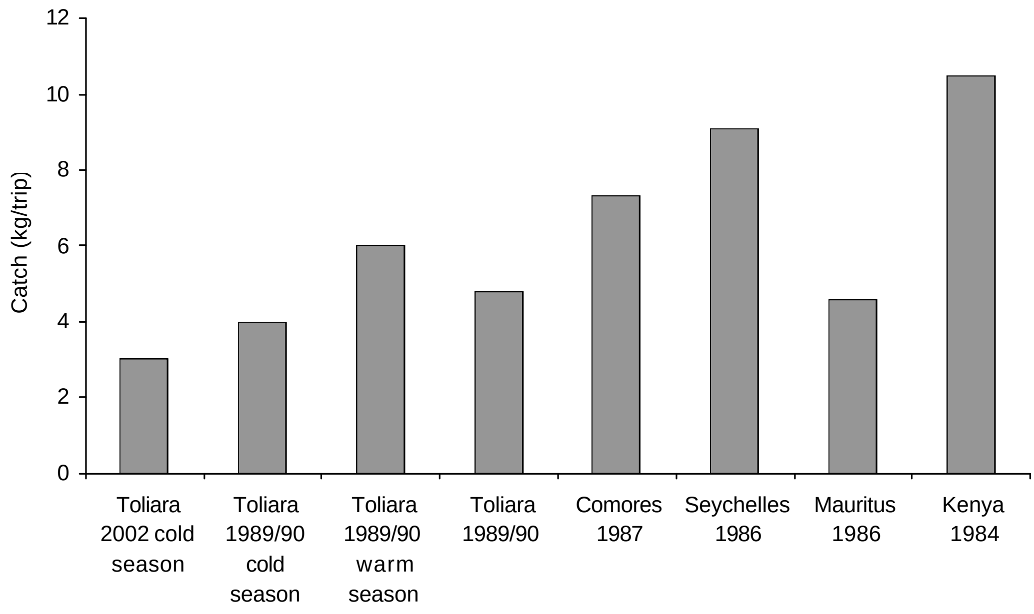


Figure 7 Comparative for line fishing fisheries in the western Indian Ocean (kg/trip) (adapted from Laroche and Ramananarivo 1995, Sanders *et al*.1988).

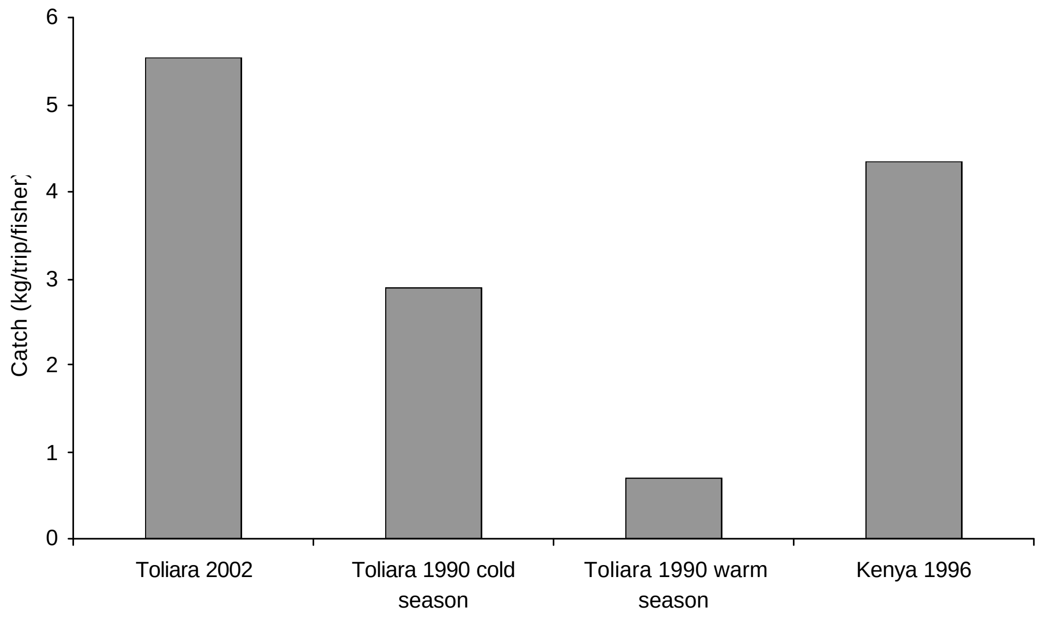


Figure 8 Comparative for gillnet fisheries in the western Indian Ocean (kg/trip/fisher) (adapted from Laroche and Ramananarivo 1995, McClanahan *et al*. 1997).

These figures show that the Beheloka catch in the Toliara region for this year was not particularly high with respect to kg/trip for gillnet and line fishing in the Indian Ocean. However when looked at with respect to the number of fishers controlling a net, the catch per fisherman was higher than other areas.

UVC data

The significant differences in abundance and biomass shown in balistidae are almost certainly due to the differences in habitat. Important site attached triggerfish such as *B. undulatus* and *B. viridescens* are dependant on coral heads or other topographically complex spots for their dens (McClanahan 1997), which occur more frequently on reef slopes as compared to walls. This may also be the case with regard to several species of Serranidae, for example. This result underscores the requirement for habitat description and assessments to be a part of every study of this type.

There is a lack of comparable surveys completed in Madagascar itself, but the use of similar techniques to estimate fin-fish density in the Indian ocean region is widespread. Due to the variety of methods used in the Indian ocean region to assess standing stocks, and the variety of species surveyed, direct comparisons of results are problematic. Density results are shown from a similar study in Kenya (McClanahan 1994) with estimates for taxa used in this study converted to a similar scale and displayed (see Figure 9).

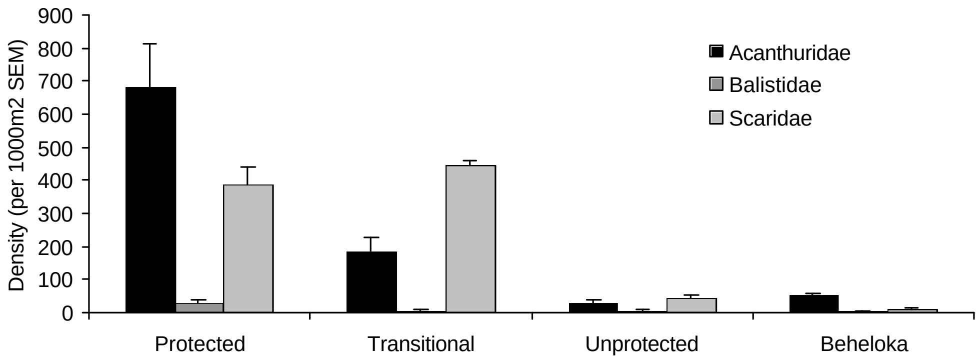


Figure 9: Comparison of group density from reefs in Kenya with varying degrees of protection (adapted from McClanahan 1994).

Totalling the estimates for the taxa sampled in similar surveys in the Masoala peninsula, McClanahan and Obura (1998) reported standing stocks of 1000kg/ha for protected areas, and 100kg/ha for heavily fished areas. The standing stock of Beheloka falls between these two extremes (640kg/ha), and is consistent with the assessment of the fishery as moderately impacted. Comparison with an earlier study of protected reefs and unprotected reefs in Mombassa, Kenya, also supports this view (McClanahan and Kaunda-Arara 1996).

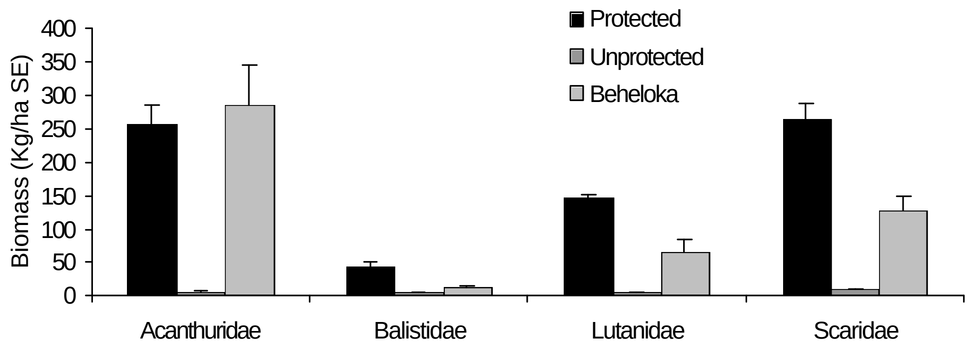


Figure 10: Comparison of standing stock biomass by taxonomic group (adapted from McClanahan and Kaunda-Arara 1996)

Conclusion

In conclusion, both the catch data and standing stock estimations point to the fin-fish fishery of Beheloka as being moderately impacted. Regular fishing on the Beheloka reef is a recent activity compared to many other areas of the Western Indian Ocean and as such has yet to greatly impact the reef system. The standing stock on the Beheloka reef is less than that for Kenyan protected areas, however with the abundance of large fish as displayed by the favourable biomass comparisons, the system seems healthy. It has been demonstrated that larger fish are more fecund than smaller ones (Sale 1991), which may suggest that it is not too late for a suitable, community based, management strategy to prevent the degeneration of this reef community.

Finally it should be noted that the methods used in this study are manpower intensive, but ideally suited to an NGO with access to pools of semi-skilled volunteers.

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