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A socio-economic perspective on gear-based management in an artisanal fishery in south-west Madagascar

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Abstract Artisanal fisheries are important socially, nutritionally and economically. Poverty is common in communities dependent on such fisheries, making sustainable management difficult. Poverty based on material style of life (MSL) was assessed, livelihoods surveyed and the relationship between these factors and fishery data collected using a fish landing study were examined. Species richness, diversity, size and mean trophic level of catches were determined for six fishing gears in an artisanal fishery in south-west Madagascar. There was little livelihood diversification and respondents were highly dependent on the fishery. No relationship was found between poverty and gear use. This suggests that poverty does not have a major impact on the nature of the fishery; however, this study was dominated by poor households, so it remains possible that communities with more variation in wealth might show differences in fishing methods according to this parameter. The fishery was heavily exploited with a predominance of small fish in the catches. Beach seines caught some of the smallest fish, overlapped in selectivity with gill nets and also had the highest catch per fishers. Thus, a reduction in the number of beach seines could help reduce the catch of small fish and the overlap in selectivity among gears.

KEYWORDS: artisanal fishing, coral reefs, economics, gear selectivity, landing study, poverty.

Introduction

Throughout the tropics, coral reefs support artisanal fisheries with an estimated annual yield of approximately six million tonnes (Mathew 2001). Artisanal fisheries account for 25% of the world catch, yet account for half of the fish used for direct human consumption (Mathew 2001). Marine resources provide an easily accessible and valuable source of protein and income for some of the poorest people in the developing world (Russ 1991; Sadovy 2005). However, small-scale fisheries have grown significantly over the past two decades (Mathew 2001) and their rapid expansion under open access regimes exerts overfishing pressures on coastal resources. Overexploitation is one of the principal threats to coral reef diversity, structure, function and resilience (Jackson, Kirby, Berger, Bjorndal K, Botsford, Bourque, Bradbury, Cooke, Erlandson, Estes, Hughes, Kidwell, Lange, Lenihan, Pandolfi, Peterson, Steneck, Tegner & Warner 2001; McClanahan 2002) and is threatening their contributions to poverty reduction (Fisheries Management Science Programme 2006).

Artisanal fisheries provide the main source of protein for coastal communities in Madagascar, particularly in the south-west Toliara Province where more than 50%

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of Madagascar's fishers operate (Laroche & Ramananarivo 1995). This is home to the Vezo tribe, who are traditionally skilled seafarers and solely dependent on the sea for survival. Toliara Province is also the poorest, with 80% of its inhabitants below the poverty line (World Bank 1996). As with many areas of Madagascar there is a high degree of unemployment, low agricultural productivity because of the arid climate and a rapidly growing population (3% nationally on average; UNICEF 2005). There are few studies assessing the artisanal fisheries of Madagascar considering the high dependency on fisheries and the reported degraded state of the coral reefs in this area (Vasseur, Gabrie & Harmelin-Vivien 1988). The available literature lacks depth in appraising fishing gears and their use and has mainly concentrated on wet weight catches, performing analyses of fish only at the family taxonomic level (e.g. Laroche & Ramananarivo 1995; Laroche, Razanoelisoa, Fauroux & Rabenevanana 1997). Understanding the selectivity of fishing gears is important for management as gear influences catch composition and the size frequencies of target species (Gobert 1994); therefore, analysis at the species level provides greater resolution of selectivity and potential overlap among gears (Bellwood 1988; McClanahan & Mangi 2004). Previous studies have mentioned socio-economic factors but none have assessed the local dependency on the fishery or other occupations. Socio-economic assessments are more widespread further afield, and encompass factors that affect over-fishing (Cinner & McClanahan 2006) and people's perceptions of the coastal resources (Cinner & Pollnac 2004). The importance of integrating local stakeholders and an understanding of poverty into management planning for coral reefs is now widely accepted (Allison & Ellis 2001; Lundquest & Granek 2005). Where there has been lack of consideration of local needs, many marine management plans have failed (Talbot & Wilkinson 2001). Whilst poverty is extensive in Madagascar (World Bank 1996), no previous studies from Madagascar or East Africa have attempted to determine how poverty might affect the use of marine resources.

The aim of this study was to assess the potential relationships between poverty and fishing gear use. The local dependency on the fishery was determined in conjunction with resource use of common artisanal gears in south-west Madagascar, which are described in terms of diversity, species composition, size and trophic level of the catches. The overall objective was to assist with future management plans for the area and ascertain the importance of the fishery.

Methods

Research was conducted from 1 March to 21 May 2008 at three villages around the Bay of Ranobe (23°00′ S 43°30′ E, 23°18′ S 43°38′ E), south-west Madagascar, covering a 10-km stretch of coast from Beravy in the south to Mangily in the north (Fig. 1). The study sites form the southern region of the Bay of Ranobe, which is sheltered by a 32-km fringing reef and contains patch reef, seagrass beds and mangroves to the north and south. The gears employed in this fishery were used in all habitats, from shore to a short distance beyond the reef and there is therefore considerable overlap in their spatial use. These study sites were chosen because they represent the typical artisanal fisheries of south-west Madagascar. Fishers use un-motorised, traditional pirogues that are 3–8 m in length and equipped with a single outrigger.

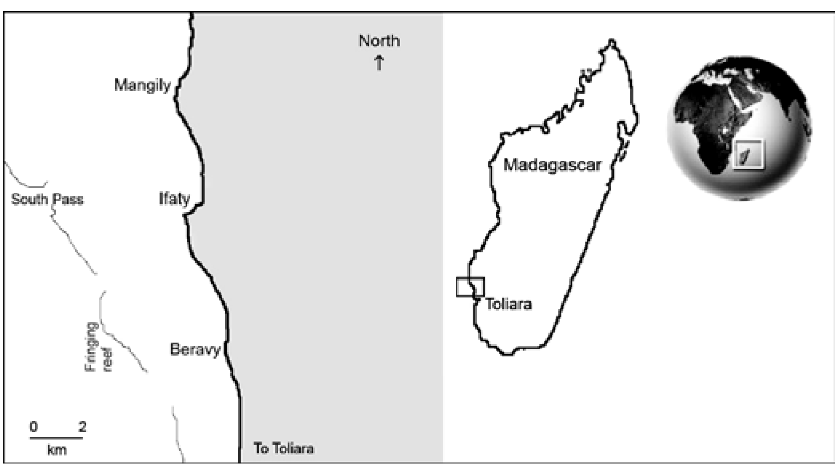

Figure 1. Map of the study area in south-west Madagascar.

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Sampling of catches was carried out from 7 January to 5 June 2008 using methodology adapted from McClanahan & Mangi (2004) and Cinner, Marnane & McClanahan (2005). No information on species composition for the remainder of the year is currently available. Fishers were approached randomly when they returned home at low tide and permission was asked to weigh their catch. Landed fish were identified by Malagasy name to the equivalent of species level and where this was unknown to genus or family level (Lieske & Myers 1994). All fish were counted and their standard length measured using a fixed marked ruler on a flat board. For large catches, common in beach seines, a randomly collected subsample was measured, so as not to delay the fishers. All fish were sampled whether for home or market use, as some of the less marketable species are kept for home consumption (Glaesel 1997). The total catch, species composition, gears used, site, duration of trip and the number of fishers who participated in the fishing were recorded for each sample.

The following indicators were obtained for each gear type: Simpson's index of diversity ($D = 1 - \sum n_i/N_t$), the mean catch per fishers (kg), the mean number of species caught per fishing trip, the mean standard length and the mean trophic level. The mean trophic level for each species was taken from FishBase (Froese & Pauly 2008). When a fish could not be identified to species level, the average trophic level for all other species in the sample of that family was used (Cinner & McClanahan 2006). The following formula from Pauly, Palomares, Froese, Sa-a, Vakily, Preikshot & Wallace (2001) was used to calculate the mean trophic level of the catch for each gear:

$$TL_k = \frac{\sum_{i=1}^{m} Y_{ik} \times TL}{\sum Y_{ik}},$$

where Y_{ik} is the catch of species i in gear k and TL the trophic level of species i for m fish species. This formula was also used to calculate the mean length, to account for the quantity of fish caught.

One-way ANOVA was used to test for differences among gears in daily catch per fishers, number of species, mean length per species and mean trophic level caught. Pairwise comparisons were calculated using Tukey–Kramer honest significant differences (HSD) test to examine where differences lay.

Demographic information was collected using a questionnaire adapted from USAID (2007) Poverty Assessment Tools. Information was obtained on the total household number, relationship, age, years of formal education, number working, wealth and perceptions of coastal resources. The head of each household was interviewed; unless unavailable, another knowledgeable adult from the household was interviewed. Interviews generally took 25–45 min. All interviews were conducted in the Vezo dialect of Malagasy. A total of 161 respondents were surveyed from the three communities (Table 1) resulting in data for a total of 821 people. Sampling of households was based on a systematic sample design (sampling every ith house) depending on the sample size required (Henry 1990; de Vaus 1991). The number of surveys per community ranged from 41 to 78. Dependence on the fishery was established by asking respondents to list all occupations or activities that their household engaged in for food or money and then rank these in order of importance (Pollnac & Crawford 2000). Wealth was evaluated using a material style of life (MSL) scale based on the presence or absence of household possessions and housing materials (Pollnac & Crawford 2000; Cinner & Pollnac 2004).

Household surveys were combined with focus group meetings and semi-structured interviews with key informants (ministry officials and village chiefs) to gain a deeper understanding of change in the fishery and village.

A multivariate analysis of variance (MANOVA) was employed to determine any relationship between the gear use and MSL. Principal components analysis was applied to the MSL items to obtain factor scores for each household to reduce the number of variables for analysis. During the survey, respondents were asked about ownership of gears; their reported primary gear was assigned to them for the analysis.

Table 1. Population and social infrastructure of the study sites

	Beravy	Ifaty	Mangily
Population	960	2130	3000
Distance from Toliara (km)	18	24	28
Average people per household	5.3	5	5.1
Average years of education	5.2	5.8	6.9
Percentage of persons $<$ 15 years of age	42	49	51
Water supply	Well (in village)	Well (1 km away)	Well (in village)
Sanitation	None	None	A few latrines
Primary school	Public	Public	Public & private
Secondary school	None	None	Public
Clinic	None	1	1
Church	1	2	3
Number of large hotels	0	3	8

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Results

A total of 54 229 fish were recorded from 475 fishing trips. In addition, 1239 other marine animals were recorded, including octopus, squid and turtle, but these were not included in analyses as they were not comparable in relation to trophic level and length.

Of the 50 most abundant species, two accounted for 65% of the total catch from all gears (Fig. 2a): blue sprat, *Spratelloides delicatulus* (Bennet), and blue striped herring, *Herklotsichtys quadrimaculatus* (Rüppell). These species were caught in very high numbers by beach seine and gill net but were not caught by other gears. The small coastal pelagic species *Dussumieria*

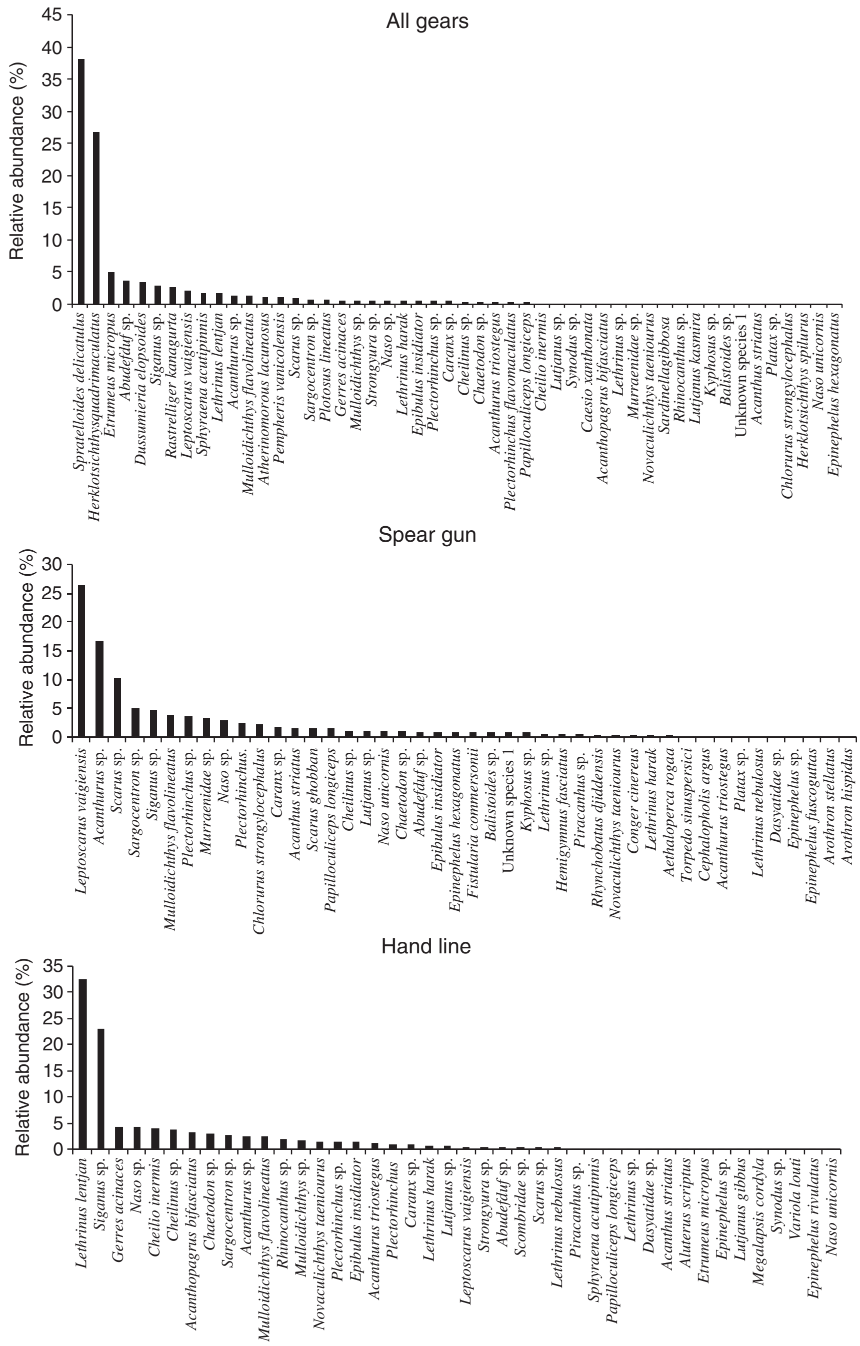

Figure 2. Relative abundance of species caught for each of the gears based on data from all study sites. The relative abundance graph for all gears and the graph for gill net show only the 50 most common species.

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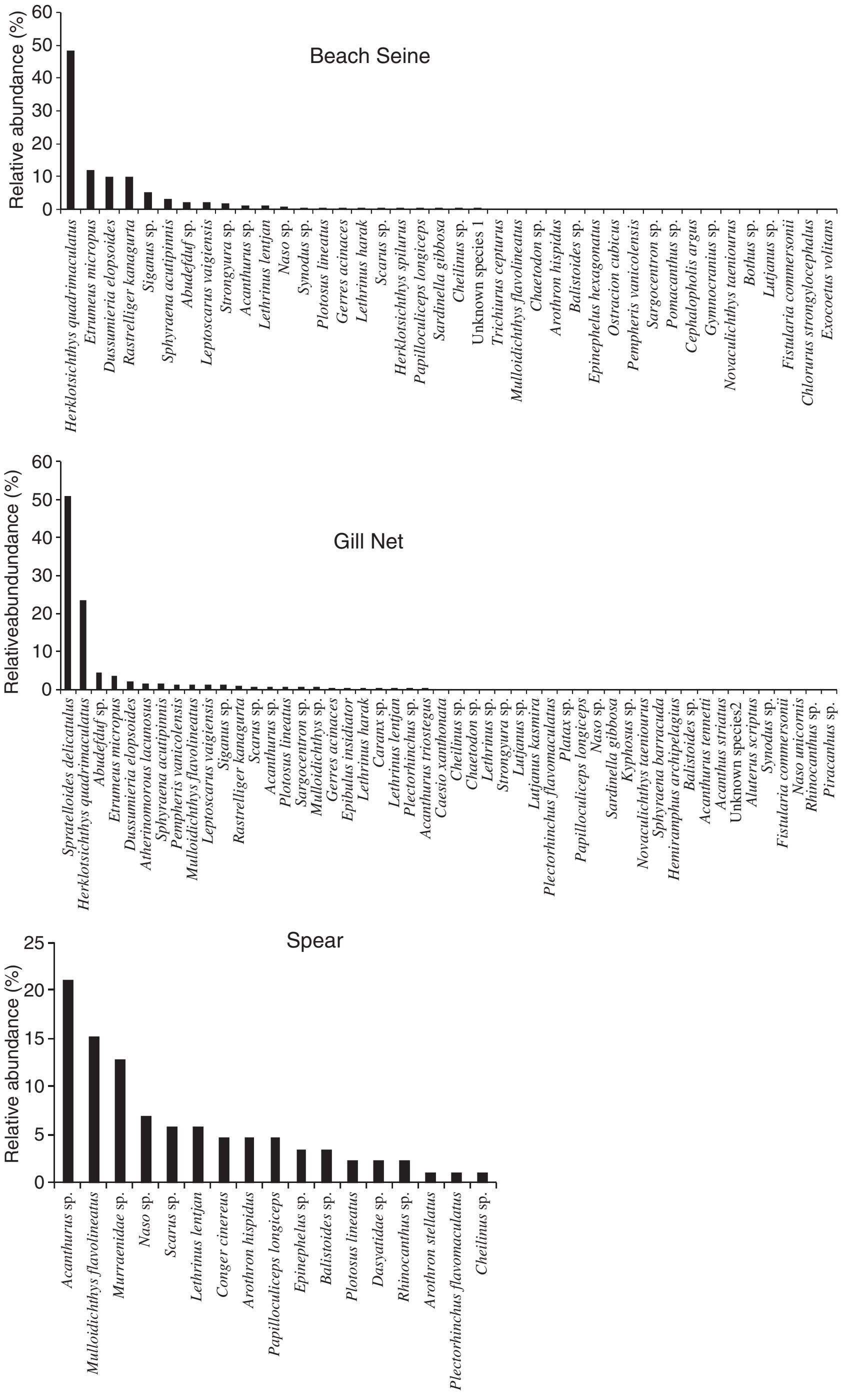

Figure 2. *(Continued).*

elopsoides (Bleeker) – 3.5% of total catch – was also caught only by net and beach seine, and *Etrumeus micropus* (Temminck and Schlegel) –5% of total catch– by beach seine only. Damsel fish, *Abudefduf* sp., was the fourth most abundant fish and accounted for 4.2% of net catches. This coral reef species was also present in beach seine (2%), spear gun (1%) and hand line (0.5%) catches. *Siganus* sp. was caught by all gears except spears, and accounted for 23% of the hand line catch. *Acanthurus* sp. dominated spear and spear gun catches at 21% and 17% respectively. Seagrass parrotfish, *Leptoscarus vaigiensis* (Quoy and Gaimaird),

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accounted for 26.5% of the catch by spear gun and was also found in lower numbers in the beach seine and hand line catches. Pink ear emperor, *Lethrinus lentjan* (Lacepède), was the primary species caught by hand lines accounting for 33% of their catch; it was also caught by spear (6%) and beach seine (1%). Long lines caught solely pelagic species, indicating where this gear is used. The remaining species were variable in each of the gears and contributed markedly less to the total catch. Spears caught the highest species diversity ($D = 0.9$) followed by spear gun, hand line, beach seine, net and long line ($D = 0.7$) (Fig. 3a).

The lowest mean length was for net catches at 8.6 cm, followed by beach seine at 13 cm. The largest individuals were caught by long lines with a mean length of 56.9 cm (Fig. 3c). Pairwise comparisons revealed significant differences between long lines and all other gears. Significant differences were also found between beach seine, net, spear and spear gun catches (Table 2).

The lowest mean trophic level was for spear gun at 2.6 and the highest for long line at 3.67. The remaining gears had a similar trophic levels ranging from 3.17 to 3.38 (Fig. 3d). Pairwise comparisons revealed significant differences in trophic level between spear gun and all other gears except beach seine and between long line and all gears except spear (Table 2).

Catch per fisher varied among gears (Fig. 3b, Table 2) ranging from 1.5 (± 0.16) kg for spear to 4.26 (± 0.03) kg for beach seine. Other gears range from 3.18 (± 0.44) kg for long lines followed by 3.25 (± 0.06) kg for hand lines, 3.36 (± 0.01) kg for nets and 3.74 kg for spear gun (± 0.09).

Material style of life analysis (Table 3) was conducted using principal components analysis with varimax rotation. This resulted in three material styles of wealth factors that together explained 52% of the variance. The first component was composed of house structure with high positive loading from cement walls and iron roofs and negative loading from reed walls and roofs. The second component was composed of housing structure and miscellaneous items, with wooden walls, generators and televisions having a high positive loading. The third component was composed of miscellaneous items with high positive loading from radios and material sails and negative loading from sails made from rice sacks. Plots of wealth factors one and two for the different gear users are shown in Fig. 4. No significant differences were found in wealth factors among different gear users (MANOVA $F_{5,128} = 1.144$, $P = 0.23$).

Principal components analysis of age, education and number of dependents per household generated one

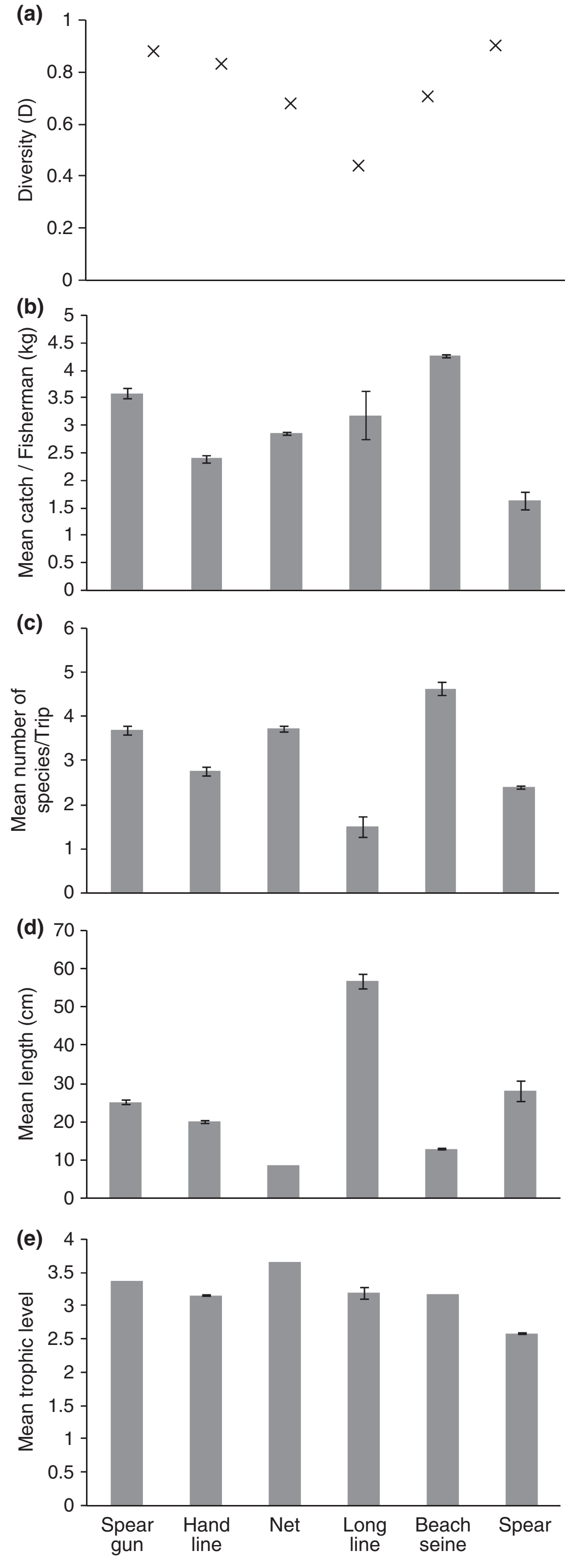

Figure 3. (a) Simpson's Index of diversity, (b) catch per fisher, (c) species per trip, (d) mean length, (e) mean trophic level for each of the six gears. Bars are standard errors. Table 2 shows the statistical analyses of the gear comparisons.

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Table 2. Results of a one-way ANOVA and pairwise comparisons (Tukey–Kramer HSD) for each of the gears for (a) daily catch per fisher, (b) mean number of species, (c) mean length and (d) mean trophic level

	Beach seine	Hand line	Long line	Net	Spear
Catch per fisher per trip (kg) ($F_{5,469}$ = 2.4, P = 0.036)					
Hand line	NS				
Long line	NS	NS			
Net	NS	NS	NS		
Spear	*	NS	NS	NS	
Spear gun	NS	NS	NS	NS	NS
Species per trip (number) ($F_{5,469}$ = 3.99, P = 0.001)					
Hand line	**				
Long line	NS	NS			
Net	NS	NS	NS		
Spear	NS	NS	NS	NS	
Spear gun	NS	NS	NS	NS	NS
Mean length (cm) ($F_{5,469}$ = 20.48, P < 0.001)					
Hand line	NS				
Long line	**	**			
Net	NS	NS	**		
Spear	**	NS	NS	**	
Spear gun	**	NS	*	**	NS
Mean trophic level ($F_{5,469}$ = 8.27, P < 0.001)					
Hand line	NS				
Long line	**	*			
Net	NS	NS	**		
Spear	*	NS	NS	NS	
Spear gun	NS	**	**	**	**

*P < 0.05, **P < 0.01.

Table 3. Wealth factor scores from the principal components analysis of material style of life items: dwelling wall and roof materials and miscellaneous items

	Wealth factors		
	1	2	3
Walls			
Reeds	−0.745	−0.321	−0.128
Wood	0.154	**0.464**	0.185
Cement	**0.772**	−0.166	0.014
Iron	0.201	0.252	−0.100
Brick	0.252	−0.100	−0.007
Roof			
Reeds	−0.921	−0.054	0.033
Iron	**0.921**	0.054	−0.033
Misc			
Radio	0.049	0.006	**0.532**
Bike	0.037	0.099	0.229
Generator	0.046	**0.953**	0.058
TV	0.046	**0.953**	0.058
Pirogue	0.014	−0.102	−0.044
Rice-sack sail	0.010	−0.068	−0.899
Material sail	−0.025	0.077	**0.919**

Values in bold denote high factor loading (>0.4).

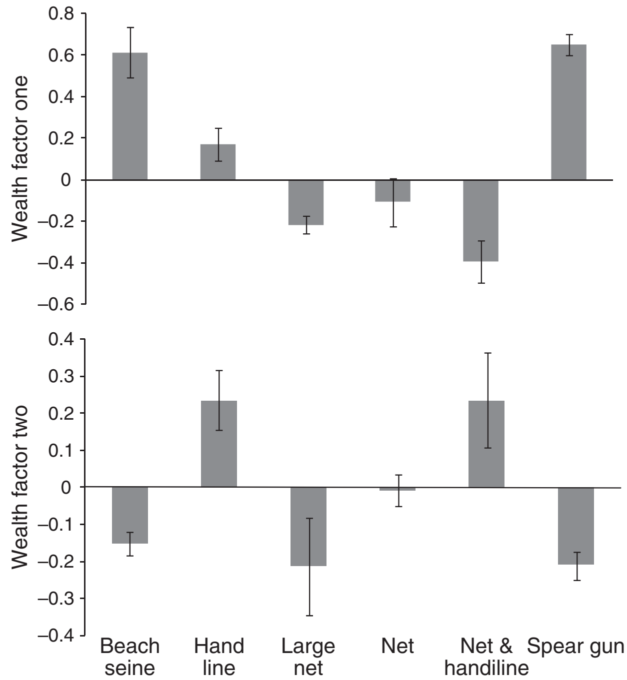

Figure 4. Plots of wealth factors one and two for the different fishing gears. Bars are standard errors.

component that explained 48% of the variation. Age was negatively loaded (−0.79) and number of dependents (0.82) and education (0.36) were positively loaded. No significant differences were found between the mean age of the household, years of education and number of dependents (MANOVA $F_{5,128} = 0.517$, $P = 0.931$).

The coastal people of the Bay of Ranobe are highly dependent on the fishery, with 70% of respondents ranking fishing as their primary source of income (Fig. 5). Fish processing accounted for 2.5% of primary and 34% of secondary occupations.

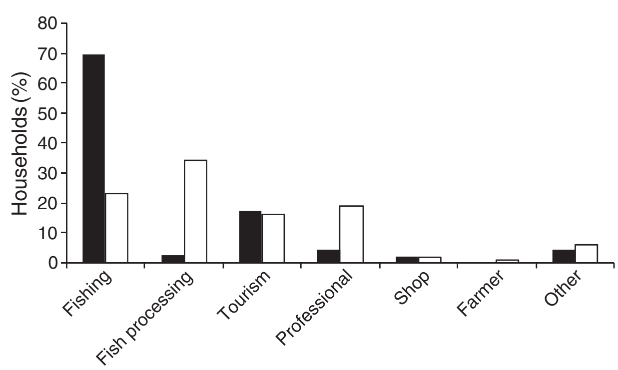

Figure 5. Distribution of primary (black) and secondary (white) household occupations.

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Fish processing includes all post-harvest activities and is usually conducted by women as a small-scale collector. They buy fish from the fishers on the beach and then sell them either to hotels or locally in the village, sometimes frying or smoking them first. Tourism was a primary source of income for 17% of respondents. Tourism activities included working in hotels, owning a small hotel or 'hotely', guiding (taking tourists fishing, snorkelling or walking in the forest) and sellers of shells and sarongs, the latter were normally women. South-west Madagascar is characterised by a low rainfall and an arid landscape leading to minimal engagement in agriculture. Less than 1% of households rated farming as their occupation. Some households owned livestock and considered it a form of insurance to sell when times got hard. There were few houses in this situation because of the need for initial credit to purchase animals. Professional occupations included teacher, nurse and presidential activities (either of associations or villages).

Discussion

Socio-economic factors

Respondents were highly dependent on the fishery, with 70% rating fishing as their primary source of income. Thirty-seven per cent of households had no second occupation, showing that there is little potential livelihood diversification for the people in the Bay of Ranobe. Whittingham, Campbell & Townsley (2003) noted that fishing may be the only source of cash income, especially for poorer households. No significant relationship between the wealth of fishers and the gears they used was found. This suggests that changes in the wealth profile of the community may not result in substantial changes in the distribution of fishing effort among gears. The lack of a relationship between wealth and gear use is puzzling, given that some gears are much more expensive than others. One reason is likely to be because some individuals are given fishing materials by associations or hotels. Another possible issue is that there may be limited variation in affluence among fishers in the bay of Ranobe. Small-scale fishers are typically not part of the lowest income group (Laroche & Ramananarivo 1995) and there were few wealthy households in the area. Hence, a comparison between rich and poor households was not possible. Communities with a greater diversity in wealth might demonstrate a relationship between gear use and poverty that is not present in less income diverse villages.

Fish catches

The south-west of Madagascar operates an almost completely non-selective multi-gear fishery, which is evident from the high diversity of species caught (Fig. 2a). Whilst fishers have preferences for certain species, any available fish will be taken and few are considered inedible. An average of three species were caught per trip, but the cumulative number of species caught over a longer sampling period was much higher and included most indigenous species. This is inline with other artisanal fisheries of East Africa (McClanahan & Mangi 2004). Coastal pelagic species (Clupidae) dominated the catches and were caught in high numbers by net and beach seine gears, the best methods to exploit this resource (McClanahan & Mangi 2004).

The south-west Madagascar fishery consisted of small fish and moderately low trophic levels ranging from 2.6 to 3.38, excluding the long line catches. It would appear that the Bay of Ranobe fits somewhere in between similar studies in a heavily exploited Kenyan fishery, with mean trophic levels of 2.6–2.9 and hand line at 3.5 (McClanahan & Mangi 2004) and the less exploited Papua New Guinea fishery with trophic levels of 2.8–3.7 (Cinner & McClanahan 2006). The maturity of a fishery is reflected in the species caught (McClanahan & Mangi 2004) and it would appear that the Bay of Ranobe fishery is heavily exploited, on par with the Kenyan fishery. Hand lines target higher trophic-level species (McClanahan & Mangi 2004) and could potentially fish down the food web (Pauly, Christensen, Froese & Pallomares 2000). Hand lines had a mean trophic level of 3.17, lower than both that of Kenya at 3.5 and Papua New Guinea at 3.7, suggesting that the higher level species have been fished out. Species caught by spears and spear guns generally indicate the largest most abundant species, as there is more scope for the fisher to actively hunt larger individuals. Spear guns caught predominantly herbivores, with *Scarus* sp. and *Acanthurus* sp. accounting for more than 43% of the catch. In a less mature fishery, spears and spear guns would be expected to catch carnivores (Pet-Soede, van Densen, Pet & Machiels 2001; Sluka & Sullivan 1997).

The mean lengths for different gears ranged from 8 to 28 cm (excluding long lines at 56.9 cm). The south-west of Madagascar captures a wider length range than that of Kenya at 13–18 cm and Papua New Guinea at 14–22 cm. The high numbers of Clupidae caught during their migratory period during the north-east monsoon (Nhwani 1980; McClanahan 1988) resulted in smaller mean lengths and higher mean trophic levels than would be expected for the year as a whole for this

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fishery. Demersal coral reef- and seagrass-associated species comprised the secondary component of this lagoon fishery, and had the sampling continued for the entire year it would be expected to dominate, in line with fisheries from East Africa (McClanahan & Mangi 2004).

Gear selectivity

In this fishery, there was overlap in the size and species caught between nets and beach seines. These gears also differed from others by catching small coastal pelagic species. Both had the smallest mean lengths, and with their small mesh size are likely to capture individuals before they are caught by other gears. The low mean length caught by the net is as a result of large numbers of the small pelagic blue sprat *S. delicatulus* (maximum standard length of 7 cm; Froese & Pauly 2008) being caught, which accounted for 51% of the catch. This coastal pelagic species is caught during its migratory period and using mosquito netting in conjunction with the usual net. It is only present in the Bay of Ranobe for a short period once every year or 2 years. Continued sampling would be expected to reveal a higher mean length for nets as Clupidae would not dominate the catch and its mesh size is generally larger than that of beach seine. Beach seine had the largest catch per fishers at 4.3 kg, which is not surprising given its large net and small mesh sizes. The small mean length, coupled with a high catch per fishers, indicates that the beach seine is a less sustainable gear than the net. In addition, total catches were lower on fishing grounds in Kenya with high beach seine use (McClanahan & Mangi 2001). Two additional gears that are likely to overlap in their selectivity are spear and spear guns, as both caught large numbers of *Acanthurus* sp. and other herbivorous species. The catch from spears and spear guns is likely to vary depending on the fishers experience and habitats they exploit (Lincoln Smith, Bell, Pollard & Russell 1989). Spears had the lowest catch per fisher at 1.5 kg. However, this gear is mainly used on the reef flat targeting octopus, but takes fish opportunistically. Octopus was not included in the analysis, but if it were, the catch it would have been much higher. Spear and spear gun have distinct user groups and this livelihood diversification is important for spreading household risk. As both users can actively hunt for their catch, there is more scope for the fishers to influence directly the selection of fish by size and species making them more sustainable than passive gears. Hand lining was distinct in that it caught *L. lentjan*, and other predatory species, giving it a significantly higher trophic level than spear guns. In addition, it caught high numbers of herbivorous *Siganus* sp., which were also caught by spear guns and in lower numbers by nets and beach seines. Long lining had the most distinct selectivity, catching the highest trophic level and also the largest mean length. This gear is used on the exterior of the reef and targets pelagic species, including sharks, *Carcharhinus* sp. It is an expensive gear and few are owned in the villages surveyed. It is unsuitable for daily use, as good weather is required to use the gear, because the pass in the reef closes during strong winds. Gears that target higher trophic-level species have the potential to influence the fishery and fish down the food web (Pauly *et al.* 2000). Recent years have seen an increasing diversity and efficiency of gears used in south-west Madagascar. Eighty years earlier, only spears and nets made from local tree bark were used by the Vezo (village elder, personal communication). This increase in catching efficiency coupled with a huge population increase is possibly the cause of the low mean trophic level seen today, which may even be underestimated because of the seasonally high proportion of high trophic-level coastal pelagic fish in the catch.

The future

Coral reef fisheries support more than 30 million people worldwide and are essential for local nutrition (Mathew 2001). Increased levels of child malnutrition amongst coastal communities in the Philippines were attributed to decreased fisheries production as a result of habitat degradation (McAllister 1988). Therefore, management of artisanal fisheries is important if they are to continue to support those who depend upon them. Fishing gear limitations have been proposed as a more acceptable form of management in poor countries, where restricting effort or catch is difficult or politically unacceptable (Wilson, Acheson, Metcalfe & Kleban 1994). This study highlighted the dependency on the fishery and the lack of livelihood diversification; thus, gear limitations are likely to be ineffective without first assessing the gear users' alternative options before implementing restrictions. Beach seine would appear to be the least sustainable gear in this fishery and bans on beach seine use have recently been implemented in some of the sites surveyed. However, beach seine is the only gear reliably able to catch *E. micropus*, a commercially important species for the local people. It also offers a livelihood opportunity to a different user group as it does not require a boat or the ability to swim. Thus, fully understanding the motivations and options of different user groups will determine how well the restrictions will be adhered to, aid

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effective management and prevent criminalising a user group who have limited livelihood opportunities.

Declining coral reef resources are of global concern and there is great uncertainty about whether the present economic and social capacity of coral reefs can be maintained (Hughes, Baird, Bellwood, Card, Connolly, Folke, Grosberg, Hoegh-Guldberg, Jackson, Kleypas, Lough, Marshall, Nyströ, Palumbi, Pandolfi, Rosen & Roughgarden 2003). Madagascar's fisheries are already considered overexploited and there is a high level of unsustainability in island coral reef fisheries worldwide (Newton, Côté, Pilling, Jennings & Dulvy 2007). With an average of 47% of the population below the age of 15 years, coupled with the predicted global increase in population growth, urbanisation and the escalating impacts of global warming, the pressures on coral reef ecosystems will inevitably increase (Whittingham *et al.* 2003; Newton *et al.* 2007). The catch reductions required to move an over-exploited fishery toward sustainability are unlikely to be achieved without identifying and supporting alternative livelihoods for many of the people currently dependent on reef fisheries (Newton *et al.* 2007). It is proposed that promoting complementary household activities whilst simultaneously encouraging children to remain in education and providing information on achievable career opportunities could help stem the flow of the next generation into fishing by increasing livelihood diversity. In addition, before management of the coastal resources can be ensured, it is important to relieve poverty; although fishers are not the poorest members of this society, they still have a precarious existence as on the edge of survival the rules will be ignored (UN 2005). During focus groups, respondents were asked what they used for insurance during hard times: replies included 'we don't eat'. This highlights the need to improve livelihood security and strengthen support services for the poor (Whittingham *et al.* 2003). No significant differences were found between gear use and poverty, suggesting that future changes in wealth may not dramatically affect fishing methods being employed. However, the ability of the reefs to continue to provide benefits to the poor is changing, and in the near future it is likely that many of those who have been helped above the poverty line will start to slip back below it unless there are radical changes in the management of coral reefs and the perceptions of reef-dependent communities.

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