



The seine-net fishery of Rodrigues Island, western Indian Ocean: Is it sustainable or in terminal decline?

Emily Ruth Hardman^{a,*}, Alasdair James Edwards^b, Jean Stephen Jovani Raffin^a

^a Shoals Rodrigues, Marine Research, Training & Education Centre, Pointe Monier, Rodrigues, Mauritius

^b School of Biology, Ridley Building, Newcastle University, Newcastle upon Tyne NE1 7RU, UK

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ABSTRACT

Despite their importance, catches of small-scale fisheries are often unreported or underestimated. This study, the first to analyse the seine-net fishery in Rodrigues, aimed to examine whether the fishery is sustainable, as suggested by government data, or in long-term decline as reported by fishers. Using government data, a Fox surplus production model suggests that a seine-net buy-back scheme may have sufficiently reduced fishing pressure to allow the fishery to be sustainable. However, the mean trophic level of the catch declined significantly from 1994 to 2006, with many locally preferred fish becoming rare. Furthermore, a detailed study of the catches of four seine-net teams over five years indicated that catch per unit effort (CPUE) and fisher earnings declined significantly. Mean trophic level was 2.7 with over half of the catch comprised of herbivores and detritivores. When the government data are reanalysed to account for a change in fishing subsidies, they too indicate a significant decline in CPUE. Overall the data show that the seine-net fishery is over-exploited and unless management measures are taken urgently it will shortly cease to be viable. The study highlights the importance of measuring fishing effort appropriately and the need for multiple information sources for effective fisheries management.

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1. Introduction

Around the world, fish catches have declined since the late 1980s (Pauly et al., 2002) and although coral reef fisheries only account for a small percentage of global fisheries catches (Sadovy, 2005), a high dependency on fish protein and rapid population growth has meant that there is now widespread unsustainability of both island coral reef fisheries (Newton et al., 2007) and those of mainland countries (e.g. Mangi and Roberts, 2006; McClanahan et al., 2008). While small-scale fisheries, especially near-shore subsistence fisheries, have been recognised as important for social, cultural, and food security reasons (Zeller et al., 2007a), they are often marginalised (Pauly, 1997) and their catches often unreported or underestimated. This may be due to either the perceived difficulties of estimating a widely dispersed fishery or to limited financial and human resources (Bunce et al., 2009; Dalzell et al., 1996). Re-estimation of catches in Guam for example, revealed a 2.5-fold discrepancy between the re-estimated catches and the reported statistics (Zeller et al., 2007a). Similarly, in Madagascar, catches according to the national fisheries agencies were underreported by at least 40% (Le Manach et al., 2012) and in

Mozambique and Tanzania, respectively, total marine catches were estimated to be 6.2 and 1.7 times greater than data reported to the Food and Agriculture Organisation of the United Nations (FAO) (Jacquet et al., 2010). The unreliability of such official data presents a significant challenge for small-scale fisheries management and can potentially contribute to their overexploitation, highlighting the need for better monitoring (Zeller et al., 2007b).

On the island of Rodrigues (Republic of Mauritius) fishing is one of the largest employment sectors, employing about 13% of the total workforce in 2006 (Central Statistical Office, 2007) and the artisanal fisheries provide food for a large proportion of the population. There have been concerns about the status of the lagoon fishery in Rodrigues going back to 1901 (Bunce et al., 2009). Tarbit (1980) reported that the fishery appeared to have been in decline since 1955 when it included 34 seine nets and exported 750 tonnes of salt fish (1500 tonnes fresh weight equivalent), noting that exports in 1974 had declined to just 98 tonnes. The seine-net fishery is one of the most important of the lagoon fisheries, accounting for 42% of the total reported lagoon fish catch in 2006, according to unpublished data of the government's Fisheries Research and Training Unit (FRTU).

Seine-net fishing has been practised in Rodrigues since 1822 (North-Coombes, 2002). It is carried out within the shallow lagoon by teams of fishers in small 'pirogues' who use a semi-circular net and herd fish into the net by walking or sailing towards it, beating the water with poles. Some coral may be snagged during retrieval

* Corresponding author. Current address: 19 Tumbledown Close, Catterick Garrison, North Yorkshire DL9 4JD, UK. Tel.: +44 07530 515 482.

E-mail address: emilyhardman@hotmail.com (E.R. Hardman).

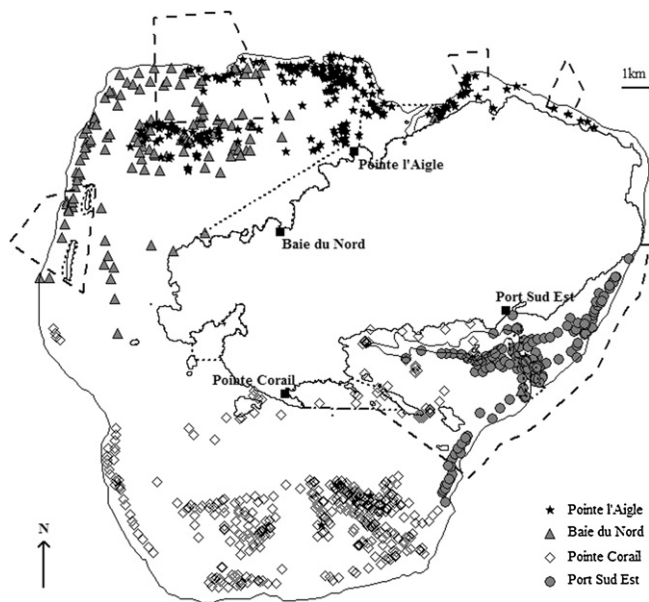


Fig. 1. The sites of seine-net hauls by the four fishing teams studied in 2002–2006. The bases of each fishing team, boundaries of the five inshore closed areas (...) and the boundaries of the new northern marine reserves and the southern marine park (---) are also shown.

of the net or damaged by fishers' feet, however, because the seine is not dragged through the lagoon, damage to the habitat is much less than for beach seines. The seine-net fishery is the most regulated of the artisanal fisheries in Rodrigues. Following concerns about overfishing, the Fisheries Act (1980) limited the number of seine-net licences for the island to 17 and introduced a number of management measures, including a 5-month closed season (start of October to end of February), five inshore areas (totalling 15.9 km²) where seine-net fishing is permanently prohibited (Fig. 1), a minimum mesh size of 9 cm and minimum catch sizes for several fish species. In addition, a buy-back scheme was initiated in 1997 to pay compensation for fishing teams who relinquish their licences; as a result, there were only 8 seine-net licences in place in 2006. The closed season appears to coincide with one of the two main spawning periods for several important fishery species in nearby Mauritius including at least three *Lethrinus* species and *Siganus sutor* (Wheeler, 1945; Ommaney, 1949) and is at a time of year when the weather is relatively good for fishing. Thus it constrains fishing at a critical time of year.

In 1965 a Bad Weather Allowance was introduced to compensate registered fishers through the payment of an allowance on days on which they are unable to go fishing because of sea conditions. This allowance was characterised by Bunce et al. (2008) as a "perverse fishing incentive" because it provided a strong incentive for people to register as full-time fishers in order to collect the subsidy. Numbers on the register rose from under 500 in the 1970s to 2069 in 1992 (Bunce et al., 2008) and stood at 175 in 2006 (Fisheries Protection Service, unpublished data). Unlike the professional seine-net fishers, many of those entering the register were more interested in the subsidy than fishing, although they have to show up at fishing sites in order to qualify for the allowance. Thus the subsidy may not have only increased fishing pressure but also exacerbated the environmental impacts of fishers trampling through the lagoon, seeking fish and octopus among the corals (Mangi and Roberts, 2006; Pearson, 1988). In 2006, the method by which the allowance was assessed was changed (see Supplementary material) with the result that the number of bad weather days when most fishers were entitled to the allowance was almost halved.

Monitoring of the lagoon fisheries in Rodrigues (fin fish and octopus) is undertaken by the FRTU, with catch data collected from 23 landing stations around the island. The published data seem to suggest that although the octopus fishery and total lagoon fish catches have declined in recent years, catches from the seine-net fishery remained relatively stable between 1994 and 2006. In contrast, seine-net fishers complain of declines in fish catches, and fishers around the island report depletion of many species, especially large predators, in the last 25 years (Bunce et al., 2008), such that many fishers are now dependent on government subsidies. This study, the first detailed analysis of the seine-net fishery in Rodrigues, aimed to investigate this apparent discrepancy by comparing the officially reported catch data with detailed catch assessments conducted with local seine-net fishing teams over five years and use these two sources of data to determine whether the fishery is indeed sustainable (in the sense that catches similar to those during the study may persist for many years to come (cf. Costanza and Patten, 1995), albeit that these catches may be sub-optimal) or, as suggested by the fishers, in decline. To see how baselines might have shifted in the longer term (cf. Jackson et al., 2001), the results are discussed in the context of unpublished fisheries data from 1978 to 1979 for Rodrigues, accounts of the similar lagoon fishery in nearby Mauritius from the 1940s, and local fishers perceptions reported by Bunce et al. (2008).

2. Methods

2.1. Catch and effort data from FRTU

Catch data are collected at 23 fish landing stations around the island on a regular basis by the FRTU and collated annually. For the seine-net fishery, data are collected for 13 species, or groups of species plus a miscellaneous category (<10% of total weight) and summed for each month of the fishing season (March–September). The primary indicator of effort is the number of registered seine-net fishers in each year. The combined catch and effort data for the seine-net fishery from 1994 to 2006 (Appendix A, Table A.1) were subjected to surplus production analysis using the Fox model (which fitted better than the Schaefer: $R^2 = 0.856$ for Fox vs. 0.719 for Schaefer) to obtain an estimate of maximum sustainable yield (MSY) for the multispecies stock and the fishing effort at MSY. Despite the multi-species nature of the fishery, the same half dozen species tend to dominate the catch each year, and we considered that a surplus production model approach would give a broad indication of the fishery's status and sustainability.

Since the number of registered seine-net fishers declined slightly over the five years (Table A.1) of our detailed study, we did not expect any detectable change in species. However, over the 1994–2006 period for which FRTU statistics were available we expected that some evidence of "fishing down the food web" (Pauly et al., 1998) might be apparent. Thus, the contribution of each taxon to the catch in each year was examined to see if there were any significant trends over the 13-year period using regression analysis on Box-Cox transformed data.

2.2. Detailed catch composition and catch and effort data

Surveys were undertaken working in collaboration with four seine-net fishing teams (half of those licensed) based respectively at Pointe l'Aigle (north), Baie du Nord (north-west), Pointe Corail (south-west) and Port Sud Est (south) during the seine-net fishing season (1st March–30th September) in 2002–2006. Catch assessments were undertaken by following a seine-net team during the course of a fishing day. A total of 124 fishing days consisting of 1119 hauls were sampled over the 5 year period (Fig. 1). For each fishing

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