



Closure of the live reef food fish fishery in Seychelles

Riaz Aumeeruddy¹ and Jan Robinson¹

Introduction

The expansion of the live reef food fish (LRFF) trade — from its original centres in Southeast Asia through much of the western Pacific and parts of the Indian Ocean — has been rapid and dramatic (Johannes and Riepen 1995; Sadovy et al. 2003). In the western Indian Ocean (WIO), poor air links, the long distance to Southeast Asian markets, and lower prices may have restricted the development of LRFF fisheries, with Maldives and Seychelles the only known exporting countries of LRFF in the region (Sadovy et al. 2003). However, while Maldives has a well-established fishery with considerable local involvement, Seychelles has been reluctant to allow further development of the LRFF fishery. This paper describes the evolution of the LRFF fishery in Seychelles, which was largely implemented on an experimental basis (Bentley and Aumeeruddy 1999), and details the factors that led to legislation in 2005 prohibiting the fishing, trade, and export of wild-caught, live finfish, effectively closing the LRFF fishery.

Seychelles is a small island state located south of the equator in the WIO (Fig. 1). It is a large archipelagic nation, comprising 115 islands of small land area (455 km²) scattered over an exclusive economic zone (EEZ) of close to 1.4 million km². A population of about 82,000 resides mainly on the larger granitic islands of Mahé, Praslin and La Digue, while the remaining granitic and coralline islands are sparsely populated. Fishing has traditionally played an important socioeconomic role in the country (Wakeford 2000). Seychelles has one of the highest per capita fish consumption rates in the world at 80 kg yr⁻¹ (FAO 2005). Most of the artisanal fisheries catch (typically 4000–4500 tonnes per annum) is consumed locally, and generally less than 10% is exported (Azemia and Robinson 2005), illustrating the importance of these fisheries for food security. Industrial fisheries that target tuna and billfish have developed rapidly since the early 1980s, and the fishing sector now constitutes a major pillar of the economy, contributing close to 40% of the gross receipts for the country in 2004 (Seychelles Fishing Authority 2005).

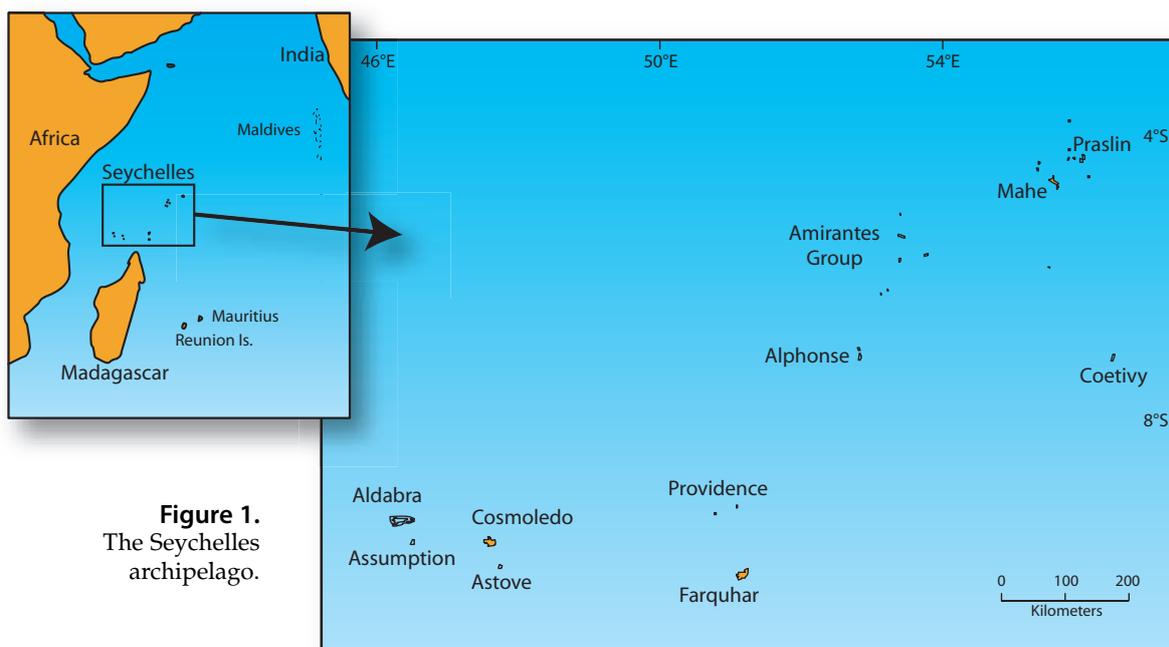


Figure 1.
The Seychelles archipelago.

1. Research Section, Seychelles Fishing Authority, PO Box 449, Fishing Port, Mahé, Seychelles. Email: raumeeruddy@sfa.sc

History and operation of the fishery

Live reef food fish were not traditionally fished, marketed or traded in Seychelles. In late 1997, a local fishing company made a request to the Seychelles Fishing Authority (SFA) for permission to fish and export LRFF to Hong Kong (Bentley and Aumeeruddy 1999). While Seychellois fishers and exporters have typically been able to respond to demand from Southeast Asian markets, and have developed local for-export fisheries based on high value products not consumed locally (e.g. shark fins and sea cucumbers), the lack of local expertise in all aspects of this fishery, notably handling and maintaining live fish, ensured that the fishery would require substantial Chinese support. The request was accepted by SFA² and the Islands Development Company (IDC)³ on a trial basis and a fishery operated over two fishing seasons in 1998 and 1999. The fishers, fish handlers and much of the infrastructure were from China. In 1998, the trial was based at Farquhar Atoll (Fig. 1). This fishing ground was chosen to reduce conflicts with traditional artisanal fishers, who rarely fished at Farquhar at that time due to rising operational costs (notably fuel prices) and stagnant local market prices. At Farquhar, the fishing operation was land-based with fishers undertaking daily trips inside the lagoon with small boats powered with outboard engines. The fish were held in 12 floating cages located in the inner lagoon (Fig. 2). The company was allocated an export quota of 40 tonnes (t), which is the amount of fish that IDC was process-



Figure 2. A fisher unloading a Napoleon wrasse (*Cheilinus undulatus*) in a holding cage.
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ing annually as salted fish. In 1998, IDC stopped all production of salted fish so as not to conflict with the trial LRFF fishing.

In 1999, due to concerns over sustainability of the fishery at Farquhar (see below), the LRFF fishing company was granted a license to fish at Astove, Assumption, Providence and Cosmoledo. Astove and Assumption were subsequently found to be unsuitable fishing areas because of low catch rates of the target species, and fishing was eventually based entirely at Providence (between February and June 1999) and at Cosmoledo (between October and December 1999) (the gap in operations from June to October was due to mothership engine problems). An export quota of 100 t was a condition of this second license, with a maximum of 25 t allowed to be taken from Providence (Bentley and Aumeeruddy 1999). This condition was applied to Providence because it had the fishing grounds most frequented by traditional artisanal fishers. To monitor and ensure compliance with quotas, the fishing company was required to return all live fish to the holding cages at Farquhar prior to export. Now having a much larger area to cover than the land-based operation at Farquhar, permission to use a single mothership with 17 fishing dories was granted to the company. Later in the year, when fishing at Cosmoledo, the company was authorised to use another mothership for the sole purpose of transporting catches from the fishing grounds to the holding cages at Farquhar. Transshipment to any another vessel at sea was not

allowed. Both the motherships and all the fishing dories were licensed by the local authorities and were required to display registration numbers. The vessels were not permitted to possess, store, transport or use any explosives or noxious substances, including sodium cyanide, nor were they permitted to use compressed air equipment for diving. The only fishing gear permitted was hook-and-line, as in the previous year (Bentley and Aumeeruddy 1999).

The fishing company chartered a live reef fish transport vessel (LRFTV) from Hong Kong to export fish from Farquhar Atoll. The LRFTV obtained port clearance from authorities on Mahé Island before proceeding to Farquhar, where it was met by SFA offi-

2. SFA is a parastatal in the executive arm of the Seychelles Government, involved in fisheries research, management, development and training.
3. IDC is a public company mandated to manage and develop activities at several outer islands groups, including Farquhar, Cosmoledo, Astove, Assumption and Providence. It has some fishing activities at some of the outer islands, including Farquhar, where fish are salted and then exported to Mahé.



Figure 3. Fishers preparing the cages to transfer fish to the LRFTV. © Riaz Aumeeruddy

cers to supervise the loading (Fig. 3). On a typical trip, the LRFTV would load about 20 t before returning to Mahé Island to obtain clearance to leave territorial waters. In total, there were six export trips during the two-year project.

Monitoring the fishery

At Farquhar, fishing operations during 1998 were monitored by an SFA officer based on the atoll. The officer was tasked with recording species composition of the retained catch, estimating catch and (holding cage) mortality rates, as well as ensuring that fishing activities were in line with agreed procedures and conditions of license. In practice, collecting weight and other data from catches proved difficult, as fishers were keen to minimize handling of fish, so at this stage, catch weights were only estimated. Monitoring of fishing operations during the second year of the trial, in 1999, proved even more problematic, as it was not possible for SFA to station an observer on the mothership. Radio reporting of mothership position and catch and effort, as required under the license conditions, was subject to concerns over reliability of the data, and communication was further hampered by the language barrier. Since export quotas were the primary management control for the fishery and were also the basis for calculating management fees imposed on the fishing company⁴, emphasis was placed on collecting accurate data while loading the LRFTV (Fig. 4), and additional SFA staff were flown to Farquhar to oversee this process. Consequently, the export data obtained were reliable and accurate.



Figure 4. Weighing the fish on the LRFTV. © Riaz Aumeeruddy

Target species, exports and cage mortality

Over the two-year trial, 102.3 t of fish were exported to Hong Kong (Table 1). Groupers in the genus *Epinephelus* constituted the majority of the exports, followed by coralgroupers or coral trout (*Plectropomus* spp.) and Napoleon wrasse (*Cheilinus undulatus*). The following species were exported in descending order of export quantities: *Epinephelus polyphkadion*, *Plectropomus punctatus*, *Cheilinus undulatus*, *E. fuscoguttatus*, *E. malabaricus*, *E. multinotatus* and *P. laevis*. After the last export of fish in January 2000, 15–20 t of fish remained in the holding cages. Although the fishing company had planned to send another LRFTV in late January 2000 to collect the remaining fish, a dispute between the company and its partners in Hong Kong delayed matters. In February 2000 the fishing company was requested by SFA to try to sell the fish locally, as the rate of mortality was increasing in the cages. With no local wholesalers or buyers showing interest, however, the company relinquished the fish to SFA and they were eventually released in the inner lagoon of Farquhar.

Accurate estimates of cage mortality rates were obtained only during the first year of the trial, when an SFA officer was stationed full time at the atoll. Mortality rates were high during the first fishing period (February–May) at Farquhar

4. A management fee of 0.60 US dollars (USD) kg⁻¹ of fish exported was introduced in the initial license conditions to cover expenses incurred by SFA for monitoring and management. The fee was increased to USD 1.00 kg⁻¹ in the second year to cover the additional expenses of monitoring the remote mothership operations.

Table 1. Exports of LRFF (kg) by fishing location, fishing period and the three main species groups.

Fishing location	Fishing period	<i>Plectropomus</i> spp.	<i>Epinephelus</i> spp.	<i>Cheilinus undulatus</i>	Total
Farquhar	Feb-May 1998	4 920	10 558	5 556	21 034
Farquhar	May-Aug 1998	5 085	5 837	1 061	11 983
Providence	Jan-Mar 1999	2 899	6 934	4 131	13 964
Providence	Mar-Jun 1999	5 051	5 821	3 697	14 569
Cosmoledo	Oct-Nov 1999	4 032	10 180	1 508	15 720
Cosmoledo	Nov-Dec 1999	639	20 846	3 519	25 004
Total:		22 626	60 176	19 472	102 274

(Table 2), representing 6389 kg of fish, or about 23.3% of the quantity caught (excluding the fish used as bait and feed). Part of the problem resulted from high densities, as the original 12 cages were insufficient given the (low) frequency of export; 12 additional cages were constructed at the end of March 1998. The feeding regime was initially poorly maintained. Once these two problems were rectified, the mortality rate improved, falling to 16.3% of the quantity caught in the second fishing period (May–August). Mortality rates (in the first fishing period) differed among species, with the epinephelids and plectropomids showing much higher rates (24.2% and 35.1%, respectively) than Napoleon wrasse (6.2%), probably due to the fact that densities in the serranid cages were greater. Operations at Farquhar slowed down from the beginning of July due to poor weather conditions at the atoll (rough seas associated with southeasterly trade winds). For the remainder of 1998, fishing was conducted only to provide feed; lower quantities of fish were consequently captured and exported during the second period of the year (Table 2). Also shown in Table 2 are estimates of the amount of bait and feed (obtained from both targeted fishing and bycatch of LRFF fishing) used in the operation, as well as estimates of total catches of all fish (the sum of exports, cage mortalities, bait and feed).

Implications for management

At the end of the trial in 1999, the fishing license was not renewed pending a review of the fishery. Four key areas of concern were identified regarding the long-term viability of a LRFF fishery of this type, all of which have been expressed in other regions in which such fisheries have operated (Sadovy et al. 2003).

Table 2. Total catches at Farquhar in 1998, by fishing period, as determined from exports, mortalities and (approximate) bait and feed estimates.

Fishing period	Exports (kg)	Cage mortality (kg)	Bait and feed (kg)	Total catch estimate (kg)
Feb-May	21 034	6 389	10 000	37 423
May-Aug	11 983	2 331	5 000	19 314
Total	33 017	8 720	15 000	56 737

Sustainability

The sustainability of the LRFF fishery was the major concern. The shore-based operation at Farquhar enabled high levels of fishing effort to be applied over a small fishing ground. As the operation obtained high catch rates for the target species, the amounts retained for export after the first fishing season (Table 1) rapidly reached a level equal to what had been estimated as maximum sustainable yield (MSY), 31.9 t, for all species available to a hook-and-line fishery in the shallow (0–75 m) stratum (Mees et al. 1998). Although total exports of LRFF caught at Farquhar (33 t) were roughly equivalent to this MSY estimate, when mortality, bycatch and targeted fishing for feed were taken into consideration, the total catch from Farquhar exceeded MSY by about 25 t. Overexploitation was achieved within 60 days of fishing by 8–14 fishers operating daily, and the exploitation rate was lessened only by rough weather during the second fishing period of 1998.

Aspects of their demography and reproductive biology (Shapiro 1987; Sadovy 2001) render the target species vulnerable to intensive fishing. Many juvenile fish, particularly Napoleon wrasse, were taken, and although the fishers did not target particular fish sizes, the market's preference for plate-sized fish may have led to such size selectivity over time, with severe implications for fishery sustainability. Of particular concern was the targeting of

spawning aggregations (Domeier and Colin 1997). Little was known regarding the status of grouper spawning aggregations at the time of the LRFF trial. The IDC, which manages many of the outer islands, knew that large aggregations of *E. polyphkadion* and *E. fuscoguttatus* formed at Farquhar in December and January (Robinson et al. in prep.), information that was used to justify the LRFF fishery commencing in February so as to avoid aggregation targeting. At Cosmoledo, however, which has no permanent IDC presence, aggregations may have been targeted in the November–December 1999 fishing period. Research conducted since the trials has identified aggregations of *E. polyphkadion* and *E. fuscoguttatus* at the atoll, and histological evidence indicates that February is the last month of the spawning season (SFA unpublished data). Based on what is known regarding the duration of spawning seasons in these species (Domeier and Colin 1997; Rhodes and Sadovy 2002; Pet et al. 2005), it is likely that aggregations also form in December and possibly November. Assuming fishing effort and mortality rates did not differ significantly between the two fishing periods at Cosmoledo, the 100% increase in export quantities of epinephelids between the two periods (Table 1) may be indicative of aggregation fishing.

Conflict with local fishers

In Seychelles, the law reserves all demersal resources to local companies or individuals. Traditional artisanal fishers perceived the LRFF fishery as being foreign-owned and of little economic value to the country. Although the fishing company was locally registered and had Seychellois owners, the principal shareholder of the company was Chinese and had only recently nationalized. Furthermore, all fishers and crews employed by the company were recruited from China. Traditional fishers also resented the wastage of non-target species. Most of the bycatch, mainly comprising emperors (Lethrinidae), snappers (Lutjanidae) and lower value groupers (Serranidae), was used for feed and bait. Since all of these species are targets for traditional fisheries and are relatively valuable in local markets, artisanal fishers considered the LRFF fishery to be not only unsustainable but an infringement of their rights.

Biodiversity

Napoleon wrasse is the most valued target species, as it fetches the highest price on Asian markets, especially plate-sized fish that can reach more than USD 100 kg⁻¹ in restaurants. In Seychelles, there is little demand for this species by the local population and it is not targeted by traditional fishers.

Given that this species was listed on the IUCN Red List of threatened species, fisheries managers were concerned that the LRFF fishery could place this species at risk in Seychelles. Moreover, there was mounting pressure internationally to list this species on Appendix II of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). If CITES listing was attained, any country wishing to export Napoleon wrasse to a country that was party to CITES would need to certify that the fish being exported was legally obtained and that the export would not be detrimental to the survival of the species. Seychelles did not want to be seen as opening a fishery that was targeting a listed species.

Economic viability

SFA considered that the organisation of the LRFF operation, based largely on Chinese manpower and trading links, was not an economically viable fishery for the country. The local LRFF fishing company was responsible for the logistics of the project, paid the salaries of three people based on Farquhar to look after the holding cages, and paid for local expenses (fuel, local supplies, shipping agent fees, port dues, local fishing licenses and management fees). The buyer in Hong Kong paid for the salaries for the crew and fishermen and supplied the mothership, fishing dories, fishing gear and the funds for the charter of the LRFTV. For its services, the local LRFF fishing company reported being paid USD 3 kg⁻¹ of fish FOB Farquhar, irrespective of the size and species of the fish. At that rate, the total exports of live fish for the two-year trial were valued at USD 306,822. The price obtained for LRFF at Farquhar was no higher than the price for fresh or processed fish on the local retail market. Seychellois wholesalers and processors on Mahé pay fishers an average price of USD 2.70 kg⁻¹ for groupers, a price that has remained stable since 1998. Moreover, when fish are sold on local retail markets and to restaurants and hotels, there is substantially more revenue generated for the local economy.

LRFF prices paid to fishers and prices on the retail market in Hong Kong can be considerably different, as there are usually several intermediaries, each of which adds mark-up on the price (Sadovy et al. 2003). The export price of USD 3 kg⁻¹ reportedly paid to the company in Seychelles is low compared to beach prices in other countries. In 1999, the average beach price for the Napoleon wrasse was USD 8–10 kg⁻¹ (nominal) in Indonesia and USD 9–10 kg⁻¹ in Australia, whilst for brown-marbled grouper average beach price was USD 5–6 kg⁻¹ (nominal) in Australia (Sadovy et al. 2003). Prices offered in Seychelles are expected to be lower than

in countries closer to Hong Kong, because of higher transportation costs and mortality rates during transport.

In terms of employment, no local jobs were created by this fishery. Even if given the opportunity, local fishers would have been reluctant to work on board the mothership because of communication problems and poor living conditions. The development of a small-scale LRFF fishery that involved local fishers and crew may have been more beneficial for the country. In February 1998, SFA organised a study mission to Hong Kong to research the LRFF trade and to examine ways to attract better prices. However, there were problems establishing reliable contacts with various middlemen and the difficulties of trading further up the supply chain were manifest. Even if more direct links to middlemen could be established for a small-scale, more locally operated fishery, the constraints of transportation would probably have been insurmountable without direct air links between Seychelles and the market, and without taking advantage of the latest technological advances in reducing mortality rates.

Closure of the LRFF fishery

Following the cessation of the LRFF fishery trial in 1999, SFA received three substantive proposals from Seychellois businessmen for the development of a locally operated LRFF fishery. Based on findings from the trial and increasing reports of problems associated with the fishery in other regions (Smith 1997; Mapstone et al. 2001), SFA adopted a precautionary approach and maintained its policy of discouraging such ventures. In the meantime, two other developments strengthened the case for prohibiting the LRFF fishery altogether:

Concerns over the status of reef fish spawning aggregations, which were known to be targeted by traditional artisanal fishers (Robinson et al. 2004), and may have been targeted in the LRFF fishery trial, led SFA to implement a four-year research and management programme for reef fish spawning aggregations (2002–2005). The idea of protecting grouper spawning aggregations has received widespread support from local fishers and the designation of closed areas and seasons is at an advanced stage. It was recognised by the fisheries managers that protection of aggregations and development of a LRFF fishery were incompatible aims for the management of groupers and other species.

Many demersal finfish resources on the Mahé Plateau, a large shallow plateau surrounding the populated granitic islands, are overexploited while those in the outer islands are lightly exploited

(MRAG 1996; Mees et al. 1998). To reduce pressure on inshore stocks (i.e. primarily demersal fish and semi-pelagic fish such as trevallies), and to realise the fisheries potential on the outer islands, plans for the development of outer island fisheries-related infrastructure in support of demersal hook-and-line fisheries have been proposed. Because of the high potential for ecotourism on the outer islands, which is already developing, the protection of spawning aggregations and restrictions on unsustainable fisheries were viewed as fundamental precautionary measures.

The Fisheries Act (1984) is the principal piece of legislation governing fisheries in Seychelles. Gazetted in June 2005, the live fish trade regulations (Fisheries (Amendment) Regulations 2005: S.I. 32 of 2005) prohibit the fishing of all finfish (all cartilaginous and bony fishes) for the live fish trade, including both the food and aquarium trades. Fishing of other species for the live fish trade, including crustaceans (e.g. the spanner crab, *Ranina ranina*), is subject to authorisation and to the imposition of conditions on fishing licences and export permits. These regulations apply to wild-caught live fish; live finfish from mariculture projects can be exported with an appropriate permit.

Discussion

Prior to the trials, the authorities in Seychelles were largely unaware of LRFF fisheries and trade. Valuable lessons have been learned. Because only certain species and size classes of fish are acceptable for the live fish markets, biomass and sustainable yield estimates that are available for reef fish as a group were found to be inappropriate as a basis for managing the LRFF fishery (Mees et al. 1998). Because of high rates of mortality and bycatch, limits should be set on total catch rather than on exports. Strict monitoring and a rapid management response are necessary for the LRFF fishery, especially where vulnerable species are targeted; these requirements were not achieved in this trial. From the outset, it was clear that monitoring and ensuring compliance would be demanding and expensive to implement in remote locations of the EEZ. Although controls on unsustainable fishing practices (e.g. cyanide fishing) appeared successful, a lack of knowledge on spawning aggregations at the time may have exposed several aggregation sites to excessive fishing. Timely recognition of these management deficiencies and other factors contributing to the closure of this fishery probably prevented extreme stock depletions at Farquhar, which in 2002 still maintained some of the highest abundances of large serranids and Napoleon wrasse in the Indo-Pacific (J.H. Choat, James Cook University, pers. comm. 2002).

The export prices reportedly paid by buyers in Hong Kong to the local LRFF company were low considering the costs incurred by the company. Moreover, it was difficult to see how a more sustainable, small-scale, locally operated LRFF fishery could achieve greater benefits than attainable through existing local markets, even if beach prices for LRFF could be improved. While a (presumably) economically viable, small-scale LRFF fishery has been established in Maldives, the situation there is different in that there is less demand for the target LRFF species on local markets, as tuna is the preference of the local population (Shakeel and Ahmed 1997), and there is consequently less competition with traditional fishers.

As stocks of LRFF target species are depleted at ever increasing distances from the main markets, continued demand and improvements in air transport technology and general trade links may erode barriers to expansion of the trade (Sadovy et al. 2003). Countries of the WIO, already some of the least developed in the Indo-Pacific, will need to make informed decisions about whether to support the development of LRFF fisheries, taking into account the costs and benefits of the LRFF trade. Initiatives to sensitize and educate fishers and fisheries managers of the many issues surrounding this trade are lacking in the region, and may be required should an expansion occur in a westward direction.

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