Structure and management issues of the emerging ornamental fish trade in Eritrea

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ABSTRACT

Following independence from Ethiopia in 1993, Eritrea resumed exploiting Red Sea and Arabian fish species for the ornamental trade in 1995 as a means to earn foreign exchange from sparsely exploited marine resources. This paper describes the findings of research conducted in 1997, in collaboration with the Eritrean Ministry of Fisheries. The capture, transport and export of aquarium fish were reviewed and potential impacts and the status of management were investigated through liaison with stakeholders and researchers. From 1995 to 1997 two companies exported approximately 60,000 fish per year, mainly to the USA, worth US$65,000 (export value). Seventy-five species (from 22 families) were exported. Damselfishes made up two-thirds of total exports but more valuable families (angelfishes and butterflyfishes) were more economically significant. To earn revenue for Eritrea, a 20% export tax was imposed, although this was calculated from declarations by the operators. The emerging nature of the trade allowed detailed monitoring by the Ministry of Fisheries. However, management efforts were constrained by a lack of capacity for enforcement and baseline research. Several potential effects of the trade exist but other, land-based impacts may be more pressing concerns for Eritrea's reefs. Research priorities for management are discussed as well as the implications of mariculture of Eritrean species by other nations.

INTRODUCTION

Reef fish from Eritrean coastal waters were first commercially collected and exported for the aquarium trade in 1968 when Eritrea was a province of Ethiopia. At its height, this early trade employed 55 local collectors and resulted in the export of approximately 50,000 fish per year (L. Perino, Kaiula Kona, Hawaii, pers. comm.). By 1975 the trade had ceased due to the intensification of the war which ultimately led to Eritrean independence in 1993. Post-war Eritrea was one of the world's poorest countries and the ornamental fish trade was actively encouraged as a potential source of much-needed foreign revenue from the country's sparsely exploited coral reef systems. Eritrea's geographical position with approximately 2500 km of southern Red Sea coastline allows access to populations of Red Sea and Arabian species not available to the southeast Asian countries that dominate the world supply of ornamental fish. The trade has again been interrupted by war since border conflicts with Ethiopia broke out in early 1998.

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In 1997 the Reefs of Massawa Expedition, a collaborative research programme organised from the University of Newcastle upon Tyne, and involving members of the Eritrean Ministry of Fisheries and the University of Asmara, was conducted in Eritrea's main port of Massawa (Daw *et al*., 1998). The broad aim of the expedition was to begin baseline research into of the status of the local coral reef resources. The aquarium trade was investigated with the aim of describing the trade's structure, composition, status of management as well as reviewing its impacts and sustainability.

MATERIALS AND METHODS

Mapping, water quality and underwater ecological surveys at 5 sites around Massawa were conducted to characterise the extent, biological composition and potential impacts on the reef ecosystem.

The perimeters of the reefs around Massawa and Green Island were mapped by boat using a Global Positioning System (GPS) and transferred to a Geographical Information System (GIS). Water samples were analysed for nutrient levels (nitrate and phosphate) using the Palintest 5000 spectrophotometer and accompanying kits.

For the ecological surveys, four replicate 50 m transects were marked out at each of the sites. Along the full length of each transect, three separate counts were made. Firstly fish species were selected within a 5 m wide belt (English *et al*., 1994). The counted fish species were those commonly collected for export. Damselfishes (Pomacentridae) were not quantified due to their small size, large aggregations and cryptic behaviour. Secondly, invertebrates were selected within a 2 m wide belt. Lastly benthic cover was assessed by recording the cover type at 200 equally spaced points on each transect. The relative number of occurrences of each cover type along the four replicate transects was extrapolated as an estimation of relative abundance. This particular method was used as it is rapid to complete and was consistent with the methodology of the University of Asmara.

The structure and management of the aquarium fish trade was reviewed through interviews with collectors, trade representatives, government officials and researchers. Collecting, holding and exporting operations were directly observed and detailed export statistics from the first 21 months of trade provided by the Eritrean Ministry of Fisheries (MoF) were analysed in the context of the ecological data collected and world ornamental trade figures.

RESULTS

Reef characteristics

At the time of this study there were no data on the location or coverage of the coral reefs in the Massawa area. In previous studies, reefs were assumed to cover

the green hatched areas of British Admiralty Charts which actually represent the intertidal areas of all types.

The reefs around Massawa, where collection was centred, were found to be narrow fringing reefs extending to shallow depths and showing the limited coral diversity typical of inshore southern Red Sea reefs. Although the condition of the reefs was variable, in 'healthy' areas there was an abundance of certain damselfishes, butterflyfishes and angelfishes (Pomacentridae, Chaetodontidae and Pomacanthidae) endemic to the Red Sea or Arabian regions and therefore of particular interest to the aquarium fish trade. A wide variety of potential impacts was noted, many of which were connected to the post-war reconstruction and development of the town of Massawa. Eutrophication, sedimentation, waste disposal, oil pollution and collection of marine curios were all potential concerns. The reef systems around the offshore Dahlak Islands, 30–250 km from Massawa were likely to show greater diversity and be less susceptible to human impacts than those in the immediate vicinity.

Nutrient results indicate that the reefs around Massawa are subject to enrichment by phosphate in particular and nitrate to a lesser extent. The location of the highest levels of nutrients were coincident with poorly flushed areas which were used for disposal of human waste. Although it is likely that the reefs are adapted to nutrient enrichment to a degree due to the seasonally high natural levels of the area, the input of additional nutrients from anthropogenic sources could lead to eutrophication. This would have serious consequences for the corals of Massawa that currently dominate the reefs during low nutrient conditions from May to September (Hillman and Tsegay, 1997).

Volume of trade

Habte (1997) reported that 103,813 fish were exported from Eritrea in the period between October 1995 and June 1997 (an average of 60,000 fish per year). This would represent approximately 0.5% of the estimated total world trade by number.

Figure 1 shows the proportions of these fish exported to different destination countries. The USA has by far the biggest market for fish exported from Eritrea. Whilst the USA is a major 'consumer' of ornamental fish and invertebrates, the fact that the company exporting the largest number of fish is American must be taken into consideration. The commencement of operations by a new company since 1997 may have increased the proportion of fish being exported to other destinations. Fish are also likely to have been re-exported to other countries in addition to the destinations shown.

Composition of exports

Statistics of fish exported between October 1995 and June 1997 demonstrate the collection of 75 species from 22 families. However, as shown in Figure 2, 66% of these individual fish were Pomacentrids, the vast majority of which were either the

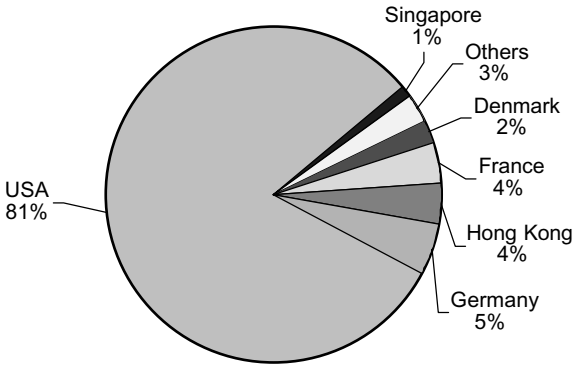

Figure 1. Destinations of aquarium fish exported from Eritrea between October 1995 and June 1997 (percentages of numbers).

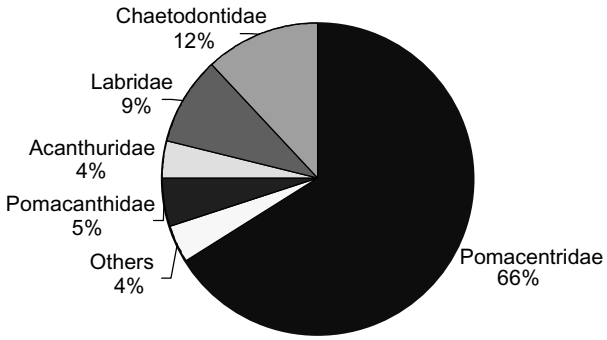

Figure 2. Composition of exports of aquarium fish exported from Eritrea between October 1995 and June 1997 by family (percentages of numbers).

blue–green chromis *Chromis viridis* (Cuvier) or the Red Sea damselfish *Dascyllus marginatus* (Ruppell). The 20 most numerous species (based on numbers of fish) from these statistics are listed in Table 1.

Value of exports

The value of exported fish were estimated to be in the region of US$65,000 per year. This figure is calculated from the records of tax paid by the exporters to the MoF, which in turn, is based on the value of the fish at their destination, as declared by the exporter. This, therefore, represents their declared value at importation rather than a measured sum at export from Eritrea. This represents 0.1–0.3% of the estimated annual world value of marine ornamental fish imports (K. Davenport, Ornamental Aquatic Trade Association, UK, pers. comm.) and about 0.25% of Eritrea's total exports (World Bank, 1995).

Table 1. The 20 most commonly exported aquarium fish species from Eritrea from October 1995 to June 1997, ranked according to their percentage of total numbers of specimens

Exported species	Family	Numbers exported	% of total numbers	% of tax revenue from the trade
Chromis viridis	Pomacentridae	29469	28.4	6.4
Dascyllus marginatus	Pomacentridae	28371	27.3	5.3
Neopomacentrus miryae	Pomacentridae	6337	6.1	0.6
Larabicus quadrilineatus	Labridae	4694	4.5	3.9
Pomacanthus asfur	Pomacanthidae	3414	3.3	24.4
Thalassoma lunare	Labridae	3038	2.9	2.2
Chaetodon semilarvatus	Chaetodontidae	2704	2.6	9.2
Chaetodon larvatus	Chaetodontidae	2545	2.4	3.6
Chaetodon mesoleucos	Chaetodontidae	2506	2.4	5.5
Heniochus intermedius	Chaetodontidae	2243	2.2	3.6
Pomacanthus maculosus	Pomacanthidae	2232	2.2	10.0
Chaetodon fasciatus	Chaetodontidae	1881	1.8	3.3
Pseudochromis flavivertex	Pomacentridae	1870	1.8	2.1
Zebrasoma xanthurum	Acanthuridae	1477	1.4	5.9
Zebrasoma desjardinii	Acanthuridae	1217	1.2	2.1
Ostracion cubicus	Ostraciidae	961	0.9	0.9
Abudefduf saxatilis	Pomacentridae	778	0.8	0.1
Cryprocentrus caeruleopunctatus	Gobiidae	773	0.7	0.8
Pomacentrus sulfureus	Pomacentridae	709	0.7	0.2
Amphiprion bicinctus	Pomacentridae	641	0.6	0.8
Others	Various	5984	5.8	9.1
Totals		103844	100	100

This declared import value of individual fish varied with species and size, ranging from US$0.10 for small *Chromis* or *Dascyllus* to US$12.50 for large specimens of the Arabian angelfish, *Pomacanthus asfur* (Forsskal), which is endemic to the Arabian region. Despite the lower proportions of Pomacanthids in the export figures (Figure 2), they are the most economically important family (Figure 3). In particular *P. asfur* accounted for 24% of the total revenue (Table 1). Prices also varied independently of size and species, possibly due to variations in demand, marketing differences between companies or different sizes of orders. The mean declared import value of fishes between October 1995 and June 1997 was US$1.09 per specimen.

Abundance of aquarium species

Although the two most heavily exported species (*C. viridis* and *D. marginatus*) were not surveyed, they were abundant on reefs around Massawa. Ten commonly exported species were counted. Figure 4 shows the relative abundances of these species plotted along with the numbers of individuals exported. For these 10

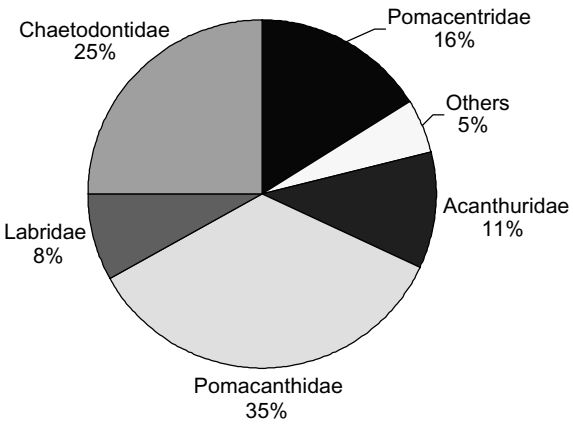

Figure 3. Value of exports of aquarium fish exported from Eritrea between October 1995 and June 1997 by family (percentages of total import value).

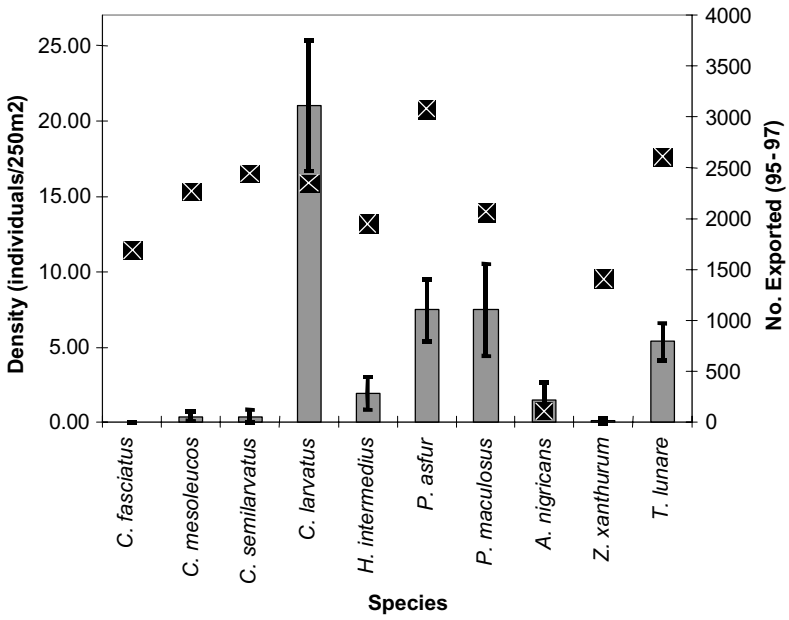

Figure 4. Mean densities (shaded columns) and numbers (white crosses on black squares) exported of selected species. Error bars show 95% confidence intervals for fish densities. Genus names in full: C = *Chaetodon*, H = *Heniochus*, P = *Pomacanthus*, A = *Acanthurus*, Z = *Zebrasoma*, T = *Thalassoma*.

species, no obvious relationship between density on the reef and numbers exported was observed. This concurs with the findings of Wood (1985) who observed that selective capture is employed by collectors to satisfy the demand for particular species.

Collection operations

From 1995 until 1997 three companies had been involved in the collection and export of aquarium fish from Eritrea. There was a short and simple chain of custody with fish being caught, held and exported by the same company. Collection by net occurred from recreational fibreglass boats out of Massawa and the fish were held at the companies' facilities before being exported by air from Asmara Airport, 115 km inland by road from Massawa.

The reefs immediately around Massawa were the most logistically favourable sites for collection, with minimal time and fuel required to reach the sites and short times between the capture of fish and their introduction to the holding facilities. Massawa's reefs could also be fished when bad weather prevented longer trips. However a wider range of species was available at sites in the Dahlak Islands. Collecting trips were made to particular sites to satisfy individual orders for rarer species.

Initially, only two, markedly different, companies conducted fish collection and export operations. The first was a regional branch of an international American company with several collecting and trading outlets throughout the world. Experienced Filipino staff administered the collecting and holding operations. Collectors used diving hookah systems or snorkelled and wore rigid rounded fins for maximum manoeuvrability and to avoid contact with the reef. Fish were captured using barrier and hand nets and then transferred to individual plastic bags with oxygen for the return to the holding facilities in Massawa. These facilities used a large re-circulating system of seawater equipped with sophisticated water quality and environmental controls. No feeding occurred during the holding period to eliminate fouling of water by faeces during transit. The holding period was typically 1–2 days. Shipments were regularly trucked to Asmara Airport for export. Unhealthy or imperfect fish, or fish that were not exported within a few days were returned to the sea in Massawa next to the holding facilities. It was claimed that only one or two percent of their collected fish were disposed of in this way. This company was responsible for 86% of fish exported in the first 21 months of the Eritrean trade.

In contrast to the well-established nature of the American company, the other 14% of fish were collected and exported by a joint Eritrean–German venture. Their holding facilities were located in Asmara, requiring both seawater and freshly collected fish to be shipped by truck from Massawa. The holding facilities were less sophisticated, using only a sand/gravel biological filtration system. This company also lacked the reliable trade network of the multinational, resulting in longer delays before export and further mortalities. These problems led to mortality rates being economically unviable, eventually causing the company to cease operations in 1997.

A third company began operations from Massawa in 1997. Although not as experienced and sophisticated as the American company, they used similar collecting and exporting methods. Their holding facilities were significantly different however, utilising fresh seawater pumped directly from the sea adjacent to the facilities.

Monitoring and control of the trade

The MoF was responsible for monitoring and managing the trade. Initial permission to commence trading was given through agreements between the companies, the Eritrean Investment Centre and the MoF. Table 2 summarises the various measures that were in place in 1997.

Table 2. Government measures for monitoring and control of the Eritrean aquarium fish trade

Monitoring or control measure	Purpose	Comments
Occasional accompaniment of collecting trips by MoF observers	Monitor collecting practices and sites for environmental damage	Useful to gain impression but undertaken infrequently. Fishers may alter practices on observed trips
Ban on exporting ornamental invertebrates	Prevent habitat degradation due to removal of coral and 'live rock'	Apparently adhered to. Perhaps unnecessary in the case of mobile molluscs and crustaceans
Closed areas at certain points around Massawa	Provide areas for monitoring and conservation	Ignored by and apparently unknown to collectors. Would be useful if effective
Export inspections	Quantify exports, monitor practices	Conducted on each packing occasion. Generates detailed export statistics. Inspectors must be competent at identifying to species level
Levy equivalent to 20% of sale price payable to Eritrean government	Earn revenue for Eritrea from aquarium fish resource	Potential for mis-reporting of prices to be quoted by companies. Dead fish not paid for. Fixed rate for observed exports may be preferable
Licence/agreement issuance by Eritrean government	Control and monitor collecting operations	Gives control over operations to Eritrean authorities. Creates strong position for negotiation/ enforcement of other measures. Non-compliance by Eritrea allows companies a 'get out clause'
Provision that Eritreans are employed and trained by companies	Impart knowledge and trade skills to Eritrea. Allow development of industry in Eritrea	Not heeded – collection conducted by Filipinos and Sri Lankans

DISCUSSION

Sustainability of the fishery

A relatively low-volume fishery, potentially dispersed over the expanse of Eritrea's coastal and island reef systems and utilising so many different target species would apparently be unlikely to result in overexploitation. However, if collecting effort was concentrated on particular areas (for logistical reasons) and particular species (for market demand or ease of capture reasons) certain localised populations could rapidly become overfished. Ohman *et al*. (1993) report local extinction of some fish species of ornamental appeal from patches of heavily exploited reef in Sri Lanka and Wood (1985) reviews other examples of depletion of species due to the aquarium trade. Export statistics show that over 90% of effort was directed at only 15 species, and Figure 4 indicates that numbers of fish collected were not related to abundance. At the time of the study there were no data available on the distribution of fishing effort. Fisheries commonly cease when the target species becomes severely depleted, as they become economically untenable. However, multispecies fisheries can continue beyond this point as collections are sustained by other species. High-value or easily-captured species are then vulnerable to local extinction.

There was inevitably a certain level of mortality associated with capture, transport and holding. These fish were a loss to the stock in addition to those that were successfully exported. The manager of one of the companies stated that only 1–2% of fish died or were rejected at any stage. Mortality from the Sri Lankan ornamental fishery was estimated at 17% (Wood, 1985) but the trade was possibly more organised in Eritrea with all collections being carried out by employees of the exporting companies. These collectors had a direct interest in the health and quality of the fish for export and were likely to have been trained by the companies. The aquarium trade companies only paid a levy on fish that had been exported and sold. Those fish that died before export were lost to the fishery without any record or financial benefit to Eritrea.

Some species of fish have requirements for particular foods or conditions which makes them difficult or impossible to keep in a normal aquarium. Most obligate coral feeders fall into this category and if exported, are unlikely to survive (K. Davenport, Ornamental Aquatic Trade Association, UK, pers. comm.). This is undesirable from an ethical point of view and there is also a danger of extra pressure being exerted on the natural populations to replace the dead fish. A survey of regulations, traders and aquarists conducted by the UK Marine Conservation Society (Wood, 1992), gave concern for the suitability of two of the commonly exported Eritrean species, on the basis that their diet or habitat requirements cannot be met and/or their behaviour is incompatible with a captive life. These were the orange-face butterflyfish *Chaetodon larvatus* (Cuvier) and to a lesser extent the white-face butterflyfish *Chaetodon mesoleucus* (Forsskal). Both these species were being exported in moderate amounts but the low densities of

C. mesoleucus observed around Massawa suggest that this species would have been more at risk.

Categorisation of unsuitable species has some complications and limitations. The survival of some species depends on the size at which they are caught, younger specimens being able to adapt better to life in captivity (Wood, 1992). Other species have local variations in feeding habits so that in some regions the fish are conditioned to feed on a food that it is impossible for the hobbyist to provide (Wood, 1992). Improvements in fish food technology, including novel live-food cultivation techniques, and husbandry may also allow a wider range of species to be successfully maintained in the future.

Information needs for management

Despite the simple nature of the fishery, the short marketing chain and the collection of detailed export statistics, management of the fishery was still hampered by a lack of information. Without reliable information on the geographical distribution of collecting effort and the natural status of fish stocks, it was impossible to determine whether the resource was being fished sustainably.

The presence of Ministry staff on collecting trips and spot checks on holding facilities would continue to increase knowledge of collection operations. To judge whether collection is having any effect on the populations, ecology or areas of coral reef habitat, more information would be particularly needed on the aspects of collecting operations shown in Table 3.

Aquarium fish collectors are a potentially useful source of the information in Table 3. Their involvement in data collection, as practised in The Sri Lanka Marine Aquarium Fishery Project (Marine Conservation Society, 1988), allows the provision of catch and effort data. This collaborative approach to research would be highly beneficial in Eritrea where human resources of the MoF were limited. Spot checks would still be advantageous to check the reliability of the incoming data.

Table 3. Information on aquarium fish collection required for management of the Eritrean trade

Information	Use for management
Distribution of fishing effort, i.e. time spent, numbers and species of fish taken at each site	Allow sites with varying amounts of effort to be compared to indicate impacts of collection. Allow sites of potential local over-exploitation to be identified and monitored
Exact methods used by each operation at each site	Indicate potential impacts on reef system (e.g. anchor damage, broken *Acropora* tables etc.)
Level of mortality and rejection between capture and export for different species	Allow actual number of fish removed from sea to be estimated

Benefits of the aquarium trade

Assuming that the political environment allows the commencement of the trade and provided that the resource can be monitored and managed in a sustainable fashion, there are several potential benefits for both Eritrea, and generally for the conservation of Eritrea's reefs. Although there is considerable awareness of the merits of habitat and biodiversity conservation in Eritrea, the primary concern is inevitably for economic development. Although the aquarium trade is a small industry, it has the potential to provide sustainable economic benefits in terms of helping to balance national trade deficits, and by providing government revenues through export levies. Employment is also generated directly for collectors and employees of the aquarium companies, and indirectly for boat services, net manufacturers, and transportation services.

These economic benefits give a strong incentive for government policy to safeguard reef ecosystems from other impacts. The results of this study suggest that large scale impacts of pollution and disturbance were the most pressing threats for the ecosystems. The world's poorest countries cannot be expected to incur the costs of mitigating these impacts without some economic return from the reefs. A sustainably managed aquarium fish trade, dependent on diverse and healthy reef systems, has the potential to generate considerable earnings with relatively little negative impact but with direct incentives for governments to facilitate the conservation of coral reefs.

There is currently much interest in the development of captive breeding and mariculture of aquarium species. The first *Pomacanthus asfur* and also Yellowbar angelfish *P. maculosus* (Forsskal) were recently bred in commercially viable numbers in Taiwan (Ornamental Fish International, 1999). As these two species are the most economically important species in the Eritrean trade, their large-scale captive breeding would inevitably have a negative impact on the economic viability of the trade. Whether captive breeding programmes will expand to this extent, however, remains to be seen. Other species which can be bred successfully in captivity, such as clownfishes, are still only being produced in relatively low numbers and there is, as yet, no evidence that this activity will take over from *in situ* collection. Given the considerable potential economic and conservation advantages of the trade described above, the development of *ex-situ* aquaculture without economic ties to the original source countries could, in situations like Eritrea's, impair conservation efforts.

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REFERENCES

Daw, T.M., Rogers, G., Mapson, P. and Kynoch, J.E. (1998) Reefs of Massawa Expedition 1997: Final Report. Xi + 99pp., Illustr.

English, S., Wilkinson, C. and Baker, V. (1994) Survey manual for Tropical Marine Resources. ASEAN – Australia Marine Science Project: Living Coastal Marine Resources, 386pp.

Habte, I. (1997) *Aquarium fish trade in Eritrea.* Internal paper. Research and Training Division, Ministry of Fisheries, Eritrea, 11pp.

Hillman, J.C. and Tsegay, S. (1997) *Coral reef research and conservation in Eritrea: Are Profile.* Paper presented to the Western Indian Ocean Regional Workshop on Coral Reef Research and Conservation, 12pp.

Marine Conservation Society (1998) *Management of Marine Aquarium Fisheries and conservation of Coral Reef Biodiversity in Sri Lanka*, Project Update, Feb. 1998, 5 pp.

Ornamental Fish International (1999) Taikong's angelic success. *Ornamental Fish International Journal*, **29**, 2.

Ohman M.C., Rajasuriya A. and Linden O. (1993) Human disturbances on coral reefs in Sri-Lanka – A case study. *Ambio*, **22**, 474–480.

Wood E.M. (1985) *Exploitation of Coral Reef Fishes for the Aquarium Trade.* Report to the Marine Conservation Society.

Wood E.M. (1992) *Trade in tropical marine fish and invertebrates for aquaria: proposed guidelines and labelling scheme.* A report for the Marine Conservation Society. 36pp.

World Bank (1995) *World Development Report*. Washington: World Bank.

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