ELSEVIER

Rapid shifts in catch composition in the artisanal Red Sea reef fisheries of Eritrea

Iyob Tsehaye [a,b], Marcel A.M. Machiels [a], Leopold A.J. Nagelkerke [a,*]

[a] *Aquaculture and Fisheries Group, Wageningen University, Wageningen Institute of Animal Sciences, Marijkeweg 40, 6709 PG Wageningen, The Netherlands*
[b] *Department of Marine Sciences, College of Sciences, University of Asmara, P.O. Box 1220, Asmara, Eritrea*

Abstract

Shifts in catch composition were registered in the Eritrean artisanal fisheries, which were launched into a renewed development after the end of the independence war in 1991. Our analysis of catch and effort data showed that total fishing effort as well as total annual catch increased more than two-fold from 1996 to 2002. Yet, overall CPUE remained unchanged upon the expansion of the fisheries, suggesting that the fisheries are still at an early stage of development. However, at lower taxonomic level, we found that the CPUE for emperors (Lethrinidae), snappers (Lutjanidae), and sharks (Elasmobranchii) decreased, while the CPUE for barracudas (Sphyraenidae), jacks (Carangidae), and tunas (Scombridae) increased. Thus, the species composition of the catches shifted toward a smaller proportion of high-value demersals (from ca. 70% in 1996 to ca. 30% in 2002), implying a change in the underlying fish community structure. Changes in CPUE could not be attributed to changes in spatial effort allocation, or to changes in gear or boats used, ruling out changes in fishing strategies as likely causes. Yet the decline in CPUE at low fishing effort does not necessarily reflect a proportional decline in fish abundance, and could possibly be caused by "hyperdepletion". Nevertheless, the trends in CPUE are consistent with earlier findings that stocks of reef-associated demersal fishes are highly vulnerable to fishing and can decline even at the early stages of the fisheries. Therefore, the changes in CPUE could indeed represent true biomass changes, with potentially important ecological consequences. These effects could even become more severe if market conditions improve, leading to activation of latent fishing capacity, which was found to make up about 75% of the registered fleet.
© 2007 Elsevier B.V. All rights reserved.

1. Introduction

The reef-associated fish resources of Eritrea's Red Sea coast have mainly been exploited by artisanal fisheries. These fisheries were launched into a renewed development in 1991 after the end of a decades long war for independence that had ground the fisheries to a halt (Reynolds et al., 1993). Since major changes in reef fish community structure can take place even at the initial stages in the development of fisheries (Dulvy et al., 2004a,b), the onset of reef fisheries in the Eritrean Red Sea presents an opportunity for exploring the effects of fishing on fish community structure in a newly developing fishery.

Most fishing operations in the Eritrean artisanal fisheries are carried out using small traditional wooden boats and primarily target reef fish and mid-sized and large pelagic fish (Reynolds et al., 1993). As a result, catches have predominantly been composed of long-lived, high trophic level, piscivorous species (Ghebremichael and Haile, 2006). However, despite continued efforts by the Eritrean Ministry of Fisheries to expand the fisheries, fishing effort is presumed to have remained relatively low, and fish stocks have thus been considered lightly exploited. Annual catches reported for the artisanal fishery rarely exceed 1000 tonnes year^{-1} (this study) and the combined total annual catches of the artisanal and (intermittent) industrial fishery amounted to a maximum of about a fifth of the maximum sustainable yield for the Eritrean Red Sea, which was estimated to be between 36,000 and 79,500 tonnes year^{-1} (Sanders and Morgan, 1989; Ghebremichael and Haile, 2006) (Table 1). In addition, some preliminary studies have documented a low level

Table 1
Estimates of the maximum sustainable yield (MSY) from Eritrean Marine Waters (in 1000 tonnes year^{-1}) from three independent studies

Resource	MSY[a,b]	MSY[c]	MSY[d]	MSY[e]
Demersal fish	10.0–15.0	8.5	18.0	17.0 + 5.0 (reef)
Shrimp	0.5	0.5	0.5	0.5
Spiny lobster (whole)	0.5	–	0.5–1.0	0.5
Coastal pelagics	50.0	25.0	25.0–50.0	24.0
Neritic and oceanic pelagics	–	–	5.0	6.0
Sharks	5.0	2.0	2.0–5.0	5.0
Total	66.0–71.0	36.0	51.0–79.5	58.0

[a] Grofit (1971). Available at the Ministry of Fisheries Library, P.O. Box 18, Massawa, Eritrea.
[b] Aubray (1975).
[c] Gaudet (1981). Available at the Ministry of Fisheries Library, P.O. Box 18, Massawa, Eritrea.
[d] Guidicelli (1984).
[e] Antoine et al. (1998). Available at the Ministry of Fisheries Library, P.O. Box 18, Massawa, Eritrea.

of exploitation, citing a constant aggregate catch per unit of effort (CPUE) over the years[1] (Moussalli and Haile, 2001). The claim of a low level of exploitation has also been evidenced by the predominance of long-lived, high trophic level, piscivorous species in the catches (Habte, 2003). Nonetheless, the total annual catch reported for the artisanal fisheries has been increasing over the years (this study). In addition, anecdotal evidence suggests that large amounts of catch are taken illegally to Yemen, where market circumstances are better than in Eritrea. These illegal catches may be as large as two thirds to three quarters of the total annual catch in the artisanal fisheries (Moussalli and Haile, 2001). When these amounts are included, the actual level of fishing in the artisanal fisheries is found to be much higher than officially reported. Moreover, even if fishing effort is limited, it is highly selective, mainly targeting predatory, high-value fishes. These circumstances underline the need for an effective assessment and management of the artisanal fisheries.

The assessment and management of the artisanal reef fisheries, like all reef fisheries, poses special challenges owing to the high diversity of target and non-target fish and invertebrates and the fragility of the ecosystem (Pauly and Murphy, 1982; Welcomme, 1999). This is particularly so given the concentration of fishing effort on selected species of fish, which are usually highly vulnerable to overfishing (McClanahan et al., 2002; Wilkinson, 2002; Dulvy et al., 2004a; Sadovy, 2005). The concentration of effort on few species could not only result in rapid over-exploitation of the target species, but also have far-reaching consequences for the overall community structure through top-down effects of fishing on ecosystems (Jennings and Lock, 1996; Parsons, 1996; Dulvy et al., 2004a).

Just as in most multispecies, multigear fisheries in the developing world (Christensen, 1996; Larkin, 1996; Bundy and Pauly, 2001), only limited research has been conducted on the state of fish stocks and fisheries in Eritrea, rendering the fisheries data-poor. The scarcity of data in these fisheries precludes the application of traditional assessment methods, which are usually readily applicable in temperate settings (Sparre, 1991; Magnusson, 1995). In such a data-poor situation, the use of

catch and effort data is the most viable option for evaluating the status of fisheries and fish stocks (Sparre and Venema, 1998; Vasconcellos and Cochrane, 2005). Consequently, the present study draws on fisheries-dependent data to assess the state of the reef-associated fisheries and fish stocks of Eritrea. In the use of fisheries-dependent data to monitor the state of fish stocks, changes in catch rate are assumed to reflect changes in fish abundance. However, changes in catch rate could be confounded by changes in fish targeting strategies, potentially leading to spurious conclusions concerning the state of fish stocks. Thus, catch rates can only be used as valid indicators of abundance if they are adjusted to account for changes in fishing strategies (King, 1995; Caddy et al., 1998; Myers and Worm, 2003). Taking these limitations of fisheries-dependent data into account, the objectives of the present study were (1) to describe the artisanal Eritrean fisheries in terms of developments in catch and effort, (2) to determine if there were significant trends in catch rate and species composition over the years and (3) to explore if trends in catch rates and species composition were potentially caused by changes in fish abundance.

2. Materials and methods

2.1. Characteristics of the fisheries

The fishing activities in the artisanal fisheries mainly take place in inshore waters off Eritrea's Red Sea coast. The coastline is approximately 1720 km long, about 1155 km of which lying along the continental shore and about 565 km around some 350 islands (Fig. 1). Most of the fishing operations are concentrated around the islands in the Dahlak archipelago, a group of more than 200 islands scattered from 20 to 160 km off Eritrea's main port of Massawa. The shelf area around the major fishing grounds of the Dahlak archipelago represents about 25% of Eritrea's total continental shelf area of 56,000 km^2. About 20% of the total shelf area, where most of the artisanal fisheries take place, is less than 30 m deep (Guidicelli, 1984). These shallow waters are off-limits to trawl fishing by industrial fisheries. The Ministry of Fisheries enforces these area restrictions by dispatching inspectors aboard trawlers on every fishing trip

[1] Hartmann (1998). Available at the Ministry of Fisheries Library, P.O. Box 18, Massawa, Eritrea.