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The Western Indian Ocean as a Source of Food

Johan Groeneveld

Opposite page: Fish drying at the Ruvuma Estuary, Tanzania. © José Paula.

INTRODUCTION

The Western Indian Ocean (or FAO major fishing area 51) extends from eastern South Africa in the south to India and the Arabian Gulf in the north. The present chapter deals only with the sub-area south of the equator, namely the Southwest (SW) Indian Ocean. The SW Indian Ocean region has a sub-tropical / tropical climate, with warm water characterised by high biodiversity, hotspots with high endemism, fishes with unique behaviour, and taxa of special design and physiology (Figure 20.1) (Smith and Heemstra 1986, van der Elst and others, 2005). It claims the world's oldest fish, the coelacanth (*Latimeria chalumnae*), and the world's largest fish, the whale shark (*Rhincodon typus*). In contrast to high biodiversity, the biomass of individual species is generally low, with marine productivity depending more on nutrient input from rivers along the coasts of eastern Africa and Madagascar, than on upwelling systems (Caddy and Bakun 1994).

Coastal inhabitants of most SW Indian Ocean countries rely heavily on fishing as a source of food and economic activity, and over many centuries fishing has become part of local culture and customs (Christie 2013). Rock paintings show that fishing took place as long as 40 000 years ago (Erlandson and Rick 2010, Gartside and Kirkegaard 2007), and more recently, the development of artisanal fishing in Ungwana Bay (Kenya) in the 9th century coincided with the rise of the East African Indian Ocean trade with Arabia, Persia and India (Fulanda 2003). Early human inhabitants were few and had comparatively small needs; thus they may only have impacted lightly on coastal environments and exploited fish stocks. Rapid population growth and global economic expansion over the past 50 years have, however, exponentially increased the pressure on coastal resources (Jackson and others, 2001, Vitousek and others, 1997). Overfishing and coastal developments hasten long-term changes to productivity, with outcomes such as reduced abundance and biological diversity.

After humans, top predators in the SW Indian Ocean are large sharks, marine mammals (mostly whales and dolphins) and seabirds. Large migratory tuna schools and billfish predate on small mesopelagic fishes, crustaceans (swimming crabs) and cephalopods (Potier and others, 2007), which in turn depend on secondary and primary productivity at lower trophic levels (José and others, 2014, Potier and others, 2014). The oligotrophic (nutrient-poor) nature of coastal waters coupled with high biodiversity underscores an interesting question: whether overfishing of higher-level predators such as sharks and tunas will alter marine food webs, with cascading consequences (Baum and Worm 2009, Pauly and others, 1998). Such a pattern might be observed from changes in the species composition of catches.

Compared to fishing, mariculture is a newcomer to food production in the SW Indian Ocean. Most documented mariculture initiatives date from the 1990s to present, but apart from successful seaweed farms, mainly in Zanzibar, farming of other organisms, such as prawns, fish

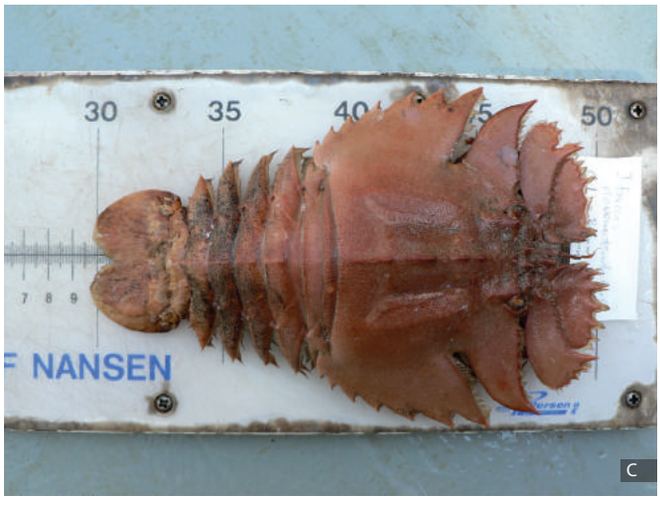

Figure 20.1. (a-c) The SW Indian Ocean is characterized by high biodiversity, hotspots with high endemism and colourful species of special design and physiology. **(a)** Emperor angelfish *Pomacanthus imperator*; **(b)** bluebarred parrotfish *Scarus ghobban* and coral rockcod *Cephalopholis miniata;* and **(c)** smooth fan lobster *Ibacus novemdentatus*. © Johan Groeneveld

and seacucumbers, have had mixed results (see Chapter 22). Nevertheless, there appears to be a general feeling of optimism around future prospects, particularly in Madagascar, Mozambique, Tanzania and Kenya (Troell and others, 2011).

Part V describes the longer term trends in the abundance of key species groups important for food security, and the social and economic aspects of fisheries and mariculture practices in the SW Indian Ocean. Observed trends are based on fisheries data from many different sources, which are often sparse, or not well resolved at species or spatial levels (van der Elst and others, 2005). Nevertheless, in combination this information provides important insights into the present status of fish resources, relative to systemic drivers such as climate change, population growth, and associated pressures such as increasing fishing and coastal development. Although all the riparian countries of the SW Indian Ocean subscribe to the Code of Conduct for Responsible Fisheries (FAO 1995), their ability to comply with it and to introduce effective measures to ensure long-term sustainability is compromised by economic and socio-political realities. Therefore, Part V also addresses emerging issues in capture fisheries and mariculture in the region, relative to progress made towards specific Millennium Development Goals (MDG).

GEOGRAPHICAL EXTENT

The SW Indian Ocean covers the maritime zones (Exclusive Economic Zones up to 200 nm offshore) of eastern South Africa, Mozambique, Tanzania (including Zanzibar), Kenya, Somalia, Madagascar, Mauritius, Seychelles, Comoros and France (by virtue of its islands including Mayotte and Reunion) (Figure 20.2; van der Elst and others, 2009). This vast area is influenced by major ocean current systems and submerged landforms, such as continental shelves, slopes and basins, mid-ocean ridges, seamounts and ocean trenches. Monsoon winds affect coastal flow in the north, where the East Africa Coastal Current (EACC) strengthens during the southeast monsoon, and weakens during the northeast monsoon, giving rise to a seasonally reversing Somali Current (Schott and McCreary Jr 2001, Schott and others, 1990). Upwelling and deep-water mixing makes the Somali Current region nutrient rich and productive, compared to oligotrophic waters further to the south. The westward flowing South Equatorial Current (SEC) flows across the Mascarene Plateau, and encounters

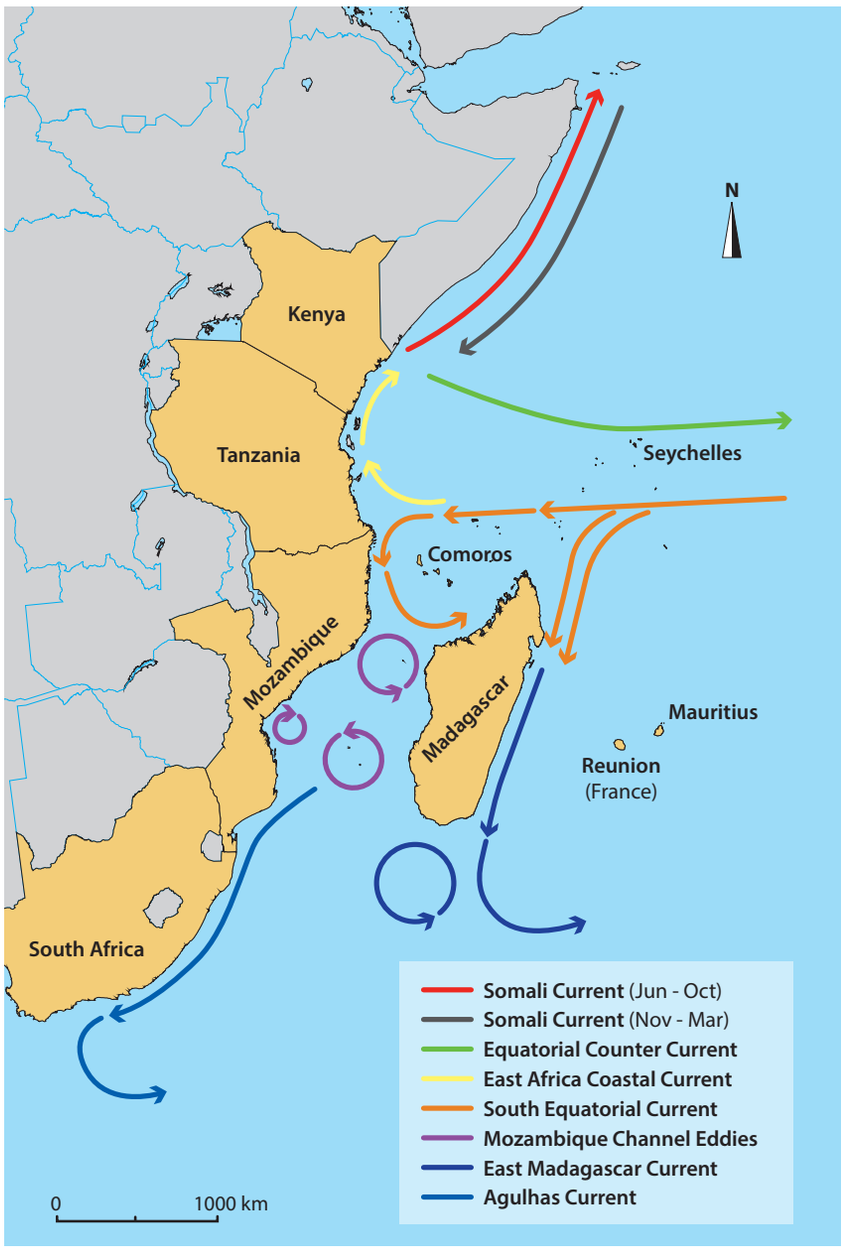

Figure 20.2. The developing countries of the SW Indian Ocean are some of the poorest in the world, but they flank onto a tropical ocean with high biodiversity and potentially rich fishing grounds. The ecosystems of the SW Indian Ocean are governed by complex ocean current systems, and monsoon seasons in the north. Adapted from Lutjeharms 2006.

eastern Madagascar, where it forks to form the East Madagascar Current (southern branch) and a northern branch that feeds into the EACC. The general circulation of the Mozambique Channel is characterised by mesoscale cyclonic and anticyclonic eddies or cells (Lutjeharms 2006, Ternon and others, 2014). The Agulhas Current originates near the southern extreme of the Mozambique Channel, and flows southwest along the shelf edge, within a few kilometres of the coast in eastern South Africa. The current moves further offshore where the Agulhas Bank widens, and it eventually retroflects northwards to form the Agulhas Return Current.

Shelf topography is narrow and steep along much of eastern Africa, widening in bights or near river deltas, such as the Natal Bight (South Africa), Maputo Bay and the Boa Paz Banks (Mozambique), the Rufiji Delta (Tanzania) and Malindi-Ungwana Bay (Kenya). A fringing coral reef extends between 0.5 and 2 km offshore along much of the Kenya and Tanzania coasts, creating shallow coastal lagoons that are easily accessible to fishers. Madagascar has an EEZ of 1.14 million km^2; its western coast consists of many estuaries and bays, colonized by dense mangrove forests, while

the eastern coast is straight and featureless, with few estuaries, capes and bays.

UTILIZATION OF SEAFOOD BY HUMANS FROM HISTORICAL TIMES TO THE PRESENT

Archaeological sites with marine shells, fish bones, fishing tools, and rock paintings as evidence of exploitation of inshore marine resources for food date from about 200 000 years BP (Breen and Lane 2004, Hu and others, 2009). Later Stone Age (4 120 years BP) hunter-gatherers used simple dug-out canoes, and by 2 300 years BP the entire littoral zone in some areas of the coast was fished using stone tool technology (Breen and Lane 2004). New forms of settlement such as stone-built architecture arose along the coast after the 8th century AD, and at this time hook-and-line and trap fishing originated. True commercialization of the SW Indian Ocean started after the 9th century, when fishing practices expanded greatly and trans-oceanic trade in commodities was introduced (Breen and Lane 2004). From about the 11th century, neritic species such as sharks and barracuda were captured using lures, and other species were fished to such an extent that several taxa showed patterns of decline over time (Christie 2013). The advent of colonialism with the arrival of the Portuguese and more modern fishing techniques in the late 15th century altered many traditional practices and economies. This was exacerbated by a shift in the balance of political power towards Oman and Zanzibar in the 17th century. Twentieth and 21st century changes in the use of marine resources have been shaped by gradual technological advances in fishing gear allowing easier access to deeper water (Kennelly and Broadhurst 2002), independence from colonialism, rapid growth of human populations and economic globalization. Today the fishermen along the coasts of the SW Indian Ocean rely heavily on marine resources across large areas of the continental shelf for food security, local trade and export to foreign markets.

SOCIAL AND ECONOMIC IMPORTANCE OF SEAFOOD

An estimated 60 million people live within 100 km of the coast in the wider WIO region (van der Elst and others, 2005), and many of them rely on the sea for their economic, social and cultural security (Standing 2009, FAO 2010, Cox 2012,). Some states in the region are amongst the poorest in the world, based on *per capita* Gross National Product (GNP) (Cunningham and Bodiguel 2005, World Bank 2011a) and a low Human Development Index (HDI) (UNDP 2013). About 80 per cent of Mozambicans live in rural areas, and 50 per cent of them rely on fish for their main protein source (van der Elst and others, 2005). The export of fish products, mainly prawns, is also a major contributor to gross domestic product (GDP) of Mozambique (FAO 2010, UNEP 2014). In Mauritius, almost all of the fish landed by the domestic sector is locally consumed, except for some high-value species that are exported (Cox 2012). A large tuna-canning factory and international fishing port in Seychelles process fish products, responsible for about 95 per cent of domestic exports (Heileman and others, 2009). Marine capture fisheries in the SW Indian Ocean are typically structured into artisanal fisheries (also called traditional, subsistence or small scale commercial fisheries) and industrial fisheries (or semi-industrial) that operate further from the coast using ocean-going fishing vessels (see Chapter 21). Compared to capture fisheries, mariculture (Chapter 22) is still in its infancy, but it is encouraged by governments as an alternative to generate fish protein and wealth, especially when capture fisheries are in decline (Rönnbäck and others, 2002).

Trading, processing (including salting and drying) and distribution of fish catches at local markets along the coast are important economic activities. Local women do most of the trading at fish markets, where they form an important role in the processing and distribution chain. Catches on these markets come mainly from artisanal fishers using small boats in nearshore waters. Women also participate in artisanal fishing, mostly by wading in the intertidal during low tides to collect invertebrates and small fish. Artisans that make and repair boats and fishing gear, and middlemen that own and rent out their own gear (seine or gill nets) or boats are also important (Jiddawi and Ohman 2002). Migrant fishers follow fish movements along the coast, thus illustrating a social adaptation to a complex environment (Fulanda and others, 2009). These migrations are associated with social and economic challenges at home and at host destinations. Fishing and its trade is therefore intricately interwoven into the socio-ecological systems of coastal communities (see Chapter 23).

Seaweed is cultured in shallow subtidal areas in Zanzibar and Pemba Islands (Tanzania), mostly by women (Bryceson and Beymer-Farris 2011). Dried seaweed is sold to middlemen, exported and used for medicine, toothpaste and agar. Fish culture is presently a small industry, with

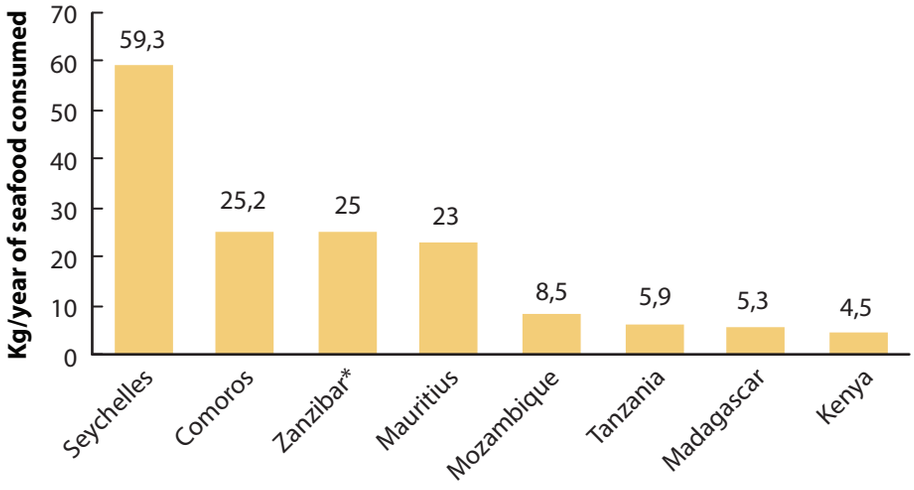

Figure 20.3. Per capita seafood consumption is much higher in island states than on the mainland, reflecting the maritime influence on communities living against the sea. *Zanzibar = part of the United Republic of Tanzania.

some farming of milkfish, sea cucumber, *Scylla* crabs and oysters (for pearls). Traditional fishers in southwest Madagascar grow sea cucumbers for export (Robinson and Pascal 2009, Iltis and Ranaivason 2011) and participate in community-based culture of red seaweed. Commercial prawn farming in Madagascar and Mozambique began in the mid-1990s, with development aid and technical assistance of the UNDP and FAO. Rising production costs, lower global prices for farmed prawns and white spot syndrome plagued prawn farms after 2007, but a rising demand for high quality products in China revived farming after 2012. A detailed description of mariculture in the SW Indian Ocean is provided in Chapter 22, and the social and economic importance of capture fisheries and mariculture is described in Chapter 23.

REGIONAL VARIATION IN HUMAN DEPENDENCE ON SEAFOOD

Per capita seafood consumption on small islands of the SW Indian Ocean (Comoros, Mauritius and Seychelles) is much higher than in Madagascar or the East African mainland states (Figure 20.3). Seychelles ranks 12th in the world for *per capita* seafood consumption (59.3 kg), and in Zanzibar seafood consumption is also high (17-30 kg; Jiddawi and Ohman 2002, Jiddawi 2012). The reliance on seafood on small islands reflects the relatively limited space for agriculture, and the proximity of communities to the sea, thus fostering a maritime culture. On the East African mainland, annual *per capita* seafood consumption is much lower, for example 3.4 kg in Kenya and 5.5 kg in mainland Tanzania (Kariuki 2005). Here, agriculture provides most animal protein, except along the coast and in burgeoning coastal cities, where seafood is more important.

Total reported landings of marine species in the region are highest in Madagascar and Mozambique. These two countries have the longest coastlines and large well-organized industrial fisheries, eg trawling for crustaceans. They also provide concessions to foreign vessels to fish for large pelagic fishes in their waters. Despite its small size and population but vast EEZ, Seychelles also reports a large marine catch, mainly because foreign longliners and purse-seiners land catches of large pelagic fishes there. A relatively long coastline, and several small islands with a maritime culture (Zanzibar, Pemba, Mafia) can explain higher landings in Tanzania than in Kenya, where the coastline is shorter and marine fisheries produce far less than those from freshwater bodies. It is almost certain that landing statistics vastly under-represent actual landings (Jacquet and others, 2010), especially in countries with large artisanal fisheries in remote areas, where catches are infrequently reported.

EMERGING ISSUES IN CAPTURE FISHERIES AND MARICULTURE

Open access fisheries: These fisheries, in which the numbers of fishers, methods used, and harvest quantities are not controlled, inevitably lead to overexploitation and habitat degradation, particularly when the numbers of fishers and their needs continue to grow. This is the main issue facing capture fisheries in the SW Indian Ocean (van der Elst and others,

2005). Given the heavy reliance of coastal communities on fisheries for food security, placing limits on harvests cannot be done without major social, economic and political upheaval, and the provision of alternative livelihood options. Consequently, there is limited political will to effect change, even in the face of strong evidence of overfishing.

Illegal, Unreported and Unregulated (IUU) fishing: This includes fishing without permission from national or international authorities, not reporting catches, or ignoring closed seasons or areas, catch limits, species limits, or gear specifications (Laipson and Pandya 2009). In the SW Indian Ocean, IUU fishing refers not only to the artisanal sector, in which many fishers are unlicensed, but also to industrial fisheries (long-lining, purse-seining, gill-netting) that operate further offshore in territorial or EEZ waters. They fall under the jurisdiction of coastal states (through licensing) or regional organizations (such as the Indian Ocean Tuna Commission, or IOTC), but most states do not have the capacity to enforce national or international laws. Consequently, IUU fishing is common in the SW Indian Ocean, where it is responsible for considerable economic, social and ecological losses in developing countries (MRAG 2005)

Development of deep-sea fisheries: To offset declining catches in nearshore fisheries, states are increasingly looking further offshore to increase catches. However, sustainable exploitation appears to be feasible for only very few deep-sea species under prevailing economic conditions and governance arrangements (Norse and others, 2012), mainly because these species are often slow-growing and have low productivity. This was recently demonstrated for a deep-water trap fishery in eastern South Africa, where spiny lobster biomass was rapidly depleted, despite low fishing effort (Groeneveld and others, 2012). The discovery of orange roughy (*Hoplostethus* sp.) concentrations on SW Indian Ocean seamounts in 1999 led to an 'explosion' of fishing effort, when 53 vessels flagged to 17 states suddenly arrived in the area (www.siodfa.org). Such was the influx of fishing vessels that *Fishing News International* (May 2000 issue), referred to "Roughy Bonanza in Indian Ocean". The fishery collapsed within a year. Other deep-sea fisheries are for alfonsino (*Beryx splendens*) and red snapper (*Etelis coruscans*) (Bensch and others, 2008).

Moving from management of single species to ecosystems approaches: Single-species approaches to fisheries management do not consider broader social, economic or ecological consequences (Jennings 2006). A paradigm shift towards managing whole ecosystems developed after the 1992 Rio Declaration on Environment and Development (United Nations Code of Conduct for Responsible Fisheries; FAO 1995). The ecosystem approach to fisheries management (EAF) is a relatively new concept in the region and supported by most states, although implementation is slow. Using ecological indicators for evaluating and comparing the status of exploited marine ecosystems in the SW Indian Ocean is a promising initiative (Shin and Shannon 2010) - a good example for the prawn fishery in coastal Kenya is provided by Swaleh and others, (2015).

From national to regional fisheries management strategies: Cooperative management of shared fish stocks among neighbouring countries may confer many ecological and economic advantages, but it is also a complex political process (see Payne and others, 2004, and the papers therein). Highly migratory tunas and billfishes are shared stocks (usually straddling stocks in high seas and EEZ waters) and managed by the IOTC. Other stocks (eg deep-water prawns) that occur across geopolitical boundaries are potentially shared, because the harvesting activities of one country may impinge on the opportunities of another (Everett and others, 2015). This has led to several recent initiatives to determine which stocks are shared and to regionalize and align fisheries policy and management objectives (van der Elst and others, 2009).

Co-management through Beach Management Units (BMUs): New legislation in some countries (e.g. Kenya, Tanzania) allow for the establishment of BMUs to co-manage fisheries jointly with officials of fisheries departments. BMU objectives are to strengthen the management of fish landing stations, involve all stakeholders in decisions, and prevent or reduce user conflicts. The expectations and requirements of setting up and running a BMU are quite demanding, thus requiring considerable financial and logistic assistance (Oluoch and Obura 2008). Nevertheless, it currently remains the most promising management approach.

Research capacity and the linkage between fisheries management and applied research: The scarcity of competent fisheries researchers in the SW Indian Ocean region is presently being addressed through capacity-building initiatives by several international programmes (for example SWIOFP, SWIOFish, InteGRADE). The linkage between fisheries management requirements and applied research undertaken by a limited number of active scientists is presently inadequate. Consequently, crucial studies, such as those to estimate stock status, or to provide solutions to recent or long-standing management issues, are not prioritized.

There are very few active fisheries management plans of any kind in the region (WIOFish 2011).

Mariculture: Mariculture is encouraged by governments as an alternative activity to generate fish protein and wealth. It is an important emerging issue with high complexity, from area planning (over land and maritime areas), to finding the right species and culture technology, and to encouraging responsible mariculture practises (see Chapter 22).

THREATS TO CAPACITY OF THE WIO TO PRODUCE SEAFOOD

Climate change, as a driver of the state of the ocean, and human use patterns, as direct impacts on the health and functioning of ecosystems, are the primary threats to food security. Climate change will potentially cause changes to sea level, the pH of oceans, water temperature and primary productivity over the next decades. The effect of these changes on the capacity of the ocean to produce food is not yet fully understood. At the same time, degradation of key habitats or nursery areas along the coast through dynamite fishing, use of drag- or mosquito nets, unplanned development, changes in land-use and fresh-water impoundments erode the biological systems on which ecological sustainability relies (Gammelsrød 1992, Wells 2009, Bush 2013, Mkare and others, 2014). Human populations in SW Indian Ocean states continue to grow at a rate of 2.5-3.0 per cent per year (2010-2014 data; World Bank 2011b), with a concurrent increase in their dependence on food extracted from the ocean. It is difficult to see how the spectre of 'too many fishers, too few fish' can be avoided without successful interventions to reduce fishing pressure and mitigate impacts of coastal development on marine resources.

CONCLUSIONS

The lack of infrastructure and management capacity of SW Indian Ocean states to moderate the multiple threats to the marine environment as a source of food, coupled with the perilous socio-economic conditions of many coastal human populations, is of great concern. The relentless increase in need for food and raw materials by growing urban centres along the coast suggests that the pressure on marine resources will continue to escalate.

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