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Introduction

The Human Dimensions of Coastal and Marine Ecosystems in the Western Indian Ocean

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As conservation theory and practice moves away from excluding resource users to creating partnerships with them, it is becoming increasingly clear that marine conservation is as much about understanding people as it is about understanding ecological processes. Social, economic, and cultural factors can influence whether and how individuals and communities overexploit resources or cooperate to conserve them. Many marine conservation projects may fail because they do not adequately understand, address, and incorporate the socioeconomic needs and concerns of stakeholders. These issues are especially pertinent in the Western Indian Ocean; a region where poverty and the geopolitics of biodiversity conservation acutely intersect.

Keywords Africa, conservation, development, fisheries, human-environment interactions, marine protected areas, social-ecological systems, socioeconomic

Over the past several decades, there has been a sea change in the way that scientists and managers perceive human–environment interactions. Discourse was previously dominated by relatively simplistic views of the role that humans play in marine systems; humans were perceived as external agents that extracted resources, destroyed habitat, and caused pollution. Management, in this view, was focused on maintaining marine systems at, or restoring them to, pristine states by keeping human influences out. The reality, however, is more complex. Humans are consumers (conscious or unconscious) of services provided by coastal and marine ecosystems. Since the article by Costanza et al. in 1997 popularized the concept coined almost 30 years ago (Ehrlich and Mooney 1983), ecosystem services have become a new reading of the relationship between nature and society. Ecosystem services are central to the millennium assessment that the United Nations (UN) led in 2000 (MEA 2003, 2005). With the spread of ecosystem services, ecosystem-based management, and linked social–ecological systems approaches in the scientific community and among coastal managers, humans are now considered an integral part of marine and coastal ecosystems, in what is sometimes referred to as an anthroposystem rather than an ecosystem. In this

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more integrated view of human–environment interactions, humans can actively sustain key processes that maintain the flow of desirable goods and services. For example, establishment of marine protected areas can facilitate processes such as herbivory that are crucial to maintain coral dominated ecosystems (Bellwood, Hughes, and Hoey 2007; Hughes et al. 2007).

This special issue highlights key developments in this more integrated view of human–environment interactions with a special emphasis on the Western Indian Ocean (WIO); a region where poverty, geopolitics, and biodiversity acutely intersect. Geographically, the region is defined by numerous islands and archipelagos that spread on a large range of latitudes from the equator to 26° south latitude. Some of these islands are administratively and politically connected to the mainland; Zanzibar is part of Tanzania, Lamu archipelago belongs to Kenya and the islands Bazaruttos or Quirimbas are part of Mozambique. Some islands are politically part of Europe; as in the case of Mayotte and Reunion islands. Others, such as Comoros, Mauritius and Seychelles are small island developing states (SIDS), while Madagascar is one of the largest islands in the world. This "encounter" between mainland countries and island countries generate a large diversity in terms of area, socioeconomic development, and population. Tanzania, the country's largest, has a population approaching 44 million inhabitants. Seychelles has less than 100,000 inhabitants living in an area of 450 km^2, more than 2,000 times and 1,300 times, respectively, lower than Tanzania and Madagascar. From an economic perspective, diversity is also large in terms of Gross Domestic Product (GDP) or GDP per capita. Except the Comoros and Madagascar, the islands have GDP/per capita much higher than continental countries although the densities are also much higher (Table 1). With more than 500 inhabitants per km^2; Mauritius is the WIO region's most densely populated country.

Despite the great geographic and economic diversity, all countries in the WIO region share similar concerns regarding the management of their marine resources and preservation of habitats that support these resources, including coral reefs, mangroves, and seagrass. However, sustaining these ecosystems can be challenging, especially in parts of the region characterized by high levels of dependence on natural resources, limited finances, and weak governance. Many developing countries have what is referred to as "biomass-based"

Table 1
Geographical scope of the WIO region (sources population.data.net and Challenge)

Countries	Size (km^2)	Population	Density people/ km^2	GDP billons US$	GDP/people US$
Tanzania	945,088	41048,532**	43.43	20.72***	521***
Mozambique	801,590	21669,278*	27.03	9.65**	465**
Somalia	637,657	9832,017*	13.42	5.58***	600***
Madagascar	587,041	20042,551**	34.14	7.71***	391***
Kenya	581,787	37953,838*	65.24	27.03***	779***
Reunion	2,512	810,600*	323	14.70**	17,927**
Mauritius	2,040	1277,000*	626	9.16*	7,146*
Comoros	1,862	752,438*	401.1	0.53**	816**
Seychelles	450	87,478*	192.3	0.71***	8,600***
Mayotte	375	198,192*	528.51	1.13****	6,500****

*2009; **2008; ***2007; ****2005.

economies, where people primarily draw their productive assets from the available natural capital. Rapidly changing population, socioeconomic development, and markets can create new incentives for resource exploitation (Cinner et al. 2009; Schmitt and Kramer 2010), and influence the success of conservation efforts (Pollnac et al. 2010). In this context, individuals, businesses, and governments must balance development aspirations, which often require transforming natural capital (such as fish and forests) into financial capital, with investments in anthroposystem services to maintain the flow of natural capital. This special issue looks at the ways that ecosystem services are valued and measured; the role of markets in both creating development opportunities for SIDS and in depleting key ecosystem processes; the role of human population, social acceptance and institutional coordination in the capacity of communities to implement conservation strategies that promote anthroposystem services.

In the context of biomass-based economies, it is critical to understand how ecosystem services are valued and how this, in turn, influences which services are invested in. The article by Hicks (this issue) evaluates economic valuation methods in the WIO to reveal a disparity in the types of services that are valued. The services where ready markets exist (cultural services such as tourism and provisioning services such as fisheries) are overrepresented, while services that lack markets (such as the regulation of ecosystem processes like coastal protection) are underrepresented. Furthermore, current studies disproportionately value the ecosystem services that flow to the global scale compared to those that flow to local beneficiaries. This means that ecosystem services with global demand curves, such as tourism, will tend to be favoured above services with local demand curves, such as subsistence fishing.

The article by Jaunky (this issue) explores what happens when provisioning services are extended to global markets. In contrast to studies that are critical about the boom and bust nature export fisheries (Berkes et al. 2006), Jaunky shows that exports of fishery products form a solid basis on which small island developing states (SIDS) can develop their economies. For many SIDS fisheries are a key resource. The establishment of exclusive economic zones of 200 nautical miles, following the 3rd Conference on the Law of the Sea (Tsamenyi and Blay 1989) means that for the WIO islands, their maritime territory is far more extensive than their land area. For example, with 1,284,997 km^2, the Mauritius exclusive economic zone (EEZ) is 630 times larger than its land area, and this could extend from 13 000 km^2 in the coming years. In this context, it is tempting to equip an offshore tuna fishing fleet and to build the infrastructure associated with it: docks, docking facility, cannery, or cold storage facilities for production destined for export without processing. But such a policy requires huge investments.

Already in 1981, Kearney noted that the purchase price of a single purse seine vessel amounted to 11 million U.S. dollars for annual operating cost of US$3 million (Kearney 1981). This amount exceeded the funding of most of the SIDS at this time. To compare, in 1980 the GDP of Tonga, Vanuatu, and the Solomon Islands were respectively 35, 50, and 120 million U.S. (Carter 1984). Buying a pole and line boat was nearly 5 times less expensive ($2 million). The establishment of a national tuna fleet is not the only specialization given to SIDS for increasing the weight of marine products in the trade balance and for developing the exploitation of fish resources in their EEZ. The example of Seychelles shows that building a cannery may be an attractive solution if it is supplied by foreign fishing vessels that operate in part outside the national EEZ. Otherwise, we return to the previous equation of building a national fleet with a new constraint added: to secure the cannery supply with the national tuna production, which is about 10,000 t of skipjack per year (Kearney 1981). The alternative is to let the exploitation of the EEZ resources to

foreign vessels which operate through bilateral or multilateral licences. This is the solution chosen by many Pacific island countries. Thus in the mid-1990s, Pacific vessels accounted for about 10% of the purse seine fleet operating in the South Pacific (Lodge 1998; Petersen 2002).

But what are the ecological costs of selling fish? Thyresson et al. (this issue) show that the market price is a significant driver for the exploitation of ecologically important parrotfish. Their findings on the role of markets are broadly consistent with studies of artisanal fisheries in Papua New Guinea (Cinner and McClanahan 2006), Solomon Islands (Brewer et al. 2009), and Nicaragua (Schmitt and Kramer 2010). If we consider that any commercial fisherman seeks the highest earning for his fishing time, in Zanzibar as elsewhere, this logic would lead fishermen to target species or size classes based on the price they hope to obtain. Such a strategy has obvious environmental impacts, but Thyresson et al. explore this in more detail to reveal a sad irony: the fish that are needed most in the water are those that fishers have the highest incentives to remove. Parrotfish are herbivores that graze the reef and prevent algae from taking over. Thyresson et al. find at the parrotfish that do the most grazing are those that also have the highest economic value.

Pelagic fish are the main target for any SIDS wishing to develop its exports of fish. Other resources exist, including deep bottom species which live on the islands' slopes and seamounts. But there stocks are poorly or not assessed and without any comprehensive study on the size of exploitable stocks, it seems risky to begin their intensive exploitation. The few studies conducted in other regions show that this type of deep water resources is extremely vulnerable to any intensive exploitation (Polovina and Ralson 1987; Cillaurren, David, and Grandperrin 2001). But should we wait for expensive and lengthy studies on population dynamics to begin fishing? The precautionary principle suggests the answer should be "yes," but in the context of many developing countries that are on the periphery of global markets (Wallerstein 1976), this solution is not economically acceptable. In contrast, exploiting of a stock without basic information to manage the fishery is unacceptable from a scientific perspective.

Can we find a middle ground? One popular tool for managing marine social–ecological systems is marine protected areas (MPAs), which limit or prohibit extractive activities such as fishing in a delineated area to allow a portion of the fishable stock to escape fishing. The focus of the remaining three articles in the special section is on the institutional, socioeconomic, and cultural conditions that can make MPAs successful. MPAs are unlikely to be successful in protecting highly mobile species such as large pelagic fish whose movements exceed a thousand miles. However, when species are sedentary, MPAs may be good tools for fisheries management, in the both cases of deep bottom fish and coral reef fish. It is on the coral reef that the more comprehensive studies are available in the region regarding the effect of MPA on the exploited species (McClanahan et al. 2006, 2009). Does this effect depend only on the characteristics of the protected ecosystem and variables inherent to MPA as its size and the duration of the closure?

The answer of Daw et al. (this issue) is clear. After studying seventeen coral reef MPAs distributed both on the continent (Tanzania, Kenya) and islands (Madagascar, Mauritius, Seychelles), their article shows that the socioeconomic context plays a major role, including population density. This result may seem logical if one considers that the population density is a proxy of fishing effort both in areas where subsistence fishing is dominant or where leisure fishing is well developed. In areas where commercial fishing is dominant, the population density is a proxy for consumer demand for fish products. But the fact that this proxy is operative clearly demonstrates the dependence of the WIO region's coastal population to the marine ecosystem and its fisheries resources. Without this dependence,

the relationship between density and the reserve effect was not so strong. The second major outcome of the study of Daw et al. is to show that even in areas of high density, a reserve effect on biomass of fish can be observed. Clearly, the anthroposystem services provided to the ecosystem to protect it, the MPA, has therefore proved effective. In concluding their article, Daw et al. stressed ". . . that in our study region, and globally (Pollnac et al. 2010), that human factors are strong predictors of closure success."

The article by Thomassin et al. (this issue) approaches MPAs from a social perspective, emphasizing social acceptance as a major driver of success or failure of MPAs. Following a previous study on the social acceptability of the marine reserve in the general population of Reunion island (Thomassin et al. 2010), the emphasis here is on recreational fishing, which is becoming a major issue in places where coastal people are keen to use their leisure time for catching fish and where they earn enough money for purchasing motor boats. MPAs that are well complied with can restore critical functions such as herbivory, increase size classes of targeted fishes, alter the species composition of fish assemblages, and increase diversity. Alternatively, poor acceptance of an MPA results in fishermen poaching in the no-take closures. If poor compliance continues, MPAs is unlikely to be more than a dysfunctional paper park (Kareiva 2006). It is possible to counteract poor compliance by targeting substantial funding toward enforcement. Such a solution is possible when the MPA has a substantial budget and means to patrol at sea, as in Reunion. But this is rarely the case and the proliferation of MPAs all around the world is hardly conducive to optimism about the average budget of MPAs in the future (Agardy et al. 2003). In the absence of this "stick" approach to conservation, how can MPAs gain social acceptance? A broad body of research on common property institutions have shown the conditions that can facilitate collective action (Ostrom 1990). These studies emphasize how institutional characteristics (such as clearly defined membership, conflict resolution mechanisms, and participation in decision-making) can create the conditions necessary for individual actors to cooperate in commons situations.

Yet it is not only individual actors' cooperation that is required for MPAs to succeed. In a global review, Grillo (this issue) examines how the success of MPA networks depends in part on whether institutions either cooperate or don't in what is known as institutional interplay. Much of the social–ecological systems literature has contained calls for linkages between institutions operating at different scales (e.g., Folke et al. 2005; Olsson et al. 2007). Yet much of this literature has been uncritical of the nature of relationships between institutions, assuming them to be complementary. A more critical view reveals considerable contestation between actors and agencies, which can make the transaction costs of interacting extremely high. Grillo reviews institutional interplay in MPA networks from around the world that have a community-based management component. Much of the institutional interplay was related to information exchange, control, and authority.

This special issue tackles critical issues at the nexus of marine conservation and socioeconomic development in one of the poorest regions in the world. It highlights the critical role of markets as both a source for meeting development aspirations and for eroding critical ecosystem services. It examines the ways that we value these ecosystem services and create biases in favour of the services desired by the global North in ways where the cost of these services are borne by the global South. It uses diverse methodologies and perspectives to explore the conditions conducive to successful conservation efforts. In some ways the issue demonstrates how much progress has been made in understanding the human dimensions of marine and coastal ecosystems, but also highlights some critical gaps. Among them: (1) decision-makers must find ways to incorporate ecosystem services that lack easy market values; (2) market incentives must be created to sustain critical functions

such as herbivory; and (3) nongovernmental organizations, donors, and governments must invest in institutions and processes that facilitate compliance with MPAs and other tools to maintain ecosystem services.

References

Agardy, T., P. Bridgewater, M. P. Crosby, J. W. Day, P. K. Dayton, R. Kenchington, D. Laffoley, et al. 2003. Dangerous targets? Unsolved issues and ideological clashes around marine protected areas. *Aquatic Conservation: Marine and Freshwater Ecosystems* 13:353–367.

Bellwood, D. R., T. P. Hughes, and A. S. Hoey. 2006. Sleeping functional group drives coral-reef recovery. *Current Biology* 16:2434–2439.

Berkes, F., T. P. Hughes, R. S. Steneck, J. H. Wilson, D. R. Bellwood, B. Crona, C. Felke, et al. 2006. Globalization, roving bandits, and marine resources. *Science* 311:1557–1558.

Brewer, T. D., J. E. Cinner, A. Green, and J. M. Pandolfi. 2009. Thresholds and multiple scale interaction of environment, resource use, and market proximity on reef fishery resources in the Solomon Islands. *Biological Conservation* 142:1797–1807.

Carter, J. 1984. *The Pacific Islands year book*. New York and Sydney:Pacific Publications.

Cillaurren, E., G. David, and R. Grandperrin. 2001. *Coastal fisheries atlas of Vanuatu, a 10-year development assessment*. Paris, IRD.

Cinner, J. E., and T. R. McClanahan. 2006. Socioeconomic factors that lead to overfishing in small-scale coral reef fisheries of Papua New Guinea. *Environmental Conservation* 33:73–80.

Cinner, J. E., T. R. McClanahan, T. M. Daw, N. A. J. Graham, J. Maina, S. K. Wilson, and T. P. Hughes. 2009. Linking social and ecological systems to sustain coral reef fisheries. *Current Biology* 19:206–212.

Costanza, R., R. d' Arge, R. de Groot, S. Farber, M. Grasso, B. Hanonnon, K. Limburg, et al. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387:253–260.

Ehrlich, P. and H. A. Mooney. 1983. Extinction, substitution and ecosystem services. *Bioscience* 33:248–254.

Folke, C., T. Hahn, P. Olsson, and J. Norberg. 2005. Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources* 30:441–473.

Hughes, T. P., D. R. Bellwood, C. S. Folke, L. J. McCook, and J. M. Pandolfi. 2007. No-take areas, herbivory and coral reef resilience. *Trends in Ecology & Evolution* 22:1–3.

Kareiva, P. 2006. Conservation biology: Beyond marine protected areas. *Current Biology* 16:R533–R535.

Kearney, R. E. 1981. Some economic aspects of the development and management of fisheries in the central and western Pacific. NewsLetter no. 22, pp. 6–15. Noumea, South Pacific Commission Fisheries.

Lodge, M. W. 1998. The development of the Palau Arrangement for the management of the western Pacific purse seine fishery. *Marine Policy* 22:1–28.

MEA (Millenium Ecosystem Assessment). 2003. Chapter 2: Ecosystems and their services. In *Ecosystems and human well-being: A framework for assessment*. Washington, DC:Island Press.

MEA. 2005. *Ecosystems and human well-being: Synthesis.* ed. R. T. Watson and A. H. Zakari, 49–62. Washington, DC:Island Press.

McClanahan, T. R., N. A. J. Graham, S. K. Wilson, Y. Letourneur, and R. Fisher. 2009. Fisheries closure size, age, and history of compliance effects on coral reef fish communities in the western Indian Ocean. *Marine Ecology Progress Series* 396:99–109.

McClanahan, T. R., M. Marnane, J. E. Cinner, and W. Kiene. 2006. A comparison of marine protected areas and alternative approaches to coral reef conservation. *Current Biology* 16:1408–1413.

Olsson, P., C. Folke, V. Galaz, T. Hahn, and L. Schultz. 2007. Enhancing the fit through adaptive comanagement: Creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike Biosphere Reserve Sweden. *Ecology and Society* 12(1):28. [online]

Ostrom, E. 1990. *Governing the commons: The evolution of institutions for collective action*. Cambridge:Cambridge University Press.

Petersen, E. H. 2002. Economic policy, institutions and fisheries development in the Pacific. *Marine Policy* 26:315–324.

Pollnac, R., P. Christie., J. E. Cinner, T. Dalton, T. M. Daw, G. E. Forrester, N. A. J. Graham, and T. R. McClanahan. 2010. Marine reserves as linked social-ecological systems. *Proceedings of the National Academy of Science*. doi:10.1073/pnas.09082661

Polovina, J. J., and S. Ralston (eds.). 1987. *Tropical snappers and groupers: Biology and fisheries management.* Boulder:Westview Press.

Schmitt, K. M., and D. B. Kramer. 2010. Road development and market access on Nicaragua's Atlantic coast: Implications for household fishing and farming practices. *Environmental Conservation* 36:289–300.

Thomassin, A., C. White, S. Stead, and G. David. 2010. Social acceptability of marine protected area: The case of Reunion Island. *Ocean & Coastal Management* 53:169–179.

Tsamenyi, B. M., and S. K. N. Blay. 1989. Extended zones of jurisdiction over marine resources: State practice in the South Pacific. In *Economics of fishery management in the Pacific islands region*, ed. H. Campbell, K. Menz, and E. Waugh, 42–50. Canberra:Australian Centre for International Agricultural Research (ACIAR) Proceedings.

Wallerstein, I. 1976. *The modern world system*: *Capitalist agriculture and the origins of the European world-economy in the sixteenth century*. New York:Academic Press.