Contribution to GSDR 2015 – chapter 3

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The international move towards ecosystem-based management (e.g. WSSD – Johannesburgh convention) have highlighted the importance in understanding the interlinkages and the ecoystem goods and services provided by the earths marine socio-ecological systems. Human societies use and depend on the goods and services that our coasts and oceans provide for security as well as supplying food resources that can be used directly to feed a population or as income opportunities, together contributing towards poverty eradication.

Biodiversity is a key ecosystem characteristics that forms the foundation for providing the ecosystem goods and service that human societies are dependent on. The Millennium Ecosystem Assessement (MEA)(Assessment 2005) provides broadly accepted definitions of an **ecosystem** (constituting both the bio-physical components and humans) and **ecosystem services** (provisioning, regulating, cultural and supporting services), and illustrates how biodiversity is a fundamental prerequisity to provide well-functioning ecosystem services. From a poverty eradication perspective the MEA shows the chain of dependency from biodiversity through well-functioning ecosystem servies that are necessary to provide for human well-being. Biodiversity has thus been show to be of great importance to human socities and the protection of biodiversity has become an important international goal, also for the management of coastal and marine areas: e.g. the Convention on Biological Diversity Aichi Target 11 for 10% of the ocean to be protected by 2020.

Palumbi et al. (2009) reviews the benefits of marine biodiversity to ecosystem services and the links to human societies, focusing on the benefits to fisheries, water quality, recreation, and shoreline protection.

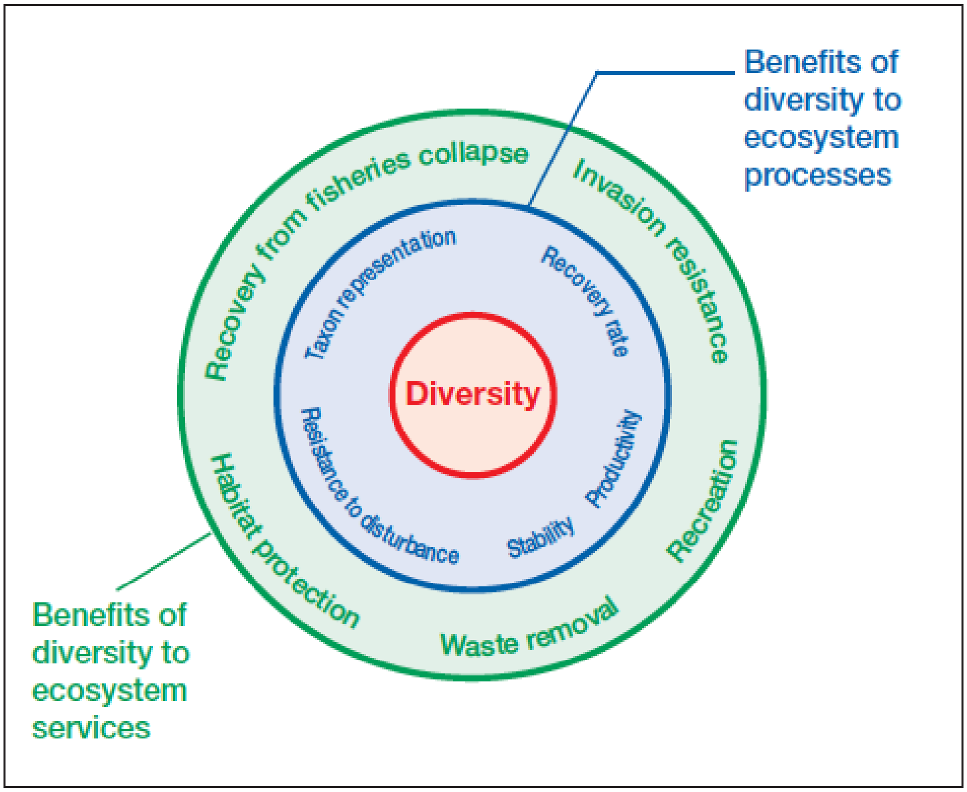

Figure 1 A schematic view of the benefits of biodiversity. From *Palumbi et al. (2009)*.

In the following chapter recent advances in our understanding of the inter-linkages between biodiversity and ecosystem services that allow for poverty eradication as well as threats to marine biodiversity is discussed both in a global perspective and using the Republic of Sudan as a case study.

Inter-linkages among oceans, marine and coastal biodiversity and poverty eradication

Mapping and cataloging marine biodiversity has been a focus area in the decade after the MEA with the Census of Marine Life (www.coml.org) (Costello et al. 2010) being the most comprehensive international undertaking, linking dozens of large-scale projects aimed at mapping biodiversity and understanding ecosystem functioning (e.g. MAR-ECO, a project aimed at studying the biology along the mid-Atlantic ridge, www.mar-eco.no) (Bergstad et al. 2008). Closer to the coast several countries initiated large-scale seafloor mapping projects, both to get better bathymetric maps, but just as importantly to survey the bio-geo-chemistry of the seafloor. Over the past decade these projects have identified numerous new species, but more importantly amassed vast amounts of data that is needed to accurately assess the ecosystem services. Such comprehensive data sets were recently used in large-scale assessment of benthic ecosystems services along the western European seaboard (Galparsoro et al. 2014). The study found that the ecosystem-service levels were highest closest to the coast and decreased with increasing depth and distance from shore. *Galparsoro et al. (2014)* did not attempt to monetize the ecosystem services studies, instead just showing the service value, underpinning *Ruckelshaus et al. (2013)* conclusion that ecosystem service assessment does not require economic valuation, a great concern when trying to evaluate the value of biodiversity.

Protection of biodiversity is a key priority in many national ecosystem-based management initiatives because of the links to ecosystem services and thereby socioeconomic development. In the US Ocean Policy "a core principle unifying these diverse interests is the protection and restoration of the productivity, biodiversity, and resilience of ecosystems" *(Lubchenco & Sutley 2010)*, while in the Norwegian integrated management plans protection of biodiversity is both a management goal and a key priority factor when identifying valuable and vulnerable areas *(Olsen et al. 2007, Ottersen et al. 2011)*.

In the recent FAO report on the state of global fisheries *(FAO 2014)* fisheries management maintaining biodiversity is linked to sustainable fisheries, especially in new developing fisheries in deep-water ecosystems and other areas that are perceived as fragile.

Impact of selected threats on the oceans, marine and coastal biodiversity and eradication nexus

Recent assessments of global marine biodiversity have expanded the analysis from merely identifying areas of high biodiversity, to assessing the high-biodiversity areas under greatest pressure from human activities and climate change (Selig et al. 2014), pointing to climate change and fisheries as the potentially most severe pressures. The Coral Triangle, as well as less well-known locations in the southwest Indian Ocean, western Pacific Ocean, Arctic and Antarctic Oceans, and within semi-enclosed seas like the Mediterranean and Baltic Seas were based on a global analysis of human impacts identified as high-priority areas for biodiversity conservation *(Selig et al. 2014)*. Coastal developments, aquaculture and habitat destruction are pressures not discussed by *Selig et al. (2014)*, but of great concern in the management of industrial developments, laying pipelines, dredging / gravel extraction, renewable energy development etc. These developments are often seen as crucial for the socioeconomic development of coastal communities and states, but can have detrimental impact on local marine ecosystems and their biodiversity. A recent and widely discussed global analysis of threats to marine biodiversity (defauniation) by *McCauley et al. (2015)* warns against a possible future mass marine extinction event driven by increased human uses of the ocean (Figure 2). *McCauley et al. (2015)* argue that effectively slowing marine biodiversity loss requires both protected areas and careful marine spatial management.

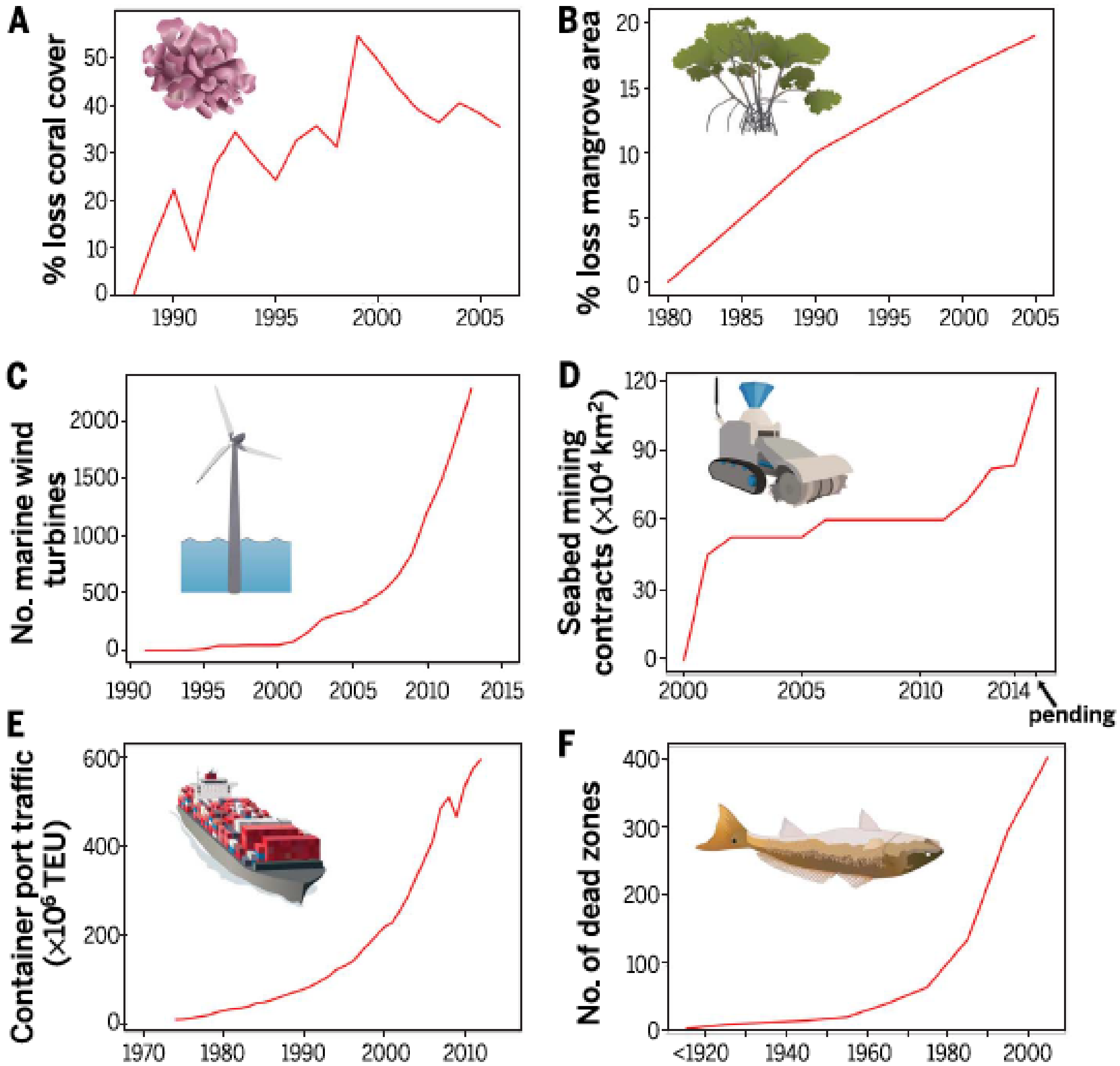

Figure 2 Habitat change in the global oceans. From *McCauley et al. (2015)*.

Ruckelshaus et al. (2013) has also shown how there is a linkage between climate change stressors and threats to total ocean sustainability. From a more practical and regional perspective the ocean health index (OHI) *(Halpern et al. 2012, Elfes et al. 2013, Halpern et al. 2013)* is an example of ongoing translation of provision of ecosystem services into traceable and quantifiable indicators. Although criticized for bias (Branch et al. 2013), the OHI affords a unique and timely approach to synthesizing complex information of ecosystem sustainability into 10 simple metrics that can easily be visualized, communicated and discussed in a development context.

Case study: Sudan –Red Sea State

The Republic of Sudan has a ~750 km coastline along the Red Sea which is semi-enclosed tropical sea-are known for its high salinity and low production. Results from the recent Norwegian funded UNIDO Project "*Surveys of renewable marine resources in the Red Sea State*" indicate that there are some local areas with higher biodiversity and production than others, in particular the Mohammed Qol area along the northern part of the coast. However, the focus of the project was on potentially commercial fish species, so it only covers part of the marine biodiversity.

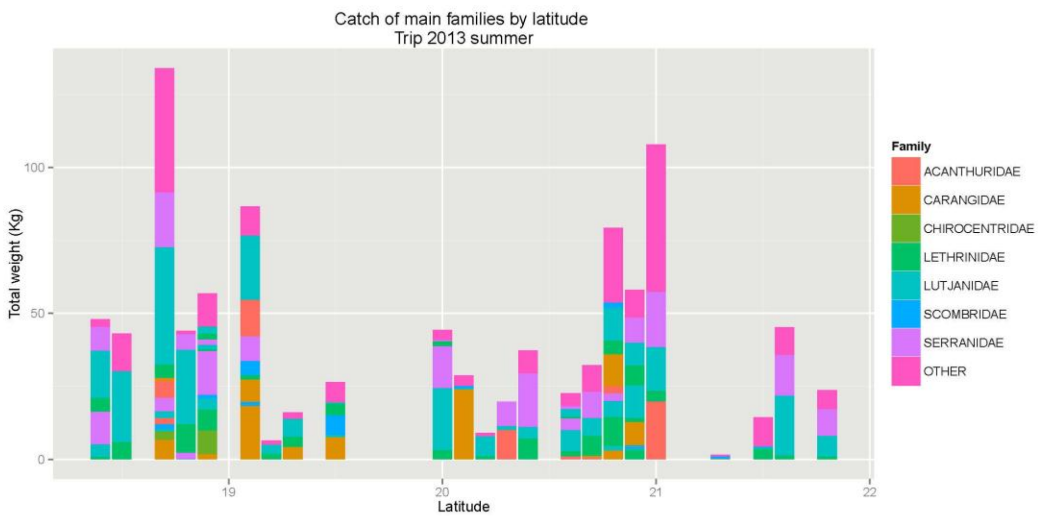

Figure 3 Latitudinal distribution of fish catches split by family groups for the summer (May-June) 2013 survey of the Sudanes coast. The survey was part of the Norwegian funded UNIDO project "Surveys of renewable marine resources in the Red Sea State".

The human uses of the coastal resources are mainly limited to artisanal fisheries that support numerous fishing villages along the coast. The fishermen are poor and are often people who have previously been herders and farmers, but who have moved to the coast as the condition inland for herding and farming have deteriorated, leading them to fishing as a last resort to get food and earn an income.

Simple hand-lines are the dominant fishing gear, usually operated from small open fishing-boats powered manned by 2-4 fishermen on fishing-trips lasting up to 2 weeks. Catches are sold to fishmongers with whom the fishermen are involved in a complex socioeconomic relationship. The fish-monger take the catches for further processing and sales at the central fish market in Port Sudan. Prices vary with the species caught, with the coral trouts 'Najil' (*Plectropomus pessuliferus)* and the related 'Silimani' (*Plectropomus areolatus*) being the most highly prized and the only fish that are exported to foreign markets. Local scientists and the fishermen are concerned of a potential overfishing of the coral trout species due to the high demand and price these species get.

For the remainder of the commercial fish species caught in the artisanal fisheries there are no indications of overexploitation or use of destructive fishing practices.
Of other species, there are some illegal catches of sea cucumber, once a legal commercial fishery, that collapsed following a period of uncontrolled exploitation leading to overfishing. In the southern and off-shore part of the EEZ there is some illegal fishery for sharks carried out by fishing-vessels from other countries. Some have been caught in the act and the fishing-vessels have been confiscated. Off-shore fisheries are non-existent, although there are some stocks of schooling tuna and mackerels in the region.

Food-security is of paramount importance to Sudan. Together with a need to diversify the economy following the secession of South Sudan and loss of 75% of the country's oil and gas resources, developing fisheries as an alternative livelihood in coastal areas has priority both at national and regional levels in Sudan.

Expanding the fisheris sector poses a threat to local and regional biodiversity in the Red Sea. The greates concern is that the fisheries and other marine sectors will develop before the coastal biodiversity and ecosystem services are properly assessed and sustainable management plans developed. This could lead to boom-and-bust industries that will not lead to long-term poverty alleviation.

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