Chapter 3
Marine Biodiversity of Angola: Biogeography and Conservation

Stephen P. Kirkman and Kumbi Kilongo Nsingi

Abstract Some major physical and oceanographic features of the Angolan marine system include a narrow continental shelf, the warm, southward flowing Angola Current, the plume of the Congo River in the north and the Angola-Benguela Front in the south. Depth, substrate types and latitude have been shown to account for species differences in demersal faunal assemblages including fish, crustaceans, and cephalopods. The extremely narrow shelf between Tômbwa (15°48′S) and Benguela (12°33′S) may serve as a barrier for the spreading of shelf-occurring species between the far south, which is influenced by the Angola-Benguela Front, and the equatorial waters of the central and northern areas. A similar pattern is evident for coastal and shallow-water species, including fishes, intertidal invertebrates and seaweeds, with species that have temperate affinities found in the far south and tropical species further to the north. In general the fauna and flora of the littoral zone appears to be consistent with a pattern of relatively low diversity of the shore and near-shore areas, that is characteristic of West Africa, but paucity of data for Angola may make such comparisons of diversity with other areas inappropriate at this stage. The Congo River delta and many features that are interspersed along the coast such as estuaries and associated floodplains, wetlands, lagoons, salt marshes and mangroves, support a rich suite of species, many of which are rare, endemic, migratory, and/or threatened, and provide important ecosystem services. While the ecological value of many areas or features is recognised, lack of any legal protection in the form of marine protected areas (MPAs) has been identified as one of the main challenges facing conservation and sustainable use of Angola's marine and coastal biodiversity and habitats, in the face of multiple threats. A current process to identify and describe ecologically or biologically significant marine areas (EBSAs) could provide a foundation for designating some MPAs in future.

S. P. Kirkman (✉)
Department of Environmental Affairs, Oceans and Coastal Research,
Cape Town, South Africa
e-mail: skirkman@environment.gov.za

K. K. Nsingi
Benguela Current Convention, Swakopmund, Namibia
e-mail: kkilongo@gmail.com

Physical and Oceanographic Context

The coastline of Angola, which is approximately 1650 km long, consists of sandy and rocky stretches of coastline, punctuated by numerous coastal features such as estuaries, mangroves, coastal lakes, wetlands and tidal flats (Harris et al. 2013). Between Rio Bero (north of Moçâmedes) in Namibe Province and to the north of Rio Coporolo in Benguela Province are rocky shores; the rest of the coastline is predominantly sandy although there are some scattered rocky shores further north of Lobito (Harris et al. 2013). The continental shelf, which extends to about 200 m depth, is relatively narrow especially near the south where it is as little as 6 km wide and very steep in parts of Namibe and Benguela, but it widens further north to 33 km width near the mouth of the Congo River, and in the south it widens a little between Tômbwa and Cunene (Figure 1, Bianchi 1992). The neritic zone (i.e. waters overlying the continental shelf) covers about one third of Angola's Exclusive Economic Zone (EEZ), which also includes extensive bathyal and abyssal zones, with depths up to 4000 m in the latter (Nsiangango et al. 2007).

Hutchings et al. (2009) describe the marine system of Angola's continental shelf area as a subtropical transition zone between the Equatorial Atlantic to the north and the Benguela's wind-driven upwelling system to the south. The conspicuous, dynamic but relatively shallow Angola-Benguela Front at 17°S in the south of Angola forms the boundary with the upwelling system, and the boundary to the north is near the plume of the Congo River. Seasons are well-defined and there is intermediate productivity; moderate to weak upwelling occurs year-round in the south and all along the coast in winter with strengthening of southeast trade winds. The major oceanographic feature of the system is the warm (>24 °C) Angola Current, which flows southward along the shelf and slope as an extension of the South Equatorial Counter-current, extending down to 200 m depth and with a mean flow at 50 m depth of 5–8 cm s^{-1} (Kopte et al. 2017). During winter and spring the Angola Current tends to retreat to the northwest and is replaced by slightly cooler waters; this is linked to the intensity of wind-driven upwelling off the Namibian coast (Meeuwis and Lutjeharms 1990; O'Toole 1980).

Other important drivers of the system are Kelvin waves propagating from the Equatorial Atlantic and the South Equatorial Counter Current (Florenchie et al. 2004; Shillington et al. 2006), as well as southward flow of brackish water with high nutrient loads from the Congo River outflow and solar heating (Veitch et al. 2010), Both result in stratification of the water column (Kirkman et al. 2016), with thermocline depth ranging from 10 m in the north down to about 50 m off central Angola (Bianchi 1992). Another feature of the Angolan system is the cold water Angola Dome, found offshore of the Angola Current. This is a cyclonic eddy that causes

doming of the thermocline, centred near 10°S and 9°E (Lass et al. 2000). The Angola Dome has lower salinity and concentrations of oxygen than surrounding waters, but it does not exist in winter and its width and extension depend on the intensity and horizontal shear of southeasterly trade winds (Signorini et al. 1999). Phytoplankton production associated with the Angola Dome strongly influences the shelf ecosystem throughout northern Angola (Monteiro et al. 2008).

## Biodiversity and Biogeography

There is a high diversity of demersal species in Angola relative to the temperate Benguela Ecosystem to the south, with species richness greatest at about 100 m depth according to research surveys (Kirkman et al. 2013). Demersal fish stocks are exploited by a multispecies bottom trawl fishery extending from southern to northern Angola, that exploits over 30 species of fish belonging to the families Sparidae (seabreams), Scianidae (croakers), Serranidae (groupers), Haemulidae (grunts) and Merlucidae (hakes). Some of the most commercially important species include Benguela Hake *Merluccius polli* and demersal sparid fish such as *Dentex* spp. (Kirkman et al. 2016); there is also bottom fishing for crustaceans, most importantly deep-sea crab *Chaceon maritae* and shrimps *Aristeus varidens* and *Parapenaeus longirostris* (Japp et al. 2011; Kirkman et al. 2016). The most important fish targeted by small pelagic fisheries include Kunene Horse Mackerel *Trachurus trecae* and *Sardinella* species, with most large pelagic fishing (tuna spp.) taking place in the south (Japp et al. 2011, Kirkman et al. 2016). Several of the above stocks are targeted both by industrial and artisanal fisheries (Duarte et al. 2005; Japp et al. 2011). The Angolan fisheries are described by Hutchings et al. (2009) as being of moderate intensity with stocks generally declining. There is also a rapidly growing local and foreign recreational shore-fishery sector in southern Angola targeting mainly Leerfish *Lichia amia*, West Coast Dusky Kob *Argyrosomus coronus* and Shad *Pomatomus saltatrix* (Potts et al. 2009).

Bianchi (1992) and later Nsiangango et al. (2007) studied the structure of demersal assemblages of the continental shelf and upper Angolan slope, including fish, crustaceans and cephalopods, based on trawl surveys. It was shown that thermal, depth-dependent stratification explained the main faunal groupings, with certain species generally restricted to waters shallower than where the lower limit of the thermocline meets the shelf, and others usually occurring in deeper waters than this. Species such as Shallow-water Croaker *Pteroscion peli*, Red Pandora *Pagellus bellotti*, Lesser African Threadfin *Galeiodes decadactylus* and Grunt *Pomadasys incisus* dominated in the shallower demersal water (coast to 100 m), with some sea breams in low densities, whereas deeper waters of the shelf and upper slope were dominated by such species as Splitfin *Synagrops microlepis*, Atlantic Green-eye *Chlorophthalmus atlanticus,* Angolan Dentex *D. angolensis* and *M. polli.* Within the different depth strata, substrate type and latitudinal gradients were the main factors affecting the composition of species assemblages, and a major latitudinal

shift both in shallow- and deep-water assemblages was shown to occur in southern Angola between Tômbwa and Cunene where the shelf widens and where Large-eyed Dentex *D. macrophthalmus* dominated the catches. Bianchi (1992) related the shift to the southern limit of warmer equatorial waters, the presence of the Angola-Benguela Front where there is year-round upwelling and cooler waters, and the extremely narrow shelf to the north of Tômbwa (up to Benguela), which may serve as a barrier to the spreading of northern species to the south and vice versa.

While deep-water coral reefs have been documented for Angola's continental slope (Le Guilloux et al. 2009), shallow-water coral reefs are absent and in general the fauna and flora of littoral zone seems to be consistent with the pattern of relatively low diversity of the shore and near-shore areas of West Africa (John and Lawson 1991). Factors that could account for this include the lack of hard substrata (most of the shoreline being sandy), upwelling of cooler water in areas, high turbidity and sediment input from a massive river such as the Congo, or loss of species associated with reductions in sea-temperatures that considerably reduced the tropical zone during Pleistocene glaciations (van den Hoek 1975; John and Lawson 1991). However, while recent studies (e.g. Hutchings et al. 2007; Anderson et al. 2012) have added to the existing species lists (e.g. Lawson et al. 1975; Penrith 1978 and others) for coastal fishes, sandy beach macrofauna, rocky shore invertebrates and seaweeds, at this stage the paucity of information in Angola may not make comparison with other areas appropriate. In general the data that exist both for coastal and estuarine fishes (Whitfield 2005; Hutchings et al. 2007) but also offshore fish species (Kirkman et al. 2013; Yemane et al. 2015) of Angola show decreasing species richness from north to south, seemingly supporting the established trend of decreasing diversity with latitude as one moves polewards from tropical regions (e.g. Rex et al. 2000; Willig et al. 2003).

Based on the latitudinal distributions of intertidal fauna of rocky shores (Kensley and Penrith 1980), the southern limit of tropical biota has previously been reported to be around the border of Angola and Namibia. Lawson (1978) on the other hand, based on analyses of seaweed flora, considered Angola to be intermediate in nature between tropical and temperate. Results of surveys of intertidal invertebrates and seaweeds by Hutchings et al. (2007) however, showed that although there was a marked discontinuity between the biota of Angola and that of northern Namibia, which supports a cool-temperate intertidal flora up to nearby the Cunene River (Rull Lluch 2002), a number of taxa found in the south of Angola had temperate affinities. This led the authors to suggest that the inshore biota of the south of Angola may be intermediate in nature, and that of the north truly tropical. This is confirmed by Anderson et al. (2012) who conclude that the overall affinities of the Angolan seaweed flora is Tropical West African, but with a well-developed temperate element in southern Angola (from about 13°S) comprising mainly cooler-water species. Broadly, this supports the division of the Angolan coast into at least two sub-areas, with the more temperate south influenced by the cooler waters of the Angola-Benguela Front. This is similar to the division between demersal assemblages of north and south (Bianchi 1992) and also congruent with a break in the pelagic ecosystem of the inshore as determined from classification of key oceanographic variables and depth (Lagabrielle 2011). It also ties in with global mapping classifi-
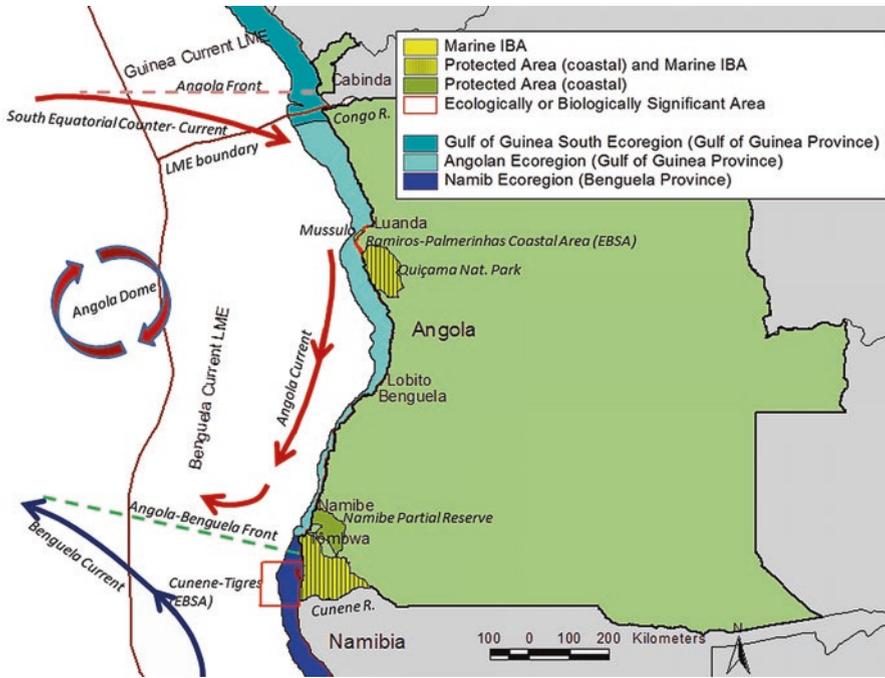
Fig. 3.1 Delineations of marine ecoregions (Spalding et al. 2007) and large marine ecosystems (Sherman 2014) that coincide with Angola. The ecoregions extend from the coast to the shelf edge. Also shown are recognised marine and coastal biodiversity areas and the approximate situations of important oceanographic processes

cation of coastal and shelf areas based on species distributions and levels of endemism of benthic and pelagic biota (Spalding et al. 2007; Briggs and Bowen 2012), that puts the divide between the temperate Benguela Province and the tropical Gulf of Guinea Province, near Moçâmedes (Fig. 3.1). Spalding et al. (2007) situate the majority of the Angolan EEZ in the Angolan ecoregion of the Gulf of Guinea Province, but include the area north of 6°30′S in the more tropical Gulf of Guinea south ecoregion. This is slightly incongruent with the mapping of large marine ecosystems (LMEs) of the world (which is expert- rather than data-derived), whereby most of Angola is included in the Benguela Current LME bounded to the north by the Angola Front (ca. 5°S), and only Cabinda in the far north included in the Guinea Current LME (Sherman 2014).

Marine and Coastal Biodiversity Hotspots, Threats and the Need for Protection

Whereas the Angolan coastal and shallow habitats are considered to be relatively low in biodiversity, coastal features such as the Congo River Delta, estuaries such as the Cuanza, Catumbela, Longa and Cunene, and associated floodplains, wetlands,

lagoons, salt marshes and (north of Lobito) mangroves support a rich suite of species, often in high abundance (Hughes and Hughes 1992; van Niekerk et al. 2008; Harris et al. 2013). This includes several rare, endemic, migratory, and/or threatened fauna such as the African Manatee *Trichechus senegalensis*, turtle species and diverse waterbird species. Recognised ecosystem services of such features include (amongst others) providing habitat for important food-fish and crustacean species and their critical life stages (e.g. performing important nursery functions for many marine fishes) or providing plant species that are useful for medicinal, subsistence or construction purposes (Hughes and Hughes 1992; van Niekerk et al. 2008). While Angola is not currently a contracting party of the Ramsar Convention, some coastal wetland sites have been identified as being potential Ramsar sites, including Quiçama National Park between the Cuanza and Longa Rivers (Fig. 3.1), which is also a confirmed Important Bird and Biodiversity Area (IBA). Other confirmed coastal IBAs in Angola include Mussulo just south of Luanda and the Iona National Park in the south between the Cunene and Curoca Rivers. These IBAs are important for numerous waterbirds and are frequented by wintering seabird species that breed further south on the sub-continent such as Cape gannet *Morus capensis* (IUCN Red List – Endangered) and Damara tern *Sternula balaenarum* (Vulnerable) (Birdlife International 2002), the latter of which is known to also breed in the Iona National Park (Simmons 2010).

While the ecological value of these and other areas is recognised, the lack of formal protection of key biodiversity areas or features in Angola's marine and coastal environments has been noted as a concern (e.g. Tarr et al. 2007). As part of a regional systematic conservation planning (SCP) project involving all three member states of the Benguela Current Convention (BCC; a legally constituted collaborative mechanism representing Angola, Namibia and South Africa), Holness et al. (2014) showed that Angola is particularly poorly off in terms of spatial protection of its marine systems, with 102 out of 133 identified ecosystem types having no protection at all. Whereas some legislative protection of coastal ecosystem types in the Cuanza, Cunene and Tômbwa areas may be afforded by terrestrial national parks (Quiçama and Iona) or reserves (Namibe Partial Reserve), this may have value for conservation of the adjacent marine areas if effective management of these areas is achieved through the provision of increased human and financial resources. Holness et al. (2014) therefore opined that a programme of rapid expansion of protected areas for the Angolan marine systems is urgently required, and the ultimate product of their study was the prioritisation of sites for protection (ideally within a MPA network).

The current lack of marine protected areas (MPAs) was described by Tarr et al. (2007) as amongst the main challenges facing conservation and sustainable use of Angola's marine and coastal biodiversity and habitats, in light of multiple threats to the ecosystem that are likely to worsen over time. These threats include (but are not limited to) rapid, unplanned coastal urbanisation causing habitat destruction and a severe problem with waste management along the coast, particularly in the area of Luanda; escalation in over-exploitation of living marine resources related to rapid urbanisation and human migration to the coastal nodes, especially since the end of

the civil war; industrial pollution caused e.g. by deposition of industrial wastes in catchment areas or cleaning of ships; offshore oil exploitation in the north, with potential for oil spills; loss of mangroves, which includes threats from pollution and wood collection for firewood and construction; rapid growth of the tourism industry; and impacts of climate change (Tarr et al. 2007; Heileman and O'Toole 2009).

With such threats in mind, Angola, like the other two member states of the BCC, has committed to implementing ecosystem-based management (EBM) of the marine environment to address responsible use of its ocean and its resources and put in practice the principles of sustainable development (BCC 2014). EBM is an integrative approach to management that takes into account all interactions in the ecosystem (including those involving human activities) and their cumulative impacts in space and time (Long et al. 2015). To be able to assist EBM with regard to the allocation and siting of ocean uses or protection measures, there is an initiative to implement marine spatial planning (MSP) in Angola and the other countries of the region (Kirkman et al. 2016). A pilot area for an experimental MSP project, covering an area of approximately 107,000 km^2 between south of Palmerinhas and the Tapado River mouth (GNC-OEM 2018), has recently been identified. A key element of the process is to identify and describe a network of Ecologically or Biologically Significant Marine Areas (EBSAs) - geographically or oceanographically discrete areas that have been identified as important for the services that they provide and for the healthy functioning of oceans (Dunstan et al. 2016) and to include these in marine spatial plans.

Currently, only two Angolan EBSAs have been described and subsequently endorsed by CBD (CBD 2014), namely the Ramiros-Palmerinhas Coastal Area which partly adjoins the Mussulo Peninsula south of Luanda, and the Cunene-Tigres EBSA which overlaps with northern Namibia and is adjacent to the Iona National Park on the Angola side (Fig. 3.1). The former includes estuaries with mangroves and salt marshes and has special importance for bird aggregations and breeding turtles. The latter includes the Cunene estuary and associated wetland as well as the Baía dos Tigres Island-Bay complex to the north of it, and has special importance for migratory birds and in terms of its nursery function for many marine species. Both of these areas have undergone thorough assessment processes with a view to expanding their areas in order to include other relevant features such as estuaries, sensitive coastline, canyons and seamounts.

Currently Angola is in the process of describing new potential EBSAs, in coastal and offshore areas, as part of a collaborative regional project with Namibia and South Africa, coordinated by the BCC (http://www.benguelacc.org). Currently, five new areas have been proposed as EBSAs which include coastal and offshore areas in the provinces of Cabinda, Zaire, Luanda, Cuanza-Sul and Namibe. Although EBSA status itself does not carry any conservation or protection interventions, legal protection is among the management measures that can be applied to secure the persistence of these special features and their ecosystem services. Therefore the process of expanding the EBSA network could provide a foundation for initiating a network of MPAs in Angola. In this regard, there is a recent project proposal for the establishment of the first MPA in Angola in the offshore area adjacent to the Iona National Park.

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