Critical Habitats Outlook - Chapter 14

Shelf sediments, offshore pelagic and deep-sea habitats

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Shelf sediments, the offshore pelagic and deep-sea habitats are spatially vast areas, encompassing the sea bed and the water above it; as with seamounts and ridges which are dealt with separately (Part III, chapter 17), they differ from the other critical habitats covered in this book in that they are not coastal. Yet the proximity of shelf sediments to critical coastal habitats means there is spatial overlap, and physical and biological processes taking place in shelf sediments, offshore pelagic and deep sea habitats have profound effects on critical coastal habitats too. These areas are also affected by coastal processes and land runoff, though sedimentary fluxes, and chemical and biological interlinkages. For the sake of simplicity, though, the habitats described herein are termed "offshore habitats", because that is what they largely cover.

Their spatial scale means they include a diverse variety of habitats within their realms. But, as described in the relevant chapters of the Regional State of the Coast Report for the Western Indian Ocean (WIO; Fennessy and Green 2015, Obura 2015a), offshore habitats are poorly known for the region, particularly with respect to the sea bed. The approach taken here is to use the considerable regional knowledge on habitats and biodiversity in the WIO which formed the basis of the identification and prioritisation of regional Ecologically or Biologically Significant Areas (EBSAs; Dunn *et al*. 2014). The rationale for this is further elaborated in Part II, Chapter 4. Notwithstanding shortcomings (Johnson *et al*. 2018), the EBSA process has aggregated arguably the best available knowledge on biodiversity and habitats within and beyond state jurisdiction, and continues to evolve (CBD 2018). This process is being co-ordinated by the Secretariat of the Convention on Biological Diversity (SCBD 2013; see Existing protection below), to which Convention all WIO states have consented to be bound. From a jurisdiction perspective, the Offshore habitat EBSAs described here include those in the EEZs of WIO coastal states, as well as in Areas Beyond National Jurisdiction (ABNJ). Further, since the Nairobi Convention applies to signatory coastal states, also included are Offshore habitat EBSAs in the South African EEZ to the west of Cape Agulhas – in other words, in the south-east Atlantic (SCBD 2014), albeit that these technically fall outside of the WIO biogeographic region (Part II, Chapter 4). Reference to coastal critical habitats occurring within these EBSAs has been minimized herein, as these are covered in other chapters. The 18 Offshore habitat EBSAs dealt with in this chapter are listed in Appendix 1. It being impractical to reproduce the extensive bibliographies supporting the rationale for these EBSAs here, readers are referred to the specific EBSA reports (SCBD 2013, 2014), and references therein, as well as the website www.cbd.int/ebsa/, for more detail. Where additional supporting literature has been consulted, citations are provided.

The WIO region covers a very large ocean area of around 24 million km^2, of which the 11 WIO EBSAs predominantly comprising Offshore habitats make up around 7.5 million km^2

(Figure 1, Table 1). Slightly less than half (44%) of the area of these Offshore habitat EBSAs falls in state EEZs, the remainder is in ABNJ; of the Offshore habitat WIO EBSAs in EEZs, only 12% of their area is on the shelf (<200m depth), reflecting that they are mainly offshore. The 7 EBSAs falling within the South African EEZ off its west coast comprise an area of around 193 000 km^2, 44% of which is on the shelf. Around 9% (~309 000 km^2) of the area of the Offshore habitat WIO EBSAs falls into existing Marine Protected Areas (MPAs) within EEZs; overall, only 4% of the area of Offshore habitat EBSAs in the WIO is in MPAs.

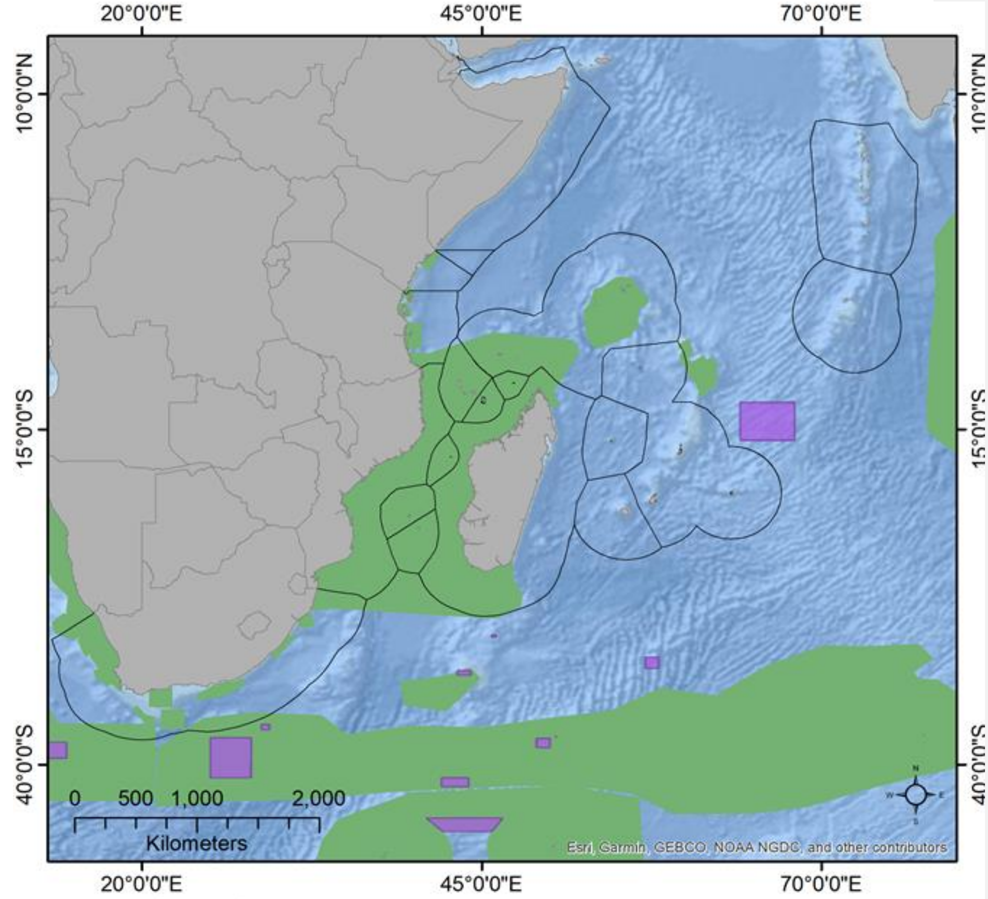

Figure 1: Map of the Western Indian Ocean area showing 18 Offshore habitat EBSAs (green) and Benthic Protected Areas (purple). EEZs denoted by black lines.

Table 1: Indicative calculated areas (all km^2), rounded off for convenience.

WIO Offshore habitat EBSA area 7 500 000		Total WIO area 24 500 000	
In EEZs	In ABNJ	In EEZs	In ABNJ
3 280 000	4 200 000	9 390 000	15 270 000

On shelf	Beyond shelf		On shelf	Beyond shelf	
380 000	2 900 000	-	500 000	8 870 000	-
MPA area			MPA area		
44 000	260 000	0	48 000	300 000	0

The WIO is home to an extraordinarily diverse suite of species (Griffiths 2005, Richmond 2011), but those known are mainly from coastal shelf waters and many more remain to be discovered or described from deeper waters. It may be expected, given their vast spatial extent, that Offshore habitats will add considerably to species counts as explorations expand into these areas. This particularly applies to benthic fauna from shelf sediments and deeper seabed habitats which have been consistently undersampled (Griffiths 2005). This is the case even in South Africa, where most ecological sea-bed research in the region has taken place – with vastly more in shallower (<100m) west coast waters, notwithstanding the enormously greater area of sea bed > 100m deep (Griffiths et al. 2010). Broadly, in shelf waters, biodiversity increases from the cool west coast ecoregion, through the warm-temperate Agulhas region off the south of the continent, into the subtropical Natal province and ultimately the extensive tropical WIO commencing off southern Mozambique (Spalding 2007); the biota of the western and southern regions are quite different and more variable compared to those of the eastern, which are more uniform (Griffiths 2005). However, deep water habitats are known to be more stable and usually their biota distributes throughout larger areas when compared to that of shallow water (Longhurst, 2007). At depths of 800 to 3 000m, the WIO forms part of the proposed Indian Ocean lower bathyal province, but based on physico-chemical proxies rather than species, while at depths > 3 000m, the south-west Indian Ocean region is proposed to be distinct from the remainder of the Indian Ocean abyssal province, based on sea temperature (UNESCO 2009).

Most offshore EBSAs characteristically identify the more readily observable and/or charismatic and endangered species, such as sea birds and marine mammals, together with threatened fishes, as part of the rationale for their ecological or biological significance. These faunal elements will be addressed more comprehensively in the chapters on Marine Birds (see Chapter 16), and Threatened Species (see Chapter 15), but the following key species in Offshore habitats are particularly noteworthy. Commencing in EBSAs off the South African west and southern coasts, some encompass key foraging areas for southern right (*Eubalaena australis*) and humpback whales (*Megaptera novaeangliae*), and have some of the highest known densities of several endemic seabirds. African penguin (*Spheniscus demersus*), Cape gannet (*Morus capensis*), Cory's Shearwater (*Calonectris borealis*) and the Atlantic Yellow-nosed and Tristan albatrosses (*Thalassarche chlororhynchos*, *Diomedea dabbenena*), amongst several other seabird species, are heavily reliant on these areas for foraging and breeding. Keystone small pelagic fish species, notably sardine (*Sardinops sagax*), anchovy (*Engraulis encrasicolus*) and horse mackerel (*Trachurus delogae*), are reliant on areas for spawning and as nurseries, as do the keystone demersal Cape hakes (*Merluccius* spp.). Endangered Southern bluefin tuna (*Thunnus maccoyii*) make extensive use of productive offshore pelagic areas for foraging. Knowledge of deeper (>200m) pelagic biodiversity is limited (UNESCO 2009), although studies have been made by oil prospecting companies, however with very restricted dissemination. Critical aggregating areas for several threatened endemic deep reef fish species are found off the southern Cape, such as red steenbras (*Petrus rupestris*), as well as aggregation of their counterparts from shelf sediment habitats e.g. silver kob (*Argyrosomus inodorus*). Vulnerable cold-water corals, such as *Goniocorella dumosa* and *Solenosmilia variabilis*, as well as hydrocorals, gorgonians and glass sponges are found on the shelf edge as well as on deep reefs and in canyons in several of these Offshore habitats.

Moving north-eastwards into the Offshore habitats of the WIO proper, the wide-ranging whales and Southern bluefin tuna persist, and there are high abundances in one of the most diverse seabird communities known. Some members of this are endangered and reliant on this region as their most important feeding area, such as Barau's petrel (*Pterodroma baraui*) and Amsterdam Albatross (*Diomedea amsterdamensis*). Further north, tropical species such as frigatebirds (*Fregatta* spp) and red-tailed tropicbirds (*Phaethon rubricauda*) are heavily reliant on waters there for foraging. On the shelf, aggregations of over-exploited endemic deep reef fishes such as seventy-four (*Polysteganus undulosus*) and slinger *Chrysoblephus puniceus*) are found. Apart from their reliance on inshore waters, vulnerable and/or threatened turtles (all five WIO species) make extensive use of offshore waters here, as do migrating humpback whales. Several threatened elasmobranch species form critical aggregations for nursery, feeding or mating purposes, either associated with shelf sediments or deep reefs; these include ragged tooth shark (*Carcharias taurus*), scalloped hammerhead (*Sphyrna lewini*), whale shark (*Rhincodon typus*) and manta rays (*Manta* spp.). There are benthic communities of invertebrates and fishes specifically adapted to muddy habitats on the shelf and in deep water, the former closely associated with outflows from large rivers. The critically endangered coelacanth (*Latimeria chalumnae*) is found in certain shelf-edge habitats, and vulnerable reef-building cold-water coral sites are known in deep water (>900m) in some areas.

Importance

For some of these offshore habitats, particularly those which are spatially extensive, physical oceanographic processes are extremely influential (see also Part II, Chapter 5). In some areas, such as on the west coast shelf of South Africa, and around oceanic fronts and convergence zones, very high levels of pelagic productivity are found, as a consequence of the interaction of currents and wind. These produce strong gradients of salinity and temperature, with vertical stratification of the water column allowing nutrients to be concentrated in the upper euphotic layers, resulting in plankton blooms and associated energy transfer higher up the food web. This accounts for the reliance of seabirds, mammals and pelagic fishes on these areas for feeding (Boersch-Supan et al. 2017). In shelf areas, the pelagic energy is transferred to benthic habitats too, permitting high levels of biomass over shelf sediments on the South African west coast. Mobile and semi-permanent oceanic mesoscale eddies typify the WIO region, also elevating nutrient levels (but not to the same extent as on the west coast), either by upwelling at their cores, or by advecting and retaining nutrients from shelf regions; these features, too, are associated with enhanced biological production (reviewed in Ternon et al. 2014). The productivity of several WIO upwelling sites, some of which spatially coincide with Offshore habitats, are being investigated in the ongoing Western Indian Ocean Upwelling Research Initiative (Roberts 2015). Over shelf sediments, large rivers are recognized as important providers of nutrients (Huggett and Kyewalyanga 2017), also evidenced from the presence of near-by industrial fisheries. However, the importance of land-based nutrient sources relative to oceanic upwelled sources in shelf environments is not fully understood, notwithstanding preliminary findings on the east coast of South Africa, reviewed in Fennessy et al. (2016). Much of the WIO, though, is naturally low in productivity, especially in surface waters (Kyewalyanga 2015, Obura 2015a, Huggett and Kyewalyanga

2017), and this is reflected in the low biomasses of fishes in contrast to those on the Atlantic coast (Fennessy et al. 2017, Krakstad et al. 2017). Further, the pathways and extent of bentho-pelagic coupling facilitating energy transfer to deep seabed habitats in the region is not well understood.

Apart from the productivity features of Offshore habitats, other physical processes were found to be critical for sustaining the organisms which occur there. Migration corridors facilitate essential seasonal movements of adult organisms to and from areas for feeding and reproduction, such as those undertaken by humpback whales from the Antarctic to the central WIO (Best 1998), or for example by marine turtles migrations (Lambardi et al., 2008). Some species, such as spiny lobsters (*Palinurus* spp), produce pelagic larval recruits which can be transported vast distances and over long (six months) periods before settling in shelf nursery areas, but other species utilize physical oceanographic features to ensure their offspring are retained close to their origin soon after hatching. However, even with a relatively short pelagic duration (one month), the larvae of some species can be transported across the Mozambique channel and remain viable (Ockhuis 2017). Recruitment can be mediated by major current systems, such as the South Equatorial Current and the Agulhas Current, or by more localized, smaller features such as eddies and gyres, or coastal currents (see Part II, Chapter 5). Recruitment processes of less mobile organisms which occur in, or close to, shelf and deep-sea sediments are not well-known in most cases. As already indicated, the biota in these habitats are poorly known throughout much of the region - with the exception of parts of the South African west and east shelves, and also if they are the target of fisheries (discussed below).

The significance of these Offshore habitats for biodiversity conservation has been elaborated in EBSA workshops with the participation of local and regional experts (SCBD 2014, 2013). Criteria for inclusion as an EBSA include high levels of productivity, vulnerability and biodiversity (reviewed in Part II, Chapter 4), and the scoring of these EBSAs, together with the Offshore habitat features which qualify them for conservation, are summarized in Appendix 1.

The value of the WIO marine economy was recently reviewed by Obura (2017). While tourism is the major contributor, Offshore habitats offer limited scope for such activities, owing to their largely inaccessible nature. Nevertheless, they provide ecosystem services in support of coastal habitats which do support tourism, albeit that the value of this support has not been calculated. Similarly, quantification of the value of Offshore habitats, particularly pelagic waters and deep-sea sediments, towards another major economic contributor, carbon sequestration, has also not been determined for the WIO region and is not as yet included in state economies. Fisheries are traditionally identified as having more obvious direct economic benefit to states, particularly those in their EEZs. Notwithstanding the socio-economic importance of the region's coastal small-scale fisheries (van der Elst et al. 2009), fisheries in Offshore habitats are economically important to WIO nations, particularly as a source of foreign currency. These are generally of an industrial nature, owing to the infrastructure required to access and process offshore resources, and are regionally epitomized by the fisheries for large pelagic fishes (long-line and purse-seine for tunas), crustaceans such as prawns and langoustines trawled over shelf and/or deep-sea sediments, and demersal fishes on seamounts in ABNJ eg trawling for orange roughy (*Hoplostethus atlanticus*) and alfonsino (*Beryx* spp).

The offshore fisheries and their target species in the WIO region are described in van der Elst and Everett (2015). For many states, the investment and expertise to harvest offshore resources is not available, and the fishing rights to their EEZs are sold to interests outside the region. The most valuable fishery is that for tuna, and most catches are made in the high seas. Annual WIO tuna catches are around 850 000 tonnes, and are valued at over US$1.3 billion (Barnes and Mfodwo 2012), although these figures are under-estimates. The most economically important South African west and south coast industrial fisheries in Offshore habitats are atypical of the WIO region in terms of the cold-water species targeted and the types of fishing gear. They take the form of demersal trawling for hakes (*Merluccius* spp.) and purse-seining for small pelagic anchovies (*Engraulis encrasicolus*) and sardines (*Sardinops sagax*) (Cochrane et al. 1997), with a combined value in the region of US$ 0.5 billion. These fisheries are heavily dependent on the elevated nutrient productivity generated by upwelling, and current-mediated recruitment (see above).

Unsurprisingly, formal literature sources on the economic value of non-renewable marine resources such as oil and gas, and polymetallic nodules, sulphides and crusts, are difficult to obtain. Revenues can be very large – the annual value of diamonds mined in shelf sediments off the west coast of South Africa and (mainly) Namibia in 2012 was around 3.5 billion US$ (reported in Baker et al. 2016). The predicted potential for polymetallic nodules in the WIO is not as high as in other oceans (Petersen et al. 2016), although some reports indicate otherwise (e.g. Rona 2008); nor are mining activities for these already occurring in the region, although further exploration is likely; owing to the depth at which these features occur, sites are often beyond EEZs (Petersen et al. 2016). The WIO has several developed oil/gas fields (Richmond 2016), most recently initiated in northern Mozambique, and there are considerable estimated reserves in the region, albeit not necessarily economically viable, and much of the area remains under-explored (U.S. Geological Survey 2012). Phosphate and diamond mining interests are currently restricted to the shelf off the west coast of South Africa, while heavy minerals such as titanium ores are often found in shelf sediments off large river mouths in the WIO (Rona 2008), although no offshore mining of these has commenced.

Threats

These can be broadly grouped into three categories – extraction of resources (renewable and non-renewable), contamination and pollution (some of which is directly associated with resource extraction), and climate change. All of these threats are, to a greater or lesser degree, anthropogenic. The ASCLME/SWIOFP Transboundary Diagnostic Analysis (2012) for the region identified several drivers which exacerbate threats to habitats, including: unsuitable governance, economic factors, insufficient financial resources, a lack of knowledge, and population growth. At the regional scale, cumulative human impacts in the WIO based on 2004-2006 data were less intense than in other regions, but with elevated levels in the north-east and south-west of the region (Halpern et al. 2008). However, a follow-up review show that regional impacts, particularly those linked to climate change, had intensified considerably by 2013, particularly in the Mozambique Channel (Tanzania) and to the east of Madagascar (Comoros, Reunion, Seychelles; Halpern et al. 2015). Threats frequently imply declines in habitat status, and threats to Offshore habitats identified during the EBSA process are therefore included in the summary table of habitat status in following section (Table 2).

Harvesting of renewable resources, largely in the form of fishing, is widely recognized as being a threat via habitat modification and/or unsustainable removal of large amounts of biota, either as bycatch or targets, causing disruptions to ecosystem functioning. While over-exploitation of some species in Offshore habitats in the WIO region is known, for example for large pelagic tunas (Pillai and Satheeshkumar 2012), evidence of changes to ecosystem functioning is limited, largely because of an absence of suitable, long-term data sets. Increasing sea temperatures and altered upwelling patterns are predicted to result in distributional shifts and changing abundance of tunas; incidences of this have already been seen in the WIO, with low primary production and major changes in tuna distribution in the late 1990s causing an eastward shift in fishing fleet operations (Robinson et al. 2010). There is some evidence of altered composition of fish families from shelf sediment habitats in Mozambique, potentially attributable to coastal over-fishing (Fennessy et al. 2017; Krakstad et al. 2017). While demersal trawling is generally recognized as having negative physical impacts on the seabed, in the WIO region this activity is at a relatively low level within EEZs, being mainly concentrated off central Mozambique and the west coast of Madagascar (van der Elst and Everett 2016) and there is limited scope for its increase, at least at depths from 200-600m (Everett et al. 2016). The potential for demersal trawling at depths greater than this, within EEZs in the region, is largely unknown. There are indications that industrial trawling effort in depths <100m is declining owing to reduced viability (Fennessy and Everett 2016), and the smaller island states have all banned demersal trawling. The situation is somewhat different off the south and west coasts of South Africa, where there is considerably greater demersal trawling effort (as well as purse-seining for small pelagic fishes), and where there is stronger (although not always unequivocal) evidence of alteration of Offshore habitats, and composition and distribution of species, due to fishing (Atkinson et al. 2011, Coetzee et al. 2008, Sink et al. 2012). Trawl-associated deep-water communities from ABNJs, frequently associated with seamounts and ridges (see Part III Chapter 17), are poorly documented in the formal literature, although sharp changes in effort and catch indicate over-exploitation of the highly vulnerable target species (e.g. orange roughy), and damage to habitats with vulnerable epifauna such as deep-water corals is known (reviewed in Clark et al. 2015). A threat still unquantified for WIO Offshore habitats is bioprospecting for marine natural products, although several states have been involved in this activity in coastal habitats (Wynberg 2016).

Exploration for and extraction of non-renewable resources both pose threats, and there is increasing interest in identifying and utilising marine sources as terrestrial sources diminish. Methods for identifying mineral resources initially rely on remote sensing to identify promising indicative geological features – such methods frequently involve use of seismic and sonar equipment. Depending on the frequencies and intensities of the sounds generated, negative impacts on a wide range of organisms, from benthic infauna to cetaceans, are possible, including disrupted communication, hearing and orientation, although there is considerable lack of knowledge of effects for many taxa (Hawkins et al 2015). Mining of minerals generally results in disruption of sediments, leading to increased turbidity and modification or loss of habitats, and contamination and destruction of biota (Ahnert and Borowski 2000; Levin et al 2016). Even excluding catastrophic failure of infrastructure leading to widespread oil spillage, drilling for and extraction of petroleum products results in contamination of sediments and surrounding water, with extirpation or modification of benthic and pelagic biological communities. Effects of these extractive activities can be localized or dispersed over thousands of kilometres (Smith et al. 2008), depending on current regimes and the extent of contamination, and can persist for many years in deep-sea habitats (Cordes et al. 2016).

The most well-known extraction of non-renewable marine resources in the WIO region is of oil and gas within state EEZs, with licenses being granted for large prospecting areas by several states. In South Africa, for example, 98% of the EEZ has been assigned for this activity, and there are large prospecting blocks in southern Tanzania and northern Mozambique. While impact assessments have been undertaken for prospecting and extraction (Richmond 2016), and monitoring is underway at localities where extraction has already commenced, details of impacts are not available in the formal literature. While extraction of metallic ores has not commenced in Offshore habitats in the WIO region, hydrothermal vent areas of potential interest have been identified, and, as interest in these resources increases, exploration is expanding. The International Seabed Authority (www.isa.org), which regulates deep-sea mining in ABNJs, is granting increasing numbers of licenses to contractors for deep-sea exploration for polymetallic nodules, massive sulphides and cobalt-ferro-manganese crusts (Boetius and Haeckel 2018). While most licenses are in other oceans, there are some on the Central Indian Ridge and the South West Indian Ridge (Levin et al 2016). Indications are that hydrothermal vent communities are intolerant of disturbance, but, more concerningly, elements released from the vents have a critical biogeochemical role in the wider ocean, for example via mediation of micronutrient productivity associated with phytoplankton blooms (see for example German et al. 2016). There are concerns that the ISA's governance processes are not sufficiently transparent and that it has limited means to enforce conditions of exploration contracts (Johnson et al. 2016). Deposits of titanium-based minerals in shelf sediments are known for several areas, notably in areas adjacent to where coastal mining is already occurring; locations of phosphate accumulations in shelf sediments are similarly known (Rona 2008). In South Africa, prospecting rights in these habitats have been granted for both of these minerals. Probability of commencement of extraction of non-renewables depends on the availability of the minerals from terrestrial sources, their prices, and on technological capabilities – these are all changeable, so the imminence of the threats posed is difficult to assess.

Shipping traffic in the region is also related to the regional economy and extraction of resources (both renewable and non-renewable), and the Indian Ocean has demonstrated very rapid growth in shipping subsequent to 2002; although considerable traffic passes through the Mozambique channel, the major route is between southern Africa, passing to the south of Madagascar, to and from Asia, and the relative densities of ships are considerably lower than in the Northern Indian Ocean (Tournadre 2014). If, as anticipated, oil and gas activities in the WIO region continue to grow apace, greater shipping traffic can be expected in the region, with associated increased pollution, ship strikes on cetaceans, and invasive species from ballast water and fouling.

By far the most marine contamination and pollution originates from the land (Hassan 2017), and the proximity of coastal and shelf habitats means they are the main recipients, while impacts in Offshore habitats tend to be less noticed owing to dispersion and their being out of the public eye. However, plastic, the most pervasive type of marine litter, has been found in sediments even in remote habitats several thousand meters deep (Woodall et al. 2015). Plastics can entangle organisms, smother habitats, and alter community structure (Gregory 2009), and ingested plastic can reduce stomach capacity, affect growth, cause internal injury, and block intestines (Plot and Georges 2010). The WIO region is less threatened by pollution than other oceans, although this is changing (Obura 2015b); for example the Indian Ocean had higher numbers and weights of plastic particles compared to other southern hemisphere oceans (Eriksen et al. 2015), and around 50% of loggerhead turtles (*Caretta caretta*) examined between Reunion and Madagascar from 2007-2013 had ingested plastic, with ingested amounts higher than in turtles from other oceans (Hoarau et al., 2014). Notwithstanding the expansion of oil and gas activities in the WIO region, there are no formal publications on impacts of associated pollutants on Offshore habitats, although monitoring has commenced in some areas, notably northern Mozambique by the *RV Dr Fridtjof Nansen* in 2018. Similarly, assessments of the threats posed by other pollutants, such as metals and organic compounds from terrestrial sources, is rare (see UNEP/Nairobi Convention Secretariat, CSIR and WIOMSA 2009; Fennessy and Green 2015).

In contrast to the threats posed by land-derived pollutants and contaminants, some WIO Offshore habitats and communities, including some in deep water, rely on sediments and nutrients provided by rivers (Gammelsrod 1992; Fennessy et al 2016; Scharler et al. 2016). Reduced flow, because of impoundments or climate change, compromises this delivery (Lamberth et al. 2009), as well as reducing recruitment of estuarine-dependent organisms to offshore habitats (Scharler et al. 2016), thereby threatening ecosystem functioning,

The deep sea plays a major role in reducing anthropogenic impacts on climate – its capacity is substantially larger than the atmosphere and land, and it has absorbed between 25-40% of human-generated atmospheric carbon dioxide (CO_2) (Khatiawala et al., 2013; McKinley et al. 2016). Oceanic absorption of atmospheric CO_2 involves chemical, physical, and biological processes, which are all sensitive to temperature; and yet absorption of CO_2 is making the sea warmer and more acidic, and is reducing its ability to hold oxygen (Cao and Zhang 2017). The Indian Ocean sea temperature is known to be increasing faster than other oceans (Hoegh-Guldberg 2014; Roxy et al 2014), increased temperatures have effects on marine communities. A meta-analysis of over 600 publications by Nagelkerken and Connell (2015) revealed that primary production by non-calcifying plankton in temperate waters increases with elevated temperature and CO_2 levels, whereas productivity of tropical plankton decreases because of acidification. Temperature increases metabolic rates in herbivores (and hence their consumption), but does not result in greater secondary production; instead, there are decreases in both calcifying and non-calcifying species. In carnivores, metabolic and foraging costs increase with increasing temperature. Species diversity and abundance decline with acidification in both tropical and temperate species, with a trend towards communities dominated by non-calcifying organisms. The CO_2 concentration affects the aragonite saturation state (ASS) of the ocean, and as ASS levels drop, the ability of calcifying organisms such as corals and shelled invertebrates to create calcium carbonate skeletons structures is reduced (Halpern et al. 2015).

A recently identified threat in Offshore habitats, even less quantified for the WIO, is posed by methyl hydrates, and an overview is given in Bollmann et al. (2010). From sediments at depths greater than 350m, and with water temperature of $< 4^{o}$ C, natural methane gas production in sediments can be stabilized into hydrates on the seabed, but with warming, the hydrates can break down, releasing methane. The hydrates are concentrated on continental slopes because that is where suitable conditions (depth, temperature and sufficient organic matter) are found to facilitate their production. Vast amounts of methane hydrate are buried in sediments on the slopes – containing far more carbon than released by fossil fuels. Micro-organisms oxidize the resulting methane gas to form the greenhouse gas CO_2 which will not only contribute to further global warming, it will also lead to increased acidification of oceans. There is also interest in mining of seabed hydrates from Offshore habitats, which would accelerate release of methane. It is likely that there have been large-scale natural releases of methane over geological time which could have resulted in mass extinctions of deep-sea organisms - further investigations are needed to assess the scale at which climate change will accelerate due to changing temperatures at depth causing methane gas release at the sea floor.

Likely effects of climate change on global ocean hydrodynamics and circulation are still being debated. Global circulation includes transport of warm, less-saline water from the Pacific to the Indian Ocean and then into the Atlantic. Data sets are not available to assess long-term change in this thermohaline circulation, but there are recent indications that in the last 10 years, the Indian Ocean has increasingly been taking up warmer water from the Pacific (Lee et al. 2015). Accelerated warming, together with intensifying winds, is reported to be accounting for the widening of the Agulhas Current in the south-west Indian Ocean (Beal and Elipot 2917), which transports water to the Atlantic Ocean.

Broadly, climate change effects are intensifying in the WIO region, particularly in areas that were previously less impacted, but available data sets for the region are limited, or are based on proxies rather than direct evidence (Halpern et al. 2015; Mahongo 2015). Regional surveys, for example as part of the Second International Indian Ocean Expedition, and by the *RV Dr Fridtjof Nansen*, will improve predictive models.

Status

Given the vast spatial extent of the EBSAs, the multiplicity of habitats within these areas, and the lack of information on Offshore habitats in the WIO, it is not practical to use the standard ecosystem indicators or IUCN ecosystem categories to assess status. The only WIO country which has made some progress towards this is South Africa, which has categorized 62 Offshore (deeper than 30 m) benthic habitats that were defined on the basis of substrate, depth, slope, geology, grain size and biogeography, and 16 Offshore pelagic habitats, that were defined based on sea surface temperature, productivity, chlorophyll, depth, eddies and fronts (Sink et al. 2012; see Case Study). Therefore, indicators of the status of Offshore habitats herein is based on the "Naturalness" category determined during the EBSA process: "Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation". The Naturalness category/status was determined during the EBSA workshops by expert assessment of habitats within each EBSA, if information was available (SCBD 2014, 2013). The rationale for assigning a particular Naturalness category (Low, Medium, High) to each EBSA is summarized in Table 2. For some of the very large EBSAs, coastal habitats are included, ie, the assigned category is not exclusively representative of the status of Offshore habitats.

Table 2: Status of Offshore habitats expressed in terms of 18 offshore EBSAs and their naturalness categories. WIO EBSAs in black, EBSAs in the South African EEZ to the west of Cape Agulhas (ie, in the adjacent south-east Atlantic) in red.

EBSA	Naturalness	Rationale
Agulhas Front	Low	Long-line fisheries operate in the area, and their bycatch of seabirds, particularly albatrosses, has caused considerable declines; there are whale entanglements in fishing gear and ships strikes on whales; however, this EBSA is still highly productive

		and large numbers of seabirds still feed there, indicating it retains some functionality. Areas around the islands are protected and managed, and have a high degree of naturalness.
Agulhas Bank	Medium	Several pelagic and demersal fishery types operate in this area - they have caused damage to some reefs, and declines in several endemic fishes. Petroleum-related activities are expanding. Consequently, several species and habitats (sediment and reef) are categorized as threatened (IUCN categories ranging from Critically Endangered to Vulnerable). There is only one pelagic habitat in this EBSA, which is in a good state, while the state of the various benthic habitats ranges from poor to good depending on exposure to fishing and petroleum activities.
Agulhas slope	High	Several pelagic and demersal fishery types operate in this area, and there are threatened species (turtles and seabirds) and threatened habitats (pelagic, sediment and reef). However, threat levels in this EBSA are lower than in other slope areas, partly because oceanographic and seabed features limit the potential for disturbance.
Offshore of Port Elizabeth	Low	There are a variety of pressures in Offshore habitats in this EBSA, including a variety of fishery types. The overall state is declining, with fair to poor conditions in most habitats. There are a variety of species (turtles and seabirds) and multiple habitat types (including muds, canyons, sandy shelf) categorized as threatened (from Critically Endangered to Vulnerable). However there are many areas which are in a good state.
Protea Banks and sardine route	Low	There are threatened habitats (particularly reefs), and threatened demersal fish species (due to fishing); the pelagic habitat state is good, with benthic habitats ranging from poor to good. Overall the state is categorized as fair to poor.
Natal Bight	Low	Threats to Offshore habitats in this EBSA include demersal fisheries on shelf and slope sediments and reefs, developing petroleum and mining interests, and further reductions in nutrient and sediment supply from riverine runoff. Fisheries and dams have already resulted in endangered states of some rare habitats, and threatened species (turtles and fishes) occur here. The overall state is fair to poor, but parts of some habitats (reef, mud, gravel) are in a good state.
Delagoa shelf edge	High	There are limited current threats here, with existing protection and usage management zones in MPAs covering habitats to the shelf edge, and consequently most of the Offshore habitats are in a good state

		(largely undisturbed), particularly documented for South African shelf habitats, which have had a longer period of more managed protection. Potential threats are petroleum exploration and proposed port development; pelagic longline fishing is not permitted within 20nm of the coast.
Quelimane to Zuni River	Medium	Much of the shelf sediment habitat to ~100m depth has been trawled extensively for many years, with both targeted prawns and some bycatch fish species being overexploited. This habitat is heavily reliant on nutrients and sediments from the Zambezi River which has been affected by existing dams; others are planned, which are likely to compromise the currently relatively pristine mangrove habitats which serve as nursery areas for the communities in Offshore habitats. Reef habitats have also been heavily fished.
Mozambique Channel	Medium	This huge EBSA has very high levels of biodiversity; some Offshore habitats in the EEZs of several bordering countries have MPA protection at varying spatial scales and management levels, suggesting healthy status for these. There are numerous species (cetaceans, birds, fishes) categorized in different threat levels (Critically Endangered to Vulnerable) which occur here. Some Offshore habitats are remote from human populations and are consequently less impacted, but, at the regional scale, vulnerability is high.
Southern Madagascar	High	There are low coastal population levels and limited pressures on Offshore habitats here, but these threats may develop as other fishing areas become depleted. There are numerous species of cetaceans and birds categorized in different threat levels (Critically Endangered to Vulnerable) which occur here. Status can generally be categorized as good.
Northern Mozambique Channel	Low	Levels of human impacts differ in various locations in this large EBSA, but there are some areas still in a good undisturbed state. Numerous species (cetaceans, birds, fishes), categorized in different threat levels (Critically Endangered to Vulnerable), occur here. Overall status is poor (Low naturalness category), but this is due to the disturbed state of coastal habitats within the EBSA which have high population pressure; Offshore habitats are likely to be in a better state.
Subtropical Convergence Zone	Low	Harvesting of whales took place here for many years, although population levels are recovering. There are likely to be fishing effects, but the area is still naturally highly productive, supporting bird and fish communities which feed here. This may be affected by climate change, but other human pressures on the area

		are not expected in the near future.
Benguela Upwelling System	Medium	Historical over-fishing, mining and petroleum exploration and production have had impacts in Offshore habits in this EBSA, and there are additional pressures such as pollution, invasive species and altered freshwater outflows. The southern part of the EBSA (off South Africa) appears to have been more stable, assisted by conservative fisheries management, but eastward shifts in distribution of several key species have had negative effects on seabird populations. However, many habitats are in good condition, and overall the area can be considered to be in a moderately natural state.
Browns Bank	Medium	There is considerable trawl fishing pressure in Offshore habitats here, with most outer shelf sediments in a poor state; one habitat is Critically Endangered with a very limited spatial extent, while some shelf-edge reefs are in a good state as they have not been trawled. The pelagic habitat is considered Vulnerable and is the most threatened of the pelagic habitats in the area. Of the bird species occurring occur here, the most threatened is categorized as Critically Endangered.
Cape Canyon and Surrounds	Medium	Several fisheries operate here, and the state of Offshore habitats ranges from good to poor. Pressures in the form of petroleum exploration and prospecting for seabed mining are increasing. There are some habitats in a good state, particularly around the canyons and on reefs where trawling is limited.
Childs Bank	High	Much of this Offshore habitat is in a good state, but with parts that are fair or poor, with fishing impacts on biodiversity or ecological process. Fishing effect has been declining, but damage to sessile benthic organisms on reef slope areas is continuing. Other anthropogenic pressures are low.
Orange Shelf Edge	High	In this EBSA, while the shelf edge and shelf sediment Offshore habitats are in IUCN threatened categories of either Critically Endangered or Vulnerable, with varying degrees of habitat degradation and loss of ecosystem function, there are still parts which are in a good state, particularly in South African waters, because there are reduced threats in the form of fishing, mining or pollution.
Orange Cone	Medium	Several demersal and pelagic communities from Offshore habitats are reliant on Orange River flow, and changes have been recorded as flows have altered. Coastal mining impacts are considerable, albeit confined to depths of 30m; the inner shelf area is considered to be largely in a good state, but there have

		been long-term declines in fish catches, suggesting changing communities.

Of the 18 EBSAs, five scored High for Naturalness, seven scored Medium and six scored Low. Offshore habitats in a poor state are invariably affected by extraction of renewable and/or non-renewable resources. Very broadly, it may be assumed that offshore habitats are in a better state than coastal habitats, owing to remoteness from human populations, and pelagic habitats are in a better state than benthic habitats, owing to an absence of vulnerable static features which support communities in the former. To some extent the global meta-analysis by Halpern et al. (2008) supports this contention, with low cumulative human impact scores in deep-water ecosystems (although long-standing fishery effects there were underestimated); surprisingly, continental shelf sediments were considered to be as heavily impacted as hard shelf and rocky reef ecosystems, owing to influences from both land and ocean.

Existing protection

A large part of the WIO falls within the EEZs of the bordering states and territories (see Table 1), which all, with the exception of Somalia, have mechanisms for the inclusion of Offshore habitats in declarations of formal marine protected areas (MPAs). Further, most of these states have some capacity for at least sector-based marine spatial planning which can offer protection eg spatial fisheries closures; these can be considered Other Effective Area-based Conservation Measures (OECMs). As will be seen below, there are a variety of regional, transnational, national and sub-national institutions and actors in the WIO whose mandates and/or mechanisms provide for protection of Offshore habitats. These will be considered separately in terms of jurisdiction – for states, this means mandates and mechanisms applicable to their EEZs, with their equivalents in ABNJs being considered separately. There are overlaps though – for example, pelagic fishes such as tuna within a state's EEZ are under the jurisdiction of the regional fisheries body (see below), while benthic organisms and mineral resources are under the jurisdiction of the state. The MPA Outlook report (*MPA Outlook report ref?*) describes in detail the mandates, governance and management of protected areas in EEZs of WIO states and should be consulted in this regard – only a brief summary thereof is provided here. Locally Managed Marine Areas are not considered here as they have not been widely adopted in the WIO and do not currently offer protection to Offshore habitats (*MPA Outlook report ref?*). Therefore the focus here is on formal MPAs for habitat protection, although OECMs in the form of fishery reserves form part of MPAs in some instances. In this regard it is worth noting that most of the WIO island states (excluding Madagascar) do not permit demersal trawling in their EEZs. While there is a WIO Regional Fisheries Body in the form of the South West Indian Ocean Fisheries Commission, under the aegis of FAO, its advisory role is confined to state EEZs and it has no mandate for declaration of protected areas.

Commented [A1]: This reference will be dealt with later, as a final reference is not yet available

Commented [A2]: Ibd

In the three islands comprising the Union of the Comoros, there is only one formal protected marine area, the Marine Park of Moheli, declared by national decree of the head of state, and administered by the Ministry of Environment, with a park management committee incorporating local communities. There is no continental shelf as such, a consequence of the volcanic origins of the islands; protected habitats are thus essentially coastal, with complete protection limited to smaller areas within the Park. A national network of Protected Areas is planned, which will be declared by a superseding decree, and which will be co-managed by a protected areas agency and village communities, legislated under the Comoros Protected Areas Act and its laws which are still being considered by the state government, and which will be under the jurisdiction of the proposed Ministry of Protected Areas. Various National Parks boards and committees will also play a management role. Offshore habitats which could receive formal protection under these mechanisms are deep volcanic slopes and pelagic marine areas.

There are a variety of types amongst the 11 MPAs in the islands comprising the Indian Ocean French Territories. Similarly to the Comoros, continental shelf areas are negligible; the motivation for the protection is mostly vulnerable, coastal, shallow-water habitats, while inhabitants (eg fishes, mammals and birds) of epipelagic habitats also effectively receive protection depending on levels of compliance with the zonation of protection levels; deep (>1 000 m) sea-bed habitats falling within the MPA boundaries also benefit. Mandate for declaration mainly stems from the French Ministry for Ecological and Inclusive Transition, and management responsibility often rests with the French Biodiversity Agency, which convenes a forum of MPA managers. The MPAs are proclaimed by decree of the relevant local authority (island prefecture). There is also management input from a range of advisory panels and committees specific to each MPA, as well as a variety of other interest groups.

Kenya has five MPAs containing zoned no-take/no disturbance areas, which were proclaimed for protection of coastal habitats. These are under the authority of the Wildlife (Conservation and Management) Act of the Ministry of Environment and Natural Resources. The parastatal Kenya Wildlife Service is responsible for management, with participation by a range of government agencies, NGOS, local communities and the private sector. Offshore habitats thus do not currently feature in MPAs; there are plans for a transboundary marine conservation area between Kenya and Tanzania, the seaward boundary of which corresponds with the 200 m depth contour (approximately five nautical miles offshore), and which will afford protection to shelf sediment habitats.

The 22 MPAs in Madagascar are decreed by the Ministry of Environment, Ecology and Forests, and are under their guardianship as well as under the Ministry of Marine Resources and Fisheries. They are managed by the parastatal Madagascar National Parks agency, collaborating with NGOs, local communities and the private sector, either individually or in combination; most MPAs are co-managed. Offshore habitats receive limited protection, other than some areas of the continental shelf, as the MPAs are essentially designated for coastal habitat protection.

In Mauritius, while the Maritime Zones Act provides for some elements of protection of the marine environment, the Environment Protection Act provides the legal framework for such protection and management thereof, while the Fisheries and Marine Resources Act provides for proclamation and management of Marine Protected Areas. Altogether there are 18 MPAs in Mauritius and Rodriguez, in the form of marine parks, fishing reserves and marine reserves, but these are all essentially coastal, with the parks having the furthest seaward extent, out to only one km beyond the fringing reefs. In Mauritius they are managed by the Ministry of Ocean Economy, Marine Resources, Fisheries and Shipping (Fisheries Division), with activities in fishing reserves being controlled by the Fisheries Protection Service and local coast guard stations. In Rodrigues, management is mainly via the Commission for

Agriculture, Forestry, Fisheries and Marine Parks.

In Mozambique, the Law for the Protection, Conservation and Sustainable Use of Biological Diversity provides the framework for protection of habitats, while the Fisheries Law deals specifically with fisheries conservation areas and closed seasons. Proclamation of individual protected areas is via specific decrees sanctioned by the national Council of Ministers. There are five MPAs in Mozambique (two national parks, one reserve, one total protection zone, and one environmental protection area). Of these, four include Offshore habitats in the form of offshore pelagic habitats, and deep sea benthic habitats including canyons, seamounts and ridges. The legally mandated management institution is the Ministry for Land, Environment and Rural Development, through its National Administration for Conservation Areas, with various advisory management committees. These include representatives of local government, local communities, NGOs and the private sector. Interestingly, agreements have been signed with the Ministry in some MPAS, permitting non-profit conservation organisations to manage the areas for fixed periods of up to 50 years.

In Seychelles, the 12 formal MPAs for habitat protection have been designated either under The Environment Protection Act or (mostly) the National Parks and Nature Conservancy act, and provide for protection of habitats in four categories: Area(s) of Outstanding Natural Beauty, Strict Natural Reserves, Special Reserves and National Parks. Most only protect shallow-water coastal habitats, with only the two most extensive including deep sea and offshore pelagic habitats. The MPAs are variously managed by foundations, societies and authorities, frequently with directors appointed by the President of Seychelles. A Protected Area Policy was recently developed as a framework for establishment and management of protected areas (including MPAs). Several new extensive MPAs are in the process of being finalized, and will include Offshore habitats for protection; a new institutional framework for management of these still has to be developed.

South Africa has 24 formal MPAs, with protected habitats in sanctuaries, and restricted, controlled and no-take zones. However, these are mostly coastal MPAs, and only four could be considered to protect Offshore habitats in the EEZ of mainland South Africa (as distinct from the islands of the Southern Ocean), which are thus poorly represented in terms of scale of protection. The primary legal instrument for the establishment and protection of MPAs is the National Environmental Management: Protected Areas Act, promulgated by the Department of Environment Affairs (DEA), which is the nationally-mandated management authority for all MPAs, and which has contracted a range of (mainly) local government conservation authorities to manage them. DEA's National Protected Area Expansion Strategy developed conservation targets to particularly address protection of Offshore habitats, and 22 new/extended MPAs were proposed in 2016 for promulgation in this regard, largely coinciding with EBSAs. On 26th October 2018, 20 of these proposed MPAs were approved by Parliament.

In the United Republic of Tanzania, the 18 Mainland MPAs fall under the Marine Parks and Reserves Act under the auspices of the Ministry of Livestock and Fisheries; the Marine Parks and Reserves Unit which manages MPAs was also constituted by this Act, with oversight by the Board of Trustees for Marine Parks and Reserves, although there is co-management with community members, advisory committees and other stakeholders. The MPAs are mostly coastal, with minor inclusion of deep sea/epipelagic areas for protection. Proposed new MPAs are also coastal, and the proposed transfrontier marine conservation area between Kenya and

Tanzania will include part of the Pemba channel which will afford some protection to deeper shelf habitats. In Zanzibar the Environmental Management Act allows for areas to be declared for protection, with management by the Marine Conservation Unit established under the Ministry of Agriculture, Natural Resources, Livestock and Fisheries, through the Fisheries Act. The MPAs are partially protected areas having a focus on fisheries management, with extensive involvement of communities; none can be considered to protect Offshore habitats, apart from one which borders the deep ~1 000m Pemba channel.

Regarding Offshore habitats beyond EEZs, notwithstanding that the Nairobi Convention has no specific mandate in ABNJ, member states agreed in 2015 to co-operate in improving governance beyond their EEZs, and the Convention secretariat assumed a co-ordinating and advisory role; it became a partner in activities dealing with ABNJ governance and mechanisms for habitat protection, and has facilitated several projects in this regard - of particular significance for Offshore habitats being the EBSA process. Readers should consult Wright and Rochette (2017) and UNEP-WCMC (2017) for more comprehensive reviews of governance of ABNJ in the WIO.

There are several international organizations and/or legal instruments which have mandates that incorporate mechanisms for protection of habitats in ABNJs, and there are Regional Seas Conventions establishing MPAs in ABNJ in the Atlantic, Pacific and Southern oceans (Rochette et al. 2014). Albeit that there are benefits to be gained by the Nairobi Convention assuming a more prominent role in ABNJ governance, it is concerning that, given non-regional states' interest in the WIO, Regional Seas MPAs are only binding on parties to the Regional Seas Programme. International legal instruments are promoted by the Division for Ocean Affairs and the Law of the Sea (DOALOS) of the General Assembly of the United Nations (UNGA), which is the only global platform at which ABNJ habitat protection can be discussed. The organizations and instruments with mandates for habitat protection, can be broadly categorized into four sectors, dealing with fisheries, shipping, mining and environmental protection.

For WIO fisheries, the regional bodies with ABNJ mandates are the Indian Ocean Tuna Commission (IOTC) and the South Indian Ocean Fisheries Agreement (SIOFA), with their counterparts off the South African west coast – the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the South East Atlantic Fisheries Organization (SEAFO). The Commission for the Conservation of Southern Bluefin Tuna (CCSBT) can be included here too. Various international instruments (eg United Nations Convention on the Law of the Sea - UNCLOS) and United Nation General Assembly (UNGA) resolutions require these Regional Fisheries Management Organizations (RFMOs) to take conservation actions. The tuna RFMOs have numerous binding and non-binding measures to reduce bycatch of cetaceans, seabirds, turtles and sharks, and their websites should be consulted for these. The IOTC currently has no designated areas for habitat protection (a small area with a time/area closure existed from 2010-2015), but in 2006, SIOFA, through its members, the South Indian Ocean Deepwater Fisheries Association (SIODFA), declared self-enforced Benthic Protected Areas (BPAs) in its area of competence, which exclude trawling by members of SIODFA, and added to these areas in 2013 (Figure 1). There are ongoing initiatives by Contracting Parties to SIOFA to reduce the amount and spatial scale of trawling effort to existing fished areas, and to formally record instances of encounters with vulnerable habitats for potential protection (Shotton 2018). This is in response to the United Nations General Assembly 2006 resolution that measures be implemented by fisheries organizations to protect habitats, which included: impact assessments to prevent significant adverse impacts on vulnerable marine ecosystems (VMEs) in ABNJ; catch threshold protocols which require vessels to move away when they encounter a VME; and closure to demersal fishing in areas where VMEs occur or are likely to occur, until conservation measures have been established. Currently there are no formally designated VME areas in the WIO ABNJ, and there has been resistance from some SIOFA parties to the conversion of the SIODFA BPAs into VMEs (Guduff et al. 2018). For the purposes of this report the Africana Seamount VME could be considered to be within the WIO, being well to the east of Cape Agulhas, but falls with the mandate of SEAFO. It is of significance that the WIO BPAs only apply to SIODFA members – so non-members are not bound by them; additionally, it is of concern that benthic fishing effort in the SIOFA competence area will expand (Guduff et al. 2018).

For shipping-related habitat protection mechanisms, the International Maritime Organization (IMO) is a UN agency with responsibility for safety and security of shipping, and ship-derived pollution. Member states can designate Special Areas under the International Convention for the Prevention of Pollution from Ships (MARPOL) and Particularly Sensitive Sea Areas (PSSAs), in both EEZs and ABNJ, through the IMO's Marine Environment Protection Committee, to protect habitats from environmental impacts due to shipping. From a habitat protection perspective, the relevant associated protective measures (APMs) include: pollution control measures, and navigational measures such as areas to be avoided and preferential routeing. However, few PSSAs exist, there are currently none designated in ABNJ, and states are not legally bound to adhere to designating resolutions; experience to date with PSSAs suggests the process is challenging (Wright and Rochette 2017).

Regarding mining, as constituted under UNCLOS, the International Seabed Authority (ISA) is responsible for activities associated with exploration for, and exploitation of, non-renewable mineral resources (solid, liquid or gaseous mineral resource) on the sea bed in ABNJ (see section on Threats above). The ISA can designate Areas of Particular Environmental Interest (APEI) to exclude mining, and its regulations can prevent prospecting if there is considerable evidence that serious harm to habitats can be incurred; to date, although exploration contracts in the WIO have been awarded, no APEIs have yet been contemplated. Contractors who receive permits can independently designate Impact reference zones and Preservation reference zones to assist with assessing impacts.

Several international environmental conventions provide mechanisms for protection of habitats or species. The CBD of the United Nations Environment Programme (UNEP) facilitated the development of scientific criteria to identify and justify EBSAs for protection, and, partly facilitated by the Nairobi Convention, several such areas have been listed for the WIO region (Appendix 1). The World Heritage Convention (WHC) of the United Nations Educational, Scientific and Cultural Organization has designated two marine world heritage sites in the region for protection, based on their natural significance, but only one (iSimangaliso on the east coast of South Africa) can be considered to protect Offshore habitats by virtue of its seaward extent. The Convention on Migratory Species, under the aegis of UNEP, has several instruments for the protection of habitats of endangered and vulnerable species; the most prominent of these in the WIO being dugongs and turtles. Albeit not dealing with habitat protection as such, the International Whaling Commission designated the Indian Ocean Sanctuary in 1979, which prohibits commercial whaling in the whole of the Indian Ocean, effectively including the WIO.

In summary, although there are a variety of mechanisms for protection of Offshore habitats, both within EEZs and in ABNJs, they are largely uncoordinated, mainly being predicated on the interests of the state concerned (in EEZs), and on the requirements of a specific sector or sectors (eg fisheries, mining). The following section discusses this further in the context of the necessity for coordinated conservation mechanisms in the face of the need for additional protected Offshore habitats.

Priority options for conservation

It is apparent from the previous section, and previously confirmed by Chevallier (2017), that WIO protected areas have many different governmental processes involved in their designation and management, and that the legal, institutional and policy frameworks of WIO states are not coordinated or integrated. The complexity of the governance partly stems from the diversity of legal regimes governing marine and coastal zones which include internal waters, territorial seas, contiguous zones, continental shelves, slopes and rises, EEZs, and the high seas. These zones each have a rationale for their designation, predicated on their value and importance to the adjacent terrestrial state, largely in terms of the exploitation or use which takes place there (or may take place in the future). The situation has heightened complexity because some WIO states have made submissions to the Commission on the Limits of the Continental Shelf to extend the outer limits of their continental shelves; others have disputes around the extent of their EEZs. Beyond EEZs, the international community has become increasingly aware of growing interest in resources in ABNJs and the threats this poses (Wright and Rochette 2017). Offshore habitats, particularly those in deep waters, are extremely vulnerable to disturbance, owing to the long-lived, slow-growing attributes of the faunal inhabitants (Clark et al. 2016). Notwithstanding that the seabed in ABNJs is considered to be the common heritage of humankind and is subject to the provisions of UNCLOS, there has been slow progress in ensuring this (see below).

Much of the protection, or at least potential for protection, currently afforded to habitats is designated in terms of a specific sector, such as fisheries (particularly), as well as shipping or mining. Protection based on fisheries mechanisms does not necessarily protect habitats from other exploitation threats, and frequently only addresses one type of fishing, permitting other types; it also tends to focus on harvestable organisms rather than the habitat itself. So the downside of a sector-based approach to governance and regulations for habitat protection is that there are often spatial and legal gaps in management – without an overarching mechanism, which is currently lacking, some Offshore habitats which require protection may not be afforded it (Gjerde 2008, Gjerde et al. 2013).

It is also apparent from the previous section, and from Table 1, that Offshore habitats in EEZs and ABNJs have little formal protection in the region, as most MPAs have a coastal focus. There are no MPAs in ABNJ in the WIO region, and only 4% of the total EEZ area falls within MPAs; 9% of EEZ shelf area has MPA protection, while only 3% of beyond-shelf area is protected. A similar conclusion was recently drawn by Fischer et al. (2019), in a meta-analysis of MPA coverage of 19 offshore geomorphic seabed features – globally, none of these features receive more than 7% protection, in contrast to coral reefs, mangroves and seagrasses which receive protection of between 18-41% of their area. Demersal trawling is potentially feasible throughout the region, apart from in the SIODFA Benthic Protected Areas (which only apply to the nine contracting states), and in the EEZs of small island states;

effectively, though, extreme depth (>2 000m) precludes this type of fishing, and much of the demersal trawling which occurs is focussed on seamounts because of their fish aggregations (see Chapter 17). Fishing for medium-sized and large pelagic species, via small-scale gillnets and/or industrial longline and purse seine, occurs over most of the region, in EEZs and ABNJs. There are no Particularly Sensitive Sea Areas or Areas of Particular Environmental Interest to exclude shipping or mining activities from vulnerable Offshore habitats in the WIO. A just-published study shows that the Indian Ocean has no areas that are not exposed to anthropogenic stressors (Jones et al. 2018). At the same time, there is a paucity of information to help prioritize such habitats for protection, particularly beyond the continental shelf. Lack of knowledge should not be a deterrent, however. Indeed, it is the lack of knowledge itself which should encourage caution.

EBSAs are the most suitable regional approach to elaborate the need for additional protection for Offshore habitats, by applying internationally agreed-on scientific criteria. Identification of EBSAs is intended to alert states, and regional and global intergovernmental agencies, about the significance of habitats and to motivate for their protection. The broadening of EBSAs to include areas within the jurisdiction of states means that they "…can use the EBSA process to (1) support CBD National Biodiversity Strategies and Action Plans, (2) promote the status of previously identified national protected areas, and (3) potentially increase access to international funding for area-based planning, resource management and conservation efforts" (Dunn et al. 2014). Albeit that these authors make the point that there is no obligation for a state to convert an EBSA into a protected area or to manage it accordingly, the EBSA process can contribute to planning and designation for protection. The size of some EBSAs (eg the Mozambique Channel) makes it impractical for them to be either designated or managed as fully protected areas, and smaller individual EBSAs should be considered within these (SCBD 2013).

The EBSA process continues to evolve, and the evidence in support of existing EBSAs, as well as that for identifying new EBSAs, is being updated and strengthened to fill gaps, especially in ABNJ. Recent modifications include discussions around categorisation of EBSAs into four site categories: fixed, transient (mobile fronts), scattered or grouped, and ephemeral (seasonal). Globally, several states have used EBSAs to inform their national processes for habitat protection and management, or to motivate for research funding to support gathering of additional evidence. In the WIO, South Africa's blue economy initiative (Operation Phakisa) has used EBSAs in combination with other marine spatial planning products to propose expanded protection in its Offshore habitats (see Case Study), and the Northern Mozambique Channel spatial planning initiative (WWF and CORDIO 2018) has built on the EBSA process's identification of the importance of this region for protection. EBSAs will be an important component in the development of an international legally-binding instrument to enhance protection in ABNJ (see below).

As early as 2004, the UNGA created a working group on biodiversity beyond national jurisdiction (BBNJ Working Group) to discuss conservation and sustainable use of marine biological diversity in ABNJs. Following its concluding meeting in 2015, states recommended to the UNGA that it open negotiations for a legally binding instrument under UNCLOS, which recommendation was endorsed. Subsequently, four meetings of a Preparatory Committee (PrepCom) took place in 2016 and 2017, which culminated in a resolution at the end of 2017 to convene an intergovernmental conference, comprising four 10-day meetings over three years, commencing in September 2018. The conference will consider the PrepComm final report recommendations, and will elaborate the text of an international legally binding instrument which addresses, amongst others, MPAs in ABNJs. The PrepComm final report (Morgera et al. 2017) reflected difficulties in achieving consensus amongst participants, particularly around terms defining geographic jurisdiction, potential prejudice of existing legal instruments and frameworks, wording expressing the trade-off between conservation and sustainable use, and about the need for area-based management tools including MPAs in ABNJs. Kraska (2018), too, expresses doubts about states' willingness to accede to constraints on navigation and to give up their potential preferential access to adjacent offshore resources, and suggests that they would likely only support small changes to existing instruments. In contrast, Elferink (2018) provides some suggestions for the negotiations, emphasizing that due regard for the rights of coastal states' is paramount, while De Santo (2018) makes recommendations on improving the evidence to support MPAS in ABNJ, as well as on compliance mechanisms and stakeholder engagement. The outcomes of the intergovernmental process which commenced in September 2018 will have profound implications for governance of ABNJs and protection of Offshore habitats in the WIO. In order to inform the discussions, the ABNJ Deep Seas Project (UNEP-WCMC 2018), jointly implemented by FAO and UNEP, aims to improve understanding, cooperation and capacity among the various stakeholders about the use of area-based planning methodologies, including EBSAs, in ABNJ. Other initiatives are also working towards this goal, such as the STRONG High Seas project (Gjerde et al. 2018).

Weak governance in the face of increasing human pressures is a major impediment to protection of marine and coastal environments in the WIO, and Momanyi (2015) elaborates on the issues at some length, drawing on the work by UNEP/Nairobi Convention Secretariat, CSIR and WIOMSA (2009). Guerreiro et al. (2011) also highlight weaknesses, notably that an international treaty is not binding on states unless they ratify it, and that not all WIO states are party to these instruments, regardless of their merits. These authors, and more recently Sorby (2018) make the point that bilateral or sub-regional mechanisms can be simpler and more effective to achieve habitat protection; to some extent this is the case in the Lubombo transboundary MPA between South Africa and Mozambique, and steps are being taken towards a similar arrangement between Kenya and Tanzania. Wright and Rochette (2017) and UNEP-WCMC (2017) concur that the WIO is not as advanced as some regions in terms of governance of ABNJ, but that there are some positive signals. Critically, few WIO states have resources to manage coastal protected areas under their jurisdiction, let alone Offshore habitats, to ensure that the protection is effective (Obura 2015a), and the MPA Outlook (*MPA Outlook report ref?*) considers this in detail.

Recommendations

The main findings of this chapter can be summarized as follows: There is a need for protection for Offshore habitats in the WIO as they are currently poorly protected; because of their vastness, there is a need to prioritize areas within these habitats, but the majority remain underexplored, and information is lacking; the EBSA process has prioritized some areas in terms of their vulnerability and environmental importance; the EBSA process continues to evolve as additional work is done and as new information becomes available; there is increasing interest in further exploitation of renewable and non-renewable resources in these habitats, with associated threats; there are mechanisms in place for declaration of protected areas within state EEZs, but there is need for a process to declare international MPAs; and there is need for effective management of existing protected areas in Offshore habitats in the

WIO. From this follows recommendations for the main stakeholders; they are not in order of priority, and are not necessarily mutually exclusive. They are partly derived from several recent sources which recognize the urgency for improving Offshore protection in the face of increasing threats, including: Johnson et al.(2016), Wright and Rochette (2017), UNEP-WCMC (2017), Wynberg (2015), Chevallier et al. (2017), Guduff et al. (2018).

The Nairobi Convention and its structures should:

- negotiate with Parties to extend the Convention's mandate to include ABNJ
- foster political awareness of issues relating to ABNJ
- facilitate the production of an inventory (atlas) of existing and planned anthropogenic activities in WIO Offshore habitats
- continue to provide a platform to solicit global funding agencies for support with capacity building in marine spatial planning, Offshore habitat research, and management of MPAs
- facilitate the development of a standardized approach to assessing management effectiveness for Offshore habitat MPAs in the WIO region
- continue to facilitate initiatives to support and mentor MPA stakeholders in the WIO region
- encourage regional cross-sectoral area-based planning to avoid the gaps in protection caused by a purely sectoral approach
- facilitate access by regional research institutions to scientific information from surveys of Offshore habitats by national and multinational agencies and companies

States (including non-WIO states in some instances), should

- recognize that the vast majority of Offshore habitats are under-explored, frequently vulnerable to anthropogenic impact, and that ecosystem services are not always able to be assigned a financial value; but should recognize that this does not imply these habitats can be exploited without caution
- facilitate their scientists' participation in the EBSA process to identify/justify particularly vulnerable Offshore habitat areas for potential protection
- strive towards building WIO regional capacity for marine spatial planning, incorporating the prioritization of areas in Offshore habitats for use zonation and protection
- avoid declaration of protected areas if they do not have the will or resources to manage them
- improve efforts towards ensuring that their citizens and state utilities, as well as companies utilizing state-owned resources, adhere to protected area and other pertinent environmental regulations
- strive towards bilateral/sub-regional agreements on transboundary MPAs for Offshore habitats
- actively participate in the UNGA process which, amongst others, aims to facilitate declaration and governance of MPAs in ABNJ
- encourage and make available resources to facilitate research on Offshore habitats, particularly those that are under-explored
- urgently facilitate the process of final designation of their EEZs and extended continental shelf claims

Regional fisheries bodies should

- urgently prioritize converting the SIODFA's BPAs into formal VME closures,
- actively promote the identification and designation of additional BPAs, and VMEs
- promote the identification of and rationale for appropriate closed fishing areas for large pelagics

Shipping stakeholders, through the International Maritime Organisation, should

- be more receptive to the designation of Particularly Sensitive Sea Areas and adoption of Associated Protective Measures in Offshore habitats in the WIO

Entities which prospect for or extract renewable or non-renewable resources should

- ensure that their operations comply with state regulations and laws of the mandated regional and international bodies
- through the International Seabed Authority, be more proactive in regard to the need for and declaration of Areas of Particular Environmental Interest, Impact reference zones and Preservation reference zones in ABNJ
- on request, make environmental data in their prospecting and exploitation areas accessible to research institutions

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Case study: Classification, mapping of assessment marine habitats in South Africa

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The South African National Biodiversity Institute uses a consistent approach to assess Ecosystem Threat Status and Protection Levels in the marine, terrestrial and inland aquatic realms. A practical, science-based method is used to assess the state of marine and other ecosystems and identify national priorities (SANBI & UNEP-WCMC, 2016). The 2018 National Biodiversity Assessment is currently underway but the 2011 assessment classified, mapped and assessed 136 marine habitat types (Sink et al. 2012). A systematic spatial approach is used to determine how threatened ecosystems are i.e. how much of each type is in a natural or near natural state, or alternatively are losing key aspects of their structure, function and composition (SANBI & UNEP-WCMC, 2016). Protection level is also determined as an indicator of the extent to which ecosystem types are represented in the protected area network.

The key requirements for such a national assessment include four key datasets. Primary inputs include a marine ecosystem classification and map, a map of ecological condition, a map of marine protected areas, and biodiversity targets that set a minimum proportion of each ecosystem type that should remain in good ecosystem condition. More detail on the five specific steps for assessing thereat status and protection level are explained in the guidelines for mapping biodiversity priorities (SANBI & UNEP-WCMC 2016) with a summary of key data sets and results presented in this case study. This approach can also be applied at a regional level as was undertaken for the Benguela Current Ecosystems (Holness et al. 2014).

South Africa's marine and coastal habitat classification incorporates several key drivers of marine biodiversity pattern: terrestrial and benthic-pelagic connectivity, substrate, depth and slope, geology, grain size, wave exposure and biogeography. The habitat classification identified and mapped a total of 136 habitat types including 37 coast types, 17 inshore (5-30 m) habitat types and 62 offshore (deeper than 30 m) benthic habitat types (Sink et al. 2012). In addition, a separate classification was undertaken to define 16 different offshore pelagic habitat types based on differences in sea surface temperature, productivity, chlorophyll, depth and the frequency of eddies, temperature fronts and chlorophyll fronts (Roberson et al. 2017).

The second key set of data required for a systematic assessment is the condition of ecosystems. To assess marine ecosystem condition, a cumulative, pressure-mapping approach based on Halpern et al. (2008, 2009, 2015), was used. Maps reflecting the relative intensity of 27 pressures or drivers of ecosystem change were produced to determine ecosystem threat status. These include 18 types of extractive marine living resource use (13 commercial fisheries, two types of recreational fishing, commercial kelp harvesting, subsistence harvesting and the shark control program), petroleum activities, diamond and titanium mining, shipping, coastal development, disturbance associated with coastal access, waste water discharge, mariculture, invasive alien species and the reduction of freshwater flow into marine ecosystems. Impact scores were calculated separately for each ecosystem type found in a 5' grid square, based on the specific pressures affecting it. This was necessary because a grid square often included multiple habitat types that may experience different impacts from the same pressures (e.g. demersal trawling has significantly different impacts on soft versus hard grounds). This method relied on standardised maps of individual pressures and the compilation of a summary of cumulative impacts for each specific ecosystem per site (Halpern et al. 2008). Pressures were standardised by scaling the intensities of different pressures to a 0-1 range to facilitate comparison and summation across multiple pressures measured in different metrics and units. Ecological condition was inferred using one of three categories (good, fair or poor), using the cumulative impact scores at that site. Numerical thresholds in the cumulative impact scores were used to classify the site condition on the basis of natural breaks in the distributions.

The third key input is the need for quantitative biodiversity targets representing the minimum proportion of an ecosystem type that needs to be kept in a near natural or natural state. This is still a developing science and South Africa used a pragmatic approach with a standard 20% target for all marine ecosystem types. This also aligns with the IUCN Red List of Ecosystems, which assigns Critically Endangered status to ecosystems that have lost more than 80% of their geographic distribution over 50 years (Bland *et al.* 2017). Critically Endangered (CR) ecosystem types have ≤ 20 % of their original extent in good/natural ecological condition and are considered likely to have lost important components of biodiversity pattern, community structure and functioning. The next threshold was set at the biodiversity target plus 15 %, so that ecosystem types with 20-35 % of their original extent in good ecological condition were defined as Endangered (EN). Ecosystems with 36-80 % of their original extent in good or fair condition were defined as Vulnerable (VU), and those with >80 % in good or fair condition, as Least Threatened (LT).

To assess protection levels, a map of protected areas was overlaid on the map of marine habitat types and the same standard target of 20 % was used to evaluate this headline indicator. If at least 20 % of an ecosystem type (i.e. 100 % of the 20 % target) occurred within protected areas, the ecosystem type was considered to be well protected. If between 50-99 % of the target was within protected areas, the ecosystem type was considered moderately protected; 5-49 % was poorly protected, and ≤ 5 % was considered not protected.

The systematic assessment of marine biodiversity revealed that offshore habitats were less threatened than coastal habitats but that offshore habitats were the most poorly protected of all ecosystem types in the country (Sink et al. 2012). In the offshore environment, there are more threatened benthic habitat types than threatened pelagic habitat types. All rocky shelf edge and most canyon types were found to be threatened. Nine offshore habitat types were considered both Critically Endangered and Not Protected. These included several offshore habitats from the WIO such as Agulhas Canyon, Agulhas Muddy Inner Shelf and Agulhas Mixed Sediment Outer Shelf. Only one pelagic habitat was considered threatened on the east coast and this is a shelf-edge habitat with high productivity and high but variable chlorophyll, associated with very frequent Sea Surface Temperature and chlorophyll fronts. This habitat represents cool productive water that has been advected onto the shelf in this shear zone through Agulhas-current driven upwelling cells (Sink et al. 2012). Other priority ecosystem types identified for increased protection include other gravel and shelf edge habitats and muddy habitats in the Natal ecoregion.

The systematic spatial assessment of marine ecosystems in South Africa demonstrates the value of a spatial approach that can objectively inform spatial planning and prioritisation where management resources are scarce. The case study on page (NOTE TO EDITOR refer to Offshore MPA case study Fielding and Sink) shows how these same spatial layers were used to develop a proposed network of offshore Marine Protected Areas.

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Appendix 1: Summarized characteristics of 18 EBSAs (www.cbd.int/ebsa/) predominantly comprising Offshore habitats. WIO EBSAs are in black, EBSAs in the South African EEZ to the west of Cape Agulhas (i.e. in the adjacent south-east Atlantic) are in red. The seven scientific criteria developed by the Convention on Biological Diversity for scoring are provided below the table. H = High, M = Medium, L = Low

EBSA	CBD scientific criteria scores							Key Offshore habitat features	Other critical habitat features	Country	Threats
	1	2	3	4	5	6	7				
Agulhas Front	H	H	H	M	H	M	L	Extremely high pelagic productivity, high biodiversity	Birds, cetaceans, bluefin tuna	South Africa, France, ABNJ	-
Agulhas Bank	H	H	H	M	M	M	M	Unique and/ or rare sand/ mud/ gravel, deep corals, nursery areas, oceanography, productivity, threatened benthic habitats, threatened endemic fishes, spawning aggregations	-	South Africa	Fisheries, oil/gas
Agulhas slope	M	H	M	H	H	H	H	Highly diverse pelagic and benthic habitats, threatened benthic habitats, endemic cold-water corals, high productivity, fish spawning/ recruitment area, bird foraging	Seamounts, turtles, birds, sharks	South Africa	-
Offshore of Port Elizabeth	M	H	H	M	H	H	L	Vulnerable canyons, rare and threatened mixed sediments and gravels, deep reef corals, unique pelagic features, high productivity, spawning/	Turtles, birds	South Africa	-

								recruitment area, bird foraging			
Protea Banks and sardine route	H	H	M	M	M	M	L	High benthic and pelagic complexity, unique deep reefs, canyons, endemic benthos, threatened endemic fishes, spawning aggregations of threatened fishes, migration pathway	Birds, sharks, cetaceans	South Africa	Fishing
Natal Bight	M	H	H	M	H	L	L	Unique and threatened sediments and gravels, strong terrestrial-marine connection, locally high productivity, unique and endemic benthos and fishes, nursery area, threatened fishes, deep reefs	Estuary, elasmobranchs, turtles,	South Africa	Fishing, oil/gas, mining, pollution
Delagoa shelf edge	M	H	M	M	M	H	H	Diverse benthic and pelagic habitats, ecoregion transition zone, high species diversity, vulnerable canyons, deep reefs/ corals, threatened habitats	Corals, sharks, turtles, coelacanths	South Africa, Mozambique	Mining, oil/gas,
Quelimane to Zuni River	H	H	M	L	H	-	M	High benthic productivity, extensive mud habitat	Estuary, mangroves, mammals	Mozambique	Fishing
Mozambique Channel	H	H	H	H	H	H	M	Globally unique eddy dynamics influenced by complex seabed geology, both influential in cross-channel connectivity and pelagic	Corals, sharks, turtles, birds, mammals	South Africa, Mozambique, Tanzania, Comoros,	Oil/gas

								productivity; high levels of biodiversity		Madagascar, France	
Southern Madagascar	H	H	H	M	H	H	H	Transition zone between tropical and temperate waters, high wave energy, high pelagic productivity, high biodiversity and endemicity	Seamounts, turtles, birds, cetaceans	Madagascar, ABNJ	-
Northern Mozambique Channel	H	H	H	H	H	H	L	Eddy dynamics leading to high interconnectedness in a region of high biodiversity	Mangroves, seagrass, corals, turtles, elasmobranchs, coelacanths, birds, mammals	Mozambique, Tanzania, Seychelles, Comoros, Madagascar, France	Oil/gas
Subtropical Convergence Zone	M	H	H	M	M	M	L	High pelagic productivity and biodiversity	Birds, bluefin tuna, cetaceans	South Africa, ABNJ	-
Benguela Upwelling System*	H	H	H	M	H	M	M	Oceanographically unique, high biological productivity, fish spawning and nursery areas, endemic biodiversity	Birds, cetaceans	South Africa (Namibia, Angola)	Oil/gas
Browns Bank	H	H	H	M	M	L	M	Unique, endangered gravel habitat, high benthic biodiversity, deep corals, fish spawning and nursery areas, high pelagic productivity	Birds	South Africa	-
Cape Canyon and Surrounds	M	H	H	H	H	M	M	Rare, endangered and unique benthic habitat types, deep corals, high pelagic productivity	Islands, birds, cetaceans	South Africa	Oil/gas, mining

Childs Bank	H	L	M	H	L	M	H	Unique benthic habitat, including cold-water corals, high fish biodiversity	Sharks	South Africa	Fishing
Orange Shelf Edge	L	M	H	M	M	H	H	High demersal fish biodiversity	Estuary	South Africa (Namibia)	-
Orange Cone*	H	H	M	M	M	M	M	Unique area, high productivity, fish recruitment	Estuary, salt marsh, birds	South Africa (Namibia)	Mining

* Only areas falling within South Africa's EEZ considered

1. Uniqueness or Rarity
2. Special importance for life history stages of species
3. Importance for threatened, endangered or declining species and/or habitats
4. Vulnerability, Fragility, Sensitivity, or Slow recovery
5. Biological Productivity
6. Biological Diversity
7. Naturalness