Species and ecosystems

Working towards a better understanding of Western Indian Ocean deep-sea ecosystems

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Summary

The deep sea is globally recognised as providing benefits for all humanity for example, as an essential carbon sink and temperature regulator. This environment maintains ecosystem health and enables unique biodiversity to thrive. Although this blue space comprises much of the volume of our planet, it is mostly under-researched, and our understanding of its life and processes is limited. The Western Indian Ocean's (WIO) deep sea is one of the world's least explored habitats due to a lack of readily available technology, expertise, and funding. With a growing coastal population and an increasing global interest in exploiting deep-sea resources, such as fisheries and minerals, it is essential to increase the understanding of these habitats and their value. This will inform management strategies for the sustainable use and stewardship of these ecosystems.

Background

The deep sea is the waters below 200 m and their habitats comprise 95 per cent of habitable space on the planet. The deep sea convey many benefits to society (Danovaro and others, 2017) for example climate regulation and nutrient cycling. The deep sea is heterogeneous. It comprises unique habitats like hydrothermal vents, cold-water coral reefs, creating a patchwork of environments (Stuart and others, 2003) created by the complex interactions of historical (e.g., tectonic shift) and contemporary factors (e.g., ocean currents). Although less studied than shallow water systems, the deep sea is equally essential for the prosperity of the global population. Its ecosystem services vary from the regulation of the climate to the provision of protein and as a place that creates wonder and inspiration (Armstrong and others, 2012).

Despite being remote, out of sight and largely out of mind, deep-sea habitats are impacted by the consequences of human activities (Ramirez-Llodra and others 2011). These span global threats such as the effects of climate change, to the damaging practices of some fisheries and newer activities such as mineral mining and extraction. The deep sea is not pristine or untouched and has been of scientific interest for decades (Boos and others, 2019).

Acknowledging that the deep sea is three-dimensional, interconnected, and heterogeneous, global extrapolations are unlikely to provide the appropriate information at a scale relevant for the management and protection of the WIO. Therefore, data should be drawn from deep-sea surveys of the WIO. This paper investigates the published research that has been conducted in the region on the biology and ecology of deep-sea systems and synthesises findings with some recommendations for consideration.

Although the deep sea is rarely mentioned in international treaties, it is integral to many as a vast and essential area. All Nairobi Convention (NC) contracting parties have exclusive economic zones (EEZ) that include the deep sea, but in the WIO, most of the deep sea is in the high seas. Pertinent is the ongoing negotiations for a legally binding instrument under the United Nations Convention on the Law of Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ). These negotiations focus on the high seas and cover technology

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transfer, marine genetic resources, and environmental impact assessments, among other issues.

The deep sea is implicitly and explicitly included in several globally recognised targets (Table 1). However, these targets require more and better deep-sea data to support countries endeavours for adequate implementation. Finally, The Decade of Ocean Science for Sustainable Development (UN Ocean Decade) is running from 2021-2030. The implementation plan (UNESCO-IOC 2021) highlights the importance of deep-water environments and the life they support. As such, this paper supports objectives 1.1 and 2.1 of this initiative.

62 references. These publications were screened for relevance leaving 43 articles within this review. Papers are reported by publishing year and academic field for each NC nation and the high seas. The focal taxonomic group is reported by class or the next lowest taxonomic group when more appropriate. NC parties' population size used UN projections (United Nations, Department of Economic and Social Affairs, Population Division 2019) but only included residents of the WIO. The Exclusive Economic Zone (EEZ) area was taken from Marine Regions v11 (Flanders Marine Institute 2021). We included any overlapping claims, and French and S African EEZ sizes were scaled to represent the area within the WIO only (Flanders Marine Institute 2020).

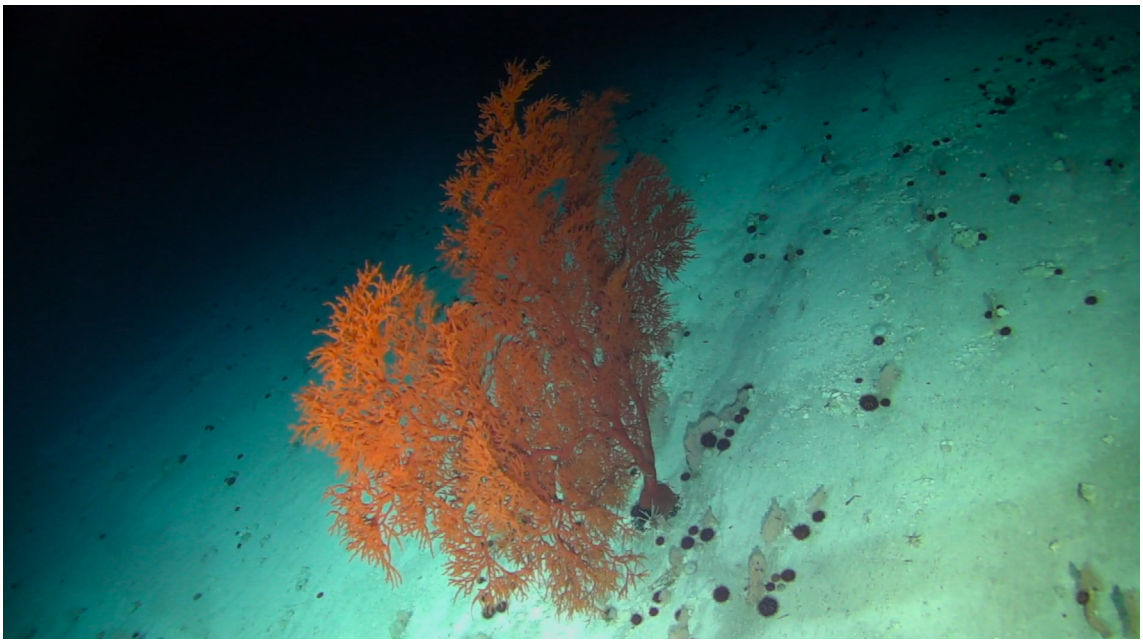

Figure 1: Black coral (Leiopathes) taken at 250m in the Outer Island of Seychelles (Seychelles First Descent)

Advances

Decision-makers rely in part on having access to usable information. This paper reviews the literature available using a systematic search on SCOPUS as a proxy for this information (SCOPUS is a citation and abstract database). This review intends to present a preliminary overview of past deep-sea biology studies. This paper excludes; grey literature and documents that were not written or translated into English.

The search terms [deep sea] or [deep-sea] and [Western Indian Ocean] or one of the contracting parties of the Nairobi Convention and [ecology] or [biology] were used and limited to papers in the fields of environmental or biological sciences. The initial search revealed

Literature included studies conducted in all the waters of all contracting parties of the NC, with around a quarter (28 per cent) being undertaken in the high seas (Figure 2). Few studies were found. The spread of research effort is not equal across all countries, and neither is it proportional to EEZ or population size (Figure 3). The island nations of Mauritius and Seychelles are under-represented in studies considering the size of their EEZ. When the population is considered, Tanzania and Kenya are also under-represented. **This preliminary analysis illustrates that research opportunities and survey efforts are not equally distributed and remain very low overall.**

Table 1: Examples of global policy frameworks that reference marine ecosystems and biodiversity in a manner that includes the deep sea.

Programme / Instrument	Target	Aim
UN Sustainable Development Goals	14.2	Manage, protect, and restore ecosystems
	14.4	Increase measures to increase sustainable fishing
	14.5	Conserve at least 10 per cent of coastal and marine areas
	14.7	Increase the economic benefits from the sustainable use of marine resources
	14.a	Increase scientific knowledge, research, and technology for ocean health
	14.c	Implement and enforce international sea law
Convention of Biological Diversity (CBD/WG2020/3/3)	1	All land and sea areas globally to be under integrated biodiversity-inclusive spatial planning
	2	Restore at least 20 per cent of degraded ecosystems
	3	Conserve at least 30 per cent of areas
	5	Harvest of wild species is sustainable and legal
	6	Invasive species
	13	Fair access to genetic resources
	14	Integrate biodiversity values
	15	Businesses to assess and report their impact on biodiversity
	16	Inform people so they can make a responsible choice in their consumption
	20	Increase knowledge for effective management of biodiversity

Over the last 10 years, there appears to have been a steady increase in the number of publications (Figure 4) resulting from deep-sea surveys within the WIO. However, with so few papers published per year, this increase could have resulted from a very small increase in expeditions and grants. Furthermore, the historical lack of publications means that it is challenging to understand the temporal-biological trends of the region. **It is evident from the publication record that deep-sea biology is understudied within the WIO.**

Twenty-three taxonomic groups were represented across the studies. The crustaceans Malacostraca are the focus of most studies (20 per cent) (Figure 5). This is the largest of the classes of crustaceans and includes crabs, lobster, and shrimp, which are of fisheries interest. Notably, fifteen taxa are only represented once, and communities of organisms (macrofauna, megafauna and micronekton) focused on only five studies in total. **Analysis suggests that all taxa are understudied within the WIO region**.

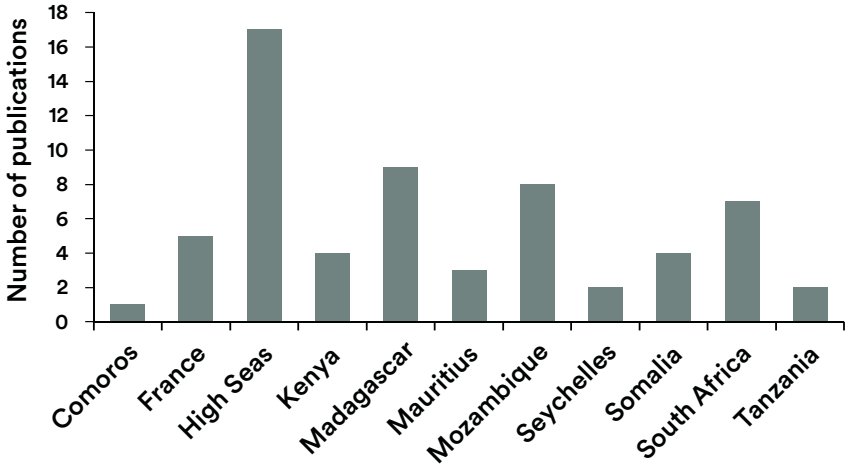

Figure 2: Proportion of peer-viewed publications on deep-sea biology that have been conducted across WIO nations.

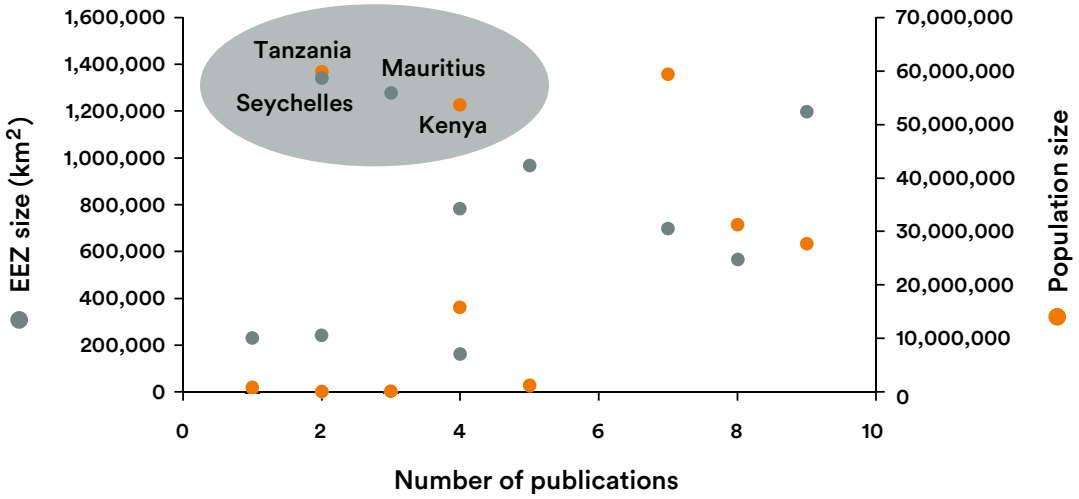

Figure 3: Correlation of deep-sea publication with EEZ and population size of WIO nations. Points within the great shaded area denote under-representation of studies

Most studies (58 per cent) investigated systematics or taxonomy. In most cases, there was a strong focus on new species descriptions, often from material collected at least a decade ago. The delay between specimen collection and species descriptions is a global phenomenon primarily due to a lack of resources and expertise to conduct this type of research (Scheltema 1996). While essential in helping to support biodiversity research, taxonomic studies alone do not contribute to a better understanding of ecological communities, habitats and processes. Community ecology is considered especially important for marine biodiversity management (Mangel and Levin 2005). Still, only six such studies have been conducted in the WIO deep sea, representing sediment, benthos, and pelagic assemblages. Each study focused on a different location and taxonomic group; therefore, no comparisons of assemblages could be made. No WIO deep-sea temporal studies were discovered during this systematic review. Temporal biodiversity data are needed to identify trends and changes in communities, which are essential to understand the influences of changes in use and the consequences of stressors. **Our findings suggest that further studies on deep-sea systems, which provide information for policymakers, are required in the WIO region.**

Outlook for the region and globally

Globally there is a recognised dearth of deep-sea data (McClain 2007), and the available data are biased to northern hemisphere locations (Menegotto and Rangel 2018). There needs to be a coordinated global program of deep-sea science to provide new knowledge to answer the fundamental questions about the deep sea and support a sustainable future for the deep ocean (Howell and others 2021).

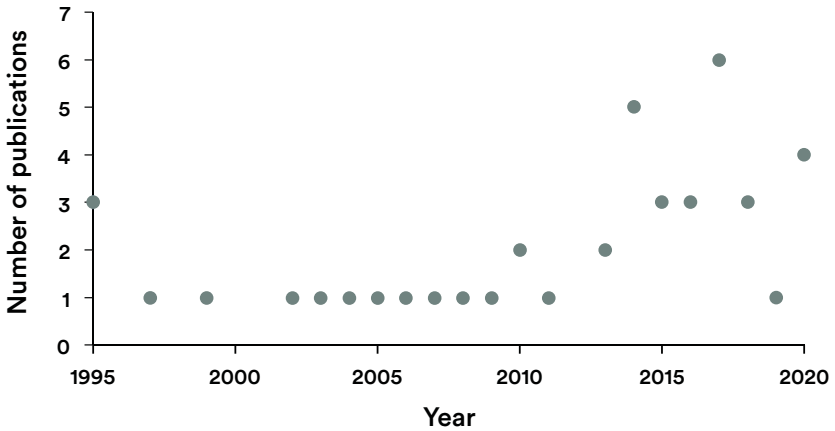

Figure 4: Change in WIO focused deep-sea publications from 1995 to 2020. 1995 was the date of the earliest study.

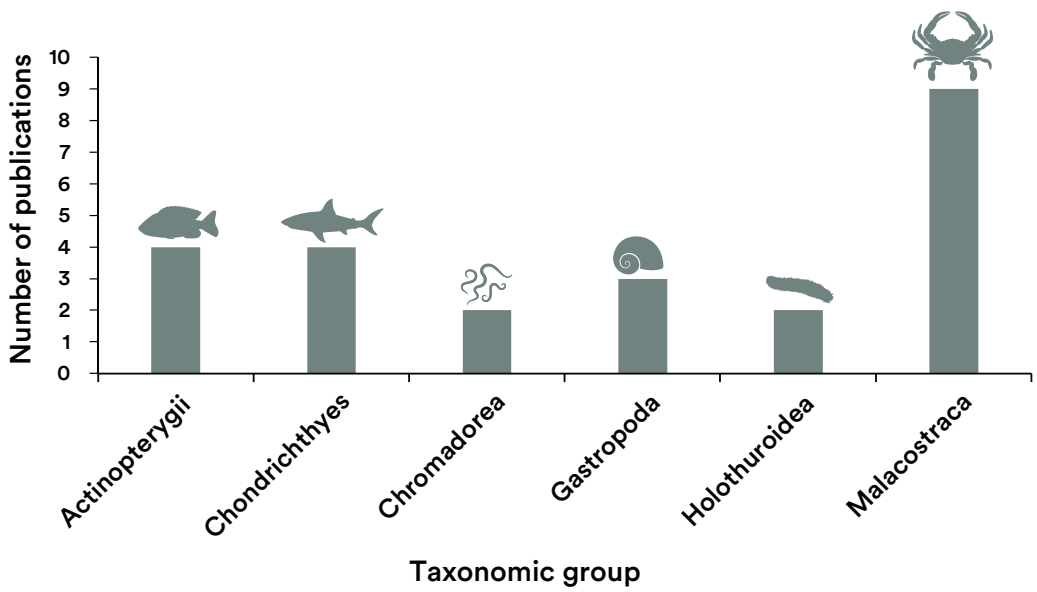

Figure 5: Number of papers per taxonomic group drawn from surveys of the WIO (only taxa with articles >1 are shown).

Recognising the historical inequalities in deep-sea science and the logistical challenges to access this space, it is unsurprising that we identified all regions, taxa and fields of study under-represented in the published literature on the deep-sea biology of the WIO. The extensive nature of this knowledge gap means a lack of usable information is available for policymakers.

This brief review was not intended to capture an exhaustive list of publications but instead act as an opportunity to identify knowledge gaps. Based on this work, we make the following recommendations to help direct future policy decisions that will support a sustainable and thriving WIO region.

1. Amplify deep-sea literacy and understanding
2. Increase data and knowledge of the deep sea
3. Increase opportunities for deep-sea research and stewardship

Technical Recommendations

1. The services of the deep sea provided by ecosystems and organisms that inhabit them should be communicated to parties. Opportunities could be available through WIOMSA, FARI or other suitable organisations. This work supports the UN Ocean Decade objectives 3.1 and 3.2.

2. A comprehensive review of deep-sea biological data (inc. grey literature and traditional knowledge) should be conducted to provide knowledge gaps and to help prioritise activities. This work supports the UN Ocean Decade objectives 1.1, 1.4, 1.5 and 2.2.

Policy recommendations

1. A deep-sea working group should be established within the mechanism of the NC to lead the advancement of deep-sea research and data usage in the WIO. This work supports the UN Ocean Decade objectives 2 and 3.

2. Parties should continue to have strong representation in the BBNJ negotiations. The deep sea is valuable for the prosperity of NC nations now and in the future.

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Protecting threatened sharks and rays in the Western Indian Ocean

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Summary

The Western Indian Ocean (WIO) is a global priority for the conservation of sharks and rays. Yet, there is limited policy in place in the WIO for their effective management and conservation. This paper provides a list of shark and ray species recommended for protection or regulated harvesting at national and regional levels within the WIO, based on retention bans or harvest regulations defined under one or more environmental agreements or fisheries bodies.

Background and rationale: Sharks and rays in the Western Indian Ocean

The WIO is known for its rich marine life and is considered a global hotspot for shark and ray diversity (Dulvy and others, 2014). At least 225 shark and ray species have been recorded in the WIO to date, many of which are found nowhere else in the world (Dulvy and others, 2014, Stein and others, 2018).

The WIO is also characterised by extensive fisheries, from artisanal fishers to industrial fleets and illegal, unreported and unregulated (IUU) fishing, all of which take sharks and rays as a target or incidental catch. There is a high demand for shark and ray products, particularly shark meat, for local consumption, and legal and illegal trade in the fins of sharks and shark-like rays (wedgefishes, guitarfishes and sawfishes), for the global shark fin trade. However, most shark and ray species grow very slowly, produce few offspring and become sexually mature only after many years. Hence, population growth is slow, making them highly susceptible to the impacts of overfishing (Worm and others, 2013).

Many shark and ray species have suffered significant stock declines, primarily due to overfishing and other human impacts (Dulvy and others, 2014, Pacoureau and others, 2021). According to the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species, 83 of the shark and ray species in the WIO (37 per cent, an increase from 22 per cent over the past 15 years) are facing a high to extremely high risk of extinction in the wild (IUCN 2021). There has also been a considerable increase over the past 15 years in the proportion of WIO endemic shark and ray species (species found only in this region) that are classified as threatened or near-threatened, from 10 to 20 per cent.

Overexploitation of shark and ray species can have direct impacts on their populations and indirect impacts on their ecosystems and food webs. Thousands of people living in coastal communities within the WIO depend on marine resources, including sharks and rays, for their income and livelihoods, making this a social and ecological issue. However, the catches of shark and ray species are currently poorly recorded, and the actual total quantities caught, particularly in artisanal, small-scale and IUU fisheries, remain unknown (Worm and others, 2013). Furthermore, human populations and the demand for marine resources are increasing throughout the WIO, with evidence of human migrations to and among coastal areas in search of improved food security and livelihoods (Barnes-Mauthe and others, 2013). There is thus a continued threat to WIO shark and ray species, the severity of which is increasing. Consequently, there is a critical need for corrective management and improved conservation of WIO shark and ray species, particularly those already threatened or likely to become threatened.

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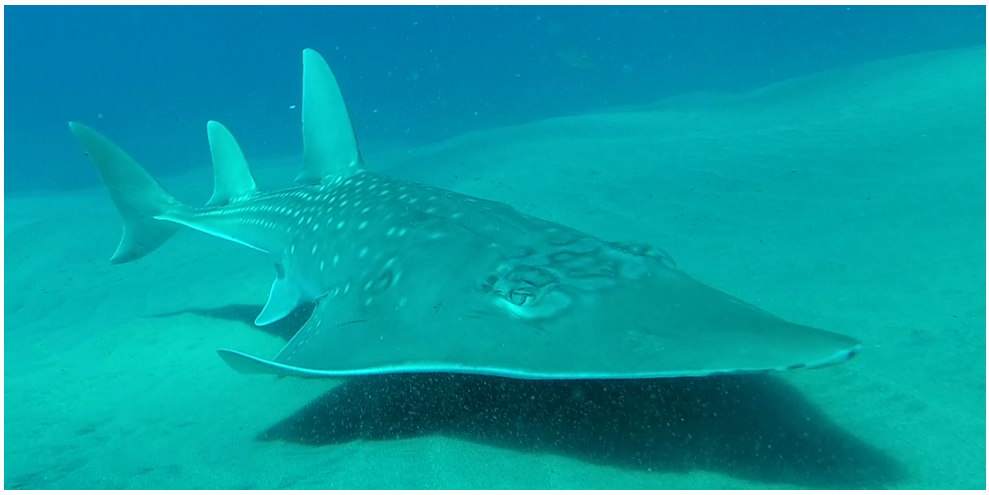

Figure 1. Rhynchobatus_djiddensis_Wildlife_Conservation_Society - A Critically Endangered whitespotted wedgefish Rhynchobatus djiddensis approaches an underwater research camera, southern Mozambique (Credit: Wildlife Conservation Society, Mozambique).

This paper responds to these issues as they relate to the WIO, particularly the Member States of the *Nairobi Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region* (UNEP 1985). The paper is intended to encourage improved protection and stricter harvesting regulations for threatened shark and ray species in the WIO through (1) the listing of appropriate shark and ray species on the Annexes of the Nairobi Convention *Protocol concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region* and (2) the protection or regulated harvesting of relevant species at the national level. Therefore, the paper identifies (i) binding shark and ray protection commitments imposed by multilateral environmental agreements and regional fisheries bodies to which Nairobi Convention Member States are party and (ii) shark and ray species that warrant protection or harvesting regulations by virtue of their threatened conservation status.

Advances: Instruments for the management of shark and ray populations

Addressing these issues at the international level

The IUCN *Red List of Threatened Species* assesses species according to their population trends and threats faced (such as fishing impacts). The Red List categories of Vulnerable, Endangered and Critically Endangered are considered "threatened" categories and include species facing a high to extremely high risk of extinction in the wild (IUCN 2001). Near Threatened species do not currently meet the criteria for any of the threatened categories but may do so in the near future. The IUCN categories impose no regulatory actions on governments; however, they provide a standardised and objective classification of the conservation status of each species, while the precautionary approach suggests that the harvesting of threatened species should be prohibited or regulated. In the Nairobi Convention area of the WIO, there are 13 Critically Endangered, 26 Endangered, 44 Vulnerable and 30 Near Threatened species (IUCN 2021).

Numerous shark and ray species are now listed on the Appendices of the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS 1979) and the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES 1983), thus increasing the mandate of governments to address their conservation and management needs. The Indian Ocean Tuna Commission (IOTC 2021) has also developed specific conservation and management measures relating to several shark and ray species that are considered to be under threat from the IOTC-linked fisheries directed at tuna and tuna-like species.

The *Convention on the Conservation of Migratory Species of Wild Animals* (CMS) is an environmental treaty of the United Nations, which provides a global platform for the conservation and sustainable use of migratory animals and their habitats. CMS brings together the "Range States" of migratory species to lay a legal foundation for internationally co-ordinated conservation measures for such species.

CMS Appendix I lists migratory species threatened with extinction. CMS Parties strive towards strictly protecting species listed in Appendix I, conserving or

Table 1: Shark and ray species in the Nairobi Convention area of the WIO that are listed under the Convention on the Conservation of Migratory Species of Wild Animals (CMS; I and II indicate relevant CMS Appendices), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; I and II indicate relevant CITES Appendix), or a prohibiting Indian Ocean Tuna Commission (IOTC) resolution, along with IUCN Red List status (CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened. *Presence in Nairobi Convention area uncertain: possibly along Indian Ocean coastline of Somalia).

Species name	Common name	CMS Appendix	CITES Appendix	IOTC Resolution	IUCN Red List
Alopiidae	**Thresher sharks**				
Alopias pelagicus	Pelagic thresher shark	II	II	12/09	EN
Alopias superciliosus	Bigeye thresher shark	II	II	12/09	VU
Alopias vulpinus	Common thresher shark	II	II	12/09	VU
Carcharhinidae	**Requiem sharks**				
Carcharhinus falciformis	Silky shark	II	II	-	VU
Carcharhinus longimanus	Oceanic whitetip shark	I	II	13/06	CR
Carcharhinus obscurus	Dusky shark	II	-	-	EN
Prionace glauca	Blue shark	II	-	-	NT
Cetorhinidae	**Basking shark**				
Cetorhinus maximus	Basking shark	I/II	II	-	EN
Glaucostegidae	**Giant guitarfishes**				
Glaucostegus halavi	Halavi guitarfish	-	II	-	CR
Lamnidae	**Mackerel sharks**				
Carcharodon carcharias	Great white shark	I/II	II	-	VU
Isurus oxyrinchus	Shortfin mako shark	II	II	-	EN
Isurus paucus	Longfin mako shark	II	II	-	EN
Lamna nasus	Porbeagle shark	II	II	-	VU
Mobulidae	**Mobulid rays**				
Mobula alfredi	Reef manta ray	I/II	II	19/03	VU
Mobula birostris	Giant manta ray	I/II	II	19/03	EN
Mobula eregoodoo	Longhorned pygmy devil ray	I/II	II	19/03	EN
Mobula kuhlii	Shortfin devil ray	I/II	II	19/03	EN
Mobula mobular	Spinetail devil ray	I/II	II	19/03	EN
Mobula tarapacana	Sicklefin devil ray	I/II	II	19/03	EN
Mobula thurstoni	Bentfin devil ray	I/II	II	19/03	EN
Pristidae	**Sawfishes**				
*Anoxypristis cuspidata**	Narrow sawfish	I/II	I	-	EN
Pristis pristis	Largetooth sawfish	I/II	I	-	CR
Pristis zijsron	Green sawfish	I/II	I	-	CR
Rhincodontidae	**Whale shark**				
Rhincodon typus	Whale shark	I/II	II	13/05	EN
Rhinidae	**Wedgefishes**				
Rhina ancylostomus	Bowmouth guitarfish	-	II	-	CR
Rhynchobatus australiae	Bottlenose wedgefish	II	II	-	CR
Rhynchobatus djiddensis	Whitespotted wedgefish	-	II	-	CR
Rhynchobatus laevis	Smoothnose wedgefish	-	II	-	CR
Sphyrnidae	**Hammerhead sharks**				
Sphyrna lewini	Scalloped hammerhead shark	II	II	-	CR
Sphyrna mokarran	Great hammerhead shark	II	II	-	CR
Sphyrna zygaena	Smooth hammerhead shark	II	II	-	VU

restoring their important habitats, mitigating obstacles to their migration and controlling other factors that might endanger them. Thirteen shark and ray species occur in the WIO, which are listed on CMS Appendix I (Table 1), and which must be protected accordingly. These include 3 Critically Endangered and 8 Endangered species, according to the IUCN Red List (IUCN 2021), highlighting their need for protection, at least among CMS Party nations.

CMS Appendix II lists migratory species that need or could benefit from international co-operation. Therefore, CMS encourages Range States to conclude global or regional agreements on such species, to ensure their appropriate management at multinational levels. There are 25 shark and ray species that occur in the WIO that are listed on CMS Appendix II (including 12 that are also listed in CMS Appendix I) (Table 1). Of the 13 species listed only in Appendix II, 3 are Critically Endangered and 4 are Endangered (IUCN 2021).

The CMS Convention text and Appendices are legally binding on Parties. The Nairobi Convention Member States of Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa, Tanzania and France (and thereby the French Departments of La Réunion and Mayotte) are party to CMS, and thus bound by commitments prescribed in this Convention. These states are thereby required to protect the 13 shark and ray species that are listed in CMS Appendix I and which occur in the WIO (Tables 1, 2 and Appendix I to this document) and control other factors that might endanger them. However, few of these species are protected within most Nairobi Convention Member States (Table 2). There are also few regional management measures for relevant species listed in CMS Appendix II.

The *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) is an international agreement among governments to ensure that

Table 2: Shark and ray species in the Western Indian Ocean required to be protected at national level through listing in Appendix I of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) or prohibited from capture in specific fisheries through an Indian Ocean Tuna Commission (IOTC) resolution, and countries in which these species are fully protected (1), prohibited in IOTC-related fisheries through permit conditions, present but receive no protection (X) or absent (-). (IUCN Red List status: CR = Critically Endangered, EN = Endangered, VU = Vulnerable). (Alpha-2 country codes: KM: Comoros, KE: Kenya, MG: Madagascar, MU: Mauritius, MZ: Mozambique, RE: La Réunion, YT: Mayotte, SC: Seychelles, So: Somalia, ZA: South Africa, TZ: Tanzania. *Presence in Nairobi Convention area uncertain: possibly along Indian Ocean coastline of Somalia).

Species name	Common name	IUCN	CMS	IOTC	KM	KE	MG	MU	MZ	RE	YT	SC	SO	ZA	TZ
Alopiidae	**Thresher sharks**														
Alopias pelagicus	Pelagic thresher shark	EN		12/09	2	2	2	2	1	X	X	2	X	1	1
Alopias superciliosus	Bigeye thresher shark	VU		12/09	2	2	2	2	1	X	X	2	X	1	1
Alopias vulpinus	Common thresher shark	VU		12/09	2	2	2	2	1	X	X	2	X	1	1
Carcharhinidae	**Requiem sharks**														
Carcharhinus longimanus	Oceanic whitetip shark	CR	I	13/06	X	1	2	2	1	X	X	2	X	2	2
Cetorhinidae	**Basking shark**														
Cetorhinus maximus	Basking shark	EN	I		-	-	-	-	-	-	-	-	-	1	-
Lamnidae	**Mackerel sharks**														
Carcharodon carcharias	Great white shark	VU	I		X	1	X	2	1	1	1	X	-	1	X
Mobulidae	**Mobulid rays**														
Mobula alfredi	Reef manta ray	VU	I	19/03	X	-	2	-	1	-	1	1	-	1	2
Mobula birostris	Giant manta ray	EN	I	19/03	X	2	2	2	1	1	1	1	X	1	2
Mobula eregoodoo	Longhorned pygmy devil ray	EN	I	19/03	X	2	2	2	1	1	1	1	X	2	2
Mobula kuhlii	Shortfin devil ray	EN	I	19/03	X	2	2	2	1	1	1	1	X	2	2
Mobula mobular	Spinetail devil ray	EN	I	19/03	-	2	2	-	1	-	1	-	X	2	2
Mobula tarapacana	Sicklefin devil ray	EN	I	19/03	-	-	2	2	1	1	-	-	-	2	2
Mobula thurstoni	Bentfin devil ray	EN	I	19/03	-	-	2	-	1	-	-	-	-	2	2
Pristidae	**Sawfishes**														
*Anoxypristis cuspidate**	Narrow sawfish	EN	I		-	-	-	-	-	-	-	-	X	-	-
Pristis pristis	Largetooth sawfish	CR	I		-	X	X	X	1	1	-	X	X	1	1
Pristis zijsron	Green sawfish	CR	I		-	X	-	X	1	1	-	-	X	1	1
Rhincodontidae	**Whale shark**														
Rhincodon typus	Whale shark	EN	I	13/05	X	1	2	2	1	X	X	1	X	1	1

international trade in specimens of wild animals and plants does not threaten their survival. CITES-listed species are subjected to international trade controls, through listing in three Appendices, according to the degree of protection needed (there are currently no marine shark or ray species listed on Appendix III, so this is not discussed further herein).

CITES Appendix I includes species threatened with extinction. International trade in specimens of these species is generally prohibited but may be permitted only in exceptional circumstances. No commercial trade is permitted for CITES Appendix I species. Of the 52 shark and ray species listed globally on the three CITES Appendices, just five (all from the family Pristidae – sawfishes) are listed on Appendix I, including two species previously known from much of the WIO – the largetooth sawfish *Pristis pristis* and the green sawfish *P. zijsron* (Table 1). However, these two Critically Endangered species have been classified as locally extinct in some places, such as South Africa (Everett and others, 2015), and whether they persist in the WIO is not certain. These species must be prohibited from commercial trade, and, as these species are also listed on CMS Appendix I, they should be prohibited from capture.

CITES Appendix II is intended to include species not necessarily threatened with extinction currently, but in which trade must be controlled to avoid utilisation incompatible with their survival. However, all 25 chondrichthyan species listed in CITES Appendix II, that are found in the WIO, are already threatened according to the IUCN Red List, including 7 Critically Endangered, 12 Endangered and 6 Vulnerable species (Table 1). At least 20 of these are (or were previously) also significant components of artisanal and/or commercial fisheries in the region. No international trade in Appendix II species is permitted without evidence that the trade does not detrimentally affect wild populations (CITES 1983), which requires a formal Non-Detriment Findings (NDF) assessment, of which the result must be positive to permit trade. However, while shark and ray species listed on this Appendix are known to be exported from the WIO countries, there are no publicly available records of NDF assessments having been developed for any CITES Appendix II shark or ray species, in any WIO country.

CITES and its Appendices are legally binding on Parties. All ten Nairobi Convention Member States are party to CITES and are thereby bound by the trade control commitments prescribed in this Convention, as they relate to shark and ray species listed in the relevant CITES Appendices. All Nairobi Convention Member States are therefore obliged to control and monitor trade in the 27 CITES-listed shark and ray species that occur in the WIO (Table 1), ensure trade is not detrimental to wild populations of these species and prevent the commercial trade in CITES Appendix

Figure 2. Sphyrna lewini_Christelle Razafindrakoto_WCS Madagascar NW2: A Critically Endangered scalloped hammerhead shark Sphyrna lewini is landed on the beach at Ankivonjy, northwest Madagascar (Credit: Christelle Razafindrakoto, Wildlife Conservation Society, Madagascar)

I species. However, the 2021 *Status of Legislative Progress for Implementing CITES* indicates that few Nairobi Convention Member States are implementing CITES effectively (CITES 2021).

The Indian Ocean Tuna Commission (IOTC) is an intergovernmental regional fisheries management organisation (RFMO), under the Food and Agriculture Organization (FAO) of the United Nations, responsible for the management of tuna and tuna-like species in the Indian Ocean (Anon. 1993). The management mandate of the IOTC is tuna and tuna-like species; however, data are also collated on non-target, associated and dependent species affected by tuna fishing operations, including sharks and rays. To ensure the sustainability of these species, the IOTC imposes Conservation and Management Measures on its Member States, which include several specific *Resolutions* on the fishing, handling, retention and reporting of selected shark and ray species or groups, or through inclusion of new or updated national legislation or policy to uphold these management measures. Retention bans are imposed for all thresher sharks (Family Alopiidae, IOTC 2012), whale sharks *Rhincodon typus* (IOTC 2013a), oceanic whitetip sharks *Carcharhinus longimanus* (IOTC 2013b) and all mobulid rays (Family Mobulidae, IOTC 2019) in IOTC-managed fisheries (Tables 1, 2).

All ten Nairobi Convention Member States are members of the IOTC and are thereby bound by the protective commitments detailed in published IOTC Resolutions. This includes prohibiting catches, by their relevant fisheries and fishing vessels, of the 12 shark and ray species that occur in the WIO which are listed as prohibited in the IOTC Resolutions (Tables 1, 2, and see Appendix I). However, few of these species are protected in most Nairobi Convention Member States (Table 2), and most of these states fall short of their binding commitments to the IOTC.

Addressing these issues in the Western Indian Ocean Region

The Nairobi Convention *Protocol concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region* (hereinafter Nairobi Convention Protocol) stresses the importance of sustainable utilisation of East Africa's fauna and flora. Article 4 of the Protocol: *Species of Wild Fauna Requiring Special Protection* calls on Contracting Parties to "take all appropriate measures to ensure the strictest protection of the endangered wild fauna species listed in annex II". Article 5 of the Protocol: *Harvestable Species of Wild Fauna* states that "Contracting Parties shall take all appropriate measures to ensure the protection of the depleted or threatened wild fauna species listed in annex III" and that "such wild fauna species shall be regulated in order to restore and maintain the populations at optimum levels" (UNEP 1985). These Annexes therefore provide an objective, centralised list of species, to inform resource managers of Member States which species warrant management or legal protection at national level. Following these Nairobi Convention Protocol articles, and considering their very high risk of extinction, species listed as Critically Endangered and Endangered on the IUCN Red List should be protected, while the harvesting of Vulnerable and Near Threatened species should be regulated, to avoid further population reductions. Listing of appropriate shark and ray species on the Protocol Annexes would provide a legal mechanism for such regulation; however, there remain no shark or ray species listed on the Annexes of this Protocol.

Recognising increasing global concern regarding the declining status of sharks and rays, and the mounting evidence of threats to shark and ray species in the WIO, the Nairobi Convention Member States agreed at their 7th Conference of the Parties (CoP7, Maputo, Mozambique, December 2012), to include sharks (understood to include rays) in the Convention's Programme of Work for 2013-2017 (Decision CP7/1). The Parties also adopted Decision CP7/12: *Conservation of Sharks*, calling for regional collaboration on the conservation and management of sharks, including with CITES, CMS, regional fisheries management organisations, and other partners. While IUCN Red List categories carry no legal requirement for action, the regulations and protective measures for threatened species imposed by CITES, CMS and IOTC are legally binding on Member States. However, many Nairobi Convention Member States currently fail to meet these binding commitments and so fall short in their obligations to implement such multilateral agreements. Mozambique is the only Nairobi Convention Member State that fully protects all CMS Appendix I and IOTC-prohibited shark and ray species; Kenya fully protects just three of these but also formally recognises the IOTC resolutions on thresher sharks (Alopiidae) and mobulid rays (Mobulidae), which thereby apply to all Kenyan fishing vessels on the IOTC Record of Authorised Vessels; Seychelles, South Africa and Tanzania protect fewer than half of these species; while Comoros, Madagascar, Mauritius, Somalia and France (French WIO Departments) protect none of these species (Table 2).

Figure 3. Sphyrna lewini_Christelle Razafindrakoto_WCS Madagascar SW2: A juvenile Critically Endangered scalloped hammerhead shark Sphyrna lewini lies on a fisher's oar, near Andavadoaka, southwest Madagascar (Credit, Christelle Razafindrakoto, Wildlife Conservation Society, Madagascar).

Outlook: recommendations for the Western Indian Ocean Region

Considering that more than one third of WIO shark and ray species are threatened, there is an urgent need for improved legislation for and management of sharks and rays at regional and national levels in the WIO, to reduce the impacts of fishing on these threatened species. However, there is generally limited legislation for sharks and rays in most WIO countries. There is also a need to improve adherence to the multilateral agreements to which Nairobi Convention Member States are party. There is also a need to list relevant shark and ray species, whose populations within the WIO require stricter management or warrant full protection, under the Annexes of the Nairobi Convention Protocol.

To address these objectives and provide a legal framework for the appropriate management and conservation of WIO shark and ray species, this discussion paper presents a list of species proposed for inclusion on the relevant Annexes of the Nairobi Convention Protocol. This list, *Recommendations for Shark and Ray Listings in the Annexes of the Nairobi Convention Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region*, presented as Appendix I to this document, lists individual shark and ray species recommended for each Protocol Annex, including justifications for such listing.

Species are recommended for listing on Annexes II, III and IV, as follows:

II. Overall, 23 shark and 20 ray species are proposed for listing on Annex II of the Protocol (see Table A1 in Appendix I), based on their listing on CITES Appendix I, CMS Appendix I, being the subject of an IOTC retention ban or falling within the Critically Endangered or Endangered IUCN Red List categories. This list includes 13 Critically Endangered and 26 Endangered species.
III. Furthermore, 51 shark species and 19 ray species are recommended for listing on Annex III of the Protocol (see Table A2 in Appendix 1), due to their being listed on CITES Appendix II, on CMS Appendix II, or as Vulnerable or Near Threatened on the IUCN Red List of Threatened Species.
IV. Finally, 43 shark species and 25 ray species are proposed for listing on Annex IV of the Nairobi Convention Protocol (which calls for co-ordinated efforts for the protection of migratory species listed in Annex IV), based on their listing on CMS Appendix I and/or II, Annex I of the CMS Sharks Memorandum of Understanding (CMS 2018), identification as being migratory or possibly migratory (Fowler 2014), or their listing on Annex I ("highly migratory species") of the United Nations Convention on the Law of the Sea (UNCLOS, UN 1982). Several species proposed for listing on Annexes II or III are also proposed here for listing in Annex IV, as Annex IV listing is based on the species' migratory ecology, rather than threat status, thus warranting separate listing (see Table A3 in Appendix I to this document).

Recalling Decision CP7/12: *Conservation of Sharks*, Article 4 of the Nairobi Convention Protocol: *Species of Wild Fauna Requiring Special Protection* and Article 5 of the Nairobi Convention Protocol: *Harvestable Species of Wild Fauna*, the Nairobi Convention Member States are urged to take the following steps, to reduce impacts on shark and ray populations in the WIO, for their improved conservation status:

1. List appropriate shark and ray species on the respective Nairobi Convention Protocol Annexes, as proposed in Appendix I to this document.
2. Implement all binding commitments in terms of species protections and trade controls at national level, as imposed by the multilateral agreements to which they are party, including (among others):
   a. protection of all shark and ray species listed in CMS Appendix I;
   b. protection of all shark and ray species prohibited in IOTC Resolutions;
   c. trade controls for all shark and ray species listed in CITES Appendices.
3. Voluntarily implement species protections and catch restrictions for threatened species and species subject to trade controls, which are not already required to be protected under other multilateral agreements, through:
   a. Following the guiding text of the Nairobi Convention Protocol, in terms of strictly protecting endangered wild fauna species;
   b. Protecting and managing species listed in Nairobi Convention Annexes;
   c. Protecting species listed under CITES Appendix I, for which commercial trade bans should already be in place;
   d. Protecting all IUCN Critically Endangered and Endangered species.
4. Develop and implement appropriate national and regional management plans and management measures for shark and ray species that require improved management, through:
   a. Developing regional management plans for species listed in CMS Appendix II;
   b. Developing management measures for IUCN Vulnerable and Near Threatened species.

Conclusions

There is a critical need for corrective management and improved conservation of threatened WIO shark and ray species. However, few of these species are protected in the WIO and there are few regional management measures or plans in place. By virtue of their being Parties to CMS, IOTC and CITES, Nairobi Convention Member States are obliged to protect, regulate the harvesting of, or control and monitor the trade in the numerous shark and ray species listed through these instruments (Table 1). However, the level of implementation of these agreements will need to be improved, as few of these species are protected or adequately managed and their trade is poorly regulated in most Nairobi Convention Member States, with most of these states falling short of their binding commitments thereto.

Many of these issues could be overcome, and WIO shark and ray populations could be better managed, through several national and regional actions, including i) the listing of appropriate shark and ray species on the respective Nairobi Convention Protocol Annexes to provide a legal framework for their improved management; ii) the implementation (or improvement therein) of binding commitments in terms of species protections and trade controls at national level; iii) the voluntary implementation of species protections and catch restrictions for threatened species not elsewhere protected or regulated; and iv) the development and implementation of appropriate management plans and management measures for shark and ray species that require improved management. The recommendations for species to be listed on the Nairobi Convention Protocol Annexes appear in Appendix I to this document, and their listing should receive appropriate consideration.

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Appendix 1

Recommendations for Shark and Ray Listings in the Annexes of the Nairobi Convention Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region

Introduction

At the 7th Conference of the Parties (CoP7) to The Nairobi *Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region*[1] (Maputo, Mozambique, December 2012), the Member States, recognising increasing global concern regarding the declining status of sharks and batoids (rays, skates, wedgefishes, sawfishes), agreed to include sharks (understood to include batoids) in the Convention's Programme of Work for 2013-2017 (Decision CP7/1) and adopted Decision CP7/12: *Conservation of Sharks*, calling for regional collaboration on the conservation and management of sharks, including with CITES, CMS, regional fisheries management organisations, and other partners, and for preparation by the Secretariat, in collaboration with the Contracting Parties, of a regional status report on the state of sharks and batoids in the Western Indian Ocean[2] (WIO). The Wildlife Conservation Society (WCS), in collaboration with the Nairobi Convention Secretariat, initiated in 2014 a project to compile a regional status report in support of Decision CP7/12 and guide discussions at CoP8.

A parallel objective linked to the regional status report was to identify shark and batoid species for consideration for listing on the Annexes of the *Nairobi Convention Protocol Concerning Protected Areas and Wild Fauna and Flora in the East African Region* (hereinafter referred to as the Nairobi Convention Protocol). The listing of species on the Nairobi Convention Protocol is intended to provide a legal instrument, in this case a centralised list of species, from which resource managers of member states can identify shark and batoid species that warrant specific management or legal protection.

There is a great need to improve the knowledge base and understanding of the status of sharks and batoids and their fisheries in the WIO; however, existing information from a range of assessments, such as those completed by the shark specialist group (Dulvy and others, 2014[3]) of the International Union for the Conservation of Nature[4] (IUCN), provide a basis for considering species for inclusion in the Annexes of the Nairobi Convention Protocol. Numerous shark and batoid species have also been listed in recent years on the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora[5] (CITES) and the Appendices of the Convention on the Conservation of Migratory Species of Wild Animals[6] (CMS), thus increasing the mandate of governments and their environment and fisheries agencies to address the conservation and management needs of these species. The Indian Ocean Tuna Commission[7] (IOTC) also lists several shark and batoid species that may not be captured or retained by the IOTC-linked fisheries directed at tuna and tuna-like species.

This document presents recommendations for the listing of shark and batoid species in Annexes II, III, and IV of the *Nairobi Convention Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region.* Due to the dynamic nature of threats to these species, and considering both declining populations and improving conservation measures, and as new data become available, it is likely that classifications such as CITES listings and IUCN Red List status will change over time. Therefore, the proposed listings should be treated as dynamic and adaptive, in order that they may be amended in the future as deemed necessary.

Recommendations for Listing of Sharks and Batoids in Annex II of the Nairobi Convention Protocol

Article 4 of the Nairobi Convention Protocol: *Species of Wild Fauna Requiring Special Protection* stipulates: "The Contracting Parties shall take all appropriate measures to ensure the strictest protection of the endangered wild fauna species listed in annex II. To this end, each Contracting Party shall strictly regulate and, where required, prohibit activities having

[1] UNEP. 1985. Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region. United Nations Environment Programme, Nairobi. United Nations.

[2] The geographic area referred to here by the term Western Indian Ocean includes the Indian Ocean territorial waters of the ten Nairobi Convention member states, from South Africa (including the Eastern Cape Province and Kwazulu-Natal Province only) in the southwest, to Somalia in the northwest, and to Mauritius in the east, following the delineation of the Indian Ocean by the International Hydrographic Organization (2002), and excludes the marginal seas to the north.

[3] Dulvy, N.K., S.L. Fowler SL, and J.A. Musick. 2014. Extinction risk and conservation of the world's sharks and rays. eLIFE 3:e00590. http://dx.doi.org/10.7554/eLife.00590

[4] IUCN 2020. The IUCN Red List of Threatened Species. Version 2020-2. http://www.iucnredlist.org

[5] www.cites.org

[6] www.cms.int/en

[7] www.iotc.org

adverse effects on the habitats of such species. In particular, the following activities shall, where required, be prohibited with regard to such species:

a. all forms of capture, keeping or killing;
b. damage to, or destruction of, critical habitats;
c. disturbance of wild fauna, particularly during the period of breeding, rearing and hibernation;
d. destruction or taking of eggs from the wild or keeping these eggs even if empty;
e. possession of and internal trade in these animals, alive or dead, including stuffed animals and any readily recognisable part or derivative thereof."

Following this definition, species proposed for listing under Annex II of the Nairobi Convention Protocol were identified based on their listing on one or more of the following:

I. **Convention on the Conservation of Migratory Species of Wild Animals (CMS) Appendix I – Endangered migratory species[8]:** This Appendix "comprises migratory species that have been assessed as being in danger of extinction throughout all or a significant portion of their range. The Conference of the Parties has further interpreted the term "endangered" as meaning "facing a very high risk of extinction in the wild in the near future" (Res. 11.33 paragraph 1)." Noting that CMS Appendix I requires that Parties *"that are a Range State to a migratory species listed in Appendix I shall endeavour to* ***strictly protect*** *them by: prohibiting the taking of such species*, with very restricted scope for exceptions; conserving and where appropriate restoring their habitats; preventing, removing or mitigating obstacles to their migration and controlling other factors that might endanger them". Thus, species listed on CMS Appendix I should be strictly protected in CMS signatory states.

II. **Indian Ocean Tuna Commission (IOTC) Prohibited Species:** IOTC resolutions prohibit the capture/retention of several species of sharks and batoids by Contracting Parties and Cooperating Non-Contracting Parties. Thus, *all such species should be* ***prohibited from capture*** in IOTC fisheries of IOTC Parties.

III. **International Union for the Conservation of Nature (IUCN) Red List of Threatened Species[9]:** species that are Critically Endangered (CR) or Endangered (EN)[10]:
   a. Critically Endangered (CR) species are "considered to be facing an extremely high risk of extinction in the wild";
   b. Endangered (EN) species are "considered to be facing a very high risk of extinction in the wild".

IV. **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I[11]:** This Appendix lists species that are "threatened with extinction and CITES prohibits international trade in specimens of these species". Thus, *species listed in CITES Appendix I should be prohibited from international trade*, from or to a signatory state.

In total, 43 species (23 shark species and 20 batoid species, Table A1), of the 225 shark and batoid species identified to date in the Nairobi Convention area of the WIO, are recommended for consideration for strict protection under Annex II of the Nairobi Convention Protocol, due to meeting one or more of the above criteria. Those species meeting criteria for both Annexes II and III are proposed here for listing under Annex II (i.e., requiring a higher level of protection).

[8] https://www.cms.int/en/page/appendix-i-ii-cms

[9] IUCN 2021. The IUCN Red List of Threatened Species. Version 2021-1. http://www.iucnredlist.org, accessed 29 July 2021

[10] IUCN 2001. *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, United Kingdom: 30 pp

[11] https://www.cites.org/eng/app/appendices.php

Table A1: Shark and batoid species recommended for listing on Nairobi Convention Annex II, based on their listing either in CMS Appendix I (CMS I), as an IOTC prohibited species (IOTC), in CITES Appendix I (CITES I), or on the IUCN Red List of Threatened Species as Critically Endangered (IUCN CR) or Endangered (IUCN EN). The current IUCN Red List status for each species is also presented (CR = Critically Endangered, EN = Endangered, VU = Vulnerable).

Family	Species	Common name	Taxonomic reference	IUCN Red List	Criteria for listing on Annex II
Sharks					
Alopiidae	*Alopias pelagicus* [a]	pelagic thresher shark	Nakamura, 1935	EN	IOTC; IUCN EN
Alopiidae	*Alopias superciliosus* [a]	bigeye thresher shark	Lowe, 1841	VU	IOTC
Alopiidae	*Alopias vulpinus* [a]	common thresher shark	(Bonnaterre, 1788)	VU	IOTC
Carcharhinidae	*Carcharhinus amblyrhynchos*	grey reef shark	(Bleeker, 1856)	EN	IUCN EN
Carcharhinidae	*Carcharhinus longimanus* [b]	oceanic whitetip	(Poey, 1861)	CR	CMS I; IOTC; IUCN CR
Carcharhinidae	*Carcharhinus obscurus*	dusky shark	(Lesueur, 1818)	EN	IUCN EN
Cetorhinidae	*Cetorhinus maximus*	basking shark	(Gunnerus, 1765)	EN	CMS I; IUCN EN
Centrophoridae	*Centrophorus granulosus*	gulper shark	(Bloch & Schneider, 1801)	EN	IUCN EN
Centrophoridae	*Centrophorus lesliei*	African gulper shark	White, Ebert & Naylor 2017	EN	IUCN EN
Centrophoridae	*Centrophorus squamosus*	leafscale gulper shark	(Bonnaterre, 1788)	EN	IUCN EN
Centrophoridae	*Centrophorus uyato*	little gulper shark	(Rafinesque, 1810)	EN	IUCN EN
Echinorhinidae	*Echinorhinus brucus*	bramble shark	(Bonnaterre, 1788)	EN	IUCN EN
Ginglymostomatidae	*Pseudoginglymostoma brevicaudatum*	shorttail nurse shark	Günther, 1867	CR	IUCN CR
Lamnidae	*Carcharodon carcharias*	great white shark	(Linnaeus, 1758)	VU	CMS I
Lamnidae	*Isurus oxyrinchus*	shortfin mako shark	Rafinesque, 1810	EN	IUCN EN
Lamnidae	*Isurus paucus*	longfin mako shark	Guitart Manday, 1966	EN	IUCN EN
Pentanchidae	*Holohalaelurus favus*	honeycomb izak	Human, 2006	EN	IUCN EN
Pentanchidae	*Holohalaelurus punctatus*	whitespotted izak	(Gilchrist, 1914)	EN	IUCN EN
Rhincodontidae	*Rhincodon typus* [c]	whale shark	Smith, 1828	EN	CMS I; IOTC; IUCN EN
Sphyrnidae	*Sphyrna lewini*	scalloped hammerhead	(Griffith & Smith, 1834)	CR	IUCN CR
Sphyrnidae	*Sphyrna mokarran*	great hammerhead	(Rüppell, 1837)	CR	IUCN CR
Stegostomatidae	*Stegostoma tigrinum*	zebra shark	(Hermann, 1783)	EN	IUCN EN
Triakidae	*Mustelus manazo*	starspotted smoothhound	Bleeker, 1855	EN	IUCN EN

[a] IOTC Resolution 12/09 (http://www.iotc.org/cmm/resolution-1209-conservation-thresher-sharks-family-alopiidae-caught-association-fisheries-iotc) "Fishing Vessels flying the flag of an IOTC Member or Cooperating Non-Contracting Party (CPCs) are prohibited from retaining on board, transhipping, landing, storing, selling or offering for sale any part or whole carcass of thresher sharks of all the species of the family Alopiidae"

[b] IOTC Resolution 13/06 (http://www.iotc.org/cmm/resolution-1306-scientific-and-management-framework-conservation-sharks-species-caught) "CPCs shall prohibit, as an interim pilot measure, all fishing vessels flying their flag and on the IOTC Record of Authorised Vessels, or authorised to fish for tuna or tuna-like species managed by the IOTC on the high seas to retain onboard, tranship, land or store any part or whole carcass of oceanic whitetip sharks"

[c] IOTC Resolution 13/05 (http://www.iotc.org/cmm/resolution-1305-conservation-whale-sharks-rhincodon-typus) CPC's "shall prohibit their flagged vessels from intentionally setting a purse seine net around a whale shark in the IOTC area of competence, if it is sighted prior to the commencement of the set" and that "in the event that a whale shark is unintentionally encircled in the purse seine net, the master of the vessel shall: a) take all reasonable steps to ensure its safe release"

Table A1 continued

Family	Species	Common name	Taxonomic reference	IUCN Red List	Criteria for listing on Annex II
Batoids (rays, skates, wedgefishes, sawfishes)					
Glaucostegidae	*Glaucostegus halavi*	Halavi guitarfish	Forsskål, 1775	CR	IUCN CR
Mobulidae	*Mobula alfredi* [d]	reef manta ray	(Krefft 1868)	VU	CMS I; IOTC
Mobulidae	*Mobula birostris* [d]	giant manta ray	(Walbaum 1792)	EN	CMS I; IOTC; IUCN EN
Mobulidae	*Mobula eregoodoo* [d]	longhorned pygmy devil ray	(Cantor 1849)	EN	CMS I; IOTC; IUCN EN
Mobulidae	*Mobula kuhlii* [d]	shortfin devil ray	(Valenciennes, 1841)	EN	CMS I; IOTC; IUCN EN
Mobulidae	*Mobula mobular* [d]	spinetail devil ray	(Bonnaterre, 1788)	EN	CMS I; IOTC; IUCN EN
Mobulidae	*Mobula tarapacana* [d]	sicklefin devil ray	(Philippi, 1892)	EN	CMS I; IOTC; IUCN EN
Mobulidae	*Mobula thurstoni* [d]	bentfin devil ray	(Lloyd, 1908)	EN	CMS I; IOTC; IUCN EN
Myliobatidae	*Aetomylaeus bovinus*	duckbill ray	(Saint-Hilaire, 1817)	CR	IUCN CR
Myliobatidae	*Aetomylaeus vespertilio*	ornate eagle ray	(Bleeker, 1852)	EN	IUCN EN
Myliobatidae	*Myliobatis aquila*	common eagle ray	(Linnaeus, 1758)	CR	IUCN CR
Pristidae	*Pristis pristis*	largetooth sawfish	(Linnaeus, 1758)	CR	CMS I; IUCN CR; CITES I
Pristidae	*Pristis zijsron*	green sawfish	Bleeker, 1851	CR	CMS I; IUCN CR; CITES I
Rajidae	*Raja ocellifera*	twineyed skate	Regan, 1906	EN	IUCN EN
Rajidae	*Rostroraja alba*	spearnose skate	(Lacepède, 1803)	EN	IUCN EN
Rhinidae	*Rhina ancylostomus*	bowmouth guitarfish	Bloch & Schneider, 1801	CR	IUCN CR
Rhinidae	*Rhynchobatus australiae*	bottlenose wedgefish	Whitley, 1939	CR	IUCN CR
Rhinidae	*Rhynchobatus djiddensis*	whitespotted wedgefish	(Forsskål, 1775)	CR	IUCN CR
Rhinidae	*Rhynchobatus laevis*	smoothnose wedgefish	(Bloch & Schneider, 1801)	CR	IUCN CR
Rhinobatidae	*Acroteriobatus leucospilus*	greyspot guitarfish	Norman, 1926	EN	IUCN EN

[d] IOTC Resolution 19/03 (https://iotc.org/cmm/resolution-1903-conservation-mobulid-rays-caught-iin-association-fisheries-iotc-area-competence) CPC's "shall prohibit all vessels from intentionally setting any gear type for targeted fishing of mobulid rays in the IOTC Area of Competence, if the animal is sighted prior to commencement of the set" and "shall prohibit all vessels retaining onboard, transhipping, landing, storing, any part or whole carcass of mobulid rays caught in the IOTC Area of Competence" and "shall require all their fishing vessels, other than those carrying out subsistence fishery, to promptly release alive and unharmed, to the extent practicable, mobulid rays as soon as they are seen in the net, on the hook, or on the deck, and do it in a manner that will result in the least possible harm to the individuals captured".

Recommendations for Listing of Sharks and Batoids in Annex III of the Nairobi Convention Protocol

Article 5 of the Nairobi Convention Protocol: *Harvestable Species of Wild Fauna* stipulates:

1. The Contracting Parties shall take all appropriate measures to ensure the protection of the depleted or threatened wild fauna species listed in annex III.
2. Any exploitation of such wild fauna species shall be regulated in order to restore and maintain the populations at optimum levels. Each Contracting Party shall develop, adopt and implement management plans for the exploitation of such species which may include:
   a. the prohibition of the use of all indiscriminate means of capture and killing and of the use of all means capable of causing local disappearance of, or serious disturbance to, populations of a species;
   b. closed seasons and other procedures regulating exploitation;
   c. the temporary or local prohibition of exploitation, as appropriate, in order to restore viable population levels;
   d. the regulation, as appropriate, of sale, keeping for sale, transport for sale or offering for sale of live and dead wild animals;
   e. the safeguarding of breeding stocks of such species and their critical habitats in protected areas designated in accordance with article 8 of this Protocol;
   f. exploitation in captivity."

Following this definition, species proposed for listing under Annex III of the Nairobi Convention Protocol were identified based on their listing on one or more of the following:

I. **IUCN Red List of Threatened Species**[12]**:** those species assessed as either Vulnerable (VU) or Near Threatened (NT)[13]:
   a. Vulnerable (VU) species are "considered to be facing a high risk of extinction in the wild";
   b. Near Threatened (NT) – a Near Threatened species "does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future".

II. **CMS Appendix II – Migratory species conserved through Agreements**[14]**:** This Appendix comprises "migratory species that have an unfavourable conservation status and that require international agreements for their conservation and management, as well as those that have a conservation status which would significantly benefit from the international cooperation that could be achieved by an international agreement. The Convention encourages the Range States to species listed on Appendix II to conclude global or regional Agreements for the conservation and management of individual species or groups of related species." This list excludes those species listed in CMS Appendix II that are also listed on CMS Appendix I and have already been included in the preceding section as proposed for inclusion on Annex II of the Nairobi Convention.

III. **CITES Appendix II**[15]**:** This Appendix lists species that are "not necessarily now threatened with extinction but that may become so unless trade is closely controlled".

In total, 70 species (51 shark species and 19 batoid species, Table A2) are recommended for listing on Annex III of the Nairobi Convention Protocol, due to their being listed as Vulnerable or Near Threatened on the IUCN Red List of Threatened Species, on CITES Appendix II or on CMS Appendix II. This list excludes those species already included in the preceding section as proposed for inclusion on Annex II of the Nairobi Convention.

[12] IUCN 2017. The IUCN Red List of Threatened Species. Version 2017-3. http://www.iucnredlist.org, accessed 26 June 2018

[13] IUCN 2001. *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, United Kingdom: 30 pp

[14] https://www.cms.int/en/page/appendix-i-ii-cms

[15] https://www.cites.org/eng/app/appendices.php

Table A2: Shark and batoid species recommended for listing on Nairobi Convention Annex III, based on their listing on the IUCN Red List of Threatened Species as Vulnerable (IUCN VU) or Near Threatened (IUCN NT), in CMS Appendix II (CMS II) or CITES Appendix II (CITES II). Current Red List status is also presented.

Family	Species	Common name	Taxonomic reference	IUCN Red List	Criteria for listing on Annex III
Sharks					
Carcharhinidae	*Carcharhinus albimarginatus*	silvertip shark	(Rüppell, 1837)	VU	IUCN VU
Carcharhinidae	*Carcharhinus altimus*	bignose shark	(Springer, 1950)	NT	IUCN NT
Carcharhinidae	*Carcharhinus amblyrhynchoides*	graceful shark	(Whitley, 1934)	NT	IUCN NT
Carcharhinidae	*Carcharhinus amboinensis*	pigeye shark	(Müller & Henle, 1839)	NT	IUCN NT
Carcharhinidae	*Carcharhinus brachyurus*	copper shark	(Günther, 1870)	VU	IUCN VU
Carcharhinidae	*Carcharhinus brevipinna*	spinner shark	(Valenciennes, 1839)	VU	IUCN VU
Carcharhinidae	*Carcharhinus falciformis*	silky shark	(Müller & Henle, 1839)	VU	CMS II; CITES II; VU
Carcharhinidae	*Carcharhinus leucas*	bull shark	(Valenciennes, 1839)	NT	IUCN NT
Carcharhinidae	*Carcharhinus limbatus*	blacktip shark	(Valenciennes, 1839)	NT	IUCN NT
Carcharhinidae	*Carcharhinus macloti*	hardnose shark	(Müller & Henle, 1839)	NT	IUCN NT
Carcharhinidae	*Carcharhinus melanopterus*	blacktip reef shark	(Quoy & Gaimard, 1824)	VU	IUCN VU
Carcharhinidae	*Carcharhinus plumbeus*	sandbar shark	(Nardo, 1827)	VU	IUCN VU
Carcharhinidae	*Carcharhinus sorrah*	spottail shark	(Valenciennes, 1839)	NT	IUCN NT
Carcharhinidae	*Negaprion acutidens*	sicklefin lemon shark	(Rüppell, 1837)	VU	IUCN VU
Carcharhinidae	*Prionace glauca*	blue shark	(Linnaeus, 1758)	NT	IUCN NT; CMS II
Carcharhinidae	*Rhizoprionodon acutus*	milk shark	(Rüppell, 1837)	VU	IUCN VU
Carcharhinidae	*Scoliodon laticaudus*	spadenose shark	Müller & Henle, 1838	NT	IUCN NT
Carcharhinidae	*Triaenodon obesus*	whitetip reef shark	(Rüppell, 1837)	VU	IUCN VU
Carchariidae	*Carcharias taurus*	ragged-tooth shark	Rafinesque, 1810	VU	IUCN VU
Centrophoridae	*Centrophorus moluccensis*	smallfin gulper shark	Bleeker, 1860)	VU	IUCN VU
Centrophoridae	*Deania calceus*	birdbeaked dogfish	(Lowe, 1839)	NT	IUCN NT
Centrophoridae	*Deania profundorum*	arrowhead dogfish	(Smith & Radcliffe, 1912)	NT	IUCN NT
Centrophoridae	*Deania quadrispinosa*	longsnout dogfish	(McCulloch, 1915)	VU	IUCN VU
Dalatiidae	*Dalatias licha*	kitefin shark	(Bonnaterre, 1788)	VU	IUCN NT
Galeocerdidae	*Galeocerdo cuvier*	tiger shark	(Peron & Lesueur, in Lesueur, 1822)	NT	IUCN NT
Ginglymostomatidae	*Nebrius ferrugineus*	tawny nurse shark	(Lesson, 1830)	VU	IUCN VU
Hemigaleidae	*Hemigaleus microstoma*	sicklefin weasel shark	Bleeker 1852	VU	IUCN VU
Hemigaleidae	*Hemipristis elongata*	snaggletooth shark	(Klunzinger, 1871)	VU	IUCN VU
Hemigaleidae	*Paragaleus leucolomatus*	whitetip weasel shark	Compagno & Smale, 1985	VU	IUCN VU
Hexanchidae	*Heptranchias perlo*	sharpnose sevengill shark	(Bonnaterre, 1788)	NT	IUCN NT
Hexanchidae	*Hexanchus griseus*	bluntnose sixgill shark	(Bonnaterre, 1788)	NT	IUCN NT
Hexanchidae	*Hexanchus nakamurai*	bigeyed sixgill shark	Teng, 1962	NT	IUCN NT
Hexanchidae	*Notorynchus cepedianus*	broadnose sevengill shark	(Peron, 1807)	VU	IUCN VU
Odontaspididae	*Odontaspis ferox*	smalltooth sand tiger shark	(Risso, 1810)	VU	IUCN VU

Table A2 continued

Family	Species	Common name	Taxonomic reference	IUCN	Criteria for Annex III
Oxynotidae	*Oxynotus centrina*	angular rough shark	(Linnaeus, 1758)	VU	IUCN VU
Pentanchidae	*Bythaelurus hispidus*	bristly catshark	(Alcock, 1891)	NT	IUCN NT
Pentanchidae	*Halaelurus boesemani*	speckled catshark	Springer & D'Aubrey, 1972	VU	IUCN VU
Pentanchidae	*Halaelurus natalensis*	tiger catshark	(Regan, 1904)	VU	IUCN VU
Pentanchidae	*Haploblepharus fuscus*	brown shyshark	Smith, 1950	VU	IUCN VU
Pentanchidae	*Haploblepharus kistnasamyi*	Natal shyshark	Human & Compagno, 2006	VU	IUCN VU
Scyliorhinidae	*Cephaloscyllium sufflans*	balloon shark	(Regan, 1921)	NT	IUCN NT
Scyliorhinidae	*Scyliorhinus capensis*	yellowspotted catshark	(Müller & Henle, 1838)	NT	IUCN NT
Somniosidae	*Centroscymnus coelolepis*	Portuguese shark	Barbosa du Bocage & de Brito Capello, 1864	NT	IUCN NT
Somniosidae	*Centroscymnus owstoni*	roughskin dogfish	Gaman, 1906	VU	IUCN VU
Somniosidae	*Centroselachus crepidater*	longnose velvet dogfish	(Barbosa du Bocage & de Brito Capello, 1864)	NT	IUCN NT
Sphyrnidae	*Sphyrna zygaena*	smooth hammerhead	(Linnaeus, 1758)	VU	IUCN VU; CITES II
Squalidae	*Squalus acutipinnis*	bluntnose spurdog	Regan, 1906	NT	IUCN NT
Squatinidae	*Squatina africana*	African angelshark	Regan, 1908	NT	IUCN NT
Triakidae	*Mustelus mosis*	Arabian smoothhound	Hemprich & Ehrenberg, 1899	NT	IUCN NT
Triakidae	*Mustelus mustelus*	common smoothhound	(Linnaeus, 1758)	VU	IUCN VU
Triakidae	*Scylliogaleus quecketti*	flapnose houndshark	Boulenger, 1902	VU	IUCN VU
Batoids (rays, skates, wedgefishes, sawfishes)					
Anacanthobatidae	*Anacanthobatis marmorata*	spotted legskate	(Von Bonde & Swart, 1923)	NT	IUCN NT
Aetobatidae	*Aetobatus ocellatus*	Indian eagle ray	(Kuhl, 1823)	VU	IUCN VU
Dasyatidae	*Dasyatis chrysonota*	blue stingray	(Smith, 1828)	NT	IUCN NT
Dasyatidae	*Himantura leoparda*	leopard whipray	Manjaji-Matsumoto & Last, 2008	VU	IUCN VU
Dasyatidae	*Himantura uarnak*	coach stingray	(Gmelin, 1789)	VU	IUCN VU
Dasyatidae	*Maculabatis ambigua*	Baraka's whipray	Last, Bogorodsky, & Alpermann, 2016	NT	IUCN NT
Dasyatidae	*Pateobatis fai*	pink whipray	(Jordan & Seale, 1906)	VU	IUCN VU
Dasyatidae	*Pateobatis jenkinsii*	Jenkins' whipray	(Annandale, 1909)	VU	IUCN VU
Dasyatidae	*Taeniurops meyeni*	blotched stingray	(Müller & Henle, 1841)	VU	IUCN VU
Dasyatidae	*Urogymnus asperrimus*	porcupine ray	(Bloch & Schneider, 1801)	VU	IUCN VU
Dasyatidae	*Urogymnus granulatus*	mangrove whipray	(Macleay, 1883)	VU	IUCN VU
Gymnuridae	*Gymnura poecilura*	longtail butterfly ray	(Shaw, 1804)	VU	IUCN VU
Narkidae	*Heteronarce garmani*	Natal electric ray	Regan, 1921	NT	IUCN NT
Rajidae	*Dipturus campbelli*	blackspot skate	(Wallace, 1967)	NT	IUCN NT
Rajidae	*Dipturus crosnieri*	Madagascar skate	(Séret, 1989)	VU	IUCN VU
Rajidae	*Leucoraja wallacei*	yellowspotted skate	(Hully, 1970)	VU	IUCN VU
Rajidae	*Raja clavata*	thornback skate	Linnaeus, 1758	NT	IUCN NT
Rhinobatidae	*Acroteriobatus annulatus*	lesser guitarfish	Smith, 1841	VU	IUCN VU
Rhinobatidae	*Acroteriobatus zanzibarensis*	Zanzibar guitarfish	(Norman, 1926)	NT	IUCN NT

Recommendations for Listing of Sharks and Batoids in Annex IV of the Nairobi Convention Protocol

Article 6 of the Nairobi Convention Protocol: Migratory Species stipulates: "The Contracting Parties shall, in addition to the measures specified in articles 3, 4 and 5, co-ordinate their efforts for the protection of migratory species listed in annex IV whose range extends into their territories. To this end, each Contracting Party shall ensure that, where appropriate, the closed seasons and other measures referred to in paragraph 2 of article 5 are also applied with regard to such migratory species."
Following this definition, species proposed for listing under Annex III of the Nairobi Convention Protocol were identified based on their listing on one or more of the following:

CMS[16] Appendix I – Endangered migratory species (CMS Appendix I) or Appendix II – Migratory species conserved through Agreements: The appendices of CMS list threatened migratory species, including sharks and batoids. Therefore, all species listed on these two CMS appendices are proposed for Annex IV of the Nairobi Convention Protocol.

CMS Memorandum of Understanding on the Conservation of Migratory Sharks (CMS Sharks MOU), Annex I: In addition to the listing of shark and batoid species on Appendices I and II of CMS, a taxon-specific MOU was developed for migratory shark and batoid species (CMS Sharks MOU). This MOU provides an instrument under the CMS for achieving a favourable conservation status for migratory sharks and batoids. The CMS Sharks MOU is non-binding, but encourages signatories "to strengthen and improve their role in taking measures to improve or restore a favourable conservation status of sharks listed in Annex 1 of the Memorandum of Understanding". Annex I lists migratory species of sharks and batoids for which this conservation measure is intended to apply, including 25 species of sharks and batoids that occur in the WIO.

Fowler[17] (2014): In a global review of migratory chondrichthyan fishes, Fowler (2014) identified and listed a number of shark and batoid species that can be defined as migratory or possibly migratory. These include 29 migratory shark species and 13 migratory batoid species, as well as 12 possibly migratory shark species and 9 possibly migratory batoid species, that occur within the WIO. Fowler (2014) used the definitions presented in CMS Article I[18] and defined "migratory species" as species for which "the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries".

The United Nations Convention on the Law of the Sea[19] (UNCLOS) Annex I *Highly Migratory Species*[20]: UNCLOS Annex I lists three species of sharks as being, and four families of sharks as containing, "highly migratory species", most of which were also identified by Fowler (2014).
The following table (Table A3) lists 68 shark and batoid species (43 shark species and 25 batoid species) that are proposed for listing on Annex IV of the Nairobi Convention Protocol, based on their listing on CMS Appendix I and/or II, the CMS Sharks MOU Annex I, identification by Fowler (2014) as migratory (M) or possibly migratory (PM), or their listing on UNCLOS Annex I at the family level (UNCLOS) or species level (UNCLOS species) as "highly migratory species". Several species proposed for listing on Annexes II or III are also proposed here for listing in Annex IV, as Annex IV listing is based on the species' migratory ecology, rather than threat status, thus warranting separate listing.

[16] https://www.cms.int/en/page/appendix-i-ii-cms

[17] Fowler, S. 2014. *The Conservation Status of Migratory Sharks*. UNEP/CMS Secretariat. Bonn, Germany. 30pp.

[18] https://www.cms.int/en/convention-text

[19] http://www.un.org/depts/los/convention_agreements/convention_overview_convention.htm

[20] http://www.un.org/depts/los/convention_agreements/texts/unclos/annex1.htm

Working towards a common regional vision for mangrove conservation

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Summary

Mangroves are unique ecosystems located along intertidal coastlines. Mangrove ecosystems play important life-sustaining functions in the Western Indian Ocean (WIO) region. Still, they are critically exposed to degradation and loss from the anthropogenic pressures, exacerbated by the negative impacts of climate change. Strong governance of natural resources in general and implementation of environmental policies and laws, as well as good coordination and coherence at the institutional level, coupled with financial and technical capacities, contribute to healthy mangrove ecosystems and improved livelihoods. Coordinated action is important to secure mangroves in the WIO region. A joint mangrove vision could be instrumental in achieving this, thereby aiding the implementation of the Nairobi Convention Conference of Parties (COP) Decision CP9/11. Creating awareness and strengthening governance capacities at the regional, national and local levels and exchanging information between the scientific community and policymakers can help ensure coordinated and cooperative protection of mangroves. The Nairobi Convention COPs offer a pivotal opportunity to rally the regional actors around the need to have a joint regional approach regarding our common mangroves. The joint development of a regional mangrove vision would create synergy with the Multilateral Environmental Agreements (MEAs) in addressing mangrove ecosystem conservation and restoration priorities within the WIO and fostering regional commitments on mangrove conservation. This approach would only be possible if an intensified and strengthened partnership is in place among actors in the WIO through, for example, the formation of a Regional Advisory Group. This group would support synergies between mangrove-related initiatives, provide strategic guidance and support a regional policy dialogue between WIO countries within the framework of the Nairobi Convention process. A strong common WIO mangrove vision, adopted by governments and key actors at regional and international policy fora and backed by commitments, can make the WIO region an internationally recognised "mangrove champion" and earn attention for priority needs.

Background

Mangroves are unique ecosystems along intertidal coastlines, forming the interface between land and sea in tropics and subtropics. According to the Global Mangrove Watch, the global mangrove habitat was 135 881 km^2 in 2016, representing a linear coverage of 12 per cent of the 1 634 701 km of the global coastline. Over 700 000 ha of mangroves cover the WIO region (Spalding and others 2021), approximately 5 per cent of the global mangrove coverage. Four countries, namely Mozambique, Madagascar, Tanzania and Kenya, contain 99 per cent of these mangroves, mainly occurring in deltas and estuaries (Bosire and others, 2016).

Mangroves deliver substantial ecosystem goods and services that play a critical role in supporting human well-being through climate regulation, disaster risk reduction, food security and poverty reduction for more than 120 million people living in tropical coastal (UNEP 2014) areas. Despite their substantial value, mangrove ecosystems have experienced net losses in cover in the past decades (Spalding and Leal 2021). The critical need to conserve, manage, and restore

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functioning mangrove forests and related coastal ecosystems are recognised in various Multilateral Environmental Agreements (MEAs), including the Ramsar Convention on Wetlands of International Importance, especially as Waterfowl Habitat, 1971; the Convention on Biological Diversity (CBD), 1992; the United Nations Framework Convention on Climate Change (UNFCCC), 1992; the United Nations Convention on the Law of the Sea, 1982; and the United Nations Watercourses Convention, 1997 as well as in global commitments such as the Sustainable Development Goals (SDGs). However, the potential of mangrove conservation in contributing towards serving such international commitments is still only marginally realised and utilised.

Besides climate change, the main drivers of environmental and ecosystem degradation at the global level are the increasing human demand for natural resources such as land, food, energy etc., pollution and unsustainable practices (Goldberg and others, 2020). Weak governance frameworks exacerbate them for nature, particularly for mangrove habitats, hence the importance of global policy action. Nature-based Solutions (NbS) (IUCN 2020), and mangrove conservation, in particular, is recognised for supporting sustainable development along global coastlines, addressing multiple societal challenges by simultaneously securing human well-being and biodiversity benefits. The 2019 Nature-Based Solutions for Climate Manifesto underscores the need for a shift in international governance to value nature and realise the potential of NbS.

The WIO region is characterised by high coastal and marine biodiversity, both in terms of species and ecosystems, which places it as one of the world's richest and most interesting ocean regions. The region has 60 million coastal inhabitants and an estimated annual economic value of US$20.8 billion, and a US$333.8 billion ocean asset base (Obura 2017). However, high poverty rates among the coastal population have led to a high resource dependence and overexploitation of coastal and marine resources and ecosystem services. Mangrove habitats are ecosystems with essential life-sustaining functions, yet they are threatened by anthropogenic pressures, which are exacerbated by the impacts of climate change, such as sea-level rise and sedimentation.

Mangrove loss rates vary immensely between regions, particularly when their distribution and health are non-linear at national and local levels. That isn't surprising in the WIO region, where four countries - Kenya, Tanzania, Mozambique and Madagascar - hold approximately 99 per cent of its mangrove cover (Bosire and others, 2016). The coastal areas of the WIO region have experienced increasing loss rates of mangrove cover over the past decades, resulting in a shortage of mangrove products, reduction in fisheries, shoreline change, pollution, and loss of livelihoods for communities living adjacent to mangrove ecosystems. A change in that trend started only to manifest in recent years (Bosire and others, 2016).

Advances – state of the art

Strong governance of natural resources in the general and adequate implementation of environmental policies and laws and good coordination and coherence at the institutional level, coupled with financial and technical capacities, contribute to improving mangroves' situation – and that of the people relying on them for their livelihoods. Significant advances have been made at the national level, for example, the national mangrove strategies currently in place in Kenya, Mozambique, Madagascar and Tanzania. Furthermore, WIO actors have expressed the need for a regional dialogue for a joint mangrove vision that may be instrumental in supporting coordinated action for securing mangroves in the WIO region as a whole and aiding the implementation of key strategies. For example, the Nairobi Convention COP Decision CP9/11 supports the implementation of marine protected areas and critical habitats outlooks. Creating awareness and strengthening governance capacities at the regional, national and local levels and exchanging data and information between the scientific community and policymakers can help ensure coordinated and cooperative protection of mangroves grounded in science and takes transboundary conservation needs into account. Dialogue is vital between scientists and decision-makers and at the institutional level among the different government agencies (Slobodian and Badoz 2019). See Figure 1 for coherent and integrated policy-making and a shared vision. Dialogue should happen at the national as well as the regional level. However, cooperation and the development of joint visions may not be realised without political will and buy-in.

Linkage to regional and global processes

Despite the focus on mangrove ecosystems in this paper, the interaction between broader coastal ecosystems is crucial. Both international, regional, and national policy-making must reflect them. In relation to climate change, especially at a global policy level,

promoting joint conservation of mangroves with other ecosystems such as coral reefs and seagrass meadows will increase effectiveness. The "Super Year 2020", now shifted to 2021 due to Covid-19, provides an opportunity to have a common vision and synergistic agenda between the various Multilateral Environmental Agreements (MEAs), eg new CBD targets and revised UNFCCC Nationally Determined Contributions. Such synergy will align and accelerate action on the ground, both in terms of overall political commitment and smart planning and implementation processes, including finance. The WIO region would benefit greatly from this opportunity if its key governments, institutions, partners, and stakeholders can establish dialogue discussions, adopt a joint approach, vision and strategies, and speak with one voice at the international stage. The Nairobi Convention COPs offer a key opportunity to rally the regional actors around the need to have a joint regional approach and voice concerning our common mangroves. The joint development of a regional mangrove vision could help to make the conservation of coastal ecosystems, such as mangroves, a priority in policy-making and to increase the acknowledgement of marine and coastal nature-based solutions in national and regional land-use planning, disaster risk management, climate change and sustainable development policies in the WIO region.

Additionally, after hosting the first global Blue Economy Conference in 2018, the WIO region is now fully engaged on the road to unlocking the potential of its blue economy. Such an economy represents great promises for the region in terms of economic benefits. Nevertheless, it is paramount that healthy oceans and good governance are developed based on sustainable premises that will ultimately enable the conservation of the region's blue natural capital and directly benefit local communities. In that regard, the role of mangroves in fisheries enhancement, coastal protection, local livelihoods, and its potential to develop innovative financing mechanisms (including those related to the carbon finance sector) is critical. It is, therefore, a crucial nature-based solution to the successful development of the blue economy. As such, efforts contributing to sustainable mangrove conservation and restoration in the region will also directly contribute to developing a sustainable, inclusive and resilient blue economy.

A regional mangrove vision would create synergy with the MEAs in addressing mangrove ecosystem conservation and restoration priorities within the WIO and foster the development of more specific agreements and regional commitments on mangrove conservation. Such agreements could take the form of specific policy frameworks for mangrove conservation at the national and regional level, such as a Cooperative Agreement on the Conservation of Mangrove Ecosystems within the Western Indian Ocean. Notably, the vision may be anchored to protecting rivers and coastal ecosystems associated with mangroves within regional and sub-regional institutions, including River Basin Organisations and Regional Economic Communities (RECs), which might serve as platforms for dialogue and promotion of environmental goals.

The subject matter to be addressed

In the WIO region, dealing with mangroves at a regional level is essential since the countries hosting this type of ecosystem share similar challenges at various levels (ecological, socio-economic, governance, etc) (Bosire and others, 2016). In that regard, dialogues and efforts to cooperate should aim at designing standard policy and legislative frameworks to manage and govern these resources in a coordinated and effective manner. For that reason, we suggest fostering the joint development of a regional mangrove vision that will pave the way towards the frameworks mentioned above. Moreover, the support of the international policy and donors' communities to a given region will be eased and most efficient when a region coalesces around a common vision. Such joint vision development is a prerequisite to regional integration and cohesion, which is important to inform and foster the development of global international policy processes. At the same time, international processes are essential to inform and guide the development of regional and national instruments and actions.

Therefore, developing a regional mangrove vision and support needs is a responsibility that all levels of governance within the WIO region should take on. Furthermore, it is vital for better recognition of the WIO region at the global policy and donor's level. In doing so, the region should simultaneously take the advantage to build a strong case for enhanced mangrove conservation goals – included in a common vision and/or an agreement with clear targets and indicators – in the space of the international community. It is worth highlighting that the development of such a regional vision should strongly correlate with national policy-making. There will be increased government commitment for mechanisms such as SDG14, GLISPA, or the Bonn Challenge. Funding and implementation

needs will be identified while ensuring harmonization to fill gaps and avoid redundant efforts. Preferably the government commitments take account of aspirations of non-state actors and local communities.

The international mangrove initiative "Save Our Mangroves Now!" (SOMN), launched by the German Federal Ministry for Economic Cooperation and Development (BMZ), the World Wide Fund for Nature (WWF), and the International Union for Conservation of Nature (IUCN), and joined by Wetlands International in its second phase (2020-2022) has the goal to reverse the decrease of mangrove habitats with a strong focus on the WIO region. Therefore, SOMN offers its capacities to support mangrove conservation by promoting a regional policy dialogue to foster a WIO-wide collective effort to developing a regional mangrove vision.

Such a vision would be most powerful if it encapsulates the region's commitments and priority needs. With the support of the Nairobi Convention Secretariat, Parties and projects (eg, WIOSAP, SAPPHIRE), as well as SOMN and other stakeholders, the WIO region promises to become a global example, a so-called "champion" on mangrove conservation. Achieving the status may lead to further successes on enhanced protection and sustainable use of mangroves. The successful conservation of mangroves in the WIO can inform other regions and promote replication of conservation approaches.

The approach described above would only be possible if an intensified and strengthened partnership is in place among actors in the WIO. Strong collaboration can be achieved, for example, through a Regional Advisory Group and the Community of Practice (CoP) platform. The latter would support synergies between mangrove-related initiatives, provide strategic guidance and support a regional policy dialogue between WIO countries within the framework of the Nairobi Convention process. The CoP enhances networking

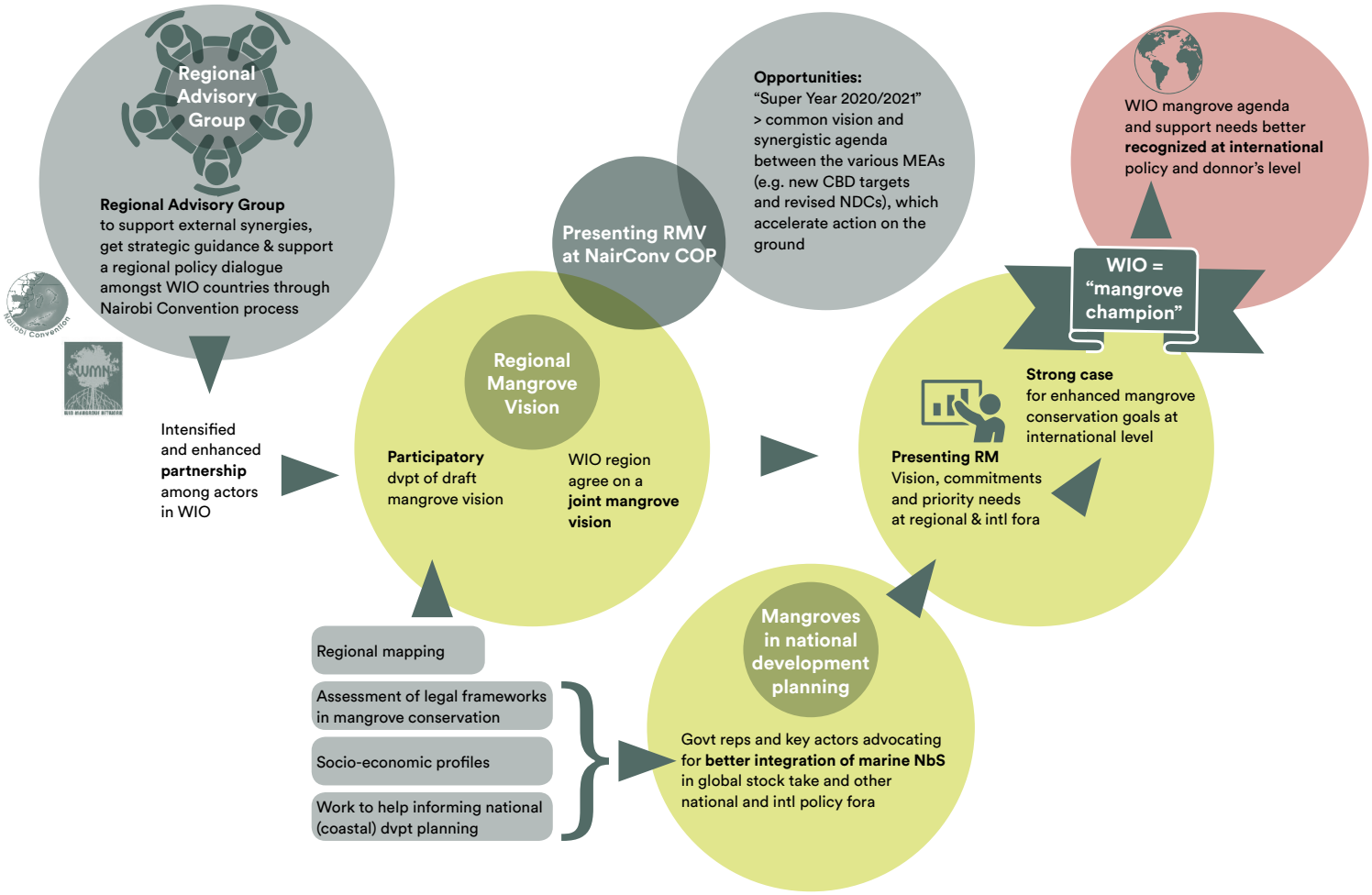

Figure 1. Suggested theory of change towards a regional mangrove vision and better recognition of the WIO region at the international level (abbreviations: WMN: Western Indian Ocean Mangrove Network, RMV: regional mangrove vision). Source: Save Our Mangroves Now!

among experts within the WIO region by providing opportunities for dynamic interactions among the different technical task forces, forums and committees of Nairobi Convention Contracting Parties. A set of activities are underway in SOMN's four target countries: Kenya, Tanzania, Mozambique and Madagascar, to support the proposed regional policy dialogues. The SOMN project is already supporting institutional capacity development of the WIO Mangrove Network (WIOMN) through the successful legal registration in March 2021. The Network has already pooled regional mangrove stakeholders (Bosire and others, 2016; UNEP 2020). It can thus become an umbrella body to host such a Regional Advisory Group as one of its subsidiary bodies as provided for by the Network's Constitution.

Institutional strengthening of the WIOMN through such an advisory group will enhance its role as provider of policy options. A strong WIOMN may also be supported by SOMN's ongoing activities on developing mangrove socio-economic profiles and a regional mangrove mapping tailored to serve national and, specifically, coastal development planning.

Policy Recommendations

A strong common WIO mangrove vision, adopted by governments and key actors at regional and international policy fora and backed by commitments, can make the WIO region an internationally recognised "mangrove champion" and earn attention for priority needs.

To achieve this, we:

- Call on the Nairobi Convention Parties to develop a regional mangrove vision (and related strategic framework as needed) that encapsulates the region's commitments and priority needs, which will accelerate action on the ground in terms of political commitment overall and also overall planning and implementation processes, including finance.
- Call on the Nairobi Convention Parties to facilitate the mainstreaming of mangroves in national development planning, eg Nationally Determined Contributions (NDCs).
- Call on the Nairobi Convention Secretariat and Parties and the WIO Mangrove Network to establish the relevant institutional structures. For example, the proposed Regional Advisory Group can support synergies between mangrove-related initiatives, craft the regional mangrove vision elements, and support regional policy dialogue on mangroves.
- Call on the Nairobi Convention Secretariat to intensify and enhance partnership among stakeholders and actors in WIO through, for example, the Community of Practice (CoP) platform to reinforce mangrove commitments and priorities in the region.
- Urge the Nairobi Convention Secretariat, Parties and partners to create a strong case for the regional mangrove vision through regional and global dialogues (beyond the discussions in the proposed Regional Advisory Group) to enhance mangrove conservation goals, commitments and priority needs at regional and international level. This will help profile the WIO region as a "mangrove champion" globally.

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Prioritization of climate refugia in the Western Indian Ocean

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Summary

Coastal dynamics over long periods of geological time in the western Indian ocean (WIO) have created a mosaic of habitats and species distributions that will continue to change as the impacts of climate change accelerate. Changes in sea level and in ocean heat and chemistry will force these ongoing changes. Therefore, it behooves coastal and Blue Economy decision makers to develop systems of management that will keep habitats such as coral reefs and linked ecosystems productive and with viable species populations. The current patterns of coral reef species distributions and centers of diversity and sanctuaries are now becoming better understood in the WIO. This knowledge provides a basis for prioritization of locations and management that can affect future states and where climate and human impacts are both reduced to sustain the region's rich habitat and diversity. These priority locations run along a coastal belt from northern Madagascar to northern Mozambique and extending north to southern Kenya. Prioritization of these areas for protection and management is needed through implementation of policies which have been shown to be a mixture of fisheries restrictions, coastal and riverine protection, and spatial planning.

Background

The Western Indian Ocean is the largest and most diverse marine and coastal region on the African continent. The coastal and marine ecosystems of the WIO not only have very high biodiversity but are important for livelihoods and national economies. The WIO's coastal and marine areas are experiencing rapid change with increased human population and expansion of fishing, tourism, shipping, and energy extraction. Climate change is projected to have large-scale impacts, including elevated sea surface temperatures, sea-level rises, changes in monsoonal systems and cyclones and coastal flooding. Coastal ecosystems such as coral reefs, seagrasses and mangroves will bear the brunt of climate change impacts. This combination of local and global stressors results in environmental degradation and undermines the ecosystem services and livelihoods of millions of local people and national economies that rely on marine natural resources in the WIO.

One solution is the establishment of marine protected areas (MPAs). Most WIO countries have established MPAs mainly focusing on nearshore ecosystems and committed to the Convention on Biological Diversity's (CBD) Aichi 11 target to protect 10 per cent of coastal and marine areas. The target has been a key driver of the rapid expansion of national marine conservation efforts in the last decades. Yet, marine and coastal ecosystems and species continue to decline in the WIO affecting coastal economies and the wellbeing of communities. A crucial policy window, the Post-2020 Global Biodiversity Framework, is currently being negotiated by the Parties to the CBD to increase protection to 30 per cent by 2030. This will require a rapid expansion of protected area coverage for many WIO nations, although some like Seychelles have already met this target. Establishing large-scale MPAs such as transboundary conservation areas (TBCA) and other large wilderness sanctuaries is one of the few tools available to achieve this area target. The benefits of large area-based management include the ability to act at the ecosystem and landscape spatial scale; conservation and management of ecosystems, species and fisheries stocks that cross national jurisdictions; promotion of integrated management and conflict resolution; and the ability to increase climate resilience on a large scale.

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Studies in the WIO have identified several potential climate refugia (see Section 3 below), including the proposed TBCA on the Kenya Tanzania border. Protection of these climate refugia confers the benefits of managing at a large spatial scale and serve as potential climate mitigation measures. The global level pact (High-level panel for a sustainable ocean economy; www.oceanpanel.org) signed by 14 nations, including Kenya, to protect and sustain ocean health provides additional impetus for their establishment, as do calls of improved ocean governance (AU and WIO regional Ocean Governance workshop), local and national marine spatial planning (MSP) efforts and contributes to meeting national blue economy (BE) aspirations.

This paper summarizes the science that has been undertaken in the WIO on climate refugia and recommends immediate action to establish large MPAs, TBCAs and other sanctuaries and wilderness areas prioritizing the areas identified in the WIO that have the conditions that serve as critical climate refugia in the face of modern climate change.

Linkage to regional and global processes

The issue under discussion aligns with several initiatives in the WIO, including regional, national, and local marine spatial planning, development of strategies for the BE, the Post-2020 global biodiversity framework, and other issues summarized below:

Marine area-based planning and management: There are an estimated 149 MPAs in the WIO. However, these are often small and rarely considered ecosystem representativeness, size, and irreplaceability in their design. Most countries that have signed the CBD convention have yet to meet the 10 per cent Aichi marine and coastal target. In addition, many MPAs lack the resources and capacity for effective management and hence fail to achieve conservation and sustainable management goals. Yet, the Post 2020 framework negotiations are underway to increase coverage to 30 per cent. This cannot be met without establishing and managing large ocean areas such as TBCAs that involve multiple nations, sectors, and jurisdictions. There is little experience in establishing TBCAs. Previous efforts to establish one in the Mnazi bay/Quirimbas complex between Tanzania and Mozambique were unsuccessful and the proposed TBCA between Kenya and Tanzania is in the early stages of planning. Many WIO nations have also embarked on national and local MSP (e.g. Seychelles, Mauritius, Kenya). A recently launched process for a Regional Strategy for Marine Spatial Planning for the WIO reflects the aspiration and desire for sustainable use and management of the ocean in the region. Therefore, the identified climate refugia must be recognized and prioritized for protection at these national and regional levels. The current MPA's especially those located in the climate refugia areas (see Section 3 below), will also require the resources to ensure that they are more effectively managed.

Blue economy: The countries of the WIO also view the Blue Economy (BE) as the next economic frontier and are developing BE strategies with a focus primarily on fishing, tourism, shipping, and mining. These are commercial sectors that are regional and global and have the potential to significantly boost national economies. However, these could also conflict with natural resource management and potentially negatively affect the livelihoods and wellbeing of coastal peoples. The challenge for large scale ocean governance will be balancing the competing interests for development and avoiding irreversible environmental loss. The BE agenda in WIO countries are often driven at a relatively high level of government. Therefore, it is important to ensure that discussions are held across all sectors and administrative levels and across borders to ensure coordination, integration, and inclusion. The discussions should also be coordinated and mainstreamed with national and regional MSP processes and align with Ecologically or Biologically Significant Marine Areas (EBSAs) and Area Beyond National Jurisdiction (ABNJs).

The Nairobi Convention (NC) for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (UNEP 1985) is the anchoring convention for the WIO. Other regional and global conventions and processes that align and can contribute to this issue include the Post-2020 Global Biodiversity Framework and Sustainable Development Goal (SDGs) 14, the African Union (AU) climate strategy and Agenda 2063 AU Blue Economy Strategy, the Paris agreement on climate change, the UN Decade of Ocean Science for sustainable development, the NC climate change strategy and the International Coral Reef Initiative's call to action amongst others.

Using climate science to manage climate impacts

Climate change and biodiversity are closely linked in the WIO. A flurry of recent research unveils how historical forces of slow geological and faster climate variability have shaped the region's diversity patterns.

Understanding this variability is critical to making intelligent decisions about ocean management that will affect people reliant on this diversity for centuries.

Changing diversity is best viewed as the expansion and contraction of species ranges as suitable conditions for species follow the spatial distribution of these pulses. Climate and ocean processes oscillate between severe and more benign conditions dependent on the severity of the back and forth of warm and cold-water current movements. These oscillations are associated with heating and cooling, which in temperate climates are driven by expanding and contracting glaciers. Glaciation effects are seen in sea levels and shorelines, even in the tropics, but the same heating and cooling also affects tropical ocean oscillations, which then drive species distributions. It also affects tropical rainfall, high-mountain glaciers, and runoff into the nearshore mangroves, seagrasses, and coral reefs.

When the climate becomes severe, as is the current situation, diversity contracts and is maintained in a few areas that are not so impacted by climate, known as climate refugia or, more importantly, sanctuaries for species. When the climate is benign, species expand and are found far from these sanctuaries. This process of pulsing in space and time has been ongoing for at least the past 3 to 4 million years and has produced the WIO's geographic patterns of diversity. Thus, while most of the species in the WIO evolved before the recent glaciation, their distributions changed and pulsed in space in response to climate oscillations. Some of these pulses and species expansions may be extensive, ranging from Indonesia to East Africa. In contrast, others are smaller and contained within the African coastline and associated large and small islands.

The current challenge is that overlain with this contraction process and expansion of reef diversity is the increasing human use and dependence on reef resources, particularly fisheries. Fisheries affect the abundance of many utilized species. Thus, many species are experiencing a contraction in their ranges and their abundances through fishing. Consequently, the key action we can take in managing species is to protect species in these climate sanctuaries.

So, where are these sanctuaries? Many but not all sanctuaries can be found by examining the distribution of species diversity. The more diverse areas often represent sanctuaries because these places are the core locations or origins of this expanding and contracting diversity in recent times. Diversity of hard corals shows the highest numbers of species generally exist around 10°S of the equator but more specifically in discrete locations in southern Kenya–northern Tanzania, southern Tanzania–northern Mozambique and northwestern Madagascar–Mayotte. These locations are the likely climate refugia and species sanctuaries where species persisted during the severe climate.

The above three areas are the highest priorities for protection. Several historical and recent efforts to establish protection in these areas can be strengthened by expansion to larger TBCAs or sanctuaries. These include the older established MPAs and reserves in northern Tanzania (Chumbe, Dar es Salaam), and in southern Kenya (Kisite-Mpunguti Marine Park and Reserve) and the more recent MPAs including the Tanga Coelacanth Reserve, the Tanga marine Reserve systems in northern Tanzania that are encompassed within the proposed Kenya -Tanzania TBCA. In the Madagascar-Mayotte area, the Mayotte Marine Reserve and the two reserves in northern Madagascar, namely Ankarea and Ankivonji, are also potential climate sanctuaries. Along the Tanzania and Mozambique borders are the historical efforts in the Mnazi Bay and Quirimbas MNPs that although unsuccessful as a trans-boundary conservation marine area, could be revisited given the need to protect potential climate refugia. In addition, the emerging northern Mozambique channel initiative has the potential to promote large-scale ocean management. Although many of these protected areas within the climate sanctuaries have many challenges and are in various states of ecological health, they form the potentiality for expansion through MSP into larger marine protected area planning frameworks such as TBCAs etc.

Recommendations for the Nairobi Convention Conference of Parties

Environmental impacts on the marine and coastal ecosystems of the WIO are projected to increase, due to climate change, rapidly expanding coastal development and the drive to develop the BE. There is an urgent need to ensure that this is balanced with enhanced ocean governance and mitigation of the threats from climate change. Taking into consideration discussions at the Nairobi Convention conference of parties meeting (Mombasa 2018) and other regional and global commitments for protecting marine and coastal ecosystems and species, the following actions are recommended:

Technical recommendations

- Urge member states to evaluate and improve the effectiveness of MPAs across the WIO, focusing on the MPAs in the areas identified as climate refugia.

- Urge Parties and relevant organizations to collaborate to identify, map, designate and develop management strategies to protect the climate refugia in the WIO.

Policy recommendations

- Encourage member states to implement approaches that ensure coordination, integration, and inclusion of all sectors in developing local and national MSP and BE initiatives
- Urge Parties when undertaking MSP, marine conservation planning and BE initiatives, especially large-scale developments such as ports and oil and gas, to consider climate refugia and mitigation measures.
- Encourage member states to implement their global and regional binding commitments to protect and manage the coastal zone and ocean governance.

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Using the IUCN Red List of Ecosystems Assessment to support national and regional alignment in coral reef management

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Summary

The IUCN Red List of Ecosystems framework provides a standard for measuring risks of ecosystem collapse, providing critical information to inform policy. The approach assesses ecosystem area and integrity, meeting the need for both metrics in national, regional and global policies for biodiversity and sustainability. We applied it to assess risks of ecosystem collapse at regional and ecoregional scales across coral reefs in the Western Indian Ocean (WIO). Overall, WIO coral reefs were classified as Vulnerable. In contrast, reefs in 11 nested ecoregions ranged from Critically Endangered (islands, driven by future warming) to Vulnerable (continental coast and Seychelles North, caused by fishing pressure). The threatened status of coral reefs reinforces the urgent need for national and regional policy responses that include mitigating and building resilience to climate change and implementing ecosystem-based management of coral reefs to reduce risks of ecosystem collapse.

Background

The Western Indian Ocean (WIO) contains 16 per cent of the world's coral reefs, and the region is a globally important hotspot for coral reef biodiversity. Coral reef ecosystems underpin the economies of the countries in the region, particularly fisheries and tourism sectors. They provide livelihood opportunities and income for local communities to the tune of an estimated US$ 8.4 billion annually and have an estimated asset value of U$ 18.1 billion.

Despite these benefits, coral reefs are highly threatened, with up to 50 per cent already considered degraded globally (IPBES 2019). The weight of evidence suggests that increasing local (fishing, pollution, coral diseases, cyclones) and global (warming, acidification) stressors give a window of only several decades (Beyer and others, 2018) before the possible collapse of this flagship ecosystem. This would have severe consequences on coastal food security, economies, and jobs. Within the WIO, widespread decline

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during global bleaching events has occurred in 1998 and 2016 (Gudka and others, 2020), with lesser events occurring in 1983, 2005, 2007 and 2010. Fishing and other environmental stressors have compounded the stress on reefs presenting complex patterns of decline and partial recovery (McClanahan and others, 2015).

Developing coherent conservation actions for coral reefs is complicated by the large quantities of contrasting information on the state of reefs.

Addressing this need, the International Union for the Conservation of Nature's (IUCN) Red List of Ecosystems (RLE, www.iucnrle.org) is emerging as a framework to assess the risk of ecosystem collapse (Keith and others, 2013). It provides a consistent information base to inform management and policy responses to reduce the risks of ecosystem collapse (Alaniz and others, 2019). The RLE builds on the success of the IUCN Red List of Threatened Species, which for over 50 years has been the global standard for assessing the risk of species extinction. The RLE adapts this approach to assess the risk of collapse for ecosystems (Figure 1).

We applied the RLE framework to assess risks of ecosystem collapse at regional and ecoregional scales across coral reefs in the WIO, covering nine out of the ten Nairobi Convention member countries. The analysis used indicators of ecosystem extent, distribution, response to future warming, and interactions among key ecosystem compartments (corals, algae, parrotfish and groupers) (Obura 2021).

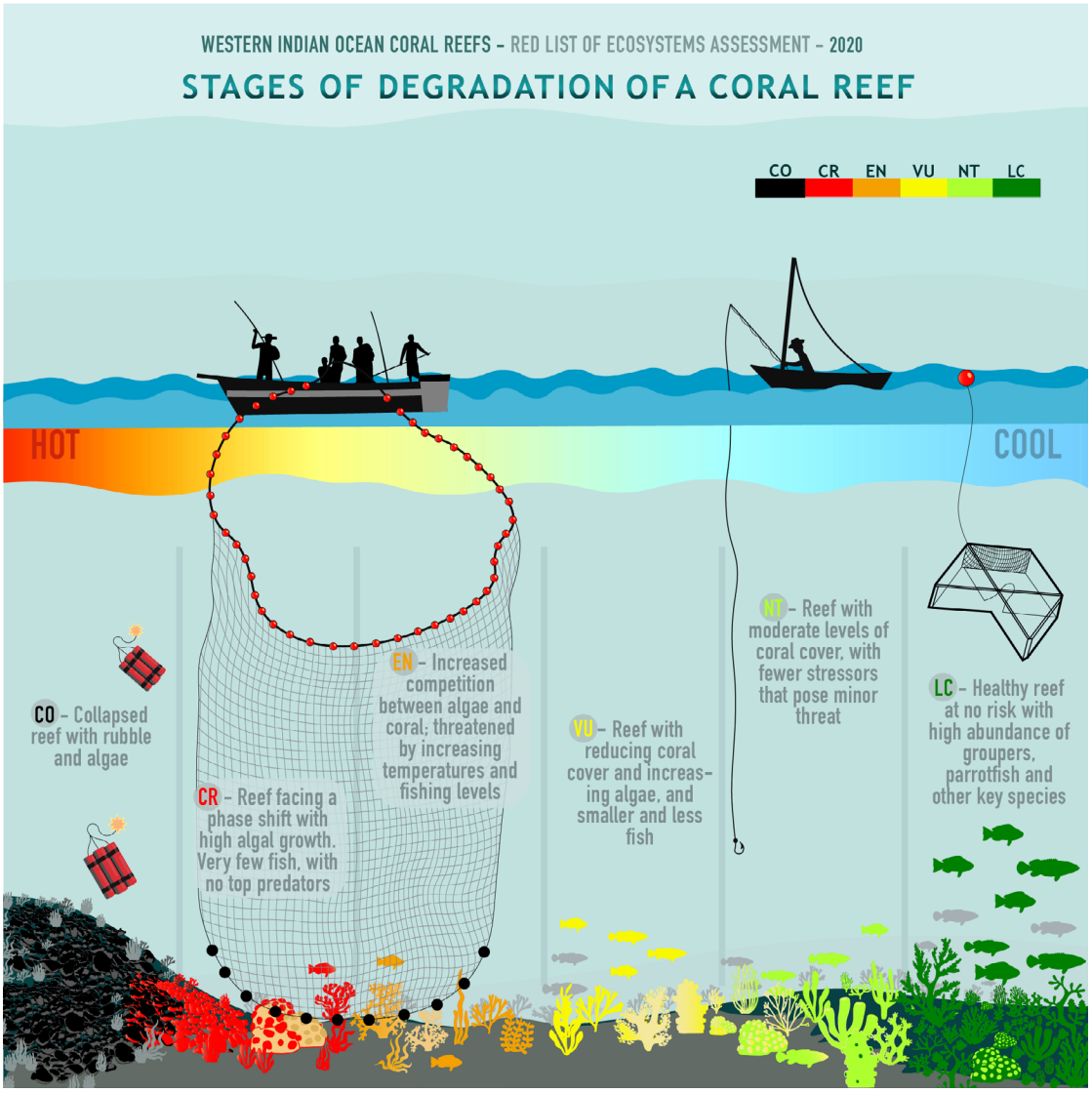

Figure 1. The stages of degradation of a coral reef, as contained in the Red List of Ecosystems. The illustration illustrates the primary drivers assessed (thermal stress, fishing) and the state of the reef system. The stages shown include: LC, Least Concern; NT, Near Threatened; VU, Vulnerable; EN, Endangered; CR, Critically Endangered; CO, Collapsed.

The assessment has produced some important advances: i) an up-to-date regional-scale analysis of reef regions most at risk; ii) a diagnosis of the dominant threats among these; iii) increased robustness and relevance of results for decision-support for coral reef management and policy; iv) updated the coral reef database compiled by the Global Coral Reef Network's (GCRMN) regional network under the Coral Reef Task Force (CRTF) of the Nairobi Convention, and v) introduced a novel assessment approach to the region that can be adapted to other critical ecosystems, such as mangroves and seagrass beds.

Advances

A key value of this analysis and the standardised outputs is promoting consistent actions and policies within ecoregions and countries at smaller scales (Momanyi 2016). This analysis is consistent with policy, actions, and processes within the Nairobi Convention, particularly through activities of the projects of the Convention supporting coherent work at local and national scales among Parties (see next section).

Western Indian Ocean coral reefs, covering 11 919 km^2 and comprising about 5 per cent of the global total (Figure 1), are Vulnerable (VU) to ecosystem collapse (Obura 2021). We assessed four of five criteria of the RLE over 50 years: decline in ecosystem extent (Criterion A), vulnerability due to restricted geographic distribution (B), and ecosystem disruption resulting from the decline in the quality of abiotic (C) and biotic factors (D). Criterion E was Not Evaluated as a quantitative model could not be applied. Two criteria (C, D) returned a result of VU (Figure 1, Table 1) based on future warming using a likely pathway for global greenhouse gas emissions (Criterion C, RCP 6.0) and biotic disruption based on reduction in piscivorous fishes indicative of fishing pressure (D). The other two criteria (A, B) returned a result of Least Concern (LC). The RLE assigns the most threatened result (VU) as the final status (Rodriguez and others, 2015).

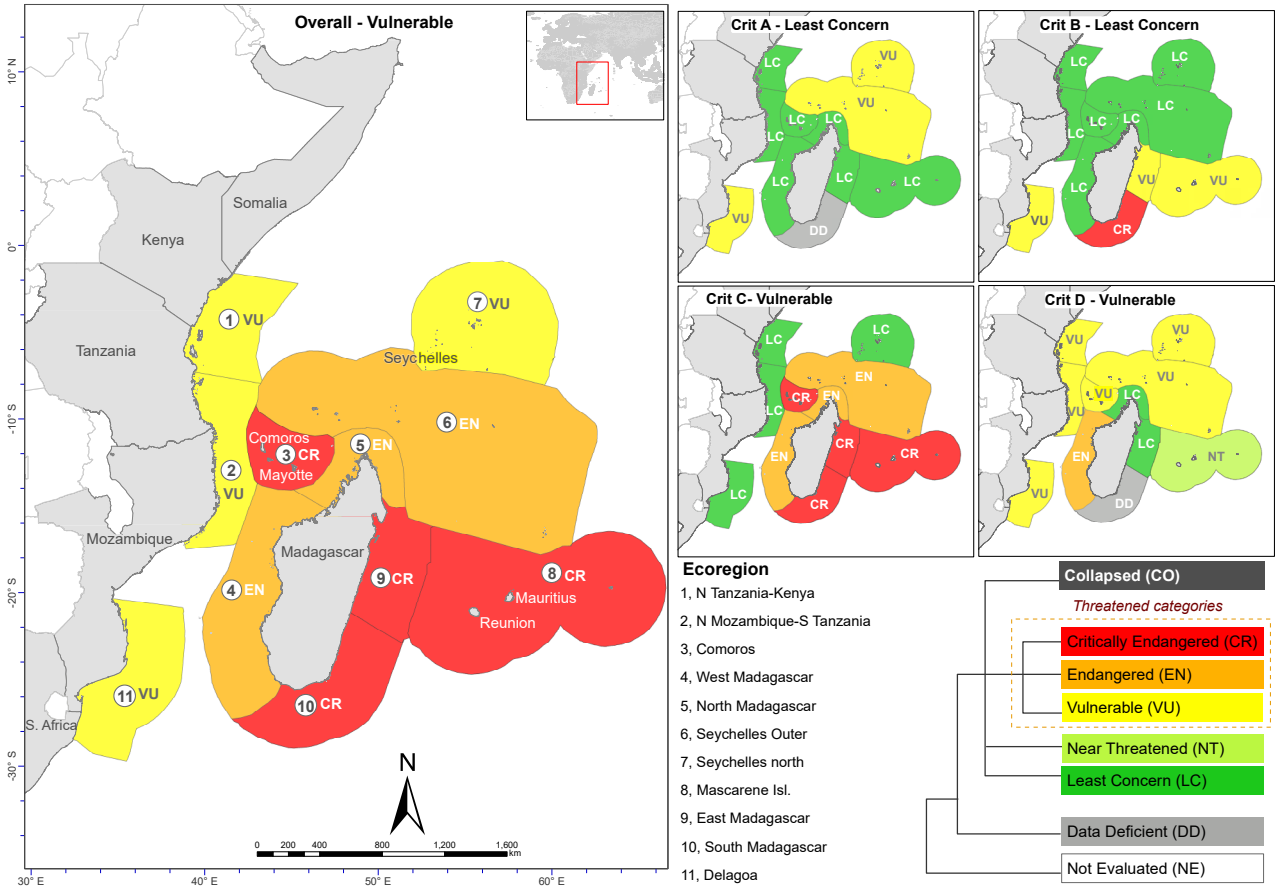

Figure 2. Coral reefs in the Western Indian Ocean and 11 of its ecoregions were evaluated using the Red List of Ecosystems (RLE). The overall risk level for each ecoregion is shown (left) and for each Criterion assessed: A, B, C and D (panels in the upper right, see also Table 2). Coral reefs in the Somali Ecoregion were Not Evaluated (NE). The ecoregion names and RLE categories hierarchy and colour codes used throughout the study are shown in the lower right—figure from Obura and others 2021.

Table 1. Risk of the collapse of Western Indian Ocean coral reef ecosystems in 11 ecoregions, across Criteria A–D of the Red List of Ecosystems. The overall result lists the final risk level and in parenthesis the criteria and subcriteria on which it is based. DD, Data Deficient; LC, Least Concern; NT, Near Threatened; VU, Vulnerable; EN, Endangered; CR, Critically Endangered. For details behind these results and the sub-criteria coding, see SI3-6). Table from Obura and others 2021.

Region		A	B	C	D	Overall
WIO region		LC	LC	VU	VU	VU(C2a,D1a)
Ecoregions						
1	N.Tanzania-Kenya	LC	LC	LC	**VU**	VU(D1a)
2	N.Mozambique-S.Tanzania	LC	LC	LC	**VU**	VU(D1a)
3	Comoros	LC	LC	**CR**	VU	CR(C2a)
4	West Madagascar	LC	LC	**EN**	VU	EN(C2a)
5	North Madagascar	LC	LC	**EN**	LC	EN(C2a)
6	Seychelles.Outer	VU	LC	**EN**	VU	EN(C2a)
7	Seychelles North	**VU**	LC	LC	**VU**	VU(A1,D1a)
8	Mascarene Islands	LC	VU	**CR**	NT	CR(C2a)
9	East Madagascar	LC	VU	**CR**	LC	CR(C2a)
10	South Madagascar	DD	EN	**CR**	DD	CR(C2a)
11	Delagoa	**VU**	**VU**	LC	**VU**	VU(A1,B1a(iii)b,B2,D1a)

At a finer geographic scale, there was considerable variation in the risk of ecosystem collapse among 11 coral reef ecoregions within the WIO (Figure 1, Table 2). The highest levels of risk were scored for seven ecoregions (four Critically Endangered (CR) and three Endangered (EN)) due to future warming in the island ecoregions spread across Madagascar, Comoros, outer Seychelles and the Mascarene Islands (Mauritius and Reunion) (Figure 2). The remaining four ecoregions were assessed as VU. Of these, reefs in the large continental ecoregions (N. Tanzania-Kenya and N. Mozambique-S. Tanzania) were Vulnerable based on declining populations of piscivorous fishes. In contrast, reefs in Seychelles North and Delagoa (southern Mozambique - northern South Africa) were Vulnerable due to a decline in reef areal extent, and in Delagoa also to the limited geographic distribution of reefs (Table 1).

Policy implications

Based on the findings, a wide range of policy and management options are available to conserve coral reefs in countries of the WIO (Table 2). Potential actions range from mitigating climate warming and minimising its impact to implementing ecosystem-based management at local scales to build the resilience of coral reefs to climate change.

Local management actions will have significant scope to maintain or improve reef health at ecoregions less threatened by future warming, ie on the mainland coast (McLeod and others, 2019). Actions should target alleviating fishing pressure (indicated here by grouper decline) and promoting coral recovery after major die-offs, such as reducing pollution in coastal waters to prevent the proliferation of algae. In addition, some of these ecoregions show strong levels of larval supply to more vulnerable ecoregions in the WIO (Crochelet and others, 2016; Gamoyo and others, 2019; Maina and others, 2020), and may therefore play a key role in the recovery of reefs through larval connectivity.

Global actions under the UNFCCC to reduce carbon emissions are essential. The most recent commitments made by countries in their NDCs in 2020 correspond to an emissions scenario greater than RCP 4.5, which will endanger most of the reefs in the region. The need for decarbonisation is reinforced by the fact that for the carbon emissions pathway RCP 2.6 (i.e. achieving the Paris Agreement), all ecoregions were assessed as Least Concern (LC), while under pathway RCP 8.5 (Business as Usual), all were considered as Critically Endangered (CR) (Obura, 2021). For the island ecoregions more threatened by warming, the next 2–3 decades will still be significant for reducing local reef threats and reef vulnerability:

a. to maintain ecosystem function and resilience to buy time for coral populations to adapt to warmer conditions through compositional shifts and/or genetic changes (McLeod and others, 2019),

Table 2. Portfolio of policy and management responses to address the main drivers of risk of collapse of Western Indian Ocean coral reefs. Given the broad scale of this assessment at ecoregional levels, multiple responses across climate and ecosystem-focused actions will likely be required within any country. VU, Vulnerable; EN, Endangered; CR, Critically Endangered; MPA, Marine Protected Areas; NDC, Nationally Determined Contribution; OECM, Other Effective Conservation Measures. Table from Obura and others (2021).

<table>
<tr><th>Risk level and critical factor</th><th>Ecoregions and specific indicators of risk</th><th>Range of policy and management responses to alleviate critical risk factors</th><th></th></tr>
<tr><td>Climate, EN-CR (C2a, SST warming)</td><td>• Comoros, Mascarene Islands, East Madagascar & South Madagascar (CR)
• North Madagascar (EN)</td><td rowspan="3">• Commit to strong climate change mitigation through the Paris Agreement/NDCs and national implementation of emission reductions and adaptation plans relevant to coral reefs.
• Use scenarios in policy and management planning to consider higher and lower risk levels to maintain future options.
• Establish climate adaptation plans, eg:
. optimise benefit flows (on 20–30 yr. time frames) until coral reefs transition to an alternative state;
. develop ecosystem and resource use policies anticipating potential alternative states of reefs, to maximise biodiversity and benefits after a transition;
. identify and develop ‚climate smart‘ fisheries with reduced ecosystem impacts and more secure livelihood benefits;
. identify alternative livelihood options and diversified income streams in coral reef landscapes;
• Identify and protect climate refugia and connectivity nodes through MPAs and OECMs.
• Invest in local (co)management (OECMs) to reduce synergistic threats, maximise climate resilience and buy time for adaptation.
• Improve management of species and pressures that disrupt ecosystem processes, such as fisheries, land-based impacts to coral reefs, direct damage from the tourism, etc.
• Develop guidance and best practices on enhancing recovery of reefs through alleviating pressures, understanding the role of herbivory, assisted restoration efforts, etc.</td><td rowspan="3">Climate and change-focus <<- - - - - - - - ->> Ecosystem resilience focus</td></tr>
<tr><td>Climate with biotic disruption, EN-VU</td><td>• Seychelles Outer (climate, EN ; coral, VU)
• West Madagascar (climate, EN; herbivores & piscivores, VU)</td></tr>
<tr><td>Biotic disruption, VU (D1a)</td><td>• N.Tanzania-Kenya, N.Mozambique-S.Tanzania (piscivores, VU)
• Seychelles North (coral & piscivores, VU)
• Delagoa (coral, algae & herbivores, A & B1/B2, VU)
• Algae is not a significant driver of the higher threat alone, but in synergy with other factors (N.Tanzania-Kenya, Delagoa)</td></tr>
</table>

b. to sustain the valuable current economic and livelihood benefits coral reefs provide (Groeneveld, 2015) for as long as possible, and
c. as part of a broader integrated and ecosystem-based management approach delivering cleaner waters, adjacent ecosystem protection, and linked recreational and economic opportunities.

Outlook – regional and global processes

Reginal processes - Nairobi Convention Decisions and Work programme elements

The importance of coral reefs is highlighted in decisions, products and ongoing projects of the Nairobi Convention and supported by this work:

- Starting with the 3rd Conference of Parties to the Nairobi Convention in Maputo, 2001, Decision CP. 3/2 recognising that "coral reefs and related fragile ecosystems of the region are increasingly under stress from both localised human threats and global climate change and thus are a major cause for concern", a number of COP decisions have been made relevant to coral reefs (Box A);

Box A – prior COP decisions focused on coral reefs:
Decision CP. 3/2: Protection of coral reefs and associated ecosystems
Decision CP7/6: Strengthening Marine and Coastal Ecosystems Based Management, Valuation of Ecosystems Goods and Services and Assessments (*in relation to management and strengthening networks of experts*)
Decision CP8/13: Enhancing Cooperation, Collaboration and Support with Partners (*in relation to the regional coral reef status report published in 2017*)
Decision CP.9/11: Development of marine protected areas and critical habitat outlooks.

- Under the Nairobi Convention work programme for 2018–2022, under the "Assessments and capacity development section", paragraph 39 cites: "promoting the uptake of information, outputs and outcomes and the use of these in policymaking: (a) Collecting and synthesising the data on coastal habitats and their threats, necessary to support a regional analysis and development of outlooks on thematic areas such as critical habitats, marine protected areas

(MPA), climate change, environmental policy, disaster planning and management, and economic performance, (b) Supporting the development of decision support tools related to the WIO regional state-of-the-coast report". Coral reefs are a key ecosystem in the Critical Habitats and MPA Outlook reports published for the current Conference of Parties of the Nairobi Convention. The results of this analysis add to their findings and can be used in planning the following Workplan of the Convention.

- The 2015 WIO State of the Coasts report highlighted coral reefs as a critical ecosystem for biodiversity, fisheries and other economic benefits (Obura, 2015).

These provide a framework for policy responses at national levels (Table 2, and see recommendations below) to be coordinated and aligned, to make the most of the comparatively good outlook for coral reefs of the WIO compared to many other reefs globally (Beyer and others, 2018; Hoegh-Guldberg and others, 2018).

The Nairobi Convention serves as a regional platform for its Parties to integrate commitments and initiatives linked to the above and other global initiatives. It is a flagship/model region relating to other regional fora – such as the Marine Regions Forum and the International Ocean Governance forum supported by the EU. The RLE for coral reef ecosystems of the WIO is a global pioneer, developed using the data and processes established under the Nairobi Convention CRTF as a regional node for the GCRMN. It thus establishes the WIO as a pioneering region for coral reef assessments and policy development. It can stimulate similar assessments in other regions through all the regional and global mechanisms listed above.

Global processes

Current consultations on new decadal targets for the Convention on Biological Diversity (CBD), called the *post-2020 Global Biodiversity Framework (GBF)*, include greater attention to ecosystem targets (Watson and others, 2020) than in the prior Strategic Plan for Biodiversity and its associated Aichi Targets (from 2011 to 2020). They strongly recommend separate measures of area and integrity for quantifying ecosystem health to guide actions to protect or restore ecosystems effectively (Diaz, 2020; Díaz and others, 2020). The RLE meets these criteria and has been proposed as a potential indicator in the monitoring framework of the GBF by the International Coral Reef Initiative (ICRI, 2020) , among others.

These new CBD indicators will also likely be applied to the Sustainable Development Goal indicator framework to replace those based on the Aichi Targets due in 2020, enabling revised indicators and milestones for 2030. An IUCN motion (74) adopted for the 2021 IUCN World Conservation Congress on adopting the ecosystem typology developed to support the RLE will further support replicating this RLE analysis across coral reefs globally.

The *global status of reefs report of the GCRMN,* launched in September 2021 (Souter and others, 2021), provides a globally consistent dataset compatible with this analysis. As a result, the RLE can be applied consistently across the ≥ 100 ecoregions (Spalding and others, 2007) that contain coral reefs globally, providing a consistent metric of reef status across all countries.

The coming decade is a critical one for biodiversity globally and thus also for coral reefs. Key 'decades' include the *Decade of Action and Delivery for sustainable development* (2020-2030), the *UN Decade of Ocean Science*, and the *UN Decade of Ecosystem Restoration*. The United Nations Environment Assembly (UNEA) has passed multiple resolutions on marine and coastal issues. Under the Paris 2015 Agreement of the UN Framework Convention on Climate Change (UNFCCC), countries are currently revising their Nationally Determined Contributions (NDCs) to include specific mention of sensitive ecosystems and ecosystems critical for human well-being, such as coral reefs.

The RLE can serve as a key indicator of coral health and contributions to these processes and evaluate country actions under them.

Recommendations from the RLE assessment of coral reefs of the Western Indian Ocean

Recommendations here focus on the Parties to the Convention and support provided by the Nairobi Convention Secretariat and partners such as the members of the Consortium for the Conservation of the Western Indian Ocean (WIO-C). These recommendations acknowledge past decisions from the COPs on coral reefs (Box A) and a wide range of possible management policy responses (Table 2). Our recommendations focus on improving the development

and integration of capacity and technical information within policy instruments and processes:

Policy

1. Build on the findings of the Red List of Ecosystems, the 2017 regional and 2021 global GCRMN coral reef status reports, and other science, to identify priority reef areas requiring effective protection through protected areas or other effective conservation measures (OECM), thereby addressing international conservation area targets in the Western Indian Ocean in a way that is compatible with sustainable use and equity at local levels.

2. Embed coral reefs as a flagship ecosystem for sustainable development within national and sub-national Marine Spatial Planning and Sustainable Blue Economy processes in countries of the WIO to resolve local stressors (ranging from fisheries to land-based development).

Technical

1. Capitalise on the findings from the Red List of Ecosystems assessment to stimulate support for national policy processes related to coral reef and marine ecosystem conservation and sustainable management eg national coral reef action or management plans and strategies

2. Formally acknowledge the RLE result within the Nairobi Convention and promote the inclusion of the Red List of Ecosystems as a component indicator in the Global Biodiversity Framework of the Convention on Biological Diversity, thus establishing its relevance for monitoring Sustainable Development Goal 14 and of national reporting in convention processes.

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Regional framework for ecosystem monitoring in the Western Indian Ocean

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Summary

Ecosystem monitoring is a tool to assess the status and trends of both ecosystems health and management blueprints over long periods. Monitoring of ecosystems is undertaken through continuous and long-term data collection of relevant regional and national indicators to evaluate the environmental status and trends and sustainable ecosystem services usage. "*The Regional Framework for Ecosystem Monitoring in the Western Indian Ocean*" represents a guideline for the Contracting Parties of the Nairobi Convention and partners. It aims to provide a standardised approach to developing national activities to support ocean ecosystem monitoring in the region. The framework encourages developing and reviewing long-term monitoring programmes through integrated, coordinated, collaborative, and effective partnerships across the Western Indian Ocean region. It has been designed in line with the 2030 Agenda and the Sustainable Development Goals (SDG), the post-2020 Global Biodiversity Framework. It is also directly linked to Step 2 of the UN Decade of Ocean Science for Sustainable Development. Relevant priority issues and concerns identified in the regional Transboundary Diagnostic Analysis (TDA) were also considered for incorporation into National Planning. A list of 30 priority indicators has been selected to assist the Contracting Parties in addressing these issues and leading their strategies to target their commitments to global and regional initiatives on conservation of biodiversity, sustainable blue economy and human development. These indicators may be used for reporting relevant data on the Ocean's ecosystem health and environmental management strategies. Recommendations are provided to consolidate the importance of synchronised and efficient initiatives nationally and regionally by incorporating this framework into national planning for promoting and uplifting the economic, cultural and social potential of coastal communities and ecosystem services of the Western Indian Ocean.

Background

The Western Indian Ocean (WIO) Region comprises the Agulhas and Somalian Current Large Marine Ecosystems (LME) and the recently recognised Mascarene Plateau LME. It incorporates the coastal waters and currents, management and governance boundaries adjacent to the continent from Somalia to southeast South Africa (15 000 km extension), sharing cultural, political and biological history. The region has a unique biodiversity and abundant natural resources of socio-economic relevance for the local communities and national economies. Coral reefs, seagrass meadows, rocky shores, estuaries and dunes are some of the habitats that provide ecosystem services for activities such as coastal agriculture, mining and energy, maritime trade, fisheries and tourism.

Ecosystem health determines the sustainability and productivity of these activities to support human well-being and, thus, relies on the successful management of the Ocean. Regional ecosystem monitoring provides a tool to assess the status and trends of ecosystems health and management blueprints over long periods. Monitoring of ecosystems is undertaken through constant and long-term data collection of regional and national indicators relevant to evaluating environmental status and trends and sustainable ecosystem services usage (CSIR 2009). It represents a proactive, dynamic and adaptive process continuously under review and refinement regarding the procedures, tools, methods, and approaches used. Thus, it is based on the adaptive management principle (WRC 2016). Difficulties in aggregating available data from

http://dx.doi.org/1x.xxx/wio.6

several countries may be minimised by setting up a standardised framework for the contextualisation, design, implementation and reporting processes. Indeed, ensuring that all generated data are fully reproducible, integrated, comparable and accessible will provide a big picture of the trends and changes in the Western Indian Ocean.

Monitoring is an essential component of the decision-making process because it allows evaluation of the effectiveness of management actions through time and thus reduces uncertainty. Monitoring also helps to determine new threats and issues that may arise over time and to re-prioritise threats and issues. Continuity, consistency, appropriate scale, expertise and effort are central to monitoring (Biber 2013). Therefore, it is expected that conducting effective monitoring can be challenging, especially in areas with limited human and financial capacity. Institutional continuity is needed from public and private institutions to undertake long-term monitoring and ensure that consistent methods are used over time. Scale considerations are also vital since there is usually a mismatch between the jurisdictional scales of an institution's mandate and the scale needed to conduct effective monitoring. An additional challenge can be the lack of uptake of the collected data by management agencies to inform the decision-making process (Cvitanovic and others, 2014; Addison and others, 2015).

The Contracting Parties to the Nairobi Convention have committed under Article 15 (on Scientific and Technical Cooperation) of the Amended Convention to cooperate in scientific research, monitoring and exchanging data and information concerning the Convention and its Protocols. Under Articles 17 and 23, it is stated that the Contracting Parties must prepare a national state of coast reports periodically. These national reports will form the basis of the regional State of Coast report to be produced every five years (Decision CP8/11: National and Regional State of Coast Reports). The Decision CP7/5: Strengthening National Reporting states that the Contracting Parties must agree to use a standard reporting template to report their progress implementing the Convention and its protocols.

The Contracting Parties and partners are currently implementing the Strategic Action Programmes (SAPs) developed by the predecessors of the SAPPHIRE (ASCLME/SWIOFP) and WIOSAP (WIO-LaB) Projects. Both projects identified the need to establish and implement a regional monitoring framework for critical habitats, coasts and shorelines in the WIO region, including inshore, offshore, and Areas Beyond National Jurisdiction (ABNJ), to assist them in addressing their regional and global conventions and commitments. Some international obligations include those under the 2030 Agenda for Sustainable Development and the Convention on Biological Diversity (CBD). The regional framework for ecosystem monitoring should be considered a guide to support Contracting Parties and the region to assess their efforts and progress in achieving them.

Advances – the state of the art

Ecosystem Monitoring Programmes (EMPs) should address priority issues in the region to provide data and information on the progress towards global and regional efforts. A regional coordinated monitoring programme addressing priority regional issues is currently not in place, highlighting a need to link and coordinate regional and national ecosystem monitoring through a pragmatic and agreed Regional Framework.

Coastal and ocean ecosystems of the WIO region face particular issues identified at the national and regional levels through the National Marine Ecosystem (MEDAs) and Transboundary Diagnostic Analyses (TDAs) undertaken by the ASCLME-SWIOFP and WIO-Lab projects. These issues directly impact the supporting, provisioning, regulating, and cultural services that are key to the region's socio-economic development and the Ocean's health. Due to the specificity of each Contracting Party, these transboundary priority issues do not have the same level of importance in each country. Thus some issues may or may not be incorporated into national EMPs if not relevant or of low priority. Regional priority issues that may not be relevant to the national level should still be incorporated into national activities to commit to regional monitoring.

While monitoring programmes are in place in most Contracting Parties, the coverage of the programmes and level of implementation differ among countries. Those parties with existing monitoring programmes do not support specific regional priority issues. This should be addressed through National Planning during the design and implementation of EMPs and/or when reviewing existing programmes. In other countries of the WIO, national monitoring of the ocean ecosystem's health is either under development or has not yet been incorporated into their national strategies

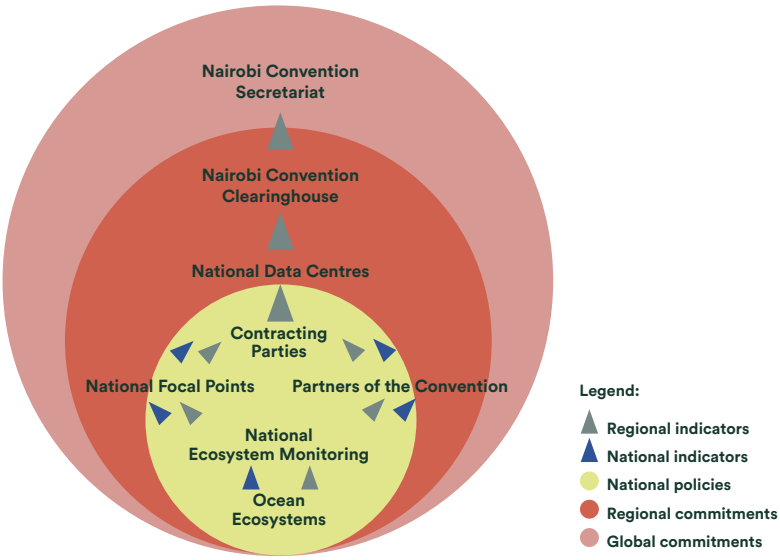

Figure 1. The flow of monitoring data obtained through national ecosystem monitoring programmes and their relationship with national policies, regional and global commitments.

and programmes. National EMPs should include the priority issues of the region in an attempt to provide data and information on the progress towards global and regional commitments, including those related to the Nairobi Convention.

Thirty regional priority indicators were selected in the regional framework and aligned with the issues and concerns identified in the Transboundary Diagnostic Analysis (TDA) of the Western Indian Ocean region. It is suggested that National Planning incorporates these regional issues and concerns during the design and implementation of EMPs and/or when reviewing existing monitoring programmes. Once agreed, the priority indicators will be used for reporting relevant data on the Ocean's ecosystem health and environmental management strategies. Reporting monitoring data will help to oversee gaps in scientific-based information on ecosystem indicators, identify challenges in the capacity for monitoring, help in decision-making, and advise regional initiatives and obligations.

It is proposed that monitoring data derived from national EMPs through the selected regional ecosystem indicators will be reported for regional monitoring. Compilation of monitoring data from national EMPs is imperative to estimate regional indicators required for regional, continental and global commitments on the conservation of biodiversity, sustainable blue economy and development accurately and objectively through national and regional investments. National Data Centres (under the direction of the respective National Data Coordinators) under the Nairobi Convention will be responsible for compiling and updating regionally-relevant monitoring data into the Nairobi Convention Clearing House Mechanism (CHM) on an annual or bi-annual basis. The Secretariat will assess and validate information received from the Contracting Parties and provide the necessary links to regional, continental and global monitoring processes. The relevant data derived from the national EMPs will be available in the CHM for consultation in decision-making processes and guiding regional initiatives.

Outlook for regional and global

The framework aims to provide a guideline on collecting and analysing relevant data to improve the reporting of information at the national and regional levels while ensuring that data production on relevant indicators is comparable across the region. It is also expected that the regional framework will assist Contracting Parties in the formulation and/or review and implementation of their national-level monitoring programmes. The regional framework is developed according to the 2030 Agenda and the Sustainable Development Goals (SDG) and the post-2020 Global Biodiversity Framework. It is also directly linked to Step 2 of the UN Decade of Ocean Science for Sustainable Development.

The framework is designed to guide the Nairobi Convention Contracting Parties on developing activities to support ecosystem monitoring at the national level. These activities will provide essential scientific information and knowledge to current regional and global commitments to keep their obligations and assist with decision making. The regional framework provides a standardised approach to support Contracting Parties in national planning and design and implement national EMPs through a standard methodology and guideline for the reporting and communicating relevant monitoring data at a regional level.

Suggested priority regional indicators were selected according to national, regional and global targets such as the Sustainable Development Goals, the draft post-2020 Global Biodiversity Framework, and its alignment with the aims of the Ocean Decade implementation plan and the Regional Seas Strategic Directive 2017–2020. Their relevance and link to the Transboundary Diagnostic Analysis under the ASCLME-SWIOF Projects.

Recommendations

The following actions for the implementation of this regional framework are proposed for consideration by the Contracting Parties:

Technical

The priority indicators suggested in this framework should be evaluated, discussed and approved by the Contracting Parties to standardise data gathering for the regional monitoring. Each Contracting Party should review the situational assessment and update it accordingly (ie, adding relevant information on ocean ecosystem monitoring).

National Data Coordinators (NDCs) from the National Data Centres of each Contracting Party should be nominated to oversee implementation. NDCs are responsible for conducting national self-assessments on the availability of information for the priority indicators; harmonising data collection methods, ensuring comparability nationally and regionally, facilitating data aggregation; and coordinating the development and implementation of regional indicators.

NDCs should designate Indicator Coordinators, who will evaluate the indicator data, oversee the progress and review the indicator monitoring for quality control and assurance.

The NDCs, Indicator Coordinator and Expert Groups should discuss the specific methodology and parameters to be collected for each of the priority indicators to ensure regional standardisation, continuous updating and evaluation of data.

Policy

After appraisal and suggested amendments, all Contracting Parties should approve and incorporate this framework in their national planning processes.

A capacity development programme is urgently required to support these recommendations. It will strengthen the capacity of National Data Centres to participate and contribute towards regional ecosystem monitoring requirements.

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