CHO Chapter 17

Seamounts and Ridges

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Zucchi, S., Ternon, J.-F., Demarcq, H., Ménard, F., Guduff, S. and Spadone, A. (2018). Oasis for marine life. State of knowledge on seamounts and hydrothermal vents. Gland, Switzerland: IUCN, vi + 50pp. https://doi.org/10.2305/IUCN.CH.2018.14.en-fr

~~Sabrina~~ Guduff, S., ~~Julien~~ Rochette, J., ~~François~~ Simard, F., ~~Aurélie~~ Spadone, A. and ~~Glen~~ Wright, G. (2018). Laying the foundations for management of a seamount beyond national jurisdictio~~oi~~n. A case study of the Walters Shoal in the South West Indian Ocean. Report. IDDRI.

Background

Oceans cover nearly 71~~%~~ per cent of the Earth's surface. With an average depth of almost 4~~,~~000 m~~etres~~, the oceans provide more than 90~~%~~ per cent of the habitable area for life on Earth. Beyond the continental shelves, 88~~%~~ per cent of the oceans are deeper than 1 km~~ilometre~~ and 76~~%~~ per cent have depths of 3~~,~~000–6~~,~~000 m (UNEP, 2006). The sea floor is reached at a depth of about 4~~,~~000 m and extends over the ocean basins at depths of 5~~,~~000 m on average. This is called the abyssal plain. The zone between the continental shelf and the abyssal plain is the bathyal zone. In some places, the sea floor drops again into elongated trenches with depths of 10–11 km. This region is the hadal zone. The ocean floor is interrupted by a mountain chain known as the mid-oceanic ridge system. Other features on the ocean floor are seamounts and hydrothermal vents (Kaiser, 2005).

Seamounts occur from the Equator to the Poles and are morphologically distinct elevations beneath the surface of the sea, rising relatively steeply from the seabed, but they do not emerge above the surface (Santos et al.~~and others~~, 2009~~,~~; Rogers, 2012). They are present throughout the world's ocean basins across a wide range of latitudes and depths (Fig.~~ure~~ 1) and form distinctive habitats in areas that would otherwise be dominated by sedimentary plains (Clark ~~and others~~et al., 2010). Most seamounts are of volcanic origin, although some, such as the Atlantis Bank in the South-West Indian Ocean, are formed by tectonic uplift or even from serpentine mud (Fryer, 1992). They are commonly conical in shape, with a circular, elliptical or more elongated base (Consalvey ~~and others~~et al., 2010).

Geologists have traditionally defined seamounts as topographic features with an elevation exceeding 1~~,~~000 m above the seabed. In most current definitions of seamounts, however, the restriction to a minimum height of 1~~,~~000 m seems to be based primarily on practical criteria since elevations of less than 1~~,~~000 m on the seafloor may enclose morphologic structures of diverse origins such as fault blocks or blocks within debris avalanche deposits (Menard, 1964;~~,~~ Schmidt and Schmincke, 2000). Smaller submarine knolls (with an elevation of 500–1~~,~~000 m) and hills (elevation of less than 500 m) also share many of the environmental characteristics of larger features and, given that the size distribution of such elevations are continuous, the term 'seamount' is used interchangeably for most features of more than 100 m in elevation (Wessel, 2007~~,~~; Staudigel and Clague, 2010).

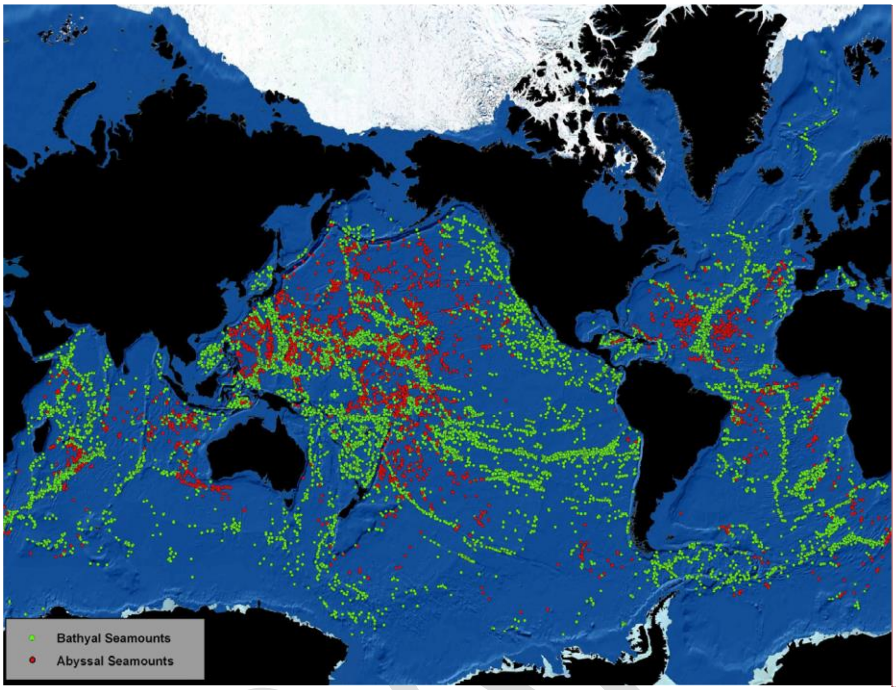

Figure 1: The distribution of seamounts predicted by Kitchingman and Lai (2004).

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Because seamounts do not break the sea's surface, knowledge of their distribution comes primarily from remote sensing. The abundance and distribution of seamounts at a global scale have been predicted many times, mostly based on satellite altimetry and ship-based sounding extrapolations (Costello ~~and others~~et al., 2010;~~,~~ Wessel et al.~~and others~~, 2010;~~,~~ Yesson ~~and others~~et al., 2011). At present, these approaches are unable to adequately detect small and deep peaks, and thus estimates of the global abundance of seamounts are still uncertain (Morato ~~and others~~et al., 2013).

Recent estimates (Wessel ~~and others~~et al., 2010; Kim and Wessel, 2011; Yesson ~~and others~~et al., 2011) of the number of seamounts in the world's underwater topography range approximately from 25 ~~,~~000 to 140 ~~,~~000 large features and potentially from 125 ~~,~~000 to 25 million small seamounts or knolls greater than 100 m in height. Despite this uncertainty and a general perception that seamounts are small, isolated spots scattered in remote areas, this habitat is one of the most extensive of all oceanic environments, ~~comprising~~encompassing an estimated area of about 28.8 million square kilometres (Etnoyer ~~and others~~et al., 2010).

The largest contiguous area of seamounts is found in the central portion of the Pacific Plate, where most studies have been conducted (Gubbay, 2003), with lower numbers in the Indian, Atlantic, Arctic and Southern Oceans (Wessel, 2007). The Indian Ocean has a surface area of ~~74 by 106 square~~ 70.5 million km^2 and is characteri~~z~~sed by a system of three active spreading mid-oceanic ridges (MOR): the Central Indian Ridge (CIR), the South-West Indian Ridge (SWIR) and the South-East Indian Ridge (SEIR) (Das ~~and others~~et al., 2005).

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The South-West Indian Ocean region corresponds to the western Indian marine ecoregion which includes an island, Madagascar, and several ~~islet~~ archipelagos such as Comoros, Mascarenes and Seychelles, each with different origins and ages (Spalding ~~and others~~et al., 2007). The continental land mass of Africa, the micro-continent Madagascar and the North Seychelles Bank are fragments of the supercontinent Gondwana, dating from pre-Cambrian times, more than 650 million years ago (mya) and which started to break up 180 mya (Peng and Mahoney, 1995).

The SWIR is a slowly spreading ridge system separating the African, Australian and Antarctic tectonic plates and has a unique geological structure. It extends from north-east to south-west in the west of the Indian Ocean basin, extending over 1~~,~~800 km and varies from 300 to 450 km in width (Romanov, 2003).

Compared with the East Pacific Rise and Mid-Atlantic Ridge, the region of the SWIO has been less studied. Recently, the SWIR's ultra-slow and oblique spreading characteristics have attracted increasing international attention (Dick ~~and others~~et al., 2003) and revealed that, rather than being formed of volcanic rock, parts of the ridge comprise large areas where mantle has been extruded onto the seafloor (Rogers and Taylor, 2012). Oceanographically, the SWIR is influenced by several fronts with the combined effect of the retroflection of the Agulhas Current (Lutjeharms, 2007) and the Subantarctic Front creating one of the most productive areas in the ocean (Read ~~and others~~et al., 2000). It is also known that the SWIO area is characteriz~~s~~ed by substantial sea surface temperature (SST) variations (Annamalai and Murtugudde, 2004).

The Madagascar Ridge consists of a massive elevation of the seafloor, extending between the micro-continent of Madagascar and the SWIR for a distance of almost 1,130 km. The ridge crest is wide and has depths ranging from 1,000 to 2,500 m (at the positions of seamounts up to 567 m). The minimum depth falls on the Walters Shoal to less than 20 m. The shoal was discovered in 1963 by the South African Hydrographic Frigate *SAS Natal* and named after its captain.

To date, more studies have been undertaken on the Walters Shoal than other seamounts, probably because it is closer to land than other areas and because of commercial fisheries interests in the region. The shoal was sampled during the 1964 Indian Ocean expedition by the research vessel *Anton Bruun* and subsequently by the *Vityaz* (Rogers, 2012). This report refers to Rogers (2012) and Rogers and Taylor (2012) for a complete list of Walters Shoal endemic species. Additionally, the research article published by Vereshchaka (1995) lists a large number of taxa as occurring on the Walters Shoal and summariz~~s~~ed several investigations on the macroplankton occurring on slopes and seamounts in the Indian Ocean.

Walters Shoal is a group of seamounts located near the southern end of the Madagascar Ridge and consists of a large number of knolls, seamounts and ridges (Fig~~ure~~. 2). It is distinctive because the shallow areas of the seamount reach 18 m below the surface and it is characteriz~~s~~ed by high biodiversity.

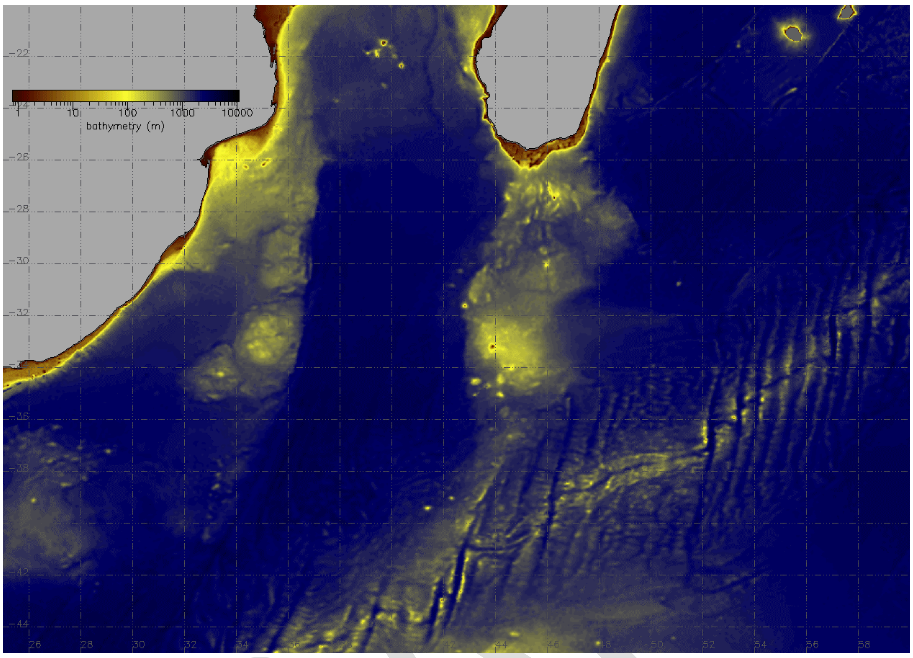

Figure 2: The Walters Shoal is located on the Madagascar Ridge, ~~450~~ 833 km~~nautical miles (nm)~~ south of Madagascar and ~~700nm~~ 1296 km east of South Africa. Bathymetry in metres (one min of arc MOA resolution). Log scale for depth. Copyright IRD Sète, Hervé Demarcq. ETOPO1

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~~Seamounts, underwater mountains of volcanic and tectonic origin, are considered hotpots of biodiversity (Postaire and others, 2014) and attract a range of oceanic predators, including seabirds, whales and sharks. They also attract deep-water fisheries, as they host many species of commercial interest, most of which are very vulnerable to over-exploitation.~~

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Importance

Seamounts, underwater mountains of volcanic and tectonic origin, are recognized as significant habitats for a wide diversity of species (Clark et al., 2012) and considered hotpots of biodiversity (Postaire et al., 2014), attracting a range of oceanic predators, including seabirds, whales and sharks. ~~Seamounts have been recognized as significant habitats for a wide diversity of species (Clark and others, 2012)~~They also attract deep-water fisheries, as they host many species of commercial interest, and are subject to human exploitation (Rowden ~~and others~~et al., 2010). Most of the deep-water species are very vulnerable to over-exploitation. Despite an increase in research on the ecology and biogeography of seamounts and oceanic islands~~ ecology and biogeography,~~ however, many basic aspects of their biodiversity are still unknown.

As described by Rogers (1994, 2004, 2012;~~,~~ Rogers ~~and others~~et al., 2007), the dominant large fauna of hard substrate on many deep-sea seamounts are attached, sessile organisms~~-~~ that feed on particles of food suspended in the water (Fig.~~ure~~ 3). Also, pelagic species of fishes, sharks, squid~~s~~ and whales tend to aggregate over shallow seamounts because of the Taylor columns that form over them. Taylor columns are gently rotating water eddies that can aggregate food resources (small fishes, larvae and plankton), due to down-welling currents around the seamounts. The predominant seamount's phylum is Cnidaria, which includes black, stony and gorgonian corals, sea pens and anemones, and hydroids (Consalvey ~~and others~~et al., 2010).

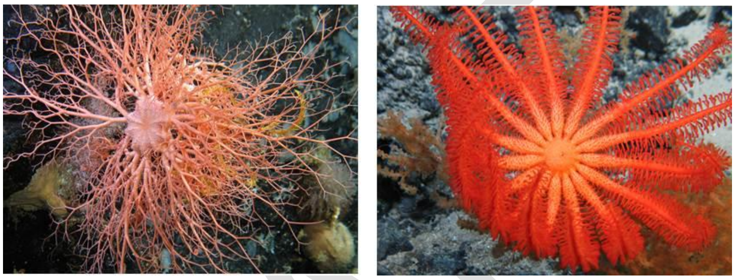

Figure 3: Examples of sessile fauna living on seamounts of the South-West Indian Ridge: left, a Basket star (*Gorgonocephalus* sp, Echinodermata) and right, Brisingid sea star~~s~~ (Order Brisingida, Echinodermata. Copyright NERC/IUCN.

As biodiversity hotspots, s~~S~~eamounts ~~have often been regarded as biodiversity hotspots as~~ they have high endemism relative to other habitats (Richer ~~and others~~et al., 2000;~~,~~ Morato and Clark 2007;~~,~~ Rogers, 2004, 2012). Understanding of global seamount biodiversity, however, is still poor, as fewer than 300 seamounts have been properly studied (Consalvey ~~and others~~et al., 2010), ~~in order to~~ which is not enough to allow a reliable descri*tion*~~be reliably~~ of the benthic community~~the assemblage composition of seabed organisms~~. Furthermore, sampling has been biased towards larger fauna such as fishes, crustaceans and corals (Stocks, 2009).

Limited biological surveys of seamounts are a problem for assessing accurate levels of species richness and endemism (Stocks and Hart, 2007) and therefore conservation measures. In addition, the hypothesis of high endemism has been questioned in recent years (Rowden ~~and others~~et al., 2010). As a result, seamount data are very sparse and the 'oasis hypothesis' (Samadi ~~and others~~et al., 2006), related to biomass, remains quantitatively untested (Rowden ~~and others~~et al., 2010).

At the macro-ecological scale, the fauna of individual seamounts ha*s*~~ve~~ been found to reflect the species groups present on neighbouring seamounts and continental margins (Samadi ~~and others~~et al., 2006~~,~~; Stocks and Hart, 2007~~,~~; McClain ~~and others~~et al., 2009~~,~~; Brewin ~~and others~~et al., 2009~~,~~; Clark ~~and others~~et al., 2010). Even ~~if~~ where dominant evidence suggests that the broad assemblage composition may ~~be similar to~~resemble the surrounding deep-sea environments, community structure may differ between these habitats (Consalvey ~~and others~~et al., 2010).

Rogers (2012) described in detail seamount habitats and associated communities, and the different hypotheses by which seamounts are locations of enhanced trophic input and determinant of community composition. However, to date, understanding of seamount ecosystems is hindered by significant gaps in global sampling, diverse analytical and scientific approaches, and sampling methods, as well as a lack of large-scale data synthesis and sharing.

Overall, the seamount ecosystem ~~biota~~ can host abundant and diverse benthic and pelagic communities. As previously stated, however, several studies have demonstrated that in many instances community composition might be similar to that ~~in~~ of adjacent habitats including continental slopes. In general, acquisition of knowledge about seamount ecosystems and their associated resources is still ongoing.

Threats

Since the second half of the 20th century, seamounts have faced two emerging threats: the exploitation of fishery resources and the potential for seabed mining (FFEM, 2013).

Fishing

The depletion of biological resources is one of the major risks associated with the fishing trade that the targeted ecosystems are facing. In only a short time, these areas can be strongly impacted by the pressure of fisheries activity. The target species are often of low global abundance and their aggregation on seamounts at certain stages of their life (e.g. reproduction) makes them particularly vulnerable. The isolation of seamounts also makes the evolutionary and ecological mechanisms of these ecosystems substantially different from those in the surrounding waters. Due to limited exchanges with communities of other seamounts or coastal communities, it would take decades to rebuild numbers in the event of weakening stocks (Simard and Spadone, 2012).

Habitat degradation and its effects on associated communities, through ~~a~~ the mechanical impact on ecosystem structure, is another of the bottom fisheries related threats. The resuspension of sediments is also an indirect consequence of this type of fishing (bottom trawling), combined with the lack of selectivity of catches. Trawl by-catch can include a broad range of benthic invertebrates, fish and seabirds, including sensitive or vulnerable species. The repercussions on these ecosystems could be observed particularly in terms of predator-prey relationships. The threat to ghost fishing gear, which continues to "fish" once lost or discarded, is thought to be low on seamounts, but is also a potential threat (Simard and Spadone, 2012).

There are an estimated 268 seamounts in this part of the Indian Ocean at "fishing depth", i.e. summit areas shallower than 2000 m. FAO reported in 2009 that the SWIO was experiencing

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a significant increase in catches, ~~. H~~however, fishing statistics in the regional are underdeveloped, with limited accessibility (Kimani ~~and others~~et al., 2009). Fishery research programmes and fishing companies have provided the most detailed biological data and bathymetric maps of the region (FAO, 2002~~,~~; Romanov, 2003~~,~~; Shotton, 2006). Only syntheses of such data are publicly available and there is no compilation on species distribution. Data obtained from research on longline and commercial fisheries are generally not published (Tracey ~~and others~~et al., 2011).

Nevertheless, almost 40 years of fishing mark the history of SWIO seamounts (Zucchi ~~and others~~et al., 2018). Industry and research for Soviet fishery resources began experimental fishing in the 1970s on the Southwest Indian Ridge (SWIR), Mozambique Ridge and Madagascar Ridge, while bottom trawling started in 1980s (Romanov, 2003~~,~~; Clark ~~and others~~et al. 2007). The French fleet also conducted experimental trawl fisheries over the same period, on the Madagascar Ridge and SWIR, and in particular on the Walters Shoal and Sapmer Bank (Collette and Paring, 1991). As previously described by Rogers et al. (2009), fisheries activities in the SWIO targeted redbait (*Emmelichthys nitidus*) and rubyfish (*Plagiogeneion rubiginosus*) with catches peaking in about 1980 and then decreasing to the mid-1980s (Clark et al., 2007). Later, fishing switched to alfonsino (*Beryx splendens*) in the 1990s as new seamounts were exploited. In 1990, new seamounts were being exploited, and the longline fleet was developing on the SWIR. While in the late 1990s, a new fishery developed on SWIR with trawlers targeting deep-water species such as orange roughy (*Hoplostethus atlanticus*), black cardinal fish (*Epigonus telescopus*), southern boarfish (*Pseudopentaceros richardsoni*), oreo (Oreosomatidae) and alfonsino (Clark et al., 2007). More recently, longliners ~~on~~ from Réunion have developed the tuna fishery in southern Madagascar, with a major effort devoted to this type of fishing in the SWIO region (Zucchi ~~and others~~et al., 2018).

Species mainly targeted by these fisheries have a low reproductive rate and gather at seamounts during breeding season. They are therefore particularly exposed and vulnerable (of low resilience) to overexploitation. Target species include orange roughy~~–~~ (*Hoplostethus atlanticus*), cardinal fish~~–~~ (*Epigonus telescopus*), pelagic armourhead~~–~~ (*Pseudopentaceros richardsoni*), oreo ~~–~~(Oreosomatidae) and alfonsino ~~–~~(*Beryx splendens*) (Clark ~~and others~~et al., 2007).

The Walters Shoal, ~~which~~ an ~~lies beyond national jurisdiction~~ABNJ, is considered in particular to be a productive fishing ground (Zucchi ~~and others~~et al., 2018). It is a known fishing ground for demersal species (Romanov~~,~~ ~~2003,~~2003; Bach ~~and others~~et al., 2011), and it has also been targeted for deep-sea lobster fishing, including the famous *Palinurus barbarae* (Rogers and Gianni, 2011~~,~~; Bensch ~~and others~~et al., 2008), and recreational fishing. The potential productivity of green prawns (*Palinurus delagoa*) in this area was estimated at 1000 t per year (Andrianaivojaona et al., 1992; Gopal et al., 2006). Exploitation of these stocks, as well as new targets such as the spiny lobster (*Palinurus barbarae*) recently discovered on the Walters Shoal (Groeneveld et al., 2006), continues (Bensch et al., 2008).

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Mining

Mining exploration activities have been conducted since the 1970s-1980s (mainly in the Clarion-Clipperton zone, in the Pacific O~~o~~cean) (Cuyvers ~~and others~~et al., 2018). ~~As~~ T~~t~~he number of metals exploited worldwide has tripled since the 1970s to meet industrial needs ~~and~~ with resources on land ~~are~~ becoming scarce, thus there is increasing interest in exploiting the deep seabed.

The concentration of metals in the marine environment is found in three forms: polymetallic nodules o~~i~~n the abyssal plains; crusts on seamounts; and hydrothermal sulphides along the ridges. Currently, engineering for the extraction of polymetallic crusts located on seamounts is the least developed. Despite the economic interest and the shallowness of the crusts (above 2500 m), extraction processes are still technically complex for this resource (Hein ~~and others~~et al., 2009, in Cuyvers ~~and others~~et al., 2018). However, extraction processes will likely cause destruction of habitat and associated fauna. They may also generate fine particles rich in toxic metals, which can be transported by bottom currents to the pelagic and suspension feeder fauna (FFEM, 2013). Potential threats from mining also include the following: noise pollution from extraction techniques (air guns, sonar, machines, drilling); pollution from sludge and drilling piles that may be contaminated by oil, chemicals and drilling fluids; and oil and gas leaks and spills (Simard and Spadone, 2012).

To date, the International Seabed Authority (ISA) has granted 28 contracts for exploration of seabed minerals in ABNJ~~beyond national jurisdiction~~, representing more than 1.2 million ~~s~~km^2~~quare kilometres~~ of seabed. Five contracts, for the exploration of two types of mineral, have been awarded ~~for exploration~~ in the Indian Ocean:

- Polymetallic nodules~~:~~

  1. Location: Central Indian Ocean Basin – Contractor: Government of India

- Polymetallic sulphides~~:~~

  2. Location: Central Indian Ocean (Mid-~~-~~Indian Ridge and SWIR~~outh West Indian Ridge~~) – Contractor: Government of India

  3. Location: Central Indian Ocean (Mid-Indian Ridge) – Contractor: Federal Institute for Geosciences and Natural Resources of the Federal Republic of Germany

  4. Location: Mid-~~-~~Indian Ridge Contractor ~~:~~ – Government of the Republic of Korea

  5. Location: ~~South West Indian Ridge~~SWIR – Contractor: China Ocean Mineral Resources Research and Development Association (COMRA)

While the number of exploration contracts granted has been increasing in recent years, exploitation is yet to begin.

In addition to these deep-sea mining and fisheries-related threats, seamounts are subject to direct or indirect impacts from other human activities, such as:

- Accidental and/or deliberate (operational) discharges from vessels
- Anchoring
- Collisions (ship strikes) with, ~~e.g.,~~for example marine mammals, sharks and~~,~~ turtles
- Grounding and shipwreck
- Invasive alien species (IAS~~s~~)

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- Noise

Seamount ecosystems could be also impacted by activities for which the ship serves primarily as a platform, such as:

- Archaeology
- Artificial islands and fixed/floating installations
- Bioprospecting
- Dumping
- Marine mining for oil and gas
- Marine scientific research
- Military activities
- Ocean-based climate-change mitigation
- Piracy/criminal activities
- Recreation
- Salvage
- Undersea cable- and pipeline-laying

Finally, there are threats from activities not involving ships, such as:

- Anthropogenic climate change
- Land-based activities
- Marine debris or litter
- Overflight
- Radionucleeides

Seamount ecosystems are particularly fragile and vulnerable to anthropogenic threats and hence their ecosystem structure is likely to have or be vulberable to tipping points. Any additional or new activity, or the intensification of an ongoing activity, could become trigger athe tipping points, leading for to the collapse of a seamount ecosystem.

Status / Level of threat

The SWIO region hosts an extraordinary proportion of endemic species and is highly threatened by human activities, hence its classification as a marine biodiversity hotspot (Roberts and otherset al., 2002, ; Bellard and otherset al., 2013, ; Gopal and otherset al., 2006). Seamounts in the SWIO have been exploited for nearly 40 years. The Soviet fleet, and associated research institutions, began exploratory fishing in the SWIR, the Mozambique Ridge and the Madagascar Ridge in the 1970s with commercial trawling beginning in the early 1980s (Romanov 2003, Clark and others, 2007). As previously described by Rogers and collaborators (2009), fisheries activities in the SWIO targeted redbait (*Emmelichthys nitidus*) and rubyfish (*Plagiogeneion rubiginosus*) with catches peaking in about 1980 and then decreasing to the mid-1980s (Clark and others, 2007). Afterwards, fishing switched to alfonsino (*Beryx splendens*) in the 1990s as new seamounts were exploited. Some exploratory trawling was also carried out on the Madagascar Ridge and the SWIR by French vessels in the 1970s and 1980s, particularly targeting the Walters Shoal and Sapmer Bank (Collette and Paring 1991). In the late 1990s, a new fishery developed on SWIR with trawlers targeting deep-water species such as orange roughy (*Hoplostethus atlanticus*), black cardinal fish

(*Epigonus telescopus*), southern boarfish (*Pseudopentaceros richardsoni*), oreo (Oreosomatidae) and alfonsino (Clark and others, 2007). It is known that the reproduction rate for these species is generally low and they form breeding aggregations on seamounts, making them particularly susceptible to overexploitation (Koslow and otherset al., 2000). In particular, the orange roughy is described as having a low resilience and high vulnerability to fishing (Branch, 2001). In the late 1980s, an estimated annual catch of more than 10 ,000 tonnes led to the subsequent rapid collapse of the population.

The Walters Shoal has been targeted by deep-sea lobster fishing (*Palinurus barbarae* and *Palinurus delagoa*) (Rogers and Gianni 2010). The potential productivity of green prawns (*Palinurus delagoa*) in this area was estimated at 1,000 tonnes per year (Andrianaivojaona and others, 1992, Gopal and others, 2006). Exploitation of these stocks, as well as new targets such as the spiny lobster (*Palinurus barbarae*) recently discovered on the Walters Shoal (Groeneveld and others, 2006), continues (Bensch and others, 2008). In 2006, some playersparticipants in the fishing industry (bottom trawlers) voluntarily closed a small portion of the bank Walters Shoal for conservation purposes (Coyle and otherset al., 2007).

Seamounts and hydrothermal vent ecosystemss display common features. Both ecosystem types:

- are considered 'hotspots' of species biodiversity;
- are already under potential threat from intensive commercial exploitation (such as mining, fishing, pharmaceutical) (UNEP, 2006, ; UNCLOS, 1982);
- could be proposed as Marine Protected Areas (MPAs), Ecologically or Biologically Significant Marine Areas (EBSAs) or Areas of Particular Environmental Interest (APEIs); and
- need a higher and targeted level of protection in particular for vulnerable and unique associated species.

In this respect, considerably more exploration and investigation, (that follow responsible research activitiespractices for new sites at key locations; (see the six recommendations described promoted in Devey and otherset al. (2007)) of new sites at key locations are essential to fill in important gaps in the understanding of biogeographical, ecological, geological, evolutionary and genetic puzzleenigmas associated with of hydrothermal vents and seamounts. Only then will it be possible , in order to advise the public and policy makers on how best to preserve these ecosystems and their outstanding beauty and uniqueness for future generations.

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Existing protection

Three Regional Fisheries Bodies (RFBs) ~~fisheries bodies~~ operate in the WIO region, each with different mandates and competences:

- The Indian Ocean Tuna Commission (IOTC)~~, which ~~P~~p~~romotes cooperation with the aim of ensuring management, conservation, and optimum utilisation of stocks of tuna and tuna-like species in the Indian Ocean. The IOTC covers both national waters and ABNJ of the Indian Ocean.

- The South Indian Ocean Fisheries Agreement (SIOFA).~~, which~~ A~~a~~ims to ensure the long-term conservation and sustainable use of fishery resources in ABNJ of the Indian Ocean through cooperation among the Contracting Parties. SIOFA only covers waters beyond national jurisdiction.

- The Southwest Indian Ocean Fisheries Commission (SWIOFC)~~,~~ A~~a~~n advisory fisheries body that promotes sustainable utilisation of the living marine resources of the SWIO region. SWIOFC only covers waters under national jurisdiction.

In addition to these ~~Regional Fisheries Bodies (~~RFBs~~) operating in the SWIO~~, it is also worth noting that two additional management bodies have mandates covering ~~the~~ adjacent waters (Fig.~~ure~~ 4). The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) aims to conserve Antarctic marine life and takes an ecosystem-based approach to managing the area. The South East Atlantic Fisheries Organisation (SEAFO) aims to ensure the long-term conservation and sustainable use of living marine resources and safeguard the environment and marine ecosystems in the South East Atlantic Ocean.

There may be value in increasing cooperation and information exchange between these bodies in order to better understand connectivity and provide further support for the development of appropriate management actions.

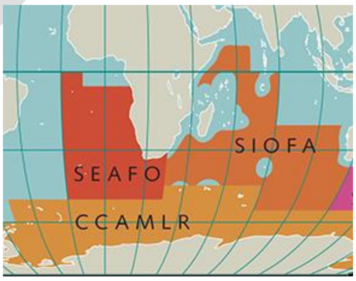

Figure 4: Areas of competence of RFMOs in the SWIO and adjacent waters. Extracted from World Ocean Review.

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Complementary to these RFBs, the operators of the vessels conducting deep-sea fishing in the region established the Southern Indian Ocean Deep Sea Fishers Association (SIODFA) in 2006. This industry association aims to promote responsible management of the deep-water fishery while conserving biodiversity, especially the deep-water benthos.

Progress has been made in the sSouthern Indian Ocean towards better protection of biodiversity in the high seas. Iin Phuket, Thailand, on the week of 25-29 June 2018, -tThe Southern Indian Ocean Fisheries Agreement (SIOFA) has declared five new Protected Areas in the high seas at its 5th -Meeting of the Parties (MoP5). These closures, defined as benthic protected areas (BPAs) apply only to bottom trawling and do not cover other fishing gear such as bottom long lining and trap fisheries which, nevertheless, will have the obligation to have observers on board 100% per cent of the time, if fishing in the designated areas.

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The protected sites are: Atlantis Bank, Coral, Fool's Flat, Middle of What and Walters Shoal, all of them being important features of the ocean floor for biodiversity - such as banks or seamounts - and covering an area of over 25,000 square kilometreskm^2.

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Priority options for conservation

Possible options for the conservation and management of the Walters Shoal are given here as an example of what could be the foundations for management of a seamount in the WIO.

Several options are possible to conserve and manage the Walters Shoalseamount, from the adoption of sectoral measures aimed at limiting impacts from certain maritime activities to the establishment of an MPA. This section studies and assesses the opportunitiesy and feasibility of such measures.

Limiting impacts from maritime activities

Fishing

IOTC fisheries closures

There are currently few operational examples of fisheries closures for highly migratory pelagic species, though in recent years interest has been growing in understanding and developing such measures (Game and otherset al., 2009,; Harley and Suter, 2007,; Hyrenbach and otherset al., 2000,; Kaplan and others,et al. 2010,; Kaplan and otherset al., 2014,; Maxwell and Morgan 2012,; Torres-Irineo and otherset al., 2011,; Young and otherset al., 2015). Pelagic ecosystems are generally characterized by high levels of species mobility, large spatial scales, and limited scientific knowledge, such that existing practice in relation to fisheries closures and MPAs cannot necessarily be applied directly to this context. Some have called for development of pelagic MPAs (Game et al.and others, 2009,; Robison, 2009;, Maxwell and otherset al., 2014; Young and otherset al., 2015), noting that "recent advances across conservation, oceanography and fisheries science provide the evidence, tools and information to address these criticisms and confirm MPAs as defensible and feasible instruments for pelagic conservation” (Game ~~and others~~et al., 2009). However, few scientific studies have so far accurately determined if such measures are effective (Kaplan ~~and others~~et al., 2014) and no consensus exists as yet on effectiveness and good practice. ~~:~~ S~~s~~ome commentators have tentatively noted the success of certain measures (Kaplan ~~and others,~~et al. 2014~~,~~; Torres-Irineo ~~and others~~et al., 2011), but others have argued that the benefits of closures and area-based measures decrease significantly for mobile species (Grüss ~~and others~~et al., 2011~~,~~; Le Quesne and Codling, 2008~~,~~; Moffitt ~~and others~~et al., 2009).

In any case, scientists currently consider tuna fisheries to have little to no impact on the Walters Shoal ecosystems. As illustrated by Fig.~~ure~~ 5, longline fisheries are distant from the Walters Shoal and there are no purse seine tuna fisheries s~~S~~outh from 15 S,[1] ~~i.e.~~consequently all purse seine fisheries are well outside the Walters Shoal area.

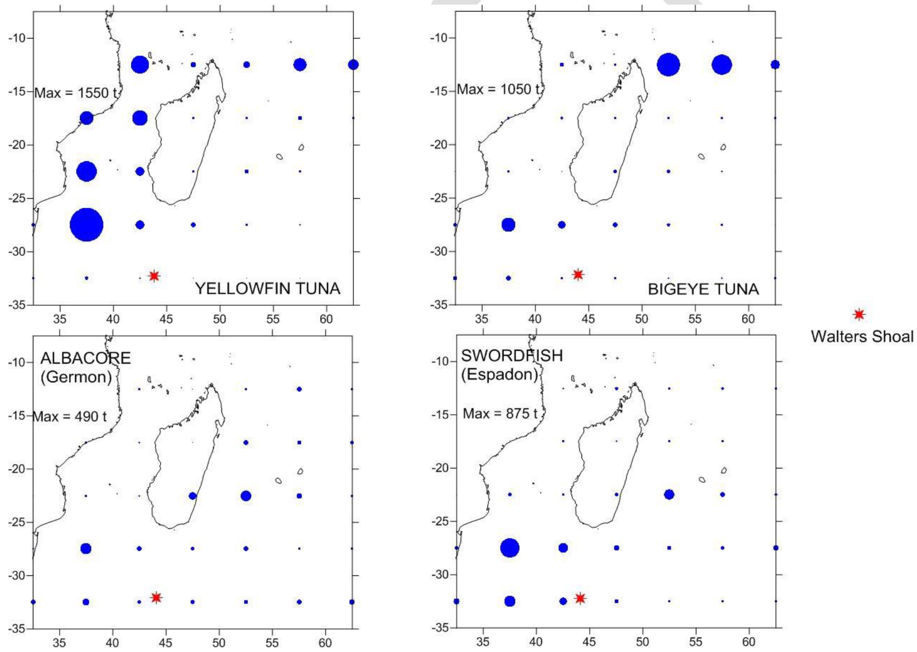

Figure 5. Main areas of longlines fisheries in the Western Indian Ocean. Extracted from F. Marsac, SARDARA database (IRD).

Against this background, it does not seem appropriate to propose an IOTC fisheries closure in the Walters Shoal area.

[1] Except in the Mozambique Channel.

SIOFA Fisheries closures

In contrast to pelagic ecosystems, benthic ecosystems are well suited to area-based management tools (ABMTs), including fisheries closures. Bottom fishing has been reported in the Walters Shoal area (FAO, 2010), thus it would be relevant to consider whether the area contains vulnerable marine ecosystems (VMEs) that should be closed to fishing or whether other management measures might be appropriate.

Although the BPAs currently in place will remain in force for the members of SIODFA, it is clear that Parties to SIOFA are also obliged to take certain measures: the UNFSA makes it clear that RFMOs are the primary vehicle for collaboration on fisheries management and UNGA resolutions require closures and other measures for the protection of VMEs.

As highlighted above, no fisheries closures have been adopted by SIOFA so far. Pressure on SIOFA to take such measures as soon as possible is however mounting. At the ~~second~~ 2nd SIOFA meeting, SIODFA submitted an "Expression of Concern" ~~at~~ over the failure to adopt measures, and the Deep Sea Conservation Coalition (DSCC) ~~argued~~highlighted that:

The draft measure CMM 14.02 for the protection of VMEs circulated last year falls far short of the commitments to protect VMEs that States Parties to SIOFA have repeatedly made through the UNGA resolutions over the past 11 years. A new measure or measures for the protection of VMEs should be drafted, adopted and implemented on an urgent basis.[2]

One relatively simple route for the adoption of VME closures within the SIOFA framework would be to study the feasibility of converting the SIODFA's BPAs – which include the Walters Shoal – into formal VME closures. Such a proposal was tabled at the ~~third~~ 3rd (La Réunion, France, 3-8 July 2016) and ~~fourth~~ 4th (Mauritius, 26-30 June 2017) meetings of the SIOFA. This proposal was supported by the majority of parties and civil society, but was ultimately not passed due to the objections of France and South Korea, which highlighted the lack of scientific data reviewed by the SIOFA Scientific Committee. France, representing its Territories in the region, also argued that the closure should apply to bottom trawling but not to other fishing gears, such as bottom longlining. This position is supported by a French legal provision that aims to expand the fishing fleet in the SIOFA area, including in several areas currently covered by the SIODFA BPAs.[3] In turn, s~~S~~tates that practice bottom trawling have rejected this counter-proposal. There is also ongoing debate amongst the SIOFA member s~~S~~tates regarding the procedure for defining fisheries footprints.

If the transformation of the whole set of BPAs into formal RFMO fisheries closures is not politically viable, an alternative option could be to discuss proposals for each area separately.

Unilateral national initiatives

[2] Ibid.

[3] Arrêté du 6 février 2017 transposant la recommandation CMM 2016/01 de l'Accord relatif aux pêches dans le Sud de l'océan Indien NOR : DEVM1625024A.

Commented [M10]: Strange that this management measure is only introduced here and not earlier. I have introduced the term at the end of the "Existing Protection" section. Hope that's correct, but needs confirmation.

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Flag s~~S~~tates retain the right to regulate their vessels even where the relevant RFMO has not adopted measures, and nothing prevents one or several s~~S~~tates from unilaterally declaring that they will prohibit or restrict fishing in the Walters Shoal area by vessels flying their flag. There is some precedent for a unilateral national initiative to prohibit or restrict fishing in ABNJ.

In the Southwest Atlantic, Spain, the only s~~S~~tate known to conduct significant bottom fishing activities, published a list of authoriz~~s~~ed vessels[4] and, in the absence of a RFMO for the region, unilaterally declared nine areas closed to bottom fishing by its vessels in July 2011 (pursuant to a European Union (EU) regulation that implemented the UNGA resolutions).[5] Between 2007-2009, Spain's Oceanographic Institute (Instituto Español de Oceanografía; IEO) conducted a series of 11 multidisciplinary research cruises with the aim of identifying VMEs in the region and making a preliminary assessment of how fishing activity was affecting these areas (Portela ~~and others~~et al., 2010). The research found that, overall, the particular fisheries in question only had a small adverse impact on VMEs in the region, but nonetheless identified nine areas that should be closed to bottom trawling to prevent significant adverse impacts. Beginning in July 2011, these areas were closed for bottom fishing for a period of six months (Gianni ~~and others~~et al., 2011). Spain also restricted its bottom fishing footprint to two areas already fished for 25 years.[6]

In New Zealand, the Government worked in consultation with industry, environmental NGOs and government departments to implement closures in its footprint area in advance of measures being formally taken by the competent RFMO for the region (the South Pacific RFMO - SPRFMO).[7] Lightly trawled areas were closed to bottom fishing, moderately trawled areas were opened subject to application of a move-on rule, and heavily trawled blocks generally remained open to bottom fishing.[8] Although these closures no doubt represent an improvement on a business-as-usual scenario, Penney and Guinotte (2013) conducted a detailed analysis of the New Zealand closures, concluding that the existing sites are "sub-optimal for protecting likely coral VMEs" (Penney and Guinotte, 2013) and Penney ~~and others~~et al. (2009) concluded that "effective protection of benthic VMEs in the Pacific Ocean high seas will probably require the establishment of a series of international spatial closures designed to protect adequate and representative areas of habitats and ecosystems" (Penney ~~and others~~et al., 2009).

[4] 45 FAO 'Deep-Sea High Seas Fisheries: Vessels Authorized to Conduct Bottom Fisheries in Areas beyond National Jurisdiction (UNGA 61/105, Paragraph 87)', available at ftp://ftp.fao.org/Fi/DOCUMENT/UNGA/deep_sea/UNGA61_105.pdf (accessed 25 February 2017).

[5] Council Regulation (EC) No 734/2008 of 15 July 2008 on the Protection of Vulnerable Marine Ecosystems in the High Seas from the Adverse Impacts of Bottom Fishing Gears 2008 8, preamble 2. It was envisaged that this regulation would mainly apply to the South West Atlantic (and to the SIO, as no RFMO was in the region at that time). European Union Report on the Implementation of Measures Pertaining to the Protection of Vulnerable Marine Ecosystems from the Impact of Bottom Fishing on the High Seas in UNGA Resolution 61/105 of 2006 and UNGA Resolution 64/72 of 2010 (2010)

[6] European Union, 'EU Report on the Implementation of Measures Pertaining to the Protection of Vulnerable Marine Ecosystems from the Impact of Bottom Fishing on the High Seas in UNGA Resolution 61/105 of 2006 and UNGA Resolution 64/72of 2010' (2010) at p. 6, available at https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/20110520_report_en.pdf (accessed 25 February 2017).

[7] New Zealand Government, 'Report on New Zealand's Implementation of Operative Paragraphs 80 and 83-90 of Resolution 61/105' at pp. 7–12, available at http://www.un.org/depts/los/general_assembly/contributions_fisheries/new_zealand.pdf (accessed 25 February 2017).

[8] Ibid. at p. 8. Additional precautionary closures of representative blocks in the moderately and heavily trawled areas may be implemented and further blocks may be closed in any area found to contain significant evidence of VMEs.

Shipping

The designation of a sea area as a Particularly Sensitive Sea Area (PSSA) is made by a non-legally binding resolution from the International Maritime Organization (IMO) Marine Environment Protection Committee (MEPC). This resolution is then given effect by the adoption of "associated protective measures" (APMs).[9] It seems that there is no specific threat to the systems; pilotage schemes; and vessel traffic management systems. The IMO may also pursue the development and adoption of other measures, provided they have an identified legal basis.

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Walters Shoal from shipping activity. As illustrated in Fig. 6, major shipping routes do not pass through the Walters Shoal area, therefore. tThe establishment of a PSSA and APMs do not therefore seem particularly relevant.

[9] These can include: pollution control measures, such as the designation of Special Areas under Annexes I-V of the MARPOL Convention, where discharges from ships are more strictly controlled or prohibited; declaration of the proposed PSSA as an "area to be avoided" by ships; navigation measures, such as ship routeing and reporting

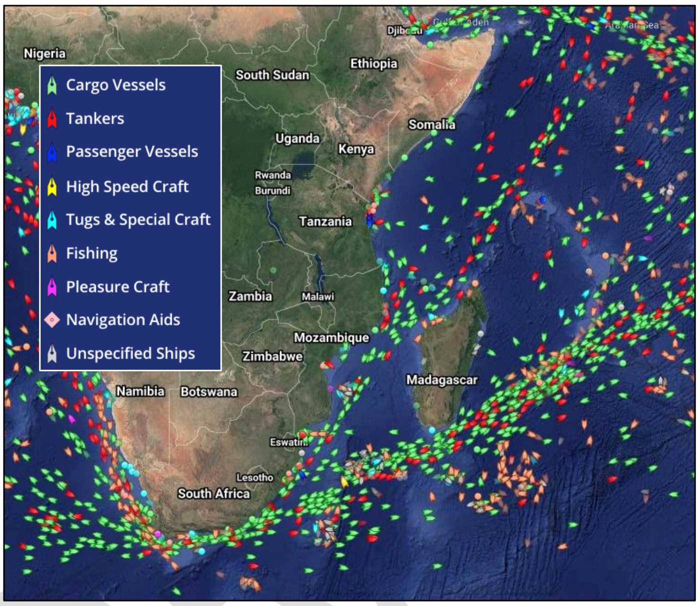

Figure 6. Shipping traffic in the Western Indian Ocean (Source: https://www.marinetraffic.com, accessed 1 September 2020).

Mining

In 2012, as part of its Environmental Management Plan for the Clarion-Clipperton Zone,[10] the ISA designated nine ~~Areas of Particular Environmental Interest (~~APEIs~~)~~ to the marine environment in the Area~~.~~[11] where n~~N~~o mining is permitted~~ in these areas~~. These designations were made in advance of contractor-designated “i~~I~~mpact reference zones” and “preservation reference zones”.[12] At the same time, the ISA Regulations on prospecting and exploration for polymetallic nodules, polymetallic sulphides, and ferromanganese crusts in the Area[13] provide

[10] ISBA/17/LTC/WP.1, Draft environmental management plan for the Clarion-Clipperton Zone , 28 January 2011, adopted 22 July 2012, ISBA/18/C/22; ISA. Decision of the Council relating to an environmental management plan for the Clarion-Clipperton Zone. 2012. ISBA/18C/22; available at http://www.isa.org.jm/files/documents/ EN/18Sess/Council/ISBA-18C-22.pdf; accessed 25 February 2017.

[11] Decision of the Council of the International Seabed Authority relating to amendments to the Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area and related matters. 2013; ISBA/19/C/17; Section V.31.6.

[12] Impact reference zones are “areas to be used for assessing the effect of each contractor’s activities in the Area on the marine environment and which are representative of the environmental characteristics of the area”. Preservation reference zones are “areas in which no mining shall occur to ensure representative and stable biota of the seabed in order to assess any changes in the flora and fauna of the marine environment”. Regulation 31(7).

[13] Decision of the Council of the International Seabed Authority relating to amendments to the Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area and related matters ISBA/19/C/17 and Decision of the Assembly of the International Seabed Authority regarding the amendments to the Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area ISBA/19/A/9; Decision of the Assembly of the International Seabed Authority relating to the regulations on prospecting and exploration for polymetallic sulphides in the Area ISBA/16/A/12/Rev.1; Decision of the Assembly of the International Seabed Authority relating to the Regulations on Prospecting and Exploration for Cobalt-rich Ferromanganese Crusts in the Area ISBA/18/A/11. See http://www.isa.org.jm/mining-code/Regulations; accessed February 2017.

that "prospecting shall not be undertaken if substantial evidence indicates the risk of serious harm to the marine environment".[14]

Exploration for mineral resources is ongoing in the Indian Ocean, including in its wWestern part (Fig. 7). The ISA is yet to define any APEIs in thise region, nor has anywhile no assessment has so far been conducted regarding their need and feasibility. This is therefore a step WIO sStates, and the international community more generally, may be interested in taking in conjunction with the ISA.

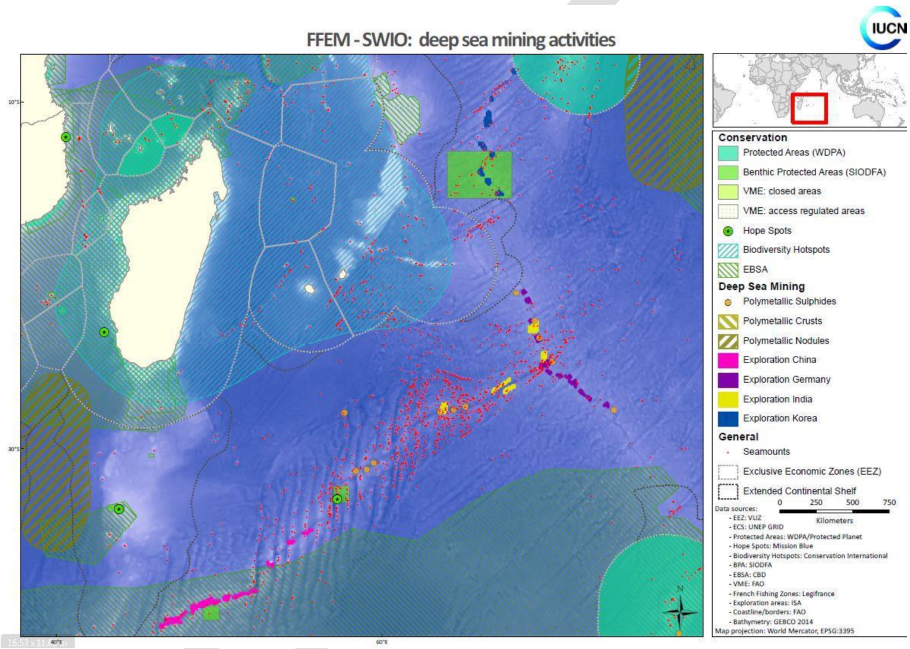

Figure 7. Deep-sea mining activities in the South West Indian Ocean. Extracted from UICN, Projet FFEM-SWIO, Michael Vollmar (2017).

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[14] Regulation 2(2). These regulations apply to prospecting and exploration only, and it remains to be seen whether eventual regulations on the exploitation of these resources will contain similar provisions.

Establishment of a marine protected area

MPAs are widely acknowledged as an important tool for biodiversity conservation, and ecologically connected networks of MPAs are crucial for sustaining high seas ecosystems (Sumaila ~~and others~~et al., 2007). The international community has committed, in numerous global fora~~ums~~, to establish a network of MPAs covering a significant percentage of the oceans (Rochette ~~and others~~et al., 2014a).[15] Therefore interest in the establishment of multi-purpose MPAs in ABNJ is strong,[16] yet currently no global mechanism exists to make this possible. Nonetheless, some efforts have been made to develop specific initiatives to conserve marine biodiversity in ABNJ through the creation of MPAs. Against this background, several options exist to establish an MPA in the Walters Shoal area.

Establishing a marine protected area through the Nairobi Convention

Some regional initiatives and organisations have progressively extended their activities to ABNJ, including through the establishment of MPAs (Rochette ~~and others~~et al., 2014b). Four areas are currently covered by a Regional Sea with a specific mandate in ABNJ: the Mediterranean through the Barcelona Convention,[17] the Southern Ocean through the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR),[18] the North-East Atlantic through the OSPAR Convention[19] and the South Pacific through the Nouméa Convention.[20]

Three Regional Seas have already developed specific actions in ABNJ through the creation of MPAs:

- **Mediterranean**: The Pelagos Sanctuary for Mediterranean M~~m~~arine M~~m~~ammals was created in 1999 by France, Italy and Monaco. The ~~Pelagos~~ Sanctuary was recognized as a Specially Protected Area of Mediterranean Importance (SPAMI) in 2001 (Scovazzi, 2011).[21] This Sanctuary incorporates the territorial waters of these three s~~S~~tates, but also ABNJ.[22]

[15] See, e.g., The Plan of Implementation of the World Summit on Sustainable Development (2002) available at: https://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/WSSD_PlanImpl.pdf; accessed 7 July 2017; The Strategic Plan for Biodiversity 2011–2020 ('Aichi Targets'), available at: https://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf; accessed 7 July 2017 (target 11 states: "By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascapes."; and the Rio+20 "Future We Want" outcome document (UNGA Resolution of 27 July 2012, A/RES/66/288).

[16] I.e., MPAs that regulate a large variety of human activities with the ultimate objective of conserving marine biodiversity.

[17] Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean, 1995.

[18] Convention on the Conservation of Antarctic Marine Living Resources, 1980.

[19] Convention for the Protection of the Marine Environment of the North-East Atlantic, 1992.

[20] Convention for the Protection of the Natural Resources and Environment of the South Pacific Region, 1986.

[21] UNEP/MAP. Report of the twelfth ordinary meeting of the Contracting Parties to the Convention for the protection of the Mediterranean Sea against pollution and its protocols, Monaco, 14-17 November, 2001,UNEP(DEC)/MED IG.13/8, 30 December 2001, Annex IV.

[22] The situation of the Mediterranean Sea is particular in that there is no point located at a distance of more than 200 nautical miles from the closest land or island. Therefore, "any waters beyond the limits of national jurisdiction (high seas) would disappear if all the coastal

States decided to establish their own exclusive economic zones (EEZ)" (Scovazzi, 2011). There are currently still ABNJ in the Mediterranean Sea because some States have not yet declared EEZs. Some States have declared Ecological Protection Zones or Fisheries Protection Zones, while there are "grey zones" where States' declarations overlap (UICN 2010).

- **Southern Ocean**: In 2009, CCAMLR endorsed a roadmap established by its Scientific Committee in order to fulfil the international requirements to establish a coherent and representative network of MPAs by 2012. The same year, CCAMLR adopted its first MPA on the South Orkney Islands continental shelf,[23] and in 2016 the Ross Sea was also designated as an MPA.

- **North East Atlantic**: Contracting Parties to the OSPAR Convention established a network of 6 six MPAs in ABNJ in 2010 (O'Leary and otherset al., 2012),[24] and agreed an additional MPA in 2012 (Freestone and otherset al., 2014).[25]

As previously noted, the Nairobi Convention geographical coverage is limited to areas within national jurisdiction. The designation of the Walters Shoal as an MPA is therefore not currently possible. However, the opportunity of extending the geographical coverage of the framework convention into ABNJ could be considered. Indeed, the United Nations Environment Assembly (UNEA) of UNEP adopted a resolution in 2016 that "encourages the contracting parties to existing regional seas conventions to consider the possibility of increasing the regional coverage of those instruments in accordance with international law" (Christiansen 2010). The parties to the Convention could therefore continue their discussions on the extension of the Nairobi Convention mandate, with a view to eventually instituting a process to develop MPAs in ABNJ.

Expansion of the mandate of the Nairobi Convention would in theory allow for such action to be taken in the WIO region. However, some important limitations are to be noted. First, such MPAs are binding only on the parties to the Regional Seas Programme and not on third parties. This means that even if the Nairobi Convention were to take this step, any future MPA or management measures would not be applicable to non-parties. Second, the management of such MPAs would also require coordination and cooperation with other bodies. As the Nairobi Convention's mandate is limited, it would need to cooperate with other bodies to ensure that complementary protective measures were taken, by, e.g.,for example SIOFA on fisheries and the ISA on deep-sea mining. Without cooperation between these organisations, any MPA declared under a Regional Seas Programme would be little more than "lines on a map".

A coalition-based approach

An alternative to the Regional Sea approach would be the use of a coalition-based approach (described above). Inspiration could be taken from the Pelagos Sanctuary in the Mediterranean, a small-scale, sState-led effort focussing on cetacean conservation, and the efforts of the Sargasso Sea Alliance (SSA) (now the Sargasso Sea Commission), a broad and cooperative initiative launched and led by civil society and a champion territory.

[23] CM 91-03 (2009), Protection of the South Orkney Islands Southern Shelf, §1.
[24] OSPAR Decisions 2010/1-6; OSPAR Recommendations 2010/12-17.

[25] OSPAR Commission, 2012 Status Report on the OSPAR Network of Marine Protected Areas (2013), <www.ospar.org/documents/dbase/publications/p00618/p00618_2012_mpa_status%20report.pdf>

The Pelagos Sanctuary~~ for Mediterranean Marine Mammals was established by France, Monaco and Italy in 1999 to protect the eight resident cetacean species in the area,~~[26] incorporated~~ing~~ both the territorial waters of these three s~~S~~tates and areas that were, at that time, beyond national jurisdiction was~~. In 2001, the Sanctuary was~~ recogniz~~s~~ed as a ~~Specially Protected Area of Mediterranean Importance (~~SPAMI~~)~~ by the Parties to the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean;[27] consequently, all contracting parties to this Protocol must abide by the regulations adopted for the Sanctuary. A joint management plan was approved in 2004 and steps have been taken to respect the MPA (Mangos and André, 2008~~, ;~~ Mayol ~~and others~~et al, 2013). The founding s~~S~~tates have also committed to seeking recognition as a PSSA by the IMO, though this has not yet come to fruition and the process appears to have stalled (Freestone~~ and others~~et al., 2014).

Commented [M14]: But that was six years ago. No update?

In comparison to other regional marine areas, the institutional landscape in the Sargasso Sea is underdeveloped. No Regional Seas Programme or broad-based RFB covers the region.[28] The only land in this area is Bermuda, a British overseas island territory. The SSA, a partnership between the Government of Bermuda, NGOs, scientists and private donors, was launched in 2011 with the aim of establishing a management regime using existing sectoral bodies and measures, and to act as a case study of what can, and cannot, be achieved within existing institutions covering ABNJ (Kaplan ~~and others~~et al., 2014).[29] Bermuda, with the support of the ~~Alliance~~SSA, has already submitted information regarding the Sargasso Sea for its potential designation as an EBSA,[30] and a range of additional actions for advancing the conservation of this region are currently being considered.

The Pelagos and Sargasso Sea examples demonstrate that a limited number of s~~S~~tates can advance conservation and sustainable use of ABNJ, but with considerable limitations. Learning from this approach, some WIO s~~S~~tates could champion a process towards a better conservation of ABNJ ecosystems, including by jointly declaring the Walters Shoal as an MPA and committing to conserving its biodiversity. This process could also be a first step to ultimately recogniz~~s~~ing the area as an MPA through an extended Nairobi Convention.

Inscription as a World Heritage Site

[26] Agreement concerning the creation of a marine mammal sanctuary in the Mediterranean, adopted in Rome, Italy, 25 November 1999. See: https://www.tethys.org/activities-overview/conservation/pelagos-sanctuary/; accessed 6 July 2017.

[27] UNEP/MAP. Report of the twelfth ordinary meeting of the Contracting Parties to the Convention for the protection of the Mediterranean Sea against pollution and its protocols, Monaco; 14-17 November 2001, UNEP(DEC)/MED IG.13/8, 30 December2001, Annex IV.

[28] The International Commission for the Conservation of Atlantic Tunas (ICCAT) is the only competent RFMO in the region: its area of competence covers a much greater area than the Sargasso Sea alone, and it is only responsible for the conservation of tunas and tuna-like species. The North Atlantic Fisheries Organization (NAFO) regulatory area may overlap slightly with the Sargasso Sea, but this is insignificant.

[29] See Sargasso Sea Alliance website, http://www.sargassoalliance.org/about-the-alliance; accessed 25 February 2017.

[30] Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity at its Eleventh Meeting, XI/17. Marine and Coastal Biodiversity: Ecologically or Biologically Significant Marine Areas, UNEP/CBD/COP/DEC/XI/17, p. 23, item 13.

Nominating the Walters Shoal for inscription on the World Heritage List appears, at present, to be unfeasible. Parties to the World Heritage Committee (WHC) would first have to decide to allow for this possibility under the WHC. Assuming that the WHC is ultimately extended to ABNJ, the Walters Shoal would then have to be nominated in accordance with the agreed procedures, and would have to be made for recognition of its "outstanding universal value". Nonetheless, sStates in the SWIO region may wish to keep in mind the possibility for such recognition as they further develop scientific knowledge of the SWIO and the Walters Shoal.

Dissociated management between the water column and the seabed

Should Madagascar's submission on the extent of its continental shelf be accepted by the United Nation's Commission on the Limits of the Continental Shelf (CLCS), this would have significant ramifications for the potential options available for the protection of the Walters Shoal. In particular, such a ruling would give Madagascar exclusive rights to explore and exploit the resources of the seabed around the Shoal (the status of the superjacent waters would, however, remain unchanged). This would mean that the ISA and RFMOs would have no mandate to implement management measures for the resources of the seabed in the area.[31] In such a case, the establishment of a comprehensive MPA or other ABMT in the area would require action by Madagascar to implement measures concerning the continental shelf, along with complementary action by sectoral bodies concerning the superjacent waters that would remain part of the high seas.

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Recommendations

As already emphasizsed by Rogers (2012), our knowledge of seamount and hydrothermal vent distribution and associated communities remains poor; in particular sampling on seamounts at equatorial latitudes is lacking. Previous surveys mainly focused on a few geographic areas (such as the North Atlantic and South-West Pacific), while little data exist for seamounts in other regions such as the Indian and the Southern Oceans. Consequently, the biological communities of tropical seamounts are poorly documented for large parts of the oceansworld. Most biological surveys on seamounts have been relatively shallow (for example, mostly less than 1,500 m) and thus the great majority of deeper seamounts remain largely unexplored. As a result, the seafloor of the oceans is not mapped to a sufficient resolution to determine the position, size and shape of the majority of the seamounts, particularly those of less than 1,000 m in elevation.

In spite of a series of intensive efforts in the 1960s (Zeitzschel, 1973), the basin-scale ecology and the fauna inhabiting seamounts of the Indian Ocean and the SWIR are remain poorly

[31] There is already some precedent for the protection of areas that are under mixed jurisdiction. Portugal, which exercises rights over an extensive continental shelf, has taken steps to conserve some of these areas and include them in their national planning. In particular, Portugal has worked together with the OSPAR Commission to create MPAs encompassing the Portuguese continental shelf and the superjacent waters, and is also currently developing a plan for these areas that contemplates possible uses of the waters superjacent to its continental shelf.

known, in part because of the ocean's remoteness to nations with large-scale historical oceanographic research programmes. However, there is now an urgent need to explore these ecosystems to complete the picture of the biodiversity and productivity associated with the Indian Ocean (Demopoulos ~~and others~~et al., 2003).

Deep-sea studies on the SWIR are limited to a series of geological surveys of the Atlantis Bank (Dick, 1998) and to the hydrothermal vents in the vicinity of Melville Banks (Tao ~~and others~~et al., 2007).

Studies of seamount and hydrothermal vent~~s~~ geology and physical oceanography are as a consequence limited. In addition, available biological data mainly originate from the deep-sea fishing industry or from national fisheries research programmes prospecting for exploitable fish stocks (FAO, 2002~~,~~; Romanov, 2003). Until recently, the most detailed bathymetric charts of seamounts in the Indian Ocean and SWIO were those generated by fishing companies (Shotton, 2006). Thus, the two major international scientific databases of seamount information held predicted bathymetries for only three seamounts in this region and few biological records (Seamounts Catalog: www.earthref.org/databases/SC/main.htm; Seamounts Online: via http://www.iobis.org/).

Seamounts have an impact on circulation of the water masses (White ~~and others~~et al., 2007) and their correct position is also necessary to forecast tsunami propagation accurately (Mofjeld ~~and others~~et al., 2001). In this respect, a detailed list of seamounts, with their position and summit depth, can be invaluable for fisheries management (Fonteneau, 1991;~~,~~ Rogers, 1994), of particular interest for conservation, ideal candidates for offshore and high-seas marine-protected areas (Roberts ~~and others~~et al., 2002;~~,~~ Alder and Wood, 2004~~,~~; Schmidt and Christiansen, 2004~~,~~; Davies ~~and others~~et al., 2007) and to implement the tsunami hazard mitigation programme. An accurate inventory of seamounts is necessary at both national and regional scales.

The growth of the research effort beyond national programmes, together with the ability to plan and carry out research at broader geographic scales, has considerably improved understanding over the last few decades of how seamounts and hydrothermal vents are structured, how they function as ecosystems and to what extent human activity has impacted them (Woodall ~~and others~~et al., 2015, Serpetti ~~and others~~et al., 2016). This scientific progress is evident in different fields, such as oceanography, geology, biology, ecology, taxonomy, conservation and fisheries.

The lack of knowledge about the location of seamounts and hydrothermal vents (described in chapter 1) is, ~~-~~however, affecting a series of functional aspects, such as understanding of habitat and community heterogeneity and complexity (for example, species composition, distribution and growth rates), connectivity and faunal dispersal, the impact of human activities (long-term biomonitoring, species recovery, assessment of trawling impacts, etc~~.~~), as well as conservation and management strategies and the ~~institution~~ development of marine protected areas.

In particular, and as Rogers (2012) has to a certain extent already stated, scientists, conservation actors and managers should focus on the following aspects to further our understanding of seamounts and hydrothermal vents:

- Food-chain architecture (such as seamount associated fish and prey populations, bentho-pelagic coupling).

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- Factors influencing the seamount-scale distribution of benthic organisms.
- Role of upwelling, vertical mixing, retention and re-suspension on primary production.
- Life histories of seamount species (use of genetic studies).
- Long-term implications of climate change and threats (for example, fisheries, pollution, seabed mining, ocean acidification and presence of alien species) to seamount and hydrothermal vent communities (introduction of database for habitat loss and degradation).
- Seamount microbial communities (substantially underestimated at present).
- Linkages of the bottom fauna with the water column.
- Comparative studiesy, in order to compare fauna of seamounts and plumes with that of other bathyal bottoms at equivalent depths.
- Measurable conservation objectives that are relevant to current policies and sensitive to meaningful thresholds in order to establish meaningful indicators and monitoring protocols (Failing and Gregory 2003).
- Creation of EBSAs and MPAs.
- Identification of potential and new stressors (debris, noise, traffic vessels, tourism, etc.).
- Creation of a list of endangered species (for both types of ecosystem).
- Improving access to data from seabed mining and high-seas fisheries activities, which is dramatically affecting scientific understanding and potential conservation measures.
- Identification of meaningful indicators, monitoring protocols and strategies to assess whether an MPA is achieving the established conservation and management objectives is a key component of overall management planning and implementation.

Overall knowledge of high-seas ecosystems remains limited due to insufficient funding for exploring and studying seamounts and hydrothermal vents.

To meet these challenges, funding for ~~advanced and~~ field programmes ~~are~~ is required. However, ensure compatible sharing of result, standardizsed sampling methods and taxonomic resolution (inter-calibration assessment studies) should be introduced as different collecting instruments have different performances and data comparison may be biased to a certain degree.

Commented [M18]: But, sounds like the challenge is lack of funding, not lack of research programmes.

In the near future it will be particularly important to enhance collaboration among scientific communities of numerous countries and multiple disciplines. In addition, a minimum set of standardizsed seamount sampling protocols should be embraced as widely as possible by countries endorsing seamount and hydrothermal vents sampling programmes.

Additionally, to strengthen conservation and management of ABNJ~~areas beyond national jurisdiction,~~ such as seamounts and hydrothermal vents, marine resources and ecosystems, molecular tools need to be introduced and applied in all field programmes in order to:

- reveal evolutionary histories of marine species;
- discriminate between cryptic species (increasing information concerning existing biodiversity and associated distribution patterns);
- track effects of climate change (von der Heyden ~~and others~~et al., 2010);
- identify marine invasive alien species (Darling and Tepolt, 2008); and
- identify potentially suspiciously~~-~~-labelled seafood (von der Heyden ~~and others~~et al., 2010).

Furthermore, genetic studies might demonstrate whether fragile and unique biota, such as that of seamount and vent ecosystems, are at an appropriate scale for protection, or whether they should be carefully protected (UNEP, 2006). Finally, as mentioned in the UNEP report (2006), availability of data regarding seamounts represents a problem.

For many seamount studies, only summary data are publicly available, with analysis of species distribution patterns and studies on assemblage composition across different seamounts and regions ~~are~~ not aggregated and often contained in the 'grey literature' ~~reports~~, such as unpublished fisheries research, trawler and commercial catch records (Tracey and others, 2011), thus not always readily accessible.

The conservation and management of marine biodiversity based on precautionary and ecosystem approaches are consequently hampered by the lack of fundamental scientific knowledge and understanding of these areas and their relationship with benthic and pelagic fish species of commercial interest. Furthermore, many seamounts are located in international waters, so the control of human activities that might adversely impact oceanic features (fishing, seabed mining activities, etc~~.~~) is a major challenge. To address these issues, appropriate mechanisms that bridge science and policy making must be established.

The knowledge gaps mentioned above need to be addressed and discussed internationally in order to create solid scientific evidence that might enable institutions, local communities and, in particular, scientists, to interpret the causes and impacts of present and future environmental changes and threats and consequently to integrate seamount and hydrothermal vent ecosystems into conservation strategies.

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