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Integrating Science and Policy for Recognising Seamounts as Vulnerable Marine Ecosystems

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Abstract

Seamounts, including knolls and hills, are vital deep-sea ecosystems that provide unique habitats and significantly contribute to marine biodiversity. The UN General Assembly resolutions from 2006 to 2022 have consistently emphasised the need to protect vulnerable marine ecosystems (VMEs), including seamounts, from significant adverse impacts. This paper examines whether these features meet the criteria for classification as VMEs under the FAO Deep Sea Fisheries Guidelines, which considers criteria such as functional significance, fragility, slow recovery, and structural complexity. To substantiate this classification, we review scientific evidence alongside definitions from the UN General Assembly, FAO Guidelines, Regional Fisheries Management Organisations and individual States. Additionally, we assess the effectiveness of current policies aimed at protecting seamounts as VMEs. Our findings reveal strong scientific support for classifying seamounts as VMEs, since surveyed seamounts meet at least four of the five VME

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criteria without exception. Visual studies have also repeatedly confirmed their capacity to sustain extensive VME communities. Consequently, the best available science supports a precautionary, ecosystem-based approach to protect seamounts.

DSCC recommends that the SIOFA Scientific Committee recommends that the MoP:

- Recognise the importance of seamounts as essential deep-sea ecosystems that provide unique habitats and significantly contribute to marine biodiversity.
- Recognise seamounts should be identified as VMEs and managed accordingly.
- Acknowledge that VME indicator taxa are characteristic features of seamounts.
- Apply a precautionary approach in data poor seamount ecosystems.
- Develop robust protection policies to protect seamounts.

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Lissette Victorero, Karli Thomas, Barry Weeber, Bronwen Golder, Duncan Currie

Table of Contents

1. Introduction

Seamounts are submarine mountains that rise from 100 metres to over 1,000 metres above the seafloor, and occur typically 200 metres or more below the ocean surface (Menard, 1964; Rogers, 2018; Staudigel & Clague, 2010). Seamounts encompass a range of complex morphologies, including hills (elevations <500 metres), knolls (elevations >500metres), ridges, and fracture zones formed at transform faults (Staudigel & Clague, 2010). Despite their varied shapes and heights, these features exhibit similar biological and ecological functions (M. R. Clark et al., 2022; Howell et al., 2010; Yesson et al., 2011). Globally, it is estimated that there are approximately 38,000 seamounts that exceed 1,000 metres in height (Yesson et al., 2021) and this ubiquitous nature makes seamounts important deep-sea ecosystems (Costello, 2009). However, only a small minority 0.004% have been scientifically surveyed (Clark et al., 2010; Rowden et al., 2010) (Figure 1). These expeditions have shown the seamount terrain comprises a varied landscape of hard substrates and geomorphologies, often in regions surrounded by abyssal plains, with vibrant communities living on them typically comprising slow-growing and long-living species (Auster, 2005).

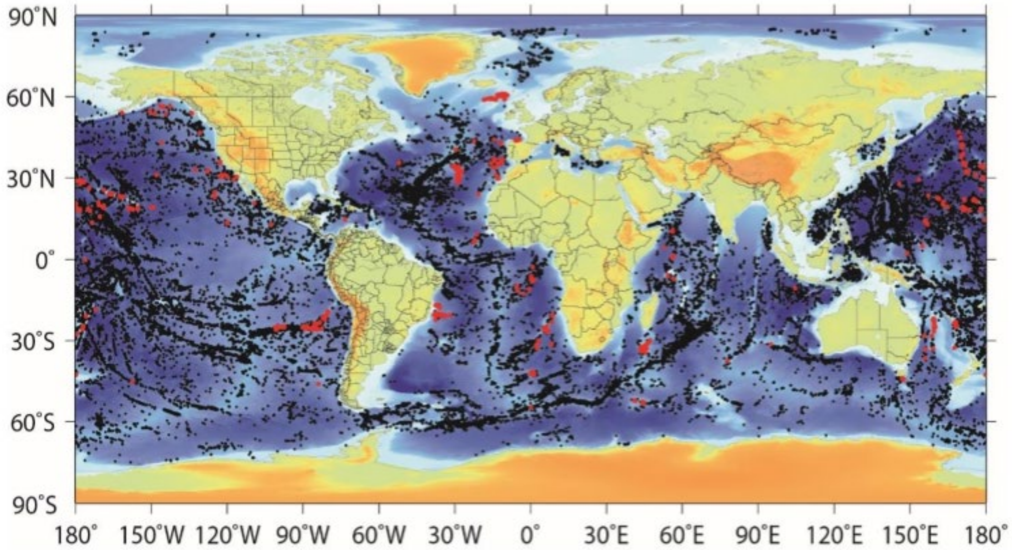

Figure 1. The global distribution of seamounts (black dots) based on 30 arc seconds bathymetry data overlaid with sampled seamounts data (red dots). The seamount distribution data is based on Yesson et al. (2011) and the sampled seamount data is from Seamounts Online (Stocks, 2010). Note that the number of sampled seamounts is likely to be slightly higher, since the sampled data set only runs till 2009.

Consequently, seamounts are now recognised as biodiversity "hotspots," hosting abundant and diverse communities of fish and benthic species, with elevated species richness, biomass, and abundance compared to surrounding abyssal plains (de Forges et al., 2000; Samadi et al., 2006). This biodiversity is largely due to enhanced habitat heterogeneity and productivity on seamounts, which promote species coexistence and frequent turnover across habitats, often occurring over spatial scales as small as 100 metres (McClain et al., 2010; Victorero et al., 2018). In line with these findings, seamounts generally display greater biomass than other deep-sea areas (Rowden et al., 2010; Sautya et al., 2011).

This increased benthic biomass attracts deep-sea fish, which use seamounts for spawning and other activities, further enhancing the biomass and ecological complexity of these features (Koslow, 1996). Globally, seamounts support at least 77 commercially important fish species and are estimated to host at least 1,222 fish and shark species in total (Kvile et al., 2014; Morato & Clark, 2007; Rogers, 1994). A study compiling data from 187 seamounts, using only described taxa, found 2,905 demersal invertebrate records spanning 27 animal taxa, along with records of 22 marine mammal species and 31 seabird species (Kvile et al., 2014). Based on intensive and comprehensive sampling, de Forges et al., (2000) reported more than 850 species associated with cold-water coral and sponge communities on seamounts in the Tasman and Coral Seas of the Southwest Pacific. A total of 237 taxa have been identified on the Davidson Seamount off the coast of California (Burton & Lundsten, 2008). While the total number of species inhabiting seamounts is undoubtedly high, exact values remain unknown due to limited sampling and the rarity and inconsistencies in deep-sea global-scale data compilations (Higgs & Attrill, 2015). Recent studies in the deep Indian Ocean, a region described as the epitome of data paucity (Ramiro-Sanchez et al., 2023), have documented many novel species and range extensions, further underscoring the ecological significance of seamount ecosystems and their largely uncharted biodiversity (Payne et al., 2025; Rengaiyan & Ingole, 2025, Rengaiyan et al., 2023, Periasamy et al, 2023).

In this paper, we review scientific evidence together with definitions from the UN General Assembly, FAO Guidelines, Regional Fisheries Management Organizations (RFMOs), and states that support the classification of seamounts as vulnerable marine ecosystems (VMEs). Concurrently, we analyse examples of policies aimed at protecting seamounts as VMEs, and illustrate the effectiveness of these protection measures. Throughout this paper, we demonstrate that there is currently no scientific evidence contradicting their classification as VMEs or their capacity to sustain VME communities, advocating strongly for a precautionary and ecosystem-based approach that includes the closure of seamounts to bottom-contact fishing.

2. Definitions and Criteria for VMEs

In response to increasing concerns over the impact of human activities on sensitive deep-sea ecosystems, the UNGA adopted Resolution 61/105 in 2006. This significant resolution recognised the immense value of deep-sea biodiversity and committed States, both individually and through RFMOs, to protect areas with vulnerable marine ecosystems. The resolutions emphasised protecting areas where "*including seamounts, cold-water coral reefs and hydrothermal vents, are known to occur or are likely to occur based on the best available scientific information*".

The term "vulnerable marine ecosystems" (VMEs) refers to deep-sea areas that are particularly sensitive to human activities and environmental changes (FAO, 2009). VMEs include habitat-forming organisms such as deep-sea sponge clusters, cold-water corals, sea pens, crinoid fields, and significant features like seamounts and hydrothermal vents. The species that make up VMEs are typically fragile, slow-growing, and highly susceptible to damage from activities such as deep-sea fishing and mining, with very slow recovery rates

(Auster et al., 1996; Clark et al., 2016; Watling & Auster, 2017). VMEs are characterised by high biodiversity, offering diverse habitats that lead to increased faunal richness, diversity, abundance, and biomass (Barrio Froján et al., 2016; Beazley et al., 2013; Buhl-Mortensen & Mortensen, 2005). Additionally, they provide essential areas for commercial fish populations and other species to aggregate, spawn, forage, and seek shelter (Baillon et al., 2012; Pham et al., 2015).

The FAO Guidelines (2009) (para 42) sets out five specific criteria for identifying areas as VMEs that require conservation efforts to protect their ecological integrity and biodiversity. The FAO Guidelines emphasises that only one of these criteria needs to be met for an area to be designated as a VME underscoring the importance of even single significant features in deep-sea conservation.

These criteria are:

1. *Uniqueness or rarity*
2. *Functional significance of the habitat*
3. *Fragility*
4. *Life-history traits or component species that make recovery difficult*
5. *Structural complexity*

While the UNGA resolution 61/105, along with the FAO Guidelines (2009) provide a comprehensive list of VME examples, including indicator taxa and geophysical features like seamounts, each RFMO can develop its own VME indicator lists. VME indicator taxa are faunal groups representing a wider range of species within an ecosystem, encompassing those that may not be directly considered or sampled, but are still affected by impacts (Watling & Auster, 2017). The presence of VME indicator taxa signifies the likely presence of a vulnerable marine ecosystem and underscores the importance of protecting the full diversity of interacting and vulnerable species within that ecosystem (Watling & Auster, 2017).

The VME indicator lists are tailored to the specific ecological and operational contexts of the regions they manage. This decentralised approach allows for regional adaptation and management, but it has been shown to lack consistency among RFMO regions regarding what is considered a VME (Baco, Ross, et al., 2023). More importantly, it risks overlooking the protection of certain areas and features. Such differences in protection are particularly evident with geophysical features like seamounts that are repeatedly acknowledged as vulnerable habitats to disturbance by bottom contact fishing gear, regardless of the region in which they occur (Clark & Koslow, 2007). The FAO Guidelines provide further guidance on the aspect of vulnerability, stating: "*The most vulnerable ecosystems are those that are both easily disturbed and very slow to recover, or may never recover*". In this context, referring to the ecosystem means that the VME concept includes the ecosystem where populations, communities, and habitats are nested and interact functionally (Watling & Auster, 2021). This means that geophysical features like seamounts are part of the ecosystem under the VME criteria.

However, the FAO Guidelines also state " *merely detecting the presence of an element is not sufficient to identify a VME. That identification should be made on a case-by-case basis through the application of relevant provisions of these Guidelines, particularly Sections 3.2 and 5.2*." These sections outline the need for thorough assessments using the established criteria for identifying VMEs, including conducting impact assessments, applying the precautionary approach, and other operational requirements. Furthermore, the 2009 FAO Guidelines should be interpreted in conjunction with the evolving UNGA resolutions, which have consistently emphasised the need to protect seamounts. Each subsequent round of negotiations has built upon these 2009 guidelines, progressively advocating for more comprehensive measures to safeguard VMEs, including seamounts and their associated species (Table 1).

Despite these provisions, certain RFMOs lack comprehensive assessments of vulnerability when an element is detected, creating gaps in VME protection. To ensure consistent protection of VMEs, their associated species, and the wider biodiversity in the deep ocean, it is essential that States and RFMOs recognise that, under both the UNGA resolutions and the FAO Guidelines, all seamounts are VME entities (Watling & Auster, 2017). This classification is further reinforced by the best available scientific evidence, which consistently shows the abundant presence of VME indicator species on seamounts.

Table 1. Overview of the UNGA resolutions focused on protecting VMEs, showing how the inclusion and protection of seamounts under the VME concept have remained central to the resolutions.

Resolution	Text concerning seamounts as VMEs
59/25 (2004)	Calls upon States, either by themselves or through regional fisheries management organizations or arrangements, where these are competent to do so, to take action urgently, and consider on a case-by-case basis and on a scientific basis, including the **application of the precautionary approach, the interim prohibition of destructive fishing practices, including bottom trawling that has adverse impacts on vulnerable marine ecosystems, including seamounts,** hydrothermal vents and cold water corals located beyond national jurisdiction, until such time as appropriate conservation and management measures have been adopted in accordance with international law;
61/105 (2006)	Calls upon States to take action immediately, individually and through regional fisheries management organizations and arrangements, and consistent with the precautionary approach and ecosystem approaches, to sustainably manage fish stocks and **protect vulnerable marine ecosystems, including seamounts,** hydrothermal vents and cold water corals, from destructive fishing practices, recognizing the immense importance and value of deep sea ecosystems and the biodiversity they contain; In respect of areas where **vulnerable marine ecosystems, including seamounts,** hydrothermal vents and cold water corals, are known to occur or are likely to occur based on the best available scientific information, to **close such areas to bottom fishing** and ensure that such activities do not proceed unless conservation and management measures have been established to prevent significant adverse impacts on vulnerable marine ecosystems;
64/72 (2009)	Calls upon States to take action immediately, individually and through regional fisheries management organizations and arrangements, and consistent with the precautionary approach and ecosystem approaches, to implement the 2008 International Guidelines for the Management of Deep-sea Fisheries in the High Seas of the Food and Agriculture Organization of the United Nations (“the Guidelines”) 23 in order to sustainably manage fish stocks and **protect vulnerable marine ecosystems, including seamounts,** hydrothermal vents and cold water corals, from destructive fishing practices, recognizing the immense importance and value of deep sea ecosystems and the biodiversity they contain;
66/68 (2011)	Calls upon States to take action immediately, individually and through regional fisheries management organizations and arrangements, and consistent with the precautionary approach and ecosystem approaches, to continue implementing the 2008 International Guidelines for the Management of Deep-Sea Fisheries in the High Seas of the Food and Agriculture Organization of the United Nations (“the Guidelines”) 26 in order to sustainably manage fish stocks and **protect vulnerable marine ecosystems, including seamounts ,** hydrothermal vents and cold water corals, from destructive fishing practices, recognizing the immense importance and value of deep-sea ecosystems and the biodiversity they contain;
71/123 (2016)	Calls upon States to take action immediately, individually and through regional fisheries management organizations and arrangements, and consistent with the precautionary approach and ecosystem approaches, to continue to implement the 2008 International Guidelines for the Management of Deep-sea Fisheries in the High Seas of the Food and Agriculture Organization of the United Nations (the Guidelines) in order to sustainably manage fish stocks and **protect vulnerable marine ecosystems, including seamounts,** hydrothermal vents and cold water corals, from fishing practices with significant adverse impacts on vulnerable marine ecosystems, recognizing the immense importance and value of deep-sea ecosystems and the biodiversity they contain as documented in the First Global Integrated Marine Assessment;
77/118 (2022)	Calls upon States to take action immediately, individually and through regional fisheries management organizations and arrangements, and consistent with the precautionary approach and ecosystem approaches, to continue to implement the 2008 International Guidelines for the Management of Deep-Sea Fisheries in the High Seas of the Food and Agriculture Organization of the United Nations (the Guidelines) in order to sustainably manage fish stocks and **protect vulnerable marine ecosystems, including seamounts,** hydrothermal vents and cold water corals, from fishing practices with significant adverse impacts on vulnerable marine ecosystems, recognizing the immense importance and value of deep-sea ecosystems and the biodiversity they contain, as documented in the first World Ocean Assessment;

3. VME Indicator Taxa as a Defining Feature of Seamounts

Visual evidence for the distribution of VME indicator taxa is comparatively rare for fisheries management decisions (Baco et al., 2023). The presence of VME indicator taxa relies mostly on fisheries bycatch data, that is known to not accurately represent the community present, due to differences in catchability between taxa, or the extent of the impact on the seafloor (Gros et al., 2022; Knudby et al., 2013; Pitcher et al., 2019; Preez et al., 2016; Watling & Auster, 2017). While bycatch records of indicator species remain a valuable tool for identifying VMEs, they should not be the sole method used to ensure the protection of VMEs.

Mapping of VME indicator taxa through imagery-based studies of seamounts is relatively rare on a global scale due to the high costs involved. Moreover, it is uncommon for more than two or three ROV dives to be conducted on any single seamount (Kvile et al., 2014; Watling & Auster, 2017). The lack of data has often been leveraged to delay the implementation of protective measures, despite strong recommendations from the scientific community advocating for precautionary approaches in fisheries management to protect understudied marine systems (Garcia, 1994; Korseberg, 2018; Macdonald, 1995)

The limited data, however, has shown that both pristine and degraded seamount landscapes consistently contain VME indicator taxa on all or parts of the seamounts. This has led to insights that VME indicator taxa are characteristic of seamount ecosystems. For example, seamounts where ROV dives have revealed VME indicator taxa include Kelvin (Lapointe et al., 2020) and Anton Dohrn (Davies et al., 2015) in the North Atlantic; and Tropic (Ramiro Sanchez et al., 2019), Anna, Knipovich, Vema Fracture Zone, and Va yda seamounts (Victorero, 2019) in the Equatorial Atlantic; Central Arctic seamounts (Morganti et al., 2022) and Schulz Bank on the Arctic Mid-Ocean Ridge (Morrison et al., 2020); Davidson (McClain et al., 2010) and Cobb (Preez et al., 2016) in the Northeast Pacific; Necker Ridge (Morgan et al., 2015) in the Central Pacific; the Graveyard seamounts on the Chatham Rise east of New Zealand (Clark & O'Driscoll, 2003); and four seamounts on the Mozambique Channel (Hanafi Portier et al., 2024) and five seamounts in the Southwest Indian Ocean Ridge (Rogers et al., 2012). The Okeanos Explorer has dived around the world, consistently documenting extensive deep-sea coral and sponge habitats on seamounts. A recent study assessed VMEs from imagery across 27 study sites worldwide. Notably, 16 of these sites provided imagery of VMEs specifically from seamount ecosystems (Baco et al., 2023). All studied seamounts within the deep seas of the OSPAR region in the North-East Atlantic contained VME indicator species, according to a review of 100 seamounts and seamount-like features (Kutti et al., 2019). Modelling studies further support this pattern, demonstrating that stony coral reef VME habitats on Tasmanian seamounts form large, continuous aggregations predominantly concentrated on the peaks and flanks of the seamounts (Williams et al., 2020).

These examples, using the best available scientific data, demonstrate that while we do not have comprehensive coverage of each seamount surveyed and its varied landscapes, and are unlikely to achieve this, we can confidently deduce that seamounts are prime habitats for VME indicator taxa.

4. Assessing Vulnerability of Seamount Ecosystems based on Scientific Evidence

Paragraph 42 of the FAO Guidelines states, “A marine ecosystem should be classified as vulnerable based on the characteristics that it possesses. The following list of characteristics should be used as criteria in the identification of VMEs.” In this section, we draw on scientific literature to evaluate how seamounts meet each VME criterion, providing examples from various regions worldwide to support their classification as VMEs. Notably, scientific research indicates that surveyed seamounts meet at least one to four of the five VME criteria without exception. Furthermore, existing evidence overwhelmingly supports their classification as VMEs, with the criterion of fragility consistently highlighted across all studies.

VME Criteria 1 – Uniqueness or rarity

“An area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems”

New species are frequently discovered on seamounts, but determining their endemicity is challenging due to the unexplored expanse of the deep ocean. Some degree of endemicity is expected, through novel discoveries and cryptic fauna (McClain et al., 2009). Endemism on seamounts could arise from site-specific speciation due to the combination of depth gradients, different substrates, and physical oceanographic barriers, which together create dispersal barriers and promote adaptation (Rowden et al., 2010).

There might also be regional differences in endemicity. In the North-East Atlantic, less than 3% of the recorded antipatharian, scleractinian, and gorgonian corals are potentially endemic to seamounts (Hall-spencer et al., 2007). Conversely, in the SW Pacific, up to 39% of sampled *Chrysogorgia* haplotypes may be restricted to a single seamount (Pante et al., 2015). At the Josephine Seamount in the North-East Atlantic, five endemic species have been discovered (OSPAR, 2011). Additionally, 25% of the gastropod species sampled by Gofas & Beu (2002) on Josephine and surrounding seamounts were identified as either unknown or rare in nearby margin areas (OSPAR, 2011). Conversely, recent research on Walters Shoal seamount located on the South Madagascar Ridge, Indian Ocean, has led to the discovery of 11 new sponge species, with the assemblage exhibiting high levels of endemism (Payne et al., 2025).

Some observations indicate that recruitment to individual seamounts may be highly localised, resulting in predominantly self-recruiting populations (Rogers, 2018). However, a recent discovery highlights the broader ecological significance of seamounts. The rare Atlantic bamboo coral *Chelidonisis aurantiaca* was discovered for the first time in the Mediterranean Sea at Janua Seamount, emphasising the crucial role these ecosystems play in supporting unique marine biodiversity (Bo et al., 2020). Research into the hidden diversity of cryptic species in the deep ocean is a growing field, likely to reshape our understanding of endemicity and rare species on seamounts. However, the true extent of endemicity remains uncertain due to significant knowledge gaps and the limited reach of deep-sea exploration.

VME Criteria 2 – Functional significance of the habitat

“Discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.”

VMEs provide habitat for commercially fished species (Baillon et al., 2012; Pham et al., 2015) and, in some instances, can be classified as essential fish habitat (EFH)—habitats necessary for the survival of fish (Shester & Ayers, 2005). Many fish species, including commercially valuable ones like the slender armorhead and orange roughy, form spawning and feeding aggregations over seamounts, rises and ridges (Boehlert & Sasaki, 1988; Clark, 1999; Roberts, 2002).

Many shark species have been associated with seamounts (Morato et al., 2010), where they can form dense aggregations (Klimley et al., 1988; Ketchum et al., 2014). For example, the Middle of What seamount on the Southwest Indian Ocean Ridge has been observed to host high densities of juvenile lantern sharks (Rogers et al., 2012). Similarly, the steep, inaccessible terrains of seamounts in the Northeast Atlantic may serve as refuges from fishing pressure, offering a stark contrast to the 90% decline in shark populations observed in more heavily fished neighbouring areas (Gibson et al., 2008). Research suggests that Walters Shoal in the Indian Ocean is likely a speciation spot for the commercially valuable yellowtail kingfish (Kerwath et al., 2021). This breeding ground produces genetically and phenotypically distinct populations (Kerwath et al., 2021).

Skates and rays in the deep sea are highly vulnerable due to their life history traits, with their extinction risk exacerbated by increased fishing efforts in deeper waters (Devine et al., 2006; Rigby & Simpfendorfer, 2015). The seamounts off Tasmania, Australia, serve as egg case nurseries for the boreal skate (*Amblyraja hyperborea*) and Richardson's skate (*Bathyraja richardsoni*), with eggs deposited within the skeletal matrix of the stony coral *Solenosmilia variabilis* (Maguire et al., 2023). Similarly, sponge grounds at the summit of the Schulz Bank on the Arctic Mid-Ocean Ridge function as nurseries for the eggs and juveniles of the boreal skate (*Amblyraja hyperborea*) in the Arctic region (Meyer et al., 2019).

The flanks of the Davidson Seamount off California host the "Octopus Garden" a 1.29-square-mile area estimated to contain over 20,000 individuals of the octopus *Muusoctopus robustus*, along with a rich megafaunal assemblage of corals and other invertebrates (Barry et al., 2023). This site provides a localised deep-sea heat source and serves as a nursery ground where octopuses incubate and hatch their eggs (Barry et al., 2023). Nearby, researchers also discovered a smaller breeding site for the same species that take advantage of the exposed rocky habitats on seamounts to reproduce (Barry et al., 2023). Based on this evidence, experts predict that other ridge-flank systems are likely to host similar nurseries.

VME Criteria 3 – Fragility

“An ecosystem that is highly susceptible to degradation by anthropogenic activities.”

Several studies have documented the high susceptibility of seamount communities to degradation by anthropogenic activities, mainly deep-sea trawling and the challenges of recovery. Research indicates that routinely trawled seamounts have generally lost most or all of their coral and other suspension feeder communities on the summits and upper flanks (Clark & O'Driscoll, 2003; Clark & Tittensor, 2010; Koslow et al., 2001).

In the Indian Ocean, there is visual evidence of fishing impacts on seamounts on the Southwest Indian Ocean Ridge, with ROV imagery showing extensive areas of coral reef severely damaged, and scars on the seabed (Rogers et al., 2012). There is also visual evidence of further environmental degradation by human litter and abandoned fishing gear (Rogers et al., 2012).

In the South-West Pacific, a regional assessment detected trawling damage on 88% (45 of 51) of seamounts in the fishery seascape off Tasmania (Williams et al., 2020). Several recovery studies in this area have illustrated how fragile seamounts are to the impacts of trawling. The Graveyard Knolls in the Chatham Rise have been closed to fishing over 15 years, yet the communities remain indistinguishable from those on currently heavily trawled features, suggesting very limited or no recovery (Clark et al., 2019). Despite the presence of neighbouring topographic features with coral coverage that should theoretically provide larvae, there is a severe lack of biodiversity (Clark et al., 2019). While a more recent survey has indicated some early signs of recovery, there is still little evidence of community function returning to pre-trawling levels (Goode et al., 2024). In this area, coral patches damaged by the orange roughy fishery are estimated to take over 100 years to recover (Probert et al., 1997). Althaus et al. (2009) observed a two orders of magnitude reduction in the cover of the cold-water coral *Solenosmilia variabilis* and a subsequent threefold loss of megabenthic species richness on trawled seamounts, with no signs of recovery on seamounts off Tasmania even after 10 years. Williams et al. (2010) found no indication of recovery in megafaunal assemblages on seamounts off New Zealand and Australia after 5–10 years, although some small and flexible species appeared to increase in abundance, suggesting they might have survived the trawling impacts.

In the North-Pacific, this fragility has been observed on the Emperor Seamount Chain, North-western Hawaiian Ridge, where extensive mapping by autonomous underwater vehicles revealed vast barren areas, scars on the seabed, and coral stumps, with very few observations of the coralliid octocorals that formerly supported the world's largest precious coral fishery (Baco et al., 2020). Here, coralliid octocorals have been used as indicator taxa to assess the recovery state of seamounts following trawling activities (Baco, Morgan, et al., 2023). Research indicates that two seamounts still subjected to trawling have been unable to recover under current levels of fishing (Baco, Morgan, et al., 2023).

In the North Atlantic, Waller et al. (2007) surveyed the summits of two seamounts in the Corner Rise complex about 10 years after trawling ceased. The summits were denuded of large sessile fauna with small specimens of sponges and plexaurid corals, most less than 15 cm in height. In the Azores, fishermen report that coral bycatch is most prevalent across seamounts and that there has been a decline in coral bycatch over time, indicating habitat impacts from repeated fishing activities (Sampaio et al., 2012). Studies in the region have shown that organisms with complex morphologies are primarily impacted, potentially causing imbalances in ecosystem dynamics and long-term alterations in community structure (Pham et al., 2014; Sampaio et al., 2012). Deep-water shark populations on seamounts are also vulnerable to deep-sea fishing. Research on the Hatton Bank coral habitats revealed that discards from bottom longlines at depths of 750-1500 metres primarily consist of adult vulnerable sharks, contributing 84% of the total weight (Muñoz et al., 2012). Sharks are highly susceptible to being captured in intricate coral habitats, because such areas likely support greater shark abundance compared to other locations (Muñoz et al., 2012). Overall, the profound and long-lasting impacts of deep-sea trawling on seamounts are evident and underscore their fragility, emphasising the need for careful management and protection of these vulnerable ecosystems.

Seamounts are also becoming increasingly vulnerable to climate change (Jones et al., 2014; Ross et al., 2020). Globally, 82% of the 33,452 seamounts are projected to experience declines in biomass due to climate change (Jones et al., 2014). In the South Pacific, biomass reductions are expected on seamounts that support major fisheries already under significant pressure from heavy exploitation and human activities (Jones et al., 2014). A study of 47 seamounts in the Northeast Pacific revealed significant long-term chemical changes, including an expanding oxygen minimum zone (OMZ), a 15% decline in deep oxygen levels since 1960, and increasingly corrosive waters above the OMZ (Ross et al., 2020). The authors suggest that VME indicator species, particularly cold-water corals, are likely to face compounded impacts on their distribution, metabolism, growth, and reproduction, potentially threatening their survival or leading to local extinctions.

VME Criteria 4 – Life-history traits of component species that make recovery difficult

"Ecosystems that are characterised by populations or assemblages of species with one or more of the following characteristics: slow growth rates; late age of maturity; low or unpredictable recruitment; or long-lived."

Slow growing and fragile hard bottom communities on seamounts have been living in one place for centuries or even millennia (Fosså et al., 2002). For example, deep-sea corals can live for thousands of years, with individual seamount colonies of the gold coral Gerardia dated at 2,742 years and the oldest known specimen of black coral aged at 4,265 years (Roark et al., 2009). The growth rates of these genera are extremely low, ranging from 4 to 35 μm per year (Roark et al., 2009). On the Tasmanian seamounts, *Solenosmilia variabilis* has been present for at least the last 47,000 years, with modern specimens exhibiting growth rates of 0.84 to 1.25 millimetres of linear extension per year (Fallon et al., 2014).

However, recruitment patterns in cold-water coral communities remain largely unknown, with reproductive aspects documented for only 4% of all known species (Waller et al., 2023). Research on the Tasmanian seamounts has shown that three species of scleractinians have effective population sizes of just 20-60 individuals (Zeng et al., 2017), indicating that only a few colonies contribute to reproduction. This makes these species extremely vulnerable to human impacts. The lack of understanding of this fundamental reproductive process limits our ability to gauge the capacity of coral species to recover from disturbances (Waller et al., 2023).

Seamount fisheries typically last only a decade often leading to overfishing, as seen in the Pelagic armorhead fishery on the Emperor Seamounts and the Orange roughy fishery on the Tasmanian Seamounts (Clark & Koslow, 2007). Similar depletion patterns have been documented across other seamounts, such as the Madeira-Canary, South Azores, Ob and Lena, Corner Rise, and Namibian seamounts (Clark & Koslow, 2007). Deep-sea fish, characterised by their longevity, late reproductive age, and low fecundity, exhibit reduced reproductive outputs, particularly as habitat depth increases (Drazen & Haedrich, 2012). Consequently, the potential for population growth declines with habitat depth. These characteristics render deep-sea fish populations particularly vulnerable to overfishing and significantly limit their capacity for rapid recovery. Many species that inhabit seamounts also tend to aggregate socially, which increases their vulnerability, as fishing often removes spawning individuals, hindering population replenishment and making these species prone to rapid depletion (Morato et al., 2006). For instance, species such as the orange roughy and roundnose grenadier, which inhabit seamounts, can live for over 200 years and 60 years, respectively (Horn & Maolagáin, 2019; Kelly et al., 1997). Both species are listed on the IUCN's Red List due to significant population declines from intensive deep-sea fishing, with the orange roughy classified as Vulnerable in the North Atlantic and the roundnose grenadier as Critically Endangered (Collette et al., 2015; Iwamoto, 2015).

VME Criteria 5 – Structural complexity

"An ecosystem that is characterised by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms."

On seamounts, there are significant concentrations of both biotic and abiotic features. The seamount landscape itself comprises complex geomorphological structures, primarily composed of basalt rock, forming ridges and flat plains, as well as vertical cliffs with slopes of varying angles. This diverse landscape creates highly heterogeneous habitats that support abundant populations of habitat-forming species, such as deep-sea corals, sponges, and other vulnerable organisms (Auster et al., 2005).Surveys conducted on five seamounts in the Southwest Indian Ocean Ridge using ROVs confirmed the presence of VMEs, consisting of scleractinians like *Madrepora oculata*, *Solenosmilia variabilis*, and *Goniocorella dumosa*. Extensive gardens of stylasterids, octocorals, and sponges were also documented, with many taxa exhibiting significant size, indicating their longevity (Rogers et al., 2012). These coral frameworks were observed to support high species richness and provide crucial habitats for diverse invertebrates including octopi, sharks, and fish species, including commercially valuable ones such as armorhead (Rogers et al., 2012).

Deep-sea sponges are vital in linking benthic and pelagic zones, facilitating energy, mass, and nutrient exchange. Their abundance suggests they significantly influence global biogeochemical cycles, including the marine silicon cycle (Hanz et al., 2022; Maldonado et al., 2019). Through filtration, sponges contribute to nitrogen cycling, help maintain oxygen levels in deep waters (Pham et al., 2019), and support benthic food webs by producing detrital waste and recycling dissolved organic matter (Bart et al., 2021). At Schulz Bank, several sponge species actively remove bioavailable nutrients such as ammonium and nitrate from the marine ecosystem through denitrification and coupled nitrification–denitrification processes (Rook et al., 2020). Recently, extensive sponge grounds exceeding 15 km² were discovered on the Karasik Seamount in the Arctic Ocean, representing the most northerly and densest Geodia community documented to date (Morganti et al., 2022). These sponge grounds play a crucial role in local biodiversity, hosting a rich variety of fauna, including octocorals and bryozoans, while also contributing to benthic-pelagic coupling and biogeochemical cycles (Morganti et al., 2022).

An analysis of over 5,000 seafloor images reveals that the average biomass of epibenthic megafauna on 20 seamounts in the southwest Pacific is nearly four times higher than that of the adjacent continental slope at comparable depths (Rowden et al., 2010).Diverse seamount communities in Australia and New Zealand, for example, are associated with a matrix formed over geological times by the scleractinian coral *Solenosmilia variabilis* (Williams et al., 2010). Rowden et al. 2017 found that starfish and crinoids exhibit parallel distribution to that of the stony coral *Solenosmilia variabilis* over several seamounts. On the Louisville Seamount Chain, camera tows repeatedly recorded VME indicator species with corals being observed at depths deeper than anticipated (Clark et al., 2014).

Further evidence suggests that seamount assemblage structures can differ from neighbouring habitats. For example, coral assemblages on North-East Atlantic seamounts are distinct from those on the continental slope (Hall-spencer et al., 2007). The relative abundance of taxa between Davidson Seamount and the adjacent slope is markedly different (McClain et al., 2009). Additionally, equivalent samples of ophiuroids in terms of depth and area showed different community compositions between seamounts and nearby continental slope areas. This variation is due to certain ophiuroid species on seamounts being repeatedly associated with *Solenosmilia variabilis* and a higher presence of cryptic species (O'Hara et al., 2008).

In addition to providing habitat for a wide array of species, seamounts could play a crucial role in deep-sea ecological processes by facilitating long-distance dispersal across ocean basins (Rowden, Dower, et al., 2010). Their vibrant communities may also serve as larval sources for nearby non-seamount habitats, contributing to ecological connectivity and enhancing regional biodiversity in deep-sea environments (McClain et al., 2009).x

Beyond the benthos, some seamounts possess unique physiographic and biological characteristics of considerable value to ocean systems that can influence species diversity at spatial scales as far as 40 km from summits (Fiori et al., 2016; Morato et al., 2010). Numerous studies have demonstrated relationships between seamount summit depths and productivity, with shallower summits, particularly those within the euphotic zone (<200–400 m), inducing substantial changes in benthic assemblage structure and supporting higher abundances of pelagic species (Hann et al., 2016; McClain & Lundsten, 2015; Morato et al., 2008). A recent study suggests that seamounts are crucial in the active transport loop of organic matter from the euphotic zone downward to the mesopelagic-benthic zone through the daily migration of zooplankton, influencing depths up to 600 metres and extending their impact over 30 kilometres horizontally (Wang et al., 2024). This transportation of organic matter to the depths induces ecological oases within the oligotrophic areas (Wang et al., 2024). On a global scale, nearly half of seamounts with summit depths above 100 m exhibit long-term, persistent, seamount-induced chlorophyll enhancements (Leitner et al., 2020). These productivity enhancements enable seamounts to support greater biomass (Morato et al., 2006). A large-scale analysis using fisheries data from the Pacific found that seamounts have higher pelagic megafauna species richness than coastal or oceanic areas (Morato et al., 2010). Species such as tunas, sharks, and other pelagic fish are attracted to seamounts, where they aggregate, and it is likely that seamounts serve as migratory pathways (Morato et al., 2010).

Seamounts are increasingly recognised as critical features in a rapidly changing seascape, not only for their vulnerability but also for their potential to act as refuges. Their slopes may help mitigate the effects of ocean warming on benthic fauna by providing migration routes that allow species to stay within their thermal limits (Tittensor et al., 2010). Additionally, remote seamounts serve as some of the last refuges for marine predators in the Indo-Pacific, offering protection from human pressures (Letessier et al., 2019).

The variability within seamounts, driven by their different shapes, summit depths, sizes, locations, and evolutionary histories, leads to these features altering their local environments in distinct ways, even in neighbouring areas (Rowden et al., 2005). Clark et al. (2011) developed a classification system using biological and environmental data, dividing the estimated 10,604 large seamounts globally into 194 groups spread across 14 bathyal biogeographic provinces as identified by Watling et al. (2013). For instance, in the biogeographic province where the Louisville seamounts are located, there are 517 seamounts categorised into 17 distinct groups. This classification illustrates the differences in biological communities on seamounts within the same bathyal or abyssal province and region, highlighting the structural complexity of seamount ecosystems despite hosting similar higher-level taxa.

5. Policy and Regulatory Frameworks for Seamount Protection as VMEs

The conservation of deep-sea biodiversity on the high seas, including the protection of seamounts, dates to 2004 with States committing to several UNGA resolutions (including paragraphs 119 and 120 of resolution 64/72). That year, CBD COP 7 Decision VII/5 recommendations stressed the urgency for rapid action to address threats on the basis of the precautionary approach and the ecosystem approach, in marine areas beyond the limits of national jurisdiction, in particular areas with seamounts, hydrothermal vents, and cold water corals, and other vulnerable ecosystems and certain other underwater features, resulting from processes and activities in such areas.

With limited progress, the 2021 UN's 2nd World Ocean Assessment highlighted that "*Fishing, especially bottom trawling, constitutes the greatest current threat to seamount ecosystems*" (Keynote points, pg. 439) (Clark et al., 2021). In 2022, reiterating the need to implement actions from previous resolutions, the UNGA resolution 77/118 urged States to take immediate action *"to sustainably manage fish stocks and protect vulnerable marine ecosystems, including seamounts, hydrothermal vents and cold water corals, from fishing practices with significant adverse impacts on vulnerable marine ecosystems, recognizing the immense importance and value of deep-sea ecosystems and the biodiversity they contain, as documented in the first World Ocean Assessment"* (UNGA, 2022).

Resolution 77/118 also reminds States to rely on the best available scientific information to ensure the wide application of the precautionary and ecosystem approaches. It emphasises that VMEs must be protected from the significant adverse impacts of bottom fishing, and that adequate measures remain in place until the knowledge gaps highlighted in previous resolutions are addressed, impact assessments consistent with the FAO Guidelines are conducted, and the actions called for in both the 2022 and previous UNGA resolutions are effectively implemented. The resolution calls for assessing the impacts of bottom fisheries on all species associated with or dependent on VMEs, emphasising comprehensive biodiversity protection rather than merely protecting percentages of overall taxonomic groups.

It is worth noting that the vulnerability of seamounts and the urgent need for their conservation were first highlighted 20 years ago. Both the UNGA (Table 1) and the CBD have established standards to which Member States have committed, requiring them to pursue sustainable development and biodiversity conservation, including the conservation of seamounts. The 2004 IUCN Resolutions also emphasised the protection of seamounts in the high seas, recognising their ecological importance as biodiversity hotspots (IUCN, 2004). Meanwhile, research studies on seamounts have documented that the recovery period following significant adverse impacts from bottom trawling extends well beyond what can be considered temporary. According to the FAO Guidelines, temporary impacts are defined as those occurring over a temporal scale of 5-20 years (FAO, 2009). However, no recovery has been observed within this timeframe (Goode et al., 2020). In the North Pacific, signs of recovery on seamounts have only been observed after 30-40 years of protection, highlighting the significant adverse impacts that occurred but also demonstrating that long-term protection can potentially lead to recovery (Baco et al., 2019). Similarly, in the South Pacific, evidence suggests that certain seamount coral communities are in the early stages of post-trawling recovery 20 years after closures (Goode et al., 2024)

Despite the well-documented vulnerability of seamounts to bottom trawling (Goode et al., 2020), the implementation of seamount protection by RFMOs remains inconsistent. Using the UNGA resolutions and the FAO Guidelines as a reference, certain RFMOs have acknowledged the importance of seamount protection. For instance, the Northwest Atlantic Fisheries Organization (NAFO) has recognised seamounts as VME indicators and has implemented closures for all seamounts within its management area at fishable depths to bottom trawling (NAFO, 2022). Similarly, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has identified seamounts as VMEs, prohibiting all trawling on the high seas in its convention area (CCAMLR, 2008). The North East Atlantic Fisheries Commission (NEAFC) has designated seamounts as VME elements (ICES, 2013), resulting in several seamount closures to bottom trawling. The General Fisheries Commission for the Mediterranean (GFCM) has also recognised seamounts as VME indicator features (GFCM, 2007). The South East Atlantic Fisheries Organisation (SEAFO) has closed at least 12 seamounts to all fishing gear (FAO, 2015). Individual States have also designated seamounts as VMEs. Fisheries and Oceans Canada (DFO) designated all Canadian Pacific seamounts as VMEs and Ecologically or Biologically Significant Areas (EBSAs) within the marine protected area (MPA) process. Following this designation, a significant Offshore Pacific Area of Interest (AOI) was established to strengthen their protection and conservation efforts (Ban et al., 2016; DFO, 2020, 2021). In 2015, Chile implemented the precautionary approach by closing its 117 seamounts to trawling (Ministerio de Economía, 2015). Nearly a decade later, a 2024 Schmidt Ocean Institute expedition to these seamounts uncovered abundant VMEs, including deep-sea coral reefs and sponge gardens, as well as the discovery of more than 100 new species to science.

Conversely, the Southern Indian Ocean Fisheries Agreement (SIOFA), the South Pacific Regional Fisheries Management Organisation (SPRFMO), the North Pacific Fisheries Commission (NPFC) have not yet recognised seamounts as VMEs. Despite the best available scientific knowledge, these organisations have not acknowledged or adopted the precautionary approach framework to close seamounts to bottom trawl fisheries. This is notable given that these RFMOs share some of the same contracting parties who implement seamount protection measures in accordance with UNGA resolution and FAO guidelines in other ocean regions. To ensure consistent protection of VMEs, associated species, and the wider biodiversity in the deep ocean, it is important that States recognise that under the UNGA resolution and the FAO Guidelines, all seamounts are VME entities (Watling & Auster, 2017).

In cases of incomplete or uncertain data, applying the precautionary approach widely, as required by the UN Fish Stocks Agreement, ensures that decisions are based on the best available scientific evidence. This principle calls for the implementation of protective measures to prevent potential harm, even in the absence of comprehensive data.

Globally, only 1.5% (n = 581) of seamounts are located within VME closed areas, with most of these closures situated in the Atlantic Ocean (Kerry et al., 2022). However, the management of the high seas is undergoing a rapid transformation due to the BBNJ (Biodiversity Beyond National Jurisdiction) agreement. While achieving the "30 by 30" global conservation target—mandated by the CBD's Kunming-Montreal Global Biodiversity Framework (Target 3) and aimed at combating biodiversity loss, mitigating climate change, and safeguarding natural systems (CBD, 2022)—may be challenging, significant progress can still be made by leveraging existing frameworks. Protecting seamounts within RFMO convention areas can be a crucial step towards achieving these protection goals and ensuring that VMEs are fully protected, as mandated by the UNGA resolutions. This approach enables RFMOs to exercise their competence over these areas, rather than deferring management responsibilities to the BBNJ agreement. Estimates suggest there are 22,040 seamounts on the high seas that rise at least 1,000 metres from the seabed (Kerry et al., 2022, Yesson et al., 2021), with average seamount size of 860 km² in area (Harris et al., 2014; Yesson et al., 2021). Seamount protection alone could potentially achieve roughly up to 9.4% of the "30 by 30" high seas conservation target.

Bibliography

Althaus, F., Williams, A., Schlacher, T. A., Kloser, R. J., Green, M. A., Barker, B. A., Bax, N. J., Brodie, P., & Hoenlinger-Schlacher, M. A. (2009). Impacts of bottom trawling on deep-coral ecosystems of seamounts are long-lasting. Marine Ecology Progress Series, 397, 279–294. https://doi.org/10.3354/meps08248

Auster, P. J., Malatesta, R. J., Langton, R. W., Watling, L., Valentine, P. C., Donaldson, C. L. S., Langton, E. W., Shepard, A. N., & Babb, I. G. (1996). The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Reviews in Fisheries Science, 4(2), 185–202.

Auster, P. J., Moore, J., Heinonen, K. B., & Watling, L. (2005). A habitat classification scheme for seamount landscapes: assessing the functional role of deep-water corals as fish habitat. In Cold-water corals and ecosystems (pp. 761–769). Springer. https://doi.org/10.1007/3-540-27673-4

Baco, A. R., Morgan, N. B., & Roark, E. B. (2020). Observations of vulnerable marine ecosystems and significant adverse impacts on high seas seamounts of the northwestern Hawaiian Ridge and Emperor Seamount Chain. Marine Policy, 115, 103834. https://doi.org/10.1016/j.marpol.2020.103834

Baco, A. R., Morgan, N. B., Roark, E. B., & Biede, V. (2023). Bottom-contact fisheries disturbance and signs of recovery of precious corals in the Northwestern Hawaiian Islands and Emperor Seamount Chain. Ecological Indicators, 148(August 2022), 110010. https://doi.org/10.1016/j.ecolind.2023.110010

Baco, A. R., Roark, E. B., & Morgan, N. B. (2019). Amid fields of rubble, scars, and lost gear, signs of recovery observed on seamounts on 30- to 40-year time scales. Science Advances, August, 1–8. DOI:10.1126/sciadv.aaw4513

Baco, A. R., Ross, R., Althaus, F., Amon, D., Bridges, A. E. H., Brix, S., Buhl-mortensen, P., Colaco, A., Carreiro-silva, M., Clark, M. R., Preez, C. Du, Franken, M., Gianni, M., Gonzalez-mirelis, G., Hourigan, T., Howell, K., Levin, L. A., Lindsay, D. J., Molodtsova, T. N., … Vic. (2023). Towards a scientific community consensus on designating Vulnerable Marine Ecosystems from imagery. PeerJ, 1–54. https://doi.org/10.7717/peerj.16024

Baillon, S., Hamel, J., Wareham, V. E., & Mercier, A. (2012). Deep cold-water corals as nurseries for fish larvae. Frontiers in Ecology and the Environment, 10(7), 351–356. https://doi.org/10.1890/120022

Ban, S., Curtis, J. M. R., Germain, C. S., Perry, R. I., & Thomas, W. (2016). Identification of Ecologically and Biologically Significant Areas (EBSAs) in Canada ' s Offshore Pacific Bioregion. In Fisheries and Oceans Canada, Ecosystems and Oceans Science. (Issue June). https://oaresource.library.carleton.ca/wcl/2016/20160718/Fs70-5-2016-034-eng.pdf

Barrio Froján, C., Downie, A. L., Sacau Cuadrado, M., Kenchington, E., & Kenny, A. (2016). Evaluation of benthic assemblage structure in the NAFO regulatory area with regard to the protection of VME. ICES Journal of Marine Science, 73(2), 405–419. https://doi.org/doi:10.1093/icesjms/fsv186

Barry, J. P., Litvin, S. Y., Devogelaere, A., Caress, D. W., Lovera, C. F., Kahn, A. S., Burton, E. J., King, C., Paduan, J. B., Wheat, C. G., Girard, F., Sudek, S., Hartwell, A. M., Sherman, A. D., Mcgill, P. R., Schnittger, A., Voight, J. R., & Martin, E. J. (2023). Abyssal hydrothermal springs — Cryptic incubators for brooding octopus. Science Advances, 3247(August), 1–13. https://doi.org/10.1126/sciadv.adg3247

Bart MC, Hudspith M, Rapp HT, Verdonschot PFM, Goeij JM De, Xavier JR. A Deep-Sea Sponge Loop? Sponges Transfer Dissolved and Particulate Organic Carbon and Nitrogen to Associated Fauna. Front Mar Sci. 2021;8(March):1-12. doi:10.3389/fmars.2021.604879

Beazley, L. I., Kenchington, E. L., Murillo, F. J., & Sacau, M. (2013). Deep-sea sponge grounds enhance diversity and abundance of epibenthic megafauna in the Northwest Atlantic. ICES Journal of Marine Science, 70(7), 1471–1490. https://doi.org/doi:10.1093/icesjms/fst124

Bo, M., Coppari, M., Betti, F., Massa, F., Gay, G., Cattaneo-Vietti, R., & Bavestrello, G. (2020). Unveiling the deep biodiversity of the Janua Seamount (Ligurian Sea): first Mediterranean sighting of the rare Atlantic bamboo coral Chelidonisis aurantiaca Studer, 1890. Deep Sea Research Part I: Oceanographic Research Papers, 156, 103186

Boehlert, G. W., & Sasaki, T. (1988). Pelagic biogeography of the armorhead, Pseudopentaceros wheeleri, and recruitment to isolated seamounts in the North Pacific Ocean. Fishery Bulletin, 86(3), 453–465.

Buhl-Mortensen, L., & Mortensen, P. B. (2005). Distribution and diversity of species associated with deep-sea gorgonian corals off Atlantic Canada. In A. Freiwald & J. . Roberts (Eds.), Cold-water corals and ecosystems (pp. 849–879). Springer-Verlag Berlin Heidelberg. https://www.academia.edu/download/39261722/09e41510fbb40a32ce000000.pdf

Burton, E., & Lundsten, L. (2008). Davidson Seamount Taxonomic Guide. In Marine Sanctuaries Conservation Series ONMS-08-08 Davidson (Issue December).

CCAMLR. (2008). Conservation Measure 22-05 (2008) Restrictions on the use of bottom trawling gear in high-seas areas of the Convention Area (Vol. 05).https://cm.ccamlr.org/en/measure-22-05-2008

CBD (2022). Decision adopted by the conference of the parties to the convention on biological diversity 15/4. Kunming-montreal global biodiversity framework. https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf.

Clark, M. (1999). Fisheries for orange roughy (Hoplostethus atlanticus) on seamounts in New Zealand. Oceanologica Acta, 22(6), 593–602. https://doi.org/10.1016/S0399-1784(00)88950-1

Clark, M., Anderson, O., Bowden, D., Chin, C., Glasgow, D., Guinotte, J., Hererra, S., Osterhage, D., Pallentin, A., Parker, S., Rowley, S., Stewart, R., Tracey, D., & Zeng, C. (2014). VOYAGE REPORT OF A SURVEY OF DEEP-SEA HABITATS OF THE LOUISVILLE SEAMOUNT CHAIN (TAN1402). May.

Clark, M., & O'Driscoll, R. (2003). Deepwater fisheries and aspects of their impact on seamount habitat in New Zealand. Journal of Northwest Atlantic Fishery Science, 31, 441–458. https://doi.org/10.2960/J.v31.a34

Clark, M. R., Althaus, F., Schlacher, T. A., Williams, A., Bowden, D. A., & Rowden, A. A. (2016). The impacts of deep-sea fisheries on benthic communities: A review. ICES Journal of Marine Science, 73, i51–i69. https://doi.org/10.1093/icesjms/fsv123

Clark, M. R., Angelo, B. F., Roberts, J. M., Bhavani, E. N., Snelgrove, P., & Tuhumwire, T. . (2021). Seamounts and pinnacles. In The Second World Ocean Assesment: Vol. I (pp. 439–451). United Nations. https://www.researchgate.net/publication/351039404_Chapter_7L_Seamounts_and_pinnacles

Clark, M. R., Bowden, D. A., Rowden, A. A., Stewart, R., Cury, P. M., & Clark, M. R. (2019). Little Evidence of Benthic Community Resilience to Bottom Trawling on Seamounts After 15 Years. Frontiers in Marine Science, 6(February), 1–16. https://doi.org/10.3389/fmars.2019.00063

Clark, M. R., & Koslow, J. A. (2007). Impacts of fisheries on seamounts. Seamounts: Ecology, Fisheries & Conservation, 413–441.

Clark, M. R., Rowden, A. A., Schlacher, T., Williams, A., Consalvey, M., Stocks, K. I., Rogers, A. D., O'Hara, T. D., White, M., Shank, T. M., & Hall-Spencer, J. M. (2010). The Ecology of Seamounts: Structure, Function, and Human Impacts. Annual Review of Marine Science, 2(1), 253–278. https://doi.org/10.1146/annurev-marine-120308-081109

Clark, M. R., & Tittensor, D. P. (2010). An index to assess the risk to stony corals from bottom trawling on seamounts. Marine Ecology, 31(SUPPL. 1), 200–211.

https://doi.org/10.1111/j.1439 -0485.2010.00392.x

Clark, M. R., Watling, L., Rowden, A. A., Guinotte, J. M., & Smith, C. R. (2011). A global seamount classification to aid the scientific design of marine protected area networks. Ocean and Coastal Management, 54(1), 19–36. https://doi.org/10.1016/j.ocecoaman.2010.10.006

Clark, M. R., Wood, B., Mackay, K., Anderson, O. F., Hart, A., Rickard, G., & Rowden, A. (2022). Underwater Topographic Features in the New Zealand region: development of an updated ' SEAMOUNT ' database and information on the extent and intensity of deep -sea trawl fisheries on them (Vol. 6480, Issue 291). https://www.mpi.govt.nz/dmsdocument/53304 -AEBR-291-Underwater-Topographic-Features-in-the-New-Zealand-region-development-of-an-updated-SEAMOUNT-database-and-information-on-the-extent-and-intensity-of-deep-sea-trawl-fisheries-on-them

Collette, B., Fernandes, P., Heessen, H., Herrera, J., & Smith-Vaniz, W. F. (2015). Hoplostethus atlanticus. The IUCN Red List of Threatened Species. https://www.iucnredlist.org/species/155168/45884209

Costello, M. (2009). Distinguishing marine habitat classification concepts for ecological data management. Marine Ecology Progress Series, 397, 253–268. https://doi.org/10.3354/meps08317

Davies, J. S., Stewart, H. A., Narayanaswamy, B. E., & Jacobs, C. (2015). Benthic Assemblages of the Anton Dohrn Seamount (NE Atlantic): Defining Deep-Sea Biotopes to Support Habitat Mapping and Management Efforts with a Focus on Vulnerable Marine Ecosystems. PloS One, 1–33. https://doi.org/10.1371/journal.pone.0124815

de Forges, R. B., Koslow, J. A., & Poore, G. C. B. (2000). Diversity and endemism of the benthic seamount megafauna in the southwest Pacific. Nature, 405(June), 944–947.

Devine, J. A., Baker, K. D., & Haedrich, R. L. (2006). Deep-sea fishes qualify as endangered. Nature Communications, 439, 29. https://doi.org/https://doi.org/10.1038/439029a

DFO. (2020). Biophysical and Ecological Overview of the Offshore Pacific Area of Interest (AOI). DFO Can (Issue April 2019). https://waves -vagues.dfo-mpo.gc.ca/library -bibliotheque/40783832.pdf

DFO. (2021). Identification of Representative Seamount Areas in the Offshore Pacific Bioregion, Canada (Issue September). https://waves -vagues.dfo-mpo.gc.ca/library -bibliotheque/41006768.pdf

Drazen, J. C., & Haedrich, R. L. (2012). A continuum of life histories in deep-sea demersal fishes. Deep Sea Research I, 61, 34–42.

Fallon, S. ., Thresher, R. ., & Adkins, J. (2014). Age and growth of the cold-water scleractinian Solenosmilia variabilis and its reef on SW Pacific seamounts. Coral Reefs, 31–38. https://doi.org/10.1007/s00338 -013-1097-y

FAO. (2009). International guidelines for the management of deep-sea fisheries in the high seas. FAO. https://openknowledge.fao.org/handle/20.500.14283/i0816t

FAO. (2015). SEAFO Convention area VMEs. http://www.seafo.org/media/73652d8b-6742-4282-8efb-4a318b11375b/SEAFOweb/pdf/SC/private/2018/eng/DOC SC 14 2018 -Protocols for opening of areas closed to all fisheries_docx

Fiori, C., Paoli, C., Alessi, J., Mandich, A., & Vassallo, P. (2016).Seamount attractiveness to top predators in the southern Tyrrhenian Sea (central Mediterranean). Journal of the Marine Biological Association of the United Kingdom, 96(3), 769–775.

Fosså, J. H., Mortensen, P. B., & Furevik, D. M. (2002). The deep-water coral Lophelia pertusa in Norwegian waters : distribution and fishery impacts. Hydrobiologia, 471, 1–12. https://doi.org/https://doi.org/10.1023/A:1016504430684

Garcia, S. M. (1994). The Precautionary Principle: its Implications in Capture Fisheries Management.

22, 99–125.

GFCM. (2007). GFCM Contribution to UN-RES 74/18 The. https://www.un.org/Depts/los/bfw/GFCM Bottom Fishing Contribution.pdf

Gibson, C., Valenti, S. V., Fordham, S. V., & Fowler, S. L. (2008). The conservation status of Northeast Atlantic chondrichthyans. Report of the IUCN Shark Specialist Group Northeast Atlantic Red List Workshop (pp. 13-15). https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=672d1a9a31445da61166d35904006b3310fdc35e

Goode, S. L., Rowden, A. A., Bowden, D. A., & Clark, M. R. (2020). Resilience of seamount benthic communities to trawling disturbance. Marine Environmental Research, 161(April), 105086. https://doi.org/10.1016/j.marenvres.2020.105086

Goode, S., Rowden, A., Clark, M., Bowden, D., & Stephenson, F. (2024). Early Signs of Recovery Suggested by Changes in the Structure and Function of Deep-Sea Megabenthic Communities on a Seamount 19 Years after Fishing. https://doi.org/https://doi.org/10.2139/ssrn.4878360

Gofas, S. and Beu, A., 2001. Tonnoidean gastropods of the North Atlantic seamounts and the Azores. American Malacological Bulletin, 17(1/2), pp.91-108.

Gros, C., Jansen, J., Dunstan, P. K., Welsford, D. C., & Hill, N. A. (2022). Vulnerable, but Still Poorly Known, Marine Ecosystems: How to Make Distribution Models More Relevant and Impactful for Conservation and Management of VMEs ? Frontiers in Marine Science, 9(June), 1–12. https://doi.org/10.3389/fmars.2022.870145

Hall-spencer, J., Rogers, A., Davies, J., & Foggo, A. (2007). Deep-sea coral distribution on seamounts, oceanic islands, and continental slopes in the Northeast Atlantic. Bulletin of Marine Science, 81(3), 135–146. https://www.ingentaconnect.com/content/umrsmas/bullmar/2007/00000081/a00103s1/art00013

Hanafi-Portier, M., Samadi, S., Corbari, L., Boulard, M., Miramontes, E., Penven, P., Leroy, B., Napol, T., Jorry, J., & Olu, K. (2024). Deep-Sea Research Part I Multiscale spatial patterns and environmental drivers of seamount and island slope megafaunal assemblages along the Mozambique channel. Deep-Sea Research Part I, 203(November 2023), 1–23. https://doi.org/10.1016/j.dsr.2023.104198

Hann, C. H., Smith, T. D., & Torres, L. . (2016). A sperm whale's perspective: The importance of seasonality and seamount depth. Marine Mammal Science, 1–12. https://doi.org/10.1111/mms.12320

Hanz U, Riekenberg P, Kluijver A De, et al. The important role of sponges in carbon and nitrogen cycling in a deep- - sea biological hotspot. Funct Ecol. 2022;(July 2021):2188-2199. doi:10.1111/1365-2435.14117

Harris, P. T., Macmillan-lawler, M., Rupp, J., & Baker, E. K. (2014). Geomorphology of the oceans. Marine Geology, 352, 4–24. https://doi.org/10.1016/j.margeo.2014.01.011

Higgs, N. D., & Attrill, M. J. (2015). Biases in biodiversity: wide-ranging species are discovered first in the deep sea. Frontiers in Marine Science, 2(August), 1–8. https://doi.org/10.3389/fmars.2015.00061

Horn, P. L., & Maolagáin, C. O. (2019). A comparison of age data of orange roughy (Hoplostethus atlanticus) from the central Louisville Seamount Chain in 1995 and 2013–15 (Vol. 5352, Issue July). https://docs.niwa.co.nz/library/public/FAR2019-29.pdf

Howell, K. L., Mowles, S. L., & Foggo, A. (2010). Mounting evidence: Near-slope seamounts are faunally indistinct from an adjacent bank. Marine Ecology, 31(SUPPL. 1), 52–62. https://doi.org/10.1111/j.1439-0485.2010.00368.x

ICES. (2013). Special request , Advice June 2013 General advice Assessment of the list of VME indicator species and elements. June, 1–13. https://ices-library.figshare.com/articles/report/Assessment_of_the_list_of_VME_indicator_species_and_elements/18687656?file=33471803

IUCN. (2004). RES 3.066 The protection of seamounts, deep-sea corals and other vulnerable deep-sea habitats from destructive fishing practices, including bottom trawling, on the high seas. https://portals.iucn.org/library/sites/library/files/resrecfiles/WC C_2004_RES_66_EN.pdf

Iwamoto, T. (2015). Coryphaenoides rupestris. IUCN Red List Threat Species, 576. https://doi.org/https://dx.doi.org/10.2305/IUCN.UK.2015 -4.RLTS.T15522149A15603540.en

Jones, D. O. B., Yool, A., Wei, C., & Henson, S. A. (2014). Global reductions in seafloor biomass in response to climate change. Global Change Biologyha, 1861–1872. https://doi.org/10.1111/gcb.12480

Kelly, C. J., Connolly, P. L., & Bracken, J. . (1997). Age estimation , growth , maturity and distribution of the roundnose grenadier from the Rockall trough. Journal of Fish Biology, 50, 1–17. https://doi.org/doi.org/10.1111/j.1095 -8649.1997.tb01336.x

Kerry, C. R., Exeter, O. M., & Witt, M. J. (2022). Monitoring global fishing activity in proximity to seamounts using automatic identification systems. Fish and Fisheries, January, 733–749. https://doi.org/10.1111/faf.12647

Kerwath, S., Roodt-Wilding, R., Samaai, T., Winker, H., West, W., Surajnarayan, S., Swart, B., Bester-van der Merwe, A., Götz, A., Lamberth, S., & Wilke, C. (2021). Shallow seamounts represent speciation islands for circumglobal yellowtail Seriola lalandi. Scientific Reports, 11(1), 3559. https://doi.org/10.1038/s41598 -021-82874-9

Ketchum, J. T., Hearn, A., Klimley, A. P., Espinoza, E., Peñaherrera, C., & Largier, J. L. (2014). Seasonal changes in movements and habitat preferences of the scalloped hammerhead shark (Sphyrna lewini) while refuging near an oceanic island. Marine Biology, 161(5), 755–767. https://doi.org/10.1007/s00227 -013-2375-5

Klimley, A. P., Butler, S. B., Nelson, D. R., & Stull, A. T. (1988). Diel movements of scalloped hammerhead sharks, *Sphyrna lewini* Griffith and Smith, to and from a seamount in the Gulf of California. Journal of Fish Biology, 33(5), 751–761. https://doi.org/10.1111/j.1095 -8649.1988.tb05520.x

Knudby, A., Kenchington, E., & Murillo, F. J. (2013). Modelling the Distribution of Geodia Sponges and Sponge Grounds in the Northwest Atlantic. PLOS ONE, 8(12), 1–20. https://doi.org/10.1371/journal.pone.0082306

Korseberg, L. (2018). The law-making effects of the FAO deep-sea fisheries guidelines. International and Comparative Law Quarterly, 67(October), 801–832. https://doi.org/10.1017/S0020589318000192

Koslow, J. A. (1996). Energetic and life-history patterns of deep-sea benthic, benthopelagic and seamount-associated fish. Journal of Fish Biology, 49, 54–74.

Koslow, J., Gowlett-Holmes, K., Lowry, J., O'Hara, T., Poore, G., & Williams, a. (2001). Seamount benthic macrofauna off southern Tasmania: community structure and impacts of trawling. Marine Ecology Progress Series, 213, 111–125.

Kutti, T., Windsland, K., Falkenhaug, T., & Biuw, M. (2019). Seamounts in the OSPAR Maritime Area-from species to ecosystems (Issue October 2020). https://imr.brage.unit.no/imr-xmlui/bitstream/handle/11250/2685885/RH%2B2019 -42.pdf?sequence=2

Kvile, K. O., Taranto, G. H., Pitcher, T. J., & Morato, T. (2014).A global assessment of seamount ecosystems knowledge using an ecosystem evaluation framework. Biological Conservation, 173, 108–120. https://doi.org/10.1016/j.biocon.2013.10.002

Lapointe, A. E., Watling, L., France, S. C., & Auster, P. J. (2020). DeepSea Research Part I Megabenthic assemblages in the lower bathyal (700 – 3000 m) on the New England and Corner

Rise Seamounts , Northwest Atlantic. Deep-Sea Research Part I, 165(January), 1–13. https://doi.org/10.1016/j.dsr.2020.103366

Leitner, A. B., Neuheimer, A. B., & Drazen, J. C. (2020). Evidence for long - term seamount - induced chlorophyll enhancements. Scientific Reports, 1–10. https://doi.org/10.1038/s41598-020-69564-0

Letessier, T., Mouillot, D., Bouchet, P., Vigliola, L., Fernandes, M., Thompson, C., Boussarie, G., Turner, J., Juhel, J., Maire, E., & Caley, M. (2019). Remote reefs and seamounts are the last refuges for marine predators across the Indo- Pacific. PLoS Biology, 1–20. https://doi.org/https://doi.org/10.1371/journal.pbio.3000366

Macdonald, J. M. (1995). Appreciating the precautionary principle as an ethical evolution in ocean management. Ocean Development & International Law, November 2014, 37–41. https://doi.org/10.1080/00908329509546062

Maguire, K., Williams, A., Neill, H. O., Althaus, F., & White, W. (2023). Seamount coral reefs are egg case nurseries for deep-sea skates. Journal of Fish Biology, March, 1455–1469. https://doi.org/10.1111/jfb.15376

Maldonado M, López-acosta M, Sitjà C, et al. Sponge skeletons as an important sink of silicon in the global oceans. Nat Geosci. 2019;12(October):815-823. doi:10.1038/s41561-019-0430-7

McClain, C. R., & Lundsten, L. (2015). Assemblage structure is related to slope and depth on a deep offshore Pacific seamount chain. Marine Ecology, 36(2), 210–220. https://doi.org/10.1111/maec.12136

McClain, C. R., Lundsten, L., Barry, J., & DeVogelaere, A. (2010). Assemblage structure, but not diversity or density, change with depth on a northeast Pacific seamount. Marine Ecology, 31(SUPPL. 1), 14–25. https://doi.org/10.1111/j.1439-0485.2010.00367.x

McClain, C. R., Lundsten, L., Ream, M., Barry, J., & DeVogelaere, A. (2009). Endemicity, biogeography, composition, and community structure on a Northeast Pacific seamount. PLoS ONE, 4(1). https://doi.org/10.1371/journal.pone.0004141

Menard, H. W. (1964). Marine geology of the Pacific.

Meyer, H. K., Roberts, E. M., Rapp, H. T., & Davies, A. J. (2019). Deep-Sea Research Part I Spatial patterns of arctic sponge ground fauna and demersal fish are detectable in autonomous underwater vehicle (AUV) imagery. Deep-Sea Research Part I, 153(March), 103137. https://doi.org/10.1016/j.dsr.2019.103137

Miller, K. J., & Gunasekera, R. M. (2017). A comparison of genetic connectivity in two deep sea corals to examine whether seamounts are isolated islands or stepping stones for dispersal. Scientific Reports, 7(November 2016), 1–14. https://doi.org/10.1038/srep46103

Ministerio de Economía, F. y T. (2015). Ley 20657: Modifica en el ámbito de la sustentabilidad de recursos hidrobiológicos, acceso a la actividad pesquera industrial y artesanal y regulaciones para la investigación y fiscalización, la Ley General de Pesca y Acuicultura contenida en la ley. N°18. https://www.bcn.cl/leychile/navegar?idNorma=1048776

Morato, T., & Clark, M. R. (2007). Seamount fishes: ecology and life histories. In T. J. Pitcher, T. Morato, P. J. B. Hart, M. R. Clark, N. Haggan, & R. S. Santos (Eds.), Seamounts: ecology, fisheries, and conservation. Blackwell Fisheries and Aquatic Resources Series (Vol. 12). Blackwell Publishing Ltd. https://www.researchgate.net/profile/Nigel-Haggan/publication/228333317_Seamount_Ecology_Fisheries_Conservation/links/59dfa1b645851537160082c0/Seamount-Ecology-Fisheries-Conservation.pdf#page=197

Morato, T., Hoyle, S. D., Allain, V., & Nicol, S. J. (2010). Seamounts are hotspots of pelagic biodiversity in the open ocean. Proceedings of the National Academy of Sciences, 107(21), 9707–9711. https://doi.org/10.1073/pnas.0910290107

Morato, T., Varkey, D. A., Damaso, C., Machete, M., Santos, M., Prieto, R., Santos, R. S., & Pitcher,

T. J. (2008). Evidence of a seamount effect on aggregating visitors. Marine Ecology Progress Serieso, 357(Fonteneau 1991), 23–32. https://doi.org/10.3354/meps07269

Morato, T., Watson, R., Pitcher, T. J., & Pauly, D. (2006). Fishing down the deep. Fish and Fisheries, 7(1), 24–34.

Morgan, N. B., Cairns, S., Reiswig, H., & Baco, A. R. (2015). Benthic megafaunal community structure of cobalt-rich manganese crusts on Necker Ridge. Deep-Sea Research Part I: Oceanographic Research Papers, 104, 92–105. https://doi.org/10.1016/j.dsr.2015.07.003

Morganti, T. M., Slaby, B. M., & de Kluijver, A. (2022). Giant sponge grounds of Central Arctic seamounts are associated with extinct seep life. Nature Communications, 13(638), 1–15. https://doi.org/10.1038/s41467-022-28129-7

Morrison, K. M., Meyer, H. K., Roberts, E. M., Rapp, H. T., Colaço, A., Pham, C. K., Clark, M. R., & Tuck, I. D. (2020). The First Cut Is the Deepest: Trawl Effects on a Deep-Sea Sponge Ground Are Pronounced Four Years on. Frontiers in Marine Science, 7(December), 1–13. https://doi.org/10.3389/fmars.2020.605281

Muñoz, P. D., Sayago-Gil, M., Patrocinio, T., González-Porto, M., Murillo, F. J., Sacau, M., González, E., Fernández, G., & Gago, A. (2012). Distribution patterns of deep-sea fish and benthic invertebrates from trawlable grounds of the Hatton Bank, north-east Atlantic: Effects of deep-sea bottom trawling. Journal of the Marine Biological Association of the United Kingdom, 92(7), 1509–1524. https://doi.org/10.1017/S002531541200015X

NAFO. (2022). NAFO input to the 2022 General Assembly review on the impacts of bottom fishing Further (Issue March). https://www.un.org/Depts/los/bfw/NAFO__2022.pdf

O'Hara, T. D., Rowden, A. A., & Williams, A. (2008). Cold-water coral habitats on seamounts: Do they have a specialist fauna? Diversity and Distributions, 14(6), 925–934. https://doi.org/10.1111/j.1472-4642.2008.00495.x

OSPAR. (2011). Background Document on the Josephine Seamount Marine Protected Area Biodiversity Series. Biodiversity Series, 1–27. https://www.ospar.org/documents?v=7278

Pante, E., France, S. C., Gey, D., Cruaud, C., & Samadi, S. (2015). An inter-ocean comparison of coral endemism on seamounts: The case of Chrysogorgia. Journal of Biogeography, 42(10), 1907–1918. https://doi.org/10.1111/jbi.12564

Payne, R. P., Samaai, T., Janson, L., Kerwath, S. E., & Gibbons, M. J. (2025). Eleven new heteroscleromorph Demospongiae (Porifera), and a new record of the tetractinellid Ancorina corticata, from Walters Shoal, a shallow seamount on the Madagascar Ridge in the South West Indian Ocean (SWIO). Zootaxa, 5575(1), 1-56.doi: 10.11646/zootaxa.5575.1.1

Pham, C. K., Diogo, H., Menezes, G., Porteiro, F., Braga-henriques, A., Vandeperre, F., & Morato, T. (2014). Deep-water longline fishing has reduced impact on Vulnerable Marine Ecosystems. Scientific Reports, 4(4837), 1–6. https://doi.org/10.1038/srep04837

Pham CK, Murillo FJ, Lirette C, Maldonado M, Colaço A, Ottaviani D. Removal of deep-sea sponges by bottom trawling in the Flemish Cap area : conservation , ecology and economic assessment. 2019:1-14. doi:10.1038/s41598-019-52250-1

Pham, C. K., Vandeperre, F., Menezes, G., Porteiro, F., Isidro, E., & Morato, T. (2015).The importance of deep-sea vulnerable marine ecosystems for demersal fish in the Azores. Deep-Sea Research Part I, 96, 80–88. https://doi.org/10.1016/j.dsr.2014.11.004

Periasamy, R., Kurian, P. J., & Ingole, B. (2023).A new deep-water coral species Telestula ridgensis sp. nov (Scleralcyonacea: Sarcodictyonidae) from the seamount of the Central Indian Ridge. Zootaxa, 5254(2), 231–244. https://doi.org/10.1007/s41208-023-00597-8

Pitcher, R., Williams, A., & Georgeson, L. (2019). Progress with investigating uncertainty in the habitat suitability model predictions and VME indicator taxa thresholds underpinning CMM 03 -

2019 (Issue Paper for SPRFMO SC7).https://www.sprfmo.int/assets/2019 -SC7/Meeting-Docs/SC7-DW21-rev1-Uncertainty-in-model-predictions-and-VME-thresholds-for-CMM-03-2019.pdf

Preez, C. Du, Curtis, J. M. R., & Clarke, M. E. (2016).The structure and distribution of benthic communities on a shallow seamount (Cobb Seamount, Northeast Pacific Ocean). PLoS ONE, 11(10), 1–29. https://doi.org/10.1371/journal.pone.0165513

Probert, P. K., McKnight, D. G., & Grove, S. L. (1997). Benthic invertebrate bycatch from a deep-water trawl fishery, Chatham Rise, New Zealand. Aquatic Conservation: Marine and Freshwater Ecosystems, 7(1), 27–40.

Ramiro-Sánchez, B., Gonzalez Irusta, J. M., Henry, L.-A., Cleland, J., Yeo, I., Xavier, J., Carreiro-Silva, M., Sampaio, Í., Spearman, J., Victorero, L., Messing, C., Kazanidis, G., Roberts, J. M., & Murton, B. (2019). Characterization and mapping of a deep-sea sponge ground on the Tropic Seamount (Northeast tropical Atlantic): implications for spatial management in the High Seas. Frontiers in Marine Science, 6(May), 278. https://doi.org/10.3389/FMARS.2019.00278

Ramiro-Sánchez, B., Martin, A., & Leroy, B. (2023). The epitome of data paucity: deep-sea habitats of the Southern Indian Ocean. Biological Conservation, 283, 110096. https://doi.org/10.1016/j.biocon.2023.110096

Rengaiyan, R., & Ingole, B. (2025). Evolutionary relationship of novel deep-sea coral species (Octocorallia: Victorgorgiidae) from the Central Indian Ridge seamount links with Pacific Ocean species. Available at SSRN, 4942083. https://ssrn.com/abstract=4942083

Rengaiyan, P., Kurian, J., & Ingole, B. (2023). Two black corals (Anthozoa: Antipatharia) from the seamount of Central Indian Ridge (1917 m) and deeper Southwest Indian Ridge (4007 m). Thalassas, 39, 1117–1124. https://doi.org/10.1007/s41208 -023-00597-8

Rigby, C., & Simpfendorfer, C. A. (2015). Patterns in life history traits of deep-water chondrichthyans. Deep Sea Research Part II: Topical Studies in Oceanography, 115(0), 30–40. https://doi.org/http://dx.doi.org/10.1016/j.dsr2.2013.09.004

Roark, E. B., Guilderson, T. P., Dunbar, R. B., Fallon, S. J., & Mucciarone, D. A. (2009). Extreme longevity in proteinaceous deep-sea corals. Proceedings of the National Academy of Sciences, 106(13), 5204–5208. https://doi.org/10.1073/pnas.0810875106

Roberts, C. M. (2002). Deep impact: the rising tool of fishing in the deep sea. Trends in Ecology & Evolution, 17(5), 242–246. https://doi.org/https://doi.org/10.1016/S0169 -5347(02)02492-8

Rogers, A. D. (1994). The biology of seamounts. In Advances in marine biology (Vol. 30, pp. 305–350). Elsevier.

Rogers, A. D. (2018). The Biology of Seamounts: 25 Years on. In Advances in Marine Biology (Vol79, pp 137-224) https://doi.org/10.1016/bs.amb.2018.06.001

Rogers, A. D., & Taylor, M. L. (2012). Benthic biodiversity of seamounts in the Southwest Indian Ocean. *Cruise Report – R/V James Cook 066 Southwest Indian Ocean Seamounts Expedition – November 7*. https://www.bodc.ac.uk/resources/inventories/cruise_inventory/reports/jc066.pdf

Rooks C, Fang JK, Mørkved PT, et al. Deep-sea sponge grounds as nutrient sinks: denitrification is common in boreo-Arctic sponges. Biogeosciences. 2020;17:1231-1245. doi:https://doi.org/10.5194/bg -17-1231-2020

Ross, T., Du Preez, C., & Ianson, D. (2020).Rapid deep ocean deoxygenation and acidification threaten life on Northeast Pacific seamounts. Global Change Biology, July, 6424–6444. https://doi.org/10.1111/gcb.15307

Rowden, A. A., Anderson, O. F., Georgian, S. E., Bowden, D. A., Clark, M. R., Pallentin, A., & Miller, A. (2017). High-Resolution Habitat Suitability Models for the Conservation and Management of

Vulnerable Marine Ecosystems on the Louisville Seamount Chain, South Pacific Ocean. Frontiers in Marine Science, 4(October). https://doi.org/10.3389/fmars.2017.00335

Rowden, A. A., Clark, M. R., & Wright, I. C. (2005). Physical characterisation and a biologically focused classification of "seamounts" in the New Zealand region. New Zealand Journal of Marine and Freshwater Research, 39(5), 1039–1059. https://doi.org/10.1080/00288330.2005.9517374

Rowden, A. A., Dower, J. F., Schlacher, T. A., Consalvey, M., & Clark, M. R. (2010). Paradigms in seamount ecology: Fact, fiction and future. Marine Ecology, 31(SUPPL. 1), 226–241. https://doi.org/10.1111/j.1439 -0485.2010.00400.x

Rowden, A. A., Schlacher, T. A., Williams, A., Clark, M. R., Stewart, R., Althaus, F., Bowden, D. A., Consalvey, M., Robinson, W., & Dowdney, J. (2010). A test of the seamount oasis hypothesis: Seamounts support higher epibenthic megafaunal biomass than ad jacent slopes. Marine Ecology, 31(SUPPL. 1), 95–106. https://doi.org/10.1111/j.1439 -0485.2010.00369.x

Samadi, S., Bottan, L., Macpherson, E., De Forges, B. R., & Boisselier, M. C. (2006). Seamount endemism questioned by the geographic distribution and population genetic structure of marine invertebrates. Marine Biology, 149(6), 1463–1475. https://doi.org/10.1007/s00227 -006-0306-4

Sampaio, I., Braga-Henriques, A., & Pham, C. (2012). Cold-water corals landed by bottom longline fisheries in the Azores (north-eastern Atlantic). Journal of Marine Biological Association of the United Kingdom, March, 1 –9. https://doi.org/10.1017/S0025315412000045

Sautya, S., Ingole, B., Ray, D., Stöhr, S., Samudrala, K., Kamesh Raju, K. A., & Mudholkar, A. (2011). Megafaunal community structure of Andaman seamounts including the Back -Arc Basin - a quantitative exploration from the Indian Ocean. PLoS ONE, 6(1). https://doi.org/10.1371/journal.pone.0016162

Shester, G., & Ayers, J. (2005). A cost effective approach to protecting deep -sea coral and sponge ecosystems with an application to Alaska's Aleutian Islands region. In A. Freiwald & M. J. Roberts (Eds.), Cold-water Corals and Ecosystems (pp. 1151–1169). Springer-Verlag Berlin Heidelberg. https://doi.org/10.1007/3 -540-27673-4_59

Staudigel, H., & Clague, D. A. (2010). The geological history of deep-sea volcanoes: Biosphere, hydrosphere, and lithosphere interactions. Oceanography, 23(1), 58–71.

Stocks K. SeamountsOnline: an online information system for seamount biology. SeamountsOnline: an online information system for seamount biology. seamounts.sdsc.edu. Published 2010. Accessed August 20, 2018.

Tittensor, D. P., Baco, A. R., Hall-Spencer, J. M., Orr, J. C., & Rogers, A. D. (2010). Seamounts as refugia from ocean acidification for cold -water stony corals. Marine Ecology, 31(SUPPL. 1), 212–225. https://doi.org/10.1111/j.1439 -0485.2010.00393.x

UNGA. (2022). 77/118 -Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks a (Vol. 1833, Issue 31363). https://documents.un.org/doc/undoc/ltd/n22/716/08/pdf/n2271608.pdf?token=vmLoDbVnqZcE4HtpCX&fe=true

UN (2016) First World Oceans Assessment. 2016

UN (2022) Second World Ocean Assessment. 2022

Victorero, L. (2019). Spatial patterns in benthic seamount habitats: Scales, drivers and effects on biodiversity. University of Southampton.

Victorero, L., Robert, K., Robinson, L. F., Taylor, M. L., & Huvenne, V. A. I. (2018). Species replacement dominates megabenthos beta diversity in a remote seamount setting. Scientific

Reports, 8(1), 4152. https://doi.org/10.1038/s41598 -018-22296-8

Waller RG, Goode S, Tracey D, Johnstone J, Mercier A. A review of current knowledge on reproductive and larval processes of deep - sea corals. Mar Biol. 2023;170(5):1-27. doi:10.1007/s00227-023-04182-8

Waller, R., Watling, L., Auster, P., & Shank, T. (2007). Anthropogenic impacts on the Corner Rise seamounts, north-west Atlantic Ocean. Journal of the Marine Biological Association of the UK, 87(05), 1075–1076. https://doi.org/10.1017/S0025315407057785

Wang, X., Li, H., Zhang, J., Chen, J., Xie, X., Xie, W., Yin, K., Zhang, D., & Ruiz-, D. (2024). Seamounts generate efficient active transport loops to nourish the twilight ecosystem. Science Advances, 10, 1–10. https://doi.org/10.1126/sciadv.adk6833

Watling, L., & Auster, P. J. (2017). Seamounts on the High Seas Should Be Managed as Vulnerable Marine Ecosystems. Frontiers in Marine Science, 4 (January), 1–4. https://doi.org/10.3389/fmars.2017.00014

Watling, L., & Auster, P. J. (2021). Vulnerable Marine Ecosystems, Communities, and Indicator Species: Confusing Concepts for Conservation of Seamounts. Frontiers in Marine Science, 8(May), 1–7. https://doi.org/10.3389/fmars.2021.622586

Watling, L., Guinotte, J., Clark, M. R., & Smith, C. R. (2013). A proposed biogeography of the deep ocean floor. Progress in Oceanography, 111, 91–112. https://doi.org/10.1016/j.pocean.2012.11.003

Williams, A., Althaus, F., Green, M., Maguire, K., Untiedt, C., Mortimer, N., Jackett, C. J., Clark, M., Bax, N., Pitcher, R., Schlacher, T., Pham, C. K., & Xavier, J. R. (2020). True Size Matters for Conservation : A Robust Method to Determine the Size of Deep-Sea Coral Reefs Shows They Are Typically Small on Seamounts in the Southwest Pacific Ocean. Frontiers in Marine Science, 7(April), 1–18. https://doi.org/10.3389/fmars.2020.00187

Williams, A., Schlacher, T. A., Rowden, A. A., Althaus, F., Clark, M. R., Bowden, D. A., Stewart, R., Bax, N. J., Consalvey, M., & Kloser, R. J. (2010). Seamount megabenthic assemblages fail to recover from trawling impacts. Marine Ecology, 31(SUPPL. 1), 183–199. https://doi.org/10.1111/j.1439-0485.2010.00385.x

Yesson, C., Clark, M. R., Taylor, M. L., & Rogers, A. D. (2011). The global distribution of seamounts based on 30 arc seconds bathymetry data. Deep Sea Research Part I: Oceanographic Research Papers, 58(4), 442–453. https://doi.org/http://dx.doi.org/10.1016/j.dsr.2011.02.004

Yesson, C., Letessier, T. B., Nimmo-smith, A., Hosegood, P., Brierley, A. S., Hardouin, M., & Proud, R. (2021). Improved bathymetry leads to > 4000 new seamount predictions in the global ocean – but beware of phantom seamounts! UCL Open Environment, 3(17), 1–9. https://doi.org/https://doi.org/10.14324/111.444/ucloe.000030

Zeng, C., Rowden, A. A., Clark, M. R., & Gardner, J. P. A. (2017). Population genetic structure and connectivity of deep- - sea stony corals (Order Scleractinia) in the New Zealand region: Implications for the conservation and management of vulnerable marine ecosystems. Evolutionary Applications, March, 1040–1054. https://doi.org/10.1111/eva.12509