Identification of Ecologically or Biologically Significant Marine Areas (EBSAs) in Areas Beyond National Jurisdiction (ABNJ): the Northwest Pacific Seamounts

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IDENTIFICATION OF ECOLOGICALLY OR BIOLOGICALLY SIGNIFICANT MARINE AREAS (EBSAS) IN AREAS BEYOND NATIONAL JURISDICTION (ABNJ): THE NORTHWEST PACIFIC SEAMOUNTS

By

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Abstract

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Marine Areas Beyond National Jurisdiction (ABNJ) are the common heritage of humankind and require coordinated protection, conservation, restoration, and sustainable use by the international community. A common first step in marine area-based management is the identification of Ecologically or Biologically Significant Marine Areas (EBSAs) using the United Nations Convention of Biological Diversity (CBD) scientific criteria. While possessing many EBSA qualities, a published EBSA assessment for the Northwest (NW) Pacific seamounts is lacking. Herein, the CBD EBSA criteria are applied to a seamount complex within ABNJ between the United States (Mariana Islands, Guam, Wake Island Marine National Monument), Federated States of Micronesia, Marshall Islands, and Japan (Ogasawara and Minamitori Island). The EBSA assessment concluded that these Magellan, Marcus-Wake, and Marshall seamounts rank *High* for all EBSA criteria except one (*Medium* ranking) and strongly identify these NW Pacific seamounts as an EBSA, including their surrounding water. Existing or anticipated threats to the seamounts include but are not limited to seabed mining and climate change. This NW Pacific Ocean Seamounts EBSA identification synthesizes the best available science and provides a robust assessment and thorough review to support marine area-based management and future CBD workshops on the region.

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Résumé

Du Preez, C., Amon, D. J., Baco, A. R., Best, M., Clyde, G., Colaço, A., Gartner, H., Lauer, R.M., Orcutt, B. N., Metaxas, A. and Tunnicliffe, V. 2023. Identification of Ecologically or Biologically Significant Marine Areas (EBSAs) in Areas Beyond National Jurisdiction (ABNJ): the Northwest Pacific Seamounts. Can. Tech. Rep. Fish. Aquat. Sci. 3571: vi + 21 p.

Les zones situées au-delà de la zone de compétence nationale constituent le patrimoine commun de l'humanité et nécessitent une protection, une conservation, une restauration et une utilisation durable coordonnées par la communauté internationale. Une première étape commune de la gestion marine par zone est la désignation des zones marines d'importance écologique ou biologique (ZIEB) à l'aide des critères scientifiques de la Convention des Nations Unies sur la diversité biologique (CDB). Bien que les monts sous-marins du Pacifique Nord-Ouest présentent de nombreuses qualités propres aux ZIEB, leur évaluation par rapport aux critères de désignation des ZIEB reste à publier. Dans le présent document, les critères de désignation des ZIEB établis dans la CDB sont appliqués à un complexe de monts sous-marin dans la ZIEB située entre les États-Unis (îles Mariannes, Guam, monument national marin de l'île), les États fédérés de Micronésie, les îles Marshall et le Japon (archipel d'Ogasawara et île Minamitori). L'évaluation par rapport aux critères de désignation des ZIEB a permis de conclure que les monts sous-marins Magellan, Marcus-Wake et Marshall se classent à un niveau *élevé* pour tous les critères, sauf un (*moyen*) et qu'il est pleinement justifié qu'ils forment une ZIEB avec leurs eaux environnantes. Les menaces actuelles ou prévues pour les monts sous-marins sont notamment l'exploitation minière des fonds marins et les changements climatiques. Le processus de désignation des monts sous-marins du Pacifique Nord-Ouest en tant que ZIEB synthétise les meilleures données scientifiques disponibles et constitue une évaluation solide et un examen approfondi à l'appui de la gestion marine par zone et des futurs ateliers de la CDB dans la région.

Introduction

Marine Areas Beyond National Jurisdiction (ABNJ) are the common heritage of humankind and require coordinated protection, conservation, restoration, and sustainable use by the international community. There are multiple international agreements supporting this objective (e.g., the Sustainable Development Goals and the Biodiversity Beyond National Jurisdiction 'treaty'; Christiansen et al. 2022), the success of which relies on all signatories to uphold the principles, rights, duties, and obligations, such as applying precautionary and ecosystem-based approaches and using science-based, transparent management.

A common first step in marine area-based management is the identification of Ecologically or Biologically Significant Marine Areas (EBSAs) using the United Nations Convention of Biological Diversity (CBD) scientific criteria as defined in Annex I of Decision IX/20 of its 9th Conference of Parties (UNEP/CBD 2008). The seven CBD EBSA criteria are (1) uniqueness or rarity, (2) special importance for life-history stages of species, (3) importance for threatened, endangered or declining species and/or habitats, (4) vulnerability, fragility, sensitivity, or slow recovery, (5) biological productivity, (6) biological diversity, and (7) naturalness. A marine feature is identified as an EBSA if it scores *High* on at least one criterion or above average across all (i.e., *Medium* or *High* for cumulative importance; DFO 2004, 2011). The possible rankings are: *No information*, *Low*, *Medium*, and *High*.

Seamounts are underwater mountains—usually volcanic in origin—that provide many essential ecosystem functions and services (summarized in DOSI 2023). Seamounts are most abundant in the North Pacific Ocean and are notably concentrated in three regions (Kitchingman et al. 2007; FAO 2023). The CBD has evaluated two of these three North Pacific seamount regions and designated large complexes of seamount chains and clusters as EBSAs in ABNJ: the 'Emperor Seamount Chain and Northern Hawaiian Ridge' (central North Pacific) and the 'Northeast Pacific Ocean Seamounts'. These EBSAs were identified because the seamount chains have unique geographic features, provide habitats for a variety of benthic species (including vulnerable and long-lived cold-water corals and sponges), are fish spawning grounds, their biological productivity is higher than that of the neighbouring ocean floor, and their chains and configurations–spanning thousands of kilometres–facilitates migration (CBD 2016a,b). Despite sharing many of these EBSA qualities—a s well as holding global distinction among seamounts—a published EBSA assessment for the Northwest (NW) Pacific seamounts is lacking.

Herein, the CBD EBSA criteria are applied to the region of NW Pacific seamounts within ABNJ, i.e. the complex of Magellan, Marcus-Wake, and Marshall seamounts. This EBSA assessment was completed by an international working group of scientists led by Fisheries and Oceans Canada. Members of the group participated in two international science workshops on the topic: the Workshop on the Development of a Regional Environmental Management Plan (REMP) for the Area of the Northwest Pacific (hosted by the International Seabed Authority (ISA), online, October 26th to November 6th 2020) and the Global Ocean Biodiversity Initiative (GOBI) EBSAs in ABNJ workshop (hosted by GOBI, in Santa Cruz, California, November 6th to 9th 2022).

At REMP workshop, invited experts reviewed data and information on seamounts in the area, much of which were pre-compiled in documents to support the discussions. The ISA Workshop Report (ISA 2022) captures the approach adopted. The workshop produced a predictive model of the areas and abundances of the region's seamounts (n = 205) (using the Benthic Terrain Modeler; Walbridge et al. 2018). EBSA-related assessments were conducted for three surveyed seamounts and the seamount complex as a whole, all scoring *Medium* to *High* rankings. At the EBSA in ABNJ workshop, invited experts reviewed and assessed EBSAs in ABNJ using the CBD EBSA workshop approach (GOBI 2023). An extended draft EBSA assessment for the NW Pacific seamount complex was discussed and refined using new publications and additional relevant biological and environmental information and datasets. The EBSA assessment for the ABNJ NW Pacific seamounts is now presented here in its completed form.

Ecological research on these ABNJ NW Pacific seamounts is still in its early stages, as indicated by the frequent discovery of “species new to science” during each expedition (e.g., Wang et al. 2016; Dong et al. 2017; Xu et al. 2017; Dong et al. 2019; Hestetun et al. 2019; Zhang et al. 2019, 2020; Kou et al. 2020; Gan et al. 2020; Shen et al. 2020; Chen et al. 2021a, b; Grischenko 2022). Very few of the seamounts have been visually surveyed, and fewer still have openly accessible data (e.g., Ocean Exploration 2016 expedition dive on Alba Seamount; https://www.ncei.noaa.gov/waf/okeanos-rov-cruises/ex1606/). Public access to video surveys of the benthos by seabed mining companies and contractors (referenced in ISA 2022) would help fill existing knowledge gaps. However, the growing body of published literature, knowledge from international subject matter experts (workshop participants), and openly available large-scale datasets (e.g., the GEBCO maps and Undersea Feature Names database (IHO-IOC GEBCO Gazetteer of Undersea Feature Names, www.gebco.net), seamount classification systems (e.g., Yesson et al. 2011), and global distributions of cold-water corals (e.g., Yesson et al. 2012, 2017)) provide more than sufficient information to complete a robust EBSA assessment of the seven criteria (e.g., CBD 2016a,b).

Location

EBSA region: NW Pacific Ocean (Figure 1).

Description of location: The Magellan, Marcus-Wake, and Marshall seamounts within ABNJ (labelled on Figure 1), in an area approximately 1,500 km in diameter, between the Northern Mariana Islands and Guam of the USA, the Federated States of Micronesia, the Marshall Islands, Wake Island Unit of the Pacific Remote Islands National Marine Monument of the USA, and Ogasawara and Minamitori Islands of Japan (labelled on Figure 1).

In alignment with the other North Pacific seamount EBSA assessments (CBD 2016a,b), the NW Pacific seamount complex is evaluated here as a single EBSA. The NW Pacific seamounts function as a unit or network, having similar geological origins and forming a dense configuration of mountainous massifs (details provided in the assessment below). The buffering and grouping of seamounts by the EBSA boundaries is in alignment with the established practices of the Government of Canada and the Convention on Biological Diversity (Ban et al. 2016; CBD 2016a,b). The EBSA includes all the seamounts (regardless of summit depth) in the complex, their footprint and the water column above (Ban et al. 2016; CBD 2016a,b).

Approximate extent: 26°0'00''N 145°0'00''E (NW corner), 26°0'00''N 165°0'00''E (NE corner), 10°0'00''N 165°0'00''E (SE corner), 10°0'00''N 145°0'00''E (SW corner).

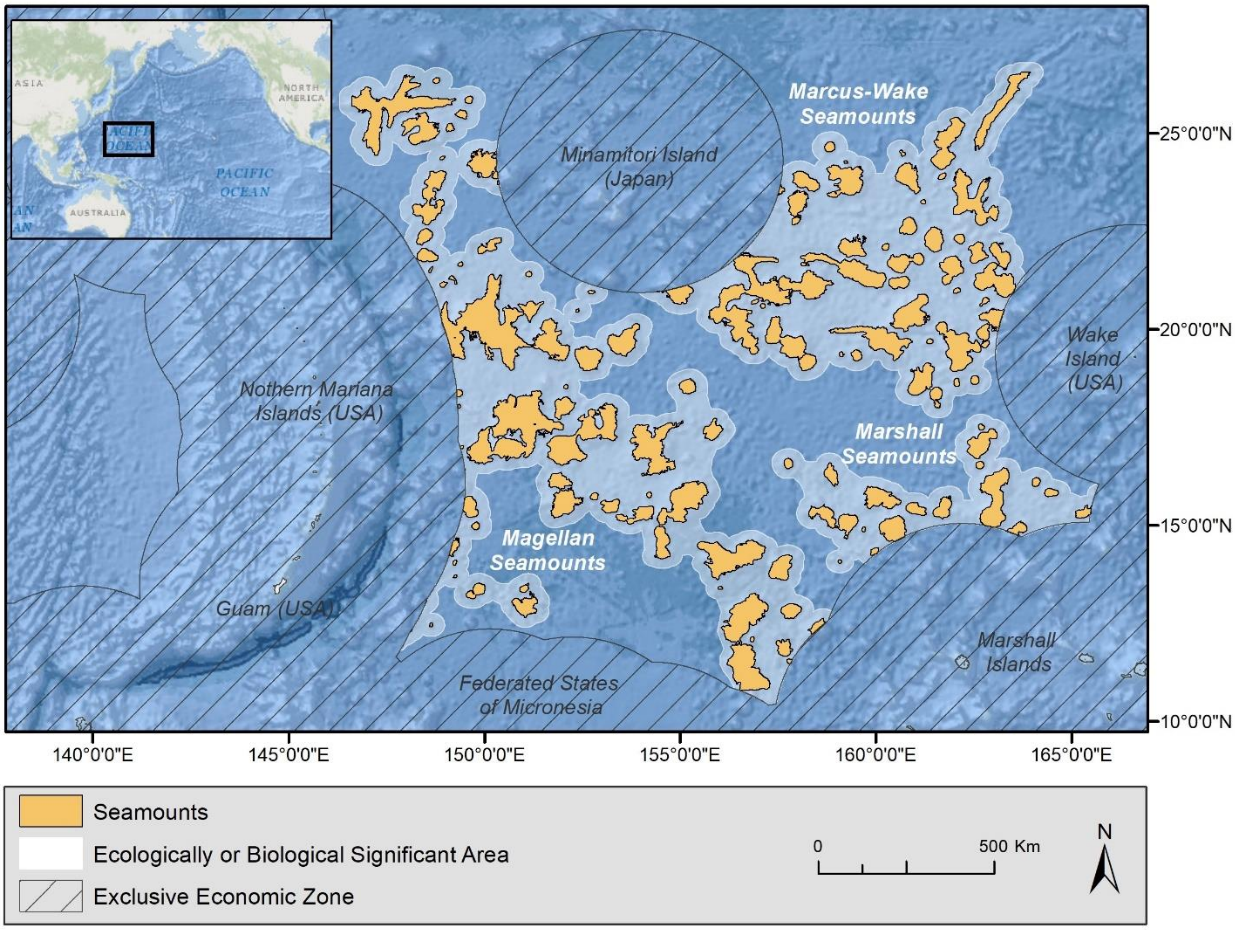

Figure 1. The Northwest (NW) Pacific Ocean Seamounts Ecologically or Biologically Significant Area (EBSA). The EBSA contains Magellan, Marcus-Wake, and Marshall seamounts in Areas Beyond National Jurisdiction (ABNJ) between the Exclusive Economic Zones (EEZs) of the United States (Northern Mariana Islands, Guam, the Wake Island Unit of the Pacific Remote Islands National Marine Monument), the Federated States of Micronesia, the Marshall Islands, and Japan (Minamitori Island and Ogasawara). Seamounts adapted from ISA 2022.

Feature description of the area

The assessed seamount complex includes the oldest seamounts and oceanic crust in the world (Clouard and Bonneville 2005; Müller et al. 2016) and some of the tallest seamounts, rising from some of the deepest basins in the world (e.g., east Marianas Basin; Stewart and Jamieson 2019) to summits as shallow as 550 m depth (e.g., Alba Guyot; Mel'nikov et al. 2016). This area also contains the highest density of seamounts in the world (Kitchingman et al. 2007; FAO 2023). Here, the Magellan, Marshall, and Marcus-Wake seamounts intersect and form a complex of volcanotectonic massifs containing approximately 205 seamounts within ABNJ (ISA 2022; only about half are named features, www.gebco.net). While abundant in number, the cumulative area of the seamounts is small and highly fragmented. Within this area, the bare rock seamounts account for only ~4.3% of the ocean floor (ISA 2022) and represent the only shallow bathyal zone habitat (between 3000 and 800 m depth; UNESCO 2009; Watling et al. 2013; ISA 2022). In contrast, the other 95.7% of the ocean floor is predominantly muddy abyssal plains and nodule fields between 6500 and 3500 m depth (UNESCO 2009; ISA 2022).

The flow of currents around and over the seamount complex is not yet resolved or well understood (ISA 2022), but it is known that these seamounts can alter local hydrodynamics, and most are within range of directly interacting with and/or impacting at least their immediate neighbours (Jiang et al. 2021; Xie et al.

2022). Prevailing currents that limit or prohibit the movement of organisms between seamounts may promote geographically isolated metapopulations or potentially endemic species. In contrast, currents that facilitate movement may result in seamount stepping stones that form a pathway for gene flow among metapopulations and migration of species (Rowden et al. 2010; Shank 2010; Miller and Gunasekera 2017).

The heights and the natural variability of the seamounts within the complex (e.g., seamount size, geomorphology, latitude, etc., summarized in ISA 2022) will drive high beta diversity within and among seamounts, and these species turnover patterns have been observed on the surveyed seamounts within the complex (e.g., Chen et al. 2021a; Shen et al. 2021). The seamounts are home to diverse fields of habitat-forming cold-water corals and sponges, dense brittle star mats, fish, sea stars, crinoids, and sea cucumbers (e.g., as summarized in ISA 2022). The seamounts are used as stopover points during migrations (e.g., as feeding grounds; Rogers 2018), and there are many transient species known to pass over the seamount complex, including commercial species (e.g., tuna and billfish; WCPFC 2019) and species of conservation concern (e.g., endangered whales, sea birds, and turtles; Block et al. 2011; IWC 2020; IUCN 2023).

Feature condition and future outlook of the area

The future outlook of the area is highly uncertain. There are cobalt-rich ferromanganese crusts (CFC) and polymetallic nodule (PMN) deep-sea mining exploration contracts from the ISA and reserve areas on dozens of the seamounts with a bias for the tallest, shallowest, flattest, and largest of the features in the complex (ISA 2022) (i.e., those most likely to have highest EBSA rankings; e.g., EBSA indicator characteristics listed in Taranto et al. 2012). These contracts are held by multiple mining entities (five companies: Beijing Pioneer Hi-Tech Development Corporation (BPHDC; China), the Government of the Republic of Korea, the China Ocean Mineral Research and Development Association (COMRA), Japan Oil, Gas, and Metals Corporation (JOGME), and the Government of the Russian Federation (https://www.isa.org.jm/maps/clarion-clipperton-fracture-zone-2/)). If mineral exploitation begins, the mining-related stressors (e.g., extreme physical disturbance, habitat removal and crushing, noise and light pollution, sediment plumes, increased ship traffic) are expected to be significant and far-reaching (i.e., on the benthos, mid-water, surface water, at and surrounding the mining sites) (e.g., Levin et al. 2016; Gollner et al. 2017; Drazen et al. 2019; and references cited therein). The concurrence of this, the first seamount mining contract and reserve areas in the world, and the EBSA qualities of these seamounts are not a coincidence. Many of the environmental conditions that make the area attractive for mining exploitation are unique, rare, and unusual biophysical and ecological seamount characteristics (e.g., geological age, environmental stability, shallow depths, accelerated currents, dense assemblage of seamounts, expansive exposed hard substrate with low sedimentation, etc.).

Additional existing and anticipated stressors in the NW Pacific include (but are not limited to) overfishing (e.g., close proximity to fishing nations), shipping traffic, pollution (including marine debris (Amon et al., 2020), microplastics, chemicals, radionuclides (e.g., Fukushima wastewater dumping; Liu and Hoskin 2023), noise and light, and climate change (e.g., Murray et al. 2015). There is evidence of overfishing of large predator species (e.g., tuna, marlin, sharks in the region; WCPFC 2019) and illegal, unreported, and unregulated fishing over these NW Pacific seamounts (Welch et al. 2022). Climate change is rapidly impacting the global ocean. It is altering temperature, acidity, oxygen concentration, currents, species distributions, marine diseases, food webs, surface conditions, etc. (IPCC 2019). Seamounts in the NW Pacific are already experiencing rapid climate change effects. For example, one of the strongest global changes in the ocean heat content in the upper 2000 m depth range occurred in this area (Cheng et al. 2021). Seamount fauna face heightened vulnerability to changing conditions due to multiple life history traits, including their limited ability to relocate (e.g., anchored in place or have a finite area of suitable habitat; Ross et al. 2020). It is unknown what cumulative and synergistic effects these local, regional, and global stressors will have on seamount-associated species, but many deep-sea studies and models forecast local and even global extinctions (e.g., Levin et al. 2020; Ross et al. 2020; Cheung et al. 2022).

Assessment of the area against the Convention on Biological Diversity (CBD) Ecological or Biological Significant Area (EBSA) criteria

The NW Pacific seamounts in ABNJ were assessed against the seven CBD EBSA criteria (Table 1).

Table 1. The Convention on Biological Diversity (CBD) Ecological or Biological Significant Area (EBSA) scientific criteria and descriptions, and the rankings and supporting information (justifications) for the Northwest (NW) Pacific seamount complex in Areas Beyond National Jurisdiction (ABNJ). Possible rankings: *No information*, *Low*, *Medium*, and *High*.

CBD EBSA Criteria	**Description**	**Ranking of criterion relevance**			
		No info.	**Low**	**Medium**	**High**
Uniqueness or rarity	**Area contains either (i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features.**				**X**

Justification

The ABNJ NW Pacific Ocean seamounts contain (i) unique, rare, and potentially endemic species (e.g., many species new to science), (ii) regionally and globally rare and distinct habitats and ecosystems (e.g., shallow, rocky, and current-swept habitats), and (iii) globally unique and unusual geomorphological and oceanographic features (e.g., some of the oldest, deepest, densest, tallest, most encrusted seamounts in the world). Therefore, the uniqueness and rarity of these seamounts is *High* (details are provided below).

The interaction of the geographic isolation of these NW Pacific seamounts and the deep-water currents within the area may be contributing to intraspecific differentiation (Kou et al. 2020) and, ultimately, endemic species. Future research is required to resolve whether new species discoveries are endemic or representative of rare species in the under-sampled region (e.g., Rowden et al. 2010). That said, the NW Pacific seamounts are proving to be a hot spot for new species discoveries and specimen collections of species that are rare or endemic species on and around the seamounts include: bryozoa, sea stars, brittle stars, sponges, corals, shrimp, barnacles, and other crustaceans (Wang et al. 2016; Dong et al. 2017; Xu et al. 2017; Dong et al. 2019; Hestetun et al. 2019; Zhang et al. 2019, 2020; Kou et al. 2020; Gan et al. 2020; Shen et al. 2020; Chen et al. 2021a,b; Grischenko 2022). This discussion on rare and endemic species also applies to the next section (i.e., 'Special importance for life-history stages of species').

In general, seamounts provide a distinctly high diversity of regionally rare habitats in close proximity, supporting a high diversity of seamount-associated species. They provide deep to shallow ocean floor, hard substrate, complex topography, altered oceanographic conditions, enhanced currents, sites of biogenic habitats (e.g., cold-water corals and sponges; Figure 2.a,b), etc. (e.g., Pitcher and Bulman 2007; Mel'nikov et al., 2016; ISA 2022; DOSI 2023). These NW Pacific seamounts, in particular, are regionally rare habitats compared to the surrounding abyssal plains. Based on analysis from the ISA 2020 workshop, only 4.26% of the ocean floor within this region of ABNJ rises over 3,000 m depth and all of it is on seamounts (ISA 2022):

- 1,000 to 0 m depth (i.e., on seamounts): 0.12%

- 2,000 to 1,000 m depth (i.e., on seamounts): 1.84%
- 3,000 to 2,000 m depth (i.e., on seamounts): 2.30%
- 3,000 to 6,000 m depth: 95.74%

The seamount habitats are also relatively rare on a global scale since the biogeographic province to which the seamounts belong is a relatively small one (i.e., the West Pacific lower bathyal province; UNESCO 2009; Watling et al. 2013), resulting in a rare corresponding faunal assemblage. Furthermore, within the biogeographic province itself, the seamounts represent unusually small and isolated patches (UNESCO 2009; Watling et al. 2013). These seamounts represent different abyssal and lower bathyal biogeographical provinces (UNESCO 2009; Watling et al. 2013) than the existing North Pacific seamount EBSAs (i.e., 'Emperor Seamount Chain and Northern Hawaiian Ridge' and 'North-east Pacific Ocean Seamounts' EBSAs; www.cbd.int/ebsa/).

The flanks and summits of NW Pacific seamounts are predicted to hold the thickest and highest concentration of ferromanganese (Fe-Mn) crust in the global ocean (Hein et al. 2013). This accumulation is caused by a unique combination of oceanographic processes (e.g., seamount-altered currents, increased deep circulation, upwelling, high nutrient concentration, high primary productivity, sediment-free lava basalt, shallow ocean floor) interacting over 75 million years (Glasby et al. 2007; Ding et al. 2009; Hein et al. 2013). Growth rates of 1-5 mm per million years (Ding et al. 2009; Hein et al. 2013) form crusts up to 200 mm thick on some of the Magellan seamounts (Glasby et al. 2007).

The unusual density and height of these NW Pacific seamounts are discussed in a section below (i.e., 'Biological productivity' and 'Biological diversity').

Special importance for life-history stages of species	**Areas that are required for a population to survive and thrive.**	**No info.**	**Low**	**Medium**	**High**
				X	

Justification

These NW Pacific seamounts connect populations and metapopulations of bathyal and benthopelagic species, allowing them to survive and thrive within the ABNJ and likely adjacent Exclusive Economic Zones (EEZs); and the shallower seamounts provide rare habitats for migratory species (oceanic migration and ontogenetic vertical migration). More research is required to understand the specific ecosystem functions provided by the seamounts to associated species, therefore, the special importance for life-history stages of species of these seamounts scored *Medium* without this information but may be determined *High* in the future (details are provided below).

These seamounts are a rare source of hard substrate habitat (exposed lava) and represent the only instances of the shallower bathyal ocean floor in the region (<3000 m depth) (ISA 2022). Therefore, the seamounts are essential habitats for all bathyal benthic and benthopelagic species and communities that are unable to live in the surrounding deep and muddy abyssal plains, such as cold-water corals and sponges, benthic and benthopelagic fish and squid, and potentially hundreds to thousands of other species (many unknown to science). Later discussions on these seamount-associated species also apply to this section.

It is well known that hydrodynamics play an important role in the biological connectivity among deep-sea populations (Shank 2010) and that seamounts influence local and regional hydrodynamics, creating areas of upwelling, enhanced flow, turbulence, tidal rectification, internal waves, eddies, lee waves, etc. (Pitcher and Bulman 2007). Depending on regional oceanographic conditions, groups of seamounts can either function as a collection of isolated submarine islands or as an interconnected network, largely depending on whether or not larval transport and colonization are facilitated by the prevailing currents (Rowden et al. 2010; Shank 2010; Miller and Gunasekera 2017).

The high density of NW Pacific seamounts generates complex flow patterns around and between seamounts, including trapped and mobile seamount-created mesoscale eddies (measured and modeled data; Jiang et al. 2021; Xie et al. 2022). Such mesoscale eddies can be important for transporting larvae around individual NW Pacific seamounts (trapped eddies) and between neighbouring seamounts (mobile eddies advected past other seamounts) (Jiang et al. 2021). Population connectivity has been documented between the individual NW Pacific seamounts and the different clusters and chains (e.g., Kou et al. 2020; Zhang et al. 2020; Chen et al. 2021a; Na et al. 2021).

Given their central location, configuration, and the uniqueness of the shallower habitats they provide, it is highly likely these ABNJ seamounts and their oceanographic processes also have larger effective oceanographic footprints, potentially influencing and connecting surrounding seamounts and other adjacent shallower bathyal habitats within the EEZs of the United States (Marianas Trench and Volcanic Arc Marine National Monument, Guam, Wake Island Marine National Monument), Federated States of Micronesia, Marshall Islands, Japan (Izu-Bonin Volcanic Arc), and possibly further. In this region, near-surface drifters tracked from the Wake Island longitude all moved westward over the seamount complex and ABNJ and into the Mariana Volcanic Arc (Kendall and Poti 2014). It is currently unknown which habitat patches support source or sink populations, what the connective pathways are, what the environmental limitations and barriers are, and how such connectivity and/or recruitment regimes change over time (e.g., steady supply of recruits, episodic recruitment events, self-recruitment; as described in Parker and Tunnicliffe 1994 and Shank 2010). The dynamics discussed above are currently unresolved but key to structuring the seamount-associated populations, contributing to the justification for the *Medium* ranking.

In addition, globally, seamounts are known to be important habitat and stopover grounds for migrating species, including commercial species, species at risk, and culturally important species (Rowden et al. 2010). Seamounts also facilitate ontogenetic vertical migration into the deep or the benthopelagic zone, with their summits acting as rare shallower nursery grounds for young to settle (e.g., Koslow 1996). As such, the migration discussion in the next section also applies here (i.e., 'Importance for threatened, endangered or declining species and/or habitats').

The importance of these offshore habitats for species to survive may increase as climate variables continue to change and impact nearshore populations first, with seamounts becoming potential refugia for some species (e.g., cold-water stony corals; Tittensor et al. 2010; summarized in Rowden et al. 2010).

Importance for threatened, endangered or declining species and/or habitats	**Area containing habitat for the survival and recovery of endangered, threatened, declining species or areas with significant assemblages of such species.**	**No info.**	**Low**	**Medium**	**High**
					X

Justification

The ABNJ NW Pacific seamounts contain habitat for the survival and recovery of endangered, threatened, declining species and areas with significant assemblages of such species, including sea turtles, sea birds, whales, sharks, pelagic fish, vulnerable cold-water corals and sponges, etc. Therefore, the importance for threatened, endangered, and declining species and habitat of these seamounts is *High* (details are provided below).

Seamounts are known hotspots of pelagic biodiversity in the open ocean and transient megafauna are known to gather around or benefit from seamount services (e.g., Rogers et al. 2018), and these NW Pacific seamounts are no exception (e.g. the presence of pelagic predators; Morato et al. 2010). Some species travel specifically to this area (e.g., polar sea birds, potentially as feeding grounds; Harrison et al. 2021), while others use converging pathways through the area to access nearby resources (e.g., Leatherback sea turtle (*Dermochelys coriacea*) nesting grounds; Benson et al. 2011; Figure 2.c). Many of these pelagic species are classified as threatened and endangered species on the International Union for Conservation of Nature (IUCN) Red List (IUCN 2023).

The International Whaling Commission currently lists data for 21 species of interest (IWC 2020), 16 of which have known primary or secondary ranges that overlap the NW Pacific seamount area, including the endangered Blue Whale (*Balaenoptera musculus*), Sei Whale (*Balaenoptera borealis*), and Sperm Whale (*Physeter marcrocephalus*; Figure 2.d). Approximately 65% of seabird species in this NW Pacific seamount area are under some degree of threat, with 44% of species classified as near threatened, vulnerable, or endangered (IUCN 2023; e.g., the Short-tailed Albatross, *Phoebastria albatrus* (Figure 2.e), the Phoenix Petrel, *Pterodroma alba,* and the Buller's Shearwaters, *Ardenna bulleri*). Sea turtle migration pathways have also been documented crossing the seamount area, including that of the vulnerable Leatherback (*D. coriacea*) and endangered Loggerhead (*Caretta caretta*) turtles (Block et al. 2011).

The area supports large pelagic fish and is a known spawning ground for many of these species (Buenafe et al. 2022). The area is surrounded by fishing nations and, as such, it experiences high pelagic fishing. The seamounts overlap the Western and Central Pacific Fisheries Commission (WCPFC) and the North Pacific Fisheries Commission (NPFC) convention areas and are located close to the southwest corner of the North Pacific Anadromous Fish Commission (NPAFC) convention area (Løbach et al. 2020). There are commercially targeted species, including declining or overfished species, in the area. For example, in 2017, the WCPFC authorized between 3,000 and 7,000 vessels to fish up to ten stocks, including Pacific Bluefin Tuna (*Thunnus orientalis*), North Pacific Striped Marlin (*Tetrapturus audax,* also *Kajikia audax*), and Oceanic Whitetip Shark (*Carcharhinus longimanus*), all three of which were assessed as 'overfished' and 'overfishing' by the WCPFC (2019) (Figure 2.f-h). Some shark, billfish, tuna, and other species had higher probability of capture and higher numbers of fish caught in association with seamounts over the southern Magellan and Marshall seamounts (Morato et al. 2010).

Most deep-sea taxa are not included in the IUCN dataset, but, based on the best available science, many of them would likely also classify as threatened or endangered. This has been recognized by the Convention on the International Trade in Endangered Species (CITES), which lists all species of black corals (Antipatharia) and many genera of stony corals (Scleractinia), coral taxa that are commonly found on seamounts of the NW Pacific, under CITES Appendix II, meaning that they may become at risk of extinction in the near future (https://cites.org/eng). In addition, many of the deep-sea species are designated by the Food and Agriculture Organization (FAO) of the United Nations and the Regional Fisheries Management Organizations as Vulnerable Marine Ecosystem (VME) indicator taxa, hence the VME discussion in the next section is also applicable here.

Vulnerability, fragility, sensitivity, or slow recovery	**Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.**	**No info.**	**Low**	**Medium**	**High**
					X

Justification

The ABNJ NW Pacific seamounts contain a relatively high proportion of sensitive habitats, biotopes and species that are functionally fragile and with slow recovery, such as all cold-water coral and sponges Vulnerable Marine Ecosystems (VMEs) that live above 3000 m in the area, all seamounts supporting these species groups, and regionally specific rare and endemic deep-sea animals. Therefore, the vulnerability, fragility, sensitivity, and slow recovery of these seamounts is *High* (details are provided below).

Cold-water coral and sponges, as well as other emergent and structure-forming invertebrates (e.g., xenophyophores), have life history characteristics such as being long-lived, slow-growing, sessile, and rigid, that make them fragile, vulnerable to impacts, and slow to recover. As such, assemblages of these taxa are considered to be VMEs (FAO 2009b; based on the designation criteria: uniqueness or rarity, functional significance of the habitat, fragility, life-history traits of component species that make recovery difficult, structural complexity). Seamounts that support these species groups are also considered VMEs (FAO 2009b).

NW Pacific seamounts are home to VME taxa, with some surveyed sites described as covered in dense and diverse cold-water coral and sponge fields (Shen et al. 2020; Shen et al. 2021; COMRA and Russian Federation expeditions reported in ISA 2022). Open data sources also confirm VME taxa occur on the surveyed seamounts (e.g., the Deepwater Exploration of the Marianas summarized in Bell et al. 2017; NOAA Deep-Sea Coral Data Portal; https://deepseacoraldata.noaa.gov/). The probability of the unexplored NW Pacific seamounts in the area harboring VME taxa is almost certain. Of the hundreds of seamounts surveyed to date in the North and Central Pacific, all have cold-water corals, sponges, and/or other VME taxa (e.g., Baco 2007; Parrish et al. 2015; Parke 2018; Baco et al. 2019; Kennedy et al. 2019; Kelley et al. 2022). These results are consistent with studies in other oceans (Watling and Auster 2017; Rogers 2018). Supporting this prediction, habitat suitability models show extremely high habitat suitability for octocorals and antipatharians on all of the NW Pacific seamounts (Yesson et al. 2012, 2017). Adjacent seamounts in the Wake Island Unit of the Pacific Remote Islands National Marine Monument host a high diversity of such corals (Kelley et al. 2022). Therefore, it is highly likely all the seamounts in the area contain vulnerable, fragile, and sensitive taxa with low resilience and slow recoveries to impacts.

Other discussions in the above sections are also relevant here. For example, rare or endemic species and geographically isolated populations, such as those on the NW Pacific seamounts, are more vulnerable to extirpation and extinction events than cosmopolitan species or populations on continental slopes (e.g., Clark et al. 2010). The species and communities on these NW Pacific seamounts are likely adapted to the extreme environmental and physical stability of the features. The CFC on the seamount slopes and the nodules on the seamount bases require millions of years of the right conditions to form (Hein and Koschinsky 2014) and, again, these are the oldest seamounts in the world. In deep-sea environments, where conditions have typically changed over geological timescales, the associated animals, adapted to these stable conditions, are expected to be highly vulnerable to any change or direct human impact, in particularly long-lived, habitat-forming deep-sea species (as summarized in Ross et al. 2020).

Biological productivity	**Area containing species, populations or communities with comparatively higher natural biological productivity.**	**No info.**	**Low**	**Medium**	**High**
					X

Justification

The ABNJ NW Pacific seamounts contain species, populations and communities with comparatively higher natural biological productivity relative to the surrounding open ocean and abyssal plains, and other seamounts in the global ocean. Therefore, the biological productivity of these seamounts is *High* (details are provided below).

Seamounts throughout the world’s oceans are associated with high biological productivity, particularly compared to the surrounding open ocean and abyssal plains (Pitcher et al. 2007). While it is generally accepted that enhanced primary production occurs over shallow and intermediate depth seamounts (e.g., Dai et al. 2020), it has also been observed in situ over a deep NW Pacific seamount (Dai et al. 2022), in contrast to the otherwise surrounding oligotrophic body of water (Yamaoka et al. 2020). In addition, visual observations from these NW Pacific seamounts of dense and high biomass cold-water coral and sponge fields and mats of ophiuroids (Chen et al. 2021a; Shen et al. 2021; ISA 2022) are consistent with seamount-associated high biological productivity, as are the enhanced sedimentation rate at the summits of seamounts (relative to the surrounding abyssal plains), organic carbon flux, and bioturbation on and around the Marcus-Wake and Magellan seamounts (Yang et al. 2020; Ota et al. 2022).

While research on these NW Pacific seamounts is still in its infancy, drivers of increased biological productivity on and around the seamounts have already been documented and are consistent with the biological observations mentioned above (i.e., enhanced primary production, sedimentation, organic carbon flux, and biomass of suspension feeders, filter feeders, and deposit feeders on and around these NW Pacific seamounts). For example,

- topographic upward movement of nutrients results in enhanced primary productivity over shallow and deep NW Pacific seamount summits (Dai et al. 2020, 2022);
- the abundance of NW Pacific seamounts creates eddies, which have critical roles in transporting, concentrating, and trapping phytoplankton and zooplankton on and around the seamounts (Jiang et al. 2021);
- current jets around the seamounts can increase the sediment and detrital suspension, enhancing food supply for suspension feeders like deep-sea corals and sponges (Jiang et al. 2021);
- enhanced near-bottom circulation and mixing by surface eddies over the seamounts (as reported by Xie et al. 2022) is expected to also increase sediment and detrital suspension;
- the raised topographic features of hard substrate support dense cold-water corals and sponges benefiting from local current enhancement and food enrichment, which in turn create local biological hotspots (Shen et al. 2021);
- seamount productivity and nutrient-enriched water is transported downstream, potentially to adjacent seamounts, by eddies or other currents (Dai et al. 2022).

Other processes likely contributing to the enhanced productivity on and around seamounts include seamount-induced current accelerations, upwelling, turbulence, and mixing (Leitner et al., 2020 and references therein) and topographic trapping of daily vertical migration (particularly for the shallower seamounts; Genin et al., 1994; Taranto et al. 2012). The spatial and temporal variation of biological productivity on and around seamounts is a complex pattern driven by these processes and others (e.g., Dower et al., 1992; Comeau et al., 1995; Dower and Mackas, 1996; Martin and Christiansen, 2009).

The high concentration of migrating species and predator species attracted to these NW Pacific seamounts discussed in the sections above are also strong indicators of high biological productivity.

The unusual density and height of the NW Pacific seamount complex discussed throughout this assessment are also pertinent in the context of biological productivity. These physical attributes (i.e., seamount size) enhance the available seafloor area for seamount-associated fauna to occupy, setting this complex apart from most other seamount areas in the world, almost all of which are less dense and contain shorter seamounts.

Biological diversity	**Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.**	**No info.**	**Low**	**Medium**	**High**
					X

Justification

The ABNJ NW Pacific seamounts contain a comparatively higher diversity of ecosystems, habitats, communities, and species, relative to the surrounding open ocean and abyssal plains, and other seamounts in the global ocean. The high alpha and beta diversity are likely owing to, in large part, the enhanced productivity, currents (discussed in the above sections), habitat complexity, and habitat heterogeneity. Therefore, the biological diversity of these seamounts is *High* (details are provided below).

Despite the limited in situ research, seamounts with the ABNJ NW Pacific are known homes to diverse benthic communities (Chen et al. 2021a; Shen et al. 2021; ISA 2022). For example, more than 90 morpho-species were recorded on a single transect between 1100 and 1300 m depth (ISA 2022) and 29 species of ophiuroids in 11 families were recorded on a single seamount (Chen et al. 2021a). The assemblages of cold-water coral and sponge fields (including large gorgonian corals and erect sponges) were described by researchers as having high biodiversity and biomass, and were recorded to completely cover the complex topography of the seamount slope and ridges (ISA 2022). In general, cold-water corals and sponges support a high diversity of invertebrate fauna and fish (e.g., Husebø et al. 2002; Buhl-Mortenson et al. 2010), providing nursery grounds, shelter, sources of food etc. (e.g., Etnoyer and Warrenchuk 2007; Baillon et al. 2012; Cau et al. 2017). Fauna associated with these NW Pacific seamount cold-water coral and sponge habitats include commensal crinoids and ophiuroids, as well as fish, crustaceans, sea stars, sea cucumbers, and sea anemones (Xu et al. 2017; ISA 2022).

These NW Pacific seamounts provide heterogeneous habitats across a range of depths as they rise from the abyssal plains across ~5.5 vertical kilometers (ISA 2022). Based on the wide depth range, in combination with the different well-stratified oceanographic layers (e.g., the western North Pacific Subtropical gyre, North Pacific Intermediate Water, and the North Pacific Deep Water; Korff et al. 2016; Yamaoka et al. 2020), and the generally accepted high depth fidelity of seamount species, we can infer a high spatial turnover (beta diversity) of benthic species on each seamount (similarly to Long and Baco 2014; Schlacher et al. 2014; Du Preez et al. 2016; Victorero et al. 2018; Morgan et al. 2019; Mejia-Mercado et al. 2019). In addition, the variability of habitats within depth bands (e.g., complex and rocky in comparison to flat and muddy) would further enhance the diversity of each seamount (e.g., Morgan et al. 2019). Lastly, with the high natural variability of the 205 seamounts (e.g., seamount size, height, sedimentation, geomorphology, latitude, etc.; ISA 2022) bathed in different oceanographic conditions (ISA 2022), high biological beta diversity between seamounts is reasonable to infer. Examples of these species turnover patterns have already been recorded within these NW Pacific seamounts. Weijia Seamount supports a dense, diverse, distinct, and highly patchy pattern of megafaunal community (inclusive of cold-water corals and sponges) as a function of habitat heterogeneity variables, such as latitude, depth, slope, curvature, rugosity, bathymetric position index, topography type, and substrate type (e.g., Chen et al. 2021a; Shen et al. 2021).

Naturalness	**Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.**	**No info.**	**Low**	**Medium**	**High**
					X

Justification

The ABNJ NW Pacific seamounts have a comparatively higher degree of naturalness as a result of the low level of human-induced disturbance and degradation relative to other seamounts (e.g., no formal bottom-contact fishing industry), but disturbance, in the form of seabed mining is under consideration in this location. Therefore, the naturalness of these seamounts is currently *High*, but that may change in the near future (details are provided below).

As summarized in ISA report (2022), these seamounts are relatively far removed from human population centers and, as a result, are isolated from many anthropogenic stressors that impact nearshore areas, such as runoff and chemical pollution. That said, the area is surrounded by fishing nations and there are pelagic fisheries over the seamounts (e.g., drifting longlines), as well as suspected illegal, unreported, and unregulated fishing (Welch et al. 2022). The removal and/or overfishing of large predator species (e.g., the tuna, billfish, and sharks fished over the seamounts; Morato et al. 2010; WCPFC 2019) can have cascading effects on ecosystem trophic structure and the environment itself (Scheffer et al. 2005). However, a survey of the Global Fish Watch database indicates very little bottom trawling effort is present (Automatic Identification System data; Kroodsma et al. 2018) —which has caused irreparable damage to the natural seafloor of many seamounts world-wide, including those in the other North Pacific seamounts EBSAs (CBD 2016a,b). No visual evidence of human activities (including mining exploration and exploitation, bottom trawl fishery, or submarine cable) was found on six surveyed seamounts in 2019 and 2020 during expeditions by COMRA (China Ocean Mineral Resources Research & Development Association) (reported in ISA 2022). No marine debris was observed on the one seamount surveyed by NOAA's Office of Ocean Exploration and Research in 2016 (Amon et al. 2020). However, whether from future mining, increased fishing, or other stressors, biological communities on seamounts are highly vulnerable to human activities (Clark et al. 2010), and climate change is rapidly impacting the global ocean, including the deep (IPCC 2019).

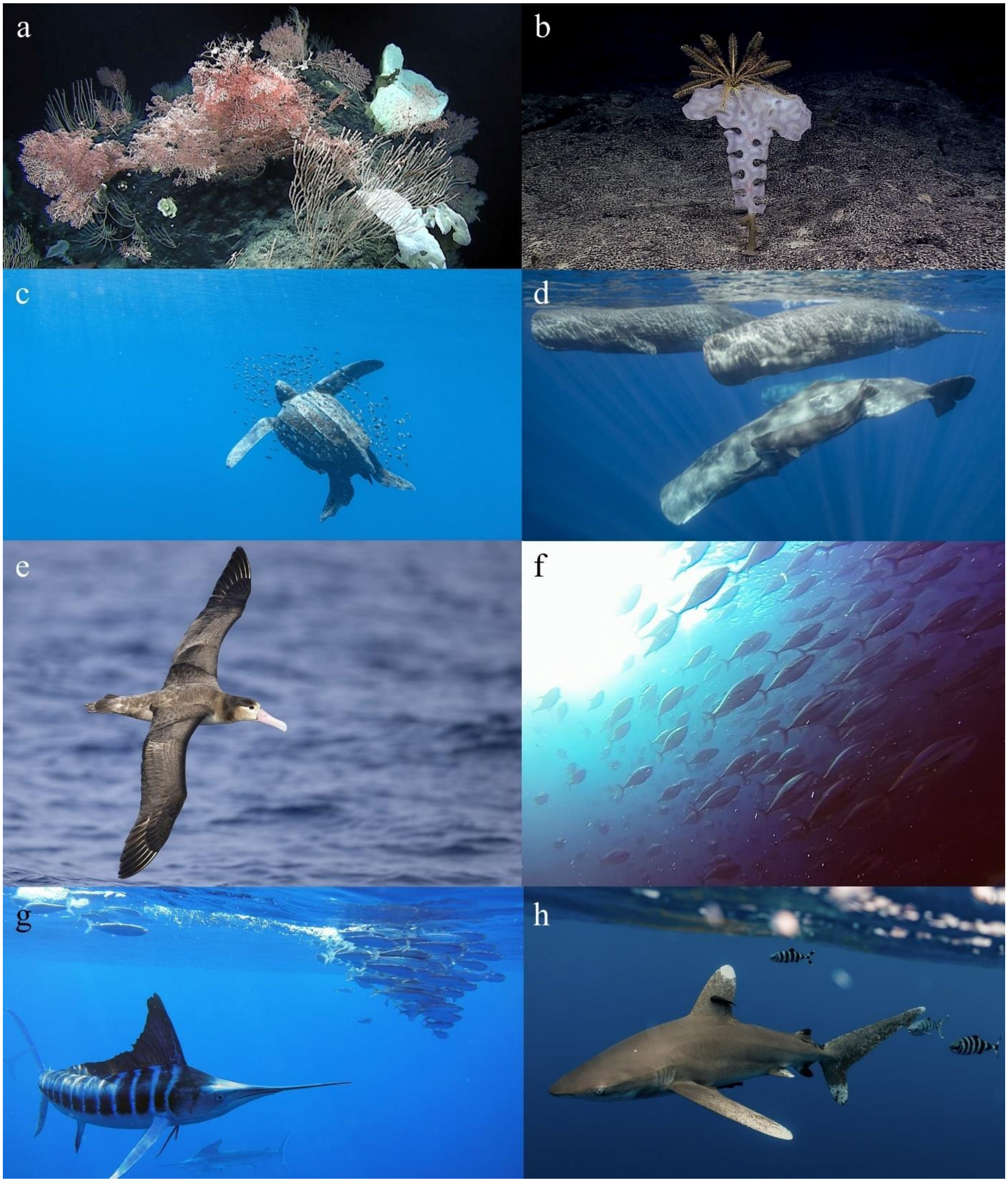

Figure 2. Northwest (NW) Pacific Ocean Seamounts support abundant and diverse communities. (a-b) Cold-water corals and sponges on ferromanganese-encrusted lava. Threatened and Endangered species include the (c) Leatherback Sea Turtle (*Caretta caretta*), (d) Sperm Whale (*Physeter marcrocephalus*), and (e) Short-tailed Albatross (*Phoebastria albatrus*). Overfished species such as the (f) Bluefin Tuna (*Thunnus orientalis*), (g) North Pacific Striped Marlin (*Tetrapturus audax*, also *Kajikia audax*), and (h) Oceanic Whitetip Shark (*Carcharhinus longimanus*). Photos courtesy of (a-b) NOAA Ocean Exploration (www.ncei.noaa.gov/waf/okeanos-rov-cruises/ex1606/), (c-g) iNaturalist (Azure 27014, Wayne and Pam Osborn, 范姜士豪 ·, Tom Mills, Royle Safaris; www.inaturalist.org), (h) Shelton Du Preez and SeaLegacy.

Conclusion

The CBD (as well as the many States that use EBSA assessments, including Canada) identifies a marine feature as an EBSA if it scores High on at least one criterion or above average across all (DFO 2004, 2011; UNEP/CBD 2008). The NW Pacific seamount complex in ABNJ scores *High* for all EBSA criteria except 'Special importance for life-history stages of species' (ranked *Medium*) and can, therefore, be classified as an EBSA (Table 2). Notably, these NW Pacific seamounts hold exceptional distinction on a regional scale, in comparison to the surrounding abyssal plains and open ocean, and on a global scale, in comparison to other seamounts and seamount complexes in the world. They are also notable for their diverse habitats, which provide high habitat heterogeneity for a wide range of species, including rare shallow-water and rocky current-swept habitats for cold-water corals and sponges, creating dense and diverse biogenic habitats. The unusual oceanographic conditions, geomorphology, and remarkable natural stability have produced rare physical and biological seamount features, such as thick cobalt-rich ferromanganese crusts, geographically isolated deep-sea populations, and rare or endemic species. The seamounts are stepping stones that form pathways for the migration of species. Pelagic species–many of which are threatened and endangered–migrate through the area and are known to benefit from the ecosystem functions provided by the seamounts. These seamounts support rich, fragile, and vulnerable species and ecosystems—from their base to their summit, the water column, and above.

This NW Pacific Ocean Seamounts EBSA identification synthesizes the best available science and provides a robust assessment and thorough review to support future CBD workshops on the region and critical regional area-based management related to fishing, climate change, seabed mining, the new Biodiversity Beyond National Jurisdiction treaty, and other spatial management processes.

Table 2. Summary of Ecological or Biological Significant Area (EBSA) assessment of the Northwest Pacific seamounts in Areas Beyond National Jurisdiction (ABNJ) against the seven criteria. Possible rankings: *No information*, *Low*, *Medium*, and *High*.

CBD EBSA Criteria	**Seamount Rating**
Uniqueness or rarity	*High*
Special importance for life-history stages of species	*Medium*
Importance for threatened, endangered or declining species and/or habitats	*High*
Vulnerability, fragility, sensitivity, or slow recovery	*High*
Biological productivity	*High*
Biological diversity	*High*
Naturalness	*High*
EBSA Identification	**Meets Criteria**

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