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Discovering the mesophotic fauna of Malpelo Ridge: biodiversity insights in a remote marine sanctuary

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Introduction

Malpelo Island is the emergent summit of the Malpelo Ridge, a NE-SW-trending oceanic volcanic ridge approximately 330 km long and 100 km wide, associated with the Cocos-Nazca volcanic province (Marcaillou et al., 2006). Numerous submerged rocky pinnacles, ridges and cones characterize the ridge. These geological features, together with the island's geographic isolation and local oceanographic conditions, provide habitat for diverse benthic communities and contribute to the development of distinct biological assemblages within the Eastern Tropical Pacific Ocean (ETPO), a region recognized for its high biodiversity, including endemic, resident, and migratory species (Enright et al., 2021). As a result, several world-renowned marine protected areas (MPAs) have been established in the region, including Malpelo Flora and Fauna Sanctuary (FFS), which has been designated as a World Heritage Site (United Nations Educational, Scientific and Cultural Organization UNESCO, 2026). Since 2020, it has also been included in the IUCN Green List (Category IV) (IUCN, 2025), and together with the Galapagos, as Particularly Sensitive Sea Areas (PSSAs) (International Maritime Organization (IMO), 2026). However, most available information on marine biodiversity in the region is limited to shallow ecosystems within the photic zone, with comparatively limited data on mesophotic and deeper habitats.

Mesophotic Coral Ecosystems (MCEs) are typically defined as occurring at depths between 30 and 150 m depth and host diverse biological communities, often with high levels of endemism (Sinniger et al., 2016). These environments are characterized by low light availability, lower temperatures, reduced dissolved oxygen concentrations, and increased hydrostatic pressure, favoring specialized biological communities (Slattery et al., 2011; Baker et al., 2016). Although advances in underwater technologies, including remotely operated

vehicles (ROVs), autonomous platforms, and mixed-gas diving, have improved access to mesophotic and deep-sea environments (Clark et al., 2006; Roberts et al., 2009), these habitats in the ETPO remain poorly documented due to logistical and technical constraints (Baker et al., 2016). In the Colombian Pacific, where deep-sea environments dominate much of the seafloor, biological and habitat mapping efforts remain limited, particularly around remote oceanic ridges and submarine elevations. Although exploratory initiatives have increased during the last decade (Cedeño-Posso et al., 2022b; Bessudo et al., 2022; Dueñas et al., 2024; Rodríguez Toscano et al., 2025), many submarine features remain insufficiently characterized.

Although Malpelo is widely recognized as an important aggregation site for pelagic species, including fishes, sharks, marine mammals, sea birds and sea turtles (Palacios-M et al., 2012), information on its mesophotic ecosystems (30–150 m depth) remain scarce. A review of datasets available through the Marine Biodiversity Information System of Colombia (SIBM), OBIS and GBIF revealed only 75 historical records within this depth ranges, primarily concentrated between 40–50 m and dating back to the early 2000s. These records include four phyla: Cnidaria (80%), Mollusca (9.3%), Chordata (8%), and Echinodermata (2.7%), indicating limited taxonomic representation and spatial coverage (NMNH, 2001; Baranova et al., 2009; NIWA, 2016; Montoya-Cadavid and Bohorquez, 2021; Bermúdez Rivas and Chaverra Castañeda, 2024; Catania and Fong, 2024; and 59 GBIF datasets accessed via <https://doi.org/10.15468/dl.df3kq5>).

In this context, the dataset presented here provides a standardized compilation of occurrence records and associated metadata describing the diversity and distribution of mesophotic species inhabiting submarine elevations and deep terraces within the Malpelo FFS. The dataset integrates imaged-based observations obtained through remotely operated vehicle (ROV) surveys, scientific diving, and biological samples collected during the 2025 Mesophotic Scientific Expedition to the Malpelo FSS, and follows international biodiversity data standards to ensure interoperability and reuse (Wieczorek et al., 2012; Lawrence et al., 2026). It provides baseline information on mesophotic biodiversity in the Colombian Pacific and supports future research, monitoring and ecosystem-based management, in MPAs.

Methods

Study area and site selection

High-resolution multibeam bathymetric data were acquired from 0–200 m depth during the first phase of the expedition (2–6 March 2025), prior to the ROV operations. Preliminary onboard processing and geomorphological interpretation of the bathymetric data enabled the identification of submarine elevations, rocky terraces, and other seabed anomalies potentially associated with mesophotic habitats. In total, 34 bathymetric anomalies were identified, of which 20 were selected as target stations for ROV surveys and biological characterization.

ROV surveys

From 8 to 12 March 2025, video transects were conducted using the remotely operated vehicle (R.O.V) FOIII *Eloy V*, owned and operated by INVEMAR. The ROV is equipped with three thrusters, a forward-facing high-definition digital video camera (Full HD/4K), high-power LED lights mounted on a tilting bar, and a pair of parallel red lasers spaced 10 cm apart for scale reference. Video recordings were obtained under two configurations: (1) Full HD for high-resolution analysis and (2) low-resolution video with on-screen display (OSD), including compass heading, vehicle azimuth, and depth. Linear video transects were conducted as the research vessel drifted over the target sites, covering a depth range of 30 to 161 m. A total of 18 ROV video transects were completed, yielding approximately 6.3 h of video footage (Figure 1). ROV positions were estimated indirectly from geographic position of the research vessel, combined with ROV depth and azimuth data recorded in the OSD system. Consequently, spatial coordinates associated with image-based records represent approximate positions along the transect and may include positional uncertainty related to vessel drift, tether angle and currents flow conditions.

Scientific diving surveys and specimen collection

Two submarine hills (sites B2 and B3) were accessible by autonomous diving (Figure 1). Scientific diving surveys were conducted on 8 March 2025 at site B3 and on 13 March 2025 at site B2. At each site, two scientific divers performed a single scuba dive, covering two distinct depth strata 37.5 and 40 m depth. During these dives, photographs and video recordings were obtained, and physical samples were collected, including rocky substrate fragments and two (2) cnidarian colonies harboring associated invertebrates. A total of 125 invertebrate specimens were separated, including echinoderms (sea urchins and ophiuroids), mollusks, crustaceans annelids, bryozoans, and other macrofaunal groups. Collected specimens were fixed in 96% ethanol. All specimens were identified to the lowest possible taxonomic level using standard taxonomic approaches and deposited in the reference collections of the Museum of Marine Natural History of Colombia (MHNMC–Makuriwa, INVEMAR), where they were catalogued and assigned unique collection numbers linked to the dataset through Darwin Core fields.

Image extraction, annotation and database construction

A total of 628 still images (JPEG format) were extracted from 6.3 hours of high definition ROV video transects at 30 s intervals using GOM Player software to reduce spatial autocorrelation within transects. Each extracted image was automatically assigned a unique filename by the software, including the transect number, date, time, observation minute. Images that were excessively dark, out of focus, or recorded at excessive camera altitude were classified as “Not Determined” (ND) and exclude from biological annotation. All extracted images were incorporated manually into a relational

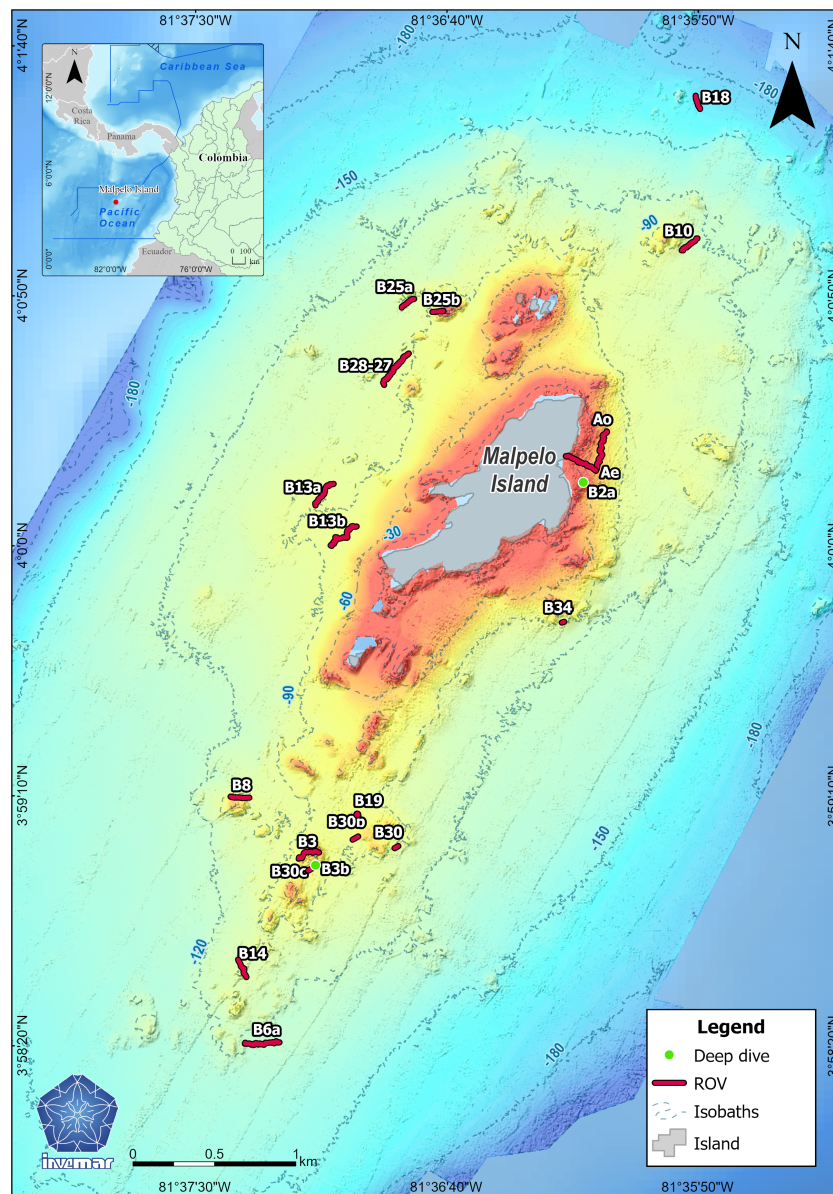


FIGURE 1

Spatial distribution of sampling locations within Malpelo Fauna and Flora Sanctuary (Colombian Pacific). Red lines represent ROV video-transects and green dots represent scientific diving stations in the mesophotic zone. Sampling locations correspond to observations and specimen collections included in the dataset, covering depths between 30 and 166.1m.

database, containing associated metadata, including transect ID, date, time, depth, azimuth, geographic position and macro-habitat classification. Macro-habitats were classified following the deep-sea macrohabitat scheme proposed by Cedeño-Posso et al. (2022a). Frames containing visible biota were subsequently annotated and screened for biological records. Mega and macrobiota were initially classified into broad taxonomic and morphological categories following the CATAMI classification scheme (CATAMI Technical Working Group, 2014). Subsequently, taxonomic identifications were refined to the lowest possible level by specialized taxonomists staff from the Museum of Marine Natural History of Colombia (MHNMC–Makuriwa, INVMAR), when diagnostic features were visible in the imagery. When species-level identification was not possible, records were assigned to higher taxonomic categories (family, order, or class), using standardized identification qualifiers

following Sigovini et al. (2016). Taxonomic nomenclature was validated against the World Register of Marine Species (WoRMS Editorial Board, 2026).

Data processing, standardization, and quality control

Data documentation and preparation followed internationally recognized biodiversity data standards (Wieczorek et al., 2012; Lawrence et al., 2026). All data tables were structured according to Darwin Core (DwC) standard for species occurrence data, ensuring compatibility with the Ocean Biodiversity Information System (OBIS), the Colombian Biodiversity Information System (SiB Colombia), and the Global Biodiversity Information Facility (GBIF). The dataset was published and validated using the

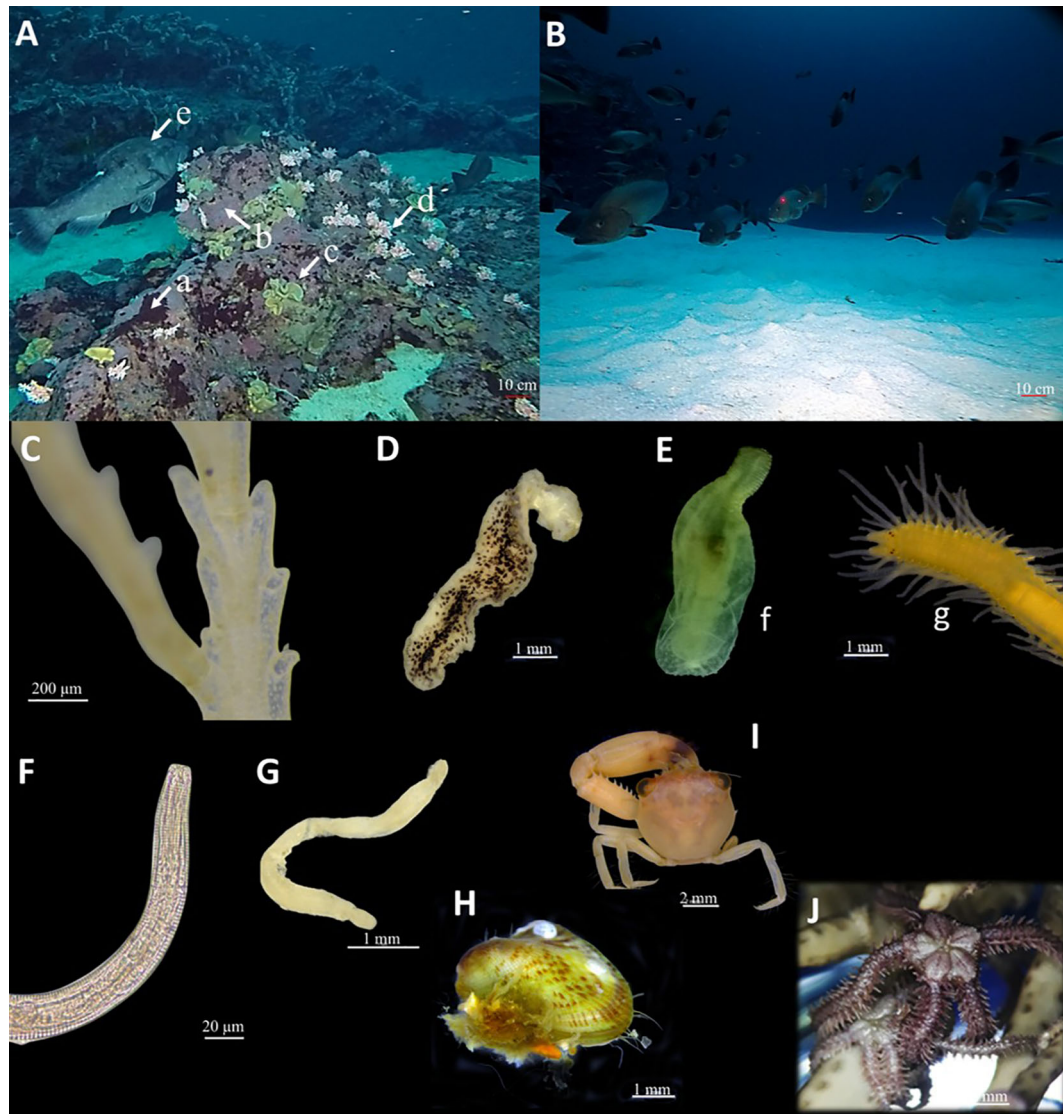


FIGURE 2

Representative specimens recorded on mesophotic rocky substrates of the Malpelo SFF (Colombian Pacific) through image-based observations and specimen collection between 30 - 100 m depth. (A) video-transect B25b: (a) Cyanobacteria; (b) Rhodophyta; (c) Porifera, *Neophrissospongia* aff. *galapagoensis*; (d) Cnidaria, Stylasteridae spp.; (e) *Hyporhodus mystacinus*; (B) video-transect B28-27: Chordata, *Hyporhodus cifuentes*; (C) Bryozoa, *Crisia* sp. (D) Platyhelminthes; (E) Annelida, (f) order Sipuncula; (g) order Syllidae; (F) Nematoda; (G) Nemertea, order Monostilifera; (H) Mollusca, *Brachidontes adamsianus*; (I) Arthropoda, *Quadrella nitida*; (J) Echinodermata, *Ophiothela mirabilis*.

Integrated Publishing Toolkit (IPT) of the OBIS Colombia node. During this process, a multi-step quality control workflow was implemented, including: (i) curatorial validation, based on verification of physical specimens and associated records; (ii) taxonomic validation, ensuring consistency with current nomenclature standards; (iii) spatial validation, including verification of geographic coordinates and sampling locations; and (iv) documentation validation, ensuring completeness and consistency of associated metadata. Standardization procedures were further assessed using IPT validation tools and institutional quality indicators to ensure compliance with OBIS, SiB Colombia, and GBIF requirements. Metadata completeness and structure were validated according to the Ecological Metadata Language (EML) standard. A final validation step was conducted prior to publication to ensure dataset integrity and interoperability. Image-derived data underwent a

structured processing workflow, including basic image editing (e.g., cleaning and labeling), extraction of occurrence information, and cross-validation between image records and preliminary taxonomic identifications. Image metadata was generated and documented in the MHNMC-Makuriwa digital repository (Flickr platform) and linked to the dataset through Darwin Core extensions for multimedia resources.

Dataset outcomes

The dataset complies standardized occurrence records derives from ROV image-based observations and specimens-based sampling conducted during the 2025 Mesophotic Scientific Expedition

to Malpelo FFS. The resource contains presence-only data associated with 20 sampling stations linked through an event core structure. A total of 588 occurrence records are included, and additionally, 821 associated records describing complementary variables (e.g., organism counts, organism type, life stage, vitality, sampling equipment, and research vessel) are provided through the Extended Measurement or Facts (eMoF) extension. Supporting multimedia documentation includes 70 annotated images available through Simple Multimedia extension.

Organisms recorded in the dataset belong to thirteen phyla: Cyanobacteria, Rhodophyta, Porifera, Cnidaria, Bryozoa, Annelida, Platyhelminthes, Nematoda, Nemertea, Mollusca, Arthropoda, Echinodermata, and Chordata (Figure 2). A total of 64 benthic megafaunal taxa and 33 fish taxa were identified from image-based analyses, encompassing multiple benthic groups with different taxonomic resolution depending on image quality and the visibility of diagnostic characters. Among primary producers, representatives of Rhodophyta (including crustose coralline algae, Corallinales), and Cyanobacteria were recorded across different depth ranges (33 and 166 m). Porifera represented one of the most conspicuous sessile groups, with 15 sponge morphotypes recognized between 37 and 161 m depth, including a morphotype assigned as aff. *Neophrissospongia galapagoensis*. Cnidarians were represented by 19 morphotypes belonging to Hydrozoa, Scyphozoa, and Anthozoa, including octocorals (*Muricea*, *Leptogorgia*, *Pacifigorgia*), antipatharians (*Antipathes* cf. *galapagoensis*), and scleractinians (*Tubastraea* spp.). A coronate scyphozoan polyp was also documented. Echinoderms were represented by 31 morphotypes, including first records of *Linckia columbiae* and *Eucidaris galapagensis*. Fish assemblages frequently associated with mesophotic rocky slopes and substrates, including large groups of olive grouper (*Hyporhamphus ciferrii*), misty grouper (*Hyporhamphus mystacinus*), and yellowtail amberjack (*Seriola lalandi*), suggest Malpelo FFS may sustain higher fish biomass than previously estimated (Quimbayo et al., 2017), and extends well into deeper reef-associated habitats. In addition, six fish species are new records for the sanctuary, as they have not been reported in peer-reviewed publications on Malpelo ichthyofauna: *Prognathodes carlhubbsi*, *Hyporhamphus ciferrii*, *Hyporhamphus mystacinus*, *Liopropoma fasciatum*, *Pronotogrammus multifasciatus*, and *Enchelycore lichenosa*, the latter one also representing a new record for Colombian Pacific.

Among the 125 benthic invertebrates collected through diving, multiple macrofaunal groups were represented, including Annelida (Polychaeta, Oligochaeta, and Sipuncula), Nematoda (Enopleia and Chromadorea), Nemertea (Monostilifera), Platyhelminthes (Polycladida and Tricladida), as well as Arthropoda (Decapoda, Isopoda, Amphipoda, Scalpellomorpha, Cyclopoida, Podocopida, Tanaidacea, and Pantopoda), Mollusca (Bivalvia, Polyplacophora, and Gastropoda) and Bryozoans. Within these groups, 54 families, 53 genera, and 56 species and morphospecies were identified. Most macrobenthic records associated with mesophotic environments in Malpelo FFS represent new records (>90%), both at family level and at species and morphospecies level.

Reuse potential

All biological specimens collected during this study were deposited in the reference collections of the MHNMC–Makuriwa, ensuring long-term preservation and accessibility. Those specimens are linked to the dataset through catalog numbers, facilitating taxonomic verification and reproducibility. The dataset constitutes a valuable resource for future research on taxonomy, systematics, biogeography, and biodiversity patterns in mesophotic ecosystems of the Colombian Pacific, a region where the topic remains poorly studied. The inclusion of multimedia records linked through Darwin Core extensions enhances its applicability for image-based ecological analyses and machine learning approaches. Additionally, the dataset contributes to improving the representation of mesophotic biodiversity in global repositories such as OBIS and GBIF.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: <https://doi.org/10.15472/t3wbrc>.

Ethics statement

Field activities were conducted within the Malpelo Fauna and Flora Sanctuary (Malpelo FFS), a protected area administered by Parques Nacionales Naturales de Colombia (PNN). Research activities were authorized by PNN through Memorandum No. 20252000000603 (21 February 2025), which granted approval for the project “Expedición científica mesofótica al Santuario de Flora y Fauna Malpelo, Pacífico colombiano”. The collection of marine invertebrate specimens was carried out by researchers from the Marine and Coastal Research Institute (INVEMAR), in accordance with Article 6 of Resolution 2064 of 2010 of the Colombian Ministry of Environment, which exempts recognized scientific research institutions from obtaining individual collection permits for scientific research on biodiversity. No vertebrates were collected, manipulated, or subjected to experimental procedures during this study. Fish records included in the dataset were obtained exclusively through non-invasive image-based observations derived from ROV video transects and scientific diving surveys.

Author contributions

CC-P: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. LC: Writing – original draft, Writing – review & editing, Formal analysis, Methodology. NL: Formal analysis,

Methodology, Writing – review & editing. EB-V: Formal analysis, Methodology, Writing – review & editing. AO: Formal analysis, Methodology, Writing – review & editing. DG: Methodology, Writing – review & editing. EM-P: Methodology, Writing – review & editing. JS: Methodology, Writing – review & editing. JL: Methodology, Writing – review & editing. GB-P: Formal analysis, Methodology, Writing – review & editing. JV: Methodology, Writing – review & editing. MF-S: Methodology, Writing – review & editing. MC-A: Methodology, Writing – review & editing. AR-T: Data curation, Validation, Visualization, Writing – review & editing. EM-C: Data curation, Methodology, Validation, Visualization, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

- Baker, E. K., Puglise, K. A., and Harris, P. T. (Eds.). (2016). Mesophotic coral ecosystems — A lifeboat for coral reefs? *The United Nations Environment Programme and GRID-Arendal*, Nairobi and Arendal, 98p.
- Baranova, O. K., O'Brien, T. D., Boyer, T. P., and Smolyar, I. V. (2009). "Plankton data," in *World ocean database 2009*. Ed. S. Levitus (NOAA Atlas NESDIS 66, U.S. Gov. Printing Office, Wash. D.C), 216.
- Bermúdez Rivas, C., and Chaverra Castañeda, F. A. (2024). *La familia Pontellidae (Crustacea: Copepoda) de las aguas superficiales del Pacífico colombiano colectados en el crucero ERFEN del año 2019. v1.0. Dirección General Marítima. Dataset/Samplingevent*. doi: 10.15472/r3yezu
- Bessudo, S., Ladino, F., Ocampo, A., Muriel, F., Cuellar, A., Rojas, E., et al. (2022). *Listado de especies del Monte submarino Bajo Navegador en el Distrito Nacional de Manejo Integrado de Yuruparí. v1.0. Fundación Malpelo y Otros Ecosistemas Marinos. Dataset/Checklist*. doi: 10.15472/j7yzrc
- CATAMI Technical Working Group. (2014). CATAMI classification scheme for scoring marine biota and substrata in underwater imagery. Version 1.4. Canberra, Australia, National Environmental Research Program, Marine Biodiversity Hub, 24pp. (Technical Report) doi: dx.doi.org/10.25607/OBP-11
- Catania, D., and Fong, J. (2024). CAS Ichthyology (ICH). Version 150.451. California Academy of Sciences. Occurrence dataset. Available online at: <http://ipt.calacademy.org:8080/resource?r=ich&v=150.451>.
- Cedeño-Posso, C., Barrios-Vásquez, E., Borrero, G., Cárdenas-Oliva, A., Lizarazo-Rodríguez, N., Montoya-Cadavid, E., et al. (2022b). "Megafauna bentónica," in *Evaluación Ambiental de las Colinas y Lomas Submarinas de la Cuenca Pacífico Norte* (Instituto de Investigaciones Marinas y Costeras José Benito Vives de Andréis, Santa Marta, Colombia), 121–205.
- Cedeño-Posso, C., Vides-Casado, M., Rocha, V., Borrero-Pérez, G. H., Polanco, F. A., and Alonso, D. (2022a). Benthic macrohabitat classification and *Madracis* spp. coral patch distribution in a deep-sea marine protected area of Colombia. *Front. Mar. Sci.* 9, 995419. doi: 10.3389/fmars.2022.995419
- Clark, M. R., Tittensor, D., Rogers, A. D., Brewin, P., Schlacher, T., Rowden, A., et al. (2006). "Seamounts, deep-sea corals and fisheries: vulnerability of deep-sea corals to fishing on seamounts beyond areas of national jurisdiction," in *UNEPWCMC* (Cambridge, UK).
- Dueñas, L. F., Ardila, N. E., Bessudo, S., Friedlander, A. M., Goodell, W., Mayorga, J. S., et al. (2024). *Caracterización de especies bentónicas y bentopelágicas asociadas al Bajo Navegador, Dorsal Yuruparí, Colombia. v1.1. Universidad Nacional de Colombia. Dataset/Occurrence*. doi: 10.15472/cwwbex
- Enright, S. R., Meneses-Orellana, R., and Keith, I. (2021). The Eastern Tropical Pacific Marine Corridor (CMAR): the emergence of a voluntary regional cooperation mechanism for the conservation and sustainable use of marine biodiversity within a fragmented regional ocean governance landscape. *Front. Mar. Sci.* 8, 674825. doi: 10.3389/fmars.2021.674825
- International Maritime Organization (IMO). (2026). Particularly Sensitive Sea Areas. Available online at: <https://www.imo.org/en/OurWork/Environment/Pages/PSSAs.aspx> (Accessed April 6, 2026).
- International Union for Conservation of Nature (IUCN) (2025). *Malpelo Fauna and Flora Sanctuary – 2025 Conservation Outlook Assessment*. IUCN World Heritage

- Outlook 4). Available online at: <https://worldheritageoutlook.iucn.org/> (accessed June 17, 2026).
- Lawrence, E., Benson, A., Biddle, M., Bosch, S., Desmet, P., Gan, Y.-M., et al. (2026). "Iobis/manual: v1.0 OBIS manual bookdown version (v1.0)," in *Zenodo*. doi: 10.5281/zenodo.20218567
- Marcaillou, B., Charvis, P., and Collot, J. Y. (2006). Structure of the Malpelo Ridge (Colombia) from seismic and gravity modelling. *Mar. Geophys. Res.* 27, 289–300. doi: 10.1007/s11001-006-9009-y
- Montoya-Cadavid, E., and Bohorquez, J. (2021). *Colección de Cnidarios del Museo de Historia Natural Marina de Colombia - Makuriwa. v3.1. Instituto de Investigaciones Marinas y Costeras - Invemar. Dataset/Occurrence*. doi: 10.15472/wesirx
- NIWA (2016). *Vulnerable marine ecosystems in the South Pacific Ocean region* (Wellington, New Zealand: National Institute of Water and Atmospheric Research (NIWA), 202873. Available online at: http://nzobisipt.niwa.co.nz/resource.do?r=vme_inverts.
- NMNH (2001). *National museum of natural history, smithsonian institution invertebrate zoology collection database* (Washington, DC: National Museum of Natural History, Smithsonian Institution, 10th and Constitution Ave. N.W.).
- Palacios-M, D., Herrera, J., Gerrodette, T., García, C., Soler, G., Avila, I., et al. (2012). Cetacean distribution and relative abundance in Colombia's Pacific EEZ from survey cruises and platforms of opportunity. *J. Cetacean Res. Manage.* 12, 45–60. doi: 10.47536/jcrm.v12i1.590
- Quimbayo, J. P., Mendes, T. C., Kulbicki, M., Floeter, S. R., and Zapata, F. A. (2017). Unusual reef fish biomass and functional richness at Malpelo, a remote island in the Tropical Eastern Pacific. *Environ. Biol. Fish.* 100, 149–162.
- Roberts, J. M., Wheeler, A. J., Freiwald, A., and Cairns, S. D. (2009). *Cold-water corals: the biology and geology of deep-sea coral habitats* (Cambridge, UK: Cambridge University Press).
- Rodríguez Toscano, A. J., Cedeño-Posso, C. M., Montoya-Cadavid, E., Borrero Pérez, G. H., Lizarazo Rodríguez, N. P., Barrios Vázquez, E. M., et al. (2025). *Megabentos batial del extremo sur occidental del DNMI Colinas y Lomas Submarinas de la Cuenca Pacífico Norte y el este del archipiélago de Malpelo. Version 2.0. Instituto de Investigaciones Marinas y Costeras - Invemar. Sampling event dataset*. doi: 10.15472/eecfal
- Sigovini, M., Keppel, E., and Tagliapietra, D. (2016). Open nomenclature in the biodiversity era. *Methods Ecol. Evol.* 7, 1217–1225. doi: 10.1111/2041-210x.12594
- Sinniger, F., Ballantine, D. L., Bejarano, I., Colin, P. L., Pochon, X., Pomponi, S. A., et al. (2016). "Biodiversity of mesophotic coral ecosystems," in *Mesophotic coral ecosystems – A lifeboat for coral reefs?* Eds. E. K. Baker, K. A. Puglise and P. T. Harris (The United Nations Environment Programme and GRID-Arendal, Nairobi and Arenda), 50–62.
- Slattery, M., Lesser, M. P., Brazeau, D., Stokes, M. D., and Leichter, J. J. (2011). Connectivity and stability of mesophotic coral reefs. *J. Exp. Mar. Biol. Ecol.* 408, 32–41. doi: 10.1016/j.jembe.2011.07.024
- United Nations Educational, Scientific and Cultural Organization (UNESCO). (2026). World Heritage List. Available online at: <https://whc.unesco.org/en/list/> (Accessed April 6, 2026).
- Wieczorek, J., Bloom, D., Guralnick, R., Blum, S., Döring, M., Giovanni, R., et al. (2012). Darwin Core: an evolving community-developed biodiversity data standard. *PloS One* 7, e29715. doi: 10.1371/journal.pone.0029715
- WoRMS Editorial Board. (2026). *World Register of Marine Species*. Available from: <https://www.marinespecies.org> at VLIZ. doi:10.14284/170