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Octocorals and Antipatharians in the Mesophotic Rocky Reefs of Colombian Pacific (Eastern Tropical Pacific)

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BACKGROUND

Octocorals and antipatharians (black corals) are usually among the main biotic groups in tropical rocky reefs. With a high diversity (111 species), abundance, and endemism, octocoral communities are a dominant seascape feature in the rocky reefs of the Eastern Tropical Pacific (ETP), hosting a particular invertebrate fauna and rich fish communities (Cortés et al., 2017; Sánchez, 2017). In the Colombian Pacific, studies of octocorals in rocky substrates are scarce and are restricted to shallow waters (<30 m). Only 14 species have been found so far (Cortés et al., 2017), but there could be more than 22 species according to unpublished reports.

Mesophotic environments are usually defined as those located between 30 and 150 m below the surface and have been considered as ecosystems with diverse biological communities and high levels of endemism (Sinniger et al., 2016). The habitats formed by octocorals are common in mesophotic environments around the globe, however, knowledge about biodiversity and ecology of these communities is nascent. To date, 87 genera of mesophotic octocorals are known globally, of which only eight have been reported for the ETP (Sánchez et al., 2019). The octocoral fauna colonizing mesophotic environments often differs from shallow water octocoral fauna, which seems to be especially true in the ETP. The only published comparison of shallow water (<30 m) and mesophotic (>30 m) octocoral communities in the ETP, has found 17 shallow and 18 mesophotic species in the coast of Oaxaca—Mexico, with just one species present over the entire depth range (0–70 m; Abeytia et al., 2013).

In the ETP region, antipatharians have been reported off the coast of Panama, Mexico, Colombia, and Ecuador, in specific areas and especially in shallow waters (Opresko, 1976; Bo et al., 2011), although in some cases they reach the upper limit of the mesophotic zone (*ca.* >30 m). Only two black coral species have been reported in this region, *Myriopathes panamensis* (Verrill, 1869) and *Antipathes galapagensis* Deichmann, 1941. *Myriopathes panamensis*, which is the only known black coral species to date from the Colombian Pacific, has been reported up to 50 m deep in Galápagos, although in the continental waters of Ecuador it is more abundant between 15 and 30 m deep (Bo et al., 2011).

There is a need for data on the poorly known communities of mesophotic octocoral and antipatharians in the ETP, especially to the south of this remote biogeographic region (Colombian Pacific). The dataset presented here is the result of the first exploration in the mesophotic environments (30–60 m deep) of the rocky reefs from the Colombian Pacific. The dataset includes taxonomic information for each collected specimen, collection data (site, depth, date), and the collection code.

The aim of this work is to contribute to the knowledge of the octocoral and black coral communities in unexplored environments at a remote region with high endemism, the Eastern Tropical Pacific, reporting relevant biological information such as bathymetric range, geographical distribution, and the morphological variation with taxonomic relevance.

DATA COLLECTION

An underwater exploration of rocky reef sites using SCUBA in the northern Colombian Pacific (Chocó) during September 2018 targeted two small "peaks" arising from around 60 m deep in the seafloor to 10–20 m deep and located about 1 km from the coastline. These sites offer a good chance to study the marine biota in a mesophotic environment. "La Mina" (6°41′11.868″ N, 77°32′57.588″ W) in the north of the Gulf of Cupica, and "Amargal" (5°34′47.352″ N, 77°30′50.76″ W) in Cabo Corrientes (**Figure 1**), are submerged headlands of basaltic rocks, remnants of the Serranía de Baudó o Baudó mountain range, pero no Cordillera del Baudo, that were covered by sea water since the last ice age, and are 125 km from each other (Posada et al., 2009). Both look structurally similar; they are mainly rocky walls with high slopes between 10 and 50 m deep that begin to decrease around 60 m deep. At the base of each feature there are multiple boulders covered by algae (turf and coralline) and dozens of whitish octocoral colonies are the dominant features of the seascape. Sponges are scarce and limited to encrusting morphotypes when present.

To assess the composition of the coral (octocorals and antipatharians) mesophotic community on each site, coral colony counts were made by two researchers in three 10 × 1 m line transects (10 m^2) horizontally disposed. A third diver was responsible for digital imagery and coral samples collection. Average density (colonies/m^2) of octocorals and antipatharians were calculated for each site and for the entire mesophotic coral community of the northern Chocó.

CORAL IDENTIFICATIONS

Species identification were performed *in situ* and specimens were collected for later validation. Before collection, photos of each colony were taken with and without scale, then they were deposited in a tagged "Ziploc" bag. The colonies were air dried for preservation and were identified using the morphological characters of the colonies and the characteristics and composition of the sclerites (Bayer, 1961; Breedy and Guzman, 2002). Measurements of the taxonomic characters of the colonies were performed using a Vernier digital caliper. In order to obtain the sclerites, a small bit of tissue was immersed in sodium hypochlorite (household bleach). The sclerites were examined and measured with a microgrid in an optical microscope (Carl Zeiss Primostar). The specimens collected were deposited in the Museo de Historia Natural Marina de Colombia—(MHNMC) of INVEMAR, and the codes are listed in **Table 1**.

DATASET OUTCOMES AND DISCUSSION

In the explored mesophotic community, 14 octocoral species in the Ellisellidae, Gorgoniidae, and Plexauridae families were found. Most of them were a white-colored such as *Ellisella limbaughi*, *Leptogorgia alba*, *L. cortesi*, *Pacifigorgia marviva*, *P. senta,* and *Muricea subtilis*, which were very conspicuous in this mesophotic twilight environment (**Figure 2**). Among the white corals some less conspicuous, but colorful (*e.g.* brown, reddish, etc.) coral colonies of the species *Pacifigorgia eximia*, *Muricea plantaginea*, *M. fruticosa, M. squarrosa, Psammogorgia* sp1, *Psammogorgia* sp2, and *Heterogorgia verrucosa* were also present. One species of black coral in the Myriopathidae family was also found (**Table 1**, **Figure 2**). Of the octocoral species reported here, six are new records for the Colombian Pacific and even for the Panama Bight ecoregion (marked with * in **Table 1**, **Figure 2**). The other two species (*L. alba* and *P. eximia*) have been reported in shallow waters (<30 m) in Chocó and other locations in the Colombian Pacific (Sánchez et al., 2011, 2014; Lozano-Cortés et al., 2012; Sánchez and Ballesteros, 2014). The Black coral *Myriopathes panamensis* was collected in Malpelo Island in 2002 according to the Colombian Marine Biodiversity System-SIBM (Instituto de Investigaciones Marinas y Costeras - INVEMAR, 2020).

These new records represent extensions in the geographical distribution or bathymetric ranges of several coral species from the ETP (**Figure 1**). For example, *Ellisella limbaughi,* that had been registered only in northern ETP in Baja California and Oaxaca, Mexico (Bayer, 1960; Abeytia et al., 2013), is now registered to the north of Panama Bight (Chocó, Colombia) at the southern part of the ETP (**Figure 1**), with depth ranges similar to those in Mexico (40–90 m) and an abundance that allows us to consider it a common and conspicuous species in the mesophotic zone, with sizes reaching 80 cm high (**Figure 2**). *Leptogorgia cortesi*, previously reported only for Golfo Dulce, Costa Rica, between 9 and 30 m deep (Breedy and Guzman, 2012), is registered now for Colombia down to 45 m deep (**Figure 1**). *Pacifigorgia marviva* was reported only in Coiba Island, Panama, between 35 and 40 m deep (Guzman and Breedy, 2011), here it is reported for the northern Chocó in Colombia between 40 and 60 m deep, where it is abundant in the mesophotic communities. *Pacifigorgia senta* are distributed in Baja California (Mexico), Costa Rica, and possibly in the Gulf of Panama (Breedy and Guzman, 2003) between 36 and 40 m, however, in Colombia this species is found between 40 and 60 m deep, and together with *Pacifigorgia marviva* are the most abundant species in this particular "whitish octocoral community" of the mesophotic zone (**Figure 2**). Finally, *Muricea subtilis*, a species recently described for Costa Rica at depths >30 m (Breedy and Guzman, 2016), was found in the sampled locations more than 45 m deep, being more abundant below 50 m deep (**Figure 1**).

During the species taxonomic identification process, some morphological variations with respect to the species original descriptions were recognized in *L. cortesi* and *P. senta*. Considering that high phenotypic variation is typical in octocorals, their taxonomy is problematic (Bayer, 1961; Breedy and Guzman, 2007; Sánchez et al., 2007), therefore

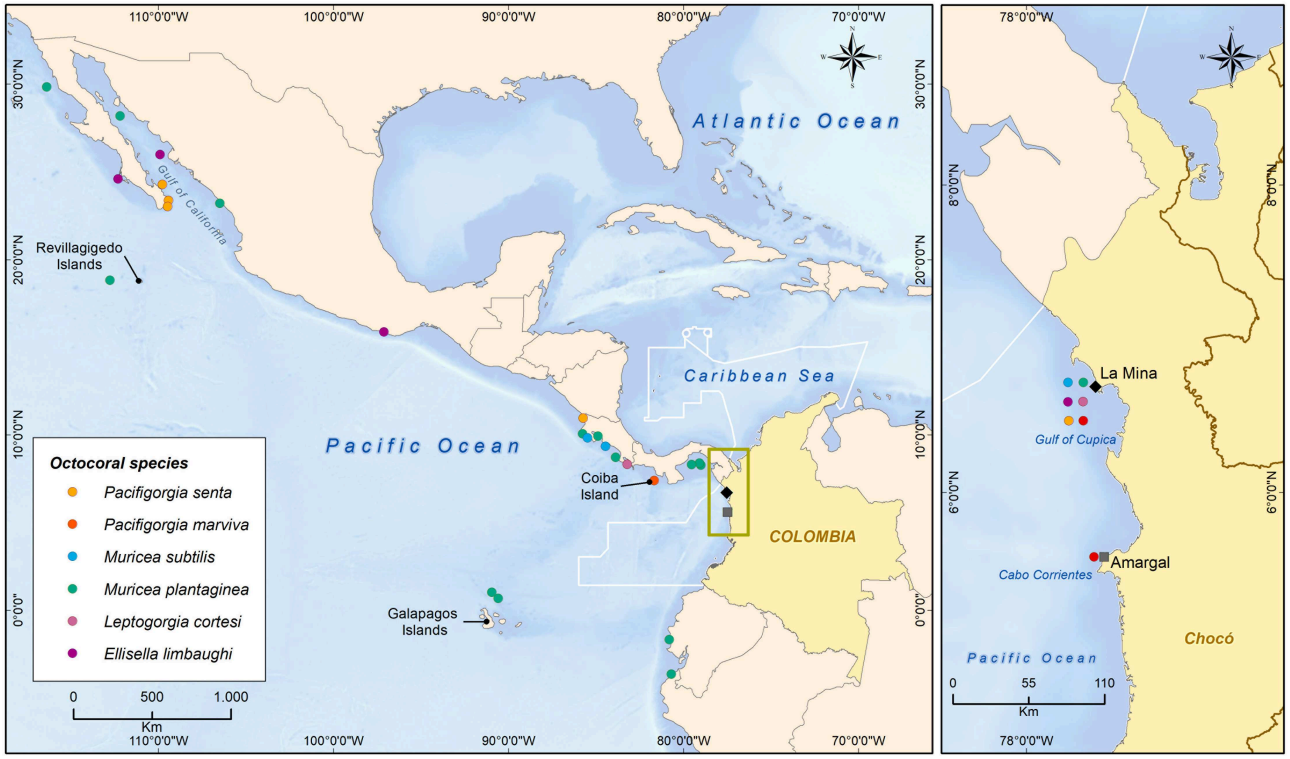

FIGURE 1 | Distribution map of the new octocoral records found in the Colombian Pacific, with species distribution along the ETP. The coordinates for species distribution in other countries were obtained from publications in the references list. Sample sites: ♦ La Mina, ■ Amargal.

it is important to document variations exhibited by octocoral species, to reduce possible misidentifications and the subjectivity in the taxonomy of the group. *Leptogorgia cortesi* is a species with prominent and tight calyxes (polyp-mounds), which confers it a wavy appearance in the branches edges (Breedy and Guzman, 2012), however, in the specimens collected in Colombia (INV CNI4224 and INV CNI4241) such polyp-mounds were absent, but the type of branching pattern and sclerites were compatible with the *L. cortesi* description and allowed us to assign it that taxonomic identity. *Pacifigorgia senta* can have coloration that ranges from light orange to pink and white and show cylindrical thick central veins in its original description (Breedy and Guzman, 2003), but all specimens collected in Colombia were a white color with a central pink area toward the base of the colony, and did not show midribs (**Figure 2**). It was initially confused with *P. marviva*, but the sclerites set is typical of *P. senta* (Breedy O., com. pers).

The coral mesophotic communities discovered in the northern Colombian Pacific harbor big and healthy colonies, that in some cases exceed the maximum colony sizes reported in several species. In the conspicuous octocoral *Muricea subtilis*, one colony reaching 41 cm height and 30 cm width was collected (INV CNI4304), being almost twice the length reported in the species description (Breedy and Guzman, 2016). *Pacifigorgia marviva* is considered a small erect fans species (≤13 cm long) in the original description (Guzman and Breedy, 2011), but we found one colony 31 × 30 cm high and wide (INV CNI4263). The bigger *P. senta* colony collected was 42 cm high and 28 cm wide (INV CNI4265), not bigger than previously reported in Costa Rica (Breedy and Cortés, 2014). In general, the biggest colonies in the coral communities were of the antipatharian *Myriopathes panamensis* which was around 1 m in length, and the octocoral *Ellisella limbaughi*, which was 80 cm in length. The rest of the observed species showed to be similar to their original descriptions. Recruits (individuals ≤5 cm) of *M. subtilis* and *P. senta/marviva*, as well as small colonies around 7 × 5 cm long, were also found.

The total average density of coral colonies (octocorals and antipatharians) considering both mesophotic communities was 9 ± 1.6 colonies/m^2 (average ± SD), with the octocorals *Leptogorgia alba* (2.63 ± 0.7 colonies/m^2) and *Muricea subtilis* (2.61 ± 1.9 colonies/m^2) being the most abundant species. The average coral density in La Mina was 9.9 ± 0.5 colonies/m^2, with 10 coral species registered (**Table 1**), five of which were exclusive for this site (*Ellisella limbaughi*, *Muricea plantaginea*, *M. subtilis, Psammogorgia sp1*, and *Psammogorgia* sp2). Amargal had an average density of coral colonies of 8.1 ± 3.3 colonies/m^2 with only seven coral species (**Table 1**). Considering the average coral density estimated on both sites, these communities can be considered as a kind of mesophotic coral garden in a similar sense to the "Coral Garden Habitat" that has been defined for deep seas in the OSPAR commission. However, due to its location on the continental platform, they do not fit totally well in that habitat definition (OSPAR Commission, 2010). Although other mesophotic octocoral communities in Mexico harbor about 18 species (Abeytia et al., 2013),

TABLE 1 | Species of mesophotic octocorals and black corals collected in the Chocó, Colombian Pacific.

Octocorals/Antipatharians Species	Site	Depth (m)	Date	Code
Class Octocorallia				
Order Alcyonacea				
Suborder Calcaxonia				
Family Ellisellidae Gray, 1859				
**Ellisella limbaughi* (Bayer, 1960)	Mina	51	17/09/18	INV CNI4219
Ellisella limbaughi (Bayer, 1960)	Mina	45	16/09/18	INV CNI4220
Suborder Holaxonia				
Family Gorgoniidae Lamouroux, 1812				
Leptogorgia alba (Duchassaing and Michelotti, 1864)	Amargal	40–45	11/09/18	INV CNI4229
**Leptogorgia cortesi* Breedy & Guzman, 2012	Mina	45	16/09/18	INV CNI4241
Pacifigorgia eximia Breedy & Guzman, 2003	Amargal	40–45	11/09/18	INV CNI4254
**Pacifigorgia marviva* Guzman & Breedy, 2011	Amargal	40–45	11/09/18	INV CNI4263
Pacifigorgia marviva Guzman & Breedy, 2011	Mina	43	17/09/18	INV CNI4264
**Pacifigorgia senta* Breedy & Guzman, 2003	Mina	51	17/09/18	INV CNI4265
Pacifigorgia senta Breedy & Guzman, 2003	Mina	50	10/09/18	INV CNI4266
Pacifigorgia senta Breedy & Guzman, 2003	Mina	46	17/09/18	INV CNI4267
Pacifigorgia sp.	Mina	45	16/09/18	INV CNI4269
Family Plexauridae Gray, 1859				
Heterogorgia verrucosa Verrill, 1868	Amargal	45	12/09/18	INV CNI4280
Muricea fruticosa Verrill, 1869	Mina	46	17/09/18	INV CNI4283
**Muricea plantaginea* (Valenciennes, 1846)	Mina	47	16/09/18	INV CNI4290
Muricea plantaginea (Valenciennes, 1846)	Mina	45	16/09/18	INV CNI4291
Muricea plantaginea (Valenciennes, 1846)	Mina	46	17/09/18	INV CNI4292
Muricea plantaginea (Valenciennes, 1846)	Mina	51	17/09/18	INV CNI4293
Muricea plantaginea (Valenciennes, 1846)	Mina	45	16/09/18	INV CNI4294
Muricea plantaginea (Valenciennes, 1846)	Amargal	45	12/09/18	INV CNI4299
Muricea plantaginea (Valenciennes, 1846)	Mina	51	17/09/18	INV CNI4300
Muricea plantaginea (Valenciennes, 1846)	Mina	45	16/09/18	INV CNI4301
**Muricea subtilis* Breedy & Guzman, 2016	Mina	45	16/09/18	INV CNI4302
Muricea subtilis Breedy & Guzman, 2016	Mina	40–45	27/04/17	INV CNI4303
Muricea subtilis Breedy & Guzman, 2016	Mina	40–45	27/04/17	INV CNI4304
Muricea squarrosa Verril, 1869	Amargal	45	12/09/18	INV CNI4299
Psammogorgia sp1	Mina	35–40	16/09/18	INV CNI4321
Psammogorgia sp2	Mina	30–40	15/09/18	INV CNI4323
Class Hexacorallia				
Order Antipatharia				
Family Myriopathidae Opresko, 2001				
Myriopathes panamensis (Verrill, 1869)	Amargal	42	11/09/18	INV CNI4327

**New records for the Colombian Pacific. Code: catalog number in MHNMC of INVEMAR.*

this work is just a first glance on the mesophotic coral communities at the Colombian Pacific, where the species richness number and the new records suggest that more sampling effort is needed to quantify the mesophotic diversity of the region.

Finally, our study contributes to the knowledge of the marine diversity in the Colombian Pacific, the Panama Bight, and the Eastern Tropical Pacific in general, and describes two coral gardens composed of a rare whitish community of mesophotic octocorals, unknown until date in Colombia. These coral gardens are unprotected and, in the course of fieldwork, several threats were evident like colony detachment caused by ghost fishing gear.

Reuse Potential

The collected corals are deposited in the cnidarian collection (INV CNI) of the Museo de Historia Natural Marina de Colombia (MHNMC) of INVEMAR, where they are preserved as part of the largest biological collection of marine biodiversity in the country. These specimens constitute a valuable source of information available for future studies on the

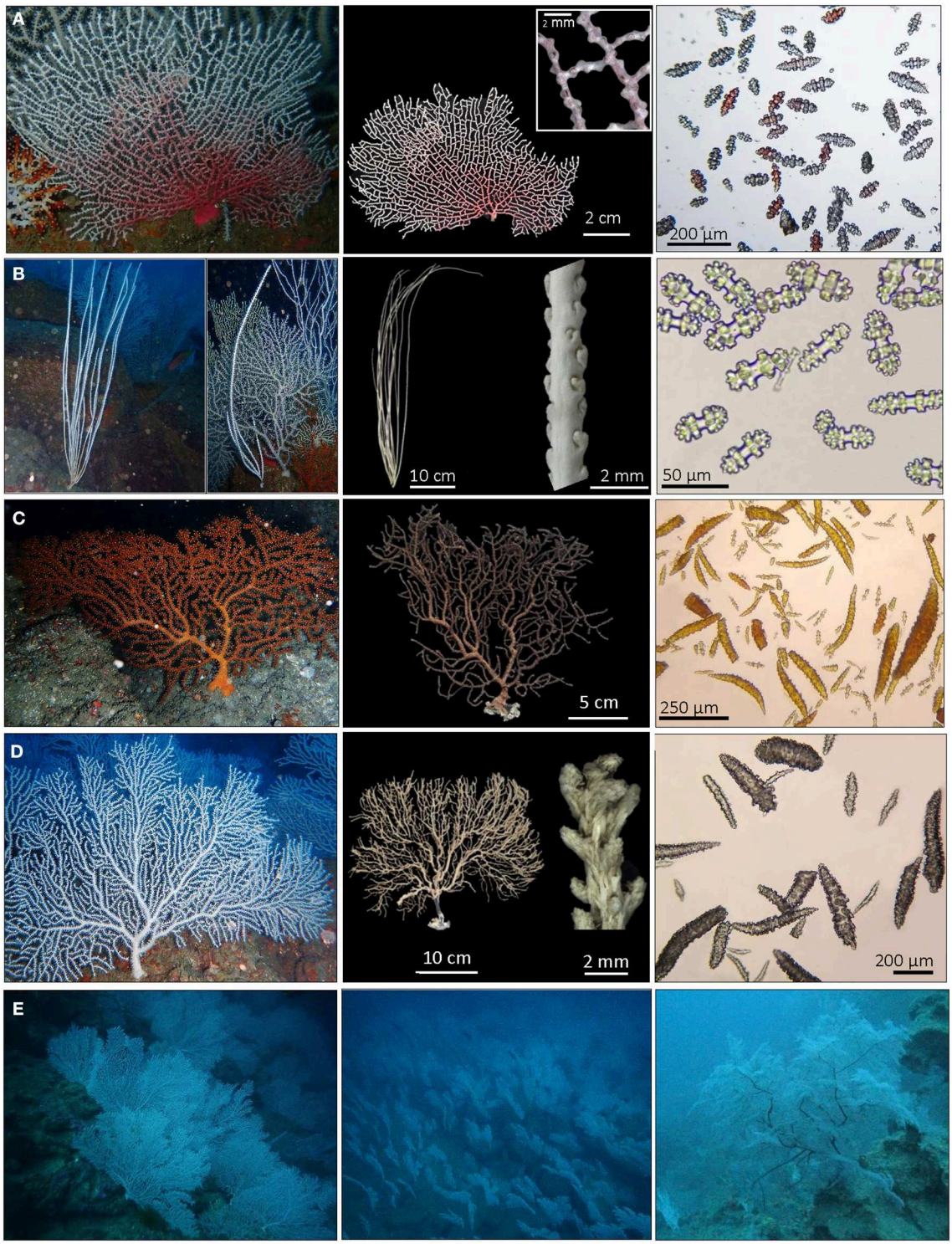

FIGURE 2 | Mesophotic octocoral and black coral communities in northern Chocó, Colombian Pacific, with photographs *in situ* (left), dry preserved (center), and sclerites (right). **(A)** *Pacifigorgia senta*. **(B)** *Ellisella limbaughi*. **(C)** *Muricea plantaginea*. **(D)** *Muricea subtilis*. **(E)** Whitish mesophotic octocorals community and one colony of the black coral *Myriopathes panamensis* (right).

systematics of the group, a very dynamic issue in this part of the world, where knowledge of octocoral biodiversity is still incomplete, particularly in mesophotic environments. The dataset presented here provide octocoral and black coral species present in the Colombian Pacific, including new records for the country, and provides the catalog

numbers of the voucher of each species for any taxonomic revision needed.

DATA AVAILABILITY STATEMENT

The dataset "Octocorals and antipatharians in the mesophotic rocky reefs of Colombian Pacific" can be found through the Integrated Publishing Tool of the OBIS Colombian nodes (SIBM-SIB Colombia), using the links: https://ipt.biodiversidad.co/sibm/resource?r=mesofoticosriscales2018; doi: https://doi.org/10.15472/staos7.

AUTHOR CONTRIBUTIONS

KM-Q and LC conceived the study, and collected the data and biological samples and wrote the manuscript. KM-Q identified and processed the material. Both authors read and accepted the manuscript.

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