frontiers in Marine Science

DATA REPORT
published: 19 November 2020
doi: 10.3389/fmars.2020.559273

Check for updates

Biodiversity and Ecological Units of the Mesophotic Coral Ecosystems in San Andrés Island, SeaFlower Biosphere Reserve

Luis Chasqui*, Katherine Mejía-Quintero and Juan David González

Programa Biodiversidad y Ecosistemas Marinos, Instituto de Investigaciones Marinas y Costeras – INVEMAR, Santa Marta, Colombia

Keywords: mesophotic coral ecosystems, Southwestern Caribbean MCEs, Colombian Caribbean, SeaFlower Biosphere Reserve, San Andrés Island, ecological units

OPEN ACCESS

Edited by:
Luisa Fernanda Dueñas, National University of Colombia, Colombia

Reviewed by:
Frine Cardone, University of Naples Federico II, Italy
Lorenzo Angeletti, National Research Council (CNR), Italy

****Correspondence:***
Luis Chasqui
luis.chasqui@invemar.org.co; luischasqui@gmail.com

Specialty section:
This article was submitted to Deep-Sea Environments and Ecology, a section of the journal Frontiers in Marine Science

Received: *05 May 2020*
Accepted: *15 October 2020*
Published: *19 November 2020*

Citation:
Chasqui L, Mejía-Quintero K and González JD (2020) Biodiversity and Ecological Units of the Mesophotic Coral Ecosystems in San Andrés Island, SeaFlower Biosphere Reserve. Front. Mar. Sci. 7:559273. doi: 10.3389/fmars.2020.559273

BACKGROUND

Mesophotic Coral Ecosystems (MCE) are usually defined as those located between 30 and 150 m deep, where diverse biological communities with high levels of endemism are being found globally (Sinniger et al., 2016). Those environments have been considered as a kind of lifeboat for shallow coral reefs because its harbor populations of fish, corals and other invertebrates which are uncommon today in shallow waters due to overexploitation and climatic change stressors (Bongaerts et al., 2010).

More than half a thousand studies globally in MCE over the last three decades have yielded an important crop of new species (e.g., Appeldoorn et al., 2016; Pyle et al., 2016; but see Pyle and Copus, 2019), and greatly expanded scientific knowledge about coral reef biota in several aspects, since species richness and distribution in general (e.g., Laverick et al., 2018) until very specific issues such as the genetic diversity of coral holobionts (e.g., Gonzalez-Zapata et al., 2018a). However, such research efforts suffer strong geographic biases, being mostly concentrated in four regions: The Tropical Western Atlantic-TWA, the Hawaiian Archipelago, the Mediterranean Sea and the Northern Red Sea. Most of the MCE research at the TWA has been done in the Caribbean, yielding important information on species richness and abundance, and vertical distribution patterns, mainly on corals and fishes (Pyle and Copus, 2019). However, even in the Caribbean most MCE are unexplored as research has focused on specific locations (i.e., Bahamas, Cayman, Mesoamerican Reef, Jamaica, Puerto Rico, US Virgin Islands, Curacao, and Bonaire; Loya et al., 2019), such that geographic biases remain at the regional scale. For example, only four publications exist on Colombian MCE (Gonzalez-Zapata et al., 2018a,b; Chasqui and González, 2019; Sánchez et al., 2019a), one of such offer data on corals diversity in the fore-reef slope of the eastern side (windward) of San Andrés Island (SAI), which account for 33 species (Sánchez et al., 2019a).

Considering that no previously published works exist related to the ecology of seascape on MCE in Colombia, this work seeks to ignite the topic and contribute with the knowledge on MCE biodiversity of SAI, in the Southwestern Caribbean at the species and habitats level, a relevant information input for the management of the SeaFlower Biosphere Reserve (SFBR) which include SAI. The dataset contains the results of the exploration with Closed-Circuit Rebreather (CCR) technical diving in the upper mesophotic zone (30–70 m deep) at the western side (Leeward) of the Island, where the ecological units Octocorals-Sponges-Mixed corals and *Agaricia* spp.-Mixed corals have been proposed, and includes taxonomic information for 160 species recorded (algae, invertebrates and fishes), collection codes for several collected specimens (corals), and relative abundances for the observed fish species.

METHODS

Study Site and Data Collection

The marine exploration was performed at the western side (leeward) of SAI, in the upper mesophotic zone of a diving spot known as "Nirvana" (12°30′8″ N, 81°44′2″ W, **Figures 1A,B**). The depth profile of the western side offers a soft slope from coastline until around 20 m depth, then, around 300 m from the coast the bottom suddenly deepens until 50 m depth, giving start to which can be considered the deep fore-reef terrace (**Figures 1C–E**), then around 50 m depth a structurally complex wall begins (reef slope), which falls until more than 300 m depth. Ledges, undercuts, ridges, and small caves are common characteristics along the slope, which confers structural complexity to the wall and are possibly increasing microhabitats' offer (**Figures 1F,G**).

Six dives lasting around 28 min between 30 and 70 m depth with O2ptima CCR and trimix were carried out in three spots at Nirvana (1: 12°30′9″ N, 81°44′2″ W; 2: 12°30′4″ N, 81°44′7″ W; 3: 12°30′15″ N, 81°44′1″ W) between March-April 2018, accounting for a total exploration time of 172 min, during which an area of 2.7 ha (approx.) was covered. The exploration allowed the recognition of the most common and conspicuous biota in the deep fore-reef terrace (30–50 m depth) and the upper reef slope (50–70 m depth) of Nirvana. The sampling involves digital imagery (Panasonic™ DMC-LX10, Nikon™ D7000), collection of typical sessile biota and visual census of fishes using roving diver technique (Schmitt and Sullivan, 1996).

Biota Identification

Sessile biota identification was based on the imagery library and the specimens collected. Each specimen was photographed with

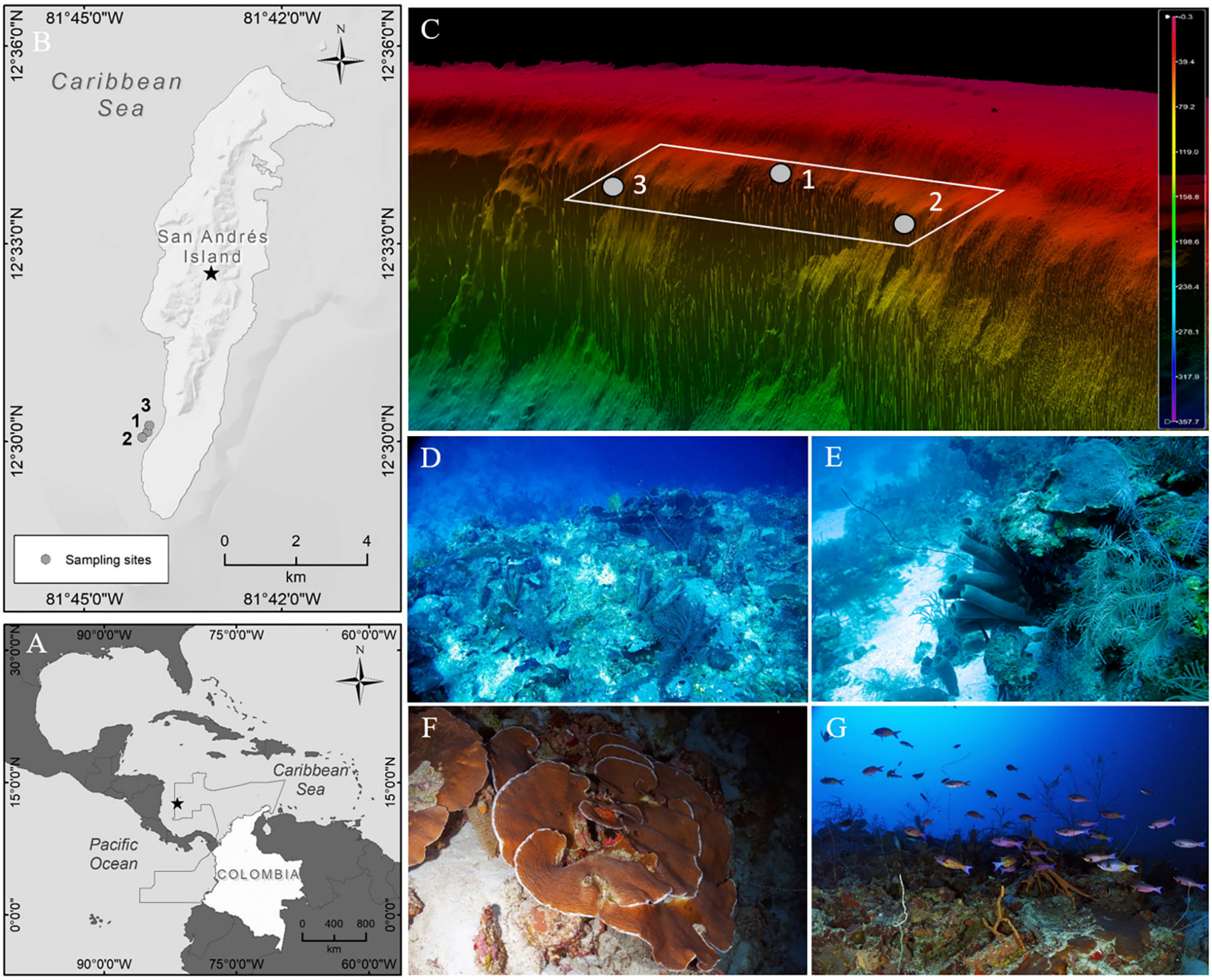

FIGURE 1 | Localization of San Andrés Island in the Caribbean Sea **(A)**, the Nirvana dive spot **(B)** and the sampling sites between 30 and 70 m deep in a 3D seabed model of the SAI leeward side **(C)**. Ecological units found along the depth gradient: **(D,E)** Octocorals-Sponges-Mixed corals on the fore reef terrace between 30 and 50 m deep. **(F,G)** *Agaricia* spp.-Mixed corals on the upper reef slope between 50 and 70 m deep.

and without scale before collection, then was deposited in a tagged "Ziploc" bag for later identification. Fish species were identified *in situ*.

The octocoral and black coral colonies were air-dried for preservation and identified according to morphological characters of the colonies and characteristics of the sclerites in octocorals and spines in black corals (Bayer, 1961; Opresko and Sánchez, 2005; Sánchez and Wirshing, 2005). Sclerites and spines were recovered from a small bit of tissue dissolved in sodium hypochlorite, then were examined and measured with a microgrid in an optical microscope (Carl Zeiss Primostar). The hard coral colonies were preserved in 70% alcohol and identified according to morphological characters (Veron, 2000; Reyes et al., 2010; Veron et al., 2016). All the specimens collected were deposited in the cnidarian collection (INV CNI) of the Museo de Historia Natural Marina de Colombia (MHNMC) of INVEMAR, the codes are listed in **Table 1**.

Data Analysis

To assign ecological units to the seascape observed in the sampling site, the guidelines of the book Áreas coralinas de Colombia (Díaz et al., 2000), in which the main aspects are the geoform and the dominant biota, were followed. In Nirvana, two different zones were visually apparent, one between 30 and 50 m depth, and the other one between 50 and 70 m depth. To determine the dominant biota, several video clips made over dives were used. Eight clips lasting 364 s and 5 clips lasting 385 s, for the 30–50 m and 50–70 m depth intervals, respectively, were analyzed. For each interval 17 photo frames from the video clips were obtained using a fixed time interval to avoid possible observer bias. Afterward, data on the conspicuous taxa (octocoral, black coral, sponges, scleractinian at the genus level when possible, algae) and abiotic components of the sea bottom were taken by overlapping an 8 x 8 grid on the frame and choosing 6 quadrants (off 64) with random numbers. To each quadrant only one category was assigned considering the most conspicuous category (frequently just one were seen). A total of 102 quadrants were reviewed for each depth interval, then 2 quadrants randomly chosen were deleted. Finally, with the number of quadrants percentages for each different taxa or abiotic feature (sand, coral rock, gap, undetermined) for each depth interval were obtained.

DATASET OUTCOMES AND DISCUSSION

This first exploration in the upper zone of the MCE in SAI leeward side allowed the recognition of two coral reef ecological units. The analysis of the quadrants show that in the deep fore-reef terrace (30–50 m depth) the octocorals (27%), sponges (13%), several hard coral species (10%), and black corals (9%) were dominant seascape features; the substrate correspond mainly with limestone matrix although some sand patches were also evident, the relief is flat in there, and wavy where corals and sponges are present (**Figures 1D,E**). The upper reef-slope (50–70 m depth) is a complex wall where the dominant taxa in terms of "conspicuousness" were *Agaricia* (21%, mainly plate-shaped colonies), sponges (12%, mainly tubular and branching, some

TABLE 1 | Species of sessile benthic biota and fishes recorded in the mesophotic coral ecosystem MCE (30–70 m depth) on the western side (leeward) of San Andrés Island, Colombian Caribbean.

Species	Code	Abundance	Habitat/ Depth
Phylum (Division) Chlorophyta			
Class Ulvophyceae			
Order Bryopsidales			
Family Halimedaceae			1
Halimeda copiosa Goreau and E.A.Graham, 1967			1, 2
Halimeda goreaui W.R.Taylor 1962			2
Halimeda opuntia (Linnaeus) J.V.Lamouroux, 1816			1
Halimeda sp.			2
Phylum Ochrophyta			
Class Phaeophyceae			
Order Dictyotales			
Family Dictyotaceae			
Dictyota bartayresiana J.V.Lamouroux, 1809			1
Dictyota humifusa Hörnig, Schnetter and Coppejans, 1992			1
Dictyota pulchella Hörnig and Schnetter, 1988			1
Dictyota sp.			1
Lobophora variegata (J.V.Lamouroux) Womersley ex E.C.Oliveira, 1977			1
Phylum Rhodophyta			
Class Florideophyceae			
Order Corallinales			
Family Corallinaceae			
Jania sp.			1
Family Lithophyllaceae			
Amphiroa tribulus (J.Ellis and Solander) J.V.Lamouroux, 1816			1
Amphiroa sp.			1
Order Peyssonneliales			
Family Peyssonneliaceae			
Peyssonnelia sp.			1
Order Rhodymeniales			
Family Rhodymeniaceae			
**Rhodymenia* sp.			2
Phylum Porifera			
Class Demospongiae			
Order Agelasida			
Family Agelasidae			
Agelas clathrodes (Schmidt, 1870)			1, 2
Agelas sceptrum (Lamarck, 1815)			2
Agelas sventres Lehnert and van Soest, 1996			2
Agelas tubulata Lehnert and van Soest, 1996			2
Order Axinellida			
Family Axinellidae			

(Continued)

TABLE 1 | Continued

Species	Code	Abundance	Habitat/ Depth
**Auletta* sp.			2
Order Clionaida			
Family Clionaidae			
Cliona delitrix Pang, 1973			1, 2
Order Dictyoceratida			
Family Dysideidae			
**Dysidea lehnerti* Van Soest and Hooper, 2020			2
Family Irciniidae			
Ircinia felix (Duchassaing and Michelotti, 1864)			1
Ircinia strobilina (Lamarck, 1816)			1
Order Haplosclerida			
Family Callyspongiidae			
Callyspongia (Cladochalina) aculeata (Linnaeus, 1759)			1
Callyspongia (Cladochalina) plicifera (Lamarck, 1814)			2
Family Niphatidae			
Amphimedon compressa Duchassaing and Michelotti, 1864			1, 2
Cribrochalina vasculum (Lamarck, 1814)			2
**Niphates arenata* Rützler, Piantoni, van Soest and Díaz, 2014			2
Niphates digitalis (Lamarck, 1814)			1
Niphates erecta Duchassaing and Michelotti, 1864			1, 2
Family Petrosiidae			
Petrosia (Petrosia) pellasarca (Laubenfels, 1934)			1
**Xestospongia arenosa* van Soest and de Weerdt, 2001			2
Xestospongia muta (Schmidt, 1870)			1, 2
Family Phloeodictyidae			
**Oceanapia peltata* (Schmidt, 1870)			2
Order Poecilosclerida			
Family Crambeidae			
Monanchora arbuscula (Duchassaing and Michelotti, 1864)			1, 2
Family Iotrochotidae			
Iotrochota birotulata (Higgin, 1877)			1
Family Microcionidae			
Clathria (Microciona) calla (Laubenfels, 1934)			2
Clathria sp.			2
Order Polymastiida			
Family Polymastiidae			
Polymastia tenax Pulitzer-Finali, 1986			2
Order Scopalinida			
Family Scopalinidae			
Scopalina ruetzleri (Wiedenmayer, 1977)			1, 2

(Continued)

TABLE 1 | Continued

Species	Code	Abundance	Habitat/ Depth
Svenzea zeai (Alvarez, van Soest and Rützler, 1998)			1
Order Verongiida			
Family Aplysinidae			
Aiolochroia crassa (Hyatt, 1875)			1, 2
Aplysina archeri (Higgin, 1875)			2
Aplysina cauliformis (Carter, 1882)			2
Aplysina fistularis (Pallas, 1766)			1
Aplysina lacunosa (Lamarck, 1814)			1
Verongula reiswigi Alcolado, 1984			1
Class Homoscleromorpha			
Order Homosclerophorida			
Family Plakinidae			
Plakortis sp.			2
Phylum Cnidaria			
Class Anthozoa			
Order Alcyonacea			
Family Anthothelidae			
**Iciligorgia schrammi* Duchassaing, 1870			2
Family Ellisellidae			
Ellisella elongata (Pallas, 1766)	INV CNI 4183–4185		2
Ellisella schmitti (Bayer, 1961)	INV CNI 4186		2
Nicella goreaui Bayer, 1973	INV CNI 4187–4189		2
Nicella sp.			2
Family Gorgoniidae			
Antillogorgia elisabethae Bayer, 1961	INV CNI 4190-4192		1
Antillogorgia sp.	INV CNI 4193–4195		2
Gorgonia mariae Bayer, 1961			1
Family Plexauridae			
Eunicea sp.			1
**Muriceopsis petila* Bayer, 1961	INV CNI 4196		2
Muriceopsis sp.			1
Pseudoplexaura flagellosa (Houttuyn, 1772)			2
Order Antipatharia			
Family Antipathidae			
Antipathes atlantica Gray, 1857	INV CNI 4176		2
Antipathes caribbeana Opresko, 1996	INV CNI 4175		2
Antipathes sp.			2
Stichopathes luetkeni Brook, 1889	INV CNI 4180		1, 2
Stichopathes occidentalis Gray, 1860	INV CNI 4179		2
Family Myriopathidae			
Plumapathes pennacea (Pallas, 1766)	INV CNI 4177–4178		2
Tanacetipathes hirta (Gray, 1857)	INV CNI 4181–4182		2

(Continued)

TABLE 1 | Continued

Species	Code	Abundance	Habitat/ Depth
Order Scleractinia			
Family Agariciidae			
Agaricia grahamae Wells, 1973			2
Agaricia lamarcki Milne Edwards and Haime, 1851			1, 2
Agaricia undata (Ellis and Solander, 1786)			2
Family Faviidae			
Colpophyllia natans (Houttuyn, 1772)			1
Mycetophyllia lamarckana Milne Edwards and Haime, 1848			1
Mycetophyllia reesi Wells, 1973			2
Scolymia cubensis (Milne Edwards and Haime, 1848)	INV CNI 4199–4202		1, 2
Family Meandrinidae			
Eusmilia fastigiata (Pallas, 1766)			1
Meandrina meandrites (Linnaeus, 1758)	INV CNI 4204		1, 2
Family Merulinidae			
Orbicella franksi (Gregory, 1895)			1
Family Montastraeidae			
Montastraea cavernosa (Linnaeus, 1767)			1, 2
Family Pocilloporidae			
Madracis pharensis (Heller, 1868)	INV CNI 4203		2
Family Poritidae			
Porites astreoides Lamarck, 1816			1
Porites sp.			2
Family Siderastreidae			
Siderastrea siderea (Ellis and Solander, 1786)			1, 2
Class Hydrozoa			
Order Anthoathecata			
Family Milleporidae			
Millepora alcicornis Linnaeus, 1758			1
Family Stylasteridae			
Stylaster roseus (Pallas, 1766)			1, 2
Phylum Arthropoda			
Subphylum Crustacea			
Class Malacostraca			
Order Decapoda			
Family Scyllaridae			
Scyllarides sp.			2
Phylum Chordata			
Subphylum Tunicata			
Class Ascidiacea			
Order Stolidobranchia			
Family Styelidae			
Symplegma viride Herdman, 1886			2
Subphylum Vertebrata			
Class Elasmobranchii			

(Continued)

TABLE 1 | Continued

Species	Code	Abundance	Habitat/ Depth
Order Carcharhiniformes			
Family Carcharhinidae			
+*Carcharhinus longimanus* (Poey, 1861)		S	3
Carcharhinus perezii (Poey, 1876)		S	3
Class Actinopterygii			
Order Anguilliformes			
Family Congridae			
Heteroconger longissimus Günther, 1870		C	1
Order Aulopiformes			
Family Synodontidae			
Synodus synodus (Linnaeus, 1758)		S	2
Order Beryciformes			
Family Holocentridae			
Holocentrus rufus (Walbaum, 1792)		S	2
Neoniphon marianus (Cuvier, 1829)		F	2
Order Syngnathiformes			
Family Aulostomidae			
Aulostomus maculatus Valenciennes, 1841		S	1
Order Scorpaeniformes			
Family Scorpaenidae			
Pterois volitans (Linnaeus, 1758)		C	1, 2
Order Perciformes			
Family Acanthuridae			
Acanthurus coeruleus Bloch and Schneider, 1801		F	1, 2
Acanthurus tractus Poey, 1860		F	1
Family Carangidae			
Caranx crysos (Mitchill, 1815)		F	3
Caranx lugubris Poey, 1860		F	3
Caranx ruber (Bloch, 1793)		F	2, 3
+*Decapterus macarellus* (Cuvier, 1833)		C	3
Seriola rivoliana Valenciennes, 1833		F	2, 3
Family Chaetodontidae			
Chaetodon capistratus Linnaeus, 1758		F	1, 2
Chaetodon sedentarius Poey, 1860		F	1, 2
Chaetodon striatus Linnaeus, 1758		F	1
Prognathodes aculeatus (Poey, 1860)		F	2
Family Gobiidae			
Coryphopterus personatus (Jordan y Thompson, 1905)		A	1, 2
Coryphopterus glaucofraenum Gill, 1863		C	1, 2
Coryphopterus thrix Böhlke y Robins, 1960		C	1
Elacatinus evelynae (Böhlke y Robins, 1968)		C	1, 2

(Continued)

TABLE 1 | Continued

Species	Code	Abundance	Habitat/ Depth
Elacatinus horsti (Metzelaar, 1922)		F	1
Elacatinus illecebrosus (Böhlke y Robins, 1968)		C	1
Gnatholepis thompsoni Jordan, 1904		A	1
Family Grammatidae			
Gramma loreto Poey, 1868		C	1, 2
Gramma melacara Böhlke y Randall, 1963		F	2, 3
Family Haemulidae			
Haemulon flavolineatum (Desmarest, 1823)		F	2
Haemulon plumierii (Lacepède, 1801)		S	2
Haemulon sciurus (Shaw, 1803)		S	1
Family Labridae			
Bodianus rufus (Linnaeus, 1758)		S	2
Clepticus parrae (Bloch and Schneider, 1801)		A	1, 2, 3
Halichoeres bivittatus (Bloch, 1791)		S	1
Halichoeres garnoti (Valenciennes, 1839)		C	1, 2
Xyrichtys novacula (Linnaeus, 1758)		C	1
Family Lutjanidae			
Lutjanus apodus (Walbaum, 1792)		F	1, 2
Lutjanus jocu (Bloch and Schneider, 1801)		F	1, 2
Lutjanus mahogoni (Cuvier, 1828)		F	1, 2
Ocyurus chrysurus (Bloch, 1791)		F	1, 2, 3
Family Mullidae			
Mulloidichthys martinicus (Cuvier, 1829)		C	1, 2
Pseudupenneus maculatus (Bloch, 1793)		F	1, 2
Family Pomacanthidae			
Holacanthus ciliaris (Linnaeus, 1758)		S	2
Holacanthus tricolor (Bloch, 1795)		F	1, 2
Pomacanthus arcuatus (Linnaeus, 1758)		F	2
Pomacanthus paru (Bloch, 1787)		F	2
Family Pomacentridae			
Chromis cyanea (Poey, 1860)		C	1, 2, 3
Chromis insolata (Cuvier, 1830)		A	1, 2, 3
Stegastes partitus (Poey, 1868)		F	1
Stegastes planifrons (Cuvier, 1830)		F	1
Family Priacanthidae			
Heteropriacanthus cruentatus (Lacepède, 1801)		S	1
Family Scaridae			
Scarus iseri (Bloch, 1789)		F	1
Scarus taeniopterus Lesson, 1829		S	1
Sparisoma aurofrenatum (Valenciennes, 1840)		S	1
Sparisoma viride (Bonnaterre, 1788)		S	1

(Continued)

TABLE 1 | Continued

Species	Code	Abundance	Habitat/ Depth
Family Scombridae			
Thunnus albacares (Bonnaterre, 1788)		A	3
Family Serranidae			
Cephalopholis cruentata (Lacepède, 1802)		F	1, 2
Hypoplectrus providencianus Acero P. and Garzón-Ferreira, 1994		S	1
Hypoplectrus puella (Cuvier, 1828)		S	1
Hypoplectrus unicolor (Walbaum, 1792)		S	1
Liopropoma mowbrayi Woods and Kanazawa, 1951		S	2
Mycteroperca bonaci (Poey, 1860)		F	2
Mycteroperca interstitialis (Poey, 1860)		S	2
Serranus baldwini (Evermann and Marsh, 1899)		S	1
Serranus tigrinus (Bloch, 1790)		F	1
Family Sparidae			
Calamus bajonado (Bloch and Schneider, 1801)		F	1
Family Sphyraenidae			
Sphyraena barracuda (Edwards, 1771)		F	1, 2
Order Tetraodontiformes			
Family Balistidae			
Canthidermis sufflamen (Mitchill, 1815)		C	3
Melichthys niger (Bloch, 1786)		C	1, 3
Family Monacanthidae			
Aluterus monoceros (Linnaeus, 1758)		C	3
Aluterus scriptus (Osbeck, 1765)		F	1, 3
Cantherhines macrocerus (Hollard, 1853)		S	1
Family Ostraciidae			
Lactophrys triqueter (Linnaeus, 1758)		S	1
Family Tetraodontidae			
Canthigaster rostrata (Bloch, 1786)		C	1, 2

**New records for SeaFlower Biosphere Reserve. +New records for San Andrés Island. Code: catalog number in MHNMC (only for collected specimens). Abundance (fishes): S, single; F, few (2–10 ind); C, common (11–100); A, abundant (>100). Habitat/Depth: 1 = bottom 30–50 m depth, 2 = bottom 50–70 m depth, 3 = water column 30–70 m depth.*

barrels), and black corals (7%, mainly sea whips) are the main biotic components (**Figures 1F,G**).

Supported in this straightforward data analysis the units Octocorals-Sponges-Mixed corals for the 30–50 m range, and *Agaricia* spp.-Mixed corals (see Díaz et al., 2000) to 50–70 m range were assigned.

In terms of biota, 160 species included in 3 kingdoms (Chromista, Plantae, and Animalia), 7 phyla, 11 classes, 29 orders, 66 families and 103 genera between algae (14 spp.), sponges (34), cnidarians (36), crustaceans (1), ascidians (1), and fishes (74), were recognized (**Table 1**). The dataset provides information on sample collection for 30 specimens of 15 species, as well as sighting data recorded *in situ* for the remaining 145 species. Additionally, fish species abundance is presented by categories. In the **Figures 2A–M** some of the common species recorded in the study are showed.

Until date, 311 species of macroalgae have been reported in the SFBR, including species in the four phyla (Cyanophyta, Rhodophyta, Chlorophyta, and Ochrophyta), but mostly from shallow waters between 0 and 31 m depth (Rincón-Díaz and Ramos-Gallego, 2016; Rincón-Díaz et al., 2018). Here we report the presence of 14 algae species in the mesophotic zone (30 and 70 m depth), most of them already listed for the SFBR except for the genus *Rhodymenia* (Rhodophyta), which has not been previously reported in the archipelago (nor in the north of Southwestern Caribbean Ecoregion), but recorded on the Colombian mainland coast (Diaz-Pulido and Díaz-Ruíz, 2003), thus expanding the presence of the genus to the north of the ecoregion.

Fifteen species of scleractinian were recorded, five of them were only seen in the deep fore-reef terrace (30–50 m depth: *Colpophyllia natans*, *Mycetophyllia lamarckana*, *Eusmilia fastigiata*, *Orbicella franksi*, and *Porites astreoides*), five more were seen exclusively in the reef slope (50–70 m depth: *Agaricia grahamae*, *A. undata*, *Mycetophyllia reesi*, *Madracis pharensis*, *Porites* sp.), and five were recorded in both deep strata (*Agaricia lamarcki, Scolymia cubensis*, *Meandrina meandrites*, *Montastraea cavernosa*, and *Siderastrea siderea*; **Table 1**). Among these hard coral species, the most conspicuous were those in the genera *Agaricia,* being frequent to observe big plate-like colonies hanging from the ledges of the wall, some of them showing severe bleaching (**Figure 2M**). Bleaching in several species of scleractinian corals in MCE (including *Agaricia* spp.) has been reported in different locations of the Western Atlantic (i.e., Puerto Rico, Bahamas, Cayman Islands, Gulf of Mexico), with the deepest coral bleaching report in the Bahamas at 91 m depth (Weil, 2019). Another striking feature of several *Agaricia* spp. colonies observed on the leeward reef slope in SAI was the obvious presence of big dark blotches (**Figure 2L**), which seems very like the *Ostreobium* endolithic algal association reported by Gonzalez-Zapata et al. (2018b) in colonies of *A. undata* on MCE at windward reefs in SAI, and other coral areas from the Colombian Caribbean.

The octocoral communities observed between 30 and 50 m depth were similar to those found on shallower zones with a dominance of species like *Antillogorgia* spp. and *Eunicea* spp., some of them previously recorded at similar depths in the windward reefs of the island (Sánchez et al., 2019a). The colonization of shallow-water coral species into deeper zones in SAI can be explained by a high light penetration that reaches deep areas in this insular region, which could be promoting an ecological divergence in some species according to Sánchez et al. (2019b). Several octocorals and black coral species which are usually common in Caribbean MCE like *Ellisella schmitti*, *E. elongata* (including the synonymous *E. barbadensis*), *Nicella goreaui*, *Nicella* sp., and the unbranched black corals *Stichopathes luetkeni* and *S. occidentalis*, were also common below 50 m depth in Nirvana, where shallow-water coral species (e.g., *Antillogorgia* spp.) begin to be rare. On the reef slope (50–70 m depth) at Nirvana, two new records of corals for the SFBR were found, *Iciligorgia schrammi* registered by photographs and *Muriceopsis petila* that was even collected. The black coral *Tanacetipathes hirta*, a species recently reported in the windward MCE of San Andrés Island by Sánchez et al. (2019a), were also seen in the leeward MCE between 50 and 70 m depth (**Figure 2C**).

The 34 sponge's species listed in the dataset were recorded mainly by photographs. Ten species were only seen in the shallower zone (30–50 m depth) and 16 were exclusively found on 50–70 m depth; the other eight species were present through the entire depth range (**Table 1**). The sponge community in the MCE of the leeward face at SAI was very similar to those reported for other Caribbean locations (Pomponi et al., 2019), commonly dominated by tubular and vase sponges like *Agelas tubulata*, *A. sceptrum*, *Aplysina archeri*, and *Xestospongia muta* (**Figures 2F,H**). However, in this work just the most conspicuous sponges were recorded—mainly massive ones—, so that sponge richness is probably underestimated, which can be assumed by the unregistered amount of different colored sponges encrusting the hard bottom. This exploration of MCE yielded five new records of sponges for the SFBR (*Auletta* sp., *Dysidea lehnerti*, *Niphates arenata*, *Oceanapia peltata,* and *Xestospongia arenosa*), which increase the species richness of the group for this Marine Protected Area, previously estimated in 164 species accounted only for shallow waters (until 30 m depth; Díaz-Sánchez and Zea, 2016).

The fish community observed in the MCE of the leeward side at SAI is very typical of the known ictiofauna in the SFBR (around 653 species; Bolaños-Cubillos et al., 2015) regarding composition, except for the species *Carcharhinus longimanus* and *Decapterus macarellus*, which are new records for the island. Conversely, some difference in species abundance between MCE fish community and fish community in shallow waters at Nirvana seems evident (**Table 1**). For example, several herbivorous fishes that are very common in the Caribbean shallow reefs such as the parrotfishes *Scarus iseri*, *Sparisoma viride*, and *S. aurofrenatum*, became difficult to observe as depth increases. Also, species like the blackcap basslet *Gramma melacara* which can hardly be observed shallower than 20 m depth, were very common in the fore-reef slope (50–70 m depth). *G. melacara* is a common species in the deep fore-reef at different sites along the Caribbean, being considered as the most abundant mesophotic reef fish of the Western/Central Caribbean (Dustan and Lang, 2019). Similarly, the longsnout butterflyfish *Prognathodes aculeatus*, an observed but uncommon fish species in shallow waters of the Caribbean reefs, was one of the common fish species in San Andrés MCE. This species is also one of the common species in the mesophotic fish communities along the Tropical Western Caribbean (Loya et al., 2019), being one of the five species that best characterized the fish assemblage at 70 m depth in Puerto Rico (Appeldoorn et al., 2019).

The lionfish *Pterois volitans*, maybe the most famous and infamous marine alien invasive species in the Western Atlantic were also seen frequently in this study, to a maximum depth

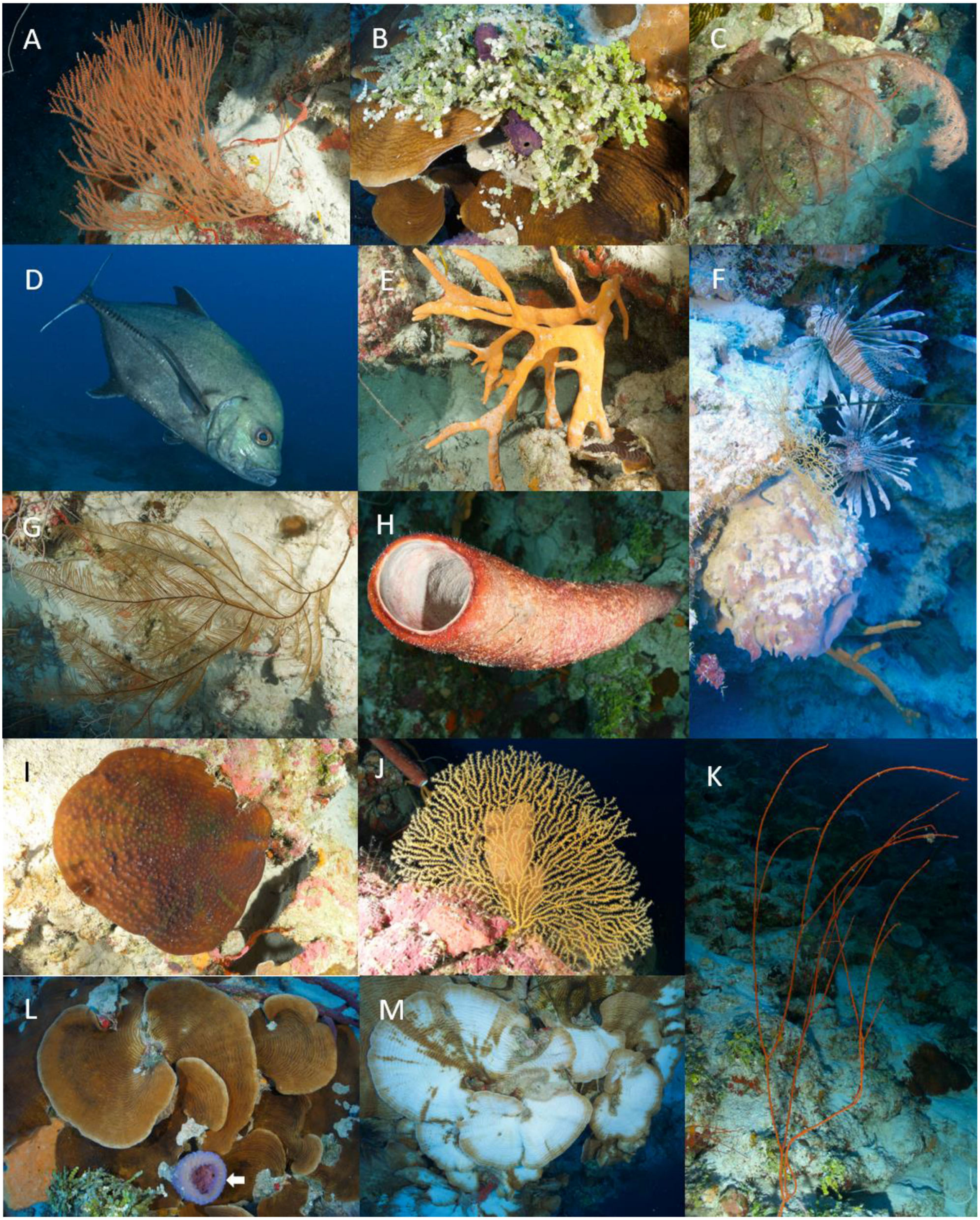

FIGURE 2 | Common biota in the Ecological Units Octocorals-Sponges-Mixed corals and *Agaricia* spp.-Mixed corals of the mesophotic coral ecosystem (MCE) (30–70 m depth) in the western side (leeward) of San Andrés Island, Colombian Caribbean. **(A)** *Ellisella schmitti*; **(B)** *Halimeda copiosa*; **(C)** *Tanacetipathes hirta*; **(D)** *Caranx lugubris*; **(E)** *Agelas sceptrum*; **(F)** *Pterois volitans* and *Xestospongia muta*; **(G)** *Plumapathes pennacea*; **(H)** *Aplysina archeri*; **(I)** *Mycetophyllia reesi*; **(J)** *Nicella* sp.; **(K)** *Ellisella elongata*; **(L)** *Agaricia* sp. and *Callyspongia* sp. (white arrow); **(M)** Bleaching in *Agaricia* sp. at 70 m depth.

of 70 m. The invader has also been recorded in other localities and ecosystems in the Colombian Caribbean, practically from the surface until 140 m depth (Chasqui et al., 2020; Polanco, unpublished data). In Colombian MCE, there are sightings of lionfish in the National Natural Park Corales de Profundidad (Chasqui and González, 2019), in San Andrés Island (this study, **Figure 2I**) and the continental platform near Santa Marta city (González, unpublished data). The non-native lionfish have invaded MCE across the Western Atlantic, and several studies in the upper MCE suggest that the species cause negative impacts on native fish communities (Andradi-Brown, 2019), making clear the urgent need to extend lionfish control measures (manual hunting, trapping, etc.) toward mesophotic coral ecosystems.

Reuse Potential

This dataset provides an update of marine organisms recorded in SFBR and specifically SAI with a focus on the mesophotic coral ecosystem, poorly known for the Island. The dataset includes the catalog numbers of the collected biota that was deposited in the Museo de Historia Natural Marina de Colombia—(MHNMC), for any taxonomic verification needed. Additionally, the categories of fish abundance are provided in the dataset for future comparisons. These species records are a valuable source of biodiversity information on MEC in the Southwestern Caribbean, available for future studies and reviews on the topic, a very nascent field of research in this part of the world, particularly in Colombia.

DATA AVAILABILITY STATEMENT

The dataset for this study titled "Biodiversidad de los Ecosistemas Mesofóticos de la isla de San Andrés" can be found through the Integrated Publishing Tool of the OBIS Colombian nodes (SIBM-SIB Colombia), using the link https://doi.org/10.15472/0itxej.

AUTHOR CONTRIBUTIONS

LC conceived the study. LC and JG collected the data and biological samples. KM-Q identified and processed the collected material. LC, KM-Q, and JG wrote the manuscript. All authors read and accepted the final version of the manuscript.

FUNDING

This work was supported by a cooperation agreement between Corporación para el Desarrollo Sostenible del Archipiélago de San Andrés, Providencia y Santa Catalina—CORALINA and Instituto de Investigaciones Marinas y Costeras—INVEMAR (Agreement 007- 2017).

ACKNOWLEDGMENTS

We thank CORALINA staff for support during fieldwork, particularly N. Bolaños for allowing access to his dive tech stuff and secure the funding to MCE research inside CORALINA. To D. Seguro (Tech Bull SAS) for dive logistics, and photo capture. To E. Montoya and N. Rincón (INVEMAR) for tunicates and algae identification. To S. Zea (Universidad Nacional) and P. Parrado (INVEMAR) for help in sponge's identification. E. Montoya and Julio Bohorquez advised on the dataset elaboration. INVEMAR Contribution Number 1281. We thank the two reviewers for their suggestions to improve the manuscript.

REFERENCES

Andradi-Brown, D. A. (2019). "Invasive Lionfish (*Pterois volitans* and *P. miles*): distribution, impact, and management," (48) in *Mesophotic Coral Ecosystems, Coral Reefs of the World*, eds Y. Loya, K. A. Puglise, and T. C. L. *Bridge (Cham: Springer Nature Switzerland AG),* 931–941. doi: 10.1007/978-3-319-92735-0_48

Appeldoorn, R., Ballantine, D., Bejarano, I., Carlo, M., Nemeth, M., Otero, E., et al. (2016). Mesophotic coral ecosystems under anthropogenic stress: a case study at Ponce, Puerto Rico. *Coral Reefs* 35, 63–75. doi: 10.1007/s00338-015-1360-5

Appeldoorn, R. S., Alfaro, M., Ballantine, D. L., Bejarano, I., Ruíz, H. J., Schizas, N. V., et al. (2019). "Puerto Rico" (7) in *Mesophotic Coral Ecosystems, Coral Reefs of the World,* eds Y. Loya, K. A. Puglise, and T. C. L. Bridge (Cham: Springer Nature Switzerland AG), 111–129. doi: 10.1007/978-3-319-92735-0_7

Bayer, F. (1961). "The shallow-water Octocorallia of the West Indian Region," in *Martinus Nijoff (La Haya),* 373.

Bolaños-Cubillos, N., Abril-Howard, A., Bent-Hooker, H., Caldas, J. P., and Acero, A. (2015). Lista de peces conocidos del archipiélago de San Andrés, Providencia y Santa Catalina, Reserva de Biosfera Seaflower, Caribe occidental colombiano. *Bol. Invest. Mar. Cost*. 44, 127–162. doi: 10.25268/bimc.invemar.2015.44.1.24

Bongaerts, P., Ridgway, T., Sampayo, E. M., and Hoegh-Guldberg, O. (2010). Assessing the 'Deep Reef Refugia' hypothesis: focus on Caribbean reefs. *Coral Reefs* 29, 309–327. doi: 10.1007/s00338-009-0581-x

Chasqui, L., Rincón-Díaz, N., and Vanegas, M. J. (2020). Abundance of the invasive lionfish *Pterois volitans* in the coastal coral reefs from Colombian Caribbean. *Bol. Invest. Mar. Cost*. 49, 157–170. doi: 10.25268/bimc.invemar.2020.49.1.779

Chasqui, L. H., and González, J. D. (2019). Fishes found in mesophotic environments of Bajo Frijol, the shallowest portion of the Corales de Profundidad Natural National Park, using CCR technical diving. *Bol. Invest. Mar. Cost*. 48, 89–101. doi: 10.25268/bimc.invemar.2019.48.1.759

Díaz, J. M., Barrios, L. M., Cendales, M. H., Garzón-Ferreira, J., Geister, J., López-Victoria, M., et al. (2000). *Áreas coralinas de Colombia. Serie Publicaciones Especiales No. 5.* Santa Marta: INVEMAR.

Diaz-Pulido, G., and Díaz-Ruíz, M. (2003). Diversity of benthic marine algae of the Colombian Atlantic. *Biota Colombiana* 4, 203–249.

Díaz-Sánchez, C. M., and Zea, S. (2016). "Esponjas (Porifera) de la Reserva de Biosfera Seaflower", in *Biodiversidad del mar de los siete colores,* eds M. Vides, D. Alonso, E. Castro, and N. Bolaños (Instituto de Investigaciones Marinas y Costeras – INVEMAR y Corporación para el Desarrollo Sostenible del Archipiélago de San Andrés, Providencia y Santa Catalina – CORALINA) (*Santa Marta*: Serie de Publicaciones Generales del INVEMAR No. 84), 72–85.

Dustan, P., and Lang, J. C. (2019). "Discovery bay, Jamaica" (6), in *Mesophotic Coral Ecosystems, Coral Reefs of the World,* eds Y. Loya, K. A. Puglise, and T. C. L. *Bridge (Cham: Springer Nature Switzerland AG),* 85–109. doi: 10.1007/978-3-319-92735-0_6

Gonzalez-Zapata, F. L., Bongaerts, P., Ramírez-Portilla, C., Adu-Oppong, B., Walljasper, G., Reyes, A., et al. (2018a). Holobiont diversity in a reef-building coral over its entire depth range in the mesophotic zone. *Front. Mar. Sci*. 5:29. doi: 10.3389/fmars.2018.00029

Gonzalez-Zapata, F. L., Gómez-Osorio, S., and Sánchez, J. A. (2018b). Conspicuous endolithic algal associations in a mesophotic reef-building coral. *Coral Reefs* 37, 705–709. doi: 10.1007/s00338-018-1695-9

Laverick, J. H., Piango, S., Andradi-Brown, D. A., Exton, D. A., Bogaerts, P., Bridge, T. C. L., et al. (2018). To what extent do mesophotic coral ecosystems and shallow reefs share species of conservation interest? A systematic review. *Environ Evid*. 7:15. doi: 10.1186/s13750-018-0127-1

Loya, Y., Puglise, K. A., and Bridge, T. C. L. (2019). *Mesophotic Coral Ecosystems, Coral Reefs of the World*. *(Vol. 12).* Cham: Springer Nature Switzerland AG. doi: 10.1007/978-3-319-92735-0

Opresko, D. M., and Sánchez, J. A. (2005). Caribbean shallow-water black corals (Cnidaria: Anthozoa: Antipatharia). *Caribb. J. Sci*. 41, 492–507.

Pomponi, S. A., Díaz, M. C., van Soest, R. W., Bell, L. J., Busutil, L., Gochfeld, D., et al. (2019). "Sponges" (32), in *Mesophotic Coral Ecosystems, Coral Reefs of the World,* eds Y. Loya, K. A. Puglise, and T. C. L. Bridge (Cham: Springer Nature Switzerland AG), 563–588. doi: 10.1007/978-3-319-92735-0_32

Pyle, R. L., Boland, R., Bolick, H., Bowen, B. W., Bradley, C. J., Kane, C., et al. (2016). A comprehensive investigation of mesophotic coral ecosystems in the Hawaiian Archipelago. *Peer J*. 4:e2475. doi: 10.7717/peerj.2475

Pyle, R. L., and Copus, J. M. (2019). "Mesophotic coral ecosystems: introduction and overview" (1), in *Mesophotic Coral Ecosystems, Coral Reefs of the World,* eds Y. Loya, K. A. Puglise, and T. C. L. Bridge (Cham: Springer Nature Switzerland AG), 3–27. doi: 10.1007/978-3-319-92735-0_1

Reyes, J., Santodomingo, N., and Flórez, P. (2010). *Corales Escleractinios de Colombia*. Santa Marta: Serie de Publicaciones Especiales del Invemar No. 14.

Rincón-Díaz, M. N., Gavio, B., Wynne, M. J., and Santos-Martínez, A. (2018). Notes on marine algae in the International biosphere reserve seaflower, Caribbean Colombia, VII: additions to the benthic flora of San Andrés Island. *Caldasia* 40, 97–111. doi: 10.15446/caldasia.v40n1.64597

Rincón-Díaz, M. N., and Ramos-Gallego, F. J. (2016). "Macroalgas marinas. El universo productivo de la Reserva de Biosfera Seaflower", in *Biodiversidad del mar de los siete colores*, eds M. Vides, D. Alonso, E. Castro, and N. Bolaños (Instituto de Investigaciones Marinas y Costeras – INVEMAR y Corporación para el Desarrollo Sostenible del Archipiélago de San Andrés, Providencia y Santa Catalina - CORALINA. Serie de Publicaciones Generales del INVEMAR No. 84) (Santa Marta: INVEMAR), 40–55.

Sánchez, J. A., Dueñas, L. F., Rowley, S. J., González, F. L., Vergara, D. C., Montaño-Salazar, S. M., et al. (2019b). "Gorgonian Corals" (39), in *Mesophotic Coral Ecosystems, Coral Reefs of the World,* eds Y. Loya, K. A. Puglise, and T. C. L. Bridge (Cham: Springer Nature Switzerland AG), 727–745. doi: 10.1007/978-3-319-92735-0_39

Sánchez, J. A., González-Zapata, F. L., Dueñas, L. F., Andrade, J., Pico-Vargas, A. L., Vergara, D. C., et al. (2019a). Corals in the mesophotic zone (40–115 m) at the barrier reef complex from San Andrés Island (Southwestern Caribbean). *Front. Mar. Sci*. 6:536. doi: 10.3389/fmars.2019.00536

Sánchez, J. A., and Wirshing, H. (2005). A field key to the identification of tropical Western Atlantic zooxanthellate Octocorals (Octocorallia: Cnidaria). *Caribb. J. Sci*. 41, 508–522.

Schmitt, E. F., and Sullivan, K. M. (1996). Analysis of a volunteer method for collecting fish presence and abundance data in the Florida Keys. *Bull. Mar. Sci*. 59, 404–416.

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 *(Nairobi and Arenda: The United Nations Environment Programme and GRID-Arendal),* 50–62.

Veron, J. E. N. (2000). *Corals of the World, Vol. 1, 2, 3*. Townsville, QLD: Australian Institute of Marine Science and CRR Qld Pty Ltd.

Veron, J. E. N., Stafford-Smith, M. G., Turak, E., and deVantier, L. M. (2016). *Corals of the World.* Available online at: http://www.coralsoftheworld.org/page/authors/ (accessed February 13, 2020).

Weil, E. (2019). "Disease problems" (41), in *Mesophotic Coral Ecosystems, Coral Reefs of the World,* eds Y. Loya, K. A. Puglise, and T. C. L. Bridge (Cham: Springer Nature Switzerland AG), 779–800 doi: 10.1007/978-3-319-92735-0_41

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.