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Fish biodiversity of Courtown Cays, seaflower biosphere reserve (Colombian Caribbean): new records and an annotated checklist

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Introduction

The Seaflower Biosphere Reserve (SFBR) is renowned for its remarkably diverse marine life, particularly its rich fish fauna. Several species inhabiting the reserve are under some threat category and there is no exclusive fish species inventory for Courtown Cays (Isla Cayo Bolívar), an atoll located in the southern part of this marine protected area where intense artisanal fishing activities are carried out and illegal fishing has increased since 2006. To address this situation and enhance our scientific understanding of the region's marine life, a dataset is presented with information about the marine fish species found in this oceanic reef complex during the Seaflower Scientific Expedition 2022. A total of 223 species were registered, distributed in 31 orders and 57 families, with Serranidae (25 spp.) and Labridae (24 spp.) showing the highest species richness. Forty-three species are recorded for the first time in this locality and one of them is recorded for the first time in the SFBR. These results highlights the critical importance of safeguarding vulnerable ecosystems, particularly oceanic coral reefs, which harbor hundreds of species of ecological and economic value and provide numerous ecological and economic benefits. This emphasizes the need of protection and prompt sustainable use of these resources.

Methods

Study area and data collection

The Seaflower Biosphere Reserve (SFBR), created in 2000, is a protected marine area of great importance for the conservation of the natural and cultural heritage of the Archipelago of San Andres, Providencia, and Santa Catalina, covering approximately 180,000 km^2. This reserve

is home to around a quarter of the Caribbean ichthyofauna (Bolaños-Cubillos et al., 2015; Acero et al., 2019), constituting one of the main reasons for the protection and proper management of its natural richness. Courtown Cays (Isla Cayo Bolívar) are located in the southern part of the reserve, at 12° 22' – 28' N and 81° 25' – 31' W, has a total area of 50.3 km^2 (Díaz et al., 2000) and is part of the complex of 10 islands, keys, banks, and shoals that give the archipelago its name.

Scientific research in this area began at the end of the 20th century (Mejía et al., 1998; Mejía and Garzón-Ferreira, 2000); Bolaños-Cubillos et al. (2015) synthesized the existing knowledge about the ichthyofauna up to that date, providing a list of species for the so-called "southern keys", Albuquerque and Courtown Cays, based on a compilation of information obtained in previous expeditions, explorations and studies that used different methodologies. The National Plan for Scientific Expeditions carried out by the government of Colombia marked the starting point in the monitoring of these remote areas and the expedition carried out during 2022 allowed the generation of an exclusive list for Cayo Bolivar due to the lack of this information.

During the Seaflower Scientific Expedition between the 9th and the 21st September, 2022, data was collected through visual censuses in coral reef formations and seagrass beds. The diversity of environments and formations (shallow peripheral reef, lagoon terrace, consolidated reefs, seagrass meadows and continental slope) made of this island an interesting site to study. Explorations were made by four divers through SCUBA diving using a 30 min timed swim method at different depths (0-35 m) in different sites of the key (Figure 1A). Occurrences and counts were conducted for all the species observed along the reef complex. Some specimens were collected to verify their identity and later deposited in the ichthyology collection of the Universidad del Valle (CIRUV). To verify new records, the works of Bolaños-Cubillos et al. (2015); Acero et al. (2019) and Robertson and Van Tassell (2019) were used as a reference.

Data availability

The dataset "Fish biodiversity of Courtown Cays, Seaflower Biosphere Reserve (Colombian Caribbean): new records and an annotated checklist" was assembled using the Darwin Core standard (DwC) and is available through the Integrated Publishing Tool of the Ocean Biogeographic Imation System (OBIS) and the Global Biodiversity Information Facility (GBIF) Colombian nodes (SIBM-SIB Colombia). Links (Acero et al., 2023):

SiB Colombia: https://biodiversidad.co/data?datasetKey=75301af4-c7b0-4b93-818f-bdf5d7cdabe0

GBIF: https://www.gbif.org/dataset/75301af4-c7b0-4b93-818f-bdf5d7cdabe0

OBIS: https://obis.org/dataset/097332d5-d8af-4e83-9f02-4750c1e439c4

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Outcomes and discussion

A total of 223 species were recorded for Courtown Cays (Isla Cayo Bolivar) (Table 1). Exploring this atoll allowed us to observe one of the highest fish richness in the SFBR [Roncador: 140 spp.; Serrana: 155 spp.; Serranilla: 166 spp.; Providencia: 248 spp.; Albuquerque: 207 spp.; Courtown Cays (present study): 223 spp.], although we noticed low abundances of large bony predators, which are in turn of high commercial interest such as snappers, groupers and some parrotfishes. Yet, 48 (22%) of the recorded species are of commercial interest to local communities. Twenty-seven of the species observed (12%) have been assigned with some threat category by the International Union for Conservation of Nature (IUCN) and/or the regional assessment included in the Red Book of Marine Fishes of Colombia (Chasqui et al., 2017), and 43 (20%) species were new records for this location.

The most abundant families were Serranidae (11%), Labridae (11%), Gobiidae (7%), Haemulidae (6%), Carangidae (5%), and Pomacentridae (5%), with other families representing less than 5% of the total fish richness (Figure 1B). Families Serranidae, Labridae, Haemulidae and Carangidae have species of commercial interest, which therefore highlights the crucial role and potential of these areas in the conservation of fish stocks.

Pomacentridae is one of the most abundant families that can be found in the Caribbean Sea assemblages and are characterized by its numerical dominance of small bodied species and broader distribution (Seeman et al., 2018). Other studies carried out in the Caribbean have found similar results, with this being one of the most recorded fish families (Dominici-Arosemena and Wolff, 2005; Alemu, 2014; Andradi-Brown et al., 2016).

Gobiidae was the third richest family in the study and contributed with 16 species. Other families of cryptic fishes, such as Chaenopsidae and Labrisomidae, were also significant as they represent 33% of the new records of this study (Figure 1C). A large proportion of tropical reef fish diversity is composed of cryptobenthic fishes: bottom-dwelling, morphologically or behaviorally cryptic species typically less than 50 mm in length (Depczynski and Bellwood, 2003). Their small body size allowed them to diversify at high rates exploiting small microhabitats and develop a wide range of life-history adaptations. However, despite their diversity and abundance, these fishes are poorly studied, overlooked and an underestimated component due to their small size, difficult identification, and cryptic habits (Herler et al., 2011). Since the information about the geographic coverage of cryptobenthic fishes is poor, this emphasizes the remarkable reservoir of biodiversity that is yet to be discovered (Brandl et al., 2018). On the other hand, the crucial ecological role of this community of fishes in coral reef trophodynamics is of great value (Bellwood et al., 2012; Goatley et al., 2016; Brandl et al., 2019) and makes necessary to apply greater efforts to study this "hidden half" of the vertebrate biodiversity on coral reefs (Brandl et al., 2018).

The high number of new records calls upon the need to continue the exploration and monitoring on remote localities and join research efforts to expand knowledge about the ecology, systematics, and conservation of understudied groups. Most of the new records may be due to reduced methodologies, limitations in sampling and few studies previously carried out in this location. The two new records of sharks were provided by Diego Cardeñosa, who carried out a study using baited remote

10.3389/fmars.2024.1327438

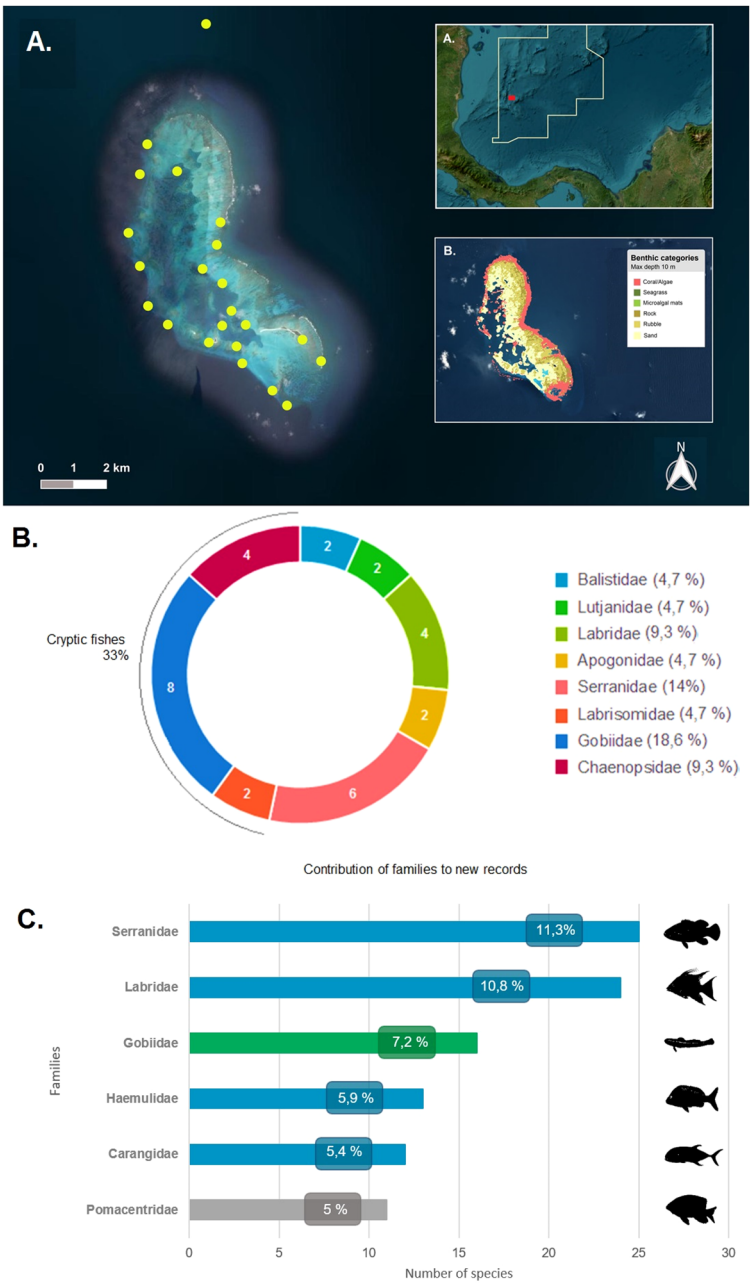

FIGURE 1
(A) Distribution of the sampling locations in Courtown Cays reef complex, Seaflower Biosphere Reserve. (AA). Geographical location of the study area. The solid line demarcates the marine protected area. (AB). Bottom characteristics and distribution of benthic categories in Courtown Cays (Allen Coral Atlas, 2022). **(B)** Families that contributed the most to new records in the study area. White numbers within the circle indicate the number of species recorded per family and the legend denote the percentages that each family contributes to the new records. **(C)** Families with the highest species richness in Courtown Cays reef complex. In green cryptic fishes and in blue families with fishes of commercial interest.

underwater videos BRUVS. The use of this methodology different from the classic visual censuses has been found to be especially effective at observing predatory and mobile species, such as elasmobranchs, since the behaviour of many fish changes in the presence of divers (Watson and Harvey, 2007).

In the case of the cherubfish *Centropyge argi*, the yellowcheek wrasse *Halichoeres cyanocephalus*, the sargassum triggerfish, *Xanthichthys ringens*, the school bass *Schultzea beta* and the chalk bass *Serranus tortugarum* it has been found that they are only present at depths greater than 30 m or are more abundant in deep environments (Randall, 1963; Colin, 1974; Moyer et al., 1983; Weaver et al. 2006; Robertson and Van Tassell, 2019) so they appear to be indicator species of mesophotic habitats (García-Sais, 2010) and are difficult species to census since depth becomes a limitation when carrying out studies through autonomous diving. Other species such as the rosy razorfish *Xyrichtys martinicensis* may have gone unnoticed previously since they do not actually live in coral reefs, but rather in sandy bottoms or near seagrass meadows.

10.3389/fmars.2024.1327438

TABLE 1 Inventory of the species observed in Cayo Bolivar during the Seaflower Scientific Expedition 2022.

Order and family	Specie	TC	CI	NR	NRSF
CARCHARHINIFORMES					
Carcharhinidae	*Carcharhinus perezii*	x	x		
	Galeocerdo cuvier	x	x		
	Negaprion brevirostris	x	x		
	Rhizoprionodon sp.	x	x	**x**	
Sphyrnidae	*Sphyrna mokarran*	x	x	**x**	
ORECTOLOBIFORMES					
Ginglymostomatidae	*Ginglymostoma cirratum*	x			
MYLIOBATIFORMES					
Dasyatidae	*Hypanus americanus*	x	x		
Myliobatidae	*Aetobatus narinari*	x	x		
ANGUILIFORMES					
Muraenidae	*Enchelycore nigricans*				
	Gymnothorax funebris				
	Gymnothorax miliaris				
	Gymnothorax moringa				
Congridae	*Heteroconger longissimus*				
Ophichthidae	*Myrichthys breviceps*				
CLUPEIFORMES					
Clupeidae	*Jenkinsia sp*				
AULOPIFORMES					
Synodontidae	*Synodus intermedius*				
	Synodus synodus				
HOLOCENTRIFORMES					
Holocentridae	*Holocentrus adscensionis*				
	Holocentrus rufus				
	Myripristis jacobus				
	Neoniphon marianus				
	Sargocentron vexillarium				
SCOMBRIFORMES					
Scombridae	*Thunnus atlanticus*		x		
SYNGNATHIFORMES					
Aulostomidae	*Aulostomus maculatus*				
Dactylopteridae	*Dactylopterus volitans*				
Mullidae	*Mulloidichthys martinicus*				
	Pseudupeneus maculatus				
Syngnathidae	*Cosmocampus elucens*			**x**	

(Continued)

10.3389/fmars.2024.1327438

TABLE 1 Continued

Order and family	Specie	TC	CI	NR	NRSF
GOBIIFORMES					
Gobiidae	*Coryphopterus dicrus*				
	Coryphopterus eidolon	x			
	Coryphopterus glaucofraenum				
	Coryphopterus personatus	x			
	Coryphopterus thrix	x		**x**	
	Coryphopterus tortugae	x		**x**	
	Ctenogobius saepepallens			**x**	
	Gnatholepis thompsoni				
	Elacatinus evelynae				
	Elacatinus horsti				
	Elacatinus lori			**x**	
	Elacatinus louisae			**x**	
	Elacatinus prochilos	x		**x**	
	Priolepis hipoliti				
	Ptereleotris helenae			**x**	
	Risor ruber			**x**	
KURTIFORMES					
Apogonidae	*Apogon conklini*				
	Apogon maculatus				
	Apogon robbyi			**x**	
	Astrapogon puncticulatus			**x**	
	Phaeoptyx sp.				
INCERTAE SEDIS – CARANGARIA					
Sphyraenidae	*Sphyraena barracuda*		x		
	Sphyraena borealis		x	**x**	
CARANGIFORMES					
Carangidae	*Alectis ciliaris*		x		
	Caranx bartholomaei		x		
	Caranx crysos		x		
	Caranx latus		x		
	Caranx lugubris		x		
	Caranx ruber		x		
	Decapterus tabl		x	**x**	**x**
	Elagatis bipinnulata		x		
	Selar crumenophthalmus		x		
	Seriola rivoliana		x		
	Trachinotus goodei		x		
	Trachinotus falcatus		x		

(Continued)

10.3389/fmars.2024.1327438

TABLE 1 Continued

Order and family	Specie	TC	CI	NR	NRSF
Coryphaenidae	*Coryphaena hippurus*		x		
Echeneidae	*Echeneis naucrates*				
	Echeneis neucratoides			x	
PLEURONECTIFORMES					
Bothidae	*Bothus lunatus*				
INCERTAE SEDIS – OVALENTARIA					
Grammatidae	*Gramma loreto*				
	Gramma melacara				
Opistognathidae	*Opistognathus aurifrons*				
	Opistognathus maxillosus				
	Opistognathus whitehursti			x	
Pomacentridae	*Abudefduf saxatilis*				
	Azurina cyanea				
	Azurina multilineata				
	Chromis insolata				
	Microspathodon chrysurus				
	Stegastes adustus				
	Stegastes diencaeus				
	Stegastes leucostictus				
	Stegastes partitus				
	Stegastes planifrons				
	Stegastes xanthurus				
BELONIFORMES					
Belonidae	*Strongylura timucu*			x	
	Tylosurus crocodrilus		x		
Exocoetidae	*Exocoetus* sp.				
Hemiramphidae	*Hemiramphus balao*				
BLENNIIFORMES					
Blenniidae	*Entomacrodus nigricans*				
	Ophioblennius macclurei				
Chaenopsidae	*Acanthemblemaria aspera*			x	
	Acanthemblemaria maria			x	
	Acanthemblemaria spinosa				
	Chaenopsis sp.			x	
	Emblemaria pandionis			x	
	Emblemariopsis sp.				
	Lucayablennius zingaro				
Labrisomidae	*Gobioclinus bucciferus*				
	Gobioclinus kalisherae			x	

(Continued)

10.3389/fmars.2024.1327438

TABLE 1 Continued

Order and family	Specie	TC	CI	NR	NRSF
	Malacoctenus aurolineatus			**x**	
	Malacoctenus boehlkei				
	Malacoctenus erdmani				
	Malacoctenus gilli				
	Malacoctenus macropus				
	Malacoctenus triangulatus				
Tripterygiidae	*Enneanectes boehlkei*				
INCERTAE SEDIS – EUPERCARIA					
Malacanthidae	*Malacanthus plumierii*				
Pomacanthidae	*Centropyge argi*			**x**	
	Holacanthus ciliaris				
	Holacanthus tricolor				
	Pomacanthus arcuatus				
	Pomacanthus paru				
Sciaenidae	*Eques punctatus*				
GERREIFORMES					
Gerreidae	*Eucinostomus* sp.			**x**	
LABRIFORMES					
Labridae	*Bodianus rufus*				
	Clepticus parrae				
	Halichoeres bivittatus				
	Halichoeres cyanocephalus			**x**	
	Halichoeres garnoti				
	Halichoeres maculipinna				
	Halichoeres pictus			**x**	
	Halichoeres poeyi			**x**	
	Halichoeres radiatus				
	Lachnolaimus maximus	x	x		
	Scarus coelestinus	x			
	Scarus guacamaia	x			
	Scarus iseri				
	Scarus taeniopterus				
	Scarus vetula	x			
	Sparisoma atomarium				
	Sparisoma aurofrenatum				
	Sparisoma chrysopterum				
	Sparisoma radians				
	Sparisoma rubripinne				
	Sparisoma viride	x			

(Continued)

10.3389/fmars.2024.1327438

TABLE 1 Continued

Order and family	Specie	TC	CI	NR	NRSF
	Thalassoma bifasciatum				
	Xyrichtys martinicensis			**x**	
	Xyrichtys splendens				
CHAETODONTIFORMES					
Chaetodontidae	*Chaetodon capistratus*				
	Chaetodon ocellatus				
	Chaetodon sedentarius				
	Chaetodon striatus				
	Prognathodes aculeatus				
ACANTHURIFORMES					
Acanthuridae	*Acanthurus chirurgus*				
	Acanthurus coeruleus				
	Acanthurus tractus				
LUTJANIFORMES					
Haemulidae	*Anisotremus surinamensis*				
	Anisotremus virginicus				
	Brachygenys chrysargyreum				
	Haemulon album		x		
	Haemulon aurolineatum				
	Haemulon carbonarium				
	Haemulon flavolineatum				
	Haemulon macrostomum			**x**	
	Haemulon melanurum		x		
	Haemulon parra		x		
	Haemulon plumierii		x		
	Haemulon sciurus		x		
	Haemulon vittatum				
Lutjanidae	*Apsilus dentatus*		x		
	Lutjanus analis	x	x		
	Lutjanus apodus		x		
	Lutjanus buccanella		x	**x**	
	Lutjanus griseus		x		
	Lutjanus jocu	x	x		
	Lutjanus mahogoni		x		
	Lutjanus synagris		x	**x**	
	Lutjanus chrysurus	x	x		
LOBOTIFORMES					
Lobotidae	*Lobotes surinamensis*				
SPARIFORMES					

(Continued)

10.3389/fmars.2024.1327438

TABLE 1 Continued

Order and family	Specie	TC	CI	NR	NRSF
Sparidae	*Calamus bajonado*				
	Calamus calamus				
PRIACANTHIFORMES					
Priacanthidae	*Heteropriacanthus cruentatus*				
LOPHIIFORMES					
Antennariidae	*Antennarius pauciradiatus*			**x**	
TETRAODONTIFORMES					
Balistidae	*Balistes capriscus*				
	Balistes vetula	x	x	**x**	
	Canthidermis maculata				
	Canthidermis sufflamen		x		
	Melichthys niger				
Diodontidae	*Diodon holocanthus*				
	Diodon hystrix				
	Xanthichtys ringens			**x**	
Monacanthidae	*Aluterus scriptus*				
	Cantherines macrocerus				
	Cantherines pullus				
	Monacanthus tuckeri				
Ostraciidae	*Acanthostracion polygonius*				
	Acanthostracion quadricornis				
	Lactophrys bicaudalis				
	Lactophrys trigonus				
	Lactophrys triqueter				
Tetraodontidae	*Canthigaster rostrata*				
	Sphoeroides spengleri				
PEMPHERIFORMES					
Pempheridae	*Pempheris schomburgkii*				
CENTRARCHIFORMES					
Cirrhitidae	*Amblycirrhitus pinos*				
Kyphosidae	*Kyphosus cinerascens*			**x**	
	Kyphosus vaigiensis				
PERCIFORMES					
Serranidae	*Cephalopholis cruentata*		x		
	Cephalopholis fulva		x		
	Diplectrum bivittatum				
	Epinephelus guttatus		x		
	Hypoplectrus aberrans				
	Hypoplectrus affinis			**x**	

(Continued)

10.3389/fmars.2024.1327438

TABLE 1 Continued

Order and family	Specie	TC	CI	NR	NRSF
	Hypoplectrus guttavarius				
	Hypoplectrus indigo				
	Hypoplectrus maculiferus			**x**	
	Hypoplectrus nigricans				
	Hypoplectrus providencianus	x			
	Hypoplectrus puella				
	Hypoplectrus randallorum			**x**	
	Hypoplectrus unicolor				
	Liopropoma rubre				
	Mycteroperca bonaci	x	x		
	Mycteroperca interstitialis	x	x		
	Mycteroperca tigris	x	x		
	Mycteroperca venenosa	x	x		
	Serranus baldwini			**x**	
	Serranus tabacarius				
	Serranus tigrinus				
	Serranus tortugarum			**x**	
	Rypticus saponaceus				
	Schultzea beta			**x**	
Scorpaenidae	*Pterois volitans*				
	Scorpaena cf. albifimbria				
	Scorpaena plumieri				

Species under some threat category: TC; species of commercial interest: CI; new record for the locality: NR; new record for the SFBR: NRSF.

These results place these small key as a strategic point in the conservation of the ichthyic fauna of the SFBR, as well as of the Greater Caribbean. However, despite the species richness found, the observed abundances indicated the presence of only a few representatives of fish families of high-body sizes and of commercial interest mainly because they are targeted by artisanal fishermen and illegal fishing. Therefore, it is imperative to direct efforts for the protection, monitoring, control and surveillance of these localities that are little studied but intensively exploited.

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 in the article/Supplementary Material.

Ethics statement

The animal study was approved by Ministerio de Ambiente y Desarrollo Sostenible. The study was conducted in accordance with the local legislation and institutional requirements.

Author contributions

AP-S: Conceptualization, Data curation, Formal analysis, Investigation, Validation, Writing – original draft. NO: Investigation, Methodology, Validation, Writing – review & editing. NR: Validation, Writing – review & editing. JT: Data curation, Investigation, Methodology, Validation, Writing – review & editing. AA: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft.

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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.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2024.1327438/full#supplementary-material

SUPPLEMENTARY FIGURE 1
Fishes observed and/or collected during the Seaflower Scientific Expedition 2022. **(A)** *Acanthemblemaria spinosa*. **(B)** *Acanthemblemaria maria*. **(C)** *Emblemaria pandionis* female. **(D)** *Elacatinus louisae*. **(E)** *Coryphopterus tortugae*. **(F)** *Gobioclinus kalisherae*. **(G)** *Canthidermis maculata* and *Lobotes surinamensis*.

References

Acero, P. A., Puentes-Sayo, A., Tavera, J. J., Pabon-Quintero, P. E., Rivas-Escobar, N., and Ossa-Hernández, N. (2023). *Biodiversidad íctica de Isla Cayos de Bolívar: potencial del territorio insular Colombiano en la conservación de especies amenazadas. v1.0* (the Ocean Biodiversity Information System: Universidad Nacional de Colombia). Dataset/Occurrence. doi: 10.15472/4a8ygj

Acero, P. ,. A., Tavera, J. J., Polanco, A., and Bolaños-Cubillos, N. (2019). Fish biodiversity in three northern islands of the Seaflower Biosphere Reserve (Colombian Caribbean). *Front. Mar. Sci.* 6. doi: 10.3389/fmars.2019.00113

Alemu, J. B. (2014). Fish assemblages on fringing reefs in the southern Caribbean: biodiversity, biomass and feeding types. *Rev. Biol. Trop.* 62 (3), 169–181.

Allen Coral Atlas. (2022). Imagery, maps and monitoring of the world's tropical coral reefs. Available at: https://allencoralatlas.org/atlas/#12.00/12.4000/-81.4167.

Andradi-Brown, D. A., Macaya-Solis, C., Exton, D. A., Gress, E., Wright, G., Rogers, E., et al. (2016). Assessing caribbean shallow and mesophotic reef fish communities using baited-remote underwater video (BRUV) and diver-operated video (DOV) survey techniques. *PloS One* 11 (12), e0168235. doi: 10.1371/journal.pone.0168235

Bellwood, D. R., Baird, A. H., Depczynski, M., González-Cabello, A., Hoey, A. S., Lefevre, C. D., et al. (2012). Coral recovery may not herald the return of fishes on damaged coral reefs. *Oecologia* 170, 567–573. doi: 10.1007/s00442-012-2306-z

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

Brandl, S. J., Goatley, C. H. R., Bellwood, D. R., and Tornabene, L. (2018). The hidden half: Ecology and evolution of cryptobenthic fishes on coral reefs. *Biol. Rev. Cambridge Philos. Soc* 93 (4), 1846–1873. doi: 10.1111/brv.12423

Brandl, S. J., Tornabene, L., Goatley, C., Casey, J. M., Morais, R. A., Côté, I. M., et al. (2019). Demographic dynamics of the smallest marine vertebrates fuel coral-reef ecosystem functioning. *Sci. (New York N.Y.).*, eaav3384. doi: 10.1126/science.aav3384

Chasqui, L., Polanco, A., Acero P., A., Mejía-Falla, P., Navia, A., Zapata, L. A., et al. (2017). *Libro rojo de peces marinos de Colombia. Instituto de Investigaciones Marinas y Costeras. Invemar, Ministerio de Ambiente y Desarrollo Sostenible* (Santa Marta, Colombia Instituto de Investigaciones Marinas y Costeras. Invemar, Ministerio de Ambiente y Desarrollo Sostenible), 552.

Colin, P. L. (1974). Observation and collection of deep-reef fishes off the coasts of Jamaica and British Honduras (Belize). *Mar. Biol.* 24 (1), 29–38. doi: 10.1007/BF00402844

Depczynski, M., and Bellwood, D. R. (2003). The role of cryptobenthic reef fishes in coral reef trophodynamics. *Mar. Ecol. Prog. Ser.* 256, 183–191. doi: 10.3354/meps256183

Díaz, J. M., Barrios, L. M., Cendales, M. H., Garzón-Ferreira, J., Geister, J., López-Victoria, M., et al. (2000). *Áreas coralinas de Colombia* (Santa Marta: INVEMAR), 176.

Dominici-Arosemena, A., and Wolff, M. (2005). Reef fish community structure in bocas del toro (Caribbean, Panama): gradients in habitat complexity and exposure. *Caribb. J. Sci.* 41 (3), 613–637.

García-Sais, J. R. (2010). Reef habitats and associated sessile-benthic and fish assemblages across a euphotic–mesophotic depth gradient in Isla Desecheo, Puerto Rico. *Coral Reefs.* 29 (2), 277–288. doi: 10.1007/s00338-009-0582-9

Goatley, C., González-Cabello, A., and Bellwood, D. R. (2016). Small cryptopredators contribute to high predation rates on coral reefs. *Coral Reefs.* 36 (1), 207–212. doi: 10.1007/s00338-016-1521-1

Herler, J., Munday, P. L., and Hernaman, V. (2011). "Gobies on coral reefs. Chapter 4.2," in *The biology of gobies*. Eds. R. A. Patzner, J. L. Van Tassell, M. Kovačić and B. G. Kapoor (Jersey, British Isles, New Hampshire: Science Publishers), 685.

Mejía, L.S., Garzón-Ferreira, J, and Acero, P A. (1998). Peces registrados en los complejos arrecifales de los cayos Courtown, Albuquerque y los bancos Serrana y Roncador, Caribe occidental. *Colombia. Bol. Ecotrópica* 32: 25–42

Mejía, L.S., and Garzón-Ferreira, J. (2000). Estructura de la comunidad de peces arrecifales en cuatro atolones del archipiélago de San Andrés y Providencia (Caribe suroccidental). *Rev. Biol. Trop.* 48 (4), 883–896.

Moyer, J. T., Thresher, R. E., and Colin, P. L. (1983). Courtship, spawning and inferred social organization of American angelfishes (Genera *Pomacanthus*, *Holacanthus* and *Centropyge*; Pomacanthidae). *Environ. Biol. Fishes.* 9 (1), 25–39. doi: 10.1007/BF00001056

Randall, J. E. (1963). Three new species and six new records of small serranoid fishes from Curaçao and Puerto Rico. *Stud. Fauna Curacao other Caribbean Islands* 19 (1), 77–110.

Robertson, D. R., and Van Tassell, J. (2019). *Shorefishes of the Greater Caribbean: online information system* (Balboa, Panamá: Version 2.0 Smithsonian Tropical Research Institute).

Seeman, J., Yingst, A., Stuart-Smith, R. D., Edgar, G. J., and Altieri, A. H. (2018). The importance of sponges and mangroves in supporting fish communities on degraded coral reefs in Caribbean Panama. *PeerJ* 6, e4455. doi: 10.7717/peerj.4455

Watson, D. L., and Harvey, E. S. (2007). Behaviour of temperate and sub-tropical reef fishes towards a stationary SCUBA diver. *Mar. Freshwat Behav. Physiol.* 40, 85–103. doi: 10.1080/10236240701393263

Weaver, D. C., Hickerson, E. L., and Schmahl, G. P. (2006). *Deep reef fish surveys by submersible on Alderdice, McGrail, and Sonnier Banks in the Northwestern Gulf of Mexico. Professional Paper NMFS 5* (Silve Springs, MD, USA: National Oceanic and Atmospheric Administration), 69–87.