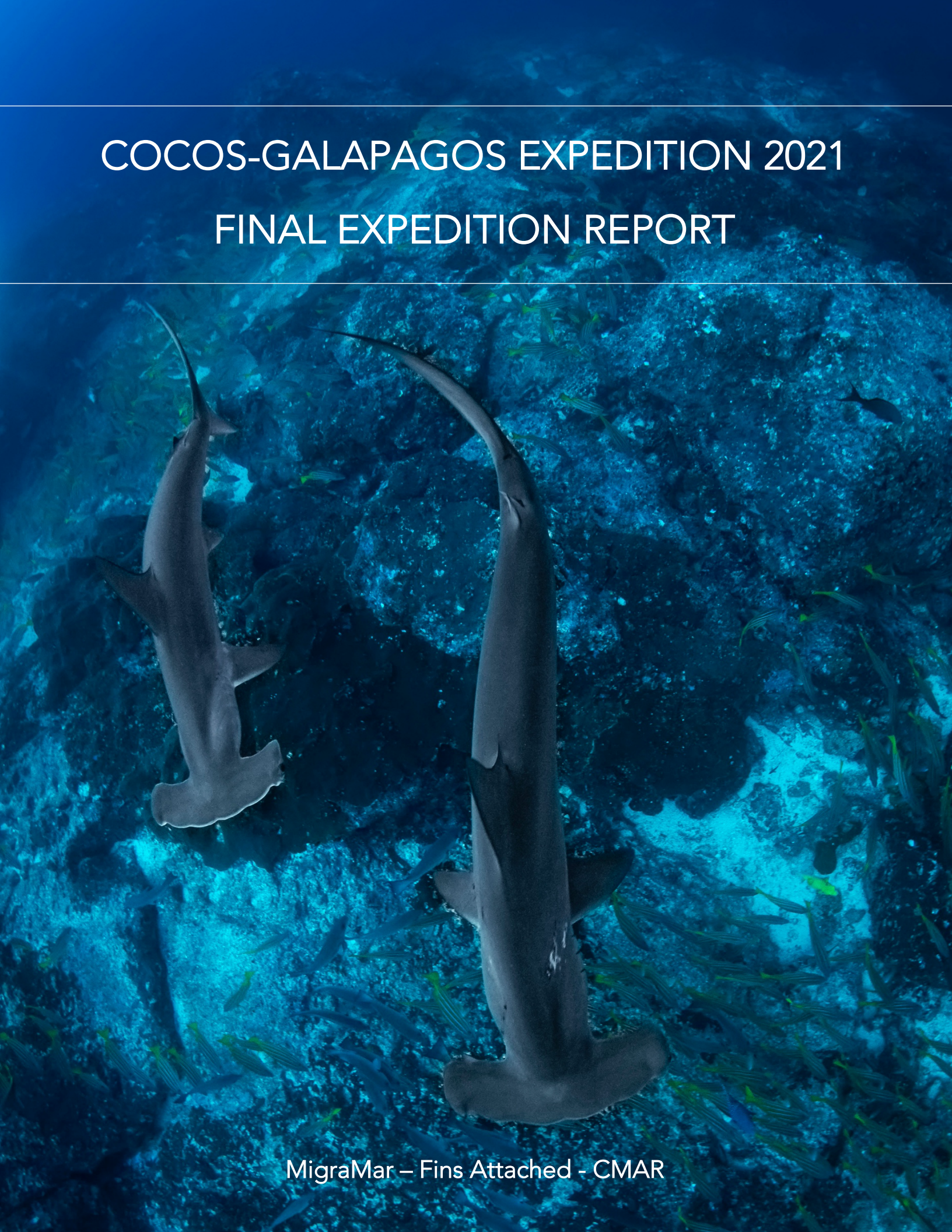
COCOS-GALAPAGOS EXPEDITION 2021

FINAL EXPEDITION REPORT



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COCOS-GALAPAGOS EXPEDITION 2021
FINAL EXPEDITION REPORT

May 3rd – 22nd, 2021

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Background

Scientific studies carried out by the MigraMar network and other scientists, show that highly migratory species such as sharks, rays, sea turtles, tuna, swordfish, billfish, dorado and whales, while protected when inside marine reserves, face significant threats once they leave. MigraMar scientists aim to quantify the overall risk to these species, based on their residency in protected waters, and to identify migratory corridors that can be used as the basis of new protected areas.

MigraMar and partners undertook a research expedition in the Eastern Tropical Pacific Ocean (ETPO), in the region known as the Cocos-Galapagos Swimway (Figure 1). This expedition was carried out within the Marine Corridor of the Eastern Tropical Pacific Ocean (CMAR) framework, which is supported by both the Governments of Costa Rica and Ecuador. The goal of this expedition was to obtain scientific information on the abundance, biomass and behavioral patterns of migratory fish species. This information will inform decision makers of the level of protection required to reduce fishery-related mortality and improved regional management schemes.

Expedition goals

Based on the work carried out in the ETPO, MigraMar and its partners defined the following expedition objectives:

1. To assess the spatial and temporal behavior of migratory marine species.
2. To assess the spatial and temporal trends in abundance, size structure and biomass productivity of migratory marine species.
3. To assess the behavior and population dynamic response of marine migratory species to changes in the oceanographic setting, particularly in relation to strong environmental events such as El Niño Southern Oscillation (ENSO) and long-term climate change scenarios.
4. To assess the genetic diversity, gene flow and effective population size between marine species (sub) populations living within the MPAs under assessment.
5. To investigate the abundance and composition of floating plastic pollution that may be encountered by marine species in this region.

Methods

Work plan

The study area was located between Cocos Island National Park (CINP) and the Galapagos Marine Reserve. The round-trip covered 1584 NM from May 3rd to May 23rd, and included seven study sites along its path (Figure 1).

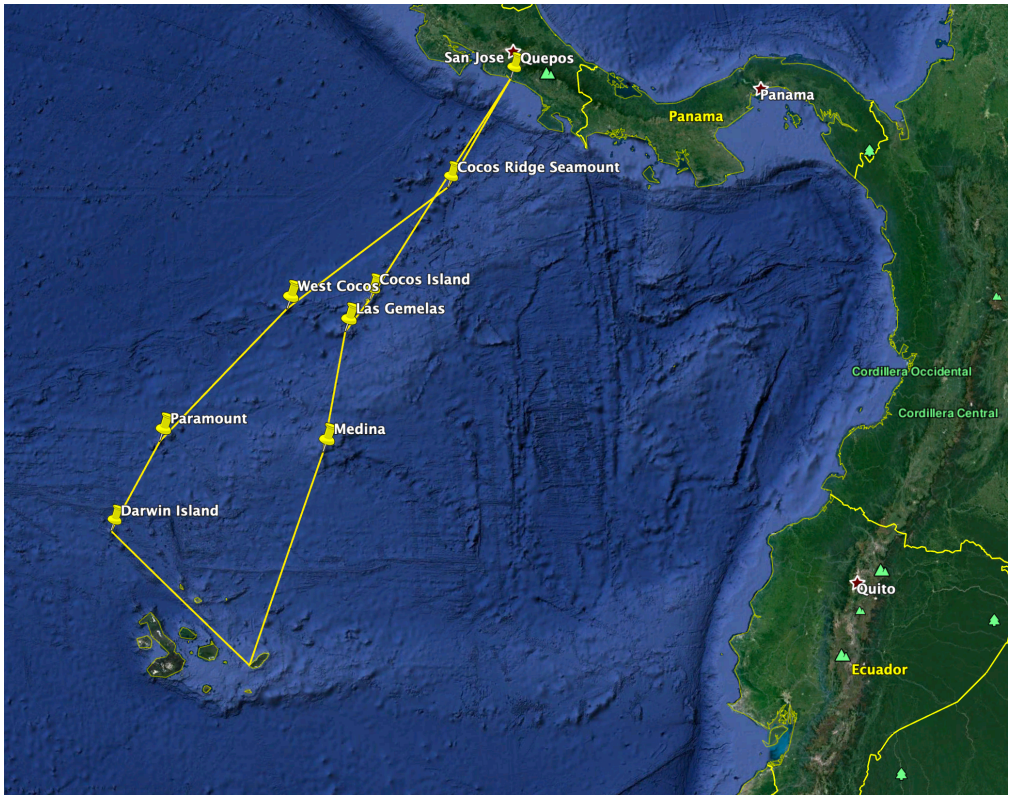

Figure 1. Expedition route along the Cocos-Galapagos Swimway.

Table 1. Description of the daily work plan.

Date	Place	Activities	Latitude	Longitude	Nav. Distance	Nav. Time
May 3th	Quepos, Costa Rica	Departure to Cocos Island.	9.425922°	-84.188114°	0 nm	NA
May 5th	Cocos Island	- BRUVS deployment. - Satellite and acoustic tagging (fishing). - eDNA and DNA tissue sampling. - Underwater visual census (shark counts). - Biodiversity counts and macroplastic transects. (sea surface).	5.563279°	-87.086108°	285 nm	28.5 h
May 7th	Las Gemelas Seamount	2 day planned work: - BRUVS deployment. - Satellite and acoustic tagging (fishing) - eDNA and DNA tissue sampling - Biodiversity counts and macroplastic transects (sea surface).	4.958721°	-87.399441°	40 nm	4 h
May 9th	Medina Seamount	2 day planned work: - BRUVS deployment. - Satellite and acoustic tagging (fishing). - eDNA and DNA tissue sampling. - Biodiversity counts and macroplastic transects (sea surface).	2.990000°	-88.050000°	115 nm	11.5 h
May 12th	San Cristobal, Galapagos	- GMR navigation permits clearance. - COVID PCR test clearance.	-0.894453°	-89.618813°	250 nm	25 h
May 13th	Press Conference	- 9AM mid-expedition press conference. MigraMar, Pacifico, DPNG, PNIC, OBT.				
May 15th	Darwin Island	2 day planned work: - BRUVS deployment. - Satellite tagging. - eDNA and DNA tissue sampling. - Underwater visual census. - Biodiversity counts and macroplastic transects (sea surface).	1.683395°	-91.979510°	210 nm	21 h
May 17th	Paramount Seamount	2 day planned work: - BRUVS deployment. - Satellite and acoustic tagging (fishing). - eDNA and DNA tissue sampling. - Biodiversity counts and macroplastic transects (sea surface).	3.349000°	-90.781000°	125 nm	12.5 h
May 19th	West Cocos Seamount	2 day planned work: - BRUVS deployment. - Satellite and acoustic tagging (fishing). - eDNA and DNA tissue sampling. - Biodiversity counts and macroplastic transects (sea surface).	5.487000°	-88.558000°	185 nm	18.5 h
May 22th	Cocos Ridge (Corcovado) Seamount	1 day planned work: - BRUVS deployment. - Satellite and acoustic tagging (fishing). - eDNA and DNA tissue sampling. - Biodiversity counts and macroplastic transects (sea surface).	7.478000°	-85.471000°	218 nm	22 h
May 23th	Quepos, Costa Rica	- Arrival from West Cocos. - COVID PCR test clearance.	9.425922°	-84.188114°	139 nm	14 h

At each site we stayed two days, during which we carried out satellite and acoustic tagging, BRUVS sampling, biodiversity counts, DNA sampling, and macroplastic transects (Table 1). Four of the seven sites are seamounts with summits less than 200 m depth. These seamounts were previously sampled with mono BRUVS techniques during a pilot fieldtrip carried out in 2017. The other two sites are located within the CINP (Cocos Island) and the GMR (Darwin Island).

Participating scientists

The science party on board of this expedition represents a combination of local and international scientists. The name, role and contact of each participant is described in Table 2.

Table 2. List of participants on board of the M/Y Sharkwater during the Cocos-Galapagos Expedition 2021.

No.	Name	Institution	Nationality	Role	email
1	Alex Hearn	Universidad San Francisco de Quito	UK	Expedition leader (Tagging)	ahearn@usfq.edu.ec
2	César Peñaherrera-Palma	MigraMar	Ecuador	Expedition Scientist (BRUVS)	cesar.penaherrera@migramar.org
3	Randall Arauz	CREMA	USA	Expedition Scientist (Tagging)	rarauz@cremacr.org
4	Andrea Vera	USFQ	Ecuador	Research assistant (eDNA)	andre.VE_912@hotmail.com
5	Marta Cambra	University of Costa Rica	Costa Rica	Research assistant (BRUVS)	m.cambra.agusti@gmail.com
6	Rosario Alvarez	MigraMar	México	Research assistant (Biodiversity Counts)	rosario.alvarez@migramar.org
7	Roy Prendas	Sea Legacy	Costa Rica	Communication lead	roy.prendas@gmail.com
8	Micaela Stacey	Sea Legacy	Ecuador	Communication support	mica.stacey91@gmail.com
10	Jennifer Suarez	Dirección del Parque Nacional Galápagos	Ecuador	Ecuador's Government representative	jmsuarez@galapagos.gob.ec
11	Isaac Chinchilla	Vice-Ministerio Aguas y Mares	Costa Rica	Costa Rica's Government representative	isaac.chinchilla@sinac.go.cr
12	Luis Javier Sandoval Alvarado	Ocean Blue Tree	México	Expedition support	javier_uyuyuy@yahoo.com
13	Juan Bonilla	Ocean Blue Tree	USA	Expedition support	juancarlosbonilla.e@gmail.com
14	James Otis III	Fins Attached	USA	Expedition support	j.otis3@outlook.com

Organizing institutions

The Research Vessel

The Sharkwater is a 134-foot vessel that was originally built in Japan and used by Japanese fisheries but now has been repurposed for the good of our oceans. Sharkwater is owned and operated by the US-based Fins Attached Foundation (Figure 2).

Figure 2. Sharkwater M/Y. For specifications, please see www.finsattached.org.

Research methods

All the research carried out by MigraMar follows the United States and Australian codes on human and animal experimentation. Our research methods have been reviewed and approved in the past by the Animal Care and Use Committee of the University of California – Davis; and the Safety, Ethics and Institutional Biosafety Committees of the University of Tasmania. Currently, we operate under guidelines of the Galapagos National Park Directorate animal welfare regulations; the Ministry of Environment and Sustainable Development through the Natural National Parks of Colombia; the Ministry of Environment of Panamá; and the Ministry of Environment of Costa Rica.

The following methods were used to answer each of the research objectives defined for this expedition:

1. To assess the spatial and temporal behavior of migratory marine species, we carried out satellite tagging and acoustic tagging. *Satellite Tagging* is used to evaluate spatial behavior of fish and marine mammals in areas of known aggregation within MPAs as well as national and international waters between them. We used two types of tagging within this expedition: i) tags that are affixed to the fin of a shark (via bolt and nuts or fin clamps), and ii) tags that freely float but were affixed via a tether nylon line and an anchoring device (place inside the individual's muscle over the dorsal area). Sharks were caught from a small boat using barbless circle hooks and nylon lines, with chunks of skipjack (*Katsuwonus pelamis*) or tuna (*Thunnus albacares*) as bait. Once sharks were hooked, they were slowly towed to the mother-vessel. Sharks were either brought on board to the back of the mother vessel or to the side of the fishing fiberglass boat. Once sharks were immobilized, their eyes were covered with a wet cloth, and seawater was pumped continuously across their gills. All sharks were measured and sexed, after which satellite transmitters were attached to the dorsal fin with nuts and bolts, or inside the musculature of the shark. Additionally, sex, size and any distinctive markings, (scars or injuries which may help future recognition), were recorded. All tags were configured to opportunistically send location data to Argos satellites whenever at the surface.

Acoustic tagging is use to assess the fine-scale habitat use and connectivity of marine species throughout the ETP region. It uses acoustic devices that emit a coded sound signal to detect a marine animal whenever it passes by the receiver stations that are permanently listening for coded signals. Sharks were fitted with coded Vemco V16-6H tags (diameter 16mm, length 95mm). These tags were surgically implanted in the abdominal cavity of fish. To detect tagged individuals, MigraMar has an array of receivers located all around the ETPO. This array is mostly comprised by Vemco VR2W receivers set at 30 m deep and anchored to concrete blocks by PVC coated marine stainless-steel cable ropes. In some deep-sea areas, Vemco VRAR underwater acoustic receivers are in place. The detection range of these receivers was previously estimated to vary from 200 to 300 m (for more technical details see Hearn et al. 2010).

2. To assess the spatial and temporal trends in abundance and biomass, we used baited remote underwater video stations (BRUVS), visual surveys and photoidentification. The *BRUVS* technique was used to assess abundance, size structure and biomass of pelagic marine species. A stereo BRUVS consist in two front-facing GOPro Hero 5 cameras placed in an angle of 8 degrees used to create a three-dimensional (stereo) image, which is later used to measure any object (or fish) that passes in front of the cameras. Each 3D camera station is also equipped with a 360-camera used to assess abundance of all fish that may approach the station from any direction. Insta 360 cameras were used for this objective. A BRUVS set (line) has three stations/rigs placed in sequence resembling a longline fishing gear. While BRUVS use bait to attract fish with the smell, it replaces hooks from longlines for the camera systems. This makes it a not invasive assessing technique in comparison to experimental fishing. BRUVS deployment is generally done near seamounts and open waters inside and outside MPAs. BRUVS are allowing MigraMar to assess previously unknown seamounts in the Swimways between Cocos and Galapagos Islands, and between Coiba and Malpelo Islands.

Visuals surveys (UVS) were used to estimate the relative abundance of marine megafauna species within and around MPAs. Two techniques were used during this research expedition: underwater visual surveys and biodiversity counts. For the former, two divers will count all the animals that pass by in a 30-minute period. The UVS generally begins at 25 m and ends at 15 m depth, ascending gradually during this time. At the same time the current strength and visibility is estimated, water temperature measured and the presence or absence of a thermocline recorded. Lastly, biodiversity counts will be carried out over the surface to measure abundance of seabirds, marine reptiles and marine mammals. A pair of observers will log the geographic location of all species observed around the boat while navigating.

3. To assess the behavior and population dynamic response of marine migratory species to changes in the oceanographic setting, *in situ* and remote sensing environmental data are used. A CTD equipment from Seabird ® was used to collect *in situ* a vertical profile of the temperature, depth, conductivity, chlorophyll a concentration (via fluorescence), dissolve oxygen, turbidity, salinity and water density. The CTD was lowered to a depth of 100 m over in each seamount and during the deployment of each BRUV line. In terms of remote sensing data, selected oceanographic variables currently used are sea surface temperature (hereafter SST) obtained from the NOAA's Optimum Interpolated Sea Surface Temperature (0.25o x0.25o resolution, o Celsius) (Reynolds et al. 2007); Chlorophyll a data from the Moderate Resolution Imaging Spectroradiometer (Modis)-Aqua satellites (4 km · 8-day composite, mg/m^3) (Maccherone and Frazier 2015); and the eddy kinetic energy (hereafter EKE) derived from the TOPEX / Poseidon and ERS-2 altimeters (0.2° spatial resolution, m^2s^2) (Fu et al. 1994). The EKE is a measure of the energy associated with the turbulent flow of the ocean (Wyrtki et al. 1976).

4. To assess the genetic diversity of marine species populations living within the MPAs under assessment, environmental DNA (eDNA) collection was carried out. Water samples were collected and preserved in Niskin crystal water bottles to preserve DNA fragments left by fish and marine species found in the area. The eDNA is a genetic tool developed to assess the species richness of an area based on traces of DNA of a species left behind when swimming freely. The use of eDNA could increase the probability of detecting species that other methods cannot detect, as demonstrated by Boussarie et al. 2018. Additionally, the use of eDNA during the expedition will represent the first time that this new emerging technique is used at pelagic environments of the ETP, highlighting its potential for detecting endangered predator species in the region.

5. To investigate the abundance and composition of floating plastic debris that may be encountered by marine species and to establish if any plastic litter gradient is visible in terms of abundance and composition, visual observations were recorded during daylight when the vessel was moving along the expedition route. Floating plastics were recorded from one side of the vessel within approximately 50 m distance, categorized by item type and size. This information will enable scientist to measure items per km^2 and to compare results with other studies in the South Pacific. The GPS position should be taken of any fish aggregation device observed in addition to a photograph and any notes on estimated size or composition of materials. Snorkel/ dive photographic surveys of FADs to document associated biota for taxonomic analysis could be undertaken if feasible. Small fragments of plastic ropes and nets

associated with FADs could be sampled so we can analyze the polymer type and compare with previously collected microplastic data.

Results

1. Spatial and temporal behavior of migratory species

Ten sharks were tagged with satellite and acoustic tags (Table 3). We tagged a large female tiger shark *Galeocerdo cuvier* on the first day at Cocos with both satellite (SPOT 6) and acoustic (internal V16) tags. Also at Cocos, we double tagged a silvertip shark *Carcharhinus albimarginatus* (Figure 3 and 4), and acoustically tagged two silvertip and a blacktip shark *C. limbatus*.

A miniPAT tag was placed on a pelagic thresher *Alopias pelagicus* at Las Gemelas. No sharks were caught at Medina and Paramount seamounts. A large hammerhead shark *Sphyrna lewini* was tagged while freediving at Darwin, along with two silky sharks that were fished off the island. Finally, a silky shark *C. falciformis* was tagged at West Cocos on May 19th.

Currently, four of the sharks are still transmitting positions (Figure 5). The tiger shark has remained in the vicinity of Cocos Islands, while one of the silky sharks tagged at Darwin has sent information from outside the Galapagos Marine Reserve.

Table 3. Tagged species during the Cocos-Galapagos Expedition.

Date	Species	TL	Sex	Satellite ID	SAT tag type	Acoustic ID	Site
2021-05-05	*Carcharhinus limbatus*	192	F	NA	NA	20063	Cocos Island
2021-05-05	*Carcharhinus albimarginatus*	220	F	209083	SPOT 6	20059	Cocos Island
2021-05-05	*Galeocerdo cuvier*	240	F	182800	SPOT 6	20061	Cocos Island
2021-05-06	*Carcharhinus albimarginatus*	149	F	NA	NA	20065	Cocos Island
2021-05-06	*Carcharhinus albimarginatus*	192	M	NA	NA	20067	Cocos Island
2021-05-08	*Alopias pelagicus*	205	M	201475	miniPAT	NA	Las Gemelas
2021-05-15	*Sphyrna lewini*	200	UNK	65452	SPOT 6	NA	Darwin
2021-05-15	*Carcharhinus falciformis*	190	F	172403	SPOT 6	20060	Darwin
2021-05-15	*Carcharhinus falciformis*	220	F	209082	SPOT 6	8422	Darwin
2021-05-19	*Carcharhinus falciformis*	150	M	209084	SPOT 6	64670	West Cocos

Figure 3. Satellite tagging of a silvertip shark (*left*; Photo by Mica Stacey) using bolts and nuts, and a hammerhead shark, while freediving (*right;* Photo by Juan Bonilla).

Figure 4. Acoustic tagging of a silky shark (*left*; Photo by Mica Stacey) and silvertip shark (*right*; Photo by Javier Sandoval).

2. Spatial and temporal trends in abundance

Two calibration sessions were carried out to prepare BRUVS: one before departing Costa Rica, and one at San Cristobal (Galápagos) (Figure 6). BRUVS were deployed along the whole expedition route (Table 4), totaling nearly 620 hours of video recording from all GOPros and 150.75 hours from all 360 cameras used. The fish assemblage in Cocos was dominated by silkys sharks, tunas and a few tiger sharks (Figure 7). At Las Gemelas, we got some hammerheads, mobula and a thresher shark. At Medina we got one black marlin, one striped marlin and some very curious pilot fish. Darwin islands recordings were particularly crowed with reef fish and pelagic fish, particularly sin the currents made the cameras drift near the island and the Arch.

A noteworthy difference in the observed number of individuals of a single species was observed when using the 360 cameras and a single GOPro camera (Figure 8 and 9). This difference was particularly important for species with schooling behavior such as yellowfin tunas and hammerhead sharks. Paramount and West Cocos had the highest number of hammerhead sharks across all study sites. A preliminary analysis of this data shows that while 360 cameras recorded one less species across the expedition, the abundance recorded was higher and better representative of what was present at each site (Figure 10). This preliminary analysis also depicts hammerhead sharks (*Sphyrna lewini*) as the most abundant predatory species found across the expedition route, followed by *Caranx hippos*, yellowfin tuna (*Thunnus albacares*), pilot fish (*Naucrates ductor*) (Figure 10).

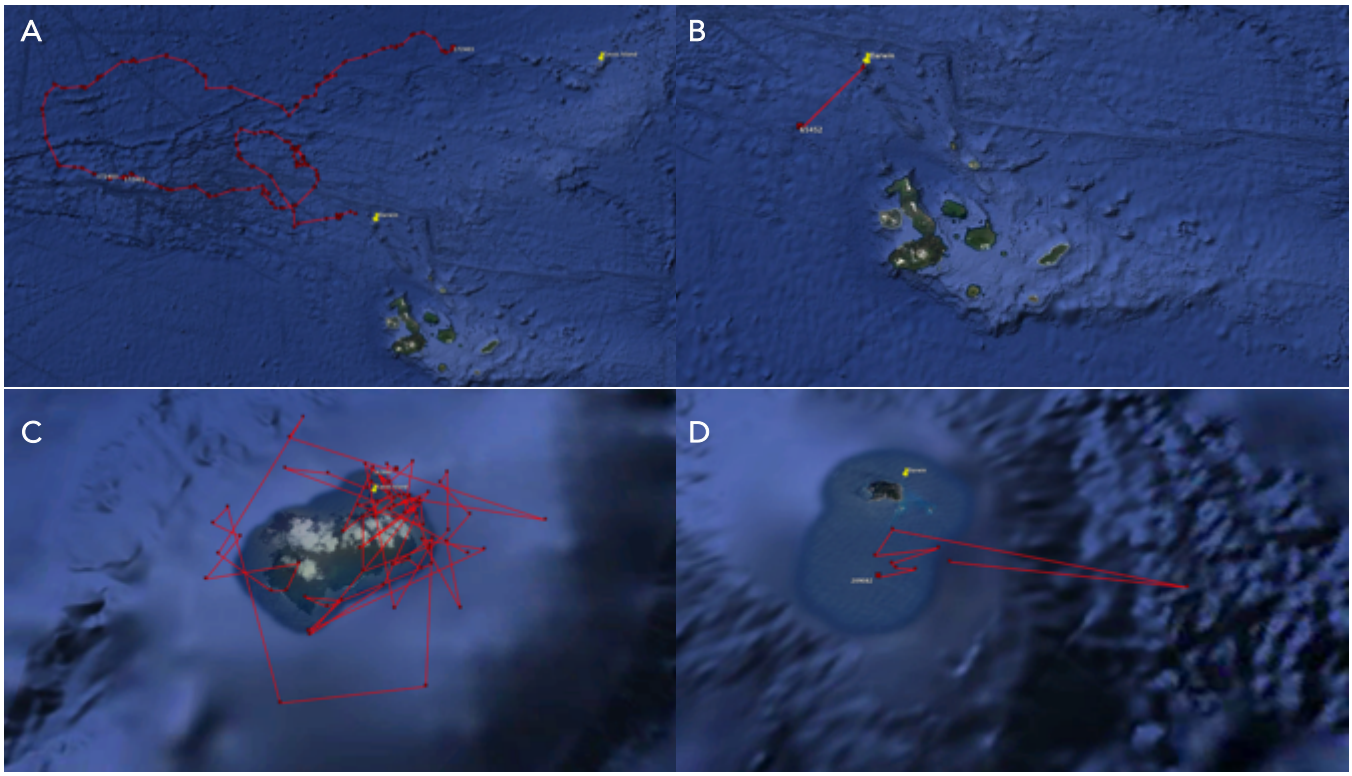

Figure 5. Routes of the tagged silky shark (A), scalloped hammerhead shark (B), tiger shark (C) and silky shark (D). Updated on July 28, 2021.

Figure 6. Stereo BRUVS calibration in confined waters (pool) before departing from Costa Rica (*top left*), and equipment preparation during before starting the first deployment at Cocos (*top right and bottom*). Photos by Micaela Stacey.

Table 4. Description of the location and number of sets per site.

Country	Site	Latitud	Longitud	Date	# of sets
Costa Rica	Cocos Island	5.56327°	-87.08610°	May 5-6, 2021	12
Costa Rica	Las Gemelas	4.95872°	-87.39944°	May 7-8, 2021	12
Costa Rica	Medina	2.99000°	-88.05000°	May 9-10, 2021	12
Ecuador	Darwin Island	1.68339°	-91.97951°	May 15-16, 2021	12
Ecuador	Paramount	3.34900°	-90.78100°	May 17-18, 2021	12
Costa Rica	West Cocos	5.48700°	-88.55800°	May 19-20, 2021	12
Costa Rica	Cocos Ridge Seamount	7.478000°	-85471000°	May 22, 2021	8

Figure 7. Tiger shark observed during the BRUVS deployment in Coco Island. Photos by César Peñaherrera, MigraMar.

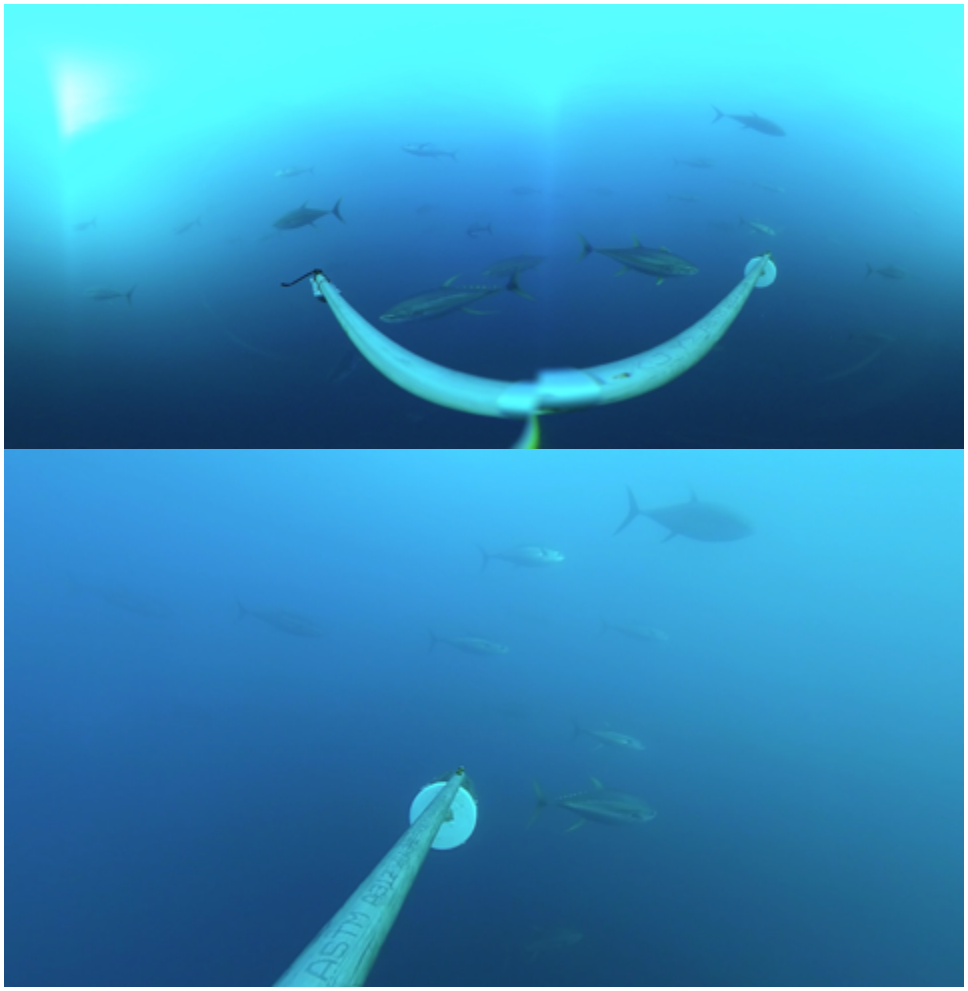

Figure 8. Comparison of the size of a tuna school observed at the same time by a 360 camera (*top*) and a regular GOPro camera (*bottom*). Photos by César Peñaherrera, MigraMar.

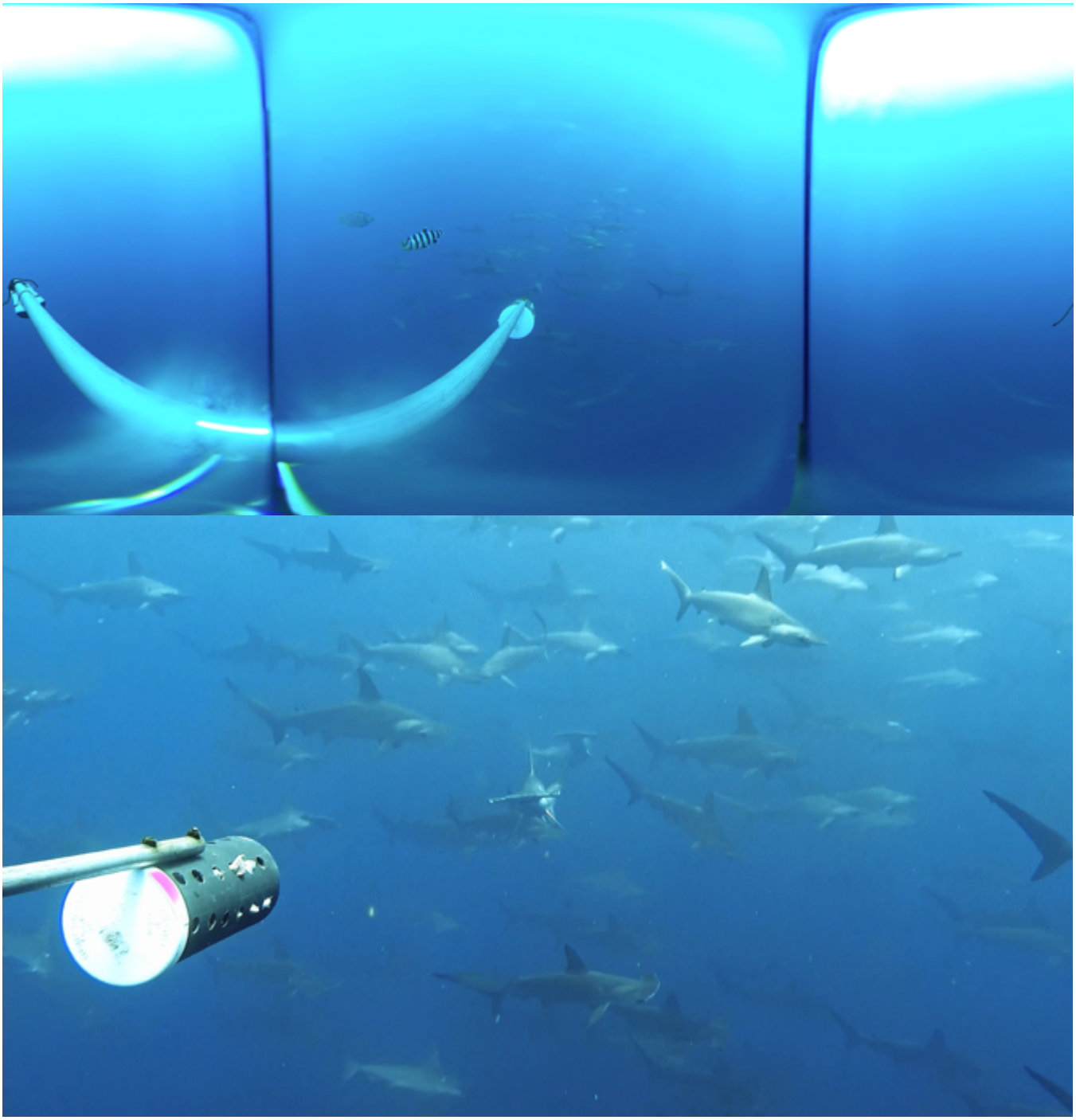

Figure 9. Comparison of the size of a hammerhead shark school observed at the same time by a 360 camera (*top*) and a calibrated GOPro camera used for the 3D system (*bottom*). Photos by César Peñaherrera, MigraMar.

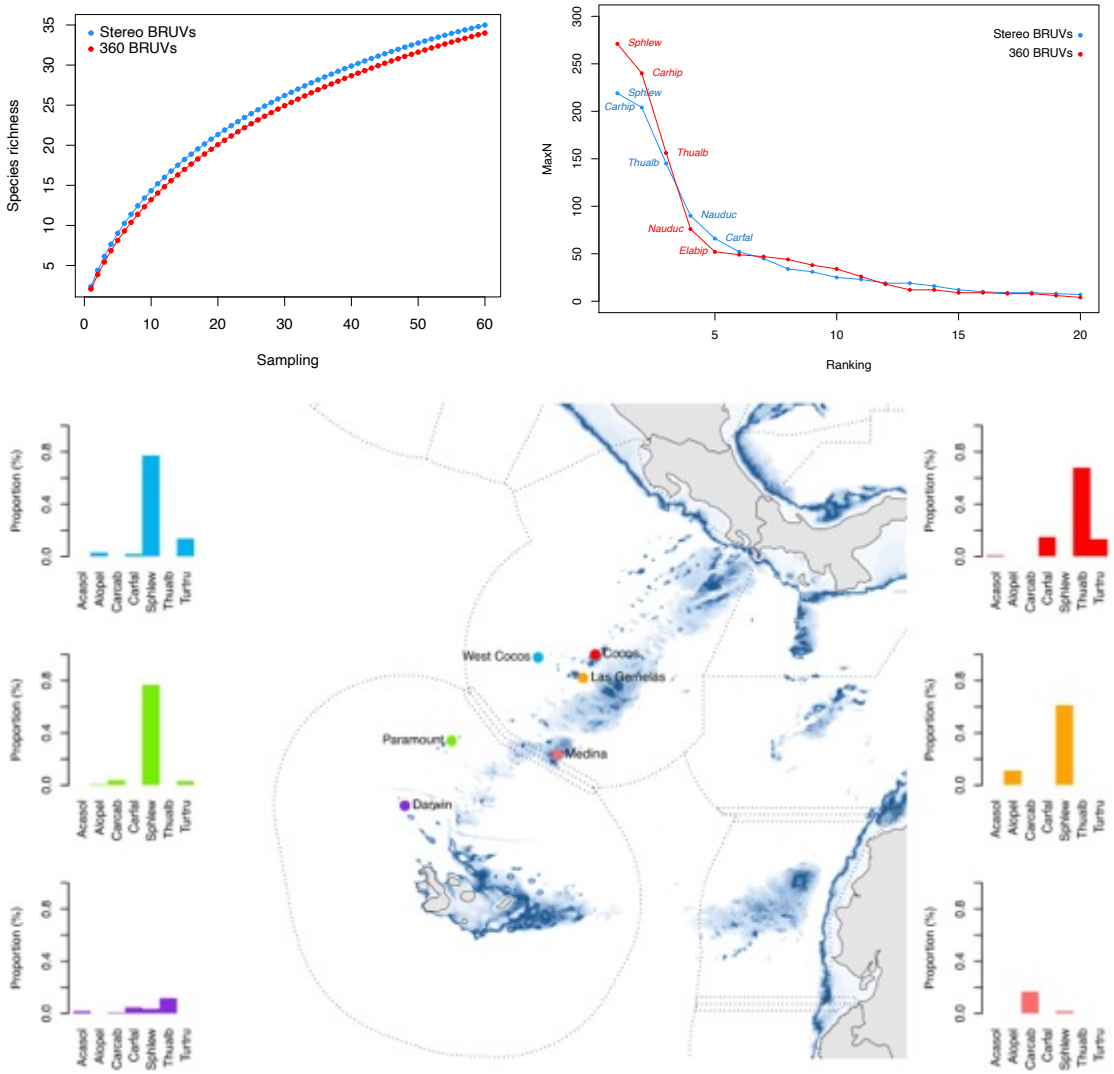

Figure 10. Preliminary analysis of the data collected using stereo and 360 cameras during the Cocos-Galapagos Expedition 2021. *Top right*: Difference in the species richness recorded by the 360 and stereo camera settings. Top left: Difference in the total abundance measured from the recorded MaxN (maximum number of individuals observed in a single frame) by 360 and stereo cameras. Bottom: Abundance proportion (relative to the overall abundance recorded) for seven predatory species per site by 360 camera equipment.

Biodiversity counts were carried out at each single stop during the expedition. A pair of scientists were assigned to observe three times per day all the fauna present around the boat (Figure 11). The storm petrel *Oceanodroma castro* was the most abundant species (141 individuals) along the expedition, followed by the brown booby *Sula leucogaster* (93 individuals), the pilot whale *Globicephala macrorhynchus* (80), the common bottlenose dolphin *Tursiops truncatus* (65), the red-footed booby *Sula sula* (52) and the frigate bird *Fregata magnificsense* (36) (Figure 12). It is important to note that most individuals were observed during morning (6-10) and afternoon (14-18) hours, with less activity observed during midday (11 – 14) hours.

Figure 11. Observation of fauna during the biodiversity counts at each study site. *Top left*, observer counting birds at Las Gemelas. *Top right*, a pod of pilot whales observed in transit to the Galapagos Marine Reserve. *Bottom left*, a common bottlenose dolphin observed at Paramount seamount. *Bottom right*, a pod of Pantropical spotted dolphins (*Stenella attenuata*) observed in transit to Cocos Ridge seamount. Photos by César Peñaherrera.

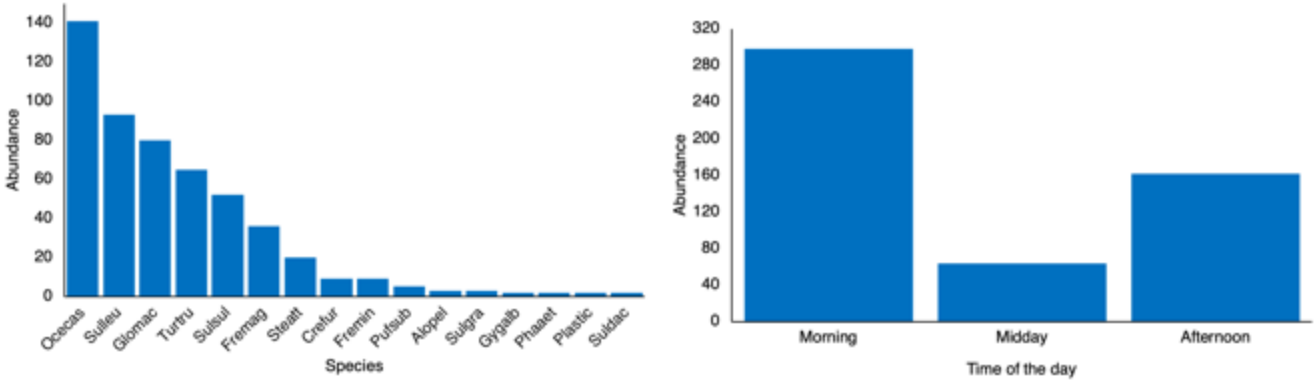

Figure 12. *Left*: Total abundance of megafauna (and plastics) observed over the surface. *Right*: Total abundance observed per time of the day.

3. Environmental parameter sampling

Sampling of oceanographic parameters was carried out via temperature loggers and a CTD equipment at each study site right next to each BRUVS line. The lowest temperature recorded by the loggers was 24°C in Darwin, while the highest was 28°C in Cocos Ridge Seamount. Descriptive stats per site of the measured mean temperature (with loggers and CTD), thermocline depth, mean turbidity, mean water density, mean conductivity, practical salinity, mean oxygen saturation, and chlorophyll a fluorescence are given in Figure 13. Temperature loggers were affixed to each BRUVS station, while CTD was lowered to almost 120 meters deep, and slowly retrieved to allow instruments read the environmental conditions (Figure 14).

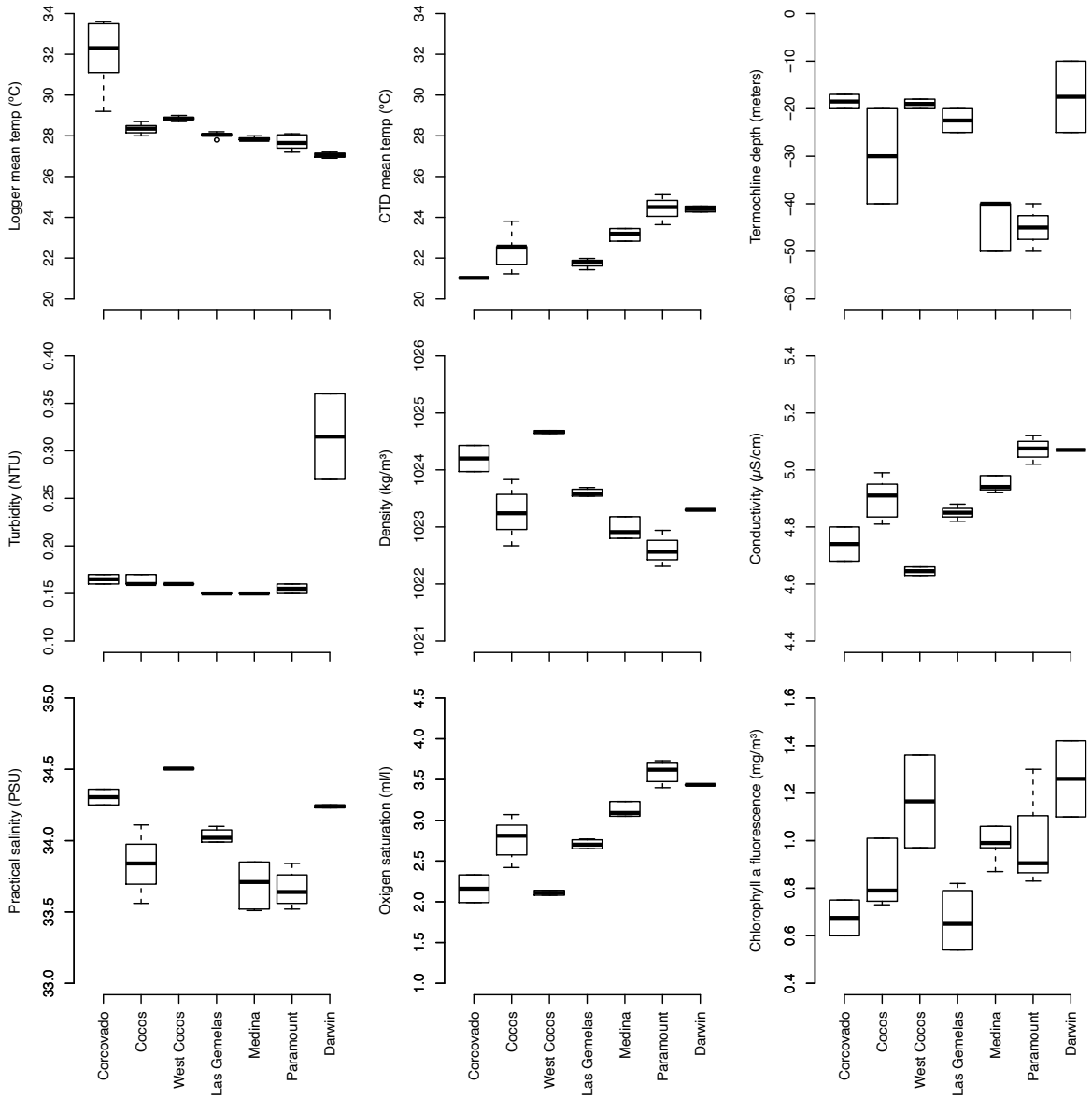

Figure 13. Median, range and extreme values measured of the mean temperature with loggers, mean temperature with CTD, thermocline depth, mean turbidity, mean water density, mean conductivity, practical salinity, mean oxygen saturation, and chlorophyll a fluorescence per site.

Figure 14. CTD equipment being prepared for deployment (*left;* Roy Prendas). Expeditioner Marta Cambra holding the Seabird CTD equipment (*center;* César Peñaherrera). Deployment of the CTD from the fiberglass fishing boat (*right:* Marta Cambra).

4. Genetic diversity sampling

Environmental DNA was collected once per day at each of the study sites (Figure 15). Water samples were post processed on board to extract only the necessary eDNA samples for future analysis. All eDNA samples currently resides at the University of San Francisco and are under analysis. eDNA analysis (and results) may take up to several months due to the demanding nature of sample processing.

Figure 15. Expeditioner Andrea Vera collecting the water sample for extracting the eDNA (*left*), and preparing the eDNA extracted sample for future analyses (*right*). Photos by: Micaela Stacey.

5. Floating plastic pollution sampling

Few drifting debris were recorded during the biodiversity counts transects, mostly comprising plastic bottles and containers (Figure 12, left). No fishing nets or fish aggregation devices were observed along the way. Apart from the plastic transects, the science party recorded the single use plastic used along the expedition and kept track of item used and lost on sea (Figure 16). The majority of the single plastic used along the expedition were wrappers (candy, chocolates, t-shirts, lens cleaning pads), with more than 500 items counted along the expedition. Other single-use plastics used were syringes, cutlery, covers and plastic bags. Only three plastic items were recorded to be lost on the trip, and were plastic bait cannisters used with the BRUVS.

Figure 16. Disembarking of trash produced along the expedition.

Discussions and recommendations

The Cocos-Galapagos Expedition 2021 was built on the success obtained during the shorter Galapagos-Cocos Expedition carried out in 2018. The data collected will provide critical scientific information regarding: 1) the abundance and dynamics of marine migratory species; 2) their vertical and horizontal habitat preferences; 3) the vertical and horizontal profile of environmental parameters, including dissolved oxygen and chlorophyll a, which will provide important insights on seamounts

oceanographic dynamics and potential climate change; and the level of plastic pollution found drifting in the high seas.

There is an important amount of information that needs to be assessed. Time will be needed to obtain the full tracks of the tagged species, the size and biomass estimation from the BRUVS technique, and diversity found in the seamounts from the eDNA analysis. This information will inform managers and stakeholders on the importance of the Cocos Ridge's seamounts to host migratory species. The information has helped and will help to train authorities and future young scientists in field research techniques. The second expedition adds up to the information previously obtained in terms of biodiversity, yet future expeditions are needed to fully understand the overall community structure and biomass productivity of these seamounts. This will allow scientists to detect changes in biomass of species of commercial and conservation value, particularly in response to climate change and adopted management regulations.

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