GALAPAGOS WHALE SHARK PROJECT

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FIELDWORK REPORT 2021

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Project Partners:	Galapagos National Park Directorate, Georgia Aquarium
Supporting Institutions:	Galapagos Conservation Trust, Galapagos Science Center, Save Our Seas Foundation, World Wildlife Fund, Galapagos Shark Diving, Galapagos Shark Sky Travel and Conservation
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Reporting on the two annual field expeditions for 2021:

August 24th- 31st, 2021	Galapagos Whale Shark Project with Georgia Aquarium Institute Field Expedition
September 9th-16th, 2021	Galapagos Whale Shark Project Field Expedition

PARTICIPATING ORGANISATIONS:

GALAPAGOS whaleshark PROJECT

Parque Nacional GALÁPAGOS Ecuador

GEORGIA AQUARIUM

Galapagos Conservation Trust

save our seas foundation

GSC GALAPAGOS SCIENCE CENTER USFQ · UNC-CHAPEL HILL

WWF

Galapagos Shark Diving

Universidad San Francisco De Quito

Figure 1: Darwin's fallen arch with Darwin Island in the background (Photo ©Jonathan R Green)

1

INTRODUCTION

The iconic Whale Shark, Rhincodon typus was first described by Dr Andrew Smith in 1828 but still today remains to a great extent a scientific mystery.

Whale shark populations are declining worldwide, mainly due to anthropogenic impacts such as fisheries, both targeted and incidental, vessel strikes, and marine pollution (Pierce and Norman, 2016).

Although the whale shark has become a widely studied animal in the past decades, there is still a lot left to discover about the ecology and reproductive behaviour of this species due to the difficulty in studying this elusive species. The reproductive

biology is particularly difficult due to the low frequency of sightings of adult females in the easily accessible coastal aggregation sites (Sequeira et al. 2013).

The Galapagos Islands provide a unique location for the study of whale sharks because of its location and unique group of whale sharks sighted yearly. The whale sharks have been reported to occur seasonally predominantly in the far northern region of the archipelago, passing by Darwin Island, between the months of July and December of every year. Over 90% of the individuals sighted are adult females (average total length 11.34 m +/- 0.12m), seen almost nowhere else in the world (Acuña-Marrero et al. 2014; Hearn et al. 2016). Only two other sighting locations have been reported worldwide to have a high adult female presence. These are Saudi Arabia and Santa Helena with around 1:1 female to male ratio (Araujo et al., in prep). Thus, this situation provides an exclusive opportunity to study adult female whale sharks which are yet understudied. Moreover, the location of the Galapagos Islands, as a mid-ocean archipelago, provides an opportunity to study whale sharks in pelagic environments. Darwin and Wolf Islands in particular are located in a pelagic environment with steep rocky slopes that descend over 100m in less than 400m distance from the islands and are separated from the rest of the Galapagos Archipelago by a 1,000m deep channel (Peñaherrera et al. 2013).

Gathering data about population dynamics, movements on a local, regional and global scale, habitat use and where they are feeding, mating and giving birth will provide us with the tools we need to create management strategy, legislation and Marine Protected Areas in order to increase levels of protection and achieve long term conservation. The fieldwork uses techniques such as Photo ID to record site fidelity and frequency of whale sharks, blood draw to verify baseline health and blood chemistry to determine reproductive status. Ultrasound examination of the free-swimming sharks also helps clarify reproductive cycle. Satellite tags are used for active tracking on both horizontal and vertical axes to better understand diving behaviour and habitat use in conjunction with sea surface temperatures, Chlorophyll concentrations, lunar cycle and benthic morphology such as sea mounts, fracture zones and undersea mountain chains.

Figure 2: Darwin's Arch, Galapagos Islands (Photo ©Jonathan R Green)

So far, past results have highlighted that the study population is comprised of almost all adult female whale sharks, the opposite of all other study groups. The tracks have shown that vertical and horizontal movements are highly influenced by ecogeographical variables and are highlighting areas of importance for this species within the Eastern Tropical Pacific (ETP). Although embryos have not been detected the sample size of female ultrasounds has not been significant to completely rule out that Galapagos may play a key role in birthing and other aspects of the natural history of this species that are critical for their survival.

The Project is now in its 10th season, during which time we have made discoveries that are new for the species and led novel field methodologies which are helping shed light on this species worldwide. Our team carried out the first

successful ultrasound and blood draw in a free-swimming environment in 2017 and 2018. The satellite tagging program has shown connectivity with other oceanic island habitats such as Cocos Island, as well as with the Peru / Chile Shelf Break and Trench.

This is part of a broader study to try to discover the reproductive state, movement and behavioural ecology of the whale sharks, 99.8% adult females (Hearn et al. 2016), in the Galapagos. These data serve to investigate habitat use with particular reference to diving behaviour and benthic morphology and to determine the role in pupping and juvenile developmental stages of the species in and around the GMR. The tracking data is also of essence for the implementation of proper policies for management and conservation strategies. .

The Project's goals and objectives depend upon the development of techniques and methodology that are to a great extent untested by the scientific community, which necessitates the adaption of existing technology to the needs of the Project.

As part of our annual field work we joined forces with one of our long-term collaborating institutions, the Georgia Aquarium (GA) for the first of two field trips. The fieldwork includes both studies of whale sharks, as well as a variety of toothy sharks. The team included a veterinary technician with the goal of studying the health status of the shark populations sighted in the far northern region of the archipelago.

2

MATERIALS & METHODOLOGY

In each immersion, it was the team's goal to sight whale sharks and undertake the following activities: satellite tagging, blood sampling, photo ID, and microbiome sampling. Divers collected data on gender, estimated sizes, and dive site conditions simultaneously.

Photo ©Jonathan R Green

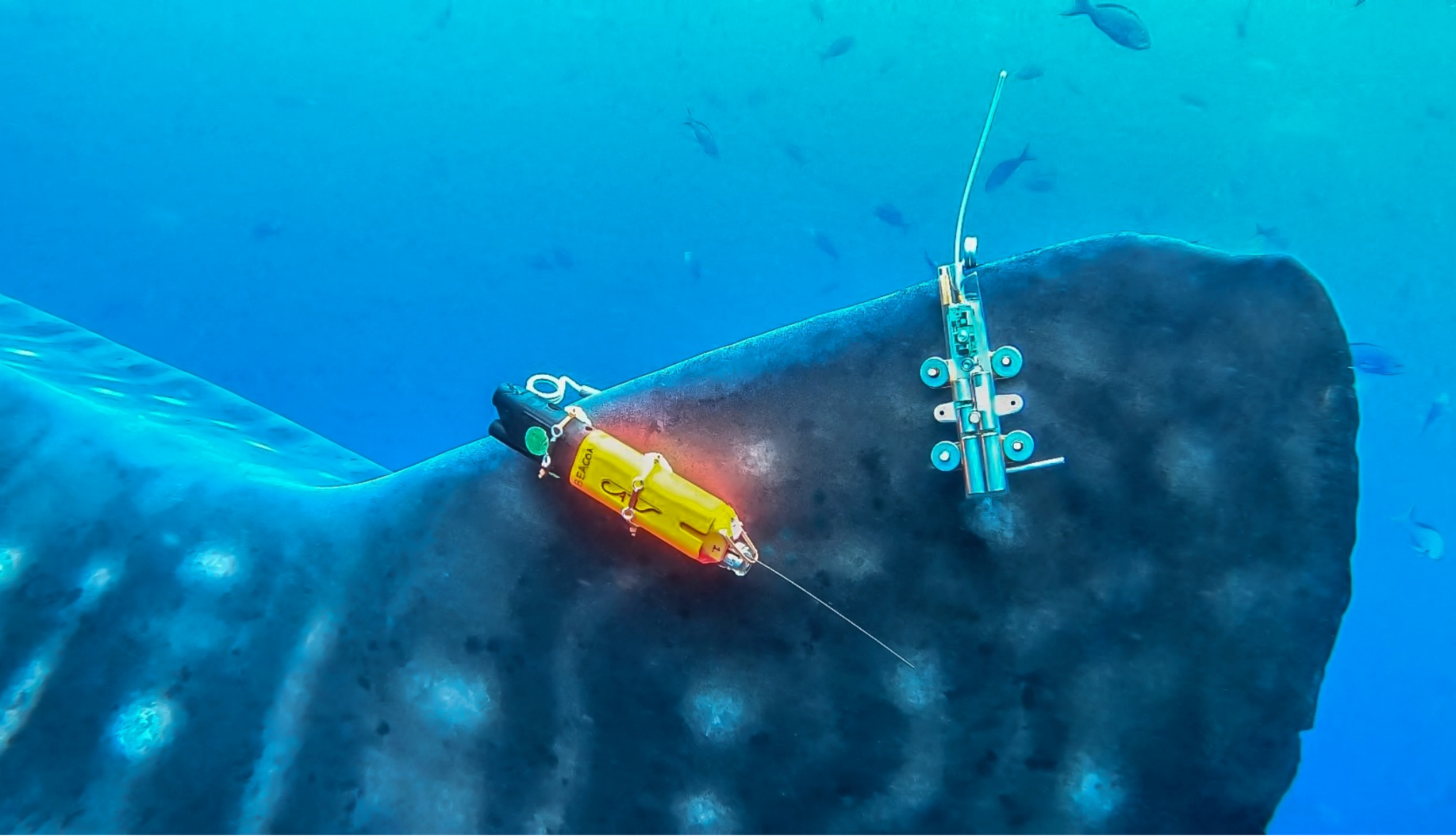


Figure 3: Whale shark dorsal fin with SPLASH10 #212419 and CATS-Cam #1 (©Jonathan R. Green GWSP 2021)

2.1 SATELLITE TAG SET-UP

The models of satellite tags used to analyze the horizontal movements and the diving behaviour of the whale sharks were the SPLASH 10-346B (Wildlife Computers, Redmond, WA) hereon after referred to as SPLASH. All tags were set-up prior to the expedition in a location with internet availability, using the manufacturers software MK10Host for SPLASH tag configurations.

Message Type	# Bins	Upper (deeper/longer/hotter) Limits of Bins													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Dive Maximum Depth (m)	14	10	20	50	100	200	300	500	750	1000	1250	1500	1750	1900	>1900
Dive Duration (min sec)	14	5m	10m	25m	50m	60m	70m	80m	90m	100m	150m	200m	300m	500m	>500m
Time-at-Temperature (C)	14	-2	0	3	6	9	12	15	18	21	24	27	30	33	>33
Time-at-Depth (m)	14	0	2	10	20	50	100	150	200	300	400	500	600	700	>700

Figure 4: Bin set-up for SPLASH10-346B tags

SPLASH tags have sensors to measure depth, temperature, and light and are set-up to record time-series depth data. The tags also record temperature, dive maximum depth (m), dive duration (min), time-at-temperature (C), and time-at-depth (m) in previously formatted bins. (figure 4).

Once deployed, the signals transmitted from these electronic tags are received by the Argos Data Collection and Location System (Argos DCLS) and processed through the WC Data Portal.

Figure 4: SPLASH tag on the upper part of the dorsal fin of the whale shark (Photo: ©Jenny Waack)

Figure 5: Researcher tagging adult female whale shark (Photo ©Jenny Waack)

2.2 SATELLITE TAGGING

The satellite tagging was carried out on all whale sharks sighted during the expedition, conditions dependent. The conditions to carry out satellite tagging safely were: the whale shark is spotted at a maximum of 20m depth, allowing for a max descent of 10m, to a depth of max 30m depth during tagging, the whale shark is swimming with the current, and the current strength is between 0-3 (on a scale of 0-5). If any of these conditions were violated, no tagging was attempted, and if the whale shark descended below 30 meters while the diver was placing the tag, the tagging process was terminated.

When a whale shark was spotted during one of the immersions, the diver in charge of tagging would approach the whale shark from the side. The diver placed him/herself above and slightly in front of the

dorsal fin, opened the fin clamp and slid it onto the top of the dorsal fin. All tagging took place in a matter of seconds.

During this expedition, a second tag was also used on some whale sharks. This was the CATS Cam, an animal-borne video camera, for underwater visualization on their behaviour (CATS, Australia, 2021). These were set up for short term deployments ranging from 2-6 hours and the tagging methodology was the same as for the SPLASH tags. They were modified to adhere to the fin using sand paper instead of golf studs and the CATS-Cam included a small SPOT tag for tacking upon release with the use of a CLS Direction Finder Goniometer. A couple of whale sharks were tagged simultaneously with both a long-term tracking tag (SPLASH tag) and the short-term camera tag (CATS-cam) (Figure 3 & 6).

Figure 6: Whale shark dorsal fin with SPLASH10 #212419 and CATS-Cam #1 (©Jonathan R. Green

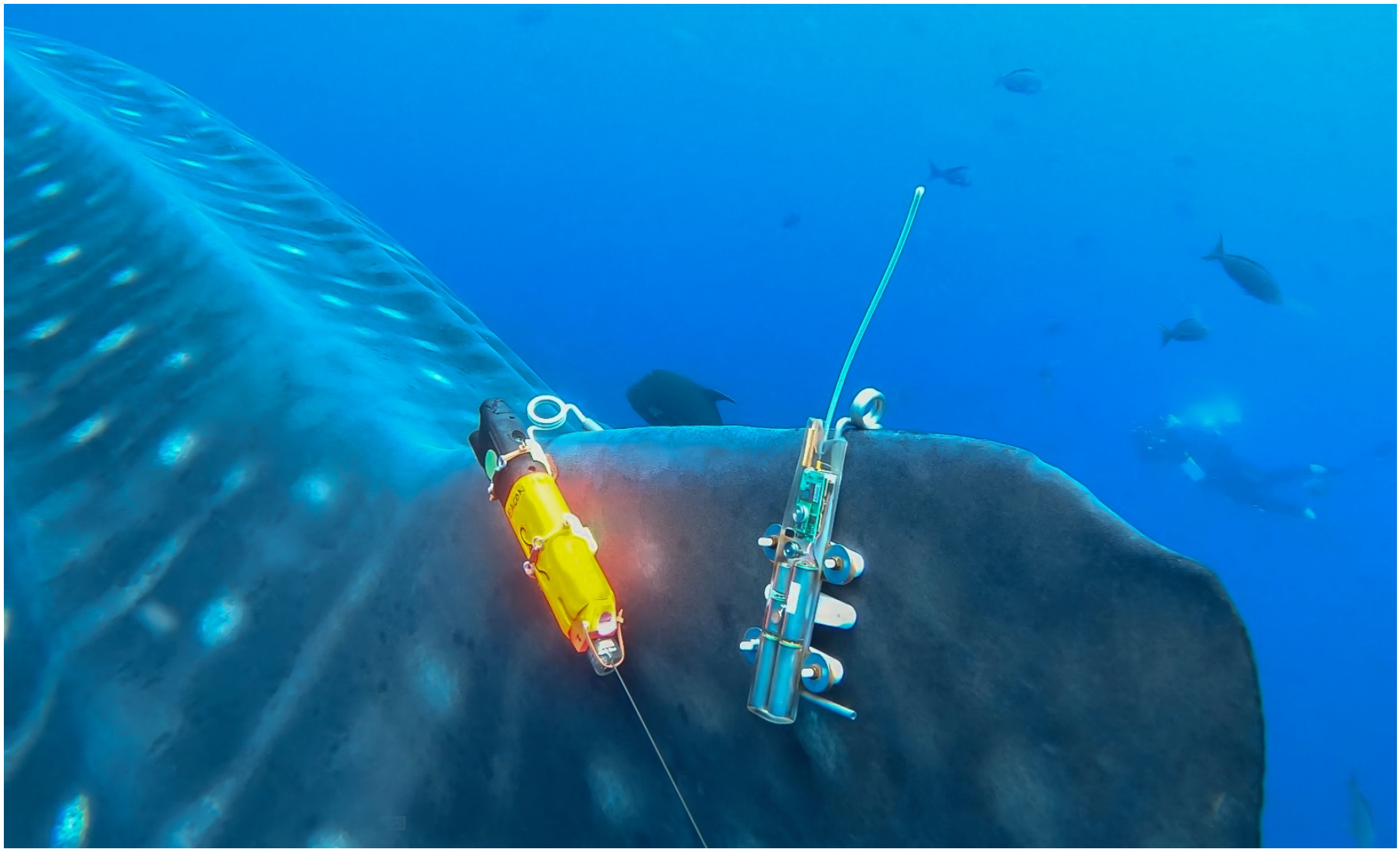


Figure 7: Diver taking blood from a adult female whale shark (Photo: ©Jonathan R Green)

2.3 BLOOD DRAWS

Blood draws were performed using a double syringe with stopcock, a 30cm draw tube and a 16-gauge needle. The double syringe was used so that the initial blood drawn through the tube, which is contaminated with seawater can be separated in one syringe, and for the pure blood sample to be separated in the other. The 30cm tube attachment was used to give the needle more mobility, making the process a bit easier on free-swimming wild whale sharks. Both syringes contain Heparin Sodium solution which serves to prevent the blood from clotting.

Blood draws are being undertaken by the team for various purposes. The samples will be analysed for hormone levels of Testosterone, Progesterone and Estrogen to create baseline data of adult female whale shark levels and at a later time be used to determine reproductive state and the possibility of pregnancy.

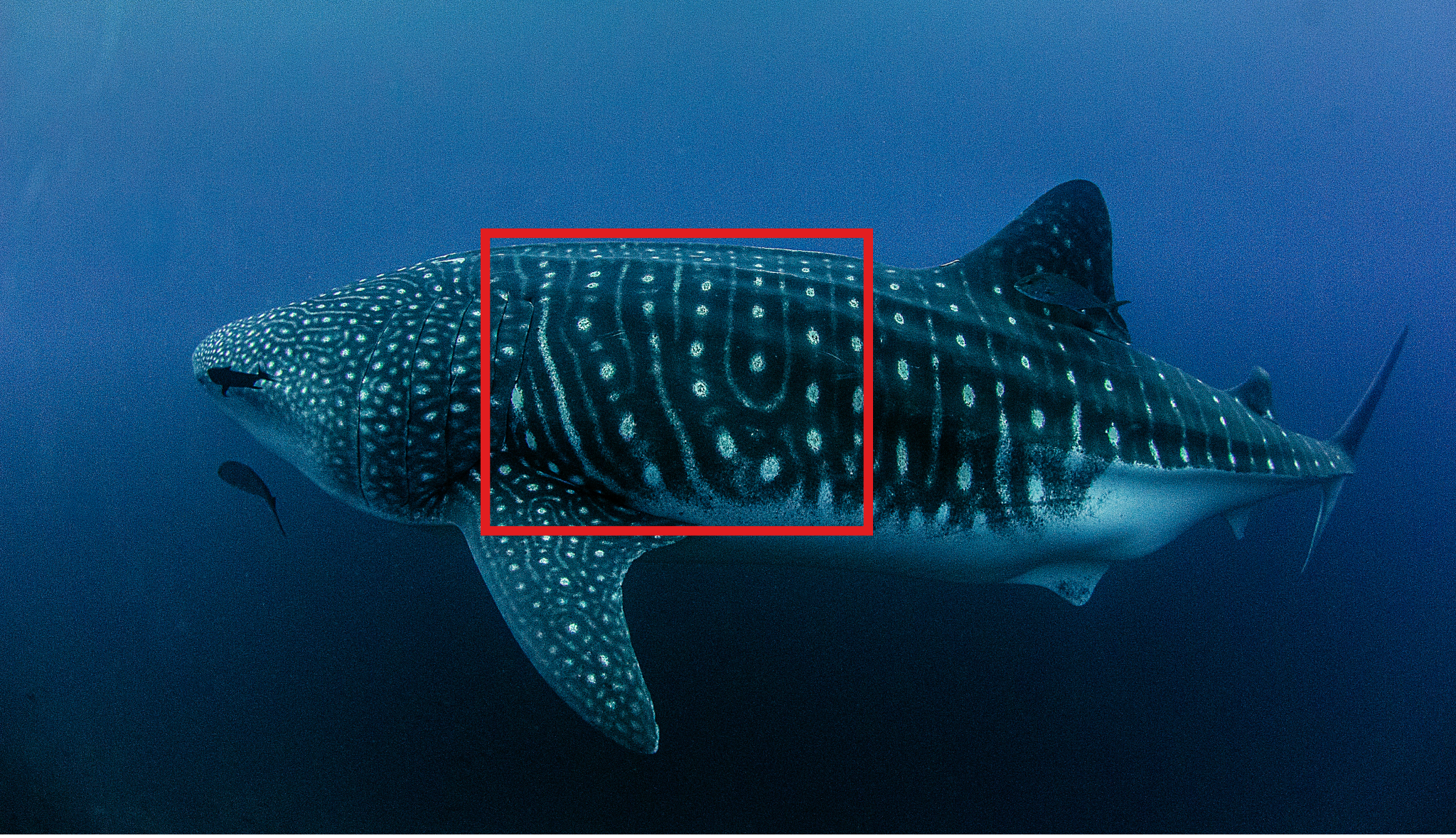


Figure 8: Whale shark ID photo (Photo: ©Jenny Waack, 2021)

2.4 PHOTO IDENTIFICATION

Underwater the divers take photographs and videos of the whale sharks sighted I order to perform photo-ID. The images are captured at a straight angle, at the same level as the shark with the intention of capturing the spot pattern between the fifth gill slit and the end of the pectoral fin. This area has been standarised as the area used for identification of each individual and matching with sightings locally, regionally and internationally.

The photo ID serves to identify each animal as an individual. By uploading it to the “Wildbook for Whale Sharks” catalog (www.sharkbook.ai), it allows you to see if the animal sighted is new to the Galapagos or if it has already been seen in the past. Photo identification is a passive way of tracking the whale shark. With this information we can study population dynamics: residence indexes, return rates, abundance and mortality.

Figure 9: Whale shark emerging from the deep (Photo: ©Sofía M Green)

2.5 MICROBIOME SAMPLING

Cotton swabs were used for microbiome sampling. During the dives, a diver approached the whale sharks with a plastic capped cotton swab. The swab was rubbed against the skin of the shark in different areas (cloaca, posterior dorsal fin slit, and gill) to collect the microbiome living in different regions of the whale shark's body.

The microbiome samples serve for innovative research which is looking at the role of body-associated microbiomes in determining elasmobranch health and how the unique microbiome might be involved in host immunity, nutrition, disease and waste- processing (Perry et al. 2021).

EXPEDITION #1: COLLABORATION WITH THE GEORGIA AQUARIUM

Photo ©Jenny Waack

3.1 TEAM MEMBERS

Name	Country	Organization
Jonathan Green	Ecuador	GWSP
Sofia Green	Ecuador	GWSP
Jenny Waack	Germany	GWSP
Manolo Yepez	Ecuador	Galapagos Sharksky Travel & Conservation
Harry Reyes	Ecuador	DPNG
Alastair Dove	Australia	GA
Lisa Hoopes	EEUU	GA
Kady Lyons	EEUU	GA
Chris Duncan	EEUU	GA
Cameron Perry	EEUU	GA/Georgia Tech
Elaine Alberts	EEUU	GA
Kirsten Jetzke	EEUU	GA
Devin Waddell	EEUU	GA
Marcy Hendryx	EEUU	GA
Katelyn Herman	EEUU	GA

Table 1: Team members involved in the 1st Expedition of 2021.

3.2 ITINERARY 24TH - 31ST AUGUST, 2021

Date	Location	Activities
24 August 2021	Itabaca Channel	Departure in the afternoon (12:30)
25 August 2021	Arrival-Darwin	Arrival (11:30) and 2 dives
26 August 2021	Darwin	3 dives and fishing for toothy sharks
27 August 2021	Darwin	3 dives and fishing for toothy sharks
28 August 2021	Darwin	4 dives and fishing for toothy sharks
29 August 2021	Darwin	4 dives and fishing for toothy sharks
30 August 2021	Wolf and Navigation	1 dive and fishing for toothy sharks
31 August 2021	Itabaca Channel	Arrival to Port

Table 2: Itinerary from the 24th of August- 31st of August, 2021

Figure 10: All reporting SPLASH10 Tags from the field season 2021. Google earth map of individual tracks until October 23rd, 2021. (©GWSP)

3.3 PRELIMINARY RESULTS

This trip we deployed four SPLASH10 fin-mount satellite tags on 3 adult female whale sharks and one juvenile female whale shark (SPLASH10 Tag #220364). Two of these adult female whale sharks were simultaneously tagged with two CATS-Cam fin-mount cameras. Blood draw for on board analysis and posterior laboratory analysis was attempted but unsuccessful. Microbiome samples were drawn from both the dorsal fin and from the cloaca from two of the sharks (See table 3).

The CATS-Cam #1 was deployed with SPLASH10 #212419 Dive #1 on the 28th August and released at @16:00 local time approximately. An attempt was made to recover the CATS-Cam but due to poor satellite coverage it was not located.

# WS	Sex	SPLASH #	Date # Dive of the day	Photo ID & WB ID	Blood Samples	Biome Sample	TL (meters)	Scars	Depth of Sighting	Tagger ID	Extra Notes
1	F	212419	28/08/2021 #1,2	GD-280821-1 G-301	0	1	11.5	Dent in head	17	JRG	Also placed CATS-Cam and took dorsal swab
2	U		28/08/2021 #1	N/A	0	0	6.0		10		Sighted, no science
3	F	212418	29/08/2021 #1, 2	GD-290821-1 G-306	0	0	12.0	Left pectoral was cut and missing the tip	18	SMG	
4	F	220362	29/08/2021 #1, 2, 3	GD-290821-2 G-319	0	0	11.0		20	JRG	JRG placed CATS-Cam on 2nd dive
5	F	220364	29/08/2021 #3, 4	GD-290821-3 G-313	0	1	5.0		15	JRG	Dorsal swab by Harry
Total	4F/ 1U	4		4	0						2 dorsal swabs

Table 3. Whale shark science, expedition 1, 2021.

CATS-Cam #2 was deployed with SPLASH10 #220362 Dive #2 on the 29th August, was resighted on Dive #3 and released @13:00 approximately and was located and retrieved using a CLS Direction Finder Goniometer with GPS that provides direction and indication of distance to the Argos transmitter. A total of 4.5 hours of video were recorded, which showed the shark remained in relatively shallow waters <100m but making repeated slow dives before swimming more actively back to the surface. Interactions between a number of species were observed, including different jack species and also Silky sharks that repeatedly rubbed themselves against the whale shark. This behaviour has been observed occasionally by

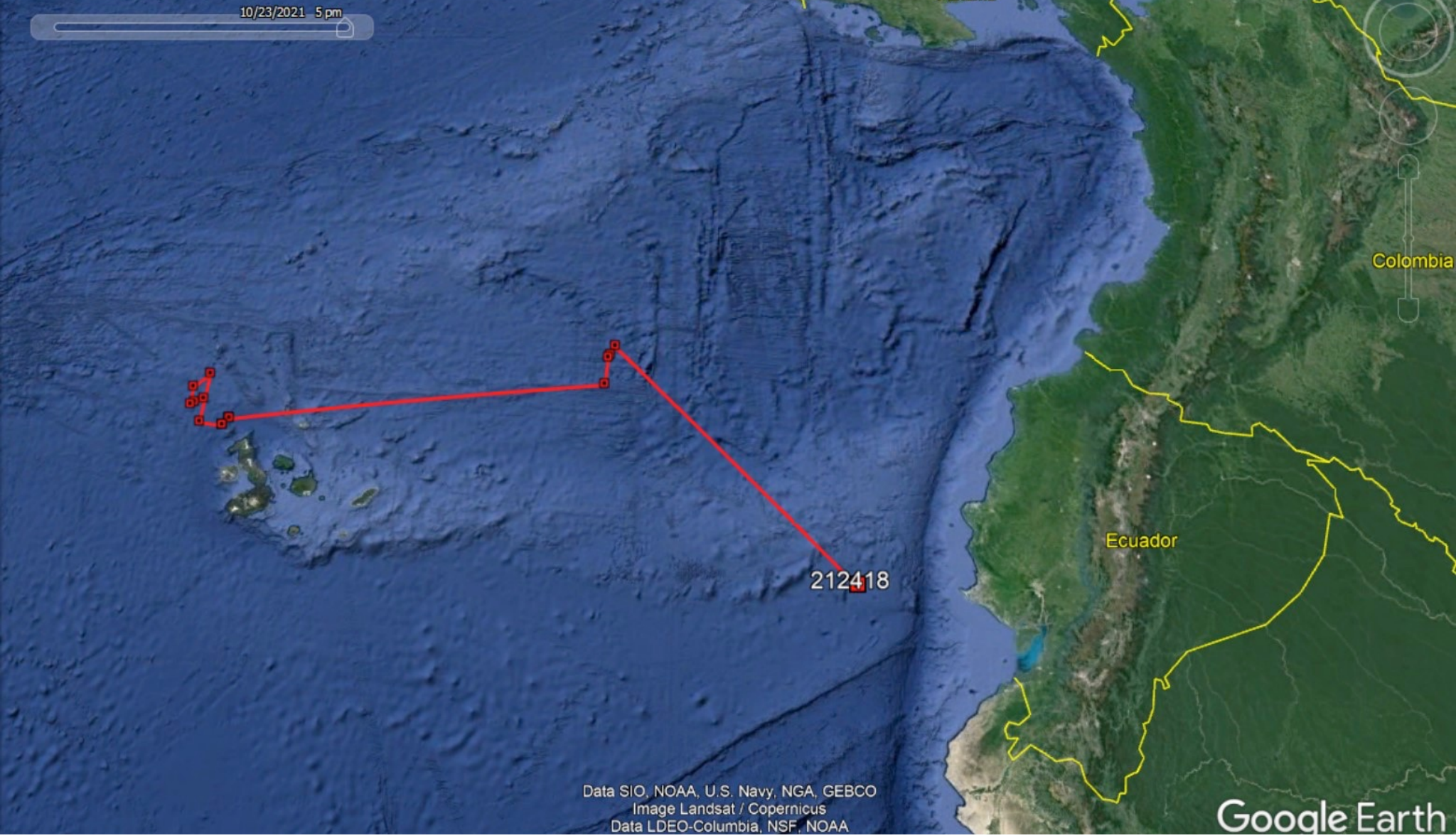


Figure 11. SPLASH10 Tag #212418. Google earth map of individual tracked until October 23rd, 2021. (©GWSP)

Figure 12. SPLASH10 Tag #212419. Google earth map of individual tracked until October 23rd, 2021. (©GWSP)

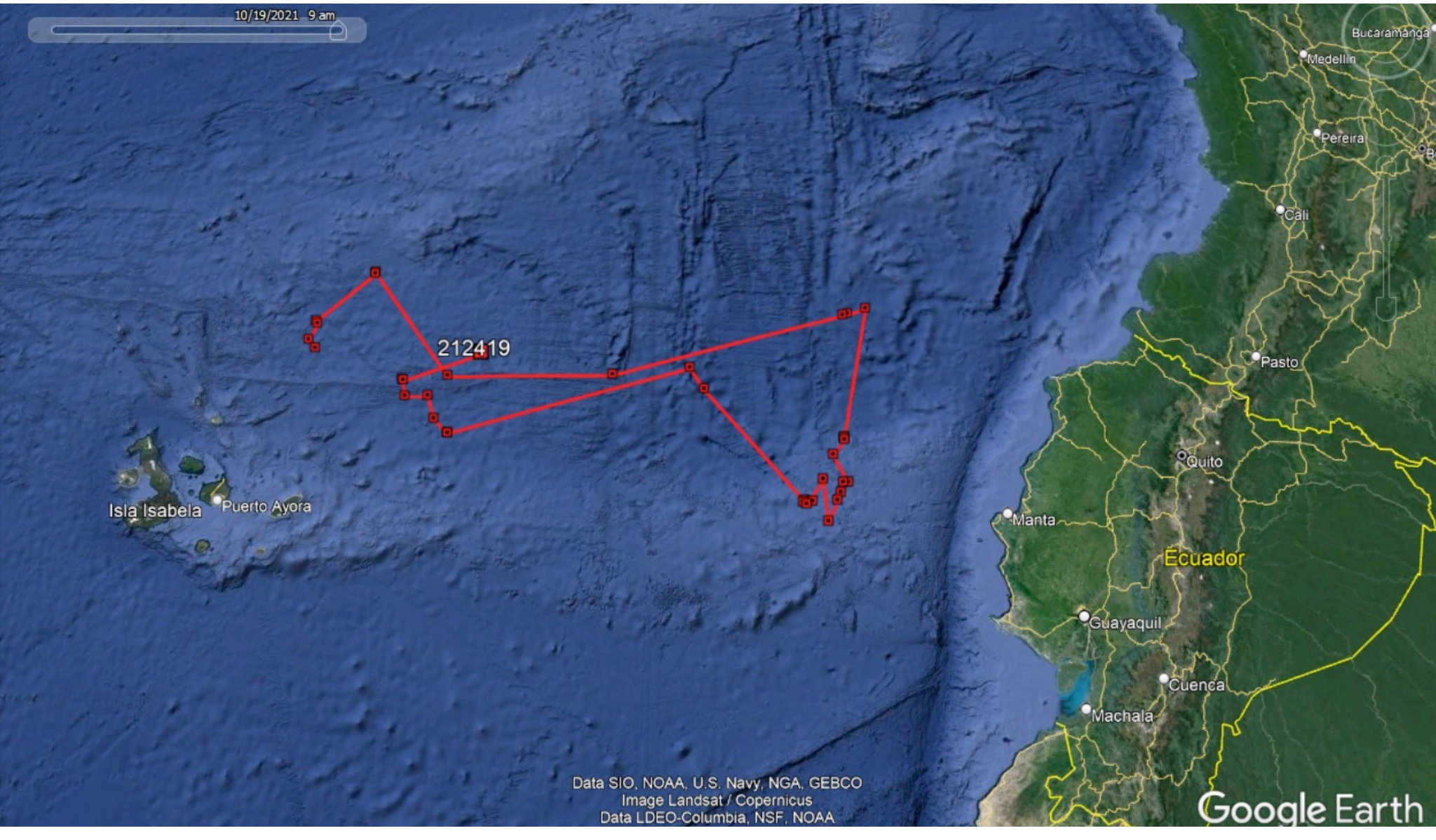


Figure 13. SPLASH10 Tag #220362. Google earth map of individual tracked until October 23rd, 2021. (©GWSP)

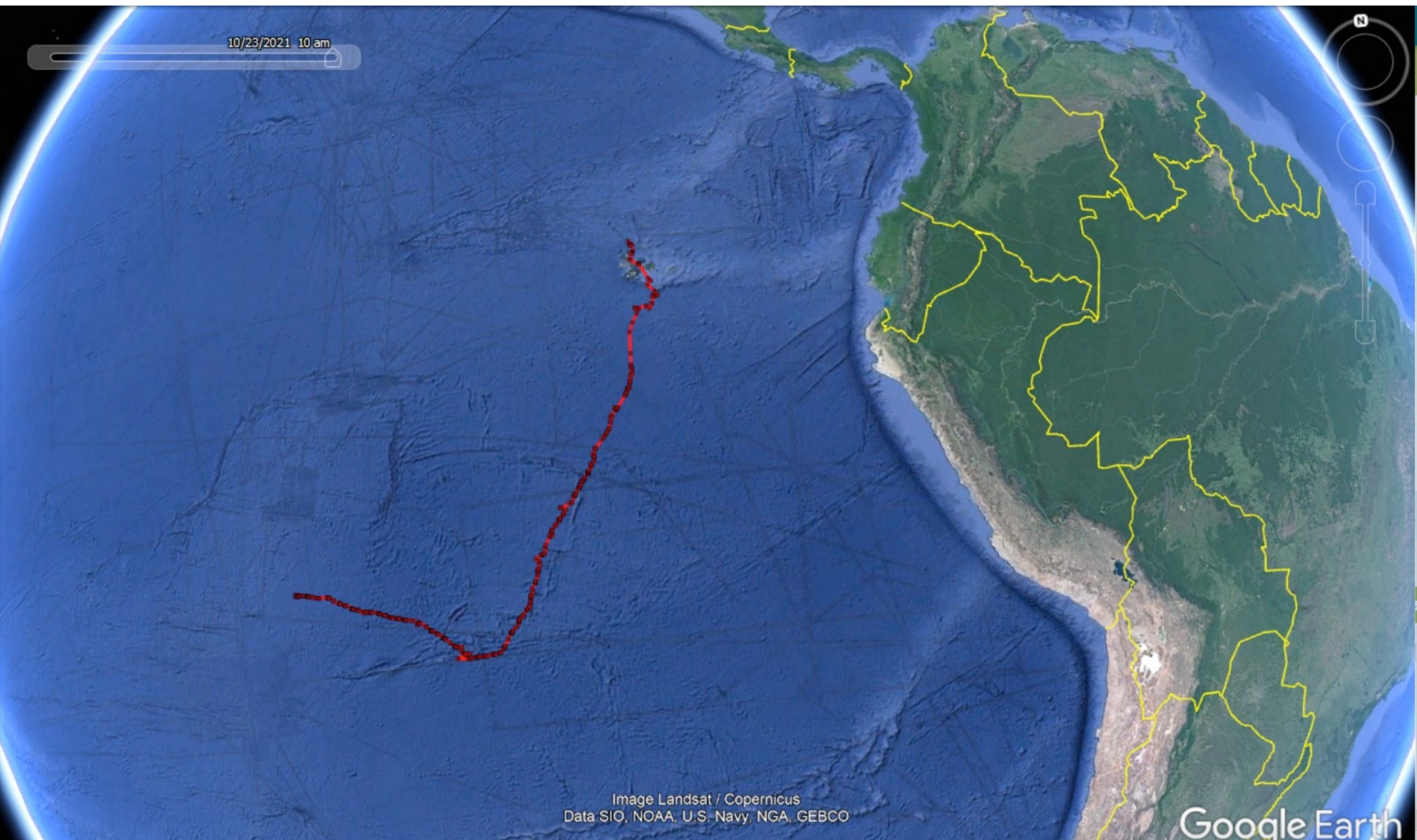


Figure 14. SPLASH10 Tag #220364. Google earth map of individual tracked until October 23rd, 2021. (©GWSP)

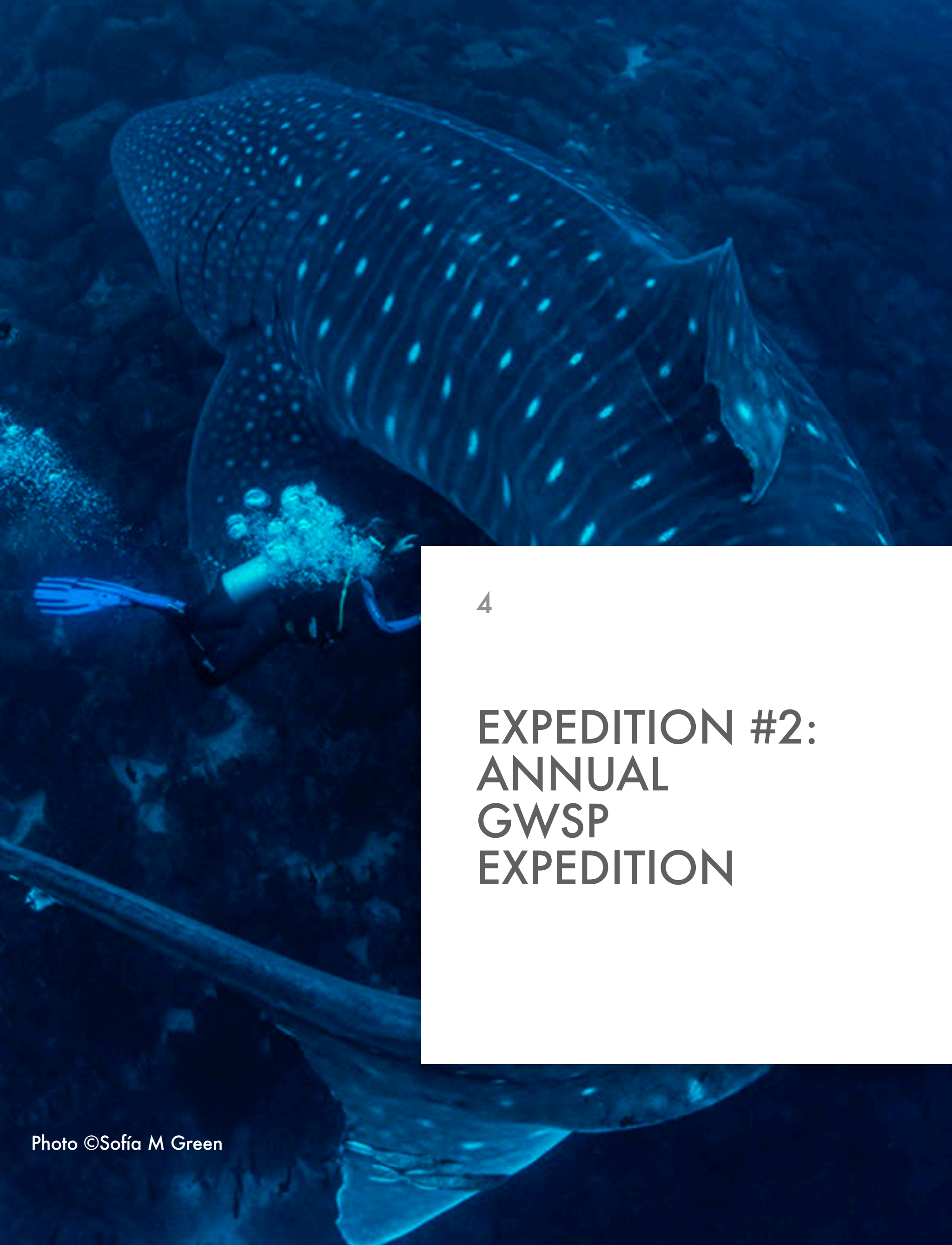
divers and is believed to be a cleaning strategy for the removal of ectoparasites by the Silkies.

All four satellite tags transmitted successfully after the trip and are currently still active (Figures 11 - 14).

Work on toothy sharks was carried out simultaneously by the Georgia Aquarium team , the fishing team (GA with Manuel Yepez, artisanal fisherman), caught nine Silky sharks, Carcharhinus falciformis, and a single Galapagos shark, Carcharhinus galapagensis. For these sharks the field work carried out: Total length measurements, microbiome sampling, tissue sampling and blood draws, when possible (Table 4).

Table 4. Work on toothy shark species, Expedition 1, 2021.

Date	Species	Sex	PCL	FL	TL	Blood (mls)	Muscle Biopsy	Gill Swab	Dorsal Swab	Cloaca Swab	fDNA swab
25/08/2021	Silky Shark	F	135		187	15	Y	Y	Y	Y	N
25/08/2021	Silky Shark	M	143	161	199	0	Y	Y	Y	Y	Y
26/08/2021	Silky Shark	F	148	210	230	12	Y	Y	Y	Y	Y
26/08/2021	Silky Shark	F	152	165	213	12	Y	Y	Y	Y	Y
27/08/2021	Silky Shark	F	164	178	229	0	Y	Y	Y	Y	Y
27/08/2021	Silky Shark	F	152	160	211	10	Y	Y	Y	Y	Y
27/08/2021	Silky Shark	F	157	168	226	12	Y	Y	Y	Y	Y
28/08/2021	Silky Shark	F	150	171	212	12	Y	Y	Y	Y	Y
28/08/2021	Galapagos Shark	M	157	178	214.5	12	N	Y	Y	N	N
29/08/2021	Silky Shark	F	179	200	249	10	Y	Y	Y	Y	Y



4

EXPEDITION #2: ANNUAL GWSP EXPEDITION

Photo ©Sofía M Green

4.1 TEAM MEMBERS

Name	Country	Organization
Jonathan Green	Ecuador	GWSP
Sofia Green	Ecuador	GWSP
Jenny Waack	Germany	GWSP
Cameron Perry	EEUU	GA/Georgia Tech
Galo Rueda	Ecuador	DPNG

Table 5: Team members involved in the 2nd Expedition of 2021.

4.2 ITINERARY 9TH - 16TH SEPTEMBER, 2021

Date	Location	Activities
09 September 2021	Puerto Ayora	Departure in the afternoon (12:30)
10 September 2021	Arrival-Darwin	Arrival (03:20) and 3 dives
11 September 2021	Darwin	3 dives
12 September 2021	Darwin	3 dives
13 September 2021	Darwin	3 dives
14 September 2021	Darwin	3 dives
15 September 2021	Darwin and Navigation	3 dive
16 September 2021	Puerto Ayora	Arrival to Port

Table 6: Itinerary from the 9th of September- 16th of September, 2021

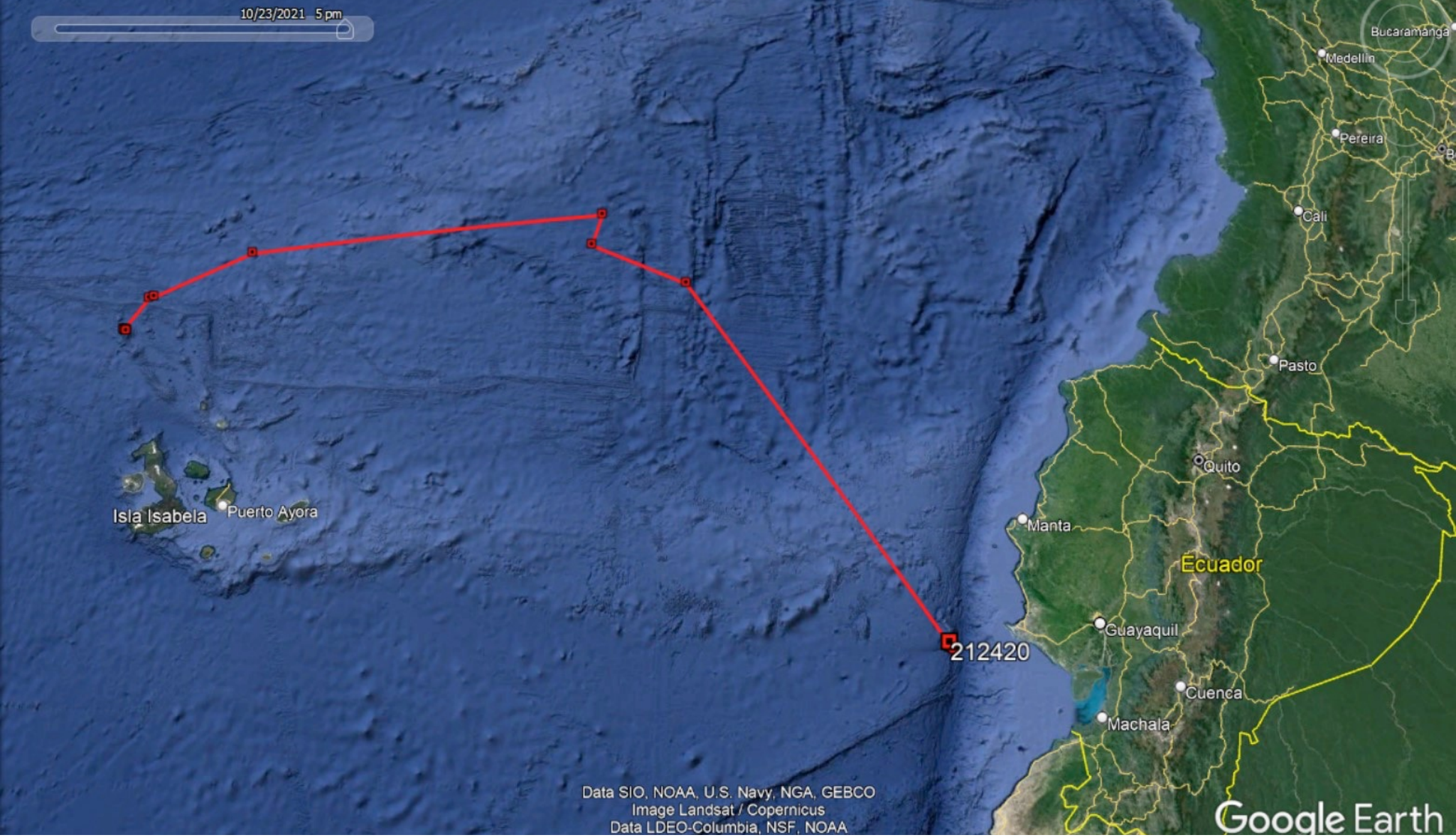


Figure 15: SPLASH10 Tag #212420. Google earth map of individual tracked until October 23rd, 2021. (©GWSP)

4.3 PRELIMINARY RESULTS

This trip we deployed four more SPLASH10 fin-mount satellite tags and a CATS-Cam fin-mount camera on four adult female whale sharks. Blood draw for on board analysis and posterior laboratory analysis was also planned but again due to inclement conditions, strong currents, swells up to 5m at the platform dive site and extremely low visibility, this was not attempted. Dorsal and cloacal swabs were drawn from two of these sharks (table 7).

# WS	Sex	SPLASH #	Date # Dive of the day	Photo ID & WB ID	Blood Samples	Biome Sample	Total Length (meters)	Scars	Depth of Sighting	Tagger ID	Extra Notes
1	F	220361	10/09/2021 #2	GD-100921-1 G-323	0	0	10		12	JRG	Also placed CATS-Cam
2	U		11/09/2021 #3	GD-110921-1 NA	0	0	5		5		Sighted, no science
3	F	212420	12/09/2021 #1,2	GD-120921-1 G-326	0	0	12	Abrasion scar along left side. Jags in dorsal. Bent top Caudal	24, 8	SMG	Dorsal and cloacal swabs
4	F		12/09/2021 #1	GD-120921-2 NA	0	2	10	Bite-looking markings on left flank above the pelvic fins	16		
5	U		12/09/2021 #2	NA	0	0	7		30		
6	F	220359	12/09/2021 #3	GD-120921-4 G-327	0	0	10		30	JRG	Dorsal and cloacal swabs
7	F	220357	15/09/2021 #3	GD-150921-1 G-328	0	2	13		6	JRG	
Total	5F/ 1U	4		4	0						

Table 7: Whale shark science, 2nd expedition, 2021.

Figure 16 SPLASH10 Tag #220357. Google earth map of individual tracked until October 23rd, 2021. (©GWSP)

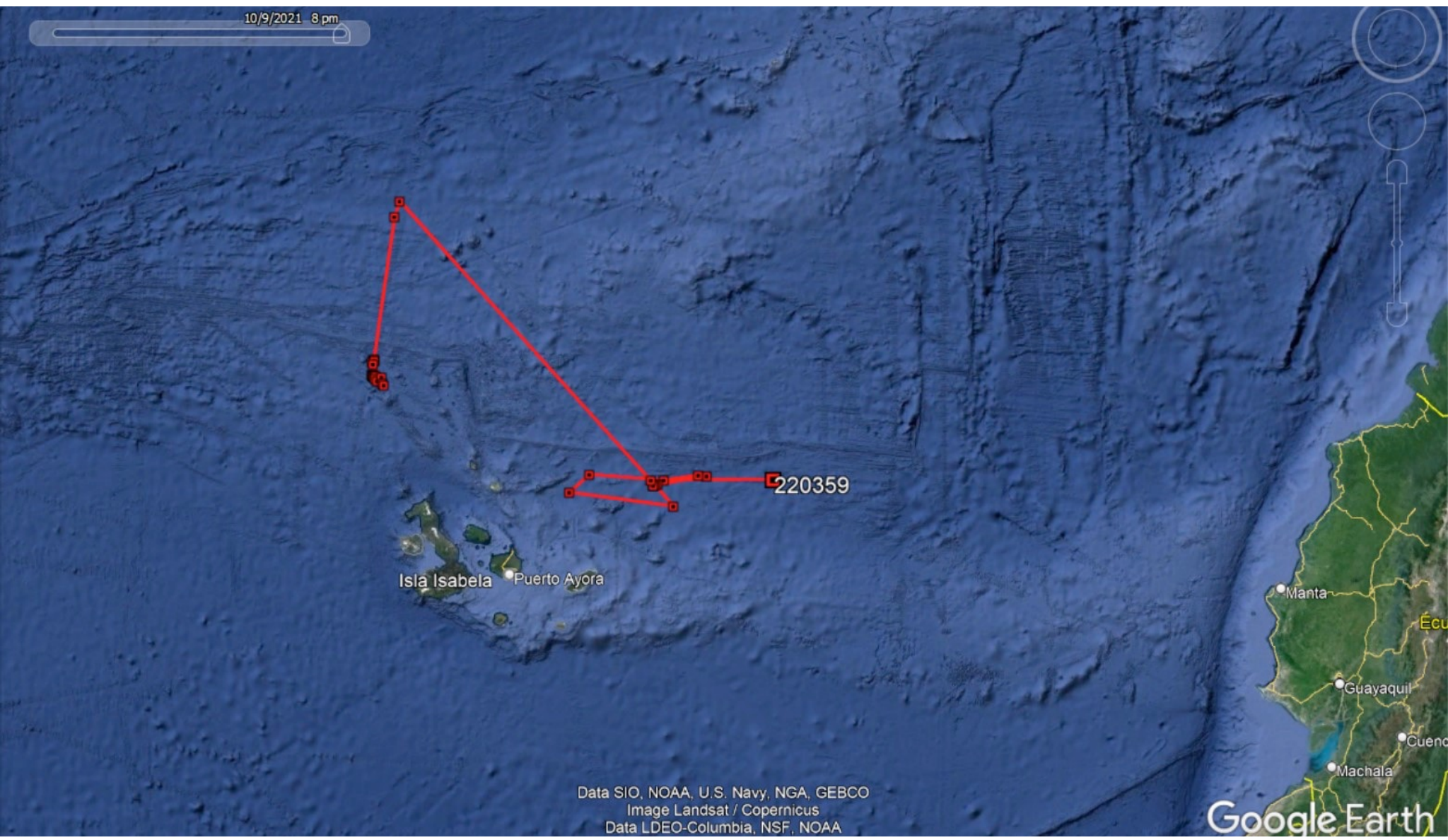


Figure 17: SPLASH10 Tag #220359. Google earth map of individual tracked until October 23rd, 2021. (©GWSP)

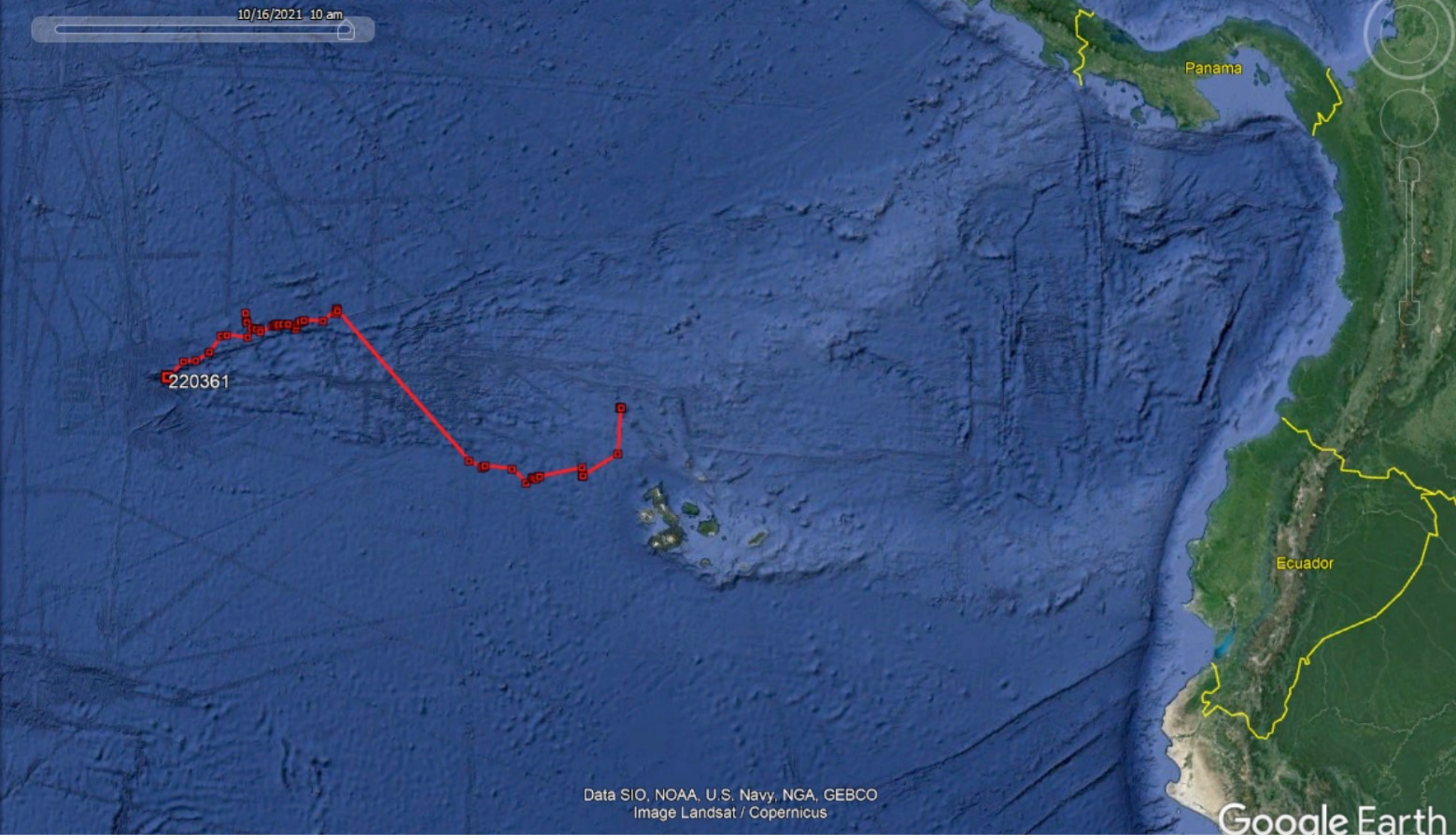


Figure 18. SPLASH10 Tag #220361. Google earth map of individual tracked until October 23rd, 2021. (©GWSP)

During the 18 dives at different locations around the platform at Darwin Arch, (depending on current and surge for the safest diving and working conditions), we sighted only seven whale sharks, five confirmed adult females of which we tagged four. Two of the sharks were at great depth so size, identification and sex could not be determined.

The CATS-Cam deployment was successful but recovery again failed as the satellite transmissions were not received by the CLS Direction Finder Goniometer. The reasons for this are unknown.

The four satellite tags deployed are transmitting successfully to date (Figures 15 - 18).

DISCUSSION

The frequency of sightings has been the lowest in the 11 years of study, with the exception of 2017 which was a “La Niña” year with anomalous low SSTs. This trend has also been confirmed by several of the Divemasters that personally communicated their sightings with the Project.

Photo ©Jenny Waack

Figure 19: Whale shark accompanied by jacks (Photo: ©Jenny Waack)

5.1 CLIMATIC CONDITIONS AND OBSERVATIONS

Whale sharks are usually sighted between the months of June – November at the dive site of Darwin Arch, Darwin Island most years. Climatic events such as the super heating event of the El Niño southern Oscillation and the cooler counter event, La Niña and subsequent hot and cold anomalous sea surface temperatures, (SSTs), might affect the seasonal frequency and number of sightings of this and other species.

According to NOAA this year presents ENSO neutral with near-to-below average sea surface temperatures with a 70-80% chance of La Niña event during the Norther Hemisphere winter 2021-2022 (NOAA, 2021).

In Galapagos, the lower SSTs in April and May (range 23-25C) brought early sightings of whale sharks but

in June and July temperatures again rose (range 25-27C) with a corresponding decrease in numbers and frequency of sightings from reports from the Divemasters and visiting divers.

During the first expedition there were no whale sharks sighted by the team or any of the vessels at Darwin Arch during the first 3 days of diving. Days 4 & 5 brought a total of 5 individual whale sharks, four of which were tagged. During the second expedition no whale sharks were sighted during the 4th and 5th day of the expedition, and sporadically sighted on dives during the other days (Appendices 1 and 2). It is, worth noting that other conditions complicated the work to be carried out and the possibility of whale shark sightings. Underwater the team met with challenging conditions as strong currents, up to 5 knots, compounded with poor visibility and powerful surge meant that certain elements of the work planned and undertaken were not successful as the safety of the divers was compromised. Blood draw which is a slow and careful process could not be attempted as divers were carried away from the dive site as they followed the sharks out into the deeper waters.

With climate change it is believed that the Oceanic phenomena's such as El Niño and la Niña will occur with higher frequencies and thus it is probable that this will affect the frequency with which whale sharks are sighted in their known aggregation locations. The events will not only increase in frequency but also in strength (Stein, 2020). The shift in seasonal sightings and possibly also location of sightings make it more complicated to apply proper measures of management for the conservation of this

species, as temperature seems to highly influence their movement behaviors and patterns. The impact of climate change on this species is uncertain and should be further studied in the near future.

Figure 20: Sea Surface Temperatures in the Eastern Tropical Pacific August 22nd 2021

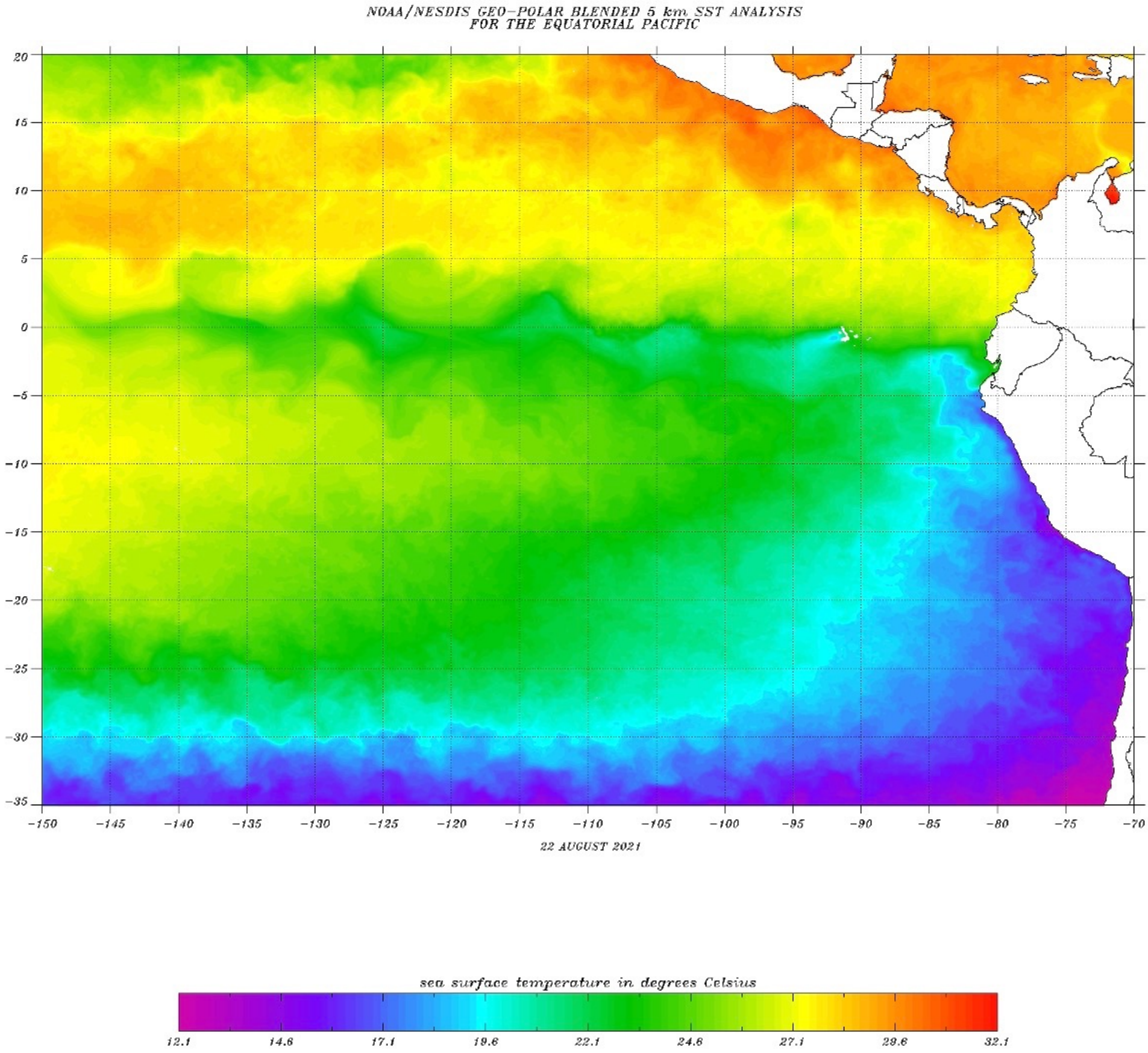


Figure 21: Screen capture of a male tiger shark at Darwin Arch swimming along the platform / sand area NE. (Photo ©Jonathan R. Green)

5.2 NOTABLE SIGHTING

Tiger sharks, Galeocerdo cuvier, have been sighted on numerous occasions by our team and divers from both science teams and tourist trips. This year the sightings have increased in frequency. They have been sighted consistently in Darwin since May of 2021. Two tiger sharks were sighted on the 2nd Expedition: an adult male of approximately 4m total length (TL) (figure 21) and an adult female, also approximately 4m TL, which had a remarkably distended abdomen that could be indicative of advanced pregnancy. Although residency has not been confirmed the observations might indicate that this is occurring. Photo ID of these individuals collected by scientists, divemasters and visitors could further indicate residency rates and site fidelity.

Figure 22: Whale Shark approaching the researchers (Photo: Sofía M Green)

6

CONCLUSION

This year, two annual expeditions were led by the Galapagos Whale Shark Project as a continuation on the study of whale shark movement patterns, ecology, behaviour, and life history strategies. The first expedition, in August of 2021, was undertaken in collaboration with the Georgia Aquarium for a study on the health status of the whale sharks and other toothy shark species found passing by Darwin Island during what is considered the cold season in the archipelago. This report specifically describes the work done with the whale shark, Rhincodon typus, while only slightly mentioning the work done on the other shark species Carcharhinus falciformis and Carcharhinus galapagensis. For more information on the toothy shark data we advise direct communication with the Georgia Aquarium team. The second

expedition of September of 2021 was managed by the core Galapagos Whale Shark Project team to culminate the activities designated for the project for this year. In total, eight whale sharks were tagged, including on juvenile female and seven adult females. Three of these whale sharks were tagged with CATS-Cams. However, only one of these cameras was recovered due to failure in equipment and inclement conditions. Also, microbiome samples were collected from 4 individuals (appendix 3). Although blood sampling was attempted, due to difficult working conditions underwater, blood draws were unsuccessful.

The satellite tag data gathered from these expeditions will serve to continue the study on “The diving behaviour of the whale shark Rhincodon typus related to geographical and environmental conditions in the Galapagos Marine Reserve and the Eastern Tropical Pacific”. The photo-ID data serves as a long-term continued passive tracking of the whale sharks registered navigating through Darwin and Wolf Islands and the microbiome samples will serve for an analysis on the health status of these sharks.

In the near future the project hopes to continue studying the species, to answer still-missing information on the reproductive ecology, navigation strategies, and behavioural ecology. These data will serve for the proper implementation of policy and management strategies for the protection of this species and other endangered species protected under the same laws and regulations.

7 ACKNOWLEDGEMENTS

Photo ©Sofía M Green

ACKNOWLEDGEMENT

The continued support and funding from Galapagos Conservation Trust and the Sackler Trust has kept the project and work going over many years, providing us with equipment, vessel hire and satellite time and tags. Save our Seas Foundation for a second year has helped with the satellite tags and blood kits and WWF Ecuador & Holland also helped with satellite tags and a DJI Mavik Drone for aerial surveying. Georgia Aquarium provided us with the platform for the first trip and will be carrying out the laboratory analysis for the blood samples from 2020. The Galapagos Science Center and in particular Anita Carrion have worked tirelessly with permitting, visiting scientist permits and the administrative details that we always need! A big shout to Federico Angermeyer for putting his beautiful vessel “m/v Vision” at our disposition with an amazing crew that helped us with such enthusiasm and professionalism. Last but not least Jenny with Galapagos Shark Diving who came through with vessel funding when all other best laid plans fell victim to Covid Delta. Your support makes this work possible and together we can make a difference for the future of our Oceans.

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APPENDICES

Photo ©Jonathan R Green

Date	Site	# Dive	Time of Dive	Length of Dive (min)	T° surface °C	T° below surface °C	Thermo cline depth (m)	Max Depth (m)	Visibility (m)	Current (0-5)	Current Direction	WS Sightings	New WS	# Individuals
25/08/21	Darwin's Arch	1	11:02	00:47	27	27	0	23.2	10	3	N-SW	0	0	0
25/08/21	Darwin's Arch	2	14:42	00:49	26.7	22	23	23.7	10	2	S-N	0	0	0
26/08/21	Darwin's Arch	3	06:57	00:56	27.4	27.4	25	23.3	15	1	N-SW	0	0	0
26/08/21	Darwin's Arch	4	10:42	01:00	27.2	27.2	25	24.2	15	1	N-SW	0	0	0
26/08/21	Darwin's Arch	5	15:05	00:50	26	26	32	24.5	10	1	N-SW	0	0	0
27/08/21	Darwin's Arch	6	06:53	00:59	26	26	30	23	15	1	NE-SW	0	0	0
27/08/21	Darwin's Arch	7	11:15	00:57	26	26	30	27.2	15	1	S-N	0	0	0
27/08/21	Darwin's Arch	8	14:45	00:53	26	26	24	24.5	12	1	S-N	0	0	0
28/08/21	Darwin's Arch	9	06:40	00:42	26	26	30	23.6	20	1	N-S	3	2	2
28/08/21	Darwin's Arch	10	09:35	00:57	26	26	30	17.4	20	1	N-S	1	0	1
28/08/21	Darwin's Arch	11	12:17	00:55	26	26	25	22.4	10	1	N-S	0	0	0
28/08/21	Darwin's Arch	12	15:05	00:56	26	26	21	26.6	15	2	N-S	0	0	0
29/08/21	Darwin's Arch	13	06:40	00:42	26	25	20	24.1	20	1	N-SW	2	2	2
29/08/21	Darwin's Arch	14	09:35	00:44	26	24	19	30.7	20	1	N-SW	4	0	2
29/08/21	Darwin's Arch	15	12:10	00:51	26	24	25	22.1	20	1	N-SW	5	1	2
29/08/21	Darwin's Arch	16	15:25	00:47	26	26	21	24.7	20	1	N-SW	2	0	1
30/08/21	Sharkbay	17	06:35	00:43	22	21	20	23.6	20	0	N-S	0	0	0

Appendix 1 - Whale shark sightings 1st Expedition

Date	Site	# Dive	Time of Dive	Length of Dive (min)	T° surface °C	T° below surface °C	Thermo cline depth (m)	Max Depth (m)	Visibility (m)	Current (0-5)	Current Direction	WS Sightings	New WS	# Individuals
10/09/21	Darwin's Arch	1	07:00	00:54	24	24	0	23.4	20	1	S-N	0	0	0
10/09/21	Darwin's Arch	2	10:35	00:40	24	24	0	26.3	20	2	N-SW	2	2	2
10/09/21	Darwin's Arch	3	14:25	00:50	24	24	0	25.6	18	3	S-N	0	0	0
11/09/21	Darwin's Arch	4	06:58	00:50	24	24	0	24.2	20	3	N-SW	0	0	0
11/09/21	Darwin's Arch	5	10:28	00:49	25	25	0	24.2	20	3	N-SW	0	0	0
11/09/21	Darwin's Arch	6	15:43	01:00:00	25	25	0	25.6	25	2	N-SW	1	1	1
12/09/21	Darwin's Arch	7	06:59	00:56	26	25	17	27.2	20	2	N-SW	2	2	2
12/09/21	Darwin's Arch	8	11:05	00:54	26	26	21	24.5	20	2	N-SW	2	1	2
12/09/21	Darwin's Arch	9	14:10	00:51	27	26	19	25.3	20	2	N-SW	1	1	1
13/09/21	Darwin's Arch	10	07:00	00:54	27	26	0	21.4	25	2	N-SW	0	0	0
13/09/21	Darwin's Arch	11	10:42	00:51	26	26	0	21.1	25	2	N-SW	0	0	0
13/09/21	Darwin's Arch	12	14:50	00:57	26	26	0	26.2	25	2	N-SW	0	0	0
14/09/21	Darwin's Arch	13	06:50	00:55	26	25	0	23.0	25	1	S-N	0	0	0
14/09/21	Darwin's Arch	14	10:45	00:53	26	25	0	21.7	25	1	S-N	0	0	0
14/09/21	Darwin's Arch	15	14:45	01:04	26	25	0	21.5	20	1	BREAK	0	0	0
15/09/21	Darwin's Arch	16	06:59	00:55	25	25	0	23.7	20	1	BREAK	0	0	0
15/09/21	Darwin's Arch	17	10:48	00:51	25	24	21	23.9	20	1	BREAK	0	0	0
15/09/21	Darwin's Arch	18	14:50	00:55	24	24	21	25.2	15	3	BREAK	2	1	1

Appendix 2 - Whale shark sightings 2nd Expedition

Date	Expedition #	Wildbook ID	Dive	Encounter	Time	Est Length (m)	Sex	Distinguishing Features	Samples taken
28/08/21	1	G-301	1	1	07:00	11.5	F	Dent in head, SPLASH tag deployed	Dorsal
28/08/21	1	G-313	3	7	12:25	5	F		Dorsal
28/08/21	1	G-313	4	8	14:30	5	F		Dorsal, Cloaca
12/09/21	2	G-326	1	1	07:40	12.5	F	SPLASH tag deployed	Dorsal, Cloaca, Water
15/09/21	2	G-328	3	1	03:10	13	F	SPLASH tag deployed	Dorsal, Cloaca, Water

Appendix 3 - Microbiome samples collected

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