GALAPAGOS whaleshark PROJECT

GALAPAGOS WHALE SHARK PROJECT

FIELDWORK REPORT 2018

JONATHAN R. GREEN
& ALEX HEARN PhD

WWW.GALAPAGOSWHALESHARK.ORG

Sofia M. Green[5], Jenny Waack[5], Jonathan R. Green[5], Harry Reyes[1], Simon J. Pierce[2], Rui Matsumoto[7], Chris Rohner[2], Kiyomi Murakumo[7] & Alex Hearn[4]

PARTICIPATING ORGANISATIONS:

[1]DIRECCION DEL PARQUE NACIONAL GALÁPAGOS,
[2]MARINE MEGAFAUNA FOUNDATION,
[3]GALAPAGOS CONSERVATION TRUST,
[4]UNIVERSIDAD SAN FRANCISCO DE QUITO,
[5]GALAPAGOS WHALE SHARK PROJECT,
[6]PLANETERRA
[7]OKINAWA CHURASHIMA FOUNDATION

Figure 1: Darwin Arch by Darwin Island, dive and study site. Photo: ©Jonathan R. Green 2016

GALAPAGOS MARINE RESERVE

With the creation of the Galapagos Marine Reserve, (GMR) extending 40 nautical miles from the outermost point of the peripheral islands, a large area of the north east Pacific provides protection to a diverse and thriving marine community. This includes many of the Galapagos endemic species as well as resident, native and migratory fauna and the world's largest fish, the whale shark, ***Rhincodon typus***.

An ocean traveller, the whale shark is found between the latitudes of 40° north and 45° south in all the oceans and is mostly associated with tropical, sub-tropical and temperate waters. Whale sharks feed predominantly by filter feeding on a wide variety of planktonic (microscopic) organisms but have been observed lunge feeding on nektonic (larger free swimming) prey, such as schooling fishes, small crustaceans, and occasionally tuna and squid. Whale sharks are ovoviviparous with eggs hatching within the female's uteri and the female giving birth to live young. Whale sharks in the GMR are seasonal with highest recorded numbers during the months of July – October. (Hearn et al. 2014) Very little is known about their biology and ecology, and their movements, particularly in the Eastern Tropical Pacific.

The Galapagos Whale Shark Project began in 2011 with a series of field trips to study the movements of whale sharks within the GMR and with satellite tagging to track their movements on a local and regional scale. Early data showed that over 99% of all sightings in the Galapagos were of adult females. (Acuña et al.2014). The study site is Darwin Arch near Darwin Island at the furthest north of the Galapagos Archipelago. (See Figures 1 & 2)

Figure 2: Map of Galapagos Marine Reserve with baseline and 40 nm limit and Bathymetric map of Darwin Island. (Cesar Peñaherrera P. CDF)

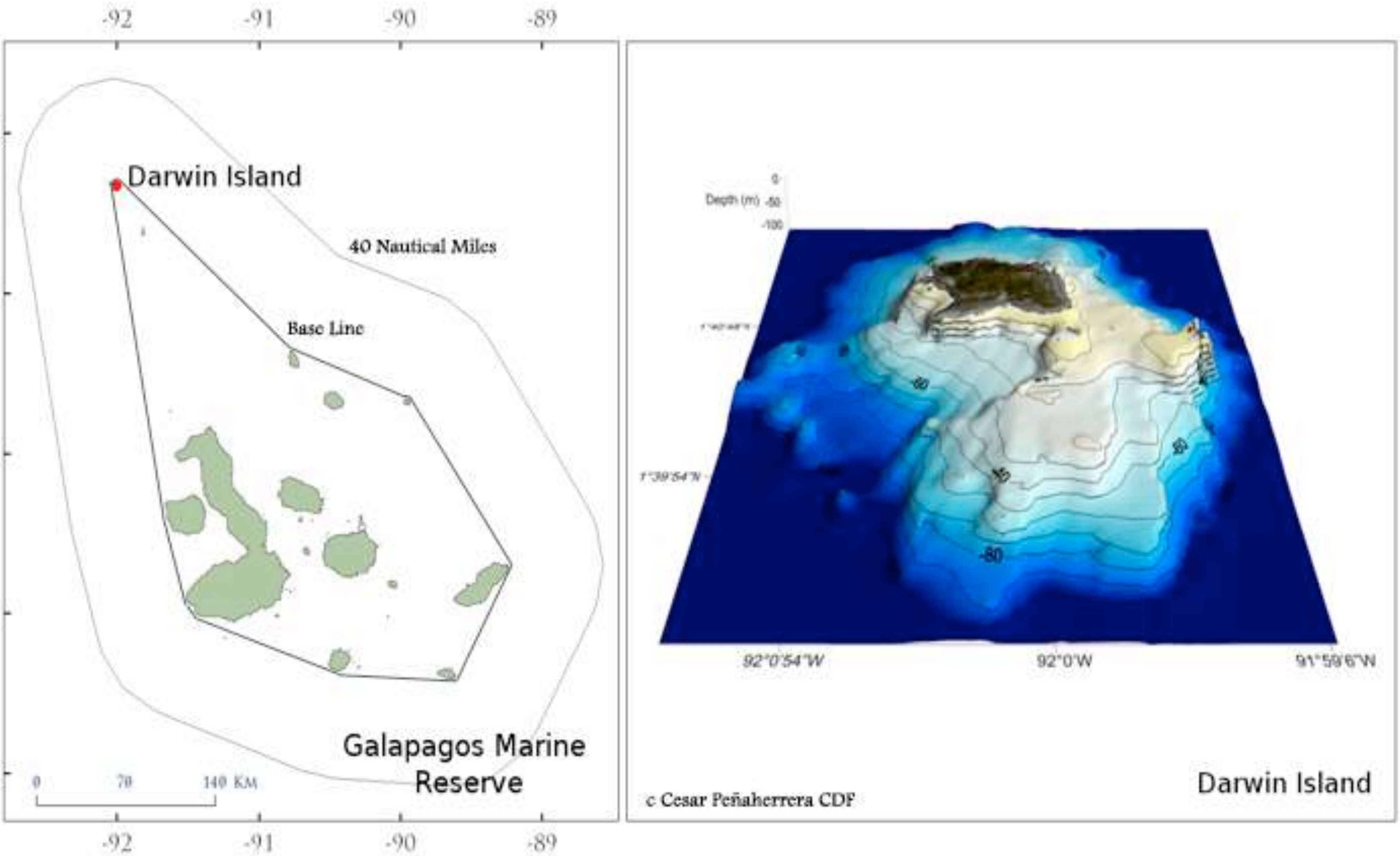


Figure 3: Whale Shark swimming over Darwin platform, with diver. Photo: ©Jonathan R. Green 2018

WHALE SHARKS

Observers also noted that none of the sharks appeared to be feeding and are mostly seen with the mouth closed or only slightly parted. Since observation began in 1991, only one whale shark has been confirmed as feeding at the dive site, El Derumbe at Wolf Island, (Green pers. ob. 2012), although reports have been made from naturalists of feeding whale sharks nearby Santiago Island, but not substantiated. Furthermore over 95% of the adult females display highly distended abdomens which may be suggestive of a state of gestation. (See Figure 4).

One of the most frequent questions concerning whale sharks is the location or locations and habitat in which the pups are born. Historically only a few neonatal, <1m, whale sharks have been reported, either through by-catch or found in shallow coastal waters by fisherman and divers. Considering their distribution and prolific nature of whale shark births, (Joung et al. 1996, Schmidt et al. 2010) this is a surprisingly small number of encounters with neonates. Similarly by-catch from fisheries such as purse seine tuna fishing in pelagic areas, also reports an extremely low number of captures, although reports exist for all three oceanic regions, Pacific, Atlantic and Indian.

Neonatal whale sharks are thought to have limited swimming abilities compared to juveniles and adults (Martin 2007). Could it be then that whale sharks are birthing below the depths at which most of the predators that would target neonates and very young whale sharks are present, on or close by marine platforms such as the Galapagos platform or around seamounts that may provide a more protected habitat than the open ocean?

Figure 4: Mature (>10m) female whale shark with highly distended abdomen.
Photo: ©Sofia M. Green 2018

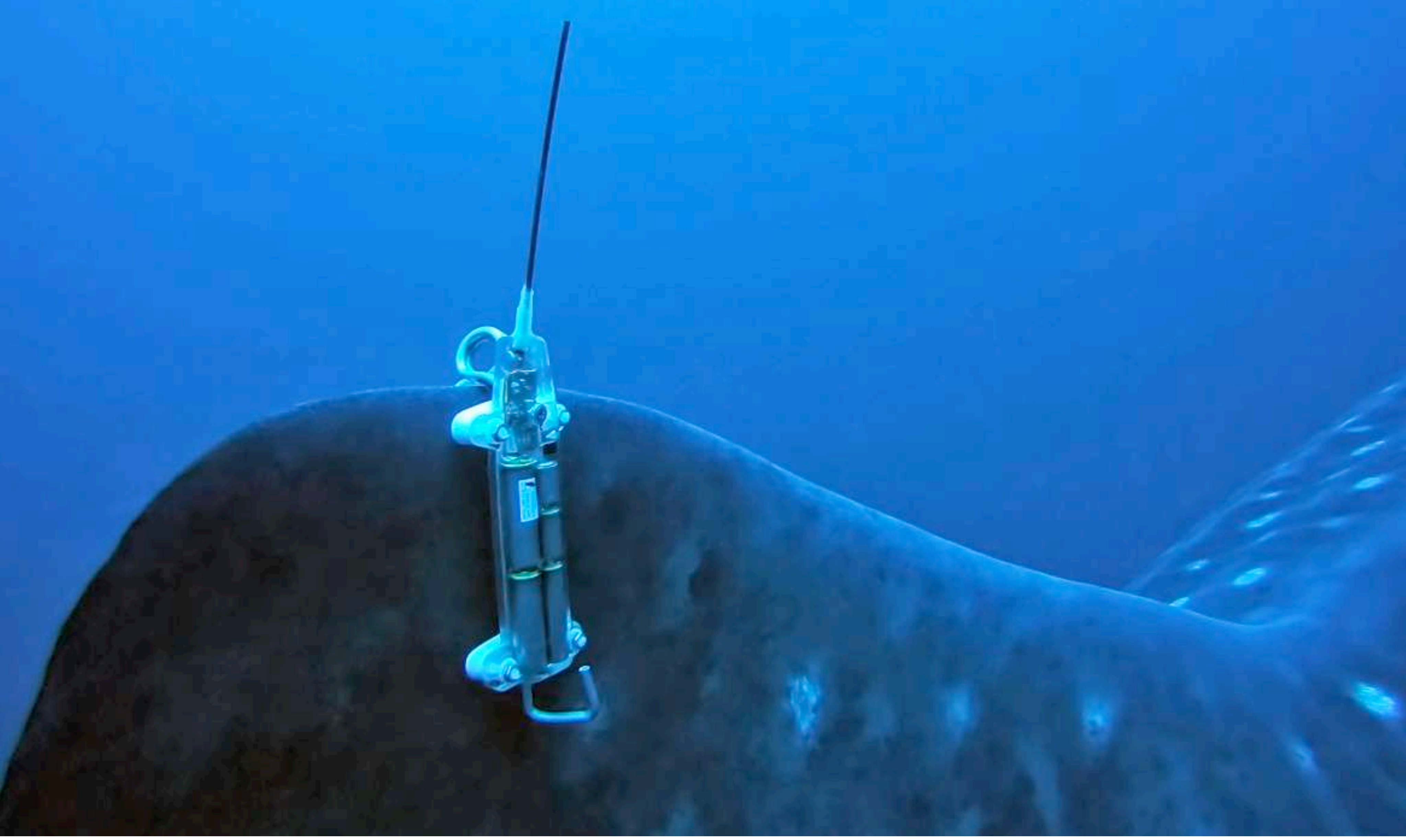


Figure 5: Fin mounted SPOT6 / 257 satellite tag. Photo: ©Jonathan R. Green 2018

SATELLITE TAGS

Tracks from satellite tags deployed in the last seven years have shown that whale sharks frequently pass by Darwin Island but few stay longer than 48-72 hours, (Acuña et al. 2014). Many of the tracks also show that after heading west the same sharks return past Darwin Arch before heading south in November-December, towards the Peru shelf break where they appear to spend time foraging in the rich upwelling areas of high productivity associated with the Peru Coastal or Humboldt current. The question that arises here is for what reason the female whale sharks are coming to Darwin?

This season we deployed a prototype design of fin mounted tags, (see Figures 5, 6 & 7), moving away from the towed tags used in previous seasons, to try to attain a higher percentage of tag retention and longer periods of data transmission. We also focused more on the reproductive state of the female sharks in order to try to ascertain pregnancy by using ultrasound equipment and taking blood samples for later analysis.

Satellite tags: In order to get long-term data from the tags we decided to use a fin mount with no floatation capability as the likelihood of recovering these tags is close to zero. Our longest deployment was last season with a SPOT6 tag that lasted approximately 360 days which was the estimated battery life given the parameters we had pre-programmed for daily transmissions.

Figure 6 (left): SPOT6 – 257 with 1500-day battery capacity. Photo: ©Jonathan R. Green 2018

Figure 7 (right): SPOT6 – 258 with 300-day battery capacity. Photo: ©Jonathan R. Green 2018

As we know that the sharks are not returning usually during this period we need data that indicates movements over a much longer period of time. The SPOT6 type 257 has an estimated battery life of 1500 days or 4.1 years. This potentially gives us a better opportunity of tracking regional movements and maybe even recording their return to the GMR. A major factor that must be taken into account, is of course fouling, as marine invertebrates and algae begin to colonise the tag surfaces and compromise functionality. The tag is coated with anti fouling paint to delay this process but protection decreases rapidly after about 18 months.

Figure 8: Dr Alex Hearn deploys a SPOT6 / 258 tag on the dorsal fin of a whale shark.
Photo: ©Jonathan R. Green 2018

In comparison to last season the fin mount tags sit high on the dorsal fin and the antenna is in a vertical position in order to maximise transmission opportunities.

We also tried a smaller, (53g as opposed to 160g of the 257), SPOT6 – 258 tag that has a battery capacity of 300 days at 250 transmissions p/day. Both tags, developed by Wildlife Computers have the Wet / Dry sensors close to the base of the antenna so that as soon as the fin of the individual breaches the surface the tag will begin to transmit positional data and temperature histograms. With the improved position on the fin and direction of antenna we are optimistic of getting superior data.

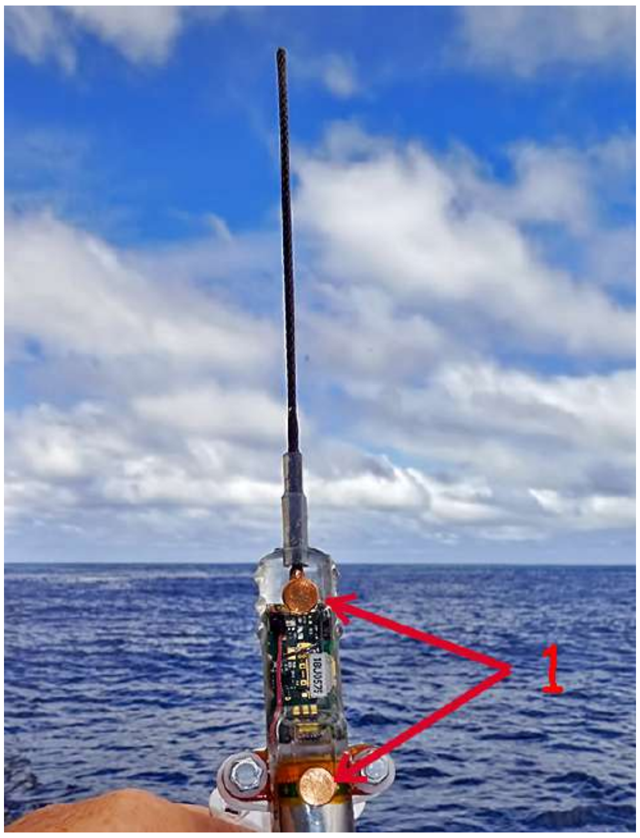
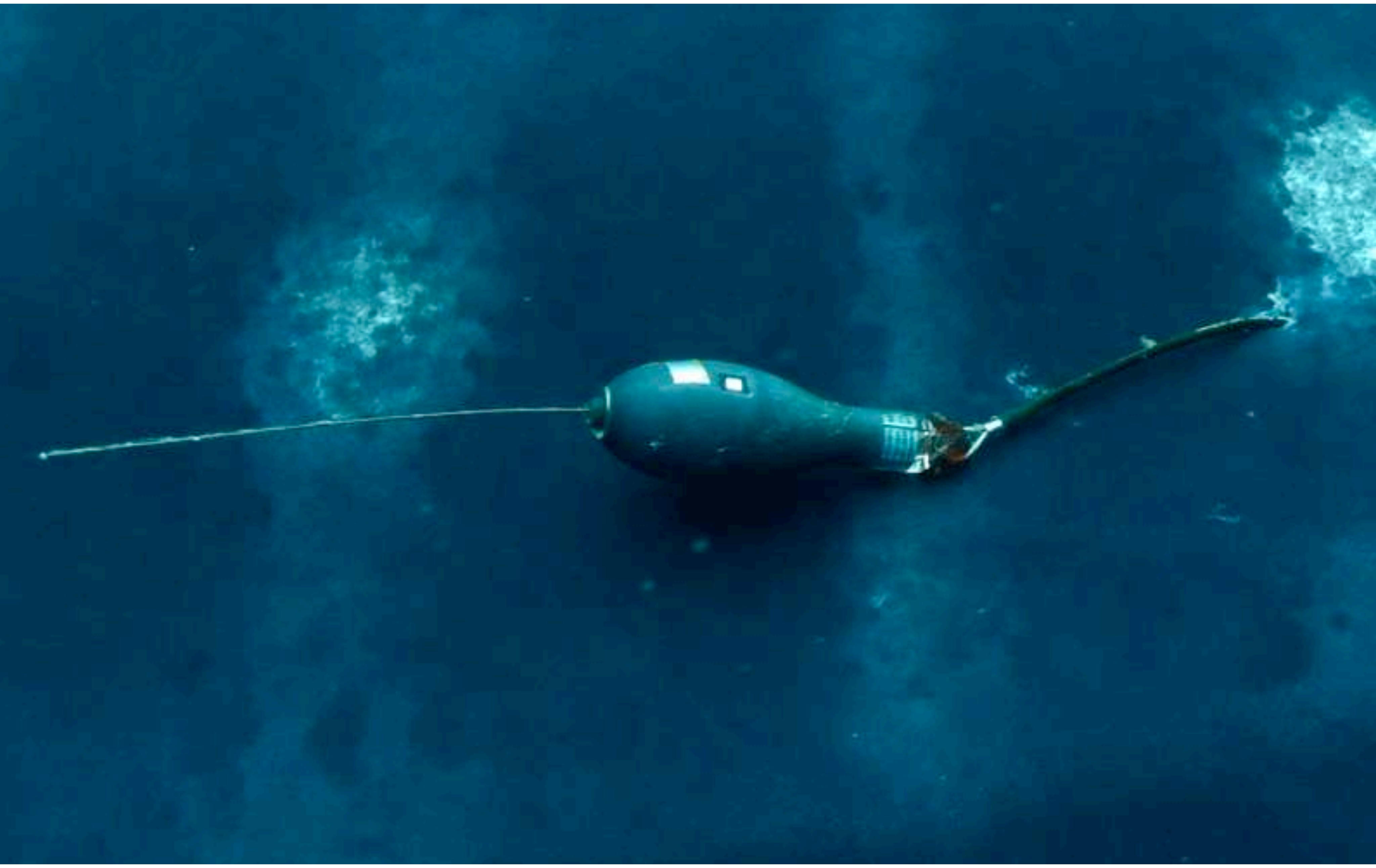


Figure 9: 1 shows Wet / Dry Sensor at the base of the antenna of the SPOT6 / 258 tag.
Photo: ©Jonathan R. Green 2018

We also deployed seven miniPAT tags, (see Figure 10), three of them double taggings with SPOT tags, (see Appendix) but we updated some of the settings to attempt to improve data and retention times with these tags also. Release depth was changed from 1400m to 1700m as all releases from last season were premature due to deep dives. Time release was also increased from 4 months to 6. The attachment is still by pneumatic spear gun but with a very short tether to reduce removal by associated species, principally other shark species and Giant Trevallies, all of which were seen closely associated with whale sharks at the time of tagging or shortly afterwards.

Figure 10: miniPAT tag with 15cm attachment cable.
Photo: ©Jonathan R. Green 2016



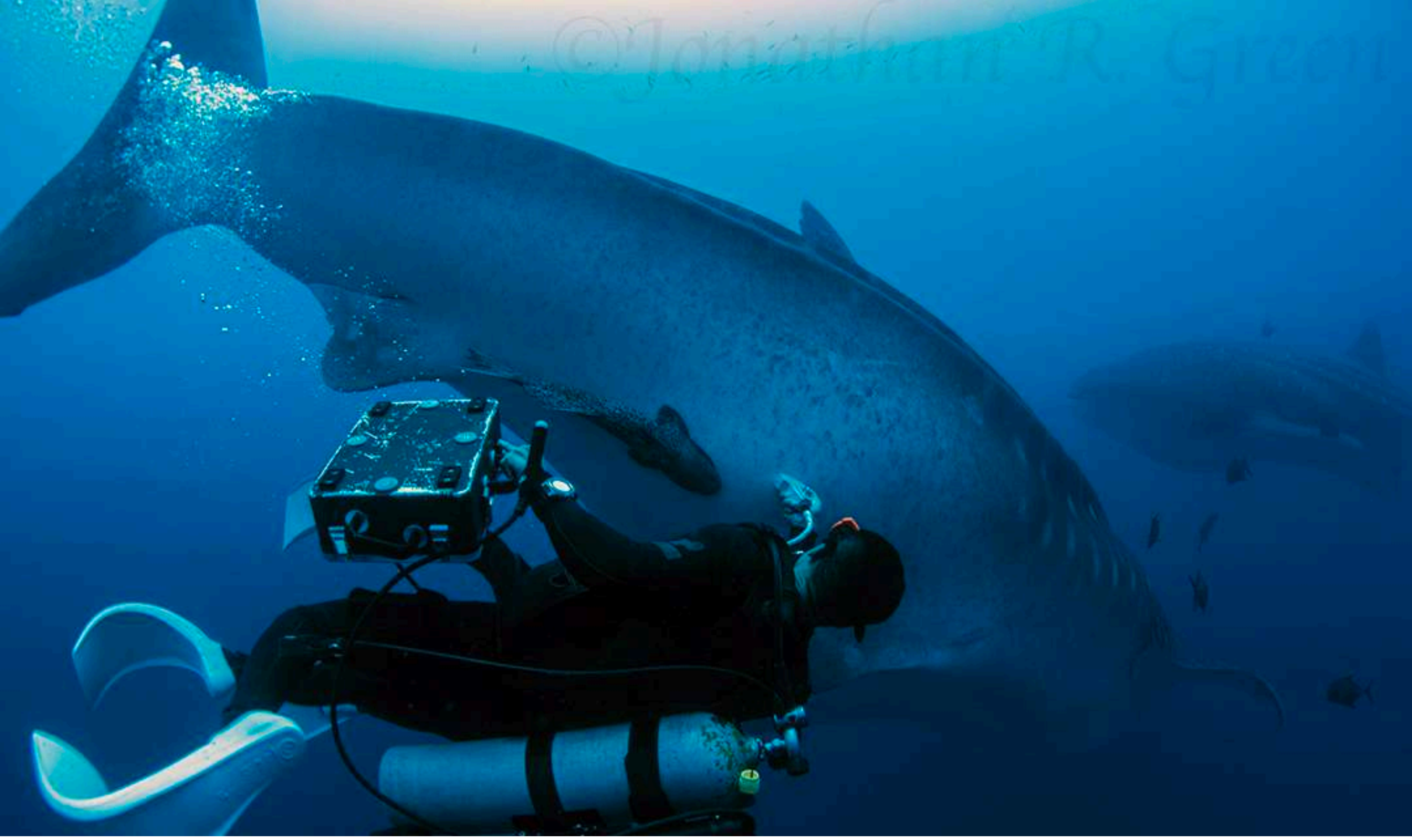


Figure 11: Rui Matsumoto carrying out ultrasound examination on a female whale shark in the wild. Photo: ©Jonathan R. Green 2018

ULTRASOUND

Although this was attempted last year no images of internal organs or structures were obtained. In order to confirm reproductive state we needed to get images that physically show indications of organs, egg cases or embryos. The same unit, a Hitachi Aloka portable system was used as the previous year but with enhanced penetration that allowed the capture of images to a depth of 40cm. This setting however produced a more dissipated beam so this was reset to 30cm for a clearer image. Our knowledge of the physiology of adult whale sharks is based mostly on individuals caught in nets then autopsied but the medical and research staff at the Okinawa Churashiama Foundation often uses ultrasonography to check the pregnancy status and baseline health of a diversity of elasmobranchs, including whale sharks.

Initially the transducer was moved in a longitudinal fashion, (see Figure 12) in order to capture images of the entire ventral area anterior of the pelvic fins but the skin thickness of the upper abdomen was so thick that the ultrasound could not penetrate the abdominal cavity and no detail could be seen. The skin in this area was 27cm thick as measured by ultrasound.

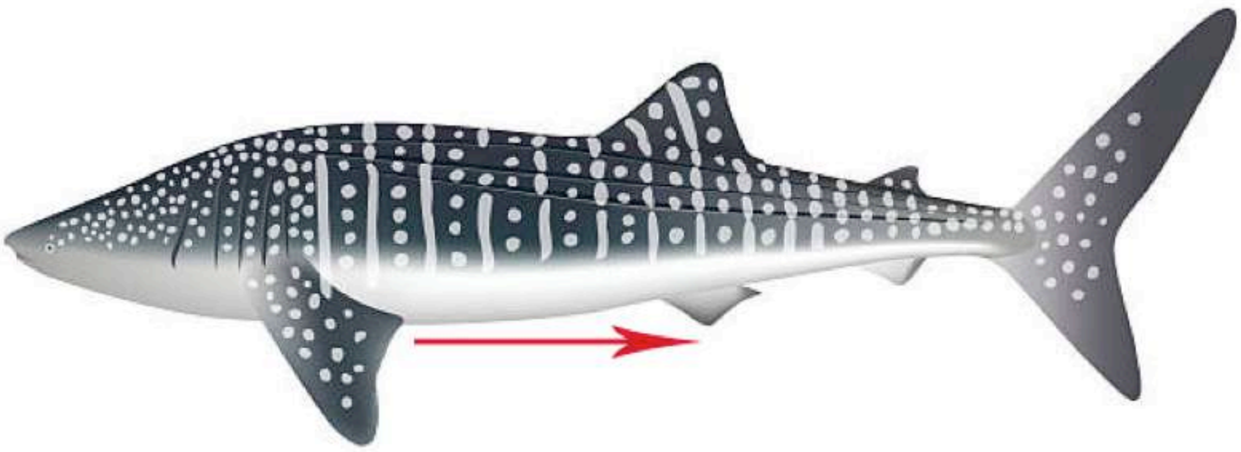


Figure 12: Longitudinal scan used at first by Dr Rui Matsumoto.

For this reason after three attempts Rui Matsumoto began to scan a transect from the upper abdominal area toward the ventral midline just anterior of the pelvic fins. (See Figure 13)

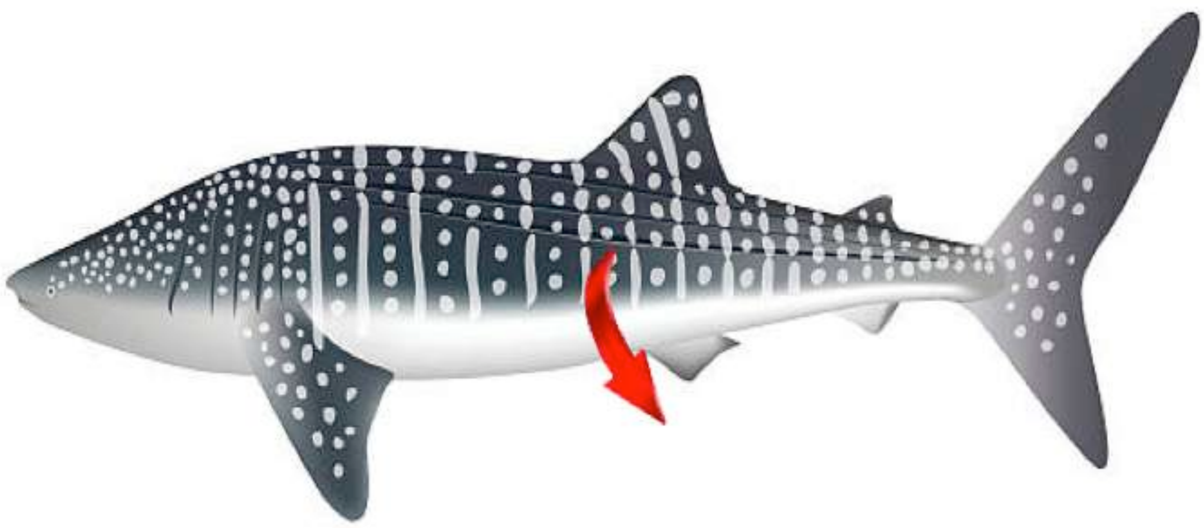


Figure 13: Transverse scan later used by Dr Rui Matsumoto.

With increasing success the images revealed organs and their contents, for the first time with mature female whale sharks in free environment and wild state, (not in aquarium or caught in nets).

The first breakthrough was when the Okinawa team were able to detect the presence of developed ovaries and within them well developed follicles. (See Figures 14, 15 & 16 Ultrasound images).

In this area, adjacent to the pelvic fins the skin thickness was just over 10cm and allowed sufficient penetration of the ultrasound.

However the area we were able to examine is very limited so although the images show for the first time the ovaries and follicles we still need to be able to examine the anterior ventral areas to determine pregnancy as pregnant sharks have a large distribution of eggs in the ovaries and the uterus and embryos, (if present) would most likely be found in the anterior area.

Figure 14: Ultrasound image of whale shark showing ovaries with follicles.
©Okinawa Churashima Foundation

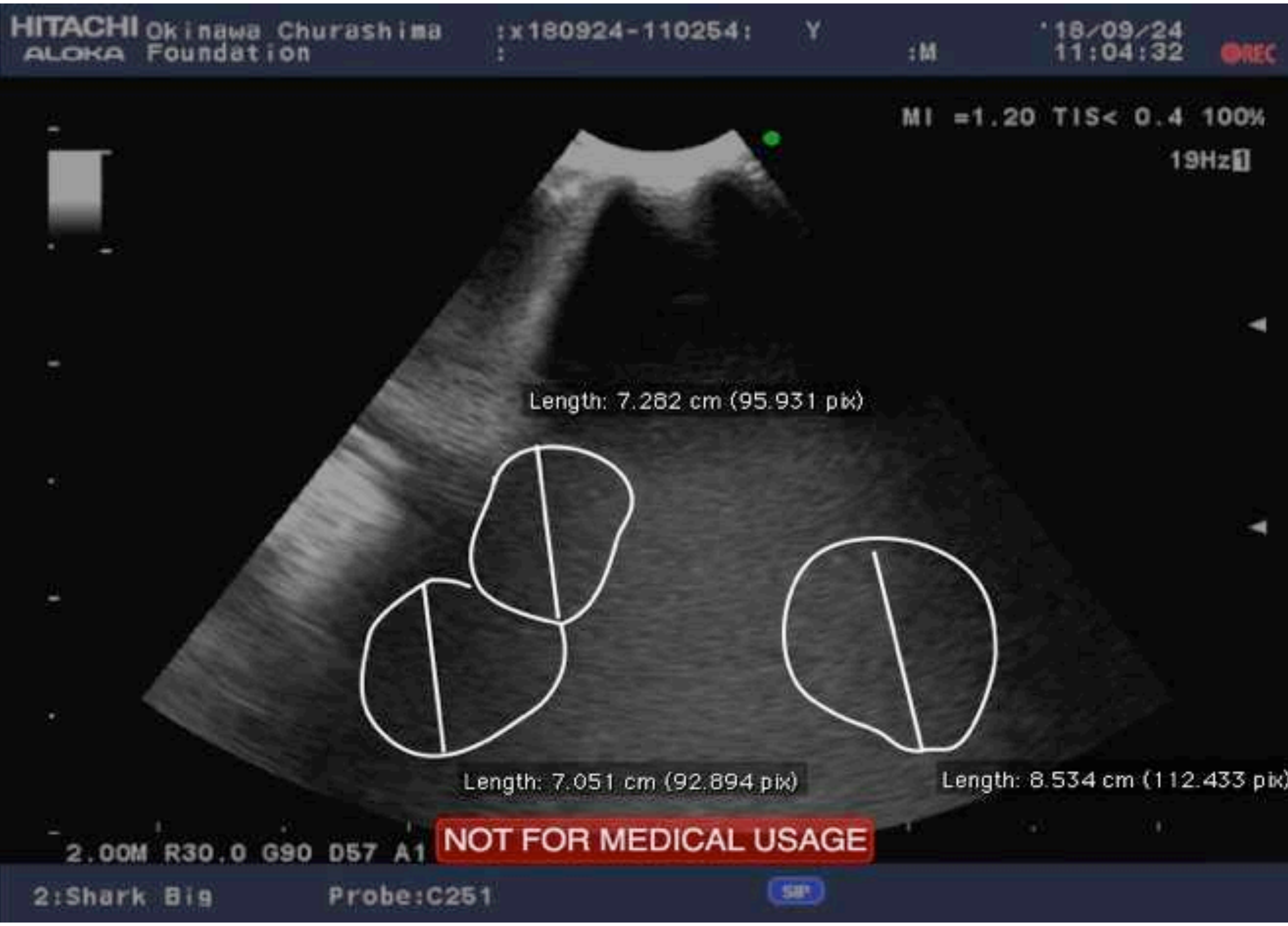


Figure 15: Ultrasound image of whale shark showing ovaries with follicles delineated and size estimates.
©Okinawa Churashimi Foundation

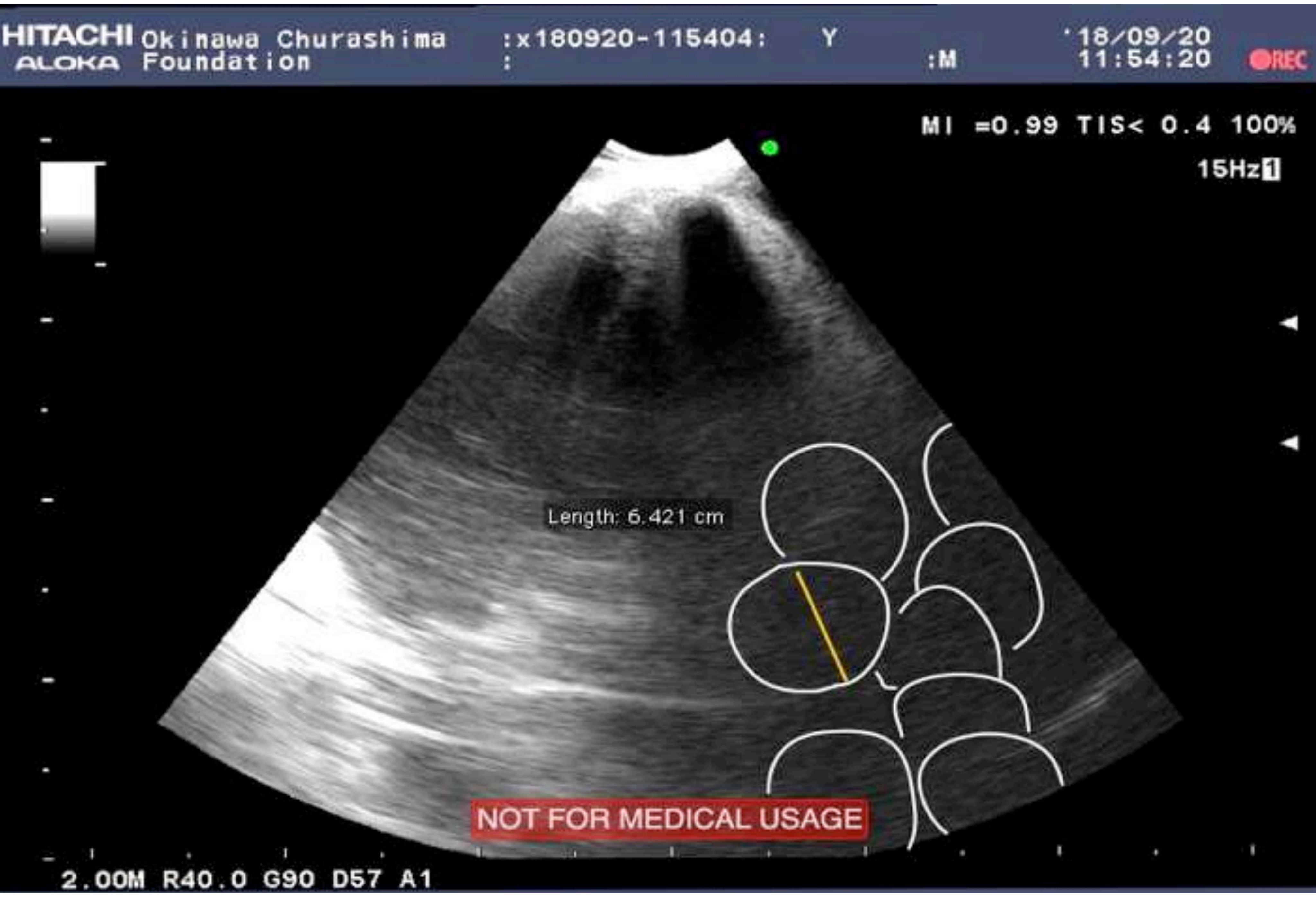


Figure 16: Ultrasound image of second whale shark showing follicles with size estimates. ©Okinawa Churashimi Foundation

Figure 17: Blood draw from the pelvic fin Photo: ©Jonathan R. Green 2018

.

BLOOD DRAW

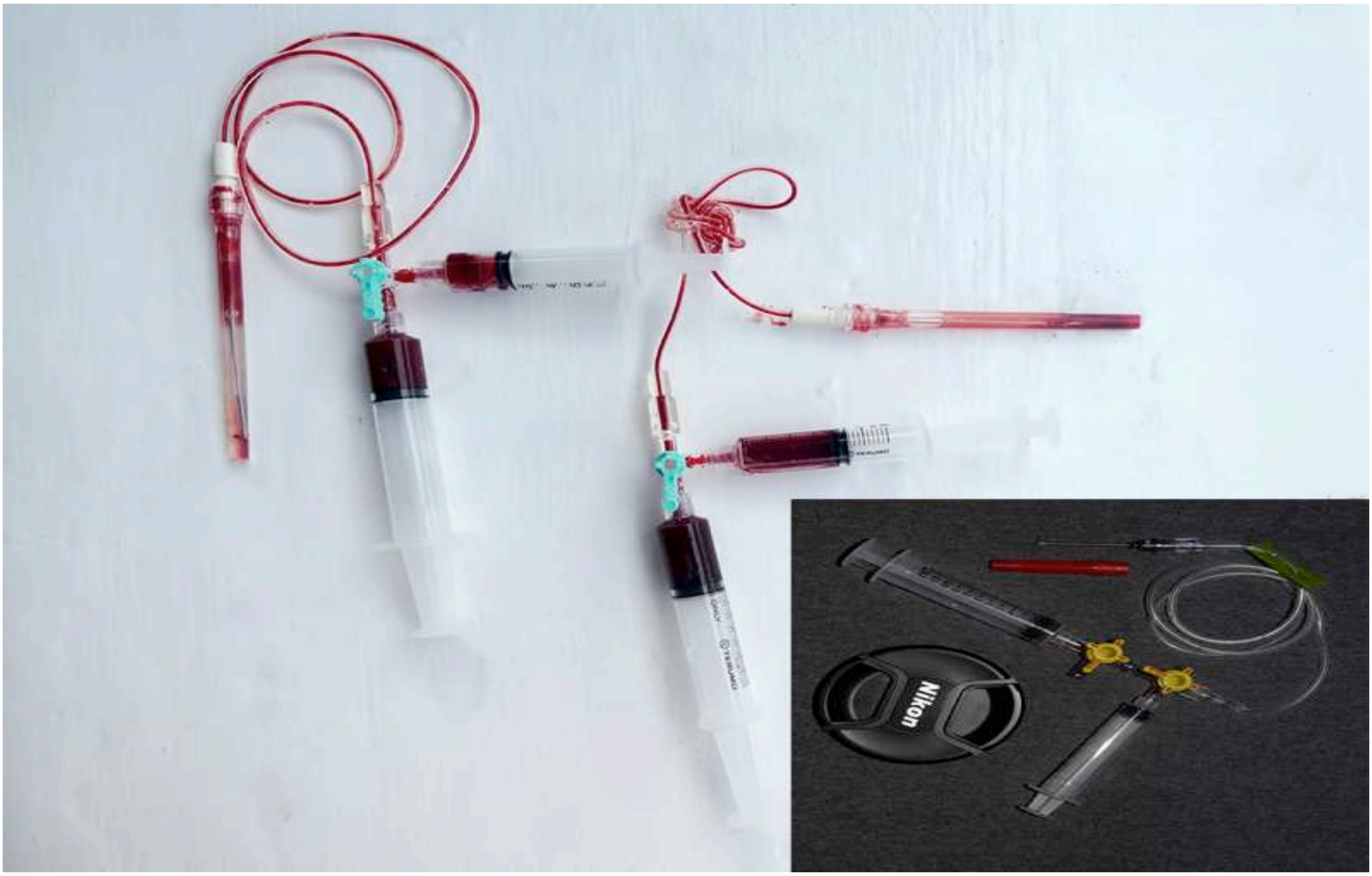
Two blood samples were drawn last season, in July 2017, but these were not analysed. We were able to obtain a further 6 blood samples, all from mature female whale sharks. One sample from last season was from an adult male. Our permit allowed us to transport 5 of the 6 from this season's samples to the San Francisco de Quito University where they were subsequently analysed along with the two from last year. A member of the Okinawa Churashima Foundation, Dr Ryo Nozu, an expert in elasmobranch reproductive physiology and endocrinologist, travelled from Japan only to undertake the analysis.

Blood was drawn by Kiyomi Murakomo, from the pelvic fin, (see Figure 17) as this has proven easier than taking blood from the dorsal and pectoral fins. For the sake of uniformity in sampling this was the only area sampled. The equipment was a double syringe with stopcock and a 189mm needle.

Blood is drawn first into the secondary syringe, contaminated with seawater, the valve closed and uncontaminated blood is then drawn in to the primary syringe. The thickness of the skin proved a challenge and the blood draw procedure often had to be carried out in under 30 seconds before the animal passed below our maximum safe operating depth of 40m (see Figures 18 & 19).

Immediately after collection the blood was taken back to the Queen Mabel for pre-analysis processing. The primary syringe was treated with lithium heparin anticoagulant to allow time for centrifuging without clotting. This allowed the separation of the sample into whole blood and plasma and the plasma is subsequently analysed for the presence and amounts of three hormones, testosterone, progesterone and oestrogen. On board the plasma and whole blood were stored in separate vials in the freezer prior to their transport to the USFQ. The sample was also

Figure 18: Blood draw equipment with blood from two adult female sharks and inset image for scale
Photo: ©Jonathan R. Green 2018



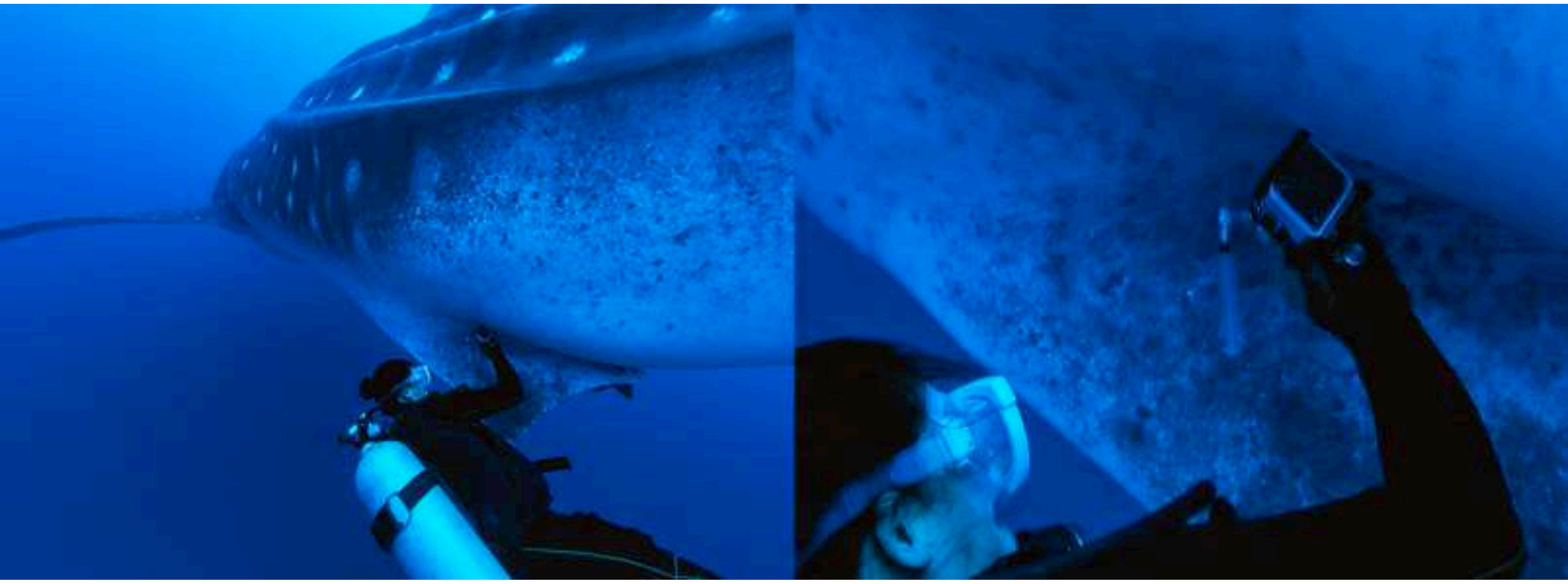


Figure 19: Blood draw from the pelvic fin
Photo: ©Jonathan R. Green 2018

tested on board for partial pressure of oxygen and carbon dioxide, lactic acid and pH to understand the physical condition of sharks. (See Figure 20). At the university the plasma was processed through electrophoresis and the results taken for further analysis by Dr Ryo Nozu, to the Okinawa Churashima Research Centre in Japan.

Figure 20: Left on board analysis of whole blood for partial pressure of O2, CO2, pH and Lactic Acid. Centre: sample is placed in centrifuge. Bottom right: Plasma and whole blood for lab analysis. (Preserved frozen in separate vials)
Photos: ©Jonathan R. Green 2018

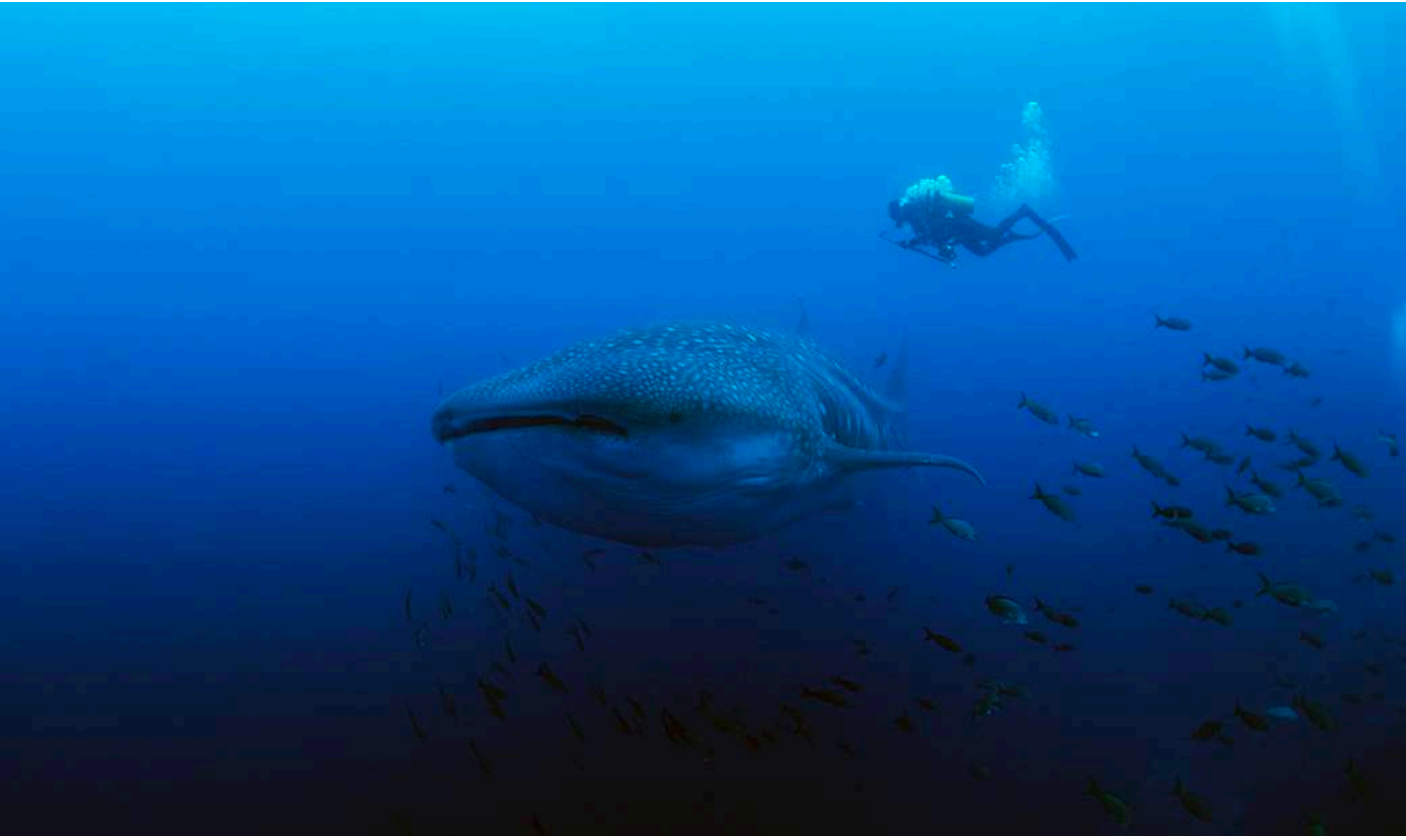


Figure 21: Diver approaches to take a biopsy. Photo: ©Jonathan R. Green 2018

.

BIOPSY / TISSUE SAMPLING

Five skin tissue samples were collected using a Cressi SL55 pneumatic spear gun with a PneuDart Marine Biopsy Tip, (see Figure 22). These were divided back on the Mabel into 3 vials, 2 preserved in 98% ethanol for DNA analysis and 1 frozen for Stable Isotope and Fatty Acids analysis.

Figure 22 (right): The skin tissue sample approx. 2cm collected using a marine biopsy tip.
Photo: ©Jonathan R. Green 2018

These are currently at the Galapagos Science Centre in San Cristobal awaiting the permits for transport.

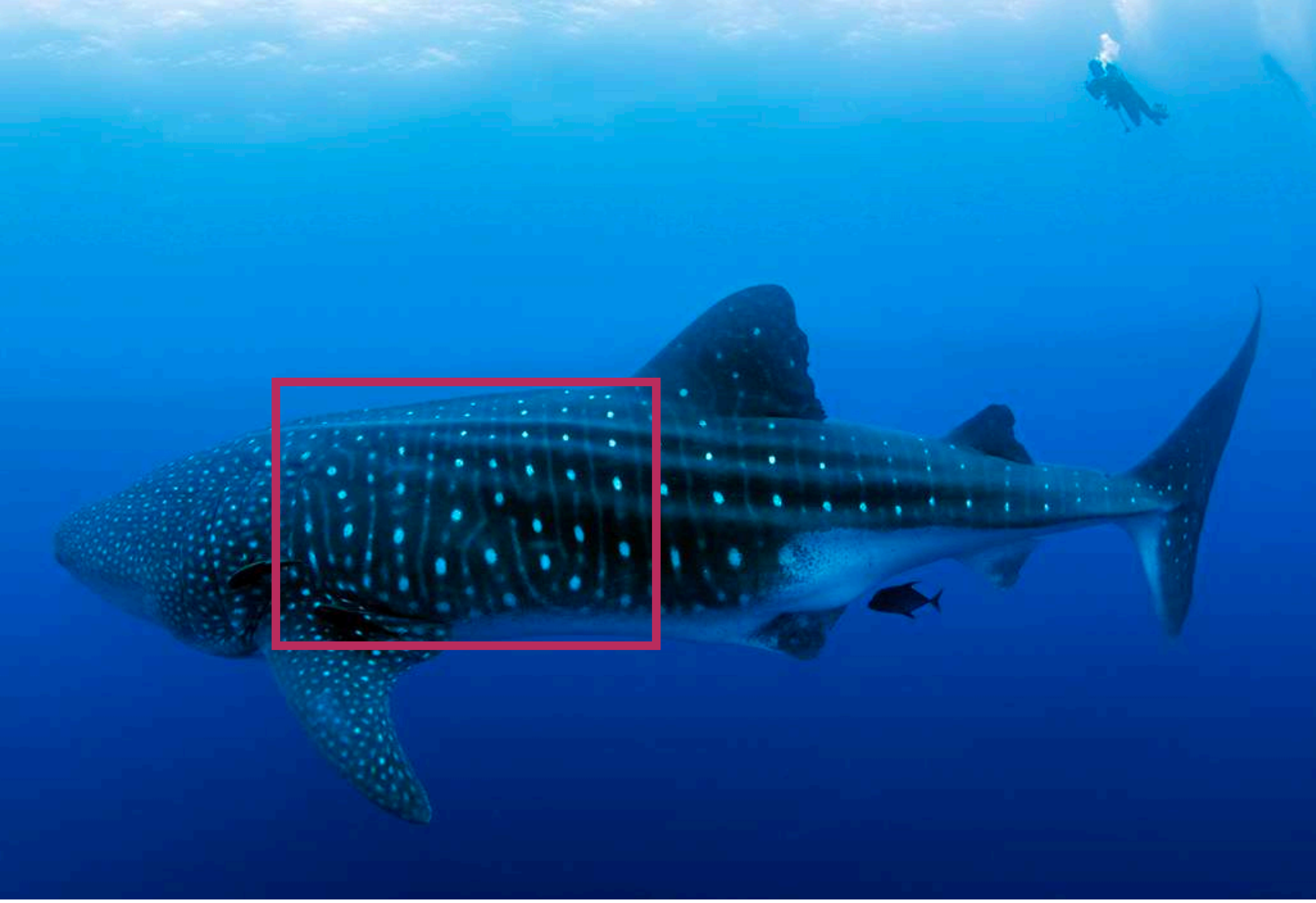


Figure 23: The area shown in red is used for mapping the unique spot patterns for identification. Photo ©Jonathan R. Green 2018

PHOTO IDENTIFICATION

A total of 35 individual whale sharks were photographed and the data submitted to the Wildbook for Whale Sharks, https://www.whaleshark.org/ global database, for identification. (See Appendix 1).

As with all previous fieldwork we try to obtain both left and right flank images from the fifth gill slit to the anterior base of the dorsal fin, with priority on the left side. (See Figure 23). The purpose of photo identification is to study site fidelity, how long they stay in the area of Darwin Arch and the frequency with which they return to this area. Also any previous or future sightings on a global level help provide data about the sharks' movements over a period of time. This data may be used to infer behaviour and identify areas of specific need such as feeding, breeding and birthing.

Figure 24: A massive mature female whale shark swims by Darwin Arch
Photo ©Sofia M. Green 2018

Figure 25: Two whale sharks glide by each other Photo: ©Jonathan R. Green 2018

RESULTS

This year we managed to carry out a number of activities with concrete results that are a first in whale shark science and investigation, in the world. The ultrasound images of the ovaries containing follicles and the blood chemical hormonal analysis give insight into the reproductive status of whale sharks. Although we have not been able to determine yet the presence, or absence of embryos, we now know that the large female whale sharks visiting the Galapagos waters are indeed sexually mature and are soon to copulate or may have recently copulated, according to Dr Rui Matsumoto. The blood samples and diagnostic analysis is still pending as Dr Ryo Nozu will follow up after his most recent trip. In situ we were able to see that the partial pressure of both O2 and CO2 indicated the whale sharks from which blood was drawn are healthy whilst lactic acid indicated very low levels of stress when compared to aquarium data, (low stress) and data from individuals that have been caught in nets during fishing operations, (high stress) by commercial fishermen in Japan. Given that one of these samples was from a female that had been previously double satellite tagged and had an ultrasound examination carried out on her this helps confirm that the scientific intervention causes little or no reaction and is not a direct cause of stress.

This year we increased the release depth for the miniPAT tags to 1700m from 1400m and the pop off time to six months from four that they were set for last season. We hope that that might extend time and depth dive profile data for the seven miniPATs deployed this season. Below are the dive profiles obtained from last season:

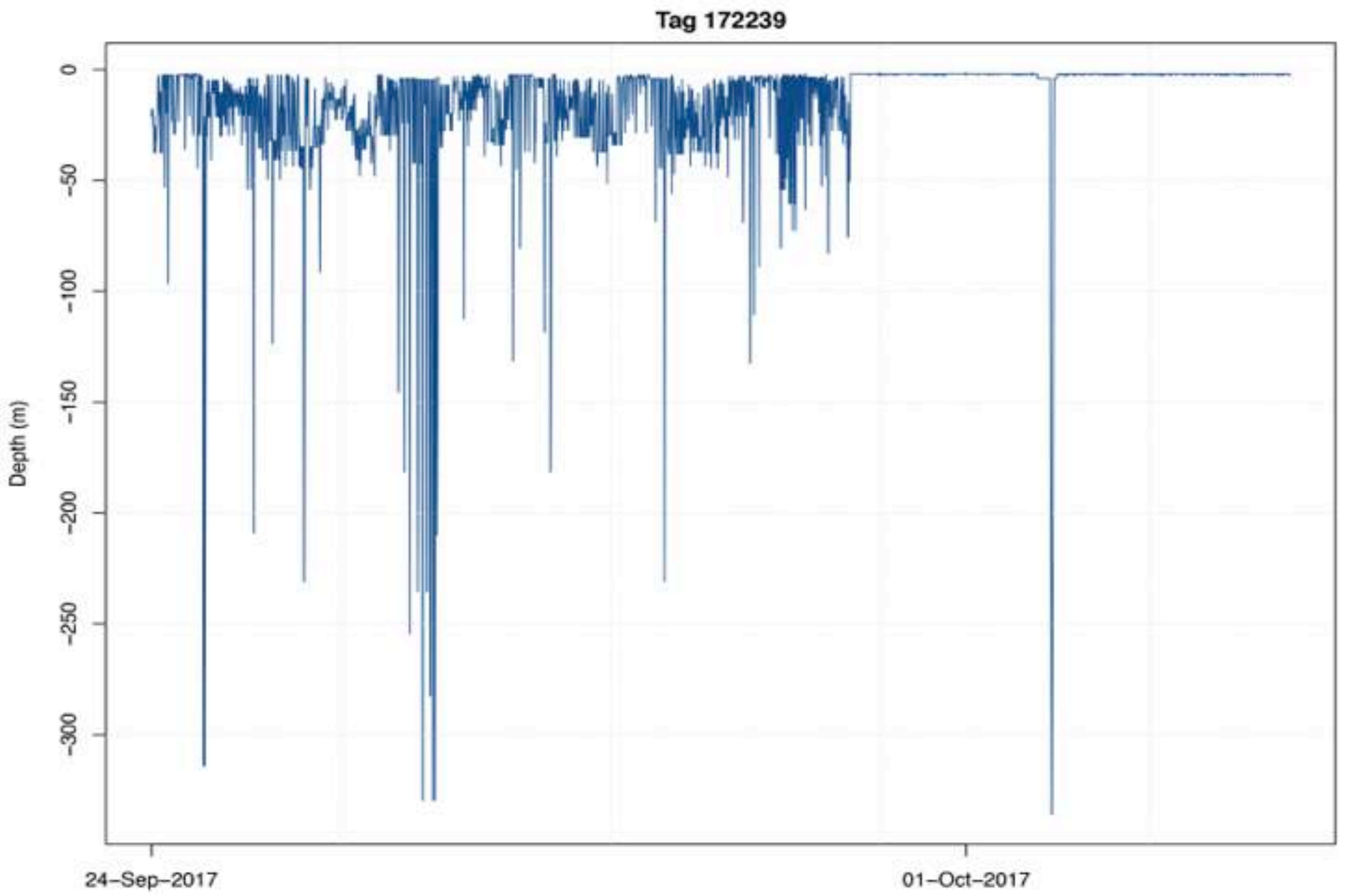


Figure 26: miniPAT #172239 dive profile ©Marine Megafauna Foundation

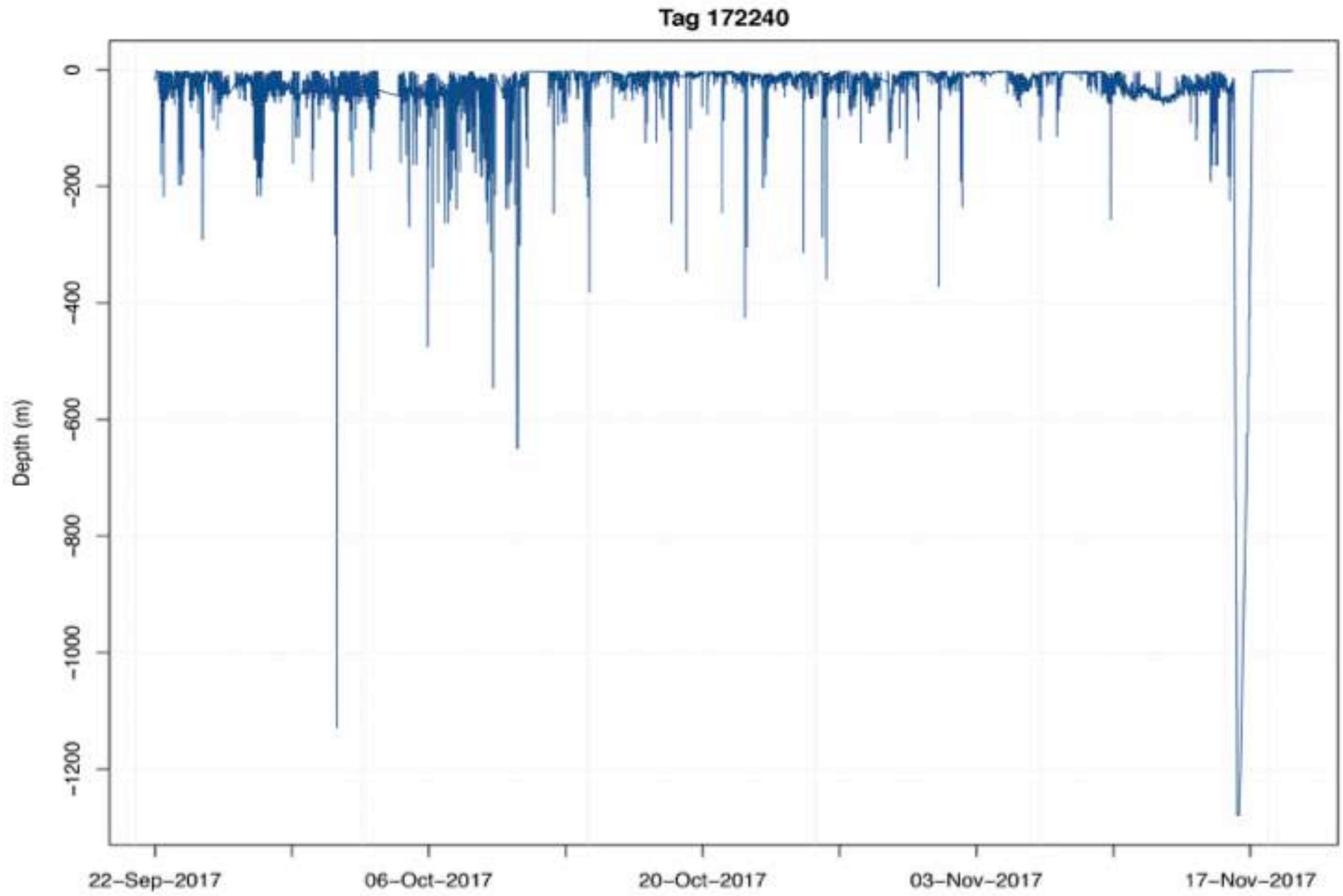


Figure 27: miniPAT #172240 dive profile ©Marine Megafauna Foundation

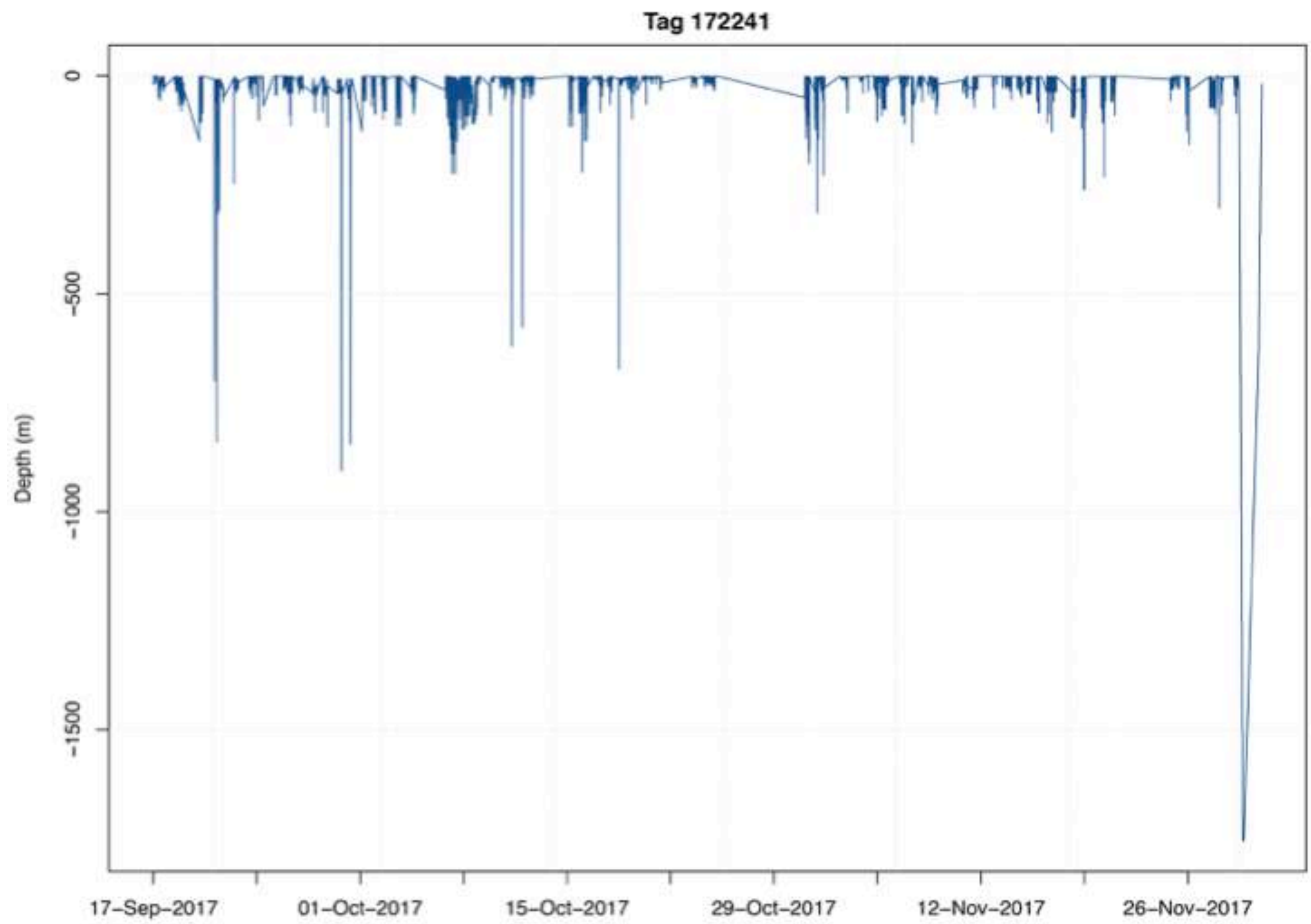


Figure 28: miniPAT #172241 dive profile ©Marine Megafauna Foundation

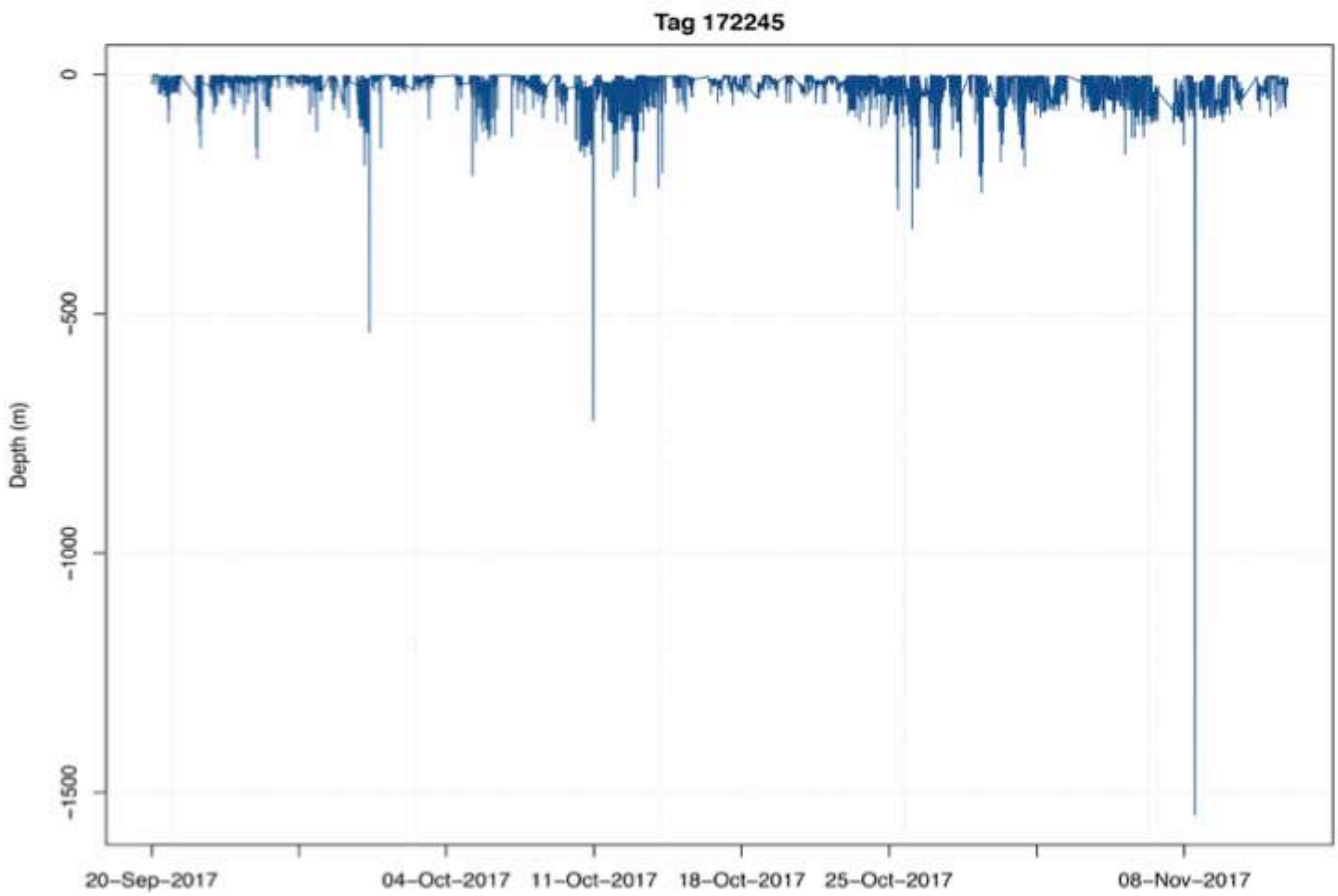


Figure 29: miniPAT #172245 dive profile ©Marine Megafauna Foundation

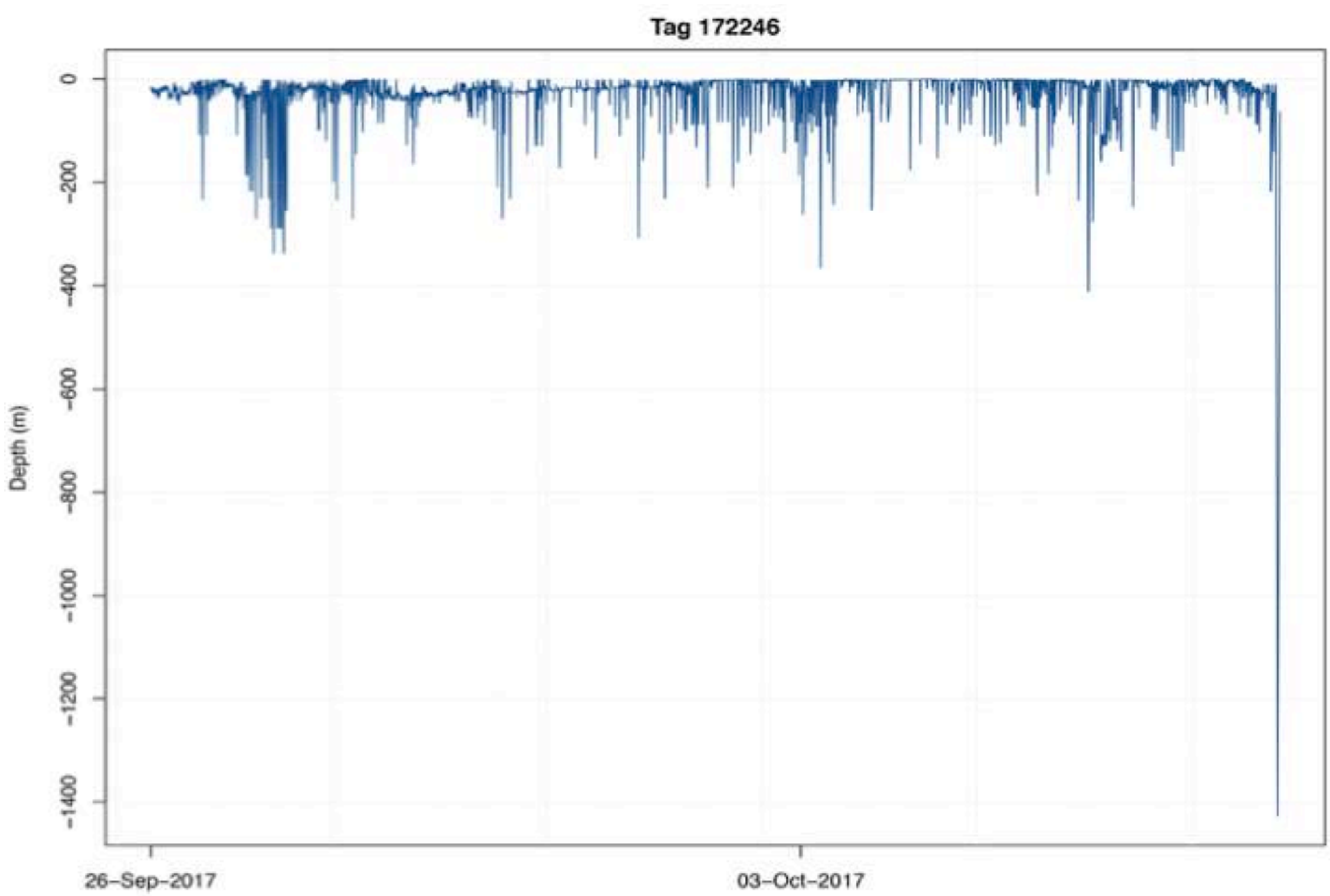


Figure 30: miniPAT #172246 dive profile ©Marine Megafauna Foundation

Graph of All Tags

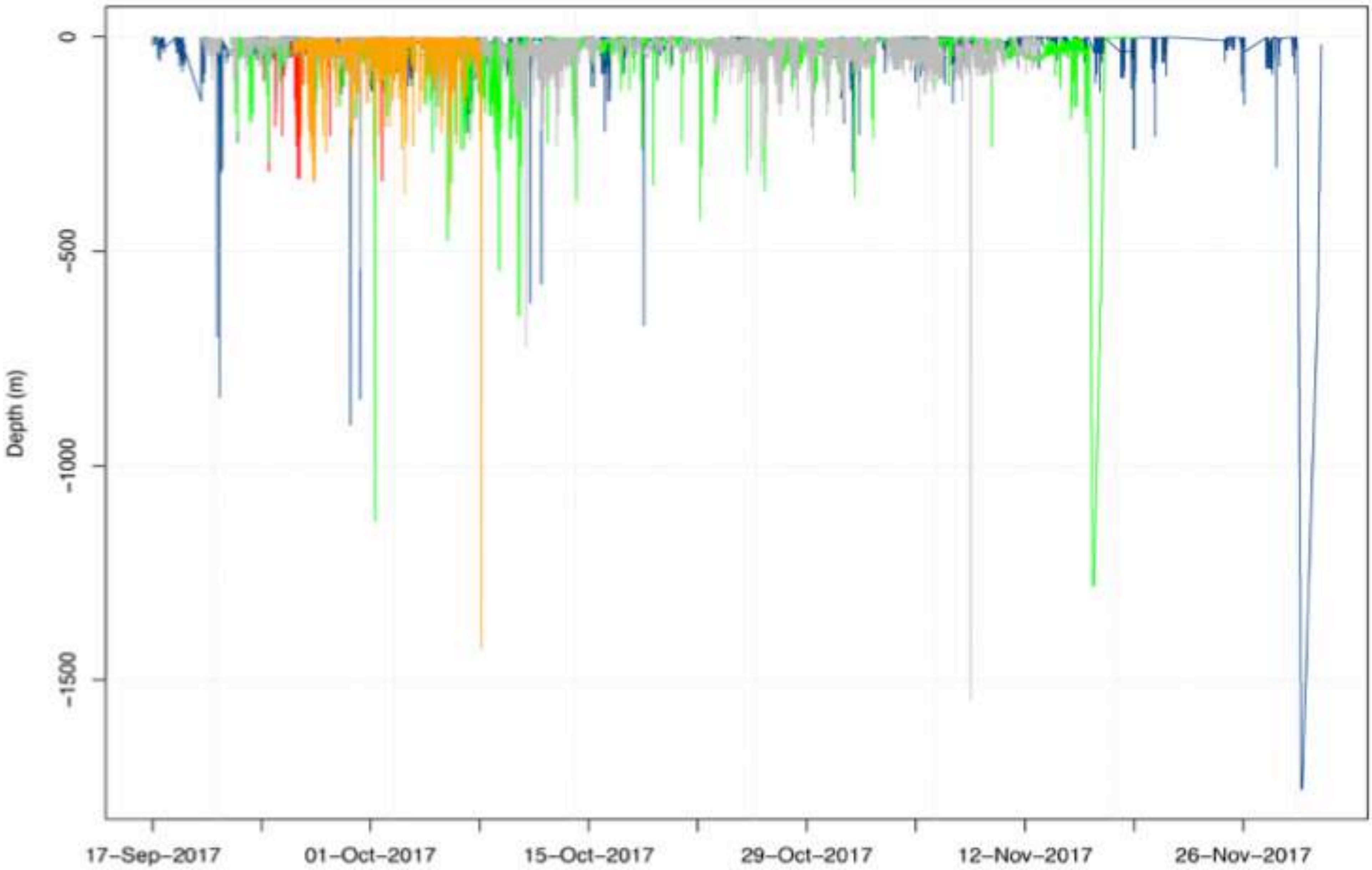


Figure 31: miniPAT dive profiles all tags ©Marine Megafauna Foundation

All of the miniPATs deployed last season released prior to their programmed release date with the longest deployment being just over 10 weeks for #172241 but the shortest less than one week, #172239 as a result of deep dives triggering release. (The exception being #172239, which released at a depth of approximately 340m for unknown reasons). The deepest dive of these sharks was #172241, which recorded a depth of approximately 1800m at which depth the tag released. The shark may have dived deeper but we have no record past this depth. The crush depth of these tags is estimated at 1850m. This dive is almost equal to the deepest dive on record of any whale shark, which was to 1928m in 2015 that of a juvenile male. (Tyminski et al. 2015)

Figure 32: Whale shark swims by out in the blue
Photo: ©Jonathan R. Green 2018

Their dive profiles show that they spend most of their time in the upper reaches of the water column with periodic deeper dives to depths of 500m or deeper. These would appear to display a regularity but the reasons for this are currently not known

One miniPAT from this season has already released due to a deep dive. #172237 released at 1688m just 35nm west of Darwin, three weeks after her tagging date on the 15th September. She was double tagged with fin mounted SPOT6 #175950 which last gave data just prior to this deep dive.

All five of the prototype fin mounted SPOT6 tags have reported positions since they were deployed. A 100% report rate is a huge improvement on previous years that have averaged 50%. We currently have positional data from all five in the last 10 days. See Figures 33 & 34).

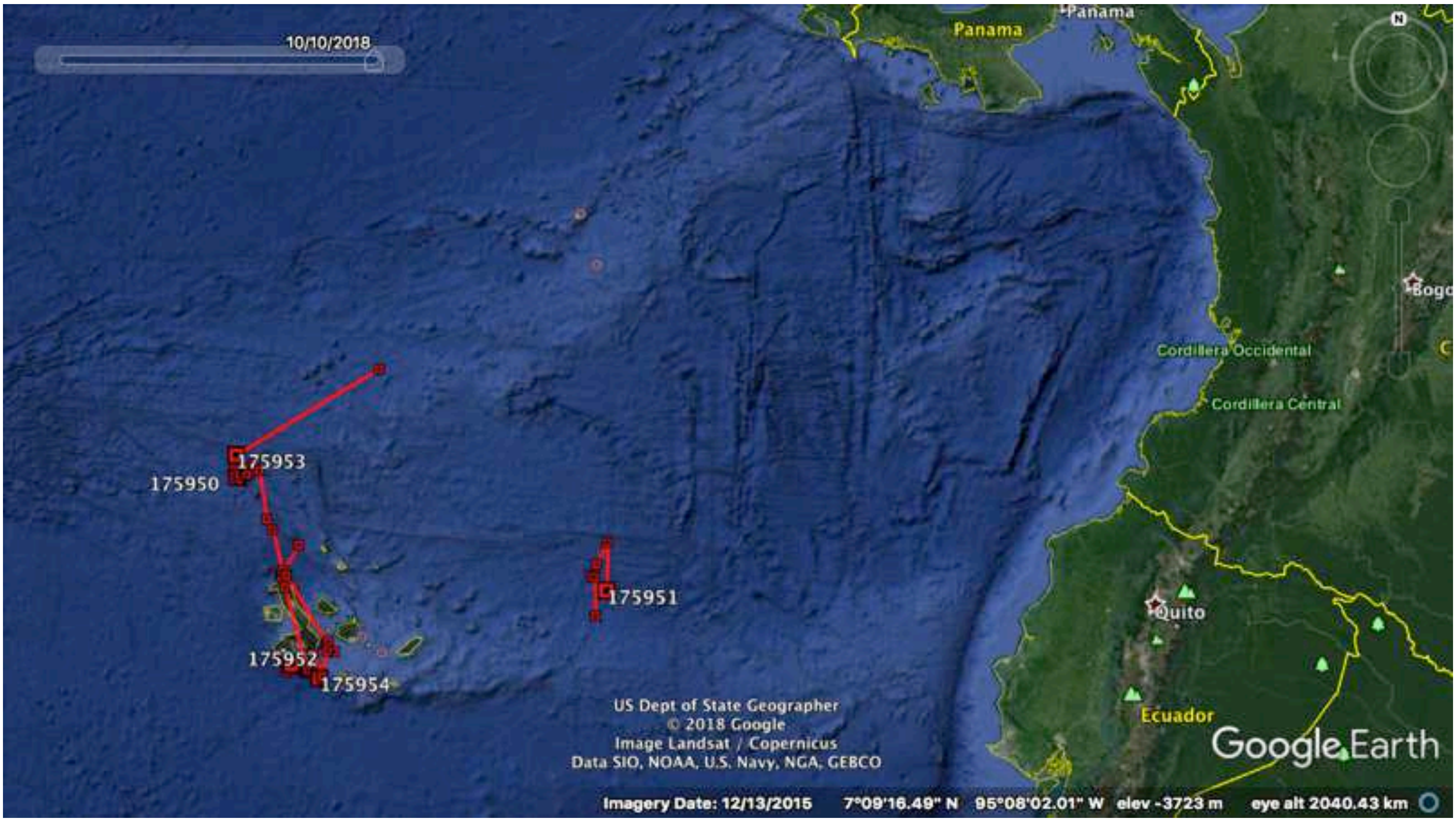
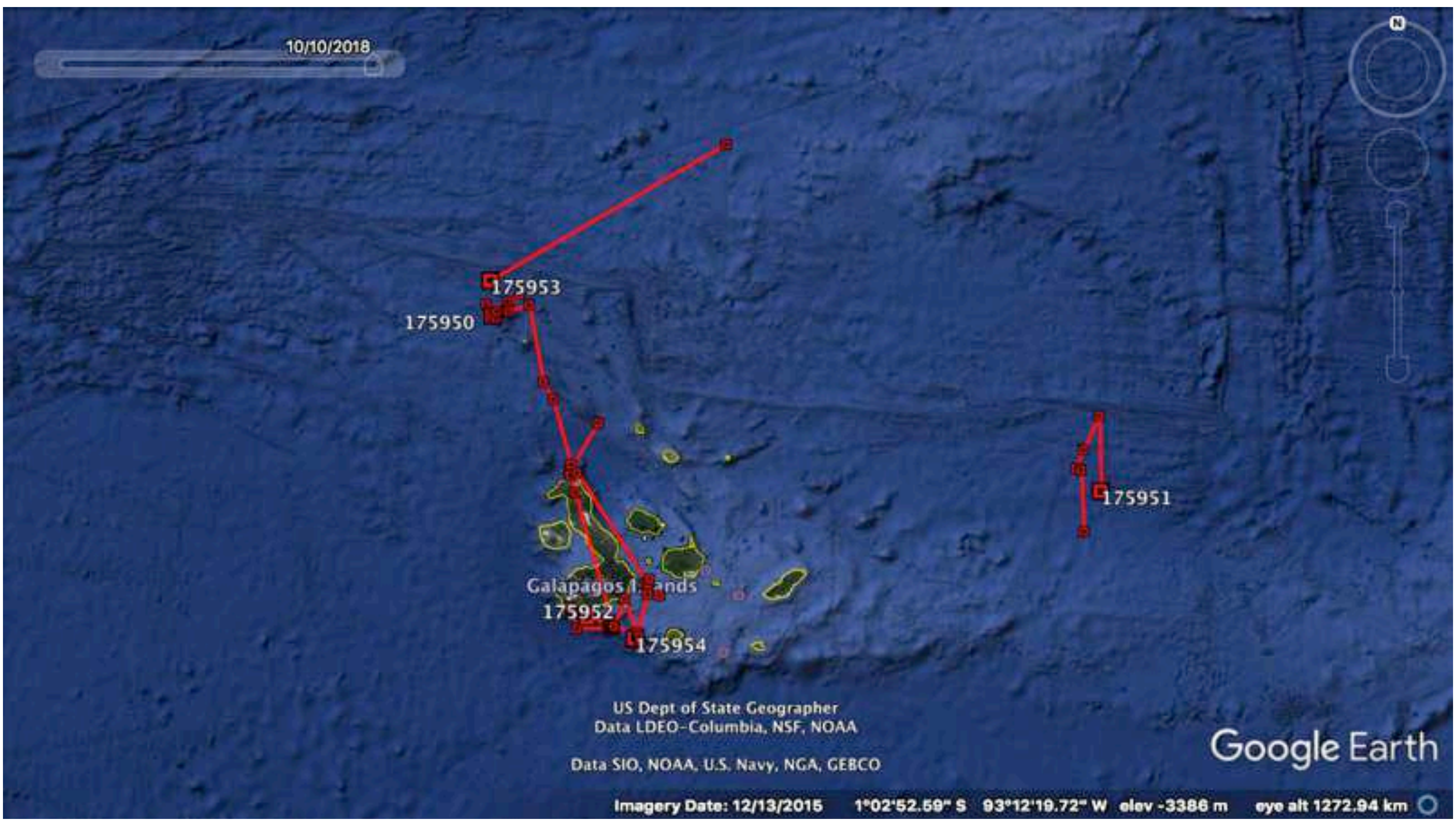


Figure 33 (above): showing the data from all five fin mounted SPOT6 tags for the previous ten days on a regional scale.

Figure 34 (below): showing the data from all five fin mounted SPOT6 tags for the previous ten days on a more local scale.



Currently:

#175950 is submerged having surfaced less than 5nm from Darwin Arch two weeks after being tagged. She dived to a depth of 1688m at which point the miniPAT #172237 released due to depth programming. Last position transmission 16:20 GMT 2nd October, (see Figure 35 below).

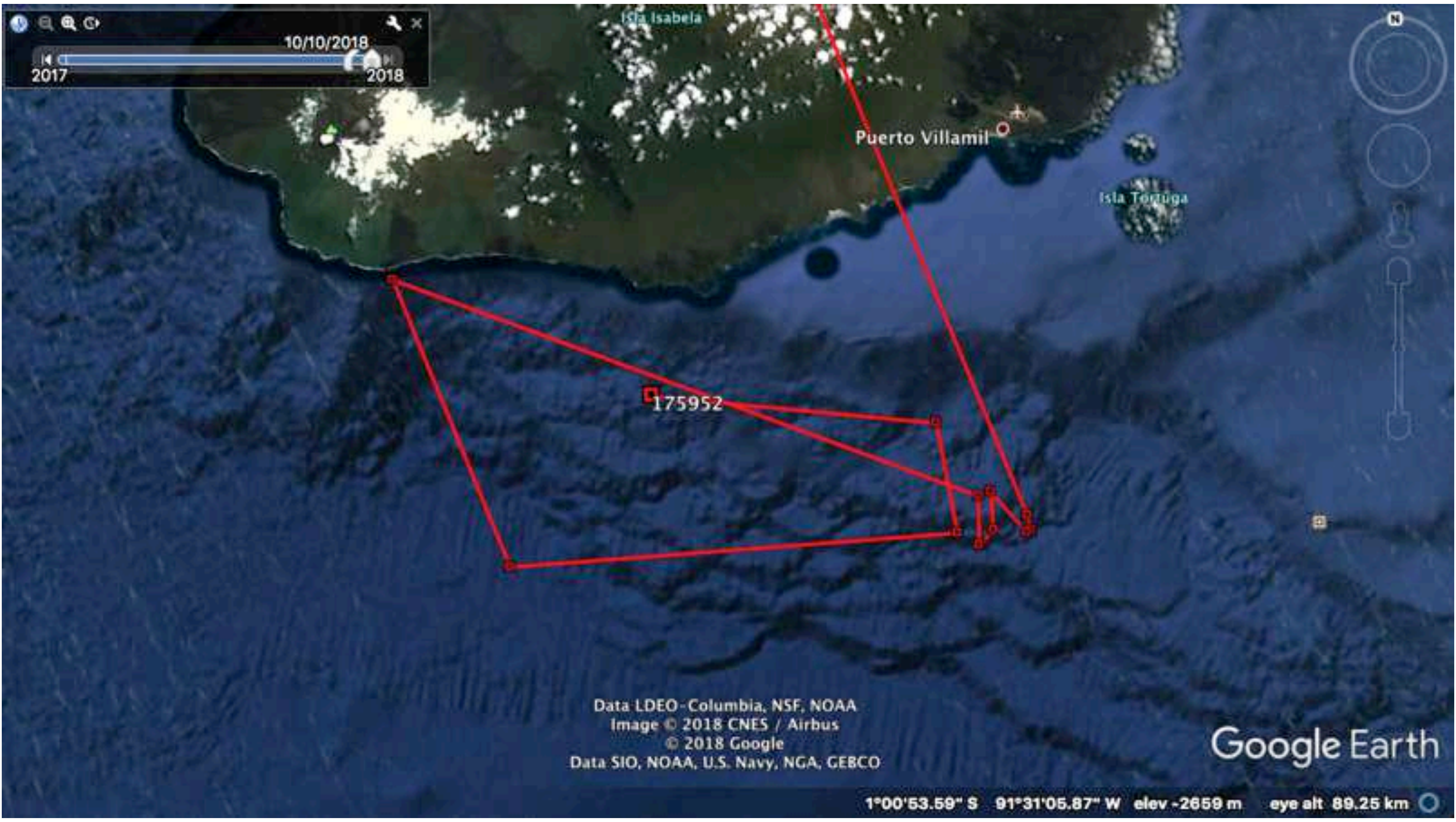
Figure 35: Google Earth map showing the movements of SPOT6 #175950

Figure 36: Google Earth map showing the movements of SPOT6 #175951

#175951 surfaced initially to the east of the Galapagos, travelled north to the very rugged fissure and fracture zone of the Galapagos Rift System, then turned south along a major fault line. Last position transmission 23:55 GMT on the 10th October, (see Figure 36 above).

#175952 Surfaced 30nm to the NE of the northeast point of Isabela Island. She then swam south to the shelf break off the Galapagos Platform and has since been swimming in a zigzag pattern along the shelf between southern Isabela and Floreana Islands. Last position transmission at 15:14 GMT on the 10th October, (see Figure 37).

Figure 37: Google Earth map showing the movements of SPOT6 #175952



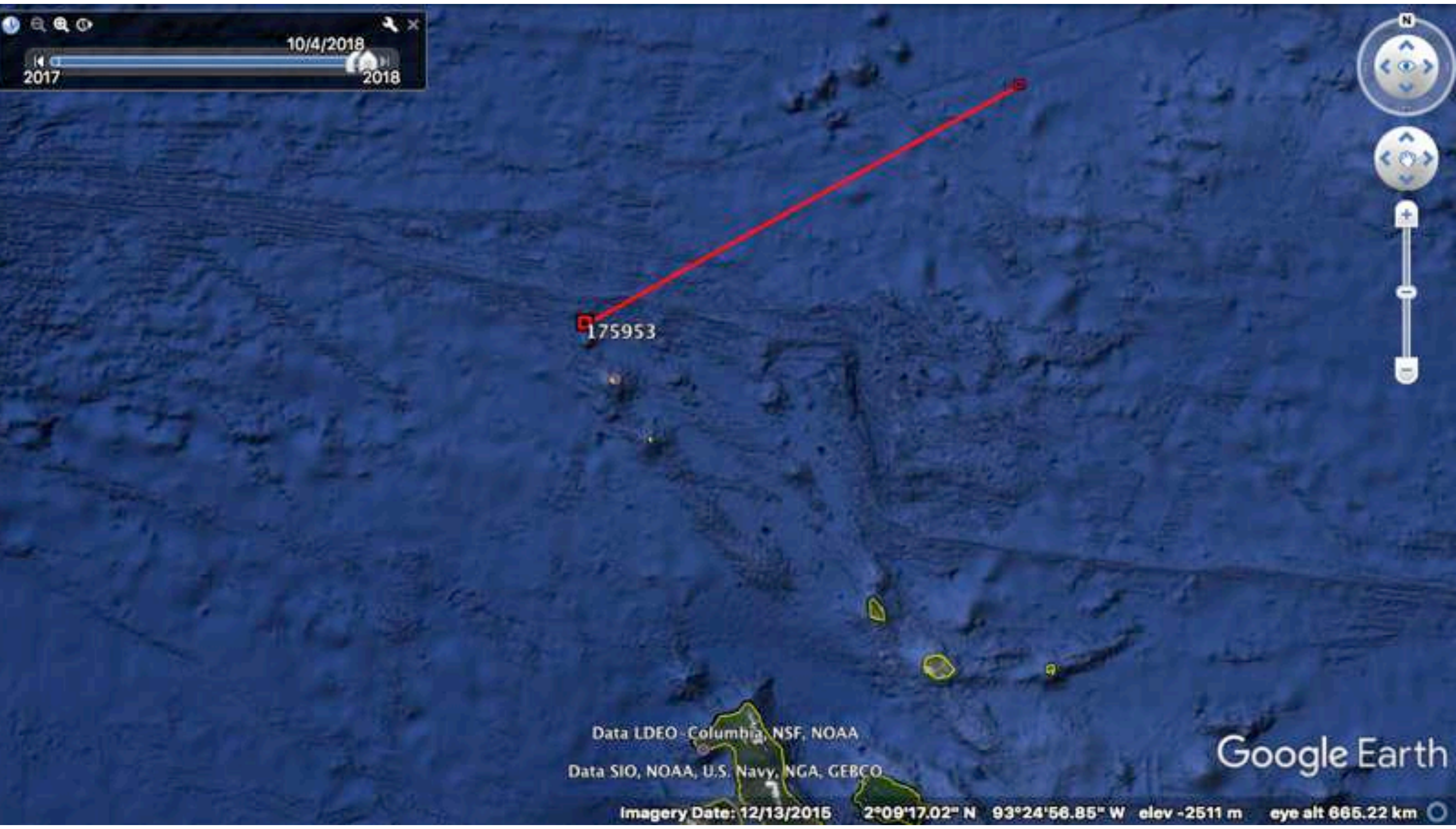


Figure 38: Google Earth map showing the movements of SPOT6 #175953

#175953 Surfaced 10 days after being tagged approximately 150nm east of Darwin. She then returned to a position 17nm due north of Darwin, where she dived on a seamount. Last position transmission 00:12 GMT on the 5th October, (see Figure 38 above).

#175954 Surfaced very close to Darwin Arch on the 20th October, two weeks after being tagged and then swam south to Isabela Island, down the east coast of Isabela to the shelf break of the Galapagos Platform and has since been swimming in a zigzag pattern along the shelf between southern Isabela and Floreana Islands. Last position transmission 15:02 GMT on the 11th October, (see Figure 39).

With increased retention, 100% and also with the increased battery life, up to 1500 days for the three 257 type SPOT6 tags we deployed this year we are hopeful of continuing data and updates will be provided via the website quarterly newsletter https://www.galapagoswhaleshark.org/.

Figure 39: Google Earth map showing the movements of SPOT6 #175954

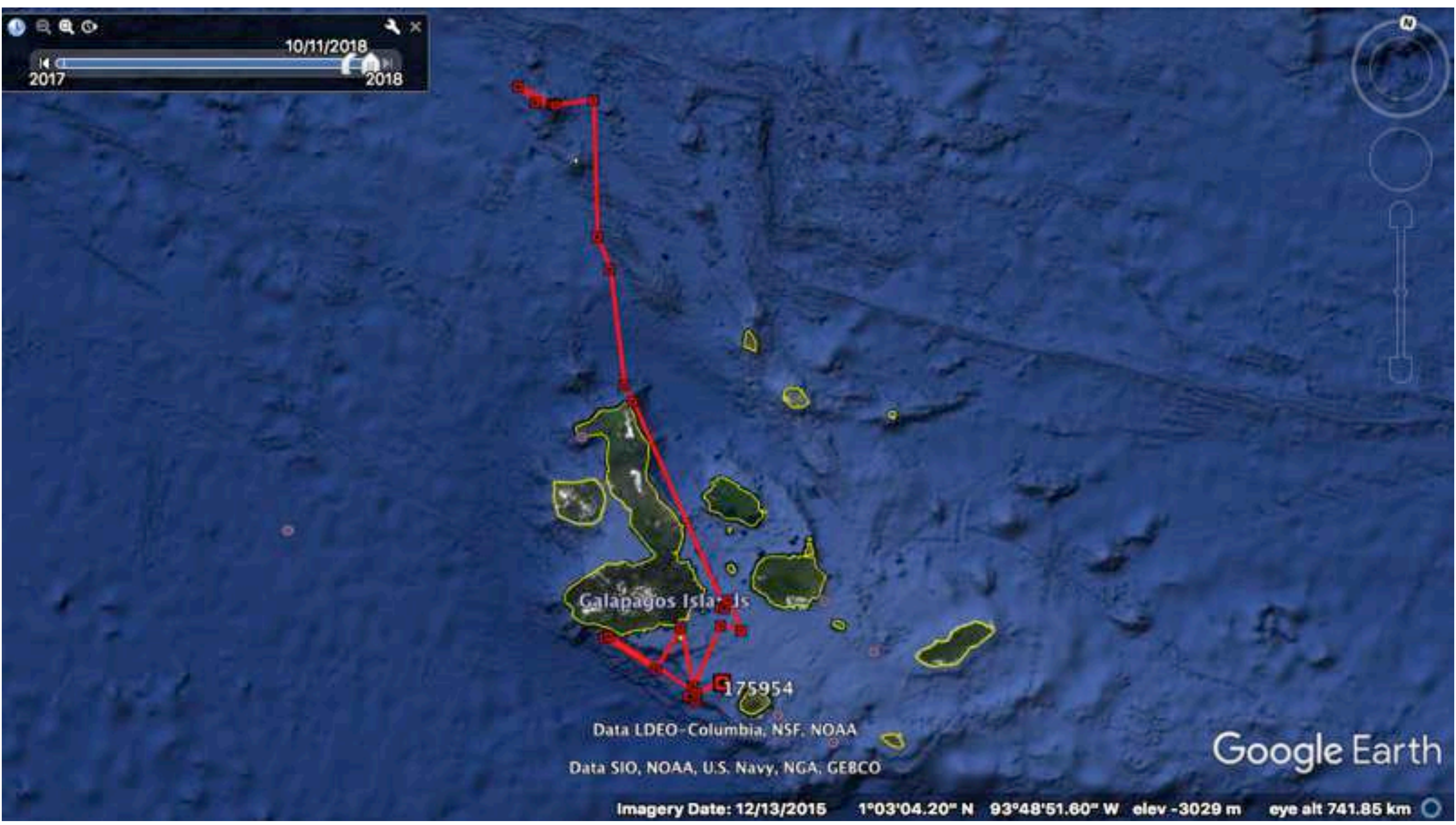


Figure 40: Diver with whale shark Photo: ©Jonathan R. Green 2018

CONCLUSIONS & FURTHER WORK

Despite not yet having the data necessary to determine whether any of the huge mature female whale sharks are indeed pregnant we have achieved a massive milestone in whale shark research.

Also very clear is that with each field season we have been able to improve on the techniques we are using and in the development of new ones. This particular field is only now beginning to become one of more general research and almost all the field equipment, techniques used for data gathering and analysis are being developed by the researchers in the field. That virtually all the scientists and technical teams involved in this research openly share and discuss developments, their finding and techniques used, is a credit to all and displays a common goal; the better understanding of this and other species in order to protect and conserve them and their habitat. There remains much still to do if we are to achieve this…

ACKNOWLEDGMENTS & THANKS

Photo: Darwin's Arch, Galapagos ©Jonathan R. Green 2018

Figure 41: Diver captures photo ID of a passing whale shark. Darwin Arch. Photo: ©Jonathan R. Green 2018

Over the years we have had incredible support from institutions and individuals. The Galapagos National Park Service have been stalwart allies since the beginning. George and Kimberly Rapier… without whom the Project would not have begun. Galapagos Conservation Trust and the Sackler Trust, who have kept the Project afloat! Planeterra through the G Expedition. Marine Megafauna Foundation, Galapagos Science Center, Georgia Aquarium, Okinawa Churashima Foundation, Fundacion Megafauna Marina del Ecuador, Doug and Debora Brown, Johannes and Xiaoyang Schoeter, Ben Pierson, Hannah Button and all those far too numerous to name who have helped make this Project such a success. Last but certainly not least a huge thank you to Eduardo "Vico" Rosero and the fair Queen Mabel, (our last trip together), who together have got us safely, not always in the easiest of seas, to Darwin and back.

Figure 42 (right): Captain „Viko" and the Queen Mabel. Photo: ©Jonathan R. Green 2018

BIBLIOGRAPHY

Acuña-Marrero D, Jiménez J, Smith F, Doherty PF Jr, Hearn A, et al. (2014) Whale Shark (Rhincodon typus) Seasonal Presence, Residence Time and Habitat Use at Darwin Island, Galapagos Marine Reserve. PLoS ONE 9(12): e115946. doi:10.1371/journal.pone.0115946

Hearn AR, Acuña D, Ketchum JT, Peñaherrera C, Green J, Marshall A, Guerrero M, Shillinger G (2014) Elasmobranchs of the Galapagos Marine Reserve. In: Denkinger J, Vinueza L (eds)

The Galapagos Marine Reserve: social and ecological interactions in the Galapagos Islands. Springer, New York, pp 23–59

Joung SJ, Chen C-T, Clark E, Uchida S, Huang WYP (1996) The whale shark, Rhincodon typus, is a live-bearer: 300 embryos found in one 'megamamma'supreme. Environ Biol Fish 46:219–223

Martin, R. A. (2007). A review of behavioural ecology of whale sharks (Rhincodon typus). Fisheries Research, 84(1), 10–16. doi:10.1016/j.fishres.2006.11.010

Ryan JP, Green JR, Espinoza E, Hearn AR (2017) Association of whale sharks (Rhincodon typus) with thermo-biological frontal systems of the eastern tropical Pacific. PLoS ONE 12(8): e0182599. https://doi.org/10.1371/journal. pone.0182599

Schmidt J, Chien-Chi C, Sheikh S, Meekan M, Norman B, Joung SJ (2010) Paternity analysis in a litter of whale shark embryos. Endanger Species Res 12(2): 117–124.

Tyminski JP, de la Parra-Venegas R, González Cano J, Hueter RE (2015) Vertical Movements and Patterns in Diving Behavior of Whale Sharks as Revealed by Pop-Up Satellite Tags in the Eastern Gulf of Mexico. PLoS ONE 10(11): e0142156. doi:10.1371/journal.pone.0142156

APPENDIX

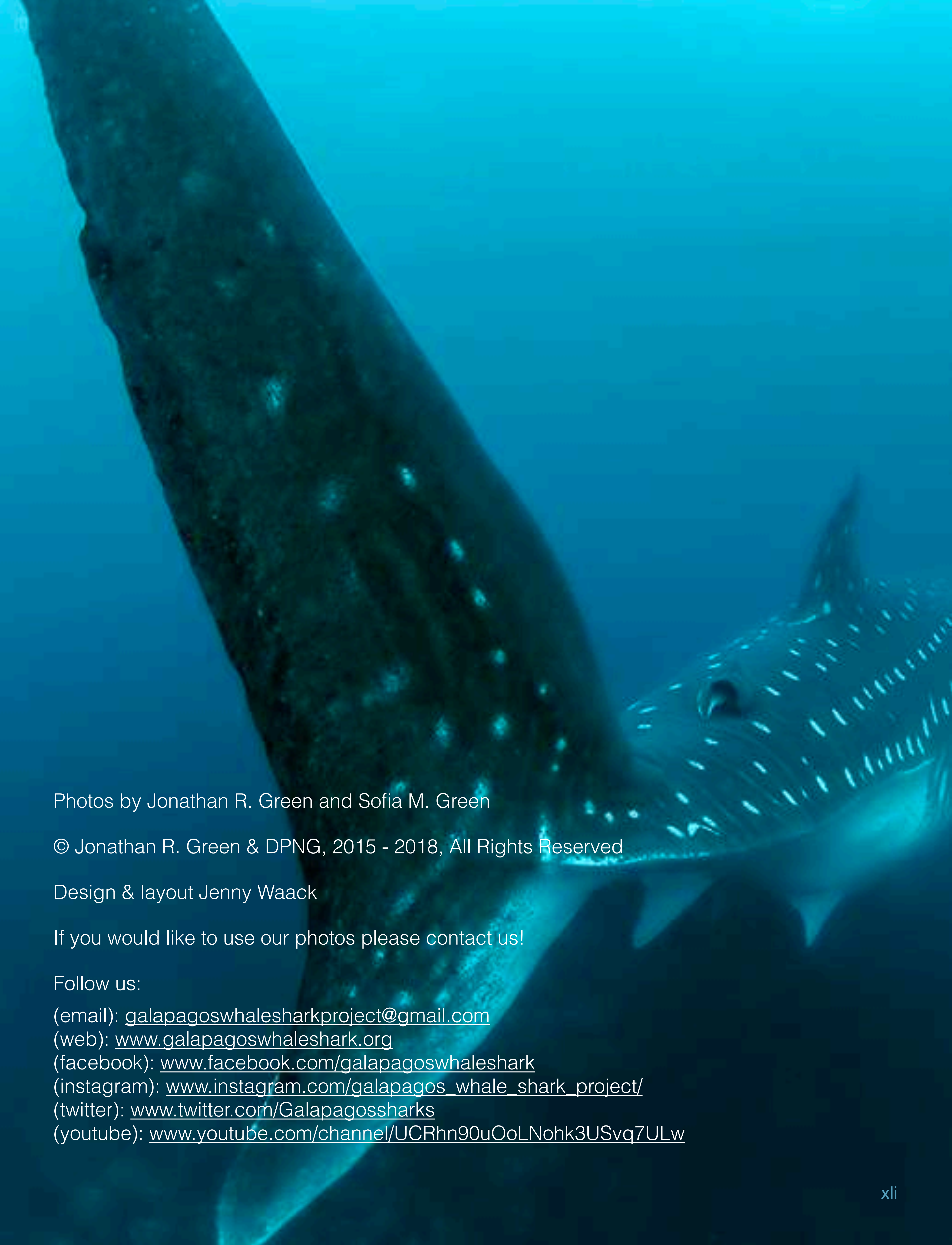
Photo: Whale Shark dwarfs the Hammerhead sharks at Darwin's Arch ©Jonathan R. Green 2018

# *Rhinodon typus*	SPOT #	miniPAT #	Date # Dive of the day	Photo ID	Blood Samples	Ultra-sound*	Biopsy	Total Length	Observations
1	175950	172237	14/9/2018 No. 1	GD 140918-1	0	1	0	12.0m - 14.0m(est.)	Doble Tagging: SPOT (finmount) & MiniPAT
			14/9/2018 No. 2	GD 140918-2	1	1	0	12.0m-14.0m (est)	Left pectoral fin missing the tip.
2	175952		15/9/2018 No. 1	GD 150918-1	0	1	0	12m (est)	Scar on left side ID. Bit missing on top caudal fin.
3		172238	15/9/2018 No. 2	GD 150918-2	0	1	0	11m (est)	Jagged tail and some scars on left side.
4		172242	15/9/2018 No. 3	GD 150918-3	0	1	0	11m (est)	
5		172172	16/9/2018 No. 1	GD 160918 1	0	0	1	10m (est)	Old fishing injury in front of dorsal fin (maybe an old rope). Healed over.
6	175954		16/9/2018 No. 1 18/9/2018 No. 1	GD 160918-2	0 0	1 1	0 0	12m (est)	Resighted after two days (16th & 18th of Sept)
7	175951	172244	17/9/2018 No. 1	GD 170918-1	0	1	0	11m (est)	Doble Tagging: SPOT (finmount) & MiniPAT
			17/9/2018 No. 2	GD 170918 -1	0	0	0	11m (est)	Seen again in dive 2
8	175953	172243	17/9/2018 No. 2	GD 170918-2	0	0	0	11m (est)	Doble Tagging: SPOT (finmount) & MiniPAT. Jagged caudal tail.
9			17/9/2018 No. 2	GD 170918-3	0	0	0	12m (est)	Only ID. Seen during safety stop.
10		172173	17/9/2018 No. 3	GD 170918-4	1	0	0	11m (est)	Dolphins swimming in front. Jagged dorsal fin.
11			17/9/2018 No. 3	GD 170918-5	1	1	0	11m (est)	Scar on left side abdomen.
12 (Mystery WS)			18/9/2018 No. 1	N/A	0	0	0	10m (est)	Far away sighting of R typus.

# *Rhinodon typus*	SPOT #	miniPAT #	Date # Dive of the day	Photo ID	Blood Samples	Ultra-sound*	Biopsy	Total Length	Observations
13			18/9/2018 No. 1	GD 180918-2	0	0	0	5m	Juvenile R typus, female.
14			18/9/2018 No. 2	GD 180918-3	1	1	0	11m (est)	
15			19/9/2018 No. 1	GD 190918-1	0	0	1	12m (est)	Double sighting during same dive. Sighted second time at the same time as R typus 16.
16			19/9/2018 No. 1	GD 190918-2	0	0	1	8m (est)	Sighted at the same time as R typus 15
17			19/9/2018 No. 2	GD 190918-3	0	1	0	No estimate	Sighted at the same time as R typus 18
18			19/9/2018 No. 2	GD 190918-4	0	0	0	No estimate	Sighted at the same time as R typus 17
19			20/9/2018 No. 1	GD 200918-1	1	1	1	10-11m (est)	Ovaries found on ultrasound. Empty? Concave
20			20/9/2018 No. 1	GD 200918-2	0	0	0	4m (est)	Juvenile R typus, gender uknown.
21			20/9/2018 No. 2	GD 200918-3	0	1	1	12m (est)	Ovaries found on ultrasound. Empty? Concave
22			22/9/2018 No. 1	GD 220918-1	0	0	0	12m (est)	Strong current. Hard to reach *R typus*
23			22/9/2018 No. 2	GD 220918-2	0	0	0	No estimate	Strong current. Hard to reach *R typus*
			22/9/2018 No.3		0	0	0		Strong current. Hard to reach *R typus*
			23/9/2018 No. 1		0	0	0		R typus at 40 m. Seen at a distance and ID as same WS as day before.
			23/9/2018 No. 3		0	0	1		Sighted again and biopsied.
			24/9/2018 No. 1		0	1	0		Seen for 3 days straight
			24/9/2018 No. 3		0	0	0		Seen at safety stop

# *Rhinodon typus*	SPOT #	miniPAT #	Date # Dive of the day	Photo ID	Blood Samples	Ultra-sound*	Biopsy	Total Length	Observations
24			23/9/2018 No. 2	GD 230918-1	0	0	0	No estimate	Seen at safety stop
25			24/9/2018 No. 1	GD 240918-1	0	0	0	No estimate	Seen at 33m depth.
26			24/9/2018 No. 2	GD 240918-2	1	1	1	No estimate	R typus stayed with divers for ~10min. 3 ultrasounds of same individual.
27			24/9/2018 No. 2	GD 240918-3	0	0	0	No estimate	Seen at the end of the dive
28			24/9/2018 No. 2 25/9/2018 No 3	GD 240918-4	0 0	0 1	0 0	No estimate No estimate	Seen at the end of the dive Spotted again during last day
29			24/9/2018 No. 3	GD 240918-5	0	1	0	No estimate	Tail slap caught diver
30			25/9/2018 No. 1	GD 250918-1	0	1	0	5m (est)	Juvenile R typus, male.
31			25/9/2018 No. 2	GD 250918-2	0	0	0	No estimate	
32			25/9/2018 No. 2	GD 250918-3	0	1	0	No estimate	
33			25/9/2018 No. 2	GD 250918-4	0	1	0	No estimate	
34			25/9/2018 No. 2 25/9/2018 No. 3	GD 250918-5	0 0	0 0	0 0	12m-13m (est)	Last R typus seen
35			25/9/2018 No. 2	GD 250918-6	0	0	0	4.5m (est)	Juvenile R typus, gender uknown.
36			25/9/2018 No. 3	GD 250918-7	0	1	0	No estimate	Several ultrasounds done on the same individual.
Total	5	7		35	6	21	7		

* Number of utrasounds corresponds to whether an ultrasound was done on *R typus* during the dive. Not the individual number of swipes.



Photos by Jonathan R. Green and Sofia M. Green

Design & layout Jenny Waack

If you would like to use our photos please contact us!

Follow us:

(email): galapagoswhalesharkproject@gmail.com
(web): www.galapagoswhaleshark.org
(facebook): www.facebook.com/galapagoswhaleshark
(instagram): www.instagram.com/galapagos_whale_shark_project/
(twitter): www.twitter.com/Galapagossharks
(youtube): www.youtube.com/channel/UCRhn90uOoLNohk3USvq7ULw