



## **Puna Aerial Reconnaissance Survey - Final Report**

Prepared by Kallie Barnes / Hawai'i Wildlife Fund

5 January 2019

### **INTRODUCTION**

On May 3rd, 2018 the Kīlauea Volcano erupted in the Lower Puna district of Hawai'i and on the night of June 3rd lava began entering the ocean at Kapoho Bay<sup>1</sup>, an area known for its snorkeling and resident turtles.

Lava ocean entries occur "when magma interacts with water, the results [of which] can be explosive and violent, at other times gentle and benign. ...Basaltic lava usually flows into the sea in a passive manner, with the interaction confined to the boiling of seawater. Occasionally, larger lava ocean entries are associated with explosive activity as seawater invades confined lava tubes."<sup>2</sup>

During the nearly four month (May 4th - August 31st) course of the lava flow from Fissure 8 and the three months (May 28th - August 29th) of active lava ocean entry, it was brought to Hawai'i Wildlife Fund's (HWF) attention that reports were being made of large numbers of stranded and trapped sea turtles<sup>3</sup> (see **Appendix 1: Social Media Posts**).

Surveys completed by state (see Department of Land and Natural Resources (DLNR) news releases<sup>4</sup>) and federal agencies claimed they saw no turtles in distress. However, some community members continued to report and share otherwise on social media platforms. Due to these conflicting reports, HWF saw the need for a third party to conduct additional surveys and report back to government agencies, Puna community members, and our social media platforms with evidence-based communication about the ongoing situation, and assist with

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<sup>1</sup> <https://www.usgs.gov/news/k-lauea-volcano-erupts>

<sup>2</sup> <https://core.ac.uk/download/pdf/29417285.pdf>

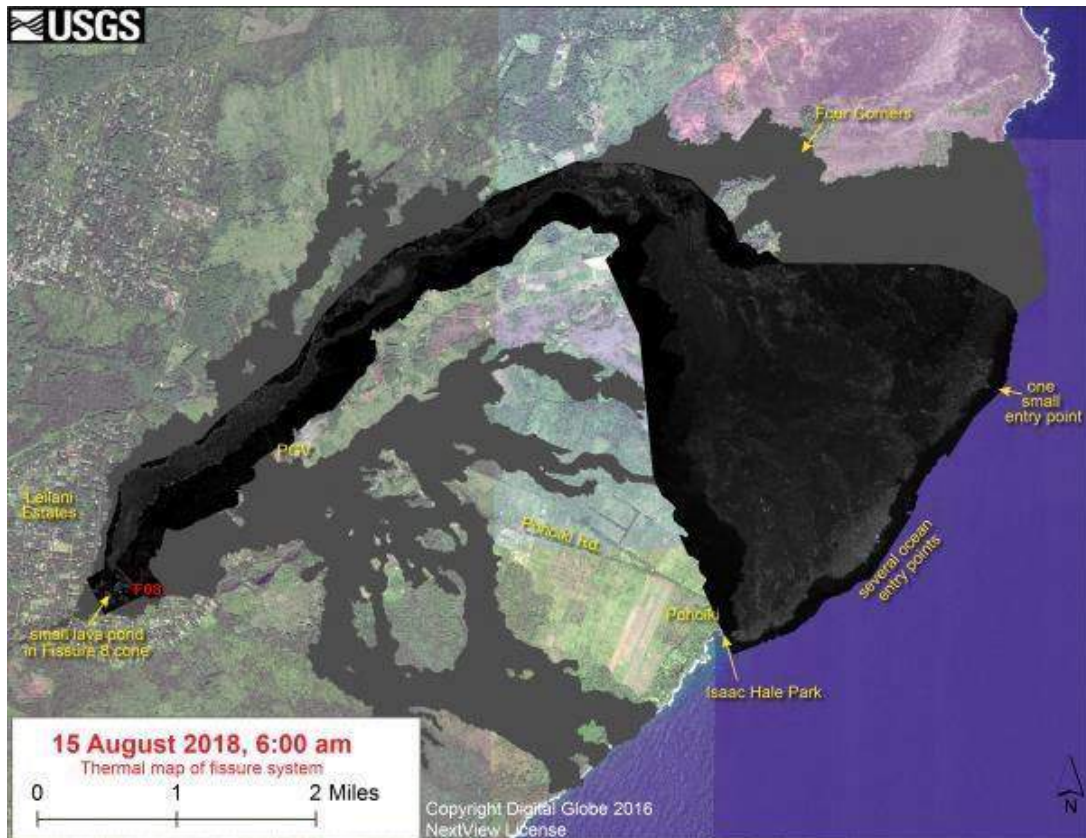
<sup>3</sup> [https://volcanoes.usgs.gov/vsc/file\\_mgr/file-179/Chronology%20of%20events%202018.pdf](https://volcanoes.usgs.gov/vsc/file_mgr/file-179/Chronology%20of%20events%202018.pdf)

<sup>4</sup> <https://dlnr.hawaii.gov/blog/2018/07/25/nr18-153-3/> and <https://dlnr.hawaii.gov/blog/2018/07/24/nr18-152/>

recovery efforts and planning, if needed. In August, HWF sought funding to perform aerial surveys, focusing on sea turtles and other marine life that have may been affected by the lava flow.

HWF was not able to secure access to the area until approximately six days after active lava-ocean entry subsided (see **USGS Thermal Map**).

### USGS Thermal Map



Latest USGS Thermal Map shows the fissure system and lava flows as of 6 am on Wednesday, August 15. The black and white area is the extent of the thermal map. Temperature in the thermal image is displayed as gray-scale values, with the brightest pixels indicating the hottest areas. <sup>5</sup>

### METHODS

The initial survey flight was completed by helicopter on the morning of September 4th, 2018 to record marine resource observations (especially sea turtles) both inside and outside of the previously active lava ocean entry areas along the Puna coastline. In order to minimize glare and increase weather visibility, the 40-minute aerial survey began early in the day (8:18 am). During the survey, weather and visibility were clear, the ocean surface calm, and there were no

<sup>5</sup> [https://volcanoes.usgs.gov/volcanoes/kilauea/multimedia\\_maps.html](https://volcanoes.usgs.gov/volcanoes/kilauea/multimedia_maps.html)

problems spotting turtles from the helicopter. However, surveyors noted increased water turbidity in lava ocean entry areas. National Oceanic and Atmospheric Administration (NOAA) tide predictions for Hilo, HI showed that the tide was rising at 8:18 am with a HIGH at 11:39 am. The high tide was predicted to be 2.47 ft, which is a relatively large high tide as compared to the average of the “higher high water height” for Hilo of 1.54 ft. The moon was a waning crescent and set at 1:26 pm.

The area survey began along the coastline near the Hawaiian Beaches subdivision and concluded along the coast near the Mackenzie State Recreation Area. Approximately 5.11 miles of coastline were directly affected by the lava flow. This estimate does not include the nearly one mile gap between the two flow fronts. However, while lava did not directly flow over this area, we are considering it an impacted area due to its location in between the two flow fronts. For the purposes of this study a total of approximately 6.07 miles of affected coastline were surveyed (see **Appendix 2: Impacted Coastline Measurements**).

Survey was conducted in a Hughes 500C helicopter at an average altitude of 409 ft and average speed of 39.9 miles per hour for Track 1 and 858 ft and 87.4 miles per hour for the Track 2 (see **Maps 1 and 2** below and **Appendix 3** for additional maps). Track 1 and Track 2 maps show the approximate track of the flight flown, approximate location of notable features, and each point of interest. We categorized areas as either inside “IN” or outside “OUT” of lava ocean entry affected areas. See **Table 1** for approximate miles flown both inside (IN) and outside (OUT) of lava ocean entry areas.

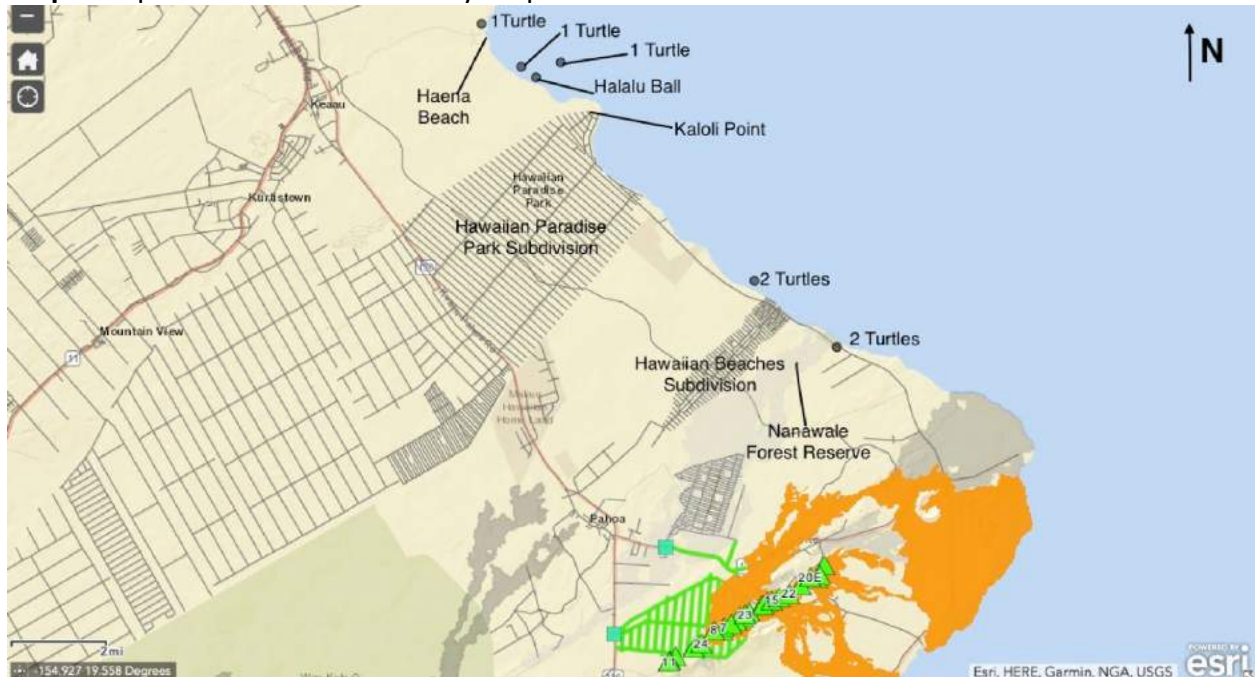
**Table 1.** Miles Flown\* inside and outside of lava impacted (lava ocean entry) coastline  
 \*Miles estimated using USGS GIS maps measurement tool and GPS Tracker iPhone application both within (“IN”) and outside (“OUT”) of the lava impact zone. This estimate does not include return trip miles from Track 1.

Miles Flown	With- <b>IN</b> Lava Ocean Entry	<b>OUT</b> -side Lava Ocean Entry
Track 1	6.07 mi	7.89 mi
Track 2	N/A	10.0 mi
Track 3	6.07 mi	18.53 mi
Track 4	6.07 mi	19.13 mi

**Map 1. September 4th Initial Survey Map “Track 1”**



**Map 2. September 4th Initial Survey Map “Track 2”**



Above maps were completed by Nikki Sanderlin / Maptastic using the data points taken during the September 4th flight with the GPS Tracker application. The orange area indicates lava impacted areas and green triangles show fissures. Each point represents a marine organism sighted and is labeled accordingly. See **Appendix 3** for maps generated by the GPS Tracker Application, which show flight path and pins for each marine resources sighted.

The follow-up survey flight was completed on the afternoon of November 16th, 2018. In order to capture potential differences in turtle behavior, this 40 minute aerial survey was completed during the afternoon (4:34 pm) near low tide and at a higher altitude in order to prevent turtles

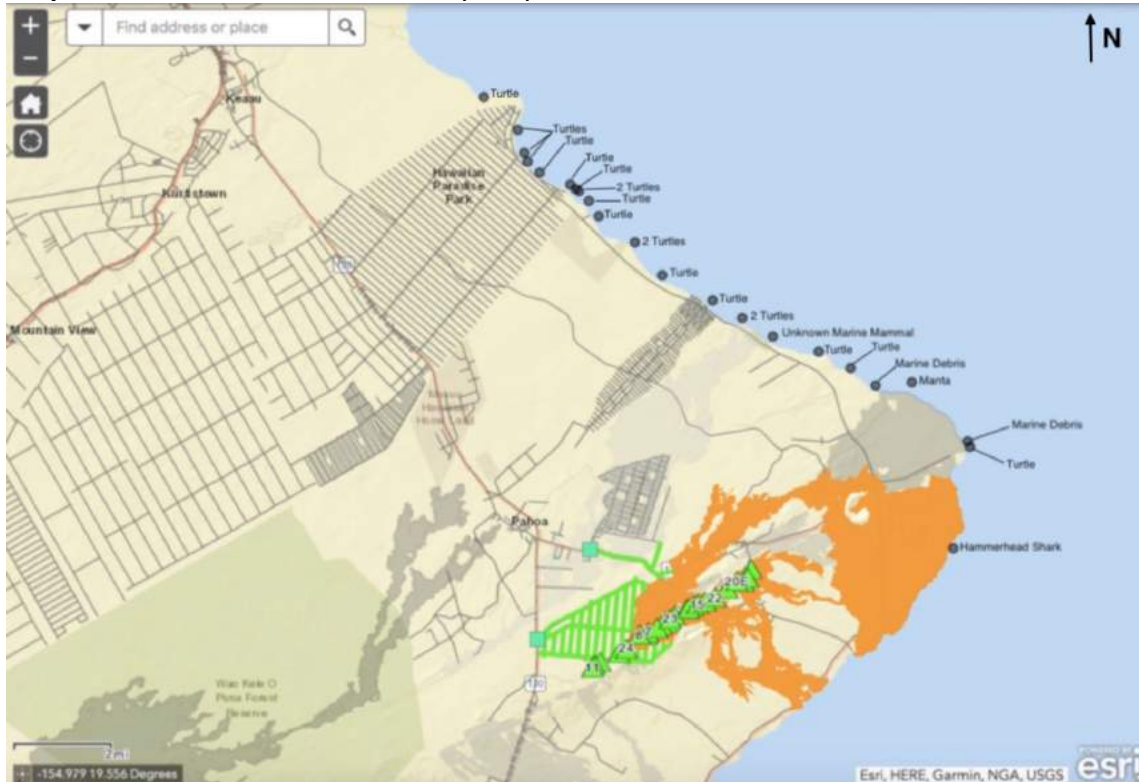
from diving due to the presence of the helicopter. Weather and visibility were clear, the ocean surface mildly agitated, and there was little to no difficulty spotting turtles with the naked eye from the aircraft. However, time of day and increased altitude did make confirmation of sightings with photos difficult due to glare (see **Figure 9** and **10**). The water turbidity in the lava impacted zone was markedly less than the initial September 4th flight. National Oceanic and Atmospheric Administration (NOAA) tide predictions for Hilo, HI showed that the tide was falling at 4:34 pm with a LOW (0.55 ft) at 5:37 pm. The moon was waning first quarter and set at 12:02 am.

Track 3 survey began along the coastline near Hā'ena (Shipman Beach) and concluded along the coast near Kalepa Point. Track 4 of the area surveyed, began again near Kalepa Point and concluded near Hā'ena (Shipman Beach). Survey was conducted in a Hughes 500C helicopter at an average altitude of 659 ft and average speed of 84.1 miles per hour for Track 3 and 611 ft and 65.3 miles per hour for Track 4 (see **Maps 3 and 4**). Track 3 and Track 4 maps show approximate location of notable features, lava affected coastline, and each point of interest. We categorized areas as either inside "IN" or outside "OUT" of lava ocean entry affected areas (see **Table 1** for miles flown).

**Map 3. November 16th Final Survey Map "Track 3"**



**Map 4. November 16th Final Survey Map “Track 4”**



Above maps were completed by Nikki Sanderlin / Maptastic using the data points taken during the November 16th flight with the GPS Tracker application. The orange area indicates lava impacted areas and green triangles show fissures. Each point represents an observation of a marine organism and is labeled accordingly. See **Appendix 3** for maps generated by the GPS Tracker Application, which show flight path and pins for each marine resources sighted.

The initial survey was conducted by HWF biologists, Kallie Barnes and Caitlin Kryss; Lauren Kurpita, Coordinator for the Hawai‘i Island Hawksbill Turtle Recovery Project; with assistance from Volcano Helicopters’ pilot, David Okita. The follow-up survey was conducted by HWF biologists, Kallie Barnes and Nohea Ka‘awa with assistance from Volcano Helicoptes’ pilot David Okita and professional photographer Joshua Lambus of the Maka Project. Surveyors collected data on potential basking beaches, turtle presence, marine debris, and other marine life with visual confirmation, tallying, and waypoint entry into a GPS Tracker iPhone application and Garmin GPSmap 62s. Particular focus was made on new potential basking beaches and coastal pool areas where stranding reports had been made. Initial survey photos were taken using a CANON 60 EOS with a 75-300 mm zoom lens, and follow-up survey photos were taken using a CANON 7D and 5D with a 75-300 mm zoom lens.

## RESULTS AND CONCLUSION

For the initial flight (September 4th) a total of 18 live turtles were sighted and marked in the GPS Tracker, in addition to one large halālū ball (juvenile akule, *Selar crumenophthalmus*), 3 eagle rays, 1 hammerhead shark, 2 marine debris observations, and various other wildlife sightings (see below **Table 2** for data and **Maps 1** and **Maps 2**). The majority of the turtles observed (16 or 88.9%) were seen outside the lava impacted zone, with only two turtles sighted within lava affected areas. However, some of these differences may have been due to the ability of observers to see turtles present in the more turbid waters within the lava-impacted zone.

The follow-up flight (November 16th) showed a similar dispersal of marine resources. A total of 32 live turtles were sighted and marked in the GPS tracker, in addition to 1 hammerhead shark, 2 marine debris observations, 1 manta ray, and 1 unidentified cetacean (see below **Table 3** data, and **Maps 3** and **Maps 4**). No turtles were sighted within (“IN”) lava ocean entry areas for the follow-up flight.

For both flights photos allowed for confirmation of some marine life observed, including: hammerhead shark, eagle rays, manta ray, water birds and sea turtles. While photos allowed for confirmation of marine life observed, identification of turtles to species was not possible. Some reasons for this include difficulties with focusing lens, aircraft speed, location of sighting, aircraft communications, turtle diving behavior in response to aircraft, and surveyor error.

**Tables 2 and 3.** Number of marine wildlife and debris sightings, waypoint coordinates, time of sighting, and elevation at sighting. The capitalized “IN” and “OUT” refer to whether the points were taken within a lava ocean entry area or outside of a lava ocean entry area, respectively. Two tracks were made for the September 4th reconnaissance survey labeled “Track 1” and “Track 2”. Track 1 includes areas both IN and OUT of lava ocean entry. Note that waypoint numbers’ 1 and 2 in Track 1 are accounted for in waypoint number 3 (turtles were congregated in 1 area). The two additional tracks for the November 16th reconnaissance survey are labeled “Track 3” and “Track 4.” Both tracks from the November 16th surveys include “IN” and “OUT” locations.

**Table 2.**

Waypoint #	Wildlife & Marine Debris Sightings	N	W	Time (AM)	Altitude (ft)
<b>Track 1 (In and Out)</b>					
<b>OUT</b>					
1	1 Turtle	19.51244	154.80782	8:20	406.335
2	1 Turtle	19.51244	154.80782	8:20	406.335
3	3 Turtles	19.51244	154.80782	8:20	406.335
<b>IN</b>					
4	1 Turtle	19.44877	154.84739	8:31	352.715

5	1 Turtle	19.44861	154.84756	8:31	357.603
6	Mackenzie Park	19.43733	154.86185	8:33	400.293
<b>OUT</b>					
7	1 Turtle	19.43311	154.86640	8:34	379.041
8	1 Turtle	19.43094	154.87209	8:34	450.675
9	1 Turtle	19.42913	154.87461	8:35	424.773
10	3 Turtles	19.42708	154.87574	8:35	427.856
12	Net Bundle (Shoreline)	19.45344	154.84453	8:39	383.660
<b>IN</b>					
13	3 Eagle Ray	19.45567	154.84357	8:41	218.565
14	Hammerhead	19.47654	154.81694	8:46	648.861
15	Buoys (Shoreline)	19.51028	154.81181	8:52	118.032
<b>Track 2 (Out)</b>					
1	2 Turtles	19.54981	154.87031	8:55	1043.633
2	2 Turtles	19.56901	154.89600	8:57	931.379
3	Halalū Ball	19.63583	154.95888	9:01	743.940
4	1 Turtle	19.63099	154.96677	9:01	769.648
5	1 Turtle	19.63343	154.97170	9:01	756.027
6	1 Turtle	19.64666	154.98418	9:02	777.841

**Table 3.**

Waypoint #	Wildlife and Marine Debris Sightings	N	W	Time (PM)	Altitude (ft)
<b>Track 3 (IN and OUT)</b>					
<b>OUT</b>					
1	Turtle	19.631506	-154.967433	4:06	199.270
2	1 Turtle	19.623157	-154.951775	4:07	201.423
3	2 Turtles	19.599408	-154.935355	4:08	183.736
4	1 Turtle	19.592333	-154.925011	4:09	155.613



5	1 Turtle	19.580193	-154.910133	4:10	195.804
6	1 Turtle	19.575159	-154.906153	4:10	195.214
7	1 Turtle	19.569896	-154.89901	4:10	189.272
8	1 Turtle	19.564727	-154.8893	4:11	186.163
9	1 Turtle	19.557127	-154.874028	4:11	198.898
10	1 Turtle	19.525976	-154.808537	4:15	197.49
11	1 Turtle	19.513167	-154.804737	4:16	244.361
<b>Track 4 (IN and OUT)</b>					
<b>IN</b>					
1	Hammerhead Shark	19.489082	-154.810102	4:31	182.696
<b>OUT</b>					
2	1 Turtle	19.51923	-154.805834	4:33	193.182
3	Marine Debris	19.520423	-154.806401	4:33	207.521
4	Manta	19.538217	-154.823114	4:35	234.741
5	Marine Debris	19.537247	-154.835654	4:36	213.486
6	1 Turtle	19.542746	-154.843221	4:37	170.794
7	1 Turtle	19.547738	-154.853582	4:37	190.265
8	Unidentified Cetacean	19.551591	-154.867784	4:38	193.257
9	2 Turtles	19.557116	-154.877789	4:39	191.522
10	1 Turtle	19.562069	-154.886822	4:40	197.782
12	1 Turtle	19.570236	-154.902919	4:41	180.067
13	2 Turtles	19.579468	-154.910784	4:42	183.910
14	1 Turtle	19.587393	-154.922224	4:42	181.469
15	1 Turtle	19.592431	-154.925935	4:43	199.580
16	2 Turtles	19.594208	-154.928422	4:43	198.118
17	1 Turtle	19.595611	-154.929868	4:43	210.264
18	1 Turtle	19.596829	-154.931449	4:43	218.513
19	1 Turtle	19.600677	-154.940157	4:43	175.373
20	1 Turtle	19.603831	-154.944591	4:44	159.975
21	1 Turtle	19.606725	-154.945872	4:44	153.835
22	1 Turtle	19.613979	-154.947806	4:45	178.826

23	1 Turtle	19.622664	-154.95849	4:46	206.906
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On the initial survey flight, special attention was paid to new possible basking beaches and pools, where the pilot was able to reduce altitude of aircraft to approximately 43 ft at both Pohoiki Boat Ramp and a newer coastal pool and possible basking beach north of Kapoho. The Pohoiki Boat Ramp and newer coastal pool / possible basking beach areas were surveyed for any turtle strandings and potential risks of future turtle isolation as a result of any new volcanic activity. No turtles were sighted in either of these areas. All surveyors noted that there appeared to be no possible hindrances for turtles attempting to move in or out of these areas, as the slope of the beach into and out of ocean and into and out of pools did not seem too steep for sea turtles to crawl in and out of. However, the temperature of the pools surveyed was presumably elevated.

Water visibility was notably lower in areas affected by lava inundation, additionally there were areas that had the appearance of being “scrubbed” of available algal food resources via wave action and newly created sand (see **Appendix 4** for photographs depicting water quality differences). Caves along the shoreline, where turtles might rest and forage, may have filled in with sand or been completely covered by lava. In addition, researchers from the University of Hawai‘i have been collecting data to help “understand the distribution of the hot water from where the lava is entering the ocean and how that’s changing through time.” They have observed that “[The hot water] doesn’t tend to spread out along the shoreline... It moves offshore, and cool water is either coming in along the shoreline or coming up from (the) depths to replace the water where the lava pours in... [This action] provides a bit of protection for the ecosystems surrounding the lava flow.”<sup>6</sup> On the November 16th survey it was noted that algal growth is now present on some of the new lava zones and is returning in lava impacted areas (see **Figure 12**).

It is important to note that these data collected on turtle abundance were helpful, but that the combined experience and knowledge of the surveyors and helicopter pilot should also be taken into account. For example, pilot David Okita was quoted from an August 21<sup>st</sup>, 2018 email as sharing:

*“Having flown over pohoiki almost daily I can tell you that the report of stranded sea turtles was short lived an[d] slightly exaggerated. There was one day when a collection of turtles congregated in the boat ramp area but by the next day none could be found. Some have returned to the area an[d] can be seen in a new lagoon that has been formed”.*

Additionally, all four biologist surveyors noted that while they believe some sea turtles were affected and killed by the lava ocean entry, it is not likely that large numbers were harmed by these recent volcanic activities.

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<https://www.hawaiitribune-herald.com/2018/07/23/hawaii-news/scientists-get-rare-chance-to-collect-data-on-impact-of-lava-on-marine-life-sea-water/>

Little is known about how sea turtle density, behavior, foraging, and basking habitat are affected by lava ocean entry. As such, this project is unique in scope and provides a snapshot into the recovery of foraging and basking habitat for sea turtles and other marine life. Future surveys could be conducted to determine the amount of time it may take for turtles to begin re-inhabiting lava impacted areas, as the majority of turtles were counted outside of these areas.

### **Acknowledgements**

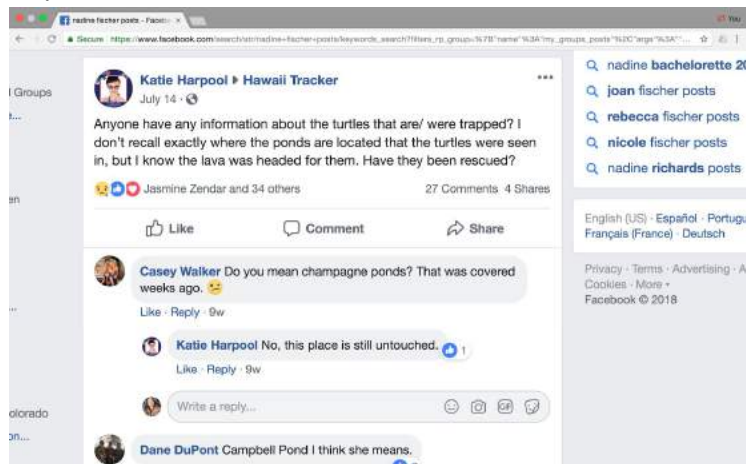
HWF would like to thank an anonymous private foundation for their support of this project to care for the wildlife and people of Puna. Additionally, many thanks to Lauren Kurpita of the Hawai'i Island Hawksbill Turtle Recovery Project who donated her time for this effort, to David Okita with Volcano Helicopters for offering a discounted flight rate to HWF, to Dane Dupont for supplying information and maps on impacted coastline, and to Joshua Lambus with the Maka Project for offering a discounted rate for photography.

## Appendix 1. Social Media Posts

### July 13, 2018 Facebook Post



### July 14, 2018 Facebook Post



### July 16, 2018 Video posted to YouTube

WARNING: Graphic footage of distressed turtle struggling in hot water due to lava inundation at Kapoho Area. Bright light being shined at turtle likely caused additional disorientation.

<https://www.youtube.com/watch?v=GZ9f1Nx-QSA&feature=youtu.be>

July 18, 2018 Shared original July 13th post from Facebook to Instagram

**bantoxicsscreens** · 31 likes

**HONU TRAPPED INSIDE BOWLS / POHOIKI.**  
NOAA has been contacted. They must approve rescue. That's not happening. Red Tape? Maybe a day or two before it's too late.

What we know:  
40-50 turtles are at Bowls + some inside 1st Bay Pohoiki  
The lava flow is 100 yards from Bowls as of this

What we know:  
40-50 turtles are at Bowls + some inside 1st Bay Pohoiki  
The lava flow is 100 yards from Bowls as of this morning  
Current is pulling the hot water south. Fish trying to cross outside the bay are killed immediately.  
The fresh water sources inside the area are (for now) keeping cooler water within the bays. Turtles are staying near fresh water entries / Campbell pond / where it flows in over broken road. This may be why turtles have remained so long in the area.  
Someone who has been helping with evacs via the boat ramp this week saw the turtles at Bowls, low tide, stacked up 40-50 some atop each other on the rocks trying to get to the cooler water / fresh water area.  
He's been trying to alert gov entities of the oncoming crisis. NOAA have equipment to do the rescue. He did get approval from DLNR to use the boat ramp. Last chance for boat rescue may be by tomorrow. Helicopter may be needed, weather dependent. Laze will now need to be factored in.

There is also active flow areas above heading towards Pohoiki (not certain the status)

Unless there is a major shift, Pohoiki will be gone by Monday or Tuesday if not sooner. Bowls likely sooner. There may be no press coverage about this now, but guaranteed press when people find out what happened.  
Please share.

**bantoxicsscreens** · 31 likes

**HONU TRAPPED INSIDE BOWLS / POHOIKI.**  
NOAA has been contacted. They must approve rescue. That's not happening. Red Tape? Maybe a day or two before it's too late.

What we know:  
40-50 turtles are at Bowls + some inside 1st Bay Pohoiki  
The lava flow is 100 yards from Bowls as of this

July 22, 2018 Facebook post

Nadine Fischer shared a video to the group **Puna Lava, Weather And Emergency Updates**.

Since authorities don't take action to prevent that more turtles get boiled alive, we want to shed light on what's happening at the lava ocean entries. This is no happy video, but we believe important to share, to prevent that this keeps happening.

Turtles that sleep at the beach or get into ocean areas that are flooded at high tide, can't escape at low tide when lava reaches the ocean and heats up the water. Boat captains and people that want to evacuate animals and belongings kept seeing more and more Honus in the Pohoiki area in the last weeks. It seems they escape the hot waters of the lava ocean entries and search refuge near the cold freshwater springs around Pohoiki and sleep at the beaches there at night. With lava approaching there, time for them is running out.

NOAA claims there are absolutely no turtles in the water and at the beaches near Pohoiki and all the reports from those that see many turtles in the area are false. They went to check the beach last Sunday during the day and high tide and flew over the area. Honus were seen at the beaches at night though and from a helicopter, you don't see them in the water, as it's already difficult to see healthy Honus from the boat, as they swim usually not at the surface.

This video was taken beginning of May when lava first entered Kapoho Bay and Champagne Ponds, near the town of Pahoa on the Big Island of Hawaii. Travis Sanders that was involved in many evacuation efforts and live coverages, was one of the very few, that were in Kapoho bay to capture the historic moment when lava hit the ocean. He said, he didn't see any turtles first, but when lava entered the water, Honus started to swim around frantically, fighting for their lives.

When he realized what's happening he put the camera down and tried to help them. He was devastated when he described, how he tried to lift them out of the water and they fell apart in his hands, as they had been boiled alive... that his hands got severely burned when he tried to rescue them, he mentioned just later... in the next days, the waters around Kapoho Bay was full of dead turtles and fish...

Lava entered Kapoho Bay a full month after the first eruptions. Scientists and authorities advised residents more than a week before lava entered the bay, that lava is on a path to hit the ocean at Kapoho Bay. There was enough time for NOAA to relocate all the Honus in the ponds, that had no chance to get out there by themselves, but they didn't do it!

Here a link to the NOAA website with the contacts to report stranded, entangled, or injured sea turtles. The people from UH Hilo Marine Option Program, that would be responsible for this area, told us that nothing is planned to prevent this from happening again. Their number: (808) 286-4359

Gordon Height from DLNR told us, that he does not care at all about what's happening with turtles. You can reach him at (808) 961-9530 if you find that as lively as we did...

John Kahapo that is responsible for field operations with DLNR, told us that he will also not do anything for the turtles in the Pohoiki area. If you want to tell him, what you think about that here his phone number: (808) 938-8266

If you have any contacts of people that care about these turtles and can do something for them, please tell us know.

60.6K Views

Like Comment Share

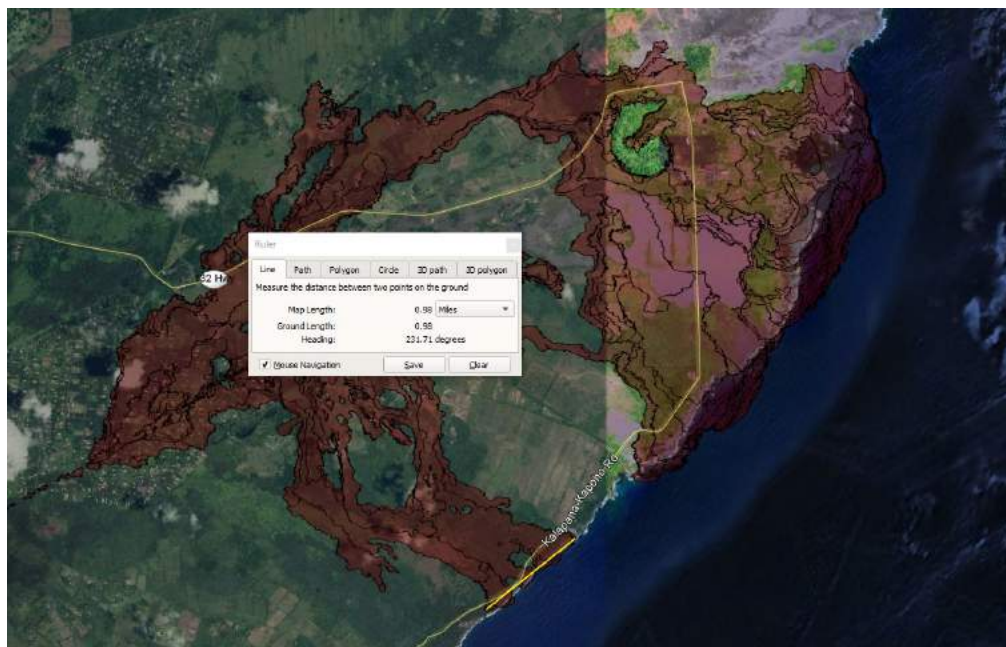
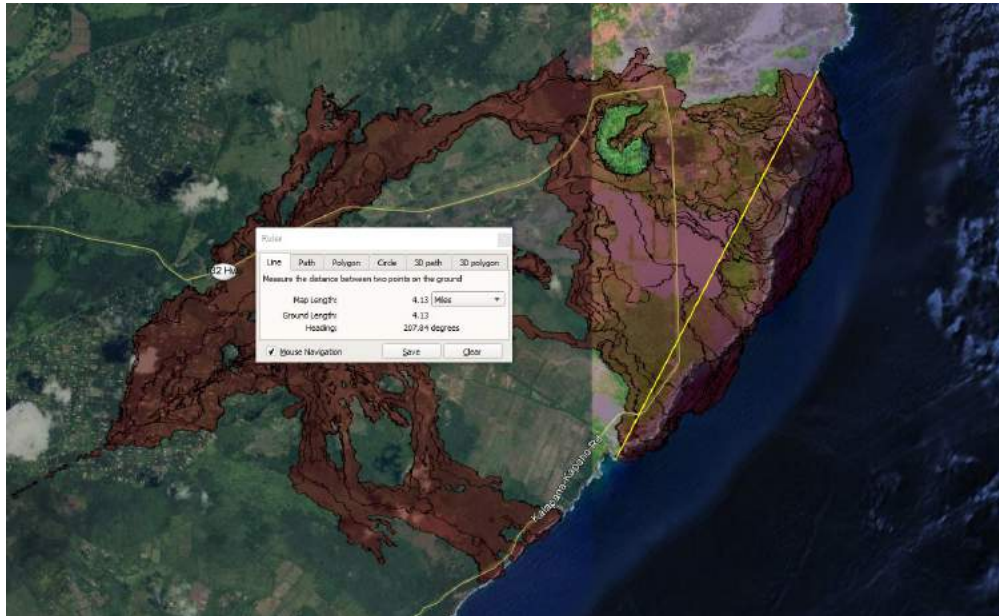
158

Jasmine Zendar and 64 others shared this

View previous comments...

Hope Solomon  
What was everyone doing as the lava was approaching the pools? Maybe gathering up this own personal belongings. Why shouldnt take more time

## Appendix 2. Impacted Coastline Measurements



Line of sight measurement maps courtesy of Dane Dupont using USGS GIS data and measuring tool. First maps shows miles of coastline affected across larger flow front and second map shows miles of coastline affected across smaller flow front at Mackenzie Park.

### Appendix 3. Flight tracks

Map 1. Track 1 (IN and OUT)



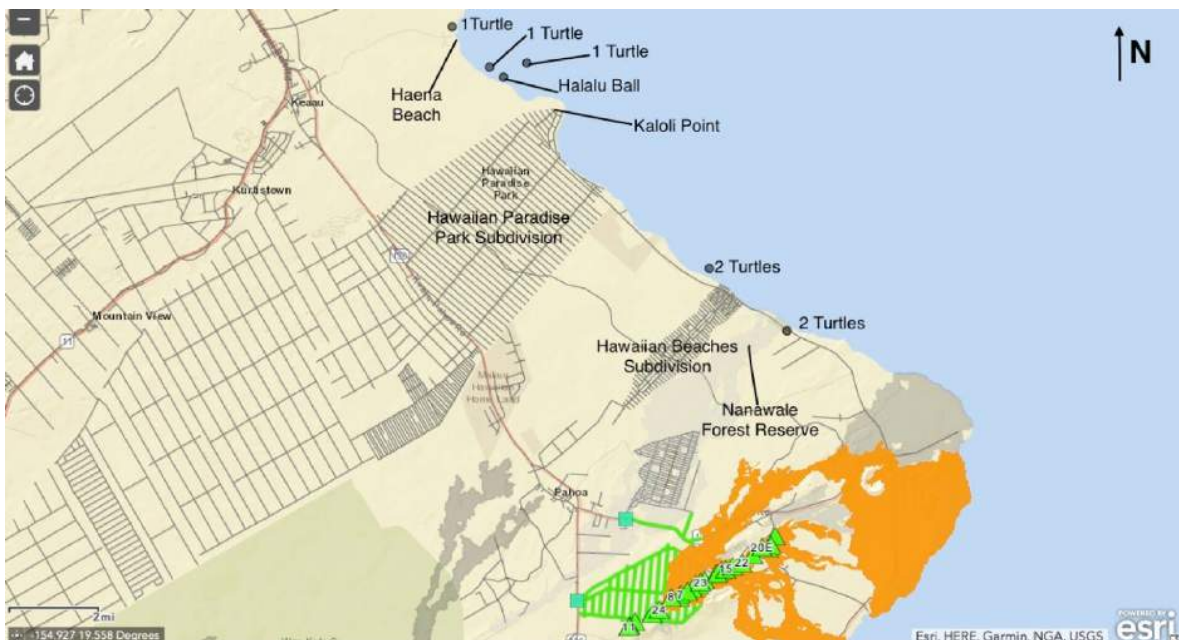
Track 1 was taken from the GPS Tracker application and shows the track of the flight flown, but does not have an updated map of the lava impacted areas. The green pin indicates the starting point, purple pins indicate marine resources sighted, and the red pin indicates the stopping point.



Map 2. Track 2 (OUT)



The Short Track was taken from the GPS Tracker application and shows the track of the flight flown, but does not have an updated map of the lava impacted areas. The green pin indicates the starting point, purple pins indicate marine resources sighted, and the red pin indicates the stopping point.





### Map 3. Track 3 (IN and OUT)



Map of Track 1 was taken from the GPS Tracker application and shows the track of the flight flow, but does not have an updated map of the lava impacted areas. The green pin indicates the starting point, purple pins indicate marine resources sighted, and the red pin indicates the stopping point.



Map 4. Track 4 (IN and OUT)



The above map of the Return Track was taken from the GPS Tracker application and shows the track of the flight flow, but does not have an updated map of the lava impacted areas. The green pin indicates the starting point, purple pins indicate marine resources sighted, and the red pin indicates the stopping point.



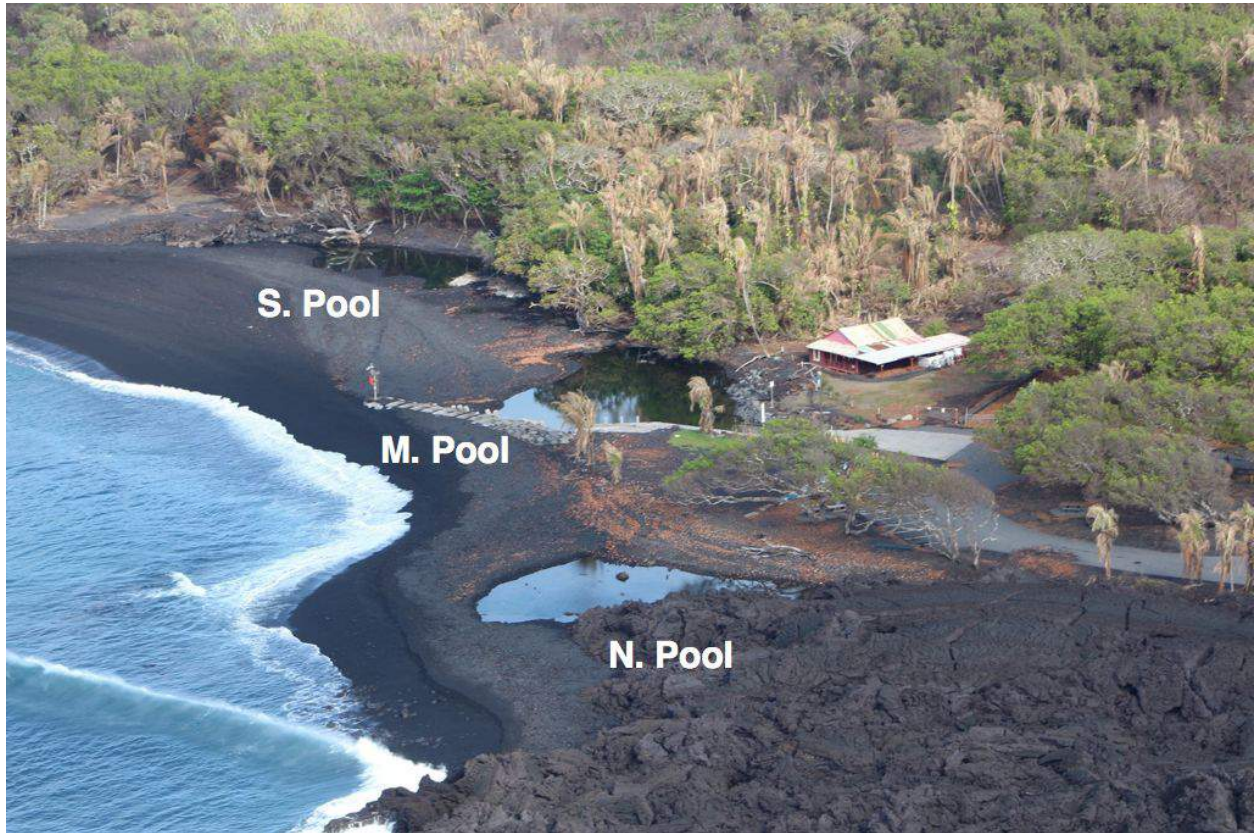
**Appendix 4.** Photo Documentation in Chronological Order

**Figure 1 (Track 1)**



Turtle sighting at waypoint # 3, photographed from an approximate altitude of 406 ft (here forward noted as "...ft"). Note clarity of water.

**Figure 2 (Track 1)**



Pohoiki Bay photographed from the NE with all 3 new pools/possible basking beaches. Each pool labeled North, Middle, and South respectively.

Figure 3 (Track 1)



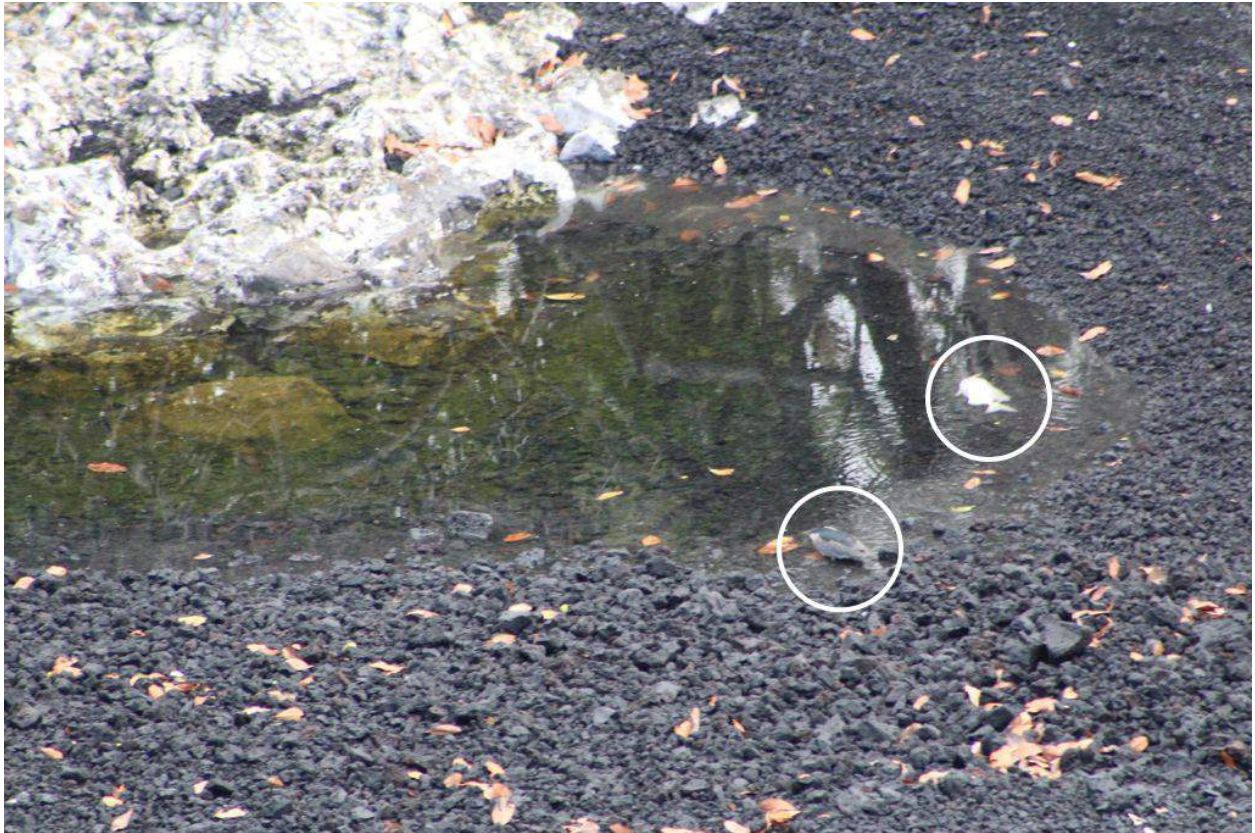
N. Pool at Pohoiki Bay

Figure 4 (Track 1)



S. Pool at Pohoiki Bay (Inset Photo 5)

Figure 5 (Track 1)



Close up of S. pool (inset from Photo 4) of Auku'u (black crowned night heron) and what appeared to be a dead Nenuë (Chub, *Kyphosus* sp.).

**Figure 6 (Track 1)**



Eagle Ray sighting at waypoint # 13 at the bay just south of Pohoiki bay and boat ramp, photographed from 218 ft.



Figure 7 (Track 1)



Derelict Fishing Gear photographed from 384 ft.

**Figure 8 (Track 1)**



Hammerhead shark photographed from 649 ft.

Figure 9 (Track 1)



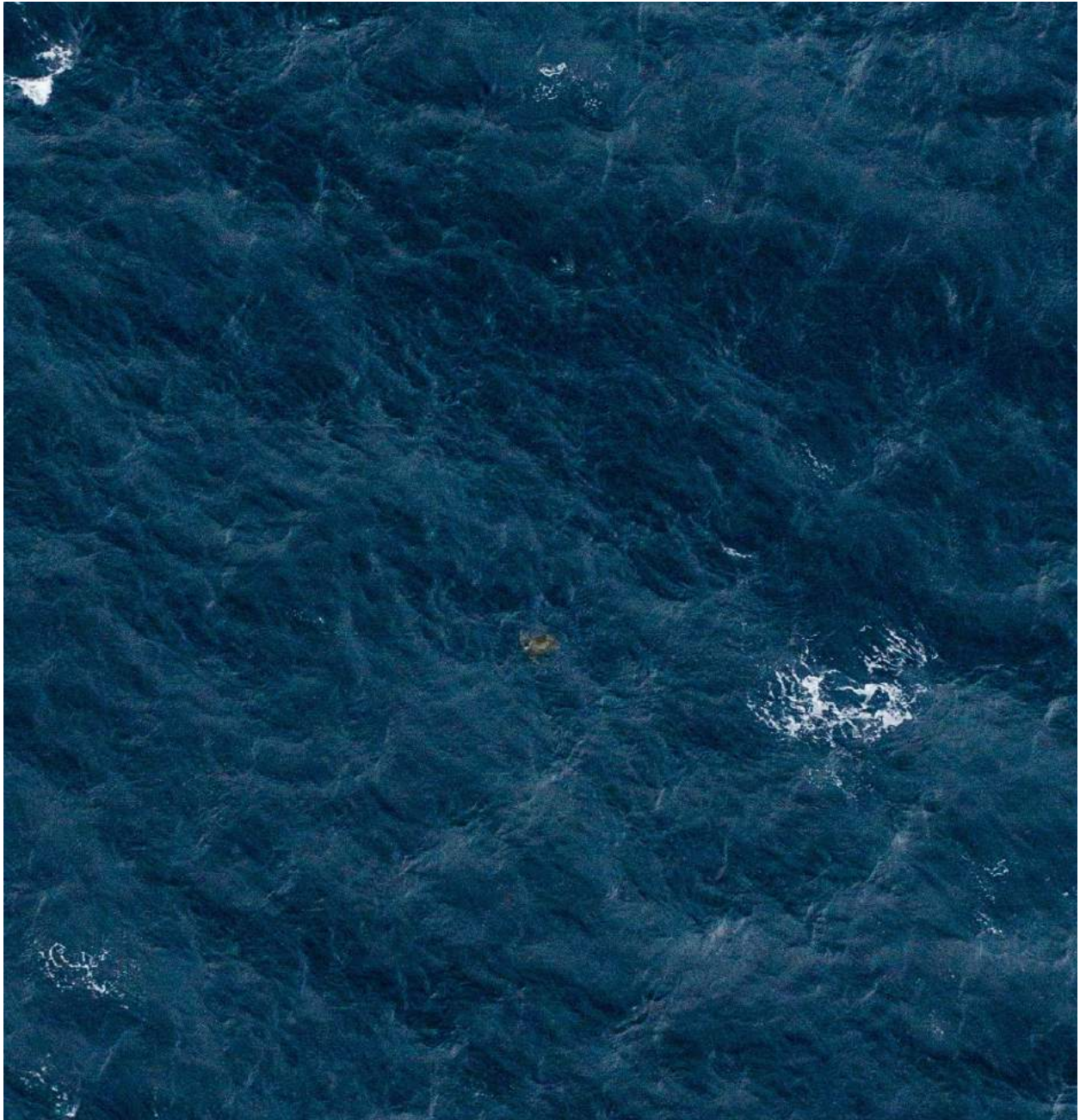
New pool/possible basking beach South of buoys (see **Track 1** map).

**Figure 10 (Track 4)**



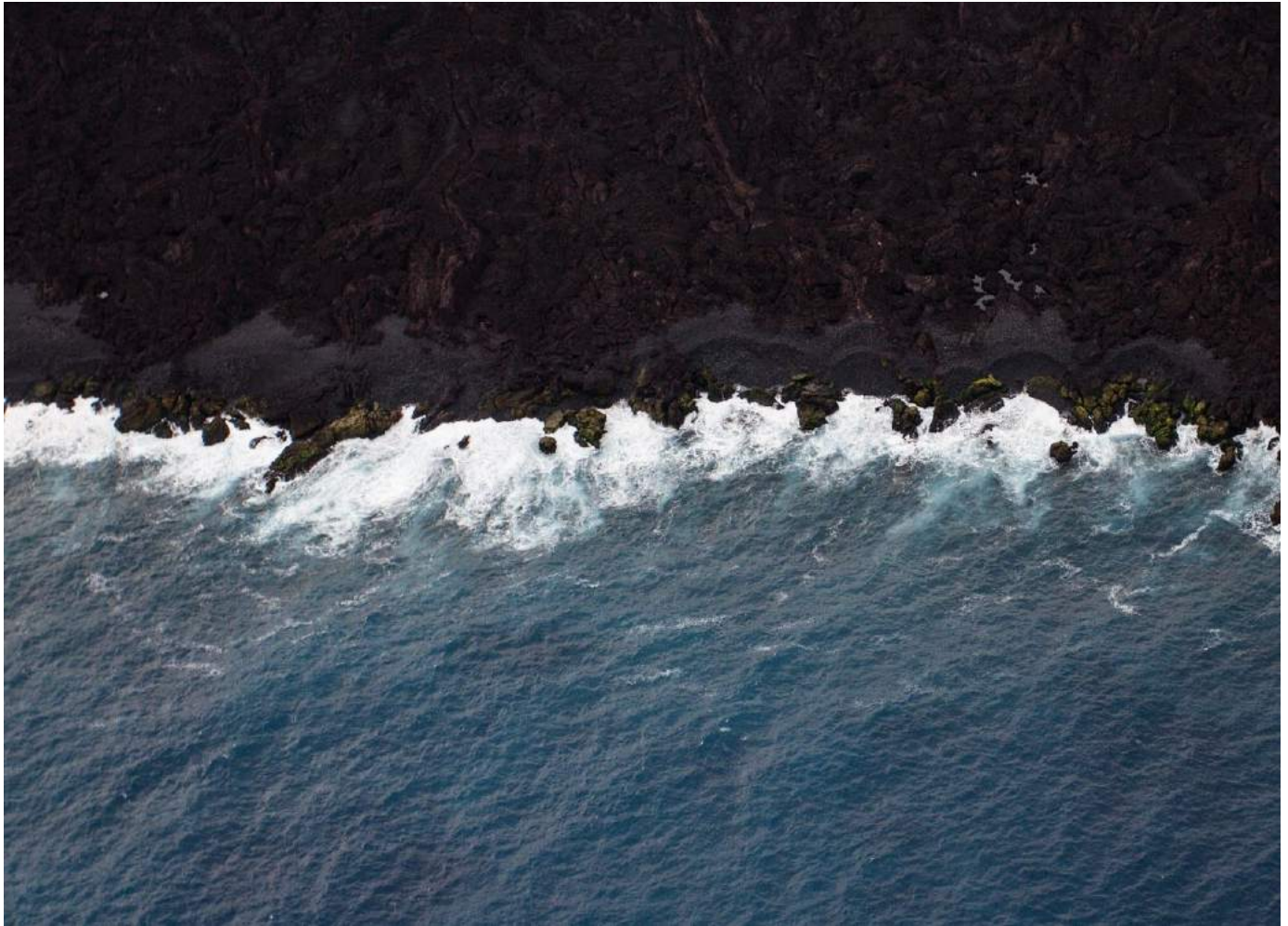
Manta ray sighting photographed from an altitude of 711 ft.

Figure 11 (Track 3)



Turtle sighting indicative of all other turtle sightings during November 16th flight, taken from an altitude of 649 ft.

Figure 12 (Track 3)



Green areas show algal growth along newly created coastline not present on the initial September flight, though this area may have been covered as the September flight was during a high tide.