Sea Turtle Grant 08-029R

Final Report

"Determining Long-term Movements of Juvenile Green Turtles in the Indian River Lagoon System"

Submitted by

W. E. Redfoot and L. M. Ehrhart

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Submitted to Mr. D. Evans
Sea Turtle Grants Program
Caribbean Conservation Corporation
4424 NW 13th St. Suite B-11
Gainesville, Florida 32609
STGP Account No. 08-029R
UCF Account No. 07240300002 RF

Introduction

For the 2008-09 Sea Turtle Grants Funding Cycle, we submitted a proposal to track the movements of juvenile green turtles in the Indian River Lagoon, captured at the University of Central Florida long-term study site (Figure 1), with the intent of using movement data to identify green turtle developmental habitats within the lagoon system. We were awarded $6,800 to purchase two FastLoc GPS/Argos satellite tags, $6,000 for satellite time, and $640 for indirect costs. The two MK-10-AFB Fastloc GPS/Argos satellite tags were ordered and received from Wildlife Computers, Redmond Washington. The first tag was deployed on a 51.4 cm straight-line carapace length (SCL) juvenile green turtle (Dylan) on 16 September 2008. The second tag was deployed on a 51.3 cm SCL juvenile green turtle (Fairly) on 13 November 2008. By early January 2009 it was apparent that there would be a surplus in the funds allotted for satellite time. It was suggested by Mr. Dan Evans, coordinator of the Sea Turtle Grants Program (STGP), that the surplus be used to purchase another satellite tag. A request for a no-cost extension and budget modification was submitted to the STPG and approved. The third Fastloc GPS/Argo was ordered and received from Wildlife Computers, and deployed on a 52.0 cm SCL juvenile green turtle (Jamie) on 3 June 2009.

Figure 1. Location of the University of Central Florida Marine Turtle Research Group long-term study site south of Sebastian Inlet, Florida. The yellow Xs mark the east and west ends of net sites over a two year period (July 2005-July 2007).

Materials and Methods

Position Accuracy

The FastLoc GPS satellite tag incorporates the technology developed by Wildtrack Telemetry Systems Ltd., Leeds, U.K.. It has the ability to acquire a GPS position almost instantaneously when the antenna is above water, store the position data, and transmit that data to Argos satellites. It has the added advantage of being able to obtain a location using the Argos technology.

The accuracy of the positions obtained by the FastLoc tag is dependent on the number of GPS satellites the tag can acquire each time the GPS antenna is above water (www.wildtracker.com). The greater the number of satellites acquired, the greater the accuracy of the position obtained; i.e., if six satellites are acquired, 28% of the time the reported position will be within approximately ± 10 m of the true position and within ± 50 m of the true position approximately 94% of the time (Table 1).

Table 1. The estimated position error as a function of the number of satellites acquired.

	Estimated Error: Percent of Positions					
Number of Satellites	± 10 m	± 25 m	± 50 m	± 100 m	± 500 m	± 1,000 m
4	8%	18%	50%	61%	89%	95%
5	9%	50 %	76%	90%	100%	
6	28 %	84 %	94%	98%	100%	
7	34%	88%	99%	100%		
8	48%	95%	100%			
9	52%	98%	100%			
10	60%	99%	100%			
> 10	67%	100%				

The accuracy of an Argos location is dependent on the number of messages received by the satellite and is cataloged by location class (CLS, 2008). Classes 0, 1, 2, and 3 are those obtained with 4 or more messages, class A with 3 messages, and class B with 2 messages. A class 3 location is accurate

within ± 250 m, a class 2 within ± 500 m, a class 1 within ± 1,500 m, and a class 0 is > 1,500 m. Accuracy can not be determined for classes A and B.

Tag Attachment

The carapace of each turtle was cleaned using water, a scrub brush, and a plastic pot scrubber. The first and second vertebrals and the first and second costal scutes on the carapace were sanded using 80 grit sand paper to increase adhesion of the epoxy. Care was taken to avoid the seams between the scutes. The attachment site was wiped down with acetone to remove any remaining dust from the sanding. The Fastloc GPS Satellite Tags were attached using Sonic Weld, a two-part epoxy putty, and Power-Fast, another two-part epoxy. The Sonic Weld was kneaded to mix the two parts and then rolled into two 1 cm diameter strands that were long enough to extend across the bottom of the transmitter and extend laterally 10 cm on each side. One was attached to the front of the transmitter and one to the rear; effectively forming lateral straps. A copious amount of Power-Fast was applied to the bottom of the tag between the strands of Sonic Weld, enough so the Power-Fast was squeezed out from under the tag when it was pressed down on the carapace. The extending strands of Sonic Weld were pressed onto the carapace. Power-Fast was then spread over the extending strands of Sonic Weld and around the tag, taking care to not cover the salt water switches on the side of the tag.

Results and Discussion

Movements

Turtle One: Dylan

Dylan was captured at the long-term University of Central Florida Marine Turtle Research Group (UCFMTRG) study site, FastLoc GPS/Argos tag attached, and released back into the lagoon at the study site 16 September 2008. Twenty-one GPS positions were obtained from 17 September to 24 October (37 days). Thirty-eight Argos satellite locations were obtained from 17 September to 1 November 2008 (45 days). Argos transmissions from the tag continued until 24 December 2008, but not enough messages were obtained to establish locations.

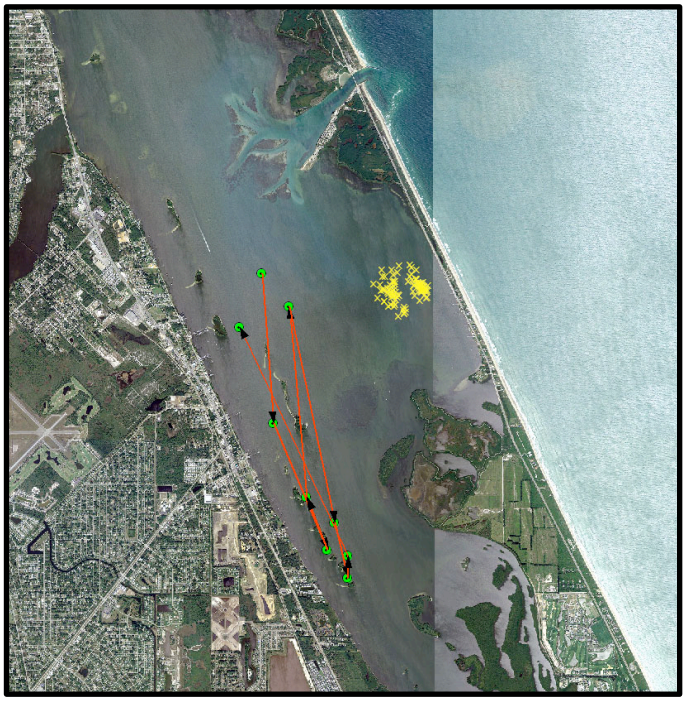

Figure 2. GPS positions and movements of Dylan from 17 through 25 September 2008.

From 17 through 25 September the GPS positions indicated Dylan was utilizing the western side of the lagoon 1.9 to 4.2 km from the center of the UCFMTRG study site (Figure 2). Three positions obtained on 27 September indicate the turtle returned to the east side of the lagoon, but moved back to the west side during the period from 29 September to 8 October (Figure 3). By 13 October Dylan had moved a straight-line distance of 6.8 km from the center of the netting site to an area on the east side of the lagoon north of Sebastian Inlet

(Figure 4). The turtle remained in that area until 22 October (Figure 4). On 24 October the last GPS position received suggests that Dylan was moving south. Argos locations (location class A and B) obtained on the 1st and 2nd of November place Dylan back at the netting site (Figure 4). Dylan's movement to the area north of Sebastian inlet is similar to that of a juvenile green turtle towing a GPS-equipped float 23 to 28 September 2005 (Redfoot, unpublished data, Figure 5).

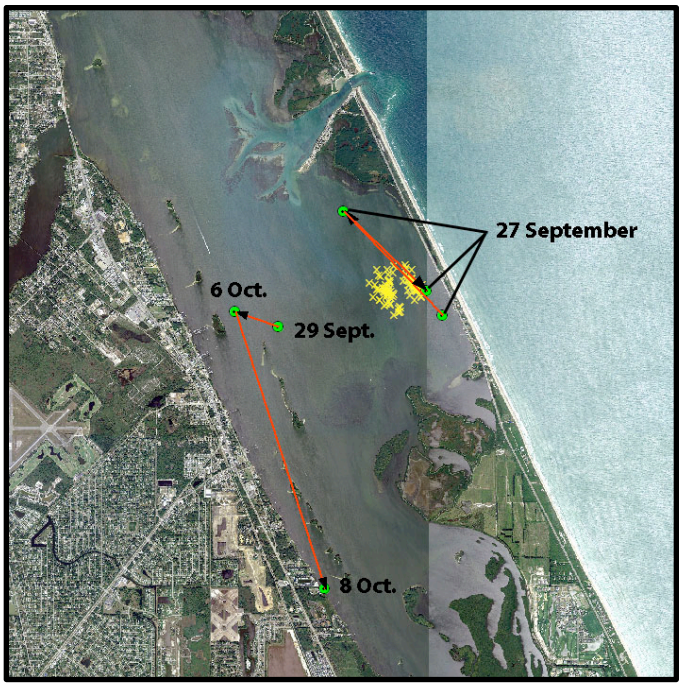

Figure 3. GPS positions and movements of Dylan from 27 September through 8 October 2008.

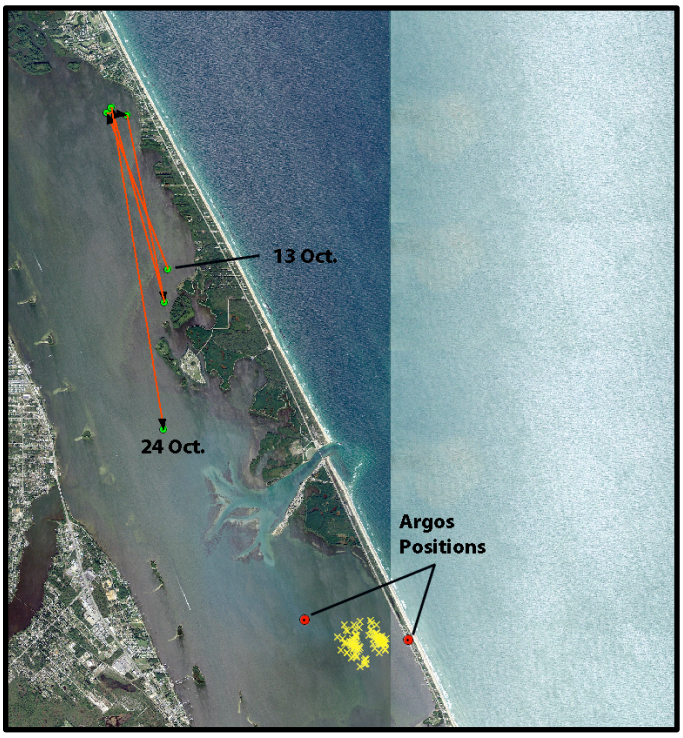

Figure 4.. GPS positions and movements of Dylan from 13 October to 24 October 2008, and Argos Satellite locations obtained on 31 October

Figure 5. Movements of a juvenile green turtle tracked via a towed float 23 - 28 September. 2005.

Turtle Two: Fairly

Fairly was captured at the UCFMTRG study site, FastLoc GPS/Argos tag attached, and released back into the lagoon at the study site on 13 November 2008. The night of 13-14 November was spent on the east side of the lagoon but by 20:31 on the 14th it had moved to the west side of the lagoon where it spent the next two days. A return was made to the east side on the evening of the 16th. The evening of the 19th Fairly moved out of the inlet into the near-shore waters of the Atlantic (Figure 6).

Whether the movement from the lagoon to the ocean was intentional or incidental is a matter of conjecture. Sebastian Inlet is infamous for its strong tidal flow. A 1963 study (Bruun et. al, 1966) measured a mean maximum ebb tide velocity of 8 ft/sec (2.4 m/sec). Flood tide

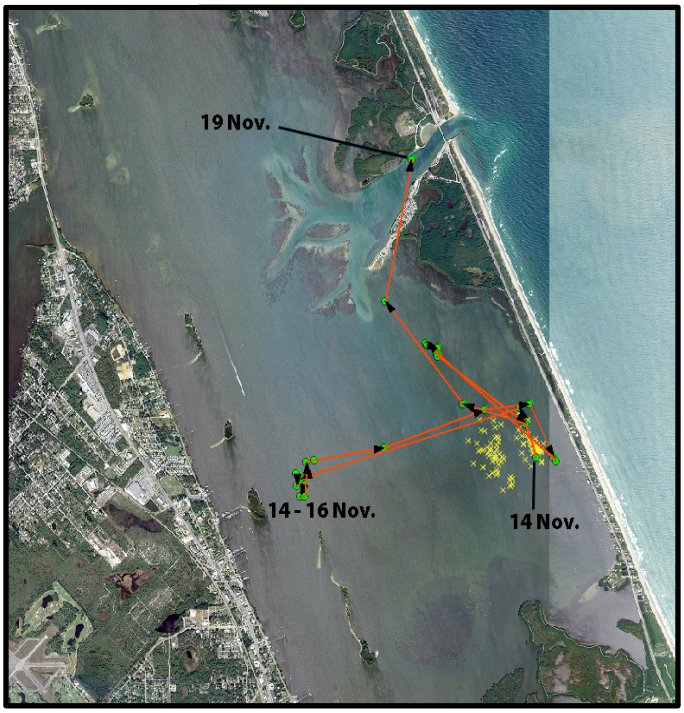

Figure 6. GPS positions and movements of Fairly from 14 through 19 November 2008.

velocity is not quite as strong with a mean maximum velocity of 6.2 ft/sec (1.9 m/sec). GPS positions place Fairly in the inlet channel at 21:19 on 19 November. Although the published low tide was at 19:20 that evening, tidal flow can continue for two or three hours after the official tide change (personal observation). Fairly may have been attempting to cross the inlet channel to move northward in the lagoon and was swept out of the inlet by the current, or may have moved through the inlet into the ocean on its own volition.

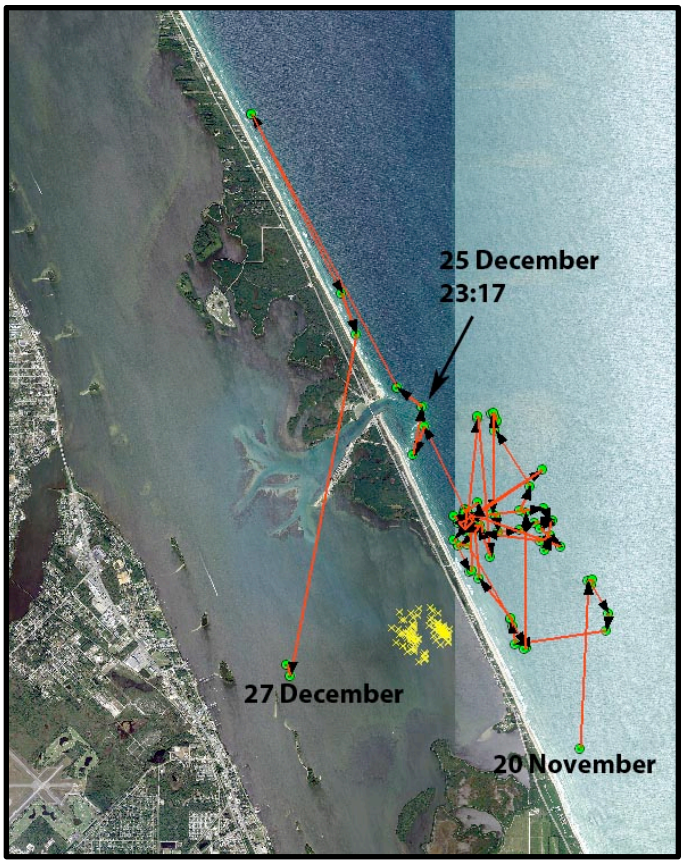

Figure 7. GPS positions and movements of Fairly from 20 November to 27 December 2008.

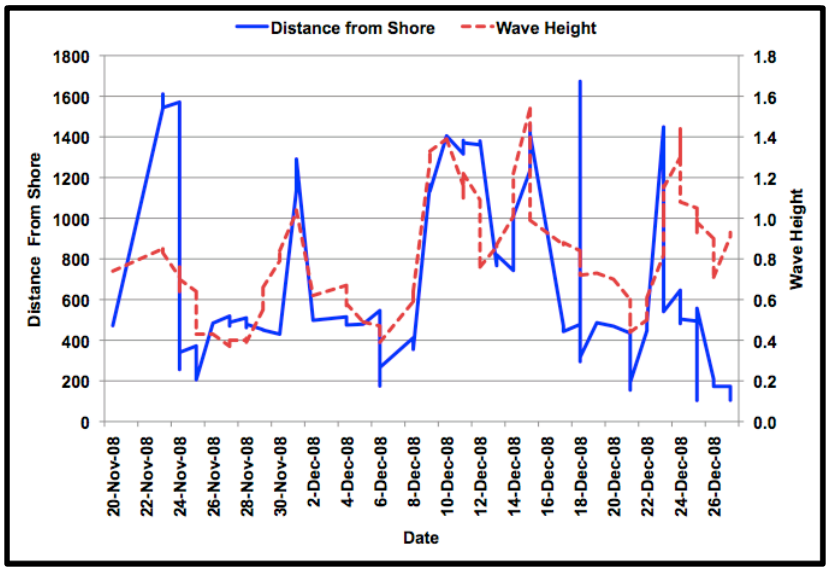

Figure 8. Wave height vs. Farily's distance from the shoreline, 20 November to 27 December 2008.

Regardless, Fairly spent the next 37 days in the nearshore waters of the Atlantic Ocean (Figure 7). An examination of Figure 7 shows clusters of GPS positions both close to and away from the

shoreline, and movements between the clusters. As seen in Figure 8, there is a correlation between wave height at Sebastian Inlet (data provided by L. Harris, Florida Institute of Technology) and Fairly's distance from shore (Spearman r = 0.42, two-tailed P < 0.0001). Green turtles are known to forage on the benthic macroalgae growing on the Sabellariid Worm Reefs (Holloway-Adkins, 2001; Gilbert, 2005). Fairly may have been moving to deeper water away from the reefs to avoid being slammed into them by the turbulence caused by larger waves.

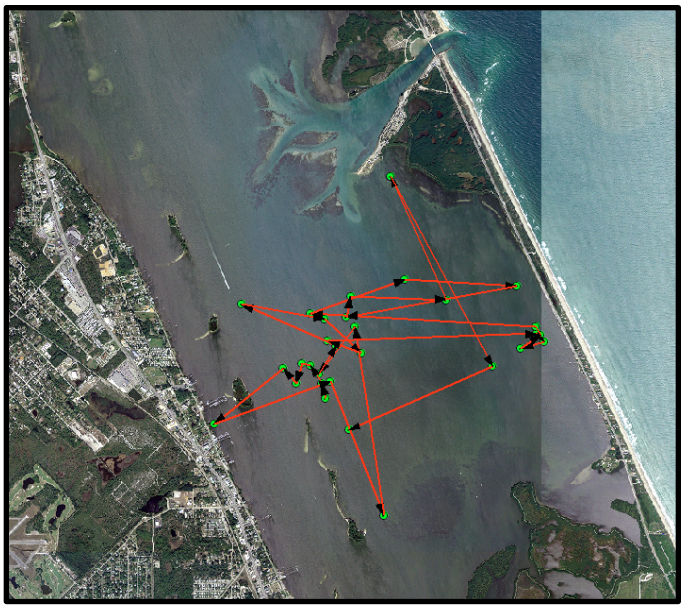

Figure 9. GPS positions and movements of Fairly from 27 December 2008 to 13 January

During the night of 25-26 December Fairly moved from south to north, seeming to skirt the mouth of the inlet (Figure 7). On that night low tide was at 00:39. As noted above, the ebb tide current in the inlet is very strong and continues for two to three hours after official low tide. Fairly was probably pushed offshore by the tidal flow while moving north, reaching the northern-most GPS position at 03:41 that night. The next two GPS positions, which indicated a southward movement, were at 04:48 and 06:48 on the morning of the 27th. High tide was at 07:39 on the 27th placing the turtle in a position where it may have been transported back into the lagoon by the flood tide current. Whether voluntary or not, the last two positions show Fairly back in the lagoon close to the UCFMTRG study site on 27 December (Figure 9).

Fairly remained in the lagoon in the general area of the UCFMTRG study site for the next 18 days (Figure 9), then moved back out into the ocean sometime between the 13th and 15th of January 2009. Between the 15th and 17th

the turtle moved approximately 41 km from the nearshore waters south of Sebastian Inlet to an area just south of Fort Pierce inlet where it spent the next seven days (Figure 10). Then, between 23 and 26 January, Fairly moved 17 km north to an area off Vero Beach, spending at least the next 42 days there. The last GPS position from the Vero Beach area was received on 7 March. Five Argos Satellite locations, including a location class 3, were received between the 8th and 10th of March indicating Fairly was still off Vero Beach.

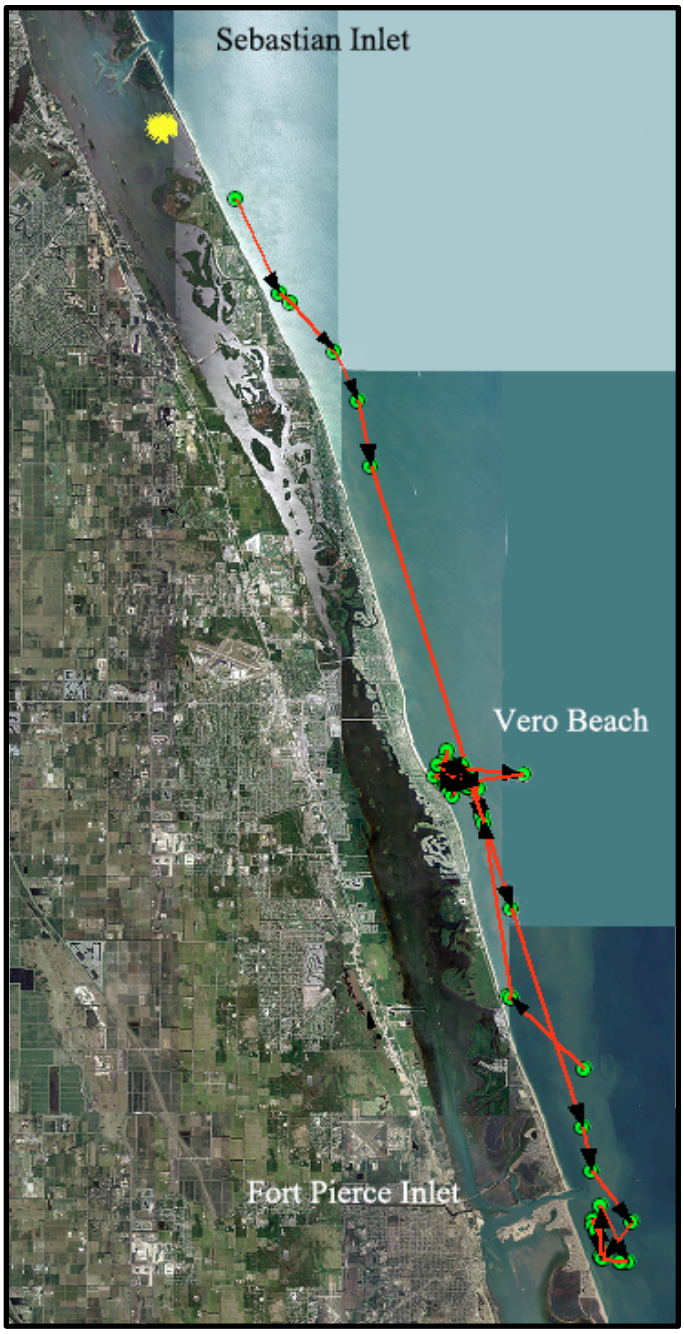

Figure 10. GPS positions and movements of Fairly from 15 January to 7 March 2009.

On 4 May, after a hiatus of 58 days, GPS positions indicated Fairly had returned to the Indian River Lagoon in the general area of the UCFMTRG netting site south of Sebastian Inlet and remained there for at least the next 11 days (Figure 11). Six Argos Satellite locations indicated Fairly had moved north to the area around Sebastian Inlet on 13 March. Although the location classes were 0, A, or B which are considered poor quality, the grouping of the six locations over 40 days lend credence to this move (Figure 11).

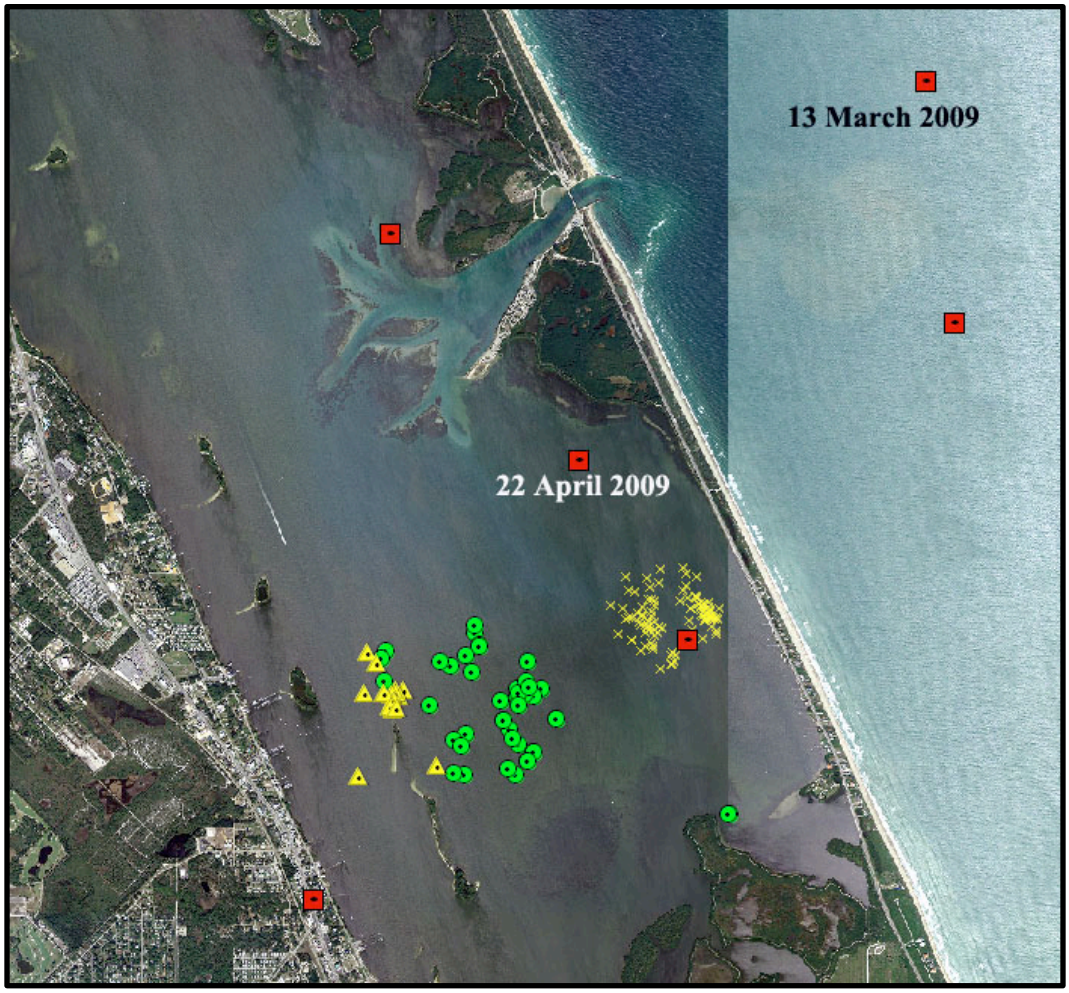

Figure 11. Fairly's Argos Satellite positions 13 March to 22 April (red squares), GPS locations 4 to 15 May (green dots), and GPS positions 16 to 21 June (yellow triangles).

Another gap in GPS positions occurred, this time for 32 days. The last GPS positions for Fairly were transmitted between the 16th and 21st of June indicating the turtle was still in the lagoon south of Sebastian Inlet (Figure 11). An additional 18 Argos Satellite locations were received between the 22nd and 25th of June (not shown on Figure 11), including a location class 2, all clustered around the Sebastian Inlet area.

Turtle 3: Jamie

Jamie was captured at the UCFMTRG study site, fitted with a transmitter, and released on 3 June 2009. GPS data were obtained for 47 days and Argos

Satellite data for 59 days. One to four GPS positions were obtained daily from 4 through 20 June. It was 13 days before the next position was obtained, and still another 18 days (21 July) before the last GPS position was acquired. The position data place Jamie in the general area of the UCFMTRG study site the entire time (Figure 12). Two location class 2 Argos Satellite locations on 30 July indicated that Jamie was still in the same area.

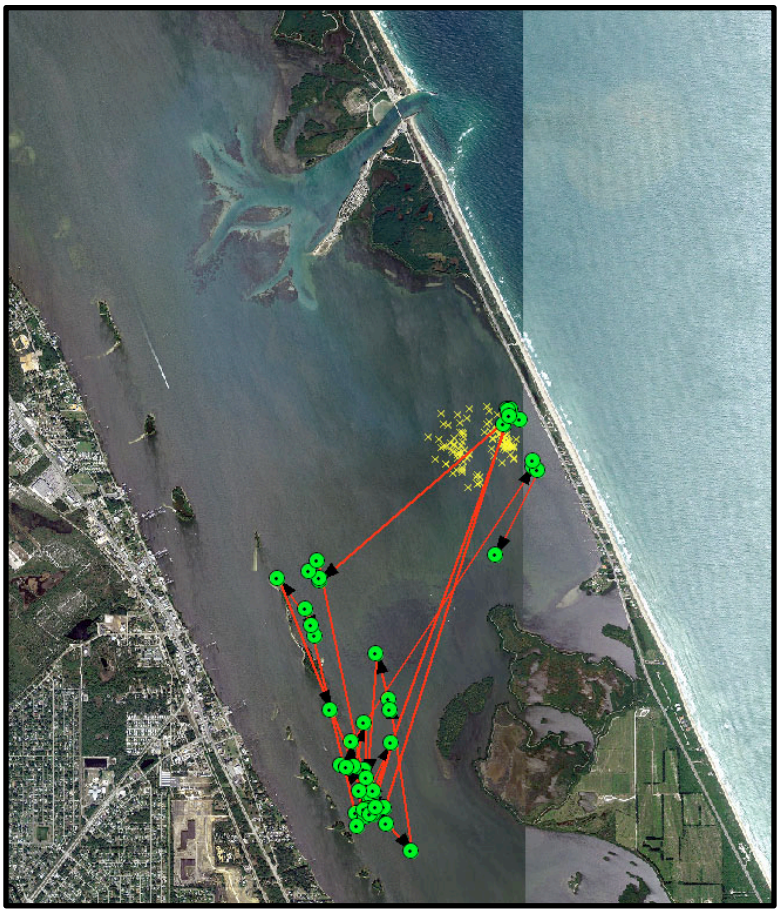

Figure 12. GPS positions and movements for Jamie 4 June through 21 July 2009.

Movements Summary

Although the tags deployed on Dylan and Jamie transmitted GPS positions for only 37 and 47 days respectively, those data showed that both turtles stayed within the central region of the Indian River Lagoon, which in itself is a significant contribution to our understanding of habitat utilization by this species. These same data would have been both more difficult to obtain and much more costly using towed floats or sonic tags. That would require the purchase of a self-contained vessel (head, galley, bunk space) at least 10 m in length, and at least

3 people to man the vessel 24 hours a day, seven days per week. In addition there would be the operating costs of the vessel and provisions for the crew.

The tag deployed on Fairly provided outstanding data over a period of 219 days, documenting movements out and back into the lagoon via Sebastian Inlet, out the inlet and along the coastline to just south of Ft. Pierce Inlet, back up the coast to the nearshore waters off Vero Beach where it spent the next 40 days, then back to UCFMTRG study site in the lagoon.

Were Fairly's movements typical of juvenile green turtles in developmental habitats or atypical? Capture data collected by both ourselves and the personnel at the St. Lucie Power Plant on Hutchinson Island, approximately 60 km south of the mouth of Sebastian Inlet, suggest the home range of at least some juvenile green turtles may extend over tens or even hundreds of kilometers of Florida's nearshore waters and estuaries. Over the 27 years we have been capturing juvenile green turtles at our lagoon study site, 8 were individuals tagged at the power plant then recaptured by us 3 months to 4 years latter. Three of the green turtles we tagged were recaptured at the power plant 10 months to 1.1 years later. Another turtle we tagged in the lagoon stranded on the beach 4 km north of the Ft. Pierce Inlet 6 months after we released it. At our Sabellariid worm rock reef study site, approximately 7 km south of Sebastian Inlet, we recaptured 3 juvenile green turtles tagged at the power plant 4 months to 5.25 years previously. Five of the green turtles we tagged at the reef study site were recaptured 2 months to 4.5 years later at the power plant. While these may seem to be paltry numbers, considering that we have captured approximately 3,000 green turtles at the lagoon study site and 1,000 at the reef study site, there are two things to keep in mind. Our recapture rates for green turtles are 12.8% in the lagoon and 9.2% at the reef study site; i.e., the chances of recapturing individuals we have tagged (ourselves) are low, much less those tagged by others. Secondly, the power plant does not pit tag their captures. Given the high rate of flipper tag loss (personal observation), we may have unknowingly

captured a number of individuals that were previously flipper tagged at the power plant.

The past 27 years have seen the beginnings of the recovery of green turtle populations in Florida (Witherington et al., 2006; Ehrhart et al., 2007). Based on anecdotal and official fisheries records though, this recovery will need to persist for some time in order to reach the historical level of juvenile green turtle populations in the lagoon. J. A. Henshall (1884) in his book *Camping & Cruising in Florida* described the green turtle fishery in the Indian River Lagoon in the vicinity of Ft. Pierce Inlet. He wrote "...there having been taken last winter (1878) several thousand turtles , varying in weight from twenty to a hundred pounds" which were shipped to northern markets. Mr. Charles Pearke of Sebastian captured 2,500 green turtles during the winter of 1886 (Wilcox, 1896). It needs to be noted that in 1886 Sebastian Inlet did not exist. The closest inlet was at Ft. Pierce, 46 km to the south, which suggests that large numbers of juvenile green turtles were utilizing extensive reaches of the lagoon system as developmental habitat until their population was decimated by the turtle fishery in the late 1800s (Ehrhart, 1983). If the the present day green turtle population in the western Atlantic is to continue to recover, adequate developmental habitats in the lagoon system need to be identified and preserved.

Utility of FastLoc GPS Satellite Tags in Marine Turtle Habitat Utilization Studies

Hazel (2009) demonstrated the substantial increase in the accuracy of positions obtained with FastLoc GPS technology over that of Argos PPTs. The question that may still remain in the minds of many researchers is whether the benefits of using FastLoc GPS satellite tags (Wildlife Computers Mk10AFB tags $3400 each) over Argos PPTs (Wildlife Computers SPOTS tags $1,350 each) is worth the extra expense, or if more data on habitat utilization could have been obtained by deploying 7 PPT tags instead of just 3 FastLoc GPS tags..

Table 2 (page 15) contains the number and percentage of locations obtained per accuracy category for both Argos PPT and FastLoc GPS for each of the turtles. Note that for all three turtles 85.7 % to 94.8% of the Argos PPT locations were location class A or B, i.e., no estimation of accuracy. Location classes 3 and 2 (accuracy of the estimated location within 500 meters of the true position) comprised 5.2% to 10.1% of the locations obtained. On the other hand, 67.9% to 80.4% of the estimated positions obtained using FastLoc GPS data were within 500 m of the true position of the turtle and 42.9% to 50.9% were within 100 m.[1]

Figure 13 (page 16) can be used to illustrate the difference in accuracy of locations obtained using Argos vs. GPS data. Between 27 January and 7 March 69 Argos locations were received, 50 class B, 15 class A, three class 1, and a single class 2. Although the class A and B locations tended to be clustered in the general vicinity of the positions indicated by the GPS data, they are ambiguous enough to question whether Fairly was in the lagoon or in the nearshore waters of the Atlantic. The four class 1 and 2 locations did accurately indicate the true position of Fairly as being in the nearshore waters. There were enough location class 1, 2, or 3 locations obtained during the entire 219 days Fairly's tag transmitted data to follow the movements of the turtle from the UCFMTRG study site, down the coast to Vero Beach, and eventually back to the study site (Figure

[1] 98% of positions obtained with 6 satellites were ± 100 m of the true positions, 100% of positions obtained with more than 6 satellites were ± 100 m.

Table 2. The number of locations obtained per accuracy category for each turtle tracked (LC = location class, Sat. = satellites).

Accuracy of Location	Dylan	Fairly	Jamie
Argos PPT LC 3	1 (2.6%)	4 (1.3%)	2 (2.3%)
Argos PPT LC 2	1 (2.6%)	16 (5.0%)	6 (7.8%)
Argos PPT LC 1	0	15 (4.8%)	3 (3.9%)
Argos PPT LC 0	0	6 (1.9%)	0
Argos PPT LC A	9 (23.7%)	67 (21.4%)	18 (23.4%)
Argos PPT LC B	27 (71.1%)	207 (66.1%)	48 (62.3%)
Total Argos Locations	38	313	77
FastLoc GPS 10 Sat.	0	1..(0.3%)	0
FastLoc GPS 9 Sat.	1 (4.8%)	9 (5.6%)	0
FastLoc GPS 8 Sat.	0	20 (6.2%)	5 (9.8%)
FastLoc GPS 7 Sat.	2 (9.5%)	42 (13.1%)	9 (17.6%)
FastLoc GPS 6 Sat.	6 (28.6%)	52 (19.3%)	12 (23.5%)
FastLoc GPS 5 Sat.	7 (33.3%)	76 (23.7%)	15 (29.4%)
FastLoc GPS 4 Sat.	5 (23.8%)	103 (32.1%)	10 (19.6%)
Total GPS Positions	21	313	51

14 on page 17). Without the GPS data, however, we could not have known for sure that Fairly spent 7 days south of Ft. Pierce Inlet. We would have also lost the resolution of movement provided by the GPS data that allowed the correlation of movement with wave height in late November and December.

There are two questions vexing us concerning the FastLoc tags. First, why did the tags on Dylan and Jamie quit transmitting less than two months after they were deployed? Knowing they were in the vicinity of our study site, we were

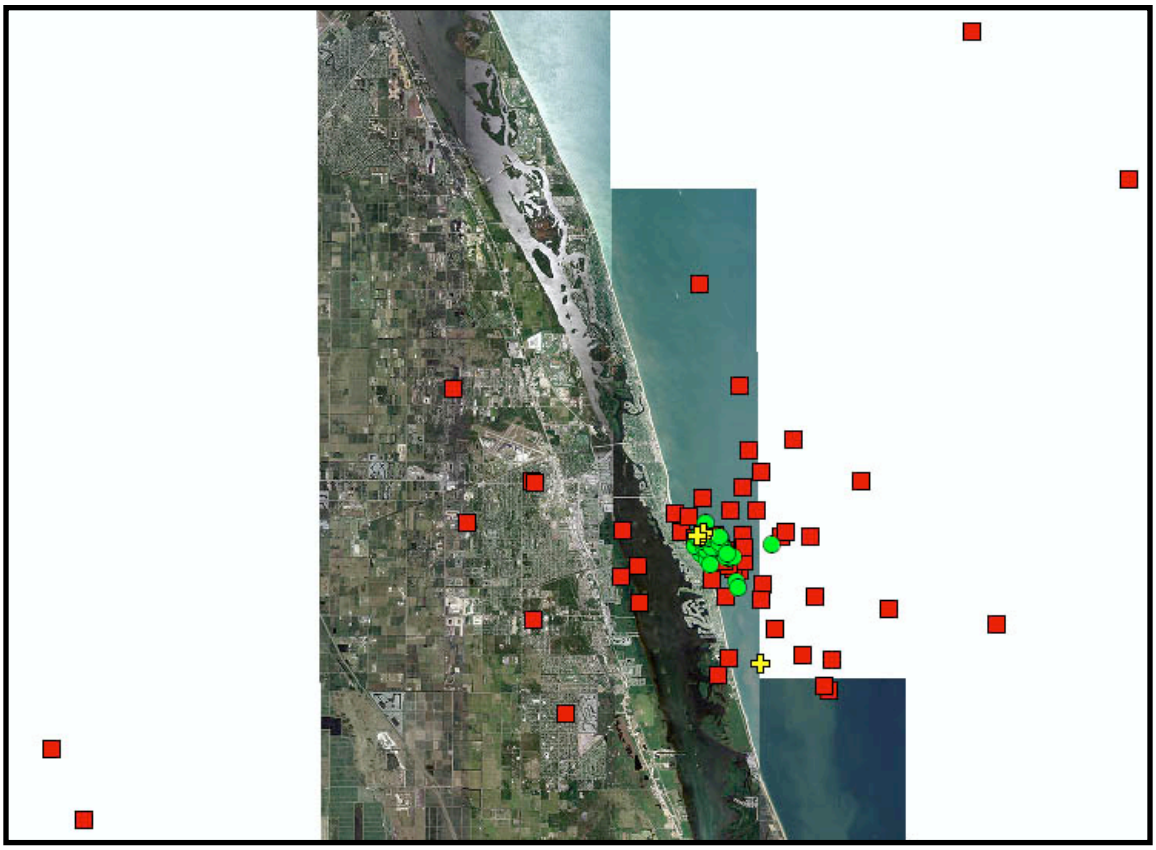

Figure 13. Argos A & B locations (red squares), Argos 1 & 2 locations (yellow crosses), and all FastLoc GPS position green dots) obtained for Fairly 27 January through 10 March, 2009. Two Argos B locations 31 and 42 km east of the center of GPS locations were omitted)

hoping to recapture them to see if they had shed the scutes the tags were attached to, if the epoxy holding the tags on their carapaces had failed, allowing the tags to fall off, or if the Argos antenna had been broken off. Alas, recapture did not occur, which was of no surprise given our low recapture rate.

Secondly, why was there a gap of 58 days in Fairly's GPS data from early March to early May, and again from 16 May to 16 June? Why were only 6 Argos locations received from 13 March to 8 May? Why were there 13 day and 18 day intervals between the acquisition of GPS positions for Jamie in June and July?

The gap in GPS position data may have occurred because the GPS and Argos antennas on the tag became covered with barnacles and algae. S. Ceriani (pers. Com.) observed barnacles growing on a FastLoc GPS/Argos tag she had applied to a nesting loggerhead south of Melbourne Beach, Florida, 3 weeks

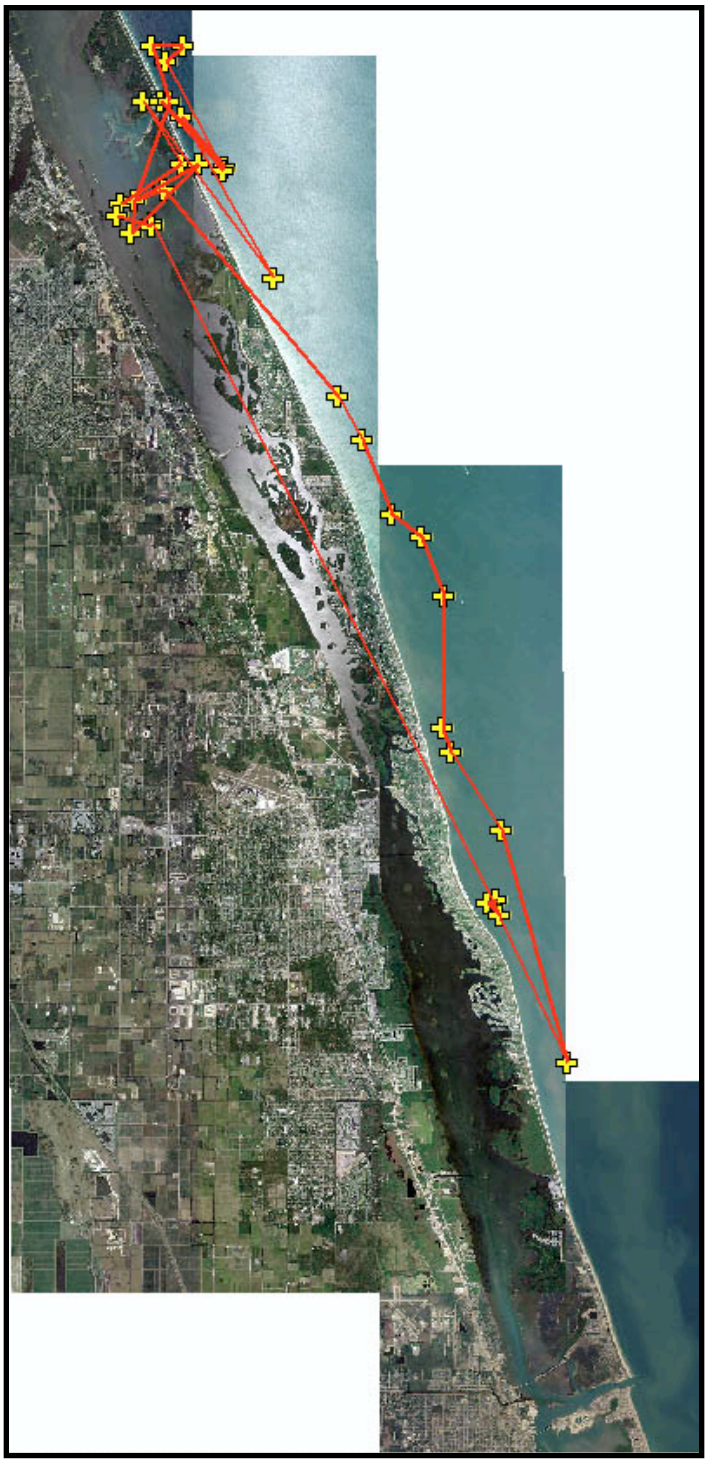

Figure 14. Location class 1, 2, and 3 locations received from Fairly 14 November 2008 to 25 June 2009.

previously. She also noted the growth of algae on the Argos antenna of several other FastLoc GPS/Argos tags applied to nesting female loggerheads on the same beach when she observed them on the beach throughout the nesting season. Could the growth on the tags have become so heavy that it prevented the acquisitions of signals from the GPS satellites and the transmission of data to the Argos satellites? If so, how was the growth dislodged, allowing the resumption of the acquisition and transmission of data, without breaking off the Argos antenna?

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