Activity of juvenile green sea turtles (*Chelonia mydas*) in their foraging grounds through the use of accelerometry

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Introduction

For millions of years, the species of sea turtles have remained largely unchanged on an evolutionary scale. There are seven species of sea turtles found in the world. Unfortunately, due to anthropogenic impacts such as by-catch and pollution, sea turtle populations are in decline and each species is classified as vulnerable, endangered, critically endangered, or data deficient by the IUCN. Juvenile green sea turtles (*Chelonia mydas*) are one of the most prominent sea turtles found in the Bahamas. This is due to the abundance of turtle grass (*Thalassia testudinum*) beds that make up the largest portion of the green turtle diet.

Past studies conducted by Cape Eleuthera Institute (CEI) have found that there was a noted decrease in the abundance of green sea turtles throughout the winter months in the waters of Eleuthera. This could be related to the fact that Southwood et al. (2003) determined that sea turtles go into a state of dormancy when exposed to temperatures of 15º Celsius or lower. However, Southwood et al. (2003) determined that there was no correlation between sea turtle abundance in the winter and summer months. The inconsistency of past research is what drives our study in the foraging grounds of Starved Creek.

We used tri-axial accelerometers to analyze turtle activity. These accelerometers measure the change in direction and speed through three different dimensions: heave, sway, and surge. Another feature of these devices is that they record depth and temperature. Our accelerometers' data can be used as a proxy to analyze activity over time (Shepard et al., 2003). Halsey et al. (2008) determined accelerometry to be an effective way to measure sea turtle activity.

Fig. 1. Accelerometer attached to carapace of juvenile green turtle

The purpose of our study is to investigate the activity of juvenile green sea turtles with accelerometers in their foraging grounds. We will be able to utilize past data on juvenile green sea turtles collected by CEI in Starved Creek as well as collect new data through the use of accelerometers. More information about the activity of juvenile green sea turtles can assist in developing protective measures that can be used towards protecting green sea turtles.

Methods

All research was conducted in Starved Creek, South Eleuthera, The Bahamas because researchers at CEI have previously captured and tagged juvenile green sea turtles in this area (Fig. 2).

To capture the turtles, a rodeo-style technique was implemented. The turtle was spotted and chased until it took three breaths, implying that the turtle was slowing down (Fig. 3).

A snorkeler was then placed in the water to swim above the turtle, and once the turtle came up for a breath of air, the swimmer grabbed the turtle under its front flippers (Fig. 4).

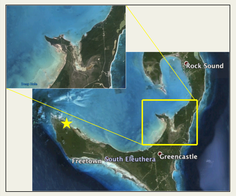

Fig 2. Starved Creek, South Eleuthera, The Bahamas. The site in which all four juvenile green sea turtles were captured and released.

Fig 3. Following the green sea turtle to tire it out, while maintaining close proximity.

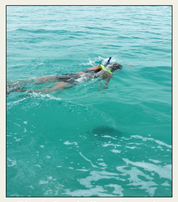

Fig 4. Snorkeling above the turtle while it swims.

Methods

Once captured, the turtle was placed on the boat where morphometric measurements were taken. If the turtle was not previously tagged, we put a tag on each back flipper (Fig. 5).

Before placing the accelerometer, the carapace was thoroughly cleaned with water and rubbing alcohol and was dried (Fig. 6). The accelerometer was attached with epoxy, a strong, glue-like substance, and was placed on the second central scute of the turtle's carapace (Fig. 7).

After approximately forty minutes, the epoxy dried and the turtle was ready to be released in the same GPS location as its capture (Fig. 8).

Approximately two weeks later, the turtle was recaptured, the accelerometer was chipped off with a chisel, and the turtle was released.

Overall Dynamic Body Acceleration (ODBA) was calculated by summing the absolute value of all three axes (heave, sway, surge). Mean morphometric measurements and temperature were also calculated.

Fig 5. Morphometric measurements are taken of the captured juvenile green sea turtle.

Fig 6. Holding the green sea turtle by its shoulder joints, the strongest part of their bodies, in order to maintain control over its movements.

Fig 7. Placement of the accelerometer on the second central scute of the turtles carapace.

Fig 8. Turtle is released with the accelerometer in the same GPS location as original capture.

Results

Population Characteristics:
Turtles captures took place in March of 2015. The total number of individual juvenile *Chelonia mydas* turtles was four (n=4). All juvenile green sea turtles caught were recaptures and the tags were used to identify each individual turtle. For exact morphometric measurements, refer to Table 1.

Table 1. Morphometric measurements (mm) of juvenile *Chelonia mydas* (n=4) caught in Starved Creek, South Eleuthera, The Bahamas.

Tag R	Tag L	SCL min	SCW	Head width	CCL min	CCW	Weight (kgs)	Body Depth
HB8323	HB8293	452	365	69	486	431	13	170
HB8318	HB8317	505	423	77	537	482	19	180
BX3785	BX3786	561	481	83	607	561	26.5	190
BX4934	BX4933	517	413	78	549	490	17	174
	Mean	508.75			544.75		18.875	
	Stdev	44.84			49.68		5.66	

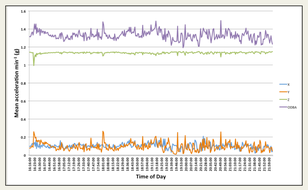

Fig. 9. Mean ODBA, calculated by summing the absolute value of all three axes, and tri-axial acceleration measurements (heave, sway, surge) of an individual green turtle over 5.5 hours.

Results

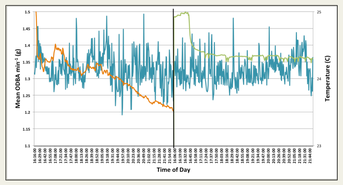

Fig. 10. The mean water temperature per minute (°C) a juvenile green turtle (n=1) experienced over the course of two separate days as compared to its ODBA (g). The minimum temperature that the turtle reached was 23.5 degrees, and the maximum was around 25 degrees.

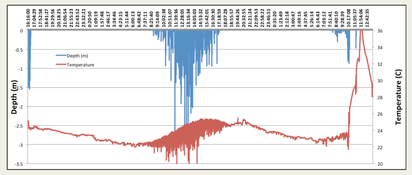

Fig. 11. The range of temperatures (°C) displayed at each depth (m) that a juvenile green turtle (n=1) experienced over a period of two days. The maximum depth that the turtle reached was 3 meters.

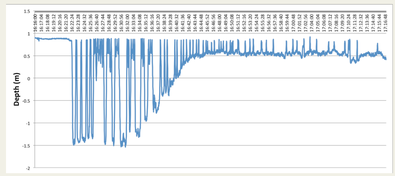

Fig. 12. An example of the fine scale diving behavior of a juvenile green turtle (n=1) over the period of an hour.

Discussion

Acceleration:
The sum of the three axes (heave, sway, and surge) is the overall dynamic body acceleration (ODBA). Figure 9 portrays the juvenile green sea turtle's (n=1) intricate movements throughout these three axes. With the data from the three axes as well as the ODBA, it can be determined how active the turtle is and with how much force the turtle moves. The ODBA of the juvenile green turtle does not change much throughout the deployment of the acclerometer, indicating relatively constant activity.

Water Temperature and Depth
Figure 10 indicates that the juvenile green turtle (n=1) spent most of its time in water temperatures of 23.5 - 25°C. The accelerometer recorded this juvenile green sea turtle's activity throughout two days, from 1600 to 2100 both days. Lower water temperatures occurred during the night, when there was no sunlight. The turtle's activity fluctuates throughout the day and there seems to be no correlation between turtle activity and the time of day. During the times that the mean ODBA is higher, the juvenile green sea turtle could be exerting more energy by swimming or avoiding predators.

Figure 11 is representative of the depths and temperatures experience by the green turtle (n=1) over a period of 48 hours. The turtle showed diving behavior in the middle of the day where there were repeated movements to higher depths. At this same period, a higher variance of temperature was shown, possibly due to the varying temperatures at different depths. The deepest depth reached over the course of the 48 hours was 3 meters. During the night, the turtle experienced shallow depths, suggesting that the turtle spends its time sleeping in the shallow creek waters, possibly to avoid predators.

Specific Diving Behaviors:
Figure 12 is a fine scale representation of the turtle's (n=1) dive activity over a one hour period. As the dives become shallower, it can be concluded that this juvenile green sea turtle is migrating into the shallower waters of Starved Creek. It is also a representation of the high levels of activity that the turtle experiences over one hour.

Discussion

Limitations
There is not a large enough sample size of accelerometer data to make any inferences about the activity patterns of the captured juvenile green sea turtles. There has been difficulties in recapturing the juvenile green sea turtles with accelerometers. To account for this difficulty, more accelerometers could be sent out to increase the statistical chances of recapturing the turtles. Accelerometers are also expensive; it is important to keep this in mind when sending out these instruments because there is always a chance they may not be received.

Future Research
The hope is that the other accelerometers will be relocated and more will be deployed so as to further understand the activity of juvenile green sea turtles. We also hope to send out accelerometers throughout the four seasons to see the changes in juvenile green sea turtle activity throughout the year. In the future, we hope to increase our sample size so that we can make activity-related inferences from the accelerometers. It is vital that we learn about juvenile green sea turtle behavior because this information will aid humans in determining how to protect green sea turtles.

Acknowledgements

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