Beyond maps: combining data-loggers with satellite tags to determine specifics of inter-nesting sea turtle behavior

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Introduction

- Rising sea temperatures resulting from global climate change can have significant impacts on the reproductive habits of sea turtles.
- It is increasingly important to understand the behavior and movement patterns of these animals during their nesting season in order to track temperature-driven changes in activity patterns and reproductive success.
- Here we used high-resolution acceleration-depth-temperature data loggers (ADLs) combined with satellite tags to quantify the behavior and activity-based energy expenditure of sea turtles over their nesting season in second-by-second detail.
- ADLs, the same technology used in smart phones, video games, and FitBits, represent a transformative tool to study marine animal behavior by recording the frequency and force of swimming movements as well as the animal's body orientation at sub-second intervals. These high-resolution data allow us to identify and quantify specific behaviors including resting, swimming, foraging, nesting events, and false beach crawls, as well as assess the energetic costs of these activities.

Methods

- During 2012-2015, we deployed and recovered ADLs from 47 nesting turtles, including 20 loggerheads, 10 green turtles, 7 hawksbills, and 10 Kemps Ridleys. Tags were deployed in the Gulf of Mexico and Caribbean.
- Turtle interception and capture took place after nesting was completed. Following a standard work-up to measure each turtle and take biological samples (i.e., genetics, isotopes), we affixed a Wildlife Computers TDR10 (44) and TDR10-DD (3) to the anterior carapace of each intercepted turtle with slow-curing epoxy (SuperBond™) in addition we adhered platform transmitter terminals (PTTs) with the same epoxy to each individual.

A 

B 

Figure 1. A) An adult female green turtle with ADL and satellite tag post-nesting in Dry Tortugas National Park B) Close-up view of a Wildlife Computers TDR10-DD "Daily Diary" with description of information that is gathered in each axis

Results

- We collected over 775 days of fine-scale behavioral data with simultaneous satellite tag locations.

Table 1. Summary of ADL deployment for each tagging location and recovery rate by species; **Recovered** (Deployed)

Location	*Caretta caretta (Cc)*	*Chelonia mydas (Cm)*	*Eretmochelys imbricata (Ei)*	*Lepidochelys kempii (Lk)*	Totals
Gulf Shores, AL	**5** (12)	0	0	0	**5** (12)
Dry Tortugas National Park, FL	**11** (17)	**7** (11)	0	0	**18** (28)
Cape San Blas, FL	**4** (7)	0	0	0	**4** (7)
Buck Island Reef National Monument, St. Croix, USVI	0	**3** (3)	**7** (9)	0	**10** (12)
Padre Island National Seashore, TX	0	0	0	**10** (16)	**10** (16)
Totals	**20** (36)	**10** (14)	**7** (9)	**10** (16)	**47** (75)
Recovery Rate (%)	55.6	71.4	77.8	62.5	62.7

A 

B 

Figure 2. A) Recovery and removal of TDR10 from a loggerhead B) In-water capture and recovery of ADL from a nesting loggerhead from the Dry Tortugas National Park in the Marquesas Keys

- Depth and acceleration profiles and the satellite tag data recovered from these turtles show significant variability in their diving habits and movement patterns during inter-nesting periods. Some turtles remained close to shore in relatively shallow areas, conducted mainly resting U-dives, while others were more active and traveled as far as 390 km away from their nesting location and exhibited a variety of dive types.
- ADL data can be used to identify nesting events and false crawls (Figure 3). For example, we detected high variability between individual loggerheads, with 33% of turtles false-crawling multiple (up to 8) times whereas 44% did not exhibit any false crawls between nesting events.
- These combined behavioral and movement data indicate that individual turtles exhibit very different behavioral patterns during their inter-nesting periods that result in significantly different levels of energy expenditure, and are thus likely to affect reproductive output.

Conclusions

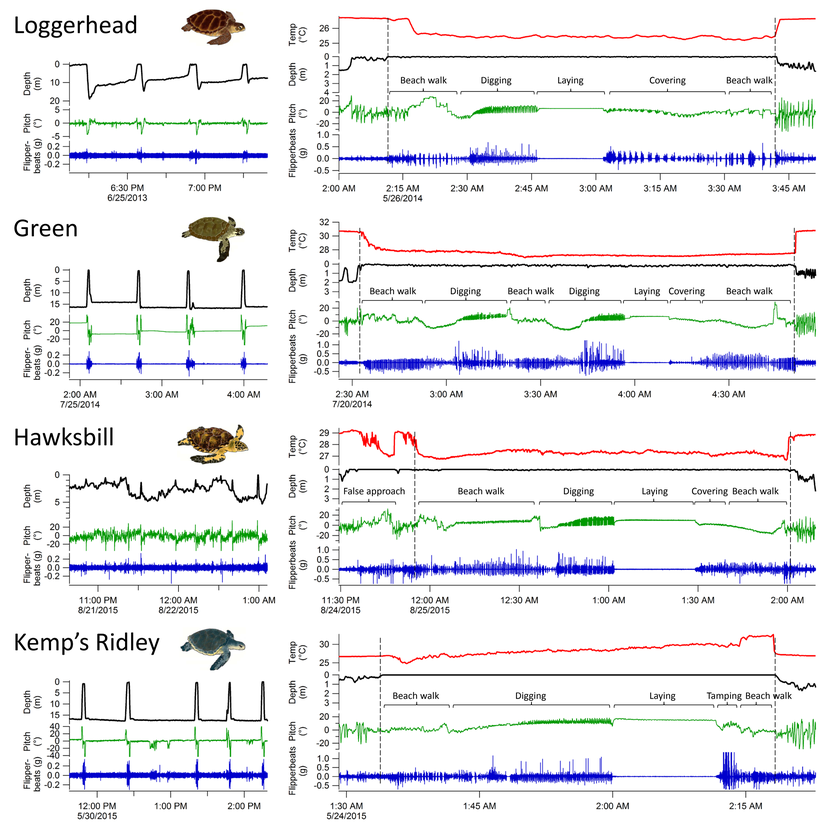

Figure 3. Example ADL data of diving and nesting behavior from four species of sea turtle. Dashed lines represent the beginning or end of a nesting event (i.e., the turtle leaving or entering the water). Loggerhead turtle panel shows S-shaped dives (used during traveling) and a nesting event validated via direct observation. Green turtle panel shows resting U-dives (the most common dive for all species) and the digging of two nests, with eggs laid in the second nest (validated through direct observation). Hawksbill panel shows shallow, active dives common in the 1-2 days preceding nesting in this species, and a nesting event after an initial false crawl and return to the water. Kemp's Ridley panel shows active U-dives (possibly foraging) and a nesting event showing high acceleration characteristic of this species as the nest is tamped down after laying.

Results, continued

Figure 3. An adult female hawksbill turtle with ADL and satellite tag returning to the water post-nesting at Buck Island Reef National Monument

Table 2. Summary of ADL tag duration by species and tagging location

Species	Turtles (#)	Location	Total Tag Duration (days)	Average Tag Duration (days)	Max	Min	SD (+/-)
Cm	7	DRTO	71.1	10.2	19.9	7.0	4.7
Cm	3	USVI	34.5	11.5	12.8	9.9	1.4
Ei	7	USVI	140.6	20.1	32.5	12.8	8.1
Lk	10	TX	163.4	16.3	32.5	7.8	6.9
Cc	5	AL	59.6	11.9	15.8	2.3	5.5
Cc	11	DRTO	259.7	23.6	43.3	7.3	13.3
Cc	4	FL	46.9	11.7	12.1	11.0	0.5

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