Foraging Ecology of Hawksbills In Roatán, Honduras: Insights From In-Water Observations and Stable Isotope Analysis

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Introduction

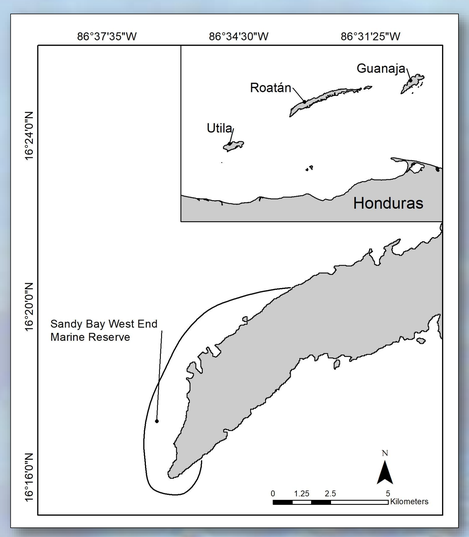

Figure 1. Geographic location of the Sandy Bay West End Marine Reserve on western end of Roatán, Bay Islands, Honduras.

- Marine protected areas (MPA) most effective when encompassing entirety of animals home range.
- MPAs often fail because of establishment before research conducted to determine optimal efficacy (Agardy et al., 2011).
- MPAs becoming increasingly important to sea turtles due to anthropogenic impacts (Amorocho, 1999).
- Critically endangered hawksbill sea turtle (*Eretmochelys imbricata*) has been recorded in coral reefs, mangroves, and sea grass beds (Meylan, 1988; Bjorndal & Bolten, 2010; Gaos et al., 2012).
- Geographic variability in foraging provides evidence that hawksbills are opportunistic foragers (León & Bjorndal, 2002).
- Forbes & Limpus (1993) introduced a non-lethal gastric lavage method, but only provides contents of foraging items within hours or days.
- Researchers have recently used stable isotope analysis (SIA) to determine foraging prey items within weeks to months.
- Our study provides the first data for the western Caribbean and aims to determine if the Sandy Bay West End Marine Reserve (SBWEMR) adequately protects hawksbill foraging resources within its bounds (Figure 1).

Methods & Materials

Figure 2. In-water capture of a juvenile hawksbill.

- We conducted 20-30 min in-water focal follows of juvenile hawksbills and recorded amount of time foraging.
- After focal follows, we hand captured each hawksbill and brought to a temporary laboratory facility (Figure 2).
- We collected morphometric data, blood and carapace samples, and conducted esophageal lavage.
- Esophageal lavages were conducted by two researchers and an assistant using rubber tubing with softened edges (Forbes & Limpus, 1993; Figure 3).
- Small samples of hawksbill food items collected during SCUBA and prepared for SIA.
- Red blood cells and plasma samples dried and packaged in tin capsules for SIA.
- Samples analyzed in continuous-flow isotope-ratio mass spectrometer at University of Florida.
- We used MixSIAR to generate Bayesian statistics to investigate hawksbill prey items (Vander Zanden et al., 2012).
- We used SAS to investigate amount of time hawksbills spent foraging on each prey item.

Figure 3. Stephen Dunbar and Dustin Baumbach conducting esophageal lavage on a juvenile hawksbill turtle at the Roatán Dive Center

Results

Table 1. Linear regression data describing amount of time hawksbills spent foraging on algae and sponge during different times of the day.

Time of Day	Type of Food Item	Back-Transformed Mean (min)	n	95% Confidence Limits		p-value
Morning	Algae	67.68	3	24.89	183.99	0.0242
Morning	Sponge	233.69	20	158.64	344.25	
Mid-Morning	Algae	357.00	1	63.15	2018.29	0.4147
Mid-Morning	Sponge	170.47	11	101.12	287.40	
Late Morning	Algae	28.84	3	10.61	78.42	<0.0001
Late Morning	Sponge	585.78	3	215.47	1592.52	
Afternoon	Algae	127.34	13	78.76	205.89	0.1073
Afternoon	Sponge	214.56	17	140.96	326.60	

- We recorded > 5 hrs of focal follows and discovered hawksbills spent more time foraging on sponge during the morning and late morning (Table 1).
- We noted significantly less sponge foraging events than algae in the afternoon when compared to the morning (OR = 0.196; 95% CI OR = 0.048, 0.805; p = 0.0238).
- We observed most turtles had sponge (*Geodia neptuni*) rather than algae (*Kallymenia liminghii*) in esophageal samples (Table 2).
- We found both sponge and algae in esophagus of two juvenile hawksbills.
- We found no difference in the stable carbon and nitrogen signatures when comparing hawksbill sizes (Figure 4).
- Deviance information criterion (DIC) values indicate that the red blood cell isospace plot represents best model for interpreting juvenile hawksbill foraging.
- Isospace plots from stable isotopes for plasma and red blood cells showed juvenile hawksbills primarily foraged on *G. neptuni* (Figure 5).

Table 2. A description of items obtained from esophageal lavages.

Turtle ID	Date Captured	CCLmin (cm)	Weight (kg)	Tag Number	Esophageal Lavage Item
RMP T014	9/20/17	57.2	21.8	BBQ202	Geodia
RMP T017	8/24/17	57.5	21.2	BBQ310	Geodia
RMP T018	9/18/16	61.4	20.5	BBQ143	Geodia
RMP T019	8/11/17	59.9	20.6	BBQ326	Kallymenia
RMP T023	7/11/17	53.2	15.2	BBQ309	Geodia
RMP T025	8/11/17	56.1	20.2	BBQ152	Geodia
RMP T031	7/9/17	52.6	15.8	BBQ318	Geodia
RMP T039	7/27/17	52.8	15.8	BBQ315	Geodia
RMP T043	9/21/17	44.0	9.4	BBQ348	Kallymenia
RMP T047	7/17/17	65.1	28.8	BBQ150	Geodia
RMP T048	7/14/17	57.4	22.0	BBQ260	Geodia
RMP T053	9/13/16	41.1	8.68	BBQ261	Geodia
RMP T068	7/27/17	63.5	26.4	BBQ258	Kallymenia
RMP T069	8/30/16	54.7	22.3	BBQ387	Geodia
RMP T085	9/3/17	38.0	6.4	BBQ170	Geodia
RMP T087	7/7/17	53.7	15.2	BBQ333	Kallymenia
RMP T092	9/2/16	60.1	26.5	BBQ263	Geodia
RMP T100	9/5/16	40.7	10.4	BBQ116	Geodia
RMP T104	9/18/16	63.7	31.4	BBQ163	Geodia
RMP T104	7/25/17	64.7	31.4	BBQ163	Geodia
RMP T110	8/31/17	39.2	6.4	BBQ303	Geodia
RMP T117	7/7/17	58.2	20.4	BBQ210	Unknown
RMP T121	7/18/17	48.0	12.2	BBQ115/ 398	Kallymenia
RMP T123	8/10/17	50.8	13.2	BBQ277	Geodia
RMP T124	8/20/17	48.2	12.2	BBQ157	Kallymenia & Geodia
RMP T125	8/15/17	57.1	19.8	BBQ199	Kallymenia
RMP T126	8/20/17	43.4	9.2	BBQ220	Kallymenia & Geodia
RMP T127	8/22/17	40.1	6.6	BBQ325	Geodia
RMP T129	8/28/17	41.7	8.2	BBQ374	Geodia
RMP T132	9/5/17	43.5	10.4	BBQ364	Geodia
RMP T133	9/6/17	48.7	13.2	BBQ294	Geodia
Mean		**52.0**	**16.7**		
Standard Deviation		**8.4**	**7.3**		

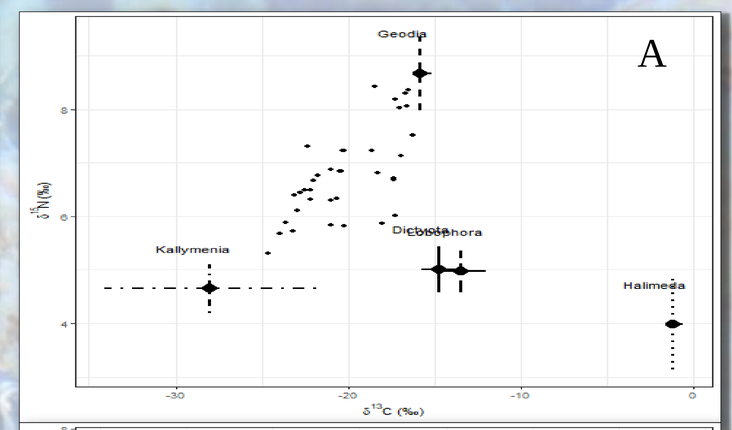

Figure 5. Isospace plots from A) plasma and B) red blood cells showing juvenile hawksbills clustered around the sponge prey item *Geodia neptuni* but spread to the alga *Kallymenia liminghii*.

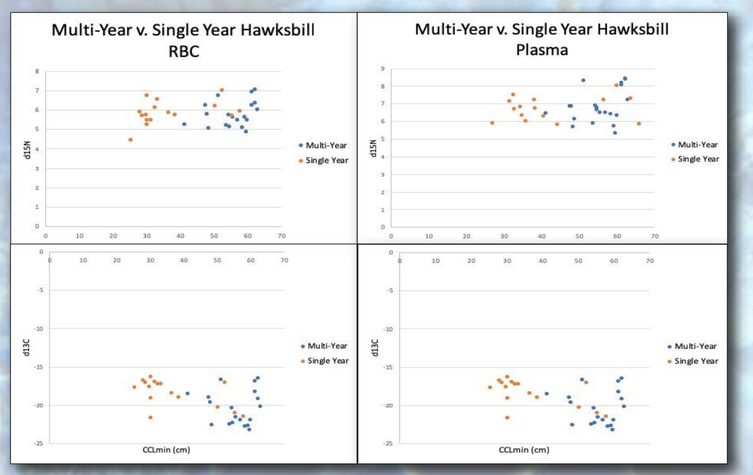

Figure 4. Stable carbon and nitrogen values by hawksbill sizes for hawksbills seen in only one year or over multiple years.

Discussion

- First study to record hawksbills foraging on the alga *K. liminghii*, although Hart et al. (2013) observed hawksbills foraging on an unidentified red algae.
- Our results indicate hawksbills spent more time foraging on *G. neptuni*, which agrees with a previous study in Roatán (Berube et al. 2012).
- Data from focal follows have small sample sizes and should be interpreted with caution.
- First-ever stable study to report SIA data on hawksbills within the western Caribbean. Only one other study reported hawksbill stable isotope data, but in the eastern Caribbean (Bjorndal & Bolten, 2010).
- Discrimination factors were used from juvenile loggerheads, since no discrimination factors previously developed for hawksbills (Vander Zanden et al., 2012).
- Hawksbill foraging did not differ between sizes or over multiple years, indicating that sub-adult and juvenile hawksbills may forage on similar prey items.
- We suggest further investigation of prey items to determine their benefit to hawksbills within the SBWEMR.

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