Effects of Diel Cycle on Observed Behavior and Abundance of the Southern Stingray, *Dasyatis americana*

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Kate Sutter is majoring in urban studies and environmental policy. An avid SCUBA diver, she spent Fall 2013 abroad in the Turks and Caicos working as a research assistant. Studies included coral bleaching acceleration, lemon shark ecology, lionfish invasion patterns, sea turtle growth rates and stingray behavior. She currently works at the American Museum of Natural History and hopes to continue in the field of marine biology and ecology. Having traveled to all seven continents, she aspires to dive them all, too.

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**ABSTRACT**

The aim of this study is to begin to understand diel patterns of the Southern stingray (*Dasyatis americana*) in an effort to identify and fill the large biological and ecological knowledge gap of the species. Encounter rates from timed swim surveys were used to analyze the effects of diel stage on abundance (rays sighted per hour) and behavior (foraging, resting, buried, swimming) at four sites around South Caicos, British West Indies. Differences were found in activity patterns between one-hour intervals, but the only variable that showed significant differences was observed disc width (larger) vs. hour (1400). Stingray activity patterns in these tropical reefs could be affected by prey availability, avoidance of humans, or thermoregulation. Limited research on elasmobranchs has been published and this study intends to provide more details on the ecological behavior of the southern stingray.

**INTRODUCTION**

The southern stingray, *Dasyatis americana*, is becoming a popularly researched species in the scientific world due to its rapid population decline. This new curiosity has led to an influx in basic behavioral and ecological research. The southern stingray is classified as “Data Deficient” by the International Union for the Conservation of Nature (IUCN), because so much more data still has to be collected and analyzed (Grubbs 2006).

Many studies describe the physical biology and ecology of Southern rays, but there are relatively few published behavioral studies. Understanding abiotic factors such as...
tides, temperatures, salinity, and depth is key to understanding the behavioral patterns and shifts expressed in diurnal (day), crepuscular (dusk and dawn), and nocturnal (night) movement of *D. americana*. Changes in behavior have been commonly attributed to tidal fluctuations (Huish & Benedict 1977; Teaf 1980), temperature, light (Wolfe & Tan Summerlin 1989), and salinity (Ortega et al. 2009), yet only two studies exist addressing specifically on diel-associated behavior (Cartamil et al. 2003; Tilley 2013). Diel shifts are largely defined by change of temperature, predation risk, tides, and prey habitation, which could effectively be the driving factors for behavioral variation. Evaluation of anthropogenic factors could also significantly influence diel patterns. However, more information is needed in order to understand diel-associated behavior on shallow water reefs. The focus of this study is the behavioral patterns of the Southern stingray in relation to diel periods. Other variables, such as encounter rate and observed disc width, will also be examined in association with diel period. This study contributes to the understanding of behavioral and biological patterns of rays in an effort to fill a knowledge gap and advance conservation management.

**METHODS**

**STUDY SITE**

This study, conducted under the supervision of the School for Field Studies, was undertaken at four separate sites off the coast of South Caicos (N21.5094°, W71.5178°W), in the Turks and Caicos Islands, British West Indies. Three of the four sites—Shark Alley (N21° 29.021', W71° 32.053'; Figure 1. Label A), The Grotto (N21° 28.836', W71° 31.743'; Figure 1. Label B), and Spanish Chain (N21° 29.015', W71° 31.271'; Figure 1. Label C)—are located on the easternmost coast. The other site, Coast Guard (N21° 34.520', W71° 29.667'; Figure 1. Label D), is situated on the northernmost tip of the island. These sites are known to be a common place for multiple sightings of stingrays.

**DATA COLLECTION**

Observations of *Dasyatis americana* were collected at four sites. After 26.5 hours of timed surveys, a total of 169 observations were recorded between 2013 October 23 and 2013 November 26. The number of observed hours, individual sightings, and methodology differed between sites depending on tide strength, visibility, and depth (Table 1).

Each transect was sampled twice in a random pattern by two pairs, averaging an 80-minute transect. The surveyed area spanned anywhere between 100 m² to 1300 m². Quantitative observations of depth and time were recorded alongside categorical notes such as sex (determined by presence or lack of claspers), and behavior (buried, swimming, foraging, or resting). A photo was taken directly above the individual with a 40 cm T-Bar next to the ray to accurately record the disc width. Other subjective notes including associated species, scars, marks, or any other unique identifier were also noted.

**DATA ANALYSIS**

Encounter rate was calculated according to relative abundance and time in the field. All data distributions were checked for normality using the Shapiro-Wilk goodness-of-fit test. Wilcoxon non-parametric analysis was conducted to check for significance in mean disc width data. A multivariable comparison Wilcoxon test was used for each pair to find specific significant differences in the behavior-time distributions. All data analysis was carried out using JMP 10 statistical software (SAS Institute Inc.).

**RESULTS**

**MEAN DISC WIDTH (CM) VERSUS TIME OF DAY OBSERVED**

A total of 169 rays were observed. Disc width sizes ranged from 30 cm to 185 cm but later proved not to be normally distributed. (Figure 2). It was determined that there was a high correlation between time of day and observed disc size (Figure 3). Rays encountered within an hour of 1400 hours were significantly larger than rays observed during all other times (z > -4.52, p < 0.0321). There also was a difference in size observations between 0900 hours and 1600 hours (p = 0.0195).

<table>
<thead>
<tr>
<th>Transect Site</th>
<th>Method</th>
<th>Total Observed Hours</th>
<th>Total Sightings</th>
<th>Encounter Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastguard</td>
<td>Snorkel</td>
<td>9.17</td>
<td>44</td>
<td>4.80</td>
</tr>
<tr>
<td>Shark Alley</td>
<td>Snorkel</td>
<td>8.32</td>
<td>49</td>
<td>5.89</td>
</tr>
<tr>
<td>Grotto</td>
<td>SCUBA</td>
<td>5.98</td>
<td>54</td>
<td>9.03</td>
</tr>
<tr>
<td>Spanish Chain</td>
<td>SCUBA</td>
<td>2.25</td>
<td>17</td>
<td>7.56</td>
</tr>
</tbody>
</table>

Table 1. Administered method, total number of sightings of *Dasyatis americana*, encounter rate (stingrays per hour), and total minutes at each surveyed site on South Caicos.
BEHAVIOR AND TIME OF DAY

The most common behavior observed was swimming. When data was skewed to calculate relative sighting-behavior relationships, swimming was the most prominently observed behavior except at hours 1100 hours, 1400 hours, 1600 hours and 1700 hours. At 1100 hours, 45% of observed rays were buried and 18% were swimming. At 1400 hours, an equal number of rays were observed swimming and buried (37.5%). The sample size observed in the hours after 1600 hours is so small that they are classified as outliers.

DISCUSSION

Although D. americana is not locally endangered in the Turks and Caicos Islands, it is a target fishery species in other regions around the world. No previous stingray research has been conducted in the Turks and Caicos, so this study is the first of its kind.

The results of this study imply that more encounters occurred within an hour of 1400 hours compared to the other studied hours. A plausible explanation for this phenomenon could be behavioral thermoregulation. Their need for heat would cause a tendency for rays to reside in shallower waters during times when they need energy. The sun is directly overhead at noon, and the few hours following that peak in diurnal cycle would in theory be the time when surface and shallow water temperatures are highest, in a phenomenon called “daily temperature lag” (Barrans 2012) (figure 5). The hottest hours are the hours following 1200 hours because the Turks and Caicos Islands follow daylight savings time, which means true noon is closer to 1300 hours. Because the study excluded 1200 hours and 1300 hours as an observed time, 1400 hours was the hottest hour that we conducted observational surveys, thus resulting in the highest sightings of rays at that time. Basic human observation tendencies could account for the sightings of larger rays. Observers could have overlooked smaller rays and only recorded the larger, more obvious rays.

Resource exploitation is another possible explanation for increased number of sightings at midday. Warmer waters attract more rays, which become more active due to the heat. Bigger rays exploit resources in warmer waters, preventing smaller rays from foraging in the popular localities. This theory is based on simple size-competition dynamics, which could explain larger observed rays during warmer hours of the day.

Basic study bias had an important effect on these results. Observers analyzed data collected from 17.5 hours of snorkeling in shallow waters compared to only 9 hours of diving in deeper waters. This results in notable data deficiency for the colder, deeper waters. If southern sting rays migrate to warmer waters during the day they probably migrate back to cooler waters at nighttime. A cause of this migration could be an increase in substrate rugosity for purposes of protection.

Diel cycles affect not only rays but also the behavior of their predators and prey. The southern stingray’s primary natural predators, coastal sharks, are predominantly nocturnal foragers (Cartamil et al. 2003). One study mentions “large rays to be distributed more in shallow areas at night and dawn, whereas small rays were in shallow waters dur-
ing the daytime and dusk” (Tilley 2013). This distribution implies that there is a correlation between predation risk and diel period because of thermoregulation. The large rays dominate the safer localities at night while energy is low. Predation could then be a plausible driving factor of diel-associated movement.

Results also showed that swimming was the most commonly observed behavior. Although this correlation proved to be insignificant, the data is fascinating. Swimming was observed at a high rate possibly due to factors such as predation or avoidance of humans. During the surveys, divers and snorkelers created high disturbances, which in turn could have startled rays and caused them to swim away. Once swimming, rays are more easily detectable. This is significant because it addresses a possible bias in future studies.

In future studies, observations should be conducted for a longer period of time at longer durations. Result accuracy increases with larger sample sizes and longer study periods. Human disturbance may skew results, so increased precaution should be emphasized in fieldwork. Although southern stingrays are not at risk in the Turks and Caicos Islands, information and data gathered from the area can be used to further understand the species. Results showed that larger rays were observed more at 1400 hours than at any other studied hour. Southern sting rays were found to be swimming more than half of the times they were encountered. With detailed ecological knowledge like this, more influential research can be done in tracking reef health, population estimates, and other biological studies.
REFERENCES:


Undergraduate Research Accomplishments: Publications

Stacey Barnaby (FCRH ’11) is first author and Nazmul Sarker (FCRH ’13) is a co-author on the article “Biomimetic formation of chicoric-acid-directed luminescent silver nanodendrites” in Nanotechnology, 23, 294011 (2012). (mentor: Ipsita Banerjee, Biological Sciences).

Stacey Barnaby (FCRH ’11) is first author and Nazmul Sarker (FCRH ’13) is a co-author on the article “Ellagic acid directed growth of Au-Pt bimetallic nanoparticles and their catalytic applications” in the International Journal of Nanoscience, 12, 1250037 (2013). (mentor: Ipsita Banerjee, Biological Sciences).


Stephen Frayne (FCRH ’12) is first author and Stacey Barnaby (FCRH ’11) and Nako Nakatsuka (FCRH ’12) are co-authors on the article “Growth and Properties of CdSe Nanoparticles on Ellagic Acid Biotemplates for Photodegradation Applications” in Materials Express, 2(4), 2012: 335-343. (mentor: Ipsita Banerjee, Biological Sciences).

Stephen Frayne (FCRH ’12) is first author and Stacey Barnaby (FCRH ’11) and Evan Smoak (FCRH ’10) are co-authors on the chapter “Growth of CdSe nanoparticles on Abscisic Acid Nanofibers and their Interactions with HeLa cells” in Smart Nanomaterials for Sensor Application, 2012: 93-110. (mentor: Ipsita Banerjee, Biological Sciences).

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Nako Nakatsuka (FCRH ’12) is first author and Stacey Barnaby (FCRH ’11) and Brian Williams (FCRH ’13) are co-authors on the article “Self-assembling peptide assemblies bound to ZnS nanoparticles and their interactions with mammalian cells” in Colloids and Surfaces B: Biointerfaces, 103, 2013: 405-415. (mentor: Ipsita Banerjee, Biological Sciences).


Nazmul Sarker (FCRH ’13) is first author and Stacey Barnaby (FCRH ’11), Aaron Dowdell (FCRH ’12), and Nako Nakatsuka (FCRH ’12) are co-authors on the article “Biomimetic Formation of Pd and Au-Pd Nanocomposites and their Catalytic Applications” in Soft Materials, 11(4), 2013: 403-413. (mentor: Ipsita Banerjee, Biological Sciences).


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