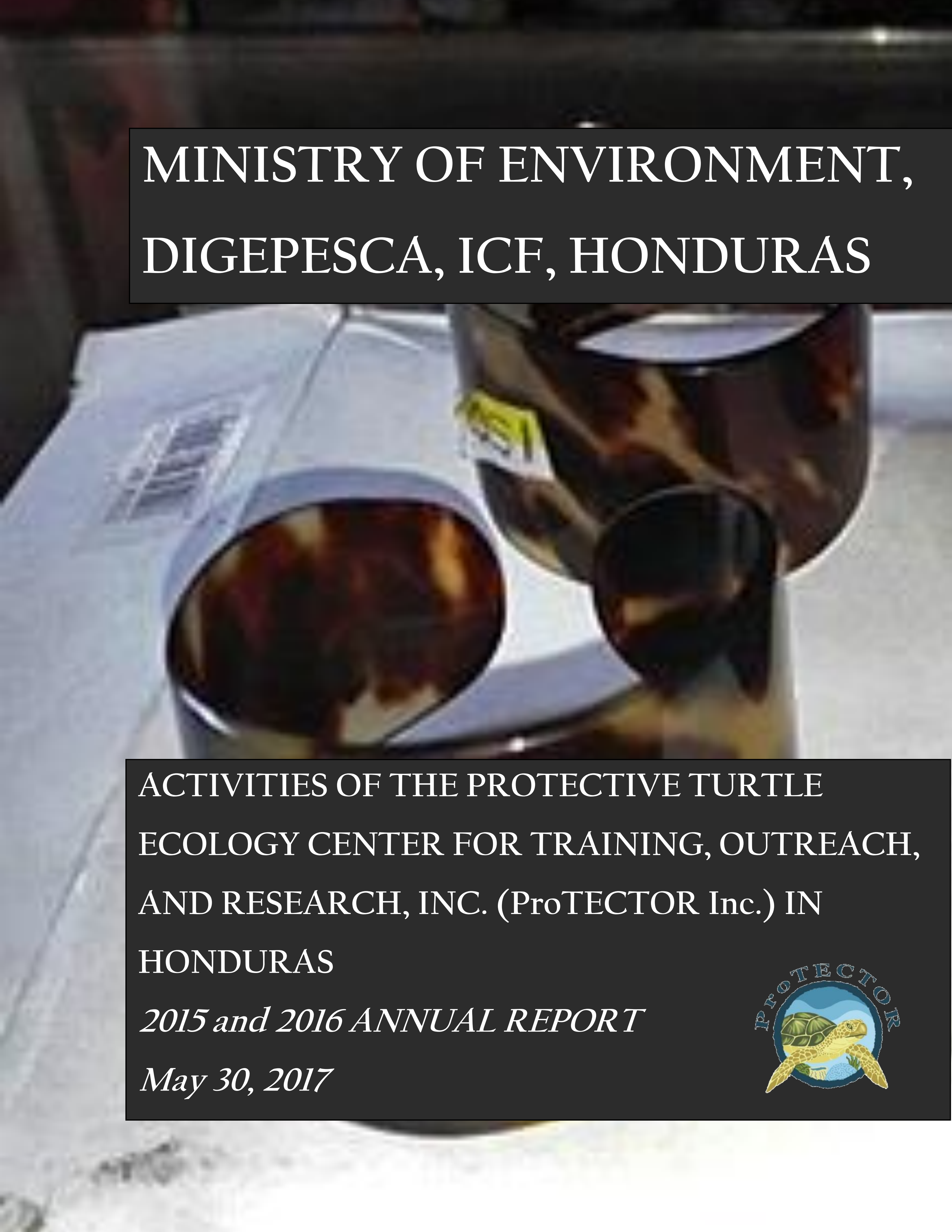

MINISTRY OF ENVIRONMENT, DIGEPESCA, ICF, HONDURAS

ACTIVITIES OF THE PROTECTIVE TURTLE ECOLOGY CENTER FOR TRAINING, OUTREACH, AND RESEARCH, INC. (ProTECTOR Inc.) IN HONDURAS

2015 and 2016 ANNUAL REPORT

May 30, 2017

ACTIVITIES OF THE PROTECTIVE TURTLE ECOLOGY CENTER FOR TRAINING, OUTREACH, AND RESEARCH, INC (ProTECTOR Inc.) IN HONDURAS

ANNUAL REPORT OF THE 2015 and 2016 SEASONS

Principal Investigator: Stephen G. Dunbar[1,2,3]
Co-Principal Investigators: Dustin Baumbach[1,3], Christian T. Hayes[1,3,4], Marsha K. Wright[1,3], and Lidia Salinas[1,2]

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4Christian's current affiliation

PREFACE

This report represents the ongoing work of the Protective Turtle Ecology Center for Training, Outreach, and Research, Inc. (ProTECTOR Inc.) in Honduras. The report covers activities of ProTECTOR Inc. during the 2015 and 2016 calendar years, and is provided in partial fulfillment of the research permit agreements provided to ProTECTOR Inc. by DIGEPESCA and ICF. All published articles resulting from this work have been supplied to the appropriate government agencies of Honduras with this report.

ACKNOWLEDGEMENTS

ProTECTOR Inc. recognizes that without the financial assistance of the Department of Earth and Biological Sciences (Loma Linda University), these ongoing projects could not take place. We are also grateful for the continued partnership of the Roatán Dive Center and the willingness of Mary and Gary Miller to be the sole facility in Roatán to house the ProTECTOR Inc. research efforts. We are grateful to Loma Linda University graduate students Dustin Baumbach, Marsha Wright, and Christian Hayes for directing field studies, to ProTECTOR Inc. Interns Emily Manzano, Ryan De La Garza, Daniel Trujillo, and Justin Cruz Leduc, and to Edward Anger (of Scuba Ted) for all their hard work on field projects. We thank Tanya Berger-Wolf, Chuck Stewart, Jason Holmberg, and Jon Crall, who were supported by NSF Awards 1453555 and 1550880, and through gifts from WildMe, for work on the PID projects. We are also indebted to Mr. Jimmy Miller for his continued assistance in logistical matters while on site in Roatán and Utila. These studies were conducted under approval from the Loma Linda University Institutional Animal Care and Use Committee (IACUC) (Protocol # 89029), and are in compliance with United States and Honduran law. We thank Lidia Salinas, Susanna Ferriera Catrileo (ICF Tegucigalpa), and Cindy Flores (ICF Roatán) for assistance in securing ICF permits, and Eloisa Espinosa and Ing. Blass Cabrera for securing DIGEPESCA, and SAG permits for Honduras. These studies were conducted in 2015 under Honduran permits from DIGEPESCA/SAG (SAG 1950-2015) and in 2016 under permits from DIGEPESCA/SAG (SAG 1950-2015) and from ICF (ICF permit #DE-MP-055-2016).

May 30, 2017

Cover image: Hawksbill jewelry is sold at many local souvenir shops around mainland Honduras. © Lidia Salinas, 2017

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INTRODUCTION AND BACKGROUND

A comprehensive background regarding previous work undertaken by ProTECTOR Inc. on the Hawksbill (*Eretmochelys imbricata*) sea turtles in the Bay Islands, and the need for continuing research on their status and plight in Honduran waters, has been provided in previous reports to DIGEPESCA (Dunbar 2006, Dunbar and Berube 2008, Dunbar and Salinas 2008, 2013, Dunbar et al. 2015). Those reports provided details on methods carried out by ProTECTOR under SAG permits **#DGPA/005/2006; DGPA/245/2006; DGPA/5428/2007, DGPA/707/2009, SAG/251/2010B, and SAG/224/2011**, and provided study results obtained up to October, 2014. The following report provides an overview of project methods and results for studies undertaken in 2015 (under **SAG 1950-2015**) and 2016 (under **SAG 1950-2015** and ICF permit #**DE-MP-055-2016**).

We provide the following report on the activities of ProTECTOR Inc. between January, 2015 and December, 2016, combining two years of activities into the current report. This report provides information on all ProTECTOR Inc. projects throughout Honduras, including the Bay Islands and South Coast. These studies continue with the aim of sampling, tagging, and tracking juvenile and adult hawksbills in their foraging grounds, and sampling, tagging, and tracking adult hawksbills at nesting beaches within our study sites. Additionally, we continue our efforts in community outreach and development of additional sea turtle research and conservation activities, with the aims of benefitting local communities, eco-tourism operators, and marine protected area (MPA) managers with information and recommendations for improved resource management and community outreach. Over the past two seasons, we have continued to further develop strong research, conservation, and ties with the community of Punta Ratón, Utila, and the West End community of Roatán.

Research work carried out in 2015 and in 2016, has provided a basis from which new investigations can be launched into in-water population analyses, in-water monitoring and ecosystem studies, nesting beach monitoring, hatchling migrations studies, the influence of plastic pollution on nesting beaches, and population genetics analyses.

In addition to the work in the Sandy Bay West End Marine Reserve (SBWEMR), additional projects were undertaken in Utila with assistance from the Bay Islands Conservation Association (BICA – Utila) and KANAHAU.

This report has been provided to all appropriate Secretariats, Ministries, and Departments of the Honduran Government, including SAG, DIGEPESCA, SERNA, ICF, and DiBio, in both Spanish and English languages. Data from this report may be included in the annual report for Honduras to the Inter- American Convention for the Protection and Conservation of Sea Turtles (IAC) when appropriately cited.

RESEARCH IN 2015

In 2015, we were unable to continue our active research in the Bay Islands of Honduras due to a long delay in the issuance of the newly required permit from the Honduran Government Institute for Forest Conservation (ICF – the Protected Areas Management Agency). We initiated an application for this permit in May, 2014 and were rejected several times without due notification from the Office of ICF. Despite our efforts to meet all documentation requested by ICF, and receiving word from the ICF office that the permit would soon be issued, were unable to secure the required permit any time during the 2015 research season. Without the required permit, dive operators in the area of the West End of Roatán were unwilling to assist us in even carrying out observational research on the turtles in the SBWEMR. This also resulted in severe protest against ProTECTOR Inc. by some members of the Board of Directors of the Roatán Marine Park organization (RMP)

SCUBA Diving Impacts on Hawksbill Behavior in the Sandy Bay West End Marine Reserve

This study was conducted by Christian, T. Hayes, Dustin S. Baumbach, David Juma, and Stephen G. Dunbar and was published as:

Hayes, C.T., Baumbach, D.S., Juma, D., Dunbar, S.G., 2017. Impacts of recreational diving on hawksbill sea turtle (Eretmochelys imbricata) behaviour in a marine protected area. Journal of Sustainable Tourism 25, 79 - 95.

Recent studies indicate that recreational diving may cause unintended behavioral changes in marine macrofauna. The hawksbill sea turtle (*Eretmochelys imbricata*) is a critically endangered species encountered pantropically by recreational divers in marine protected areas (MPAs). No other studies to date however, have examined the impacts of recreational diving on sea turtle behavior.

We conducted in-water observations of 61 juvenile hawksbill turtles from June 12 to September 2, 2014 in the Sandy Bay West End Marine Reserve (SBWEMR), Roatán, Honduras (Figure 1), to quantify impacts of recreational diving on hawksbill behavior. We recorded turtle behaviors and the number of behavioral bouts to test the effects of diver approach on sea turtle behavior. As a control for diver interactions, we began all observations by recording turtle behavior for approximately 3 – 5 min. To test if diver approach affected a change in turtle behavior, we instructed different sized groups of divers (1 - 4) to slowly approach each turtle. We used the Interactive Individual Identification System (I^3S): Pattern (Version 4.0.1) to test for repeat individuals. To test for associations between behavioral bouts and behavior time, we ran Spearman's correlations. We also ran repeated measures ANCOVAs, comparing the total time turtles engaged in each behavior before and after divers approached turtles. Our results for 1027.3 min of observation time indicated the amount of time turtles engage in eating (16.5%), investigating (16.3%), and breathing (4.0%) activity was highly correlated with the number of behavior bouts of each behavior (Table 1).

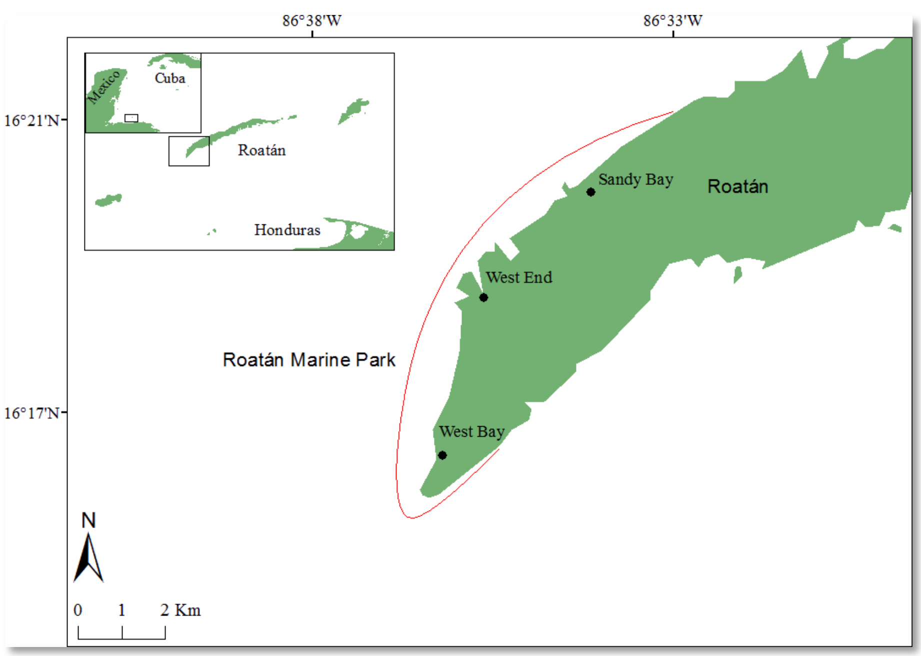

Figure 1. Map of the study site in the Sandy Bay West End Marine Reserve area (outlined in red), with regional view of the Bay Islands (inset).

We also found the mean time turtles spent eating (2.2 ± 0.5 min) and investigating (2.2 ± 0.4 min) (Figure 2), as well as the median time turtles spent breathing (0.5 ± 0.1 min), decreased when approached by divers. Our results suggest diver habituation may negatively impact sea turtle eating, investigating, and breathing behaviors, however, it is unknown if recreational diving has a cumulative effect on turtle behavior over time.

We recommend that MPA managers implement monitoring programs that assess the impacts of dive and snorkel tourism on sea turtles. In our study, we established monitoring of hawksbills, which have the potential to be heavily impacted by dive tourism, as a representative species of reef inhabitants. Furthermore, we provide specific recommendations for continued monitoring of sea turtle populations in other MPAs, recognizing the importance of accounting for diver impacts during in-water studies.

Table 1. Results of timed observations of hawksbill behaviors observed during SCUBA diving in the presence of the turtles.

Behavior	Mean time of each activity ± S.E.	Range (min)	Proportion of observation time
Swimming	7.8 ± 0.7	0.0 – 25.5	57.9
Eating	2.2 ± 0.5	0.0 – 15.9	16.5
Investigating	2.2 ± 0.4	0.0 – 12.8	16.3
Breathing	0.5 ± 0.1	0.0 – 3.6	4.0
Reacting	0.5 ± 0.2	0.0 – 7.0	3.4
Interacting	0.2 ± 0.1	0.0 – 5.8	1.4
Resting	0.1 ± 0.1	0.0 – 3.0	0.4
Scratching	0.1 ± 0.1	0.0 – 0.5	0.1

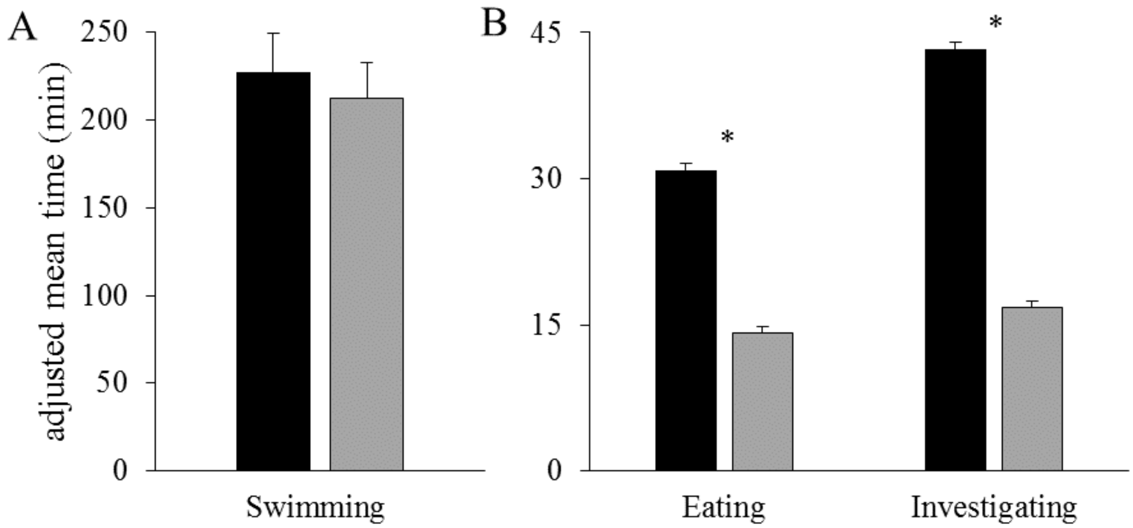

Figure 2. Adjusted mean time of three main activities of observed hawksbill turtles during control (black) and diver approach (grey) periods. There was a significant decrease in the amount of time turtles spent eating and investigating when divers approached compared with when divers were at the control position.

Development of Local and Global Citizen-Science Sea Turtle Monitoring

This study was conducted by Dustin S. Baumbach, Edward Anger, and Stephen G. Dunbar and was published as:

Baumbach, D.S., Dunbar, S.G., 2017. Animal mapping using a citizen-science web-based GIS in the Bay Islands, Honduras. Marine Turtle Newsletter 152, 16 - 19.

Geographic Information Systems (GIS) are changing how ecosystems and individual species are monitored by providing ease of access to wide-scale spatial views. With recent developments in web-based GIS, citizen-scientists are now able to participate with researchers in scientific studies by providing data points of their own observations.

Recently, we developed and launched two interactive maps with nine editable fields for logging in-water turtle sightings around the islands of Roatán and Utila (Figure 4), located in the Bay Islands of Honduras. Ninety-eight dive site locations for the island of Roatán and 74 dive site locations for the island of Utila were mapped with latitude and longitude positions on ESRI’s ArcGIS Online web map. We embedded these maps on the website for the Protective Turtle Ecology Center for Training, Outreach, and Research, Inc. (ProTECTOR, Inc.) and distributed it to dive shops on Roatán for use in logging turtle in-water sightings and uploading photographs and metadata. Dive shops on Utila have not yet been provided with the sightings link because we have not returned to that island since the maps were launched.

To date, 105 sea turtle sightings have been logged for the Roatán map (Figure 5). However, we recognized that dive tourists do not always have immediate access to a computer to log sea turtle sightings.

In order to facilitate the collection of important information, smartphone applications designed to map wildlife sightings are used for citizen-scientists to aid researchers in collecting scientific data. Many smartphone applications are currently available for Androids and iPhones that help log animal information worldwide utilizing GPS positions from the user's phone. We recently designed a smartphone application called *Turtles Uniting Researchers and Tourists (TURT)* (Figure 6) for logging global citizen-science sea turtle sightings. We utilized ESRI's AppStudio native quick report template to specify the basic identifying application information, insert the feature class, and create custom code to provide instructions for logging information. The feature class was then linked to our interactive web map in order to facilitate the ease of logging sightings on Roatán without having to use a computer. We limited identifying information provided to the user to prevent poachers from taking advantage of GPS locations for turtle sightings.

After TURT was released to the Google Play and Apple App stores, we announced the release of the application to the C-Turtle e-mail list and to dive shops in the Caribbean and Southeast Asia. Currently, hundreds of turtle sightings consisting of Greens, Leatherbacks, Hawksbills, Loggerheads and undetermined turtles have been logged for several different countries, as well as states within the United States of America.

We suggest that dive guests should be engaged directly to inspire self-motivation to act as citizen-scientists. However, we have found it challenging to engage the public and other researchers to use these applications, and are currently considering the use of incentives. These data may allow marine protected area managers to easily estimate and monitor sea turtle populations with the combined use of TURT and region-specific web maps.

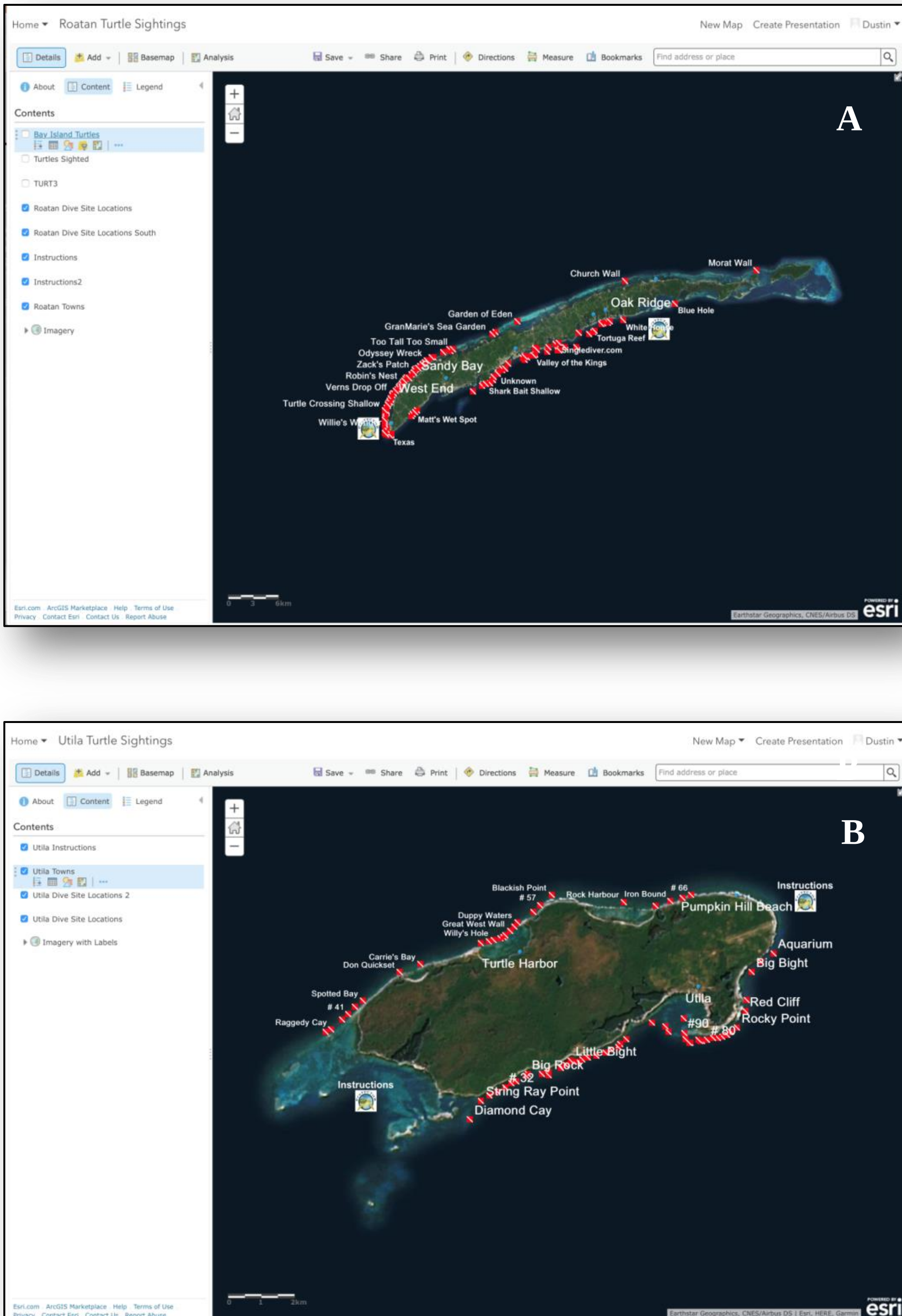

Figure 4. GIS computer-based maps of Roatán (A) and Utila (B) showing clickable dive sites on which sightings of turtles can be recorded by citizen-scientists.

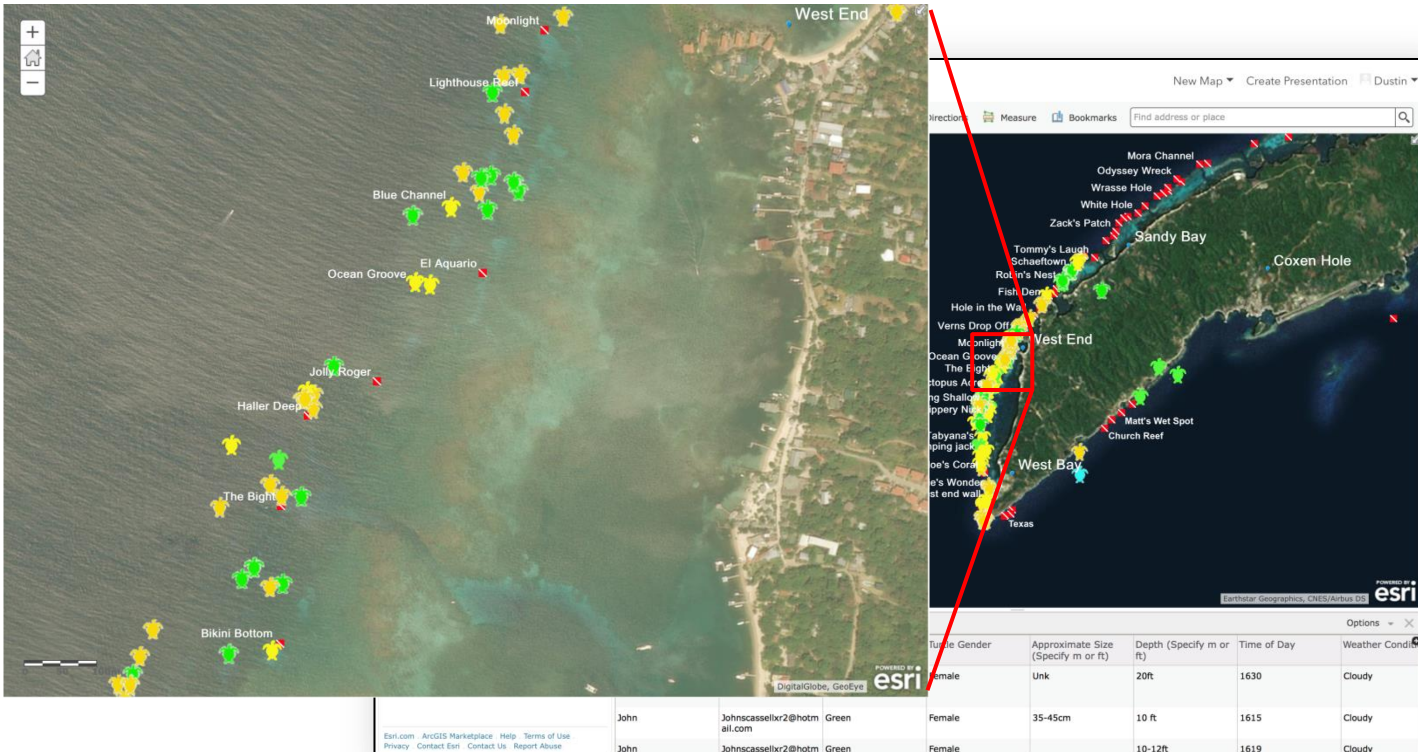

Figure 5. Roatán sightings records map showing details of turtle sightings (zoomed in). Each record contains meta-data, including dive site, date, depth of sighting, and photographs. Photographs can then be extracted from a record to be used in the photo-ID software system.

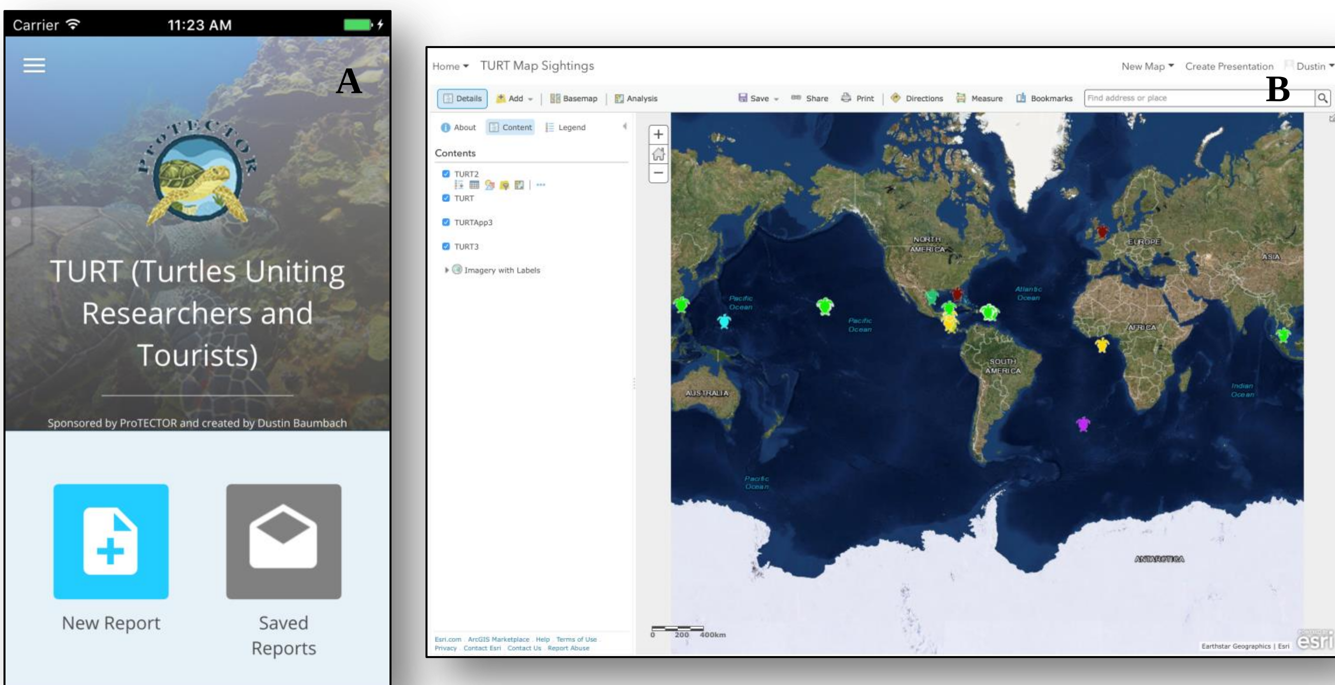

Figure 6. The front page of the Turtles Uniting Researchers and Tourists (TURT) smartphone application (A) and the global map of sightings reported within the app (B).

Area Abundance of Hawksbill Prey Items Within the Sandy Bay West End Marine Reserve, Roatán, Honduras

This study was conducted by Dustin S. Baumbach, Marsha K. Wright, Lidia Salinas, and Stephen G. Dunbar.

Hawksbills are thought to be primarily spongivores throughout their range, helping to control the population of sponges and aiding the health of coral reef ecosystems by limiting competition for space. However, hawksbills have also been observed foraging on small invertebrates and algae.

Recently, Baumbach et al. (2014) observed juvenile hawksbills foraging on sponge (*Geodia spp.*), brown algae (*Dictyota spp.* and *Lobophora spp.*), green alga (*Halimeda spp.*) and red alga (*Kallymenia spp.*) within the Sandy Bay West End Marine Reserve (SBWEMR). Hawksbills have rarely been observed foraging on algae and have not previously been reported feeding on *Kallymenia spp.* throughout their range.

To determine the area abundance of each identified prey item, we conducted representative transects for each of 16 dive sites. Five to seven transects per site were conducted by laying a 30 m rope, marked every five meters with colored string and a number, over a section of the reef. We placed a 1 m^2 quadrat at each of the six markers, taking photographs from approximately 2 m above each quadrat (Figure 7A). Photos were sorted by dive site and transect number, taken into Photoshop CS6 for editing, and imported into Coral Point Count with Excel extensions (CPCe). Each identified prey item was then traced to determine the area of abundance within each dive site (Figure 7B). A percentage of total m^2 for each dive site was computed by dividing the total area of each prey item by the total number of quadrats in each dive site (30, 36, or 42). Mean percent areas and standard deviations were then calculated in Microsoft Excel 2016 for each prey item.

Although hawksbills are known to be spongivores, we found the sponge *Geodia* has the lowest average density for dive sites (0.04% ± <0.001% SD), whereas algae represent the highest average density across dive sites (10.34% ± 0.030% SD) (Figures 8 and 9). *Dictyota* represents the highest average density of the algae (4.51% ± 0.035% SD) followed by *Lobophora* (1.70%

± 0.023% SD), whereas *Halimeda* represents the lowest average density (0.15% ± 0.002% SD) (Figures 8 and 9). *Kallymenia spp.* was not observed during area analysis due to its growth on the underside of corals and thus, is not reported. However, during dives, we were able to locate and collect samples of this prey item for further analysis.

We suggest that the high percentage of dead coral (19.91 ± 6.51% SD) within the SBWEMR provides a large area on which macroalgae may grow. Future studies will investigate the full range of prey items available and their energy benefits. These investigations may help explain why hawksbills are frequently observed foraging on algae, and may help determine if the boundaries of the SBWEMR are adequate for this population.

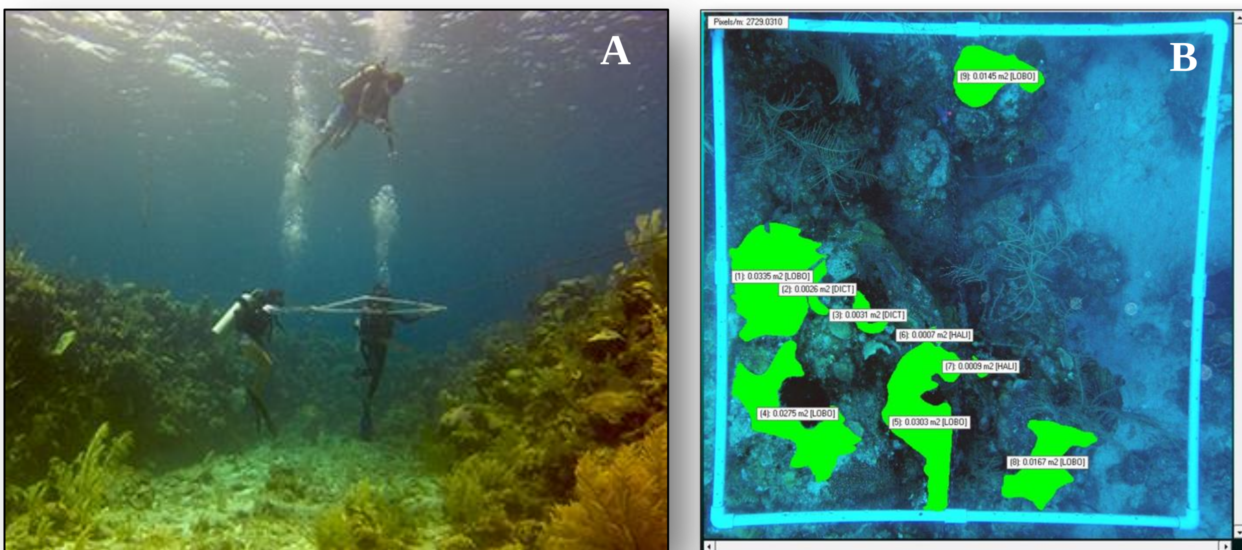

Figure 7. Underwater transect surveys were accomplished by photographing 1m^2 quadrats (A) along randomly placed 30m transects within a dive site location. Photographs were then analyzed in Coral Point Count with Excel extension (CPCe) to calculate the area of each type of item of interest (B).

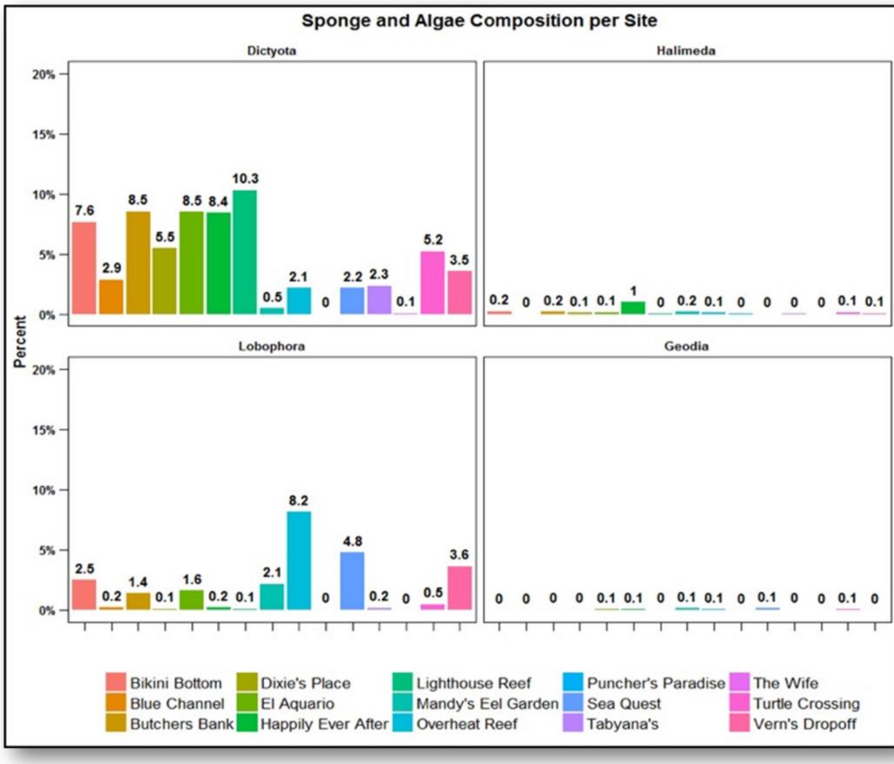

Figure 8. Hawksbill food item area abundance by dive site. The alga, *Dictyota*, is more prevalent across dive sites, whereas the sponge, *Geodia*, is scarce across dive sites.

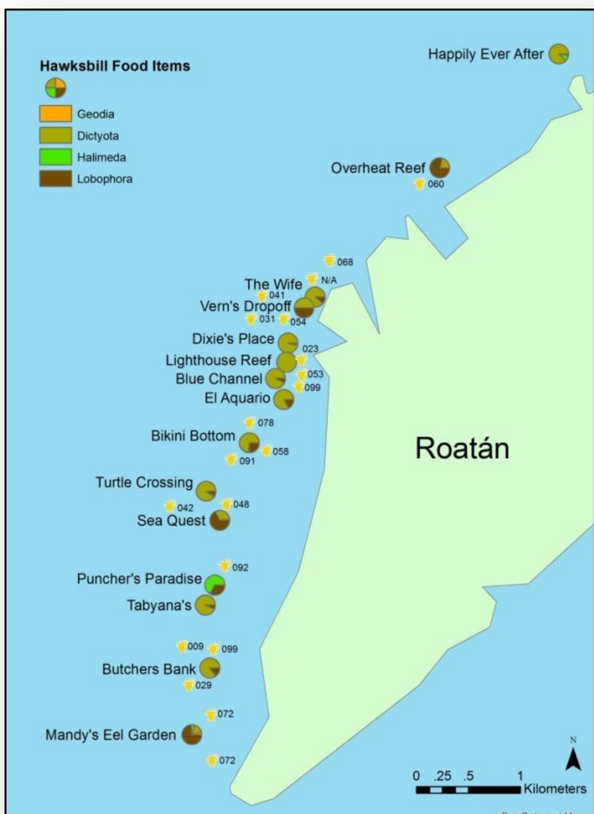

Figure 9. Hawksbill food item area abundance calculated from habitat transects by dive site along with hawksbill foraging sightings.

RESEARCH 2016

HotSpotter: Less Manipulating, More Learning, and Better Vision for Turtle Photo Identification

This study was conducted by Stephen G. Dunbar, Dustin S. Baumbach, Marsha K. Wright, Christian T. Hayes, Jason Holmberg, Jonathan Crall, Tanya Berger-Wolf, and Charles V. Stewart.

The value of individual animals in research increases with the ability to identify each one from other individuals in the population. Individuals are often identified through markings, yet these may impact animal behavior and physiology. Photo ID (PID) has successfully been used to evaluate population dynamics, growth rates, behaviors, and movement in many animal studies, yet only recently emerged in sea turtle research with several studies still reliant on manual photo matching. Turtle studies using computer-assisted programs to match photographs have reported four common challenges that reduce efficiency and viability. These are: 1) the requirement to acquire clear, high-quality images at restricted angles, 2) time-consuming pre-processing of photographs before submission to the database, 3) the potential for high numbers of false matches in program outputs, and 4) the requirement for manual verification of many potential matches provided by the program.

The computer vision program HotSpotter (HS), developed for PID of the Kenyan population of Grévy's zebra (*Equus grevyi*), works by localizing and matching SIFT keypoints using the Local Naive Bayes Nearest Neighbor search algorithm. We used HS to build a database of hawksbill photographs taken in-water during 2014 and 2015. We trained the program by submitting multiple photos of the head and both faces, and queried the program for matches. Initially, whether matches were found or not found, we labelled all photos from a single individual with that turtle's ID number until all photos from 2014 and 2015 were identified and the program trained for all individuals from those years. In 2016, we photographed, captured, and tagged turtles. Tags provided a positive measure of some individuals. Some turtles were photographed, but not captured for tagging. We then tested the database by submitting several head and face photos from each individual photographed in 2016, without providing tag numbers (if available).

From each test a turtle ID number was returned and checked against the tagging record. For each query we visually inspected the top two results (Figure 10). If either of these was correct, the query was marked as returning a correct match. We analyzed for 3 classes of results (true matches, false positives, and false positive new (new turtles that were not present in the database)), as well as compared the program's first choice matches and second choice matches (Table 2).

We developed a database of 251 images from 2014 and 2015 used to initially train HS. From June – December 2016, we introduced an additional 1,155 images to the database for a total of 1,406 photographs. From these, we used a small subset to test HS matching. Out of 111 tests, HS correctly predicted and matched 77.33% of queries in first choice matches and 57.33% of queries in second choice matches (Figure 11). When both first and second choice matches were combined, correct matches increased to 81.33% (Figure 12). Advantages of HS are that the time required to manipulate photos is greatly reduced from other programs, since it requires only inserting two points on each photo to generate a "chip" (the examination field), photos of low quality can be used, and photos taken from many different angles are of benefit in training the program to recognize individuals. Future developments will automatically orient the photo and generate the chip, allowing input of photos and matching processes to integrate without the need for user manipulation.

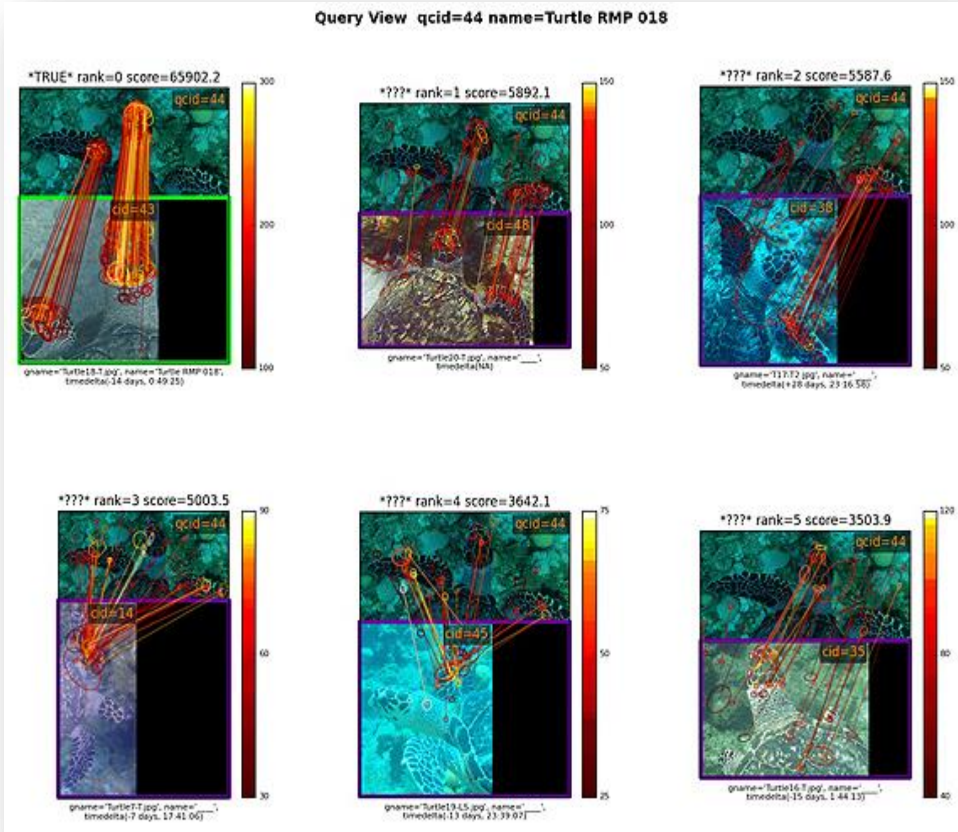

Figure 10. A representative view of a query result, where each query feature matches 1- 10 features in the database photo, forming a potential set of match pairs of photos.

Table 2. Table of analyses of HotSpotter first and second choices for matches of test photographs. We removed False Positive (New) from the analyses (*).

	Mean score ± 1SD (n) [range] for 1st Choice	**Mean Score ± 1SD (n) [range] for 2nd Choice**	**Total n in Both Choices**
True Matches	**8,373 ± 10,058 (58) [347.8 – 65,898.9]**	**4,419 ± 3,249 (43) [458.8 – 12,332.7]**	**61**
False Positives	**1,043 ± 5712 (17) [354.1 - 2,233.5]**	**895 ± 589 (32) [0 – 2,359.4]**	**14**
False Positives (New)*	**1,480 ± 773 (36) [417.3 – 3,871.6]**	**1,068 ± 388 (36) [315.1 – 2,039.8]**	**36**
Total Tests	**(111)**	**(111)**	**(111)**

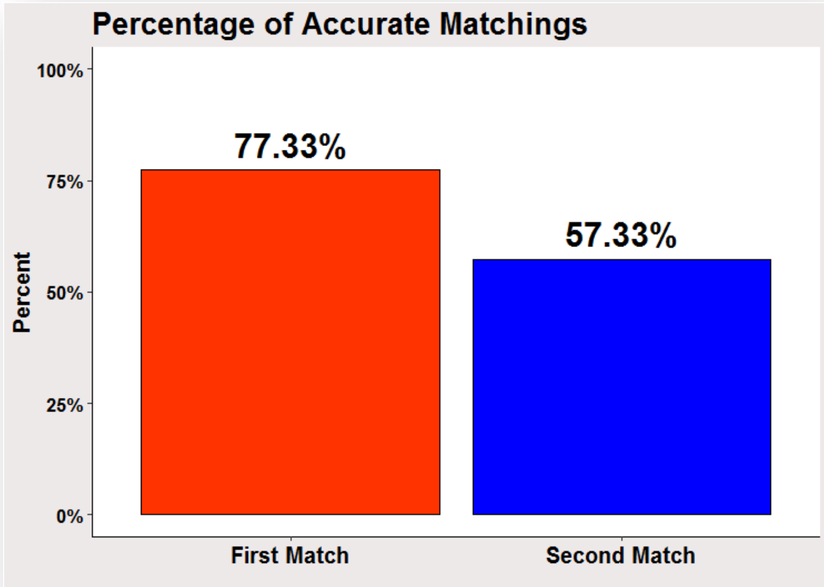

Figure 11. HotSpotter first and second choice matches analyzed independently for accuracy.

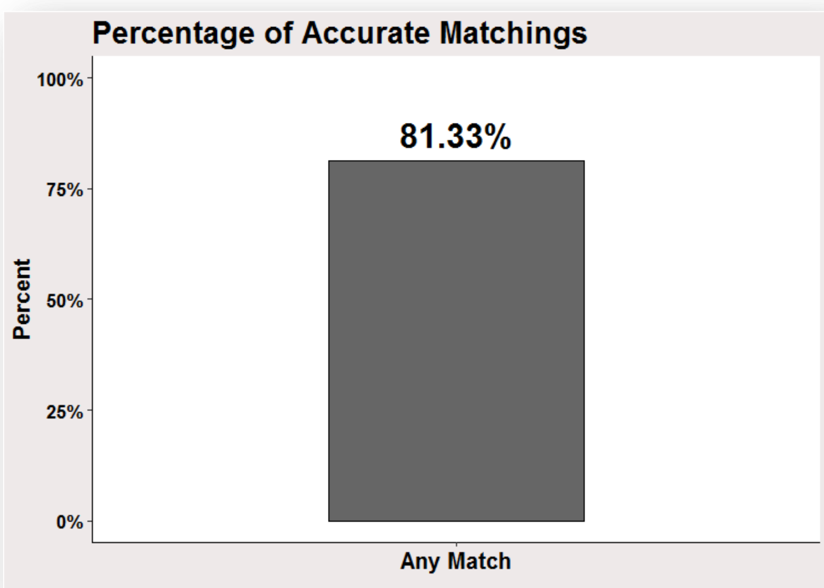

Figure 12. HotSpotter match accuracy when first and second choices are combined.

Beta Testing Nesting Safe – New Technology for Nest Finding and Environmental Temperature Monitoring

This study was conducted by Stephen G. Dunbar, John Bonardelli, Emily Manzano, Ryan De La Garza, and Lidia Salinas.

Locating turtle nests is a challenge, especially on beaches where nest markings allow nest poaching. Yet, regularly locating and monitoring nests *in situ* during incubation are vital for understanding interactions of climate change, nest temperatures, egg development, and sex ratios. Furthermore, monitoring environmental temperatures is critically important in understanding sea turtle nesting biology. However, monitoring environmental temperatures *in situ* during nest incubation or dynamic beach conditions without disrupting the nest or nearby environment has, until now, remained a difficult challenge. This is because previous technology did not permit external monitoring of the devices after burial. Thus, temperature data could neither be detected nor displayed until the monitoring term ended. In some cases, logger failures resulted in loss of time and valuable data.

Nesting Safe developed an innovative application of Radio Frequency Identification (RFID) technology to detect specially designed CRADAL (Concealed RADio Activated Localization) nest tags (Figure 13A) and temperature loggers (Figure 13B) addressing issues of relocating turtle nests and monitoring beach environments. Using a responsive mobile application to record geo-referenced nesting events and temperature loggers allows real time monitoring of nests with selected upload of *in situ* data. After uploading to a referential database, nest emergence times and temperatures are visualized in real time.

We tested Turtle Nesting Safe Professional technology in two field applications. First, we deployed nest CRADAL tags on 5 beaches in countries at variable latitudes to validate positioning and map visualizations in the database. Some nests were relocated to hatcheries with associated tags moved to continue monitoring. We also deployed 2 temperature loggers with integrated sensors, and 2 loggers with 50 and 100cm probes to measure nest temperatures at different nest depths.

Second, we deployed 16 hermetically sealed data loggers on a nesting beach in Utila, Honduras from July 4 – July 28, 2016 in a beach pollution experiment in four corridors with varying amounts of debris coverage to monitor surface sand temperatures (Figure 14). Four RFID temperature loggers were placed in each corridor and set to log temperatures every 20 minutes. Temperature loggers were scanned *in situ* every 4 – 5 days, and data saved in an offline mode on a mobile tablet until uploaded with an Internet connection. Temperature data were automatically stitched in the web database and later analyzed by ANOVA.

We referenced 10 nests and were able to relocate all unmarked nests, and monitor *in situ* temperatures in both natural and relocated nests daily without having to mark or disrupt nests in any way (Figure 15). In Honduras, we found sand temperatures were significantly lower for the high density pollution corridor than for the control corridor by 0.6C during the day (Table 3) and by 0.71C overnight (Table 4).

These and other results demonstrate that Turtle Nesting Safe Professional technology can facilitate real-time nest locating, and nest and environmental temperature monitoring *in situ*. The ability to both locate nests and carry on *in situ* nest and environmental temperature monitoring without disrupting incubation has the potential to provide new insights into factors that influence hatchling success and sex ratios in response to global climate change.

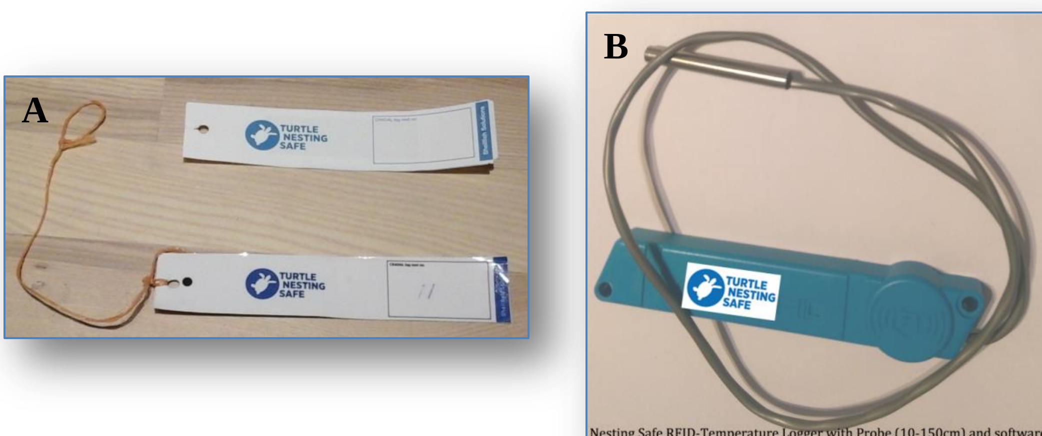

Figure 13. Nesting Safe RFID nest tags (A), and temperature data loggers (B).

Figure 14. Pollution density corridors set up on Pumpkin Hill Beach. Corridors consisted of a control, low density, medium density, and high density pollution.

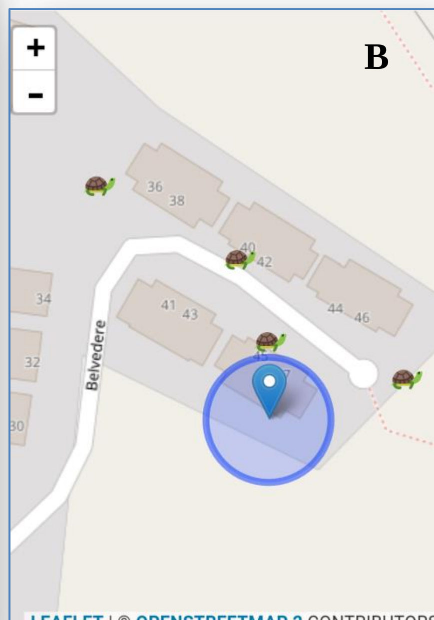

Figure 15. Representative nest tag locations mapped in the database accessed through the Nesting Safe mobile application (A). Detailed, high resolution mapping allows accurate nest finding (B).

Table 3. ANOVA analysis with Tukey post-hoc tests for comparison of mean temperatures in the three treatment corridors and control corridor during the day. Significance level = 0.05

Contrasts	p-value
Low-Control	**0.534**
Medium-Control	**0.947**
High-Control	**0.037**
Medium-Low	**0.810**
High-Low	**0.376**
High-Medium	**0.076**

Table 4. ANOVA analysis with Tukey post-hoc tests for comparison of mean temperatures in the three treatment corridors and control corridor during the night. Significance level = 0.05

Contrasts	p-value
Low-Control	**0.491**
Medium-Control	**0.944**
High-Control	**0.015**
Medium-Low	**0.716**
High-Low	**0.138**
High-Medium	**0.012**

Quantification and Impacts of Nautical Traffic on Hawksbill Presence in an Honduran Marine Protected Area: A Progress Report

This study was conducted by Marsha K. Wright, Dustin S. Baumbach, Daniel Trujillo, Justin Cruz LeDuc, Lidia Salinas, and Stephen G. Dunbar.

Marine protected areas (MPAs) have been implemented to help reduce negative impacts of human activities on marine organisms. However, many MPAs overlook specific threats, such as nautical traffic. Boat presence has been shown to alter typical activity patterns, increase stress, and lead to physical injury in marine animals.

The Sandy Bay West End Marine Reserve (SBWEMR) was implemented to protect the northwestern shore and marine environments of Roatán, Honduras, and the organisms that inhabit them, including the hawksbill sea turtle. However, there are many dive centers, hotels, and marinas in the SBWEMR, all of which generate boat traffic.

To evaluate the variation in boat traffic, and its relation to hawksbill presence throughout the SBWEMR, we divided the reserve into 3 zones: West Bay (WB), West End (WE), and Sandy Bay (SB). We further divided these zones into sectors for counting purposes. The WB, WE, and SB zones were comprised of 4, 5, and 5 sectors, respectively (Figure 16). Boat counts took place over a period of 70 days, with observations in each sector lasting 20 minutes within three time periods: morning (8:30-10:30), midday (12:00-14:00), and late afternoon (14:30- 16:30). Boat counts in each time period were used to calculate boat intensity (i.e. the number of boats passing through an area per hour).

A total of 2,957 boats were counted. Our data did not show a difference in boat intensity between the WB and WE zones (Figure 17). However, boat intensity in the SB zone was significantly lower than both the WB and WE zones. We also found no difference between the morning (WB = 44, WE = 44, SB = 11), midday (WB = 36, WE = 37, SB = 5), or late afternoon (WB = 38, WE = 43, SB = 9) time periods. A total of 93 in-water hawksbill surveys were completed using SCUBA in the WB and WE zones in the morning (WB = 30, WE = 14) and late afternoon (WB = 18, WE= 31). During the surveys, hawksbill sightings were recorded in WB and WE in the morning (WB= 22, WE=12) and late afternoon (WB= 15, WE= 24). Sightings were normalized to account for unequal observations, with no differences in hawksbill sightings observed between zones or time periods (Figure 18).

These preliminary results suggest there is no difference in hawksbill presence in the WB and WE zones. However, more data collection is needed from the SB zone to complete the analysis of turtle presence throughout the SBWEMR. Preliminary in-water observations of hawksbills in the presence of boats suggest that they are indifferent to boat traffic. However, other factors, such as maturity and near-encounters with boats, could affect their responses.

Further studies of juvenile hawksbills in the presence of boats will help clarify the impacts of boat traffic on hawksbill behavior and their resulting distribution throughout the reserve. Data collected from this study can be used to determine the adequacy of the marine reserve and if boat traffic should be monitored and regulated.

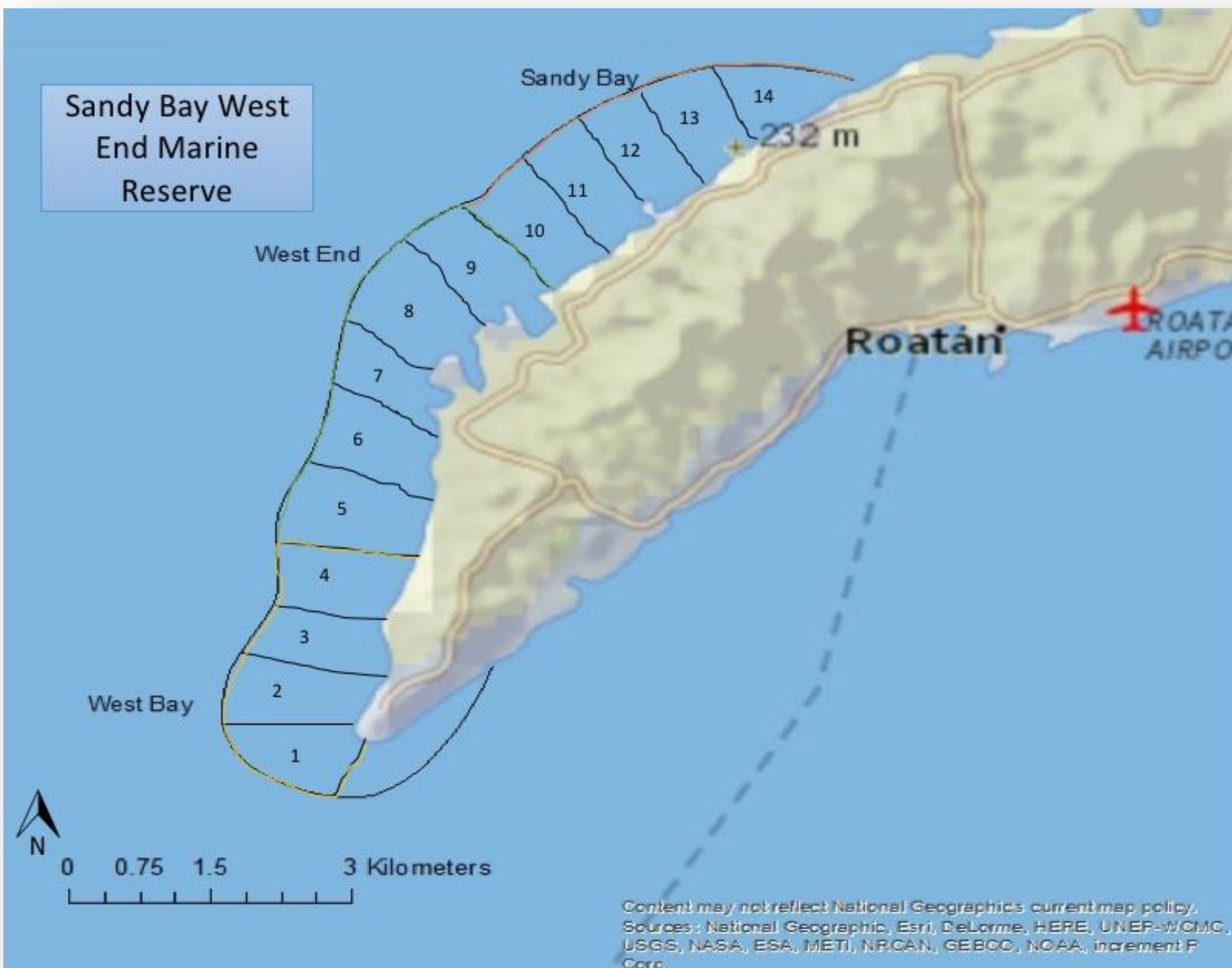

Figure 16. The Sandy Bay West End Marine Reserve (SBWEMR) divided into zones and sectors to facilitate boat counts and comparative analyses.

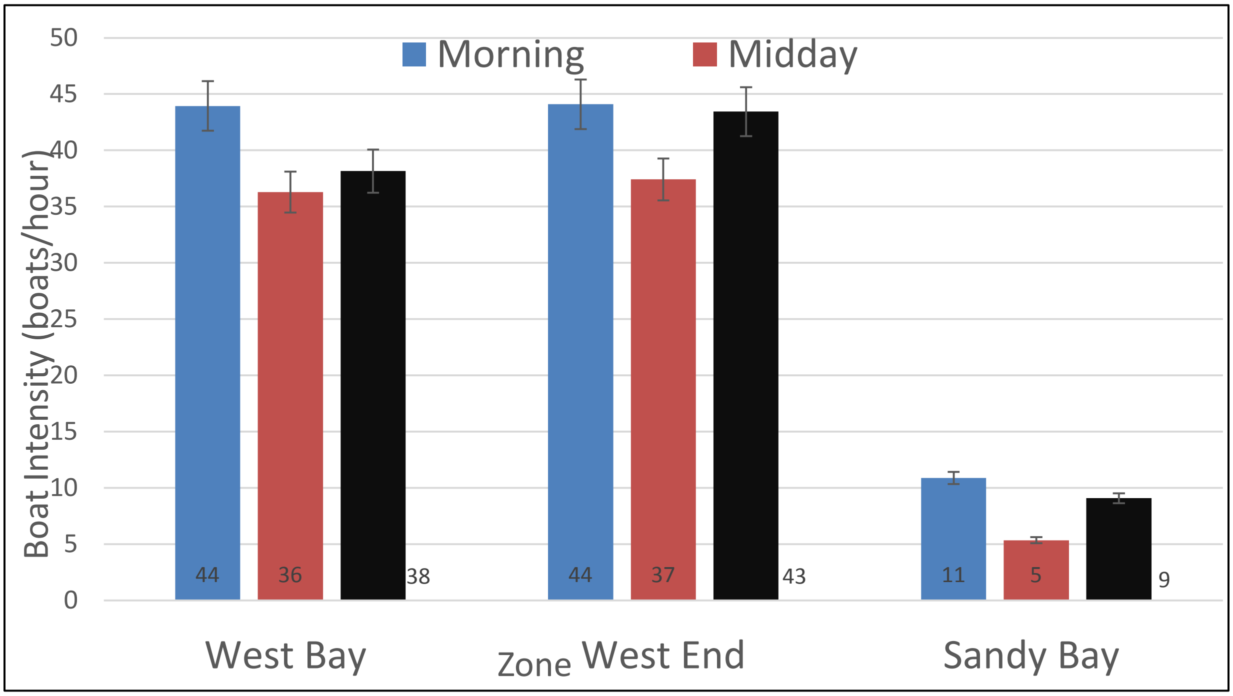

Figure 17. Boat intensity by zones during three time periods.

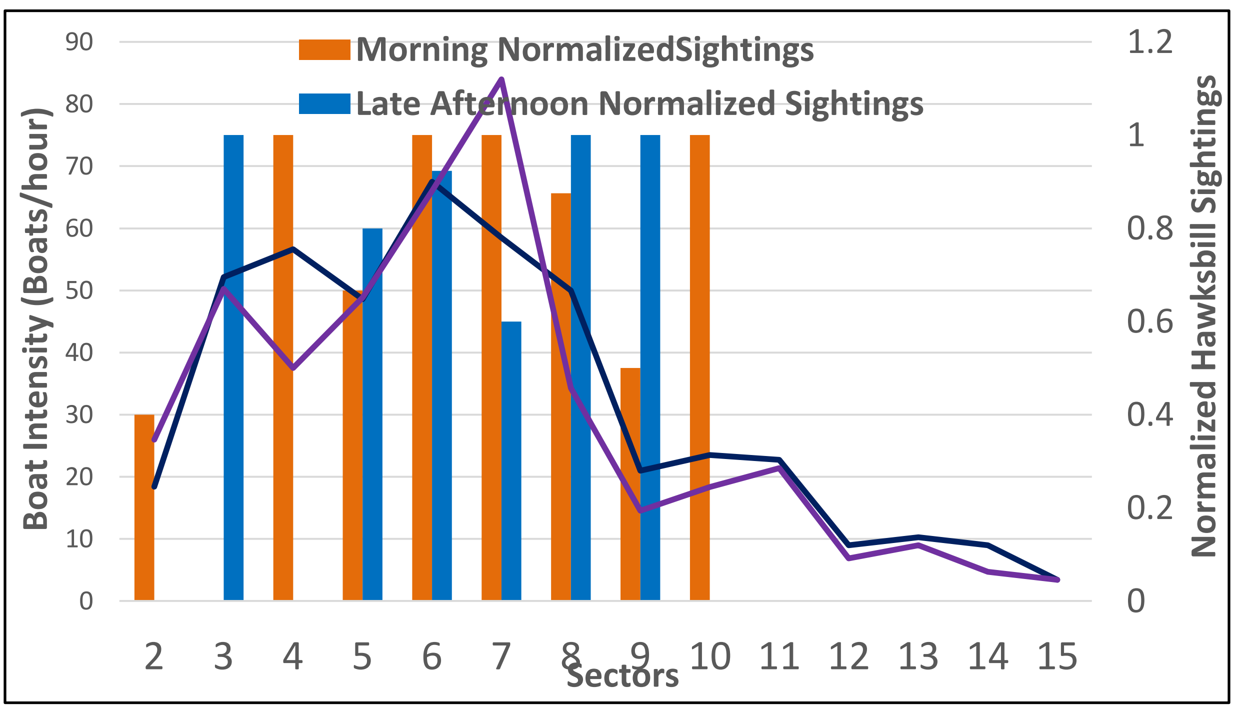

Figure 18. Morning and afternoon boat intensity vs normalized hawksbill sightings during SCUBA diving.

Mapping the Goods: Using the TURT Smartphone Application to Record Hawksbill Product Use in the Country of Honduras

This study was conducted by Lidia Salinas and Stephen G. Dunbar. A portion of this study has been presented in:

Harrison, E., von Weller, P., Nahill, B., 2017. Endangered Souvenirs; Hawksbill Sea Turtle Products For Sale in Latin America and the Caribbean, Too Rare To Wear, 32.

The historical and recent exploitation of hawksbill turtle shell (tortoiseshell) has been a driving force in the decline of hawksbill populations on a global scale. However, the hawksbill is by no means the only species that has been severely impacted by the anthropogenic use of turtle products. People around the world consume turtle meat and eggs on a regular basis, while tourists may request turtle products for consumption as a novelty, or unwittingly purchase turtle products as souvenirs. However, without a clear understanding of where turtle products are both sourced and marketed, turtle conservation efforts to inform government agencies, tourists, and tourism operators, will be hampered by lack of product-use locations and trends.

Recently, ProTECTOR, Inc. released the *Turtles Uniting Researchers and Tourists* (*TURT*) smartphone application for recording in-water and nesting beach turtle sightings on a global scale. We decided to investigate the use of the *TURT* application for recording and mapping both locations and photographs of turtle products use in the country of Honduras.
We used a standard oral survey (Figure 19) in conjunction with the *TURT* smartphone app to collect information and map restaurants, souvenir shops, airports, open food markets, and hotels that use or sell either primary or secondary sea turtle products. We considered products that came directly to the vendor without pre-production to be primary products (eggs and meat), whereas products that underwent some form of pre-production prior to reaching the vendor were considered secondary products (jewelry, carvings). We also recorded sites that did not sell turtle products, allowing us to calculate a ratio of turtle product sellers to non-sellers for different types of vendors (hotels, restaurants, markets, souvenir shops). Additionally, we also collected information on the motivation of vendors for selling turtle products.

We have surveyed 97 sites of potential turtle product sales in the cities of Tegucigalpa (Figure 20), La Ceiba, and Choluteca, Honduras, to date (surveys are continuing). Of these, 38 were souvenir shops, 5 open food markets, 50 restaurants, and 4 hotels. When survey data is combined for all three cities, we found that 42% of souvenirs shops sold secondary turtle products, 100% of markets sold primary products, 16% of restaurants sold primary products, and 50% of hotels sold primary products (Table 5).

Motivations for selling secondary products (Figure 21) appear to be for sale to the tourism market, while sales of primary products appear to be motivated by traditional demand by local residents. The *TURT* app was a highly useful mobile tool for quickly collecting data and immediately mapping sites and product types.

This study provides good evidence that mobile phone technology can be used to map trends in turtle product use at both local and national levels. Understanding where turtle products are used and sold will provide government agencies information on how to enforce national and international laws governing turtle exploitation, and increase awareness by tourists of their impacts on the use of turtle products. In the future, *TURT* may be used to map global trends in turtle products uses and movements, in conflict with both national and international regulations.

Data Collection Sheet for Turtle Products Use Project, 2016 – 2017

For the area of (Region, Province, City, Area – provide as much detail as possible)

Date (mm/dd/yy)	Location Name	GPS (lat/long) in DMS	Type of Product Sold/Used*	Numbers/week**	Why Product Used***	Know it is Illegal? (Y/N)	Photograph of Products
16/nov/2016	Souvenir Jireh	Avenida República de Chile (Cerca de Puente San Rafael) 478545.12 m E, 1559241.41 m N	Jewelry	3 a 4 pair of earrings, 1 necklace/per week	The foreigners want	No	yes
16/nov/2016	Souvenir MAYA	Plaza de la Iglesia Los dolores 2 477671.28 m E, 1559618.95 m N	Jewelry	3 bracelet, 5 pair of earrings, 3 necklace/per week	30 years tradition selling	No	yes
16/nov/2016	Souvenir collares y mas	Plaza de la Iglesia Los Dolores 1 477670.92 m E, 1559636.19 m N	Jewelry	2 pair of Earrings, 1 bracelet/per week	Tradition	No	yes
16/Nov/2016	Souvenir Candu	Frente al Hotel Honduras Maya 478683.17 m E, 1559156.87 m N	Jewelry	10 pair of earrings, 6 necklace, 7 bracelet/per week	Demand , tradition	No	yes

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Figure 19. Data collection survey sheet for recording information about turtle product use in markets, hotels, restaurants, and souvenir shops.

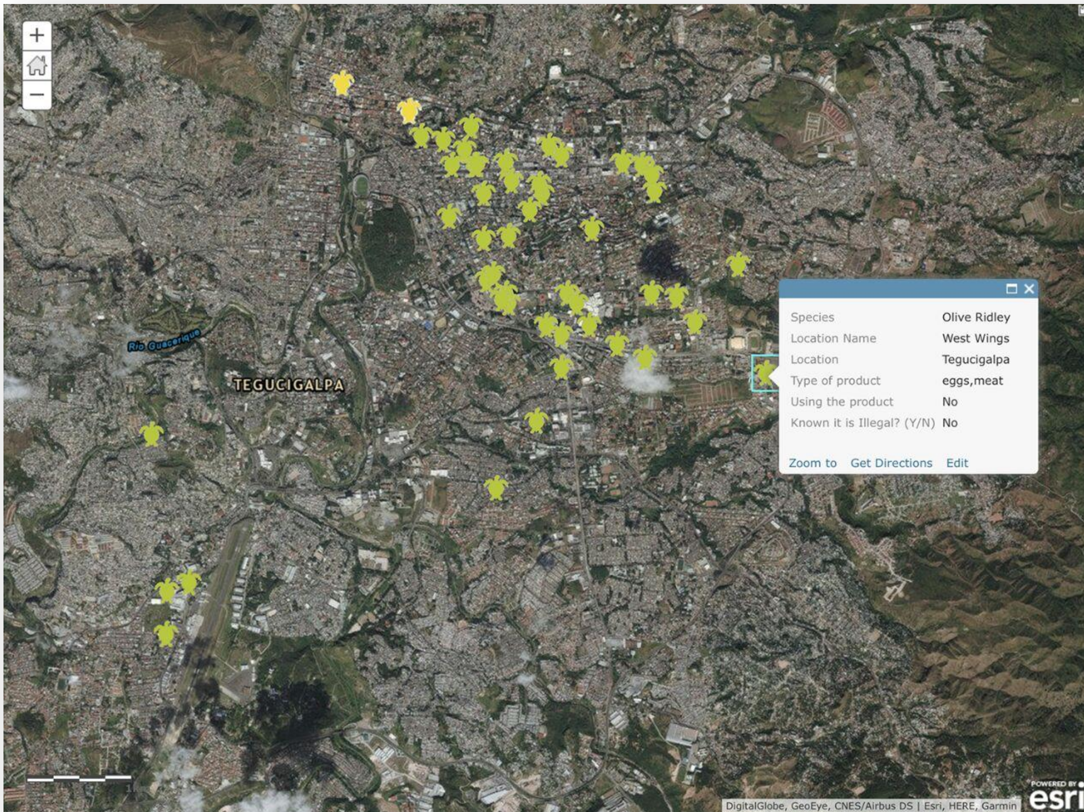

Figure 20. Sites surveyed in the city of Tegucigalpa where turtle products (eggs, meat, or shell jewelry) are sold.

Table 5. Collected information on types and numbers of locations in which either primary (meat and eggs) or secondary (worked products) sea turtle products are openly sold. Knowledge of illegal use of turtle products appears to be limited.

Location Type	#	Type of Product	Using products	Know it is illegal
Restaurants	50	Eggs	16%	0%
Souvenir Shops	38	Jewelry (Hawksbill)	42%	26%
Markets	5	Eggs	100%	0%
Hotels	4	Meat/Eggs	50%	0%

Figure 21. Examples of hawksbill shell jewelry sold in souvenir shops and markets in the city of Tegucigalpa.

RECOMMENDATIONS

Based on these findings we make **the following recommendations:**

SCUBA Diving Impacts on Hawksbill Behavior in the Sandy Bay West End Marine Reserve

Firstly, additional in-water observation studies should be conducted both inside and outside MPAs to determine if policies and management enforcement within MPAs protect sea turtles from the potential impacts of recreational diving. Specifically, foraging and flight response behaviors of turtles within and outside MPAs should be compared to quantify the effect of recreational diving policy on sea turtle behaviors.

Secondly, additional long-term sightings and dive log surveys should be conducted in MPAs, particularly in areas heavily impacted by diving. These surveys should be combined with habitat assessments of local sea turtle foraging grounds to evaluate if recreational diving pressure indirectly impacts sea turtle population levels through the degradation of foraging habitats.

Thirdly, long-term sea turtle photo-identification surveys using software systems, such as I3S Spot and I3S Pattern should be implemented in MPAs to facilitate accurate species identification and long-term studies of individual turtles. If implemented over an entire MPA, long-term photo-identification surveys would enable management officials to estimate sea turtle population sizes, monitor changes in sea turtle populations over multiple years, and re-identify resident and migrating individuals.

Fourthly, additional studies, such as regular health assessments through the capture and blood/skin/scute sampling of individuals should be undertaken on a regular basis to assess potential contamination issues in both the habitat and the turtles in the protected area. While there is good merit in observational studies (i.e. tracking individuals and estimating populations through observational and photo-ID studies), there is no substitute for tracking the health, genetics, and movements of turtles, which may only be accomplished through standard techniques of capture and re-capture, blood and tissue sampling, flipper/radio/satellite tagging. These measures should never be undertaken by those not holding appropriate permits, and without appropriate experience in handling and sampling sea turtles.

Development of Local and Global Citizen-Science Sea Turtle Monitoring

We recommend that both local NGO's in the area of the Sandy Bay West End Marine Reserve (SBWEMR), as well as local businesses become involved with furthering the research work of ProTECTOR Inc. in understanding the population numbers and distribution of juvenile turtles in the area of the MPA.

This can be accomplished by cooperation of the Roatán Marine Park (RMP) in fulfillment of their mandated responsibilities as co-managers of the SBWEMR. As a leading local NGO in the area, the RMP should also encourage local businesses to willingly and regularly contribute information on turtle sightings through both the dive sightings map and the TURT smartphone app. Furthermore, local dive operators should encourage their dive tourists to contribute their sightings information and photographs to the ProTECTOR Inc. research projects. The information gathered will assist the RMP and other co-managers of the MPA to understand and better manage both the MPA, as well as the turtle population residing in the protected area.

Area Abundance of Hawksbill Prey Items Within the Sandy Bay West End Marine Reserve, Roatán, Honduras

We recommend that this study continue into the following years of the ProTECTOR Inc. research within the SBWEMR and that more detailed analysis, such as assessing gastric lavage content and collecting samples of food materials immediately following direct observations of turtles eating in-water.

Additional transect and quadrat analyses should be undertaken to further assess the presence and distribution of hawksbill prey items within the SBWEMR. Understanding the abundance and distribution of prey items may assist MPA managers to assess whether the MPA boundaries are sufficient for protecting the population of juveniles residing in and recruiting to the SBWEMR.

HotSpotter: Less Manipulating, More Learning, and Better Vision for Turtle Photo Identification

It is apparent that photo-ID (PID) is a useful tool in assessing the number of individual turtles within the MPA. We recommend that all co-management entities, as well as businesses in the area of the SBWEMR, as well as those in Utila, be encouraged to fully contribute sightings information and photographs to ProTECTOR Inc. for further understanding of hawksbill and green turtle abundance and residence times within these protected areas. These data my, in turn, provide estimates for time to maturity for turtles residing in the SBWEMR.

Beta Testing Nesting Safe – New Technology for Nest Finding and Environmental Temperature Monitoring

Much more information, both on nest temperatures at the nesting beach at Pumpkin Hill, as well as on the impacts of beach debris on sand temperatures and their impacts on both nesting and hatching turtles is in need of collection at the site.

We urge all co-managing local NGO's to fully cooperate with the efforts of ProTECTOR Inc. to further investigate the ecology of the only known regular nesting beach in the Bay Islands, as well as to assist in furthering hawksbill nesting recovery at Pumpkin Hill Beach.

We further recommend that the Central and Bay Islands governments investigate the possibility of securing Pumpkin Hill Beach land, which is currently on the market for sale. The sale of this property may permanently jeopardize any hopes of future recovery of the nesting population of hawksbills in the Bay Islands region.

Quantification and Impacts of Nautical Traffic on Hawksbill Presence in an Honduran Marine Protected Area: A Progress Report

This study provides important information on the amount of boat traffic within the SBWEMR that has the potential to negatively impact sea turtles through increasing boat strikes. We recommend the co-managers of the SBWEMR act to develop mitigation strategies for turtle-boat interactions.

We further recommend that the RMP and dive operators in the area of the MPA, contribute information on boat strikes to turtles, to the ProTECTOR Inc. research efforts in order to fully analyze rates of actual boat strike occurrences. These data will assist the co-managers of the SBWEMR to develop turtle-boat avoidance policies that can be enacted to reduce the growing potential for boat strikes on turtles within the protected zone.

Mapping the Goods: Using the TURT Smartphone Application to Record Hawksbill Product Use in the Country of Honduras

The information gathered through this project is of high potential importance for government agencies charged with enforcement of CITES regulations. In some cases, turtle products, such as eggs and hawksbill shell products, may be crossing Honduran borders through black market transportation. The presentation of data in the TURT app may provide a means by which authorities can enforce turtle product laws, and make targeted efforts against the trafficking of all sea turtle products across international borders in contradiction to CITES regulations.

LITERATURE CITED

Dunbar, S. G. 2006. Preliminary Report on Activities Under Interim Permits # DGPA/005/2006 and DGPA/245/2006 by the Turtle Awareness and Protection Studies (TAPS) Group under the Protective Turtle Ecology Center for Training, Outreach, and Research (ProTECTOR). Loma Linda University, Loma Linda.

Dunbar, S. G., and M. D. Berube. 2008. Hawksbill sea turtle nesting beach reconnaissance Roatan, Honduras Final Report. United States Fish and Wildlife Services, Washington, D.C.

Dunbar, S. G., N. Duran, C. T. Hayes, and L. Salinas. 2015. Activities of the Protective Turtle Ecology Center for Training, Outreach, and Research, Inc. (ProTECTOR Inc.) in Honduras; Annual Report of the 2013 and 2014 Seasons. Loma Linda University, Loma Linda, CA.

Dunbar, S. G., and L. Salinas. 2008. Activities of the Protective Turtle Ecology Center for Training, Outreach, and Research, Inc. (ProTECTOR) on Olive Ridley (*Lepidochelys olivacea*) in Punta Raton, Honduras Protective Turtle Ecology Center for Training, Outreach, and Research, Inc. (ProTECTOR), Loma Linda.

Dunbar, S. G., and L. Salinas. 2013. Activities of the Protective Turtle Ecology Center for Training, Outreach, and Research, Inc (ProTECTOR) in Honduras; Annual Report of the 2011 and 2012 Seasons ProTECTOR, Loma Linda, CA.