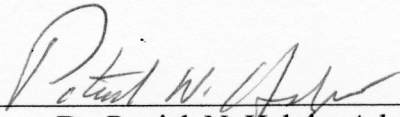


ENHANCING SEA TURTLE CONSERVATION USING MOBILE APPS

by

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A handwritten signature in cursive script, appearing to read "Patrick N. Halpin", written in dark ink above a horizontal line.

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ABSTRACT

With the advent of mobile devices, opportunities exist for increased citizen science data collection. This study evaluates options for how smartphones and tablets can enhance existing sea turtle conservation efforts in North Carolina and Puerto Rico. Social media applications (Twitter, Flickr, and YouTube), productivity apps (Google Drive's sheets and forms), and creation of a stand-alone application are evaluated with an eye toward a streamlined user experience. The goal of the project is to create a social media protocol or mobile application that aids sea turtle volunteers in collecting nesting and stranding data in the field and stores that information in a database on a remote server. Outputs from the database include daily-generated .csv and .kml files.

An evaluation of needs for North Carolina's and Puerto Rico's sea turtle volunteer networks showed that for Puerto Rico, any sea turtle nesting data collected needs to remain private to prevent poachers from using the information to raid nests for eggs. This consideration significantly changed the nature of the project from start to finish. Additionally, researchers in both areas require detailed data collection. Since some locations are remote, any protocol or app developed needs to work when no cell phone or wifi signal is available. These constraints led to a custom stand-alone app as the best-fit solution. The results of a survey of mobile device ownership and usage by sea turtle volunteers showed that iOS devices (iPhone and iPad) and Android phones and tablets were the most popular mobile devices.

The application, called Caretta, uses the open source PhoneGap development framework to allow for easier modification of a single HTML5, CSS3 and JavaScript code base to create mobile apps for all kinds of devices, independent of platform. By quickly creating an app that could be deployed to iOS devices as well as Android, Blackberry, Windows Phone and others, the opportunity to engage more people in citizen science is increased significantly. Though this study focuses on North Carolina and Puerto Rico, the findings can be applied to any location and any discipline where smartphone or tablet data collection would be useful.

INTRODUCTION

In 1973 the Endangered Species Act¹ began protecting the six sea turtle species that inhabit United States waters, specifically the green, hawksbill, Kemp's ridley, leatherback, loggerhead, and olive ridley turtles.² The first five species come ashore each summer to lay their eggs on U.S. beaches. Olive ridley turtles do not nest on U.S. shores, but occur in U.S. waters during feeding migrations.³ A seventh species, the flatback sea turtle, occurs only in Australia.²

The United States Fish and Wildlife Service (FWS) and the National Oceanic and Atmospheric Administration (NOAA) share responsibility for administering The Act. For sea turtles, the FWS takes the lead on conservation and recovery when turtles are on nesting beaches and NOAA takes the lead when sea turtles are in the marine environment.²

Numerous sea turtle conservation organizations assist in the protection and preservation of these vulnerable species. With the advent of smartphones, tablets and mobile applications, increased opportunities exist to not only engage more volunteers in citizen science, but more easily collect field data as well. Provided with an easy-to-use protocol or mobile application, volunteers and conservation staff could potentially collect large amounts of data which could be used to enhance existing sea turtle conservation efforts.

The Coastal Walkabout Project⁴ is one example of using the power of smartphones and citizen scientists for marine conservation in Western Australia. Given the rapid rate of development actions along the coast, scientists are concerned that they cannot assess and document the western Australian ecosystems in a traditional, scientific way and still keep pace with development. By enlisting everyday citizens to assist with documenting the marine coastal ecosystems, this team of scientists is beginning to collect more data than they could have gathered alone and is making it available to anyone interested in the areas of potential conflict between human activities and marine resources such as dolphin habitat.⁴

The idea behind this study is to see if the model used in the Coastal Walkabout Project could be applied to sea turtle conservation in North Carolina and Puerto Rico and if so, what modifications would be necessary. The goal is create a tool - a social media protocol or mobile application - that aids sea turtle volunteers in collecting nesting and stranding data while in the field and stores that information in a remote database. Outputs from the database include daily-

generated cumulative .csv and .kml files, which biologists can download to view in Excel and Google Earth respectively.

METHODS

Since the final tool will be used by sea turtle conservation organizations in North Carolina and Puerto Rico, obtaining input from experts connected to those organizations was an important step. Dr. Matthew Godfrey, Sea Turtle Program Coordinator (State Coordinator) with the North Carolina Wildlife Resources Commission and Dr. Robert J. Mayer, Associate Professor and Director of the University of Puerto Rico's Center for Coastal Conservation and Restoration in Aguadilla, Puerto Rico provided key information regarding the needs and desires of sea turtle biologists, conservation staff and volunteers.

Keeping in mind the constraints and desires of the two volunteer groups, the author researched possible technological options, starting with a combination of social media applications similar to the Coastal Walkabout Project. Social media mobile apps considered included Twitter, Flickr, and YouTube. Existing productivity apps, such as Google Drive⁵ - Google's desktop and mobile app for accessing Google documents, sheets and forms - were also considered. To cover the full range of development options, creating a new stand-alone mobile application using various methods was also considered. These methods included using PhoneGap, "an open source framework for quickly building cross-platform mobile apps using HTML5, Javascript and CSS",⁶ and programming in each device's native language.

A survey of mobile device ownership and use within the two volunteer communities was devised and deployed. North Carolina volunteers were offered an online survey to complete and Puerto Rican volunteers could fill out a paper survey distributed at a sea turtle meeting or fill out the online survey after they returned home from the meeting.

RESULTS / OBSERVATIONS

Results from Discussions with Sea Turtle Biologists and Volunteer Coordinators

Both Puerto Rican and North Carolinian volunteers collect relatively detailed data on sea turtle strandings and nestings. Data collection in North Carolina is a bit more automated since volunteers are supposed to enter data from field datasheets into an online web-based form that

adds that data to the SeaTurtle.org database, while the Puerto Rican data remains largely on the paper datasheets that volunteers fill out. Since the Puerto Rican sea turtle biologists would like to expand and standardize the data they collect, the data structure the North Carolina biologists are currently using is the core structure for the database that holds all the sea turtle data that will be collected. The data fields and example data for both the stranding and nesting databases for North Carolina are included in Appendix A.

The two volunteer networks also vary in the need to keep data private. While the need for privacy has not been necessary in North Carolina, in Puerto Rico, it is important that the data remain private to prevent poachers from using the information to raid nests. The Puerto Rican DNR, NOAA and USFWS require that nest information not be made public (Robert Mayer, personal communication). Even with these precautions, poaching persists as shown recently when approximately 400 eggs were stolen from four out of six leatherback nests on a beach in Puerto Rico during the 2012 nesting season (Elimelec Medina, personal communication).

While the two locations have different levels of data collection and consolidation, Matthew Godfrey and Robert Mayer agree that both volunteer networks could benefit from using mobile devices to collect data. In Puerto Rico, having a centralized location for all sea turtle data that is collected with a consistent set of data fields, and then distributing that data to scientists on an approved, or “blessed” list, would be a noticeable step forward. In North Carolina, Matthew Godfrey would like to eventually enter all the data electronically while in the field and have that data go directly to the SeaTurtle.org database, bypassing the need to write data down on paper and enter it into a computer at a later time.

Since the SeaTurtle.org website provides a mapping interface for the North Carolina data, a separate mapping tool is not needed. There is no mapping interface for the Puerto Rican data, so scientists there would benefit from an interface that allows approved users to see the data collected each day. In the interest of creating an appropriate data collection solution as quickly as possible, the author determined that creating updated .kml files each day during nesting season was the best way to quickly provide spatially-enabled data for viewing. Creating .kml files to be viewed in Google Earth requires significantly less development work than other options and provides a functional tool for a large number of users given the widespread use of Google Earth.

Since remote beaches exist in both locations, any mobile tool needs to work even if a cellular network or wifi signal is not available. The GPS functionality of mobile devices

continues to work when out of range of a cellular or wifi signal since, under these circumstances, the device determines its location from the constellation of GPS satellites that ships and airplanes use to determine their locations.

Results of Volunteer Surveys

The two groups of sea turtle volunteers, those in North Carolina and Puerto Rico, were surveyed to determine the extent of smartphone and tablet usage and volunteers attitudes towards using mobile devices in the field. Appendix B shows the paper survey that was distributed.

North Carolinian Responses

In North Carolina 257 volunteers responded to the survey out of approximately 850 volunteers that were emailed a link to the online version of the survey, yielding a 30% response rate. Of those 257 responses, 254 or 99% owned cell phones or other devices and 3 (1%) did not. The break down of the types of devices owned by the 254 respondents with cell phones or other devices is shown in Table 1. The percentages in the table do not add up to 100% since many individuals owned multiple devices. The initial survey did not list an Android Tablet specifically, but the information was captured in the “other” field for this question. Since more than 4% of the respondents had Android tablets, that statistic was included in the Table 1.

Table 1. Respondents Answers to Question 1b in Percentages.				
Question 1b) If you use a cell phone, smart phone and/or tablet, please check all the devices you use.				
99% of the 257 respondents had a cell phone or other device and therefore answered this question.				
Regular Cell Phone	Blackberry	iPhone	Android Phone	Windows Phone
32.3	3.5	42.1	28.0	0.4
iPad	Kindle	Nook	Other	Android Tablet
31.5	24.8	8.3	6.7	4.3

Table 2 includes the responses to the final question of the survey asking how interested respondents are in using mobile technology to collect sea turtle data in the field. Only 14% of respondents are not interested in using smart phones or tablets to collect data and would prefer to continue using paper and pencil to record data in the field. The remaining 86% were interested at varying levels of enthusiasm. A little less than 25% would be interested if appropriate training were provided on the use of the device and any mobile apps that would be provided. Note: the online survey provided a “Moderately Interested” option, which the paper version in Appendix B did not include, otherwise the paper and online surveys were identical.

Table 2. Respondents Answers in Percentages.			
Question 5) When collecting data in the field, how interested are you in using an electronic device such as a smart phone or tablet to collect that data?			
95% of the 257 respondents answered this question.			
Very Interested	Moderately Interested	Interested only if training provided	Not interested
41	22	23	14

Perhaps the most interesting nuggets of information gleaned from the surveys came from the “Comments” section at the end. Several volunteers stated that they were concerned that salt water and sand do not mix well with mobile devices. Some of these volunteers used that as a reason why they were not interested in using mobile devices in the field, while others making this comment were interested in using the devices, just mentioned their concern. A handful of other respondents commented that they were already using mobile devices to communicate with other volunteers while doing sea turtle conservation, specifically calling or texting other volunteers at critical times and sending photos of nest activity or stranded turtles at key moments.

Puerto Rican Responses

In Puerto Rico, 55 respondents filled out a paper survey and 9 completed the online survey yielding a total of 64 responses out of 105 people surveyed giving a 61% response rate. Two reasons this response rate could be higher than North Carolina’s is that the network is smaller than in North Carolina and all respondents were presented with the survey face to face at a sea turtle meeting.

Of the 64 respondents, 100% owned a cell phone or other mobile device. Table 3 displays the breakdown of the types of devices Puerto Rican volunteers have access to and use. Android and iOS devices dominated the types owned with Android phone being the most dominant in Puerto Rico, compared to iPads and iPhones being the most dominant in North Carolina.

Table 3. Respondents Answers to Question 1b in Percentages.				
Question 1b) If you use a cell phone, smart phone and/or tablet, please check all the devices you use.				
100% of the 64 respondents had a cell phone or other device and therefore answered this question.				
Regular Cell Phone	Blackberry	iPhone	Android Phone	Windows Phone
26.6	6.3	25.0	42.2	3.1
iPad	Kindle	Nook	Other	Android Tablet
12.5	1.6	1.6	10.9	7.8

Regarding Puerto Rican volunteers enthusiasm in using mobile devices in the field to collect data (shown in Table 4), 15% would rather continue to use only paper and pencil – a result very similar to volunteers in North Carolina. The fraction of people interested only if training were provided, 25%, is also very similar to the North Carolina result of 23%. The extremely low fraction of respondents who are moderately interested is a reflection of the low number of respondents filling out the online survey since the paper survey included only three

options for level of interest: very interested, interested only if training provided and not interested, whereas the online survey added in the option for being moderately interested. In hindsight it would have been better to have the paper surveys include all four options, however this was not an option at the time.

Table 4. Respondents Answers in Percentages.			
Question 5) When collecting data in the field, how interested are you in using an electronic device such as a smart phone or tablet to collect that data?			
92% of the 64 respondents answered this question.			
Very Interested	Moderately Interested	Interested only if training provided	Not interested
58	2	25	15

Users in Puerto Rico made the following comments: the device’s screen can be hard to read in the sunshine; in order to avoid disturbing turtle(s) at night, one volunteer said s/he would use her/his mobile device only during the day to collect data; and some users will want to continue using pencil and paper in addition to electronic data entry using a mobile device.

To summarize the results of the needs assessment and the survey, the mobile device protocol or application needs to:

- 1) work on multiple types of devices (especially iOS and Android devices)
- 2) work when no cell phone or wifi signal is available
- 3) collect detailed data
- 4) keep that data private

Possible Incarnations of the Tool

In light of the needs assessment for the North Carolina and Puerto Rico volunteer networks and the mobile device ownership survey, various options for creating an appropriate protocol or application were evaluated. For each possible tool, diagrams that show the flow of

information for stranding and nesting data are included. In Puerto Rico, it is not uncommon for people to call the Police when they observe stranded sea turtles or hatchlings, however the Police often do not know whom to call and it can be quite some time before the appropriate biologists are contacted to care for the stranded turtles or hatchlings (Robert Mayer, personal communication).

A) Social media:

For this incarnation of the tool, volunteers would use existing mobile apps (Google Drive, Flickr and YouTube) to collect data, which would then be stored in a database for present and future use. Originally Twitter was considered for this option, however due to the limitations imposed by Twitter's terms of service, it seems unwise to build a tool that relies on functionality of the Twitter app that violates the terms of service since that tool may become unavailable at an inopportune time if Twitter enforces their terms of service. The relevant sections of Twitter's terms of service are included in Appendix C. Additionally, given that volunteers in both North Carolina and Puerto Rico are collecting more data than would fit within Twitter's current limit of 140 characters, Twitter does not seem like a good fit for this particular application. Using the Google Drive app, which accesses Google documents, sheets and forms is an alternative to using Twitter. Another option is to use a pre-defined email message (i.e. an email template) that would contain the same information.

Figure 1. Social Media Stranding Data Information Flow

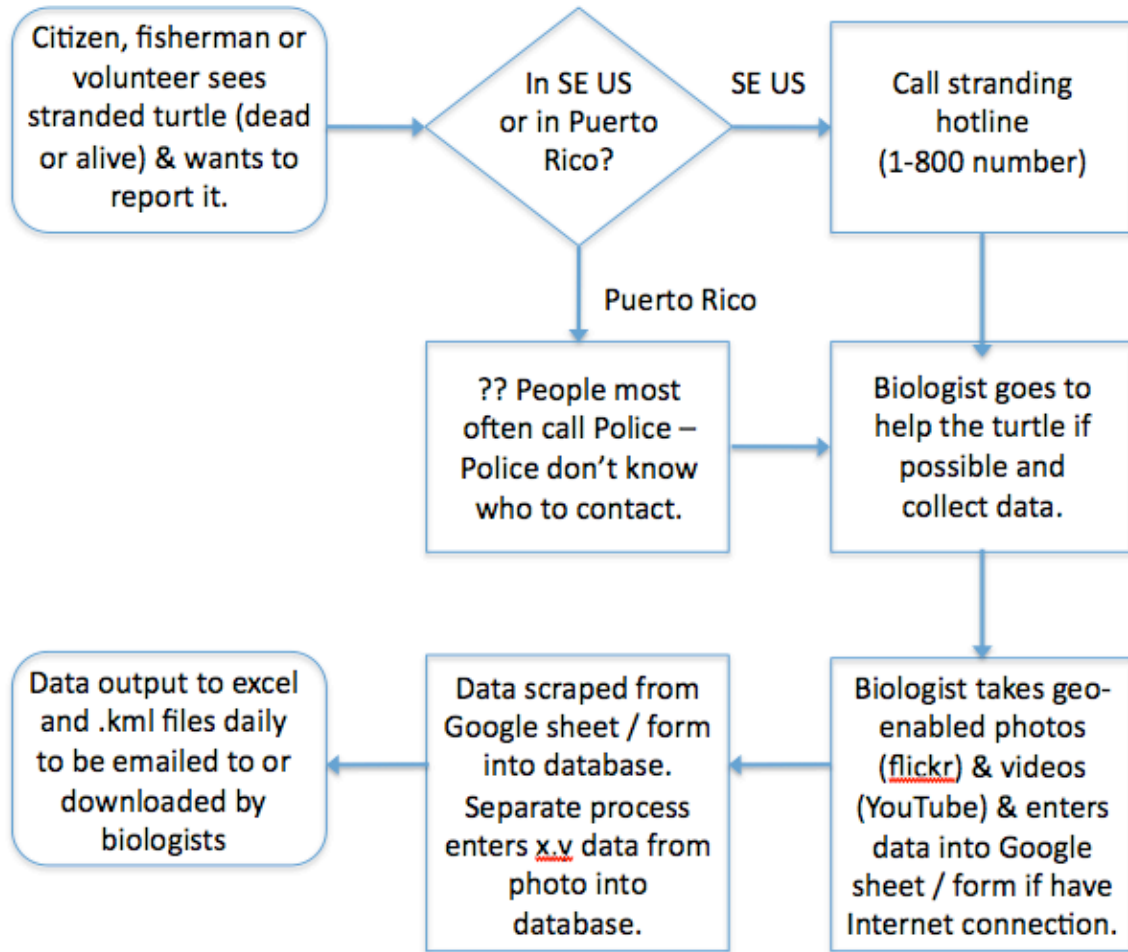
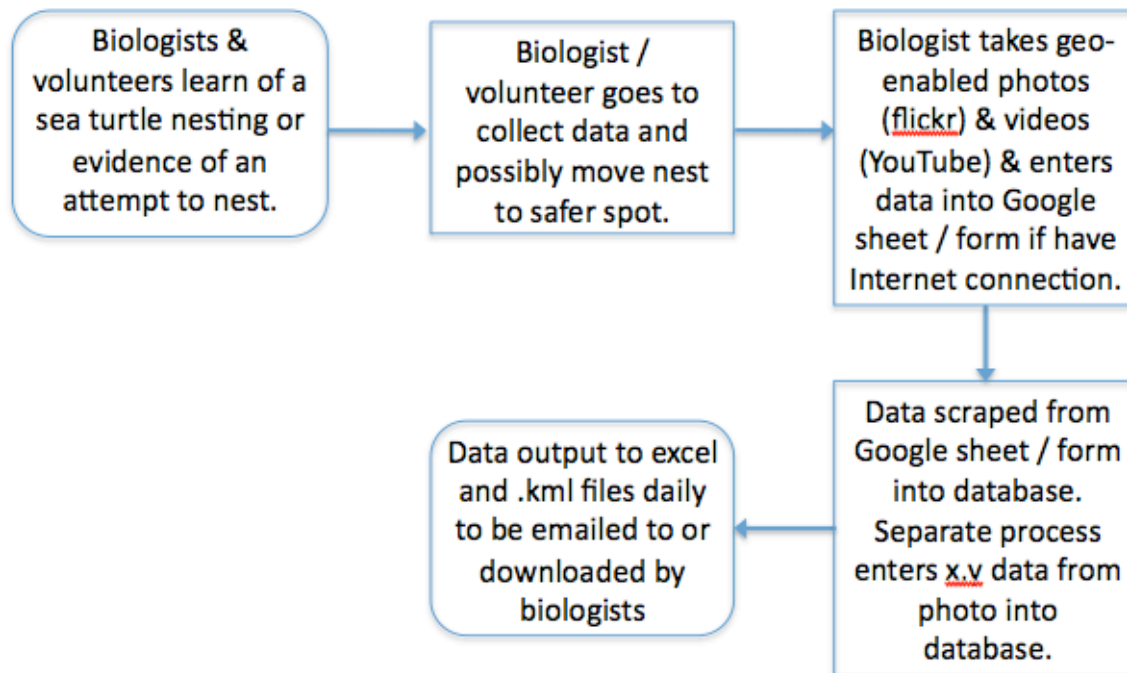


Figure 2. Social Media Nesting Information Flow



Pros:

- Apps exist already, just need to write a protocol.
- Users might already be familiar with the apps and how they function.
- Information immediately available provided user has an Internet connection or cell phone signal.

Cons:

- Google sheets and forms do not work when no cellular or wifi signal is available.
- Difficult to gather all the data desired. One idea is to have Puerto Rican volunteers take a video of themselves verbally filling out a data sheet and then have undergraduate students transcribe that data and enter it into a Google sheet or form which only they would know about (in order to keep the data private). This is very time consuming and not a viable option for North Carolina.
- Twitter terms of service do not allow geo-enabled tweets to be stored in a database and do not allow scraping of their service without prior consent.

- Users have to go through many hoops to keep the data private and even then, there is some question about how private that data is since social media is, by design, meant to be very public.
- Added step of entering location information from geo-enabled photos or videos into database from a separate location app. Not all location apps provide the accuracy of the location, which is important information, especially when mobile devices are being used since the accuracy can vary significantly from one location to the next.

B) Stand-alone App using PhoneGap

For this incarnation of the tool, a stand-alone application for iOS and Android devices (and other platforms as needed) would be created using a single software development framework, PhoneGap.

Figure 3. Stand-alone PhoneGap App Stranding Data Information Flow

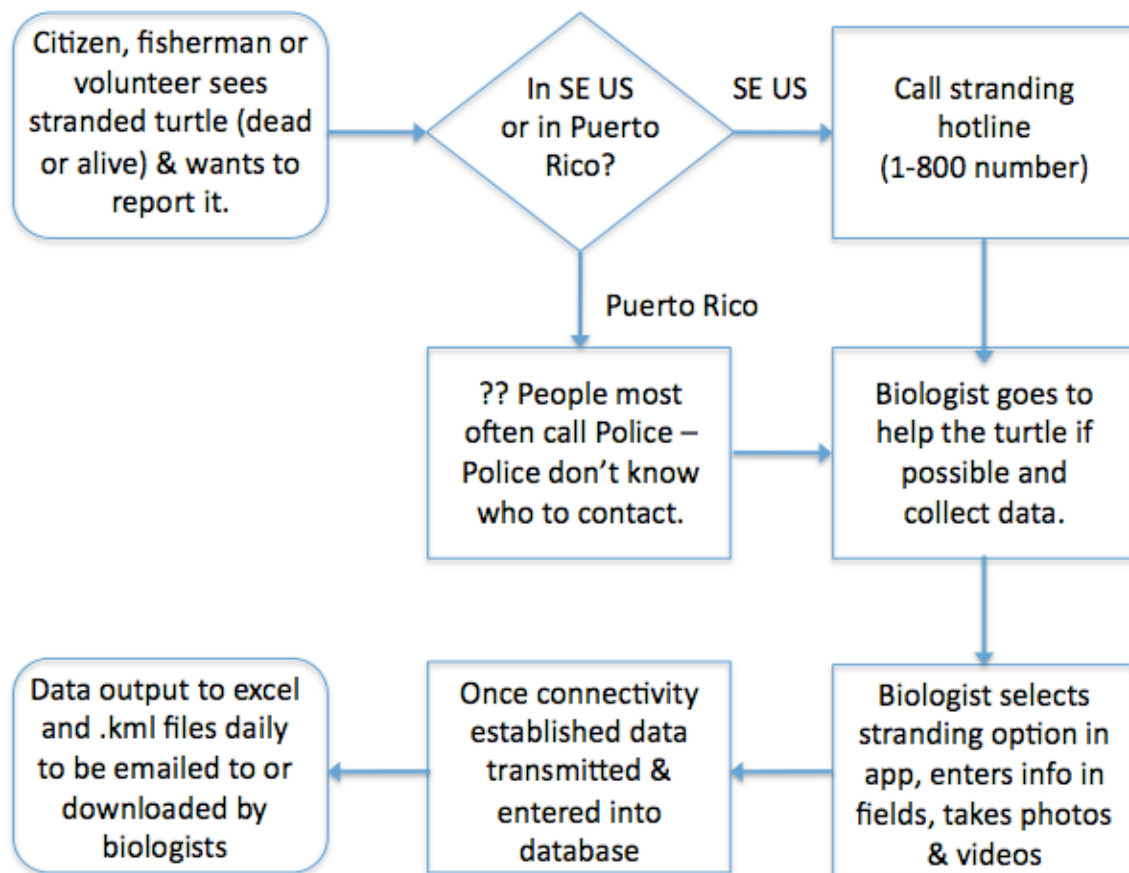
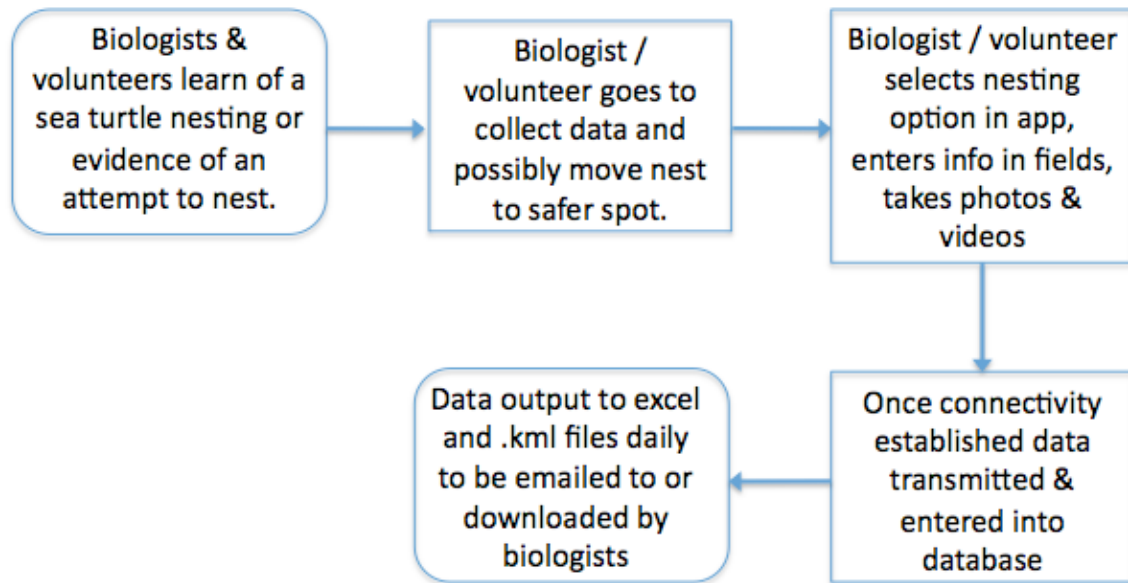


Figure 4. Stand-alone PhoneGap App Nesting Information Flow



Pros:

- Uses HTML5, CSS3 and JavaScript so no need to specialize by learning Objective C (for iOS) or Java (for Android) to build mobile apps.
- Creates a native mobile app where all the information goes directly into the desired database.
- Phone gap is open source.
- Privacy of data is ensured.
- Easy flow of correct information into the database since much less room for error during data entry than if a Google sheet or an email is used for data collection.

Cons:

- Publishing costs:
 - o Developer has to pay a one-time fee to get Android app on the Android Market Place (Google Play).
 - o Developer has to pay \$99/year plus tax to be part of the iOS developer program that is required to debug an iOS app on a device (not in a simulator which is free) and to publish an app in the Apple App Store (the iPhone and iPad app download site).

- Publishing time: approval of an iOS app is not instantaneous. The Apple review time, the longest of all the platforms, at the time of publication is approximately 6 days.⁷ Developers can request an expedited review⁸ and a time-sensitive event is a legitimate reason to request such a review. In the author's opinion, the onset of sea turtle nesting would qualify as a time-sensitive event.

C) ESRI SDK + PhoneGap

For this incarnation of the tool, ESRI's Software Development Kit (SDK) would be used to create a web map on ArcGIS Online that provides the background for an app. Location data could be collected and viewed in near real time provided an Internet connection or cell phone service is available.

This process would use ArcGIS online as the base map. It is useful if users want to display the information that has been gathered in near real time. For sea turtle data collection, this capability is probably not critical, though it does have a "gee wiz" factor in order to see where other volunteers have observed turtles nesting or being stranded. This information could be viewed from a web page displayed on a computer after the field session is over, however.

Figure 5. ESRI & PhoneGap App Stranding Data Information Flow (Same as PhoneGap flow)

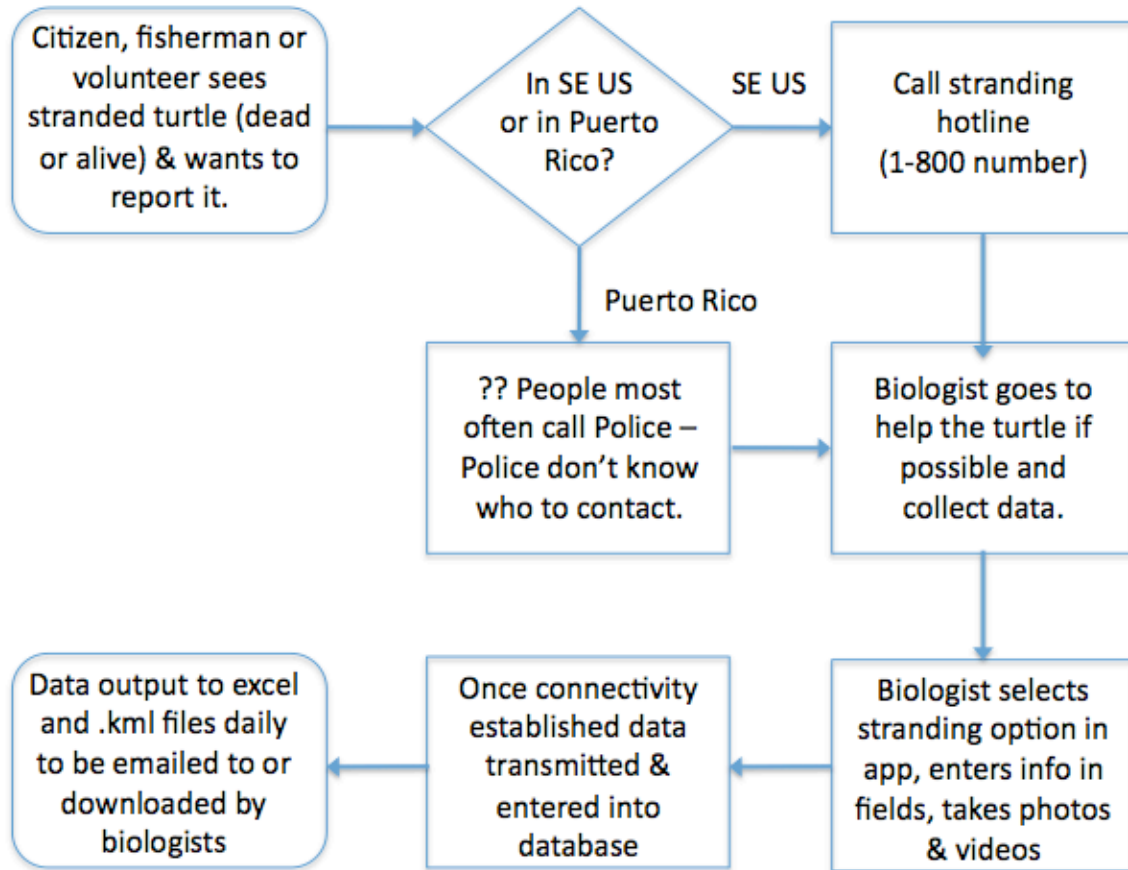
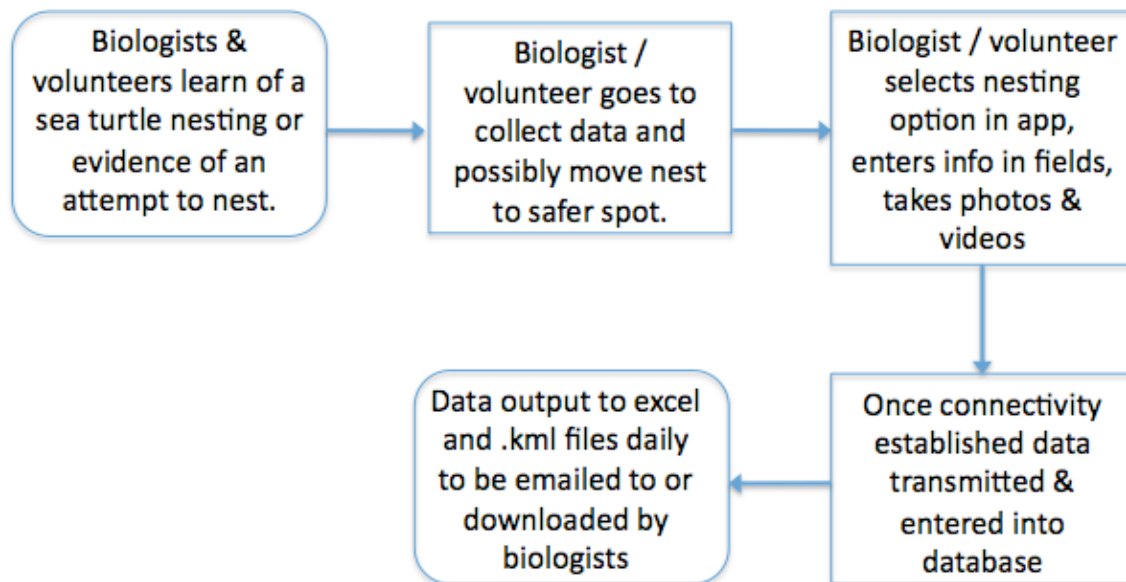


Figure 6. ESRI & PhoneGap App Nesting Information Flow (Same as PhoneGap flow)



Pros:

- Being able to see sea turtle data added in near real time could be a good educational tool as well as make the process of gathering data more fun for volunteers.
- This option has the same benefits as the stand-alone PhoneGap solution, especially ensuring the data remains private.

Cons:

- This option adds a layer of programming complexity (using ESRI's SDK) for added functionality that is not critical.
- In order to see the data in near real-time, Internet connectivity is required to see the latest version of the feature class displayed on an ArcGIS online base map.
- Publishing costs and review time are the same as for the stand-alone PhoneGap solution.

D) Programming in the Native Language of Each Device

In order to program in the native language of each device, developers need to be conversant in the Objective-C language and Cocoa Touch for iOS devices (iPhone and iPad), the Java language for Android and Blackberry devices including each system's specific APIs and

frameworks, and C# and Silverlight on Windows Phone.^{9, 10} (Note: Java is a completely different language from JavaScript, though the two languages have similar names.) The flow of information for natively programmed apps is the same as for the last two options, PhoneGap and ESRI & PhoneGap, so the diagrams were not included again.

Pros:

- Full range of programming possibilities available with a single debugging software package.

Cons:

- Large investment of time to learn appropriate operating system language for a single platform.
- Developers tend to specialize in a single language/platform so multiple developers could be needed to create an app that will truly cross multiple platforms.
- Lengthy period of time to develop an app on multiple platforms, leading to a more costly solution.
- Publishing costs and review time are the same as for the stand-alone PhoneGap solution.

DISCUSSION AND CONCLUSION

While the original plan was to see if the framework used in the Coastal Walkabout Project could be extended to sea turtle conservation, the need to keep the Puerto Rican data private, the desire to collect detailed data and the need for offline functionality caused the project to take a turn in a different direction and a stand-alone app emerged as the best-fit solution.

App Specification

Based on the discussions with conservation experts and the survey of existing technology options, the following application features and requirements evolved:

- 1) Collect detailed data on nesting and stranding events with different sets of fields for each event.
- 2) App must work when no Internet connection is available, i.e. when no cellular or wifi signal is available. (Since almost all locations are expected to be out in the open,

concerns about the difficulty in obtaining a GPS fix due to tall trees or buildings nearby are minimal.)

- 3) App must save data when power to the device has been turned off (or the device runs out of power due to a low battery while in the field.)
- 4) The app should work on multiple devices (e.g. iPhone and iPad) and multiple operating systems (e.g. iOS and Android).
- 5) The data for Puerto Rico must be separate from the North Carolina data and must be kept private.

Other desirable attributes:

- 6) App should work independent of the orientation of the device, and the user should be able to zoom in on a page if needed to make the text or data entry fields larger.
- 7) The interface should be intuitive and easy to navigate.

Existing Customizable Data Collection Apps

Two customizable data collection apps currently exist: iGeoTrak and Open Data Kit.¹¹ iGeoTrak¹² is a fee-based comprehensive iOS solution, which allows users to create custom forms for all types of data collection. Open Data Kit¹³ is a free, open-source option for Android devices that also allows a variety of user created forms and data storage on a remote server. No pre-existing solution for data collection across multiple platforms appears to be available at the time of publication.

The Best-Fit Option

For this project, PhoneGap was the best option since the Puerto Rican data needs to remain private, detailed data needs to be recorded, the volunteers have a range of types of mobile devices, and by using HTML5, CSS3, and JavaScript, it was easier for the author to come up to speed quickly to build a functional application in a relatively short period of time. The author also felt that to get the highest quality data possible, it was important to make things as easy for the user as possible. Following a protocol that uses multiple existing applications and a set of private social media accounts did not seem to create a streamlined, positive user experience especially given the other constraints of this project. Though PhoneGap does not provide every

single native functionality available on a device, it provides access to all the native functionality this project required included geolocation / GPS capability, camera and audio recording capability, local storage on each type of device, and means to test for network connectivity.

The author chose to use jQuery-mobile¹⁴ to aid in creating a visually pleasing user interface since a goal of the project was to get a working prototype of the app functioning as soon as possible. By using existing user interface designs contained in jQuery-mobile, the author could create a respectable-looking application extremely quickly. JQuery-mobile's ThemeRoller tool allows developers and designers to create new visual themes and apply them to an app in a matter of minutes.

For the database on the back end or server-side of the application, the author decided to use Parse.com, a cloud-based data storage option in the interest of time. Since Parse handles all the server maintenance and the majority of the server-side programming, the author could focus on the app itself. The core database structure was based on the data fields that North Carolina uses for recording nesting and stranding events (see Appendix A), so data collected with the Caretta app can be integrated with the SeaTurtle.org database at a future point in time if desired.

Though any user can download the app and enter data, only data submitted by users on the “approved” or “blessed” list will be distributed to scientists who are also on the “blessed” list. For the .csv and .kml creation, the author is expecting to use Python to convert the output from the Parse.com database (JSON objects) into .csv and .kml files that will be available for approved users to download from a secure website.

Caveats (Things to keep in mind)

As with any ongoing data gathering effort, maintenance of the database requires some effort. Depending on the complexity of the data and the situation, this maintenance could be minimal or rather extensive. As new versions of operating systems and programming frameworks emerge, the code base will need to stay current. Using PhoneGap provides an advantage in that the code base for all devices is basically the same, so updating that code is much easier than for completely separate apps for iOS, Android, Blackberry, Windows Phone, etc. which use different programming languages.

While using PhoneGap provides tangible gains in deploying an app across multiple device operating systems, a few considerations bear keeping in mind. When moving an app

from one platform to another, a few minor tweaks need to be performed. More importantly, there are few comprehensive single-product debuggers for PhoneGap applications, though this is an area where improvements are being made daily. Adobe, which distributes and supports the open source PhoneGap framework has created the Edge Suite of tools for web development. The Edge Inspect program, a debugger interface for mobile applications, appears to fill this gap. Another difference between using PhoneGap and separate development paths is the ability to use compatible frameworks and libraries such as JQuery-mobile, which makes creating a visually pleasing mobile interface extremely fast. The down side to using these extra libraries is that when debugging, making sure the library and third-party interface is working properly can be harder to debug than code in a single language with a single library. Additionally, if unused library elements are not removed when moving from a development app to a production app that is ready for deployment, the resulting application can be bloated with unused library elements, making it much less responsive than if those unused elements were removed.

The final consideration is position accuracy. While mobile devices can be relatively accurate as seen in the device correctly locating itself on a map in an area with many cellular towers and wifi hotspots, they also can be rather inaccurate as the large blue circle shows before the device's position is determined more accurately. If no cellular or wifi signal is available at a particular beach where a sea turtle is nesting, the battery could be drained much more quickly as the device uses its GPS capability to find its position – a notoriously energy intensive process. Recording position accuracy along with latitude and longitude is an important parameter in order to judge if the position data is sufficiently accurate for the project at hand. If extremely high accuracy is needed, smartphones and tablets may not be an acceptable solution.

Conclusion

Even with the possible added programming and debugging challenges, the ability to use a single, core code base for apps that deploy to all devices is a drastic time saver that significantly outweighs the relatively minor considerations that need to be made to adapt the code for all devices. Additionally, a wider pool of web development professionals can use their existing knowledge of JavaScript, HTML5 and CSS3 with minor re-tooling costs to migrate into the mobile world from the web. This could be extremely valuable to organizations that have limited resources. If they have an interested web developer, he or she could branch into mobile

development without having to invest the time to learn a new language such as Objective-C or Java, they could more cost-effectively deploy an app to multiple device platforms, and can more cheaply maintain those applications.

Compared to purchasing a fleet of programmable GPS units, using an app on a smartphone or tablet can provide significant cost-savings for location-based data collection when extreme accuracy is not necessary. Being able to enlist more people because the equipment costs are low can lead to noticeable gains in the quantity of data collected, provided some basic level of data quality is maintained.

While the benefits of using the Caretta app have yet to be realized, the gains for Puerto Rico are likely to be larger initially than for North Carolina since a centralized database of sea turtle data does not exist for Puerto Rico. However both locations could benefit if a significant number of volunteers use the app while in the field. Long-term, having a larger quantity of quality data available in a centralized database will likely aid scientists in gaining insights into sea turtle biology.

Future Research and Improvements

It is expected that future versions of the application will include the capability to take a photo, video, or audio recording associated with each nesting or stranding event. The names of the photos, videos and audio recordings of an event will be stored with the event's record so they can be easily recalled. Providing a stranding hotline phone number and email address, which users can call or email directly using their mobile device is a feature the author hopes to incorporate in the next version of the app. After the iOS and Android versions of the app are publically available, building Blackberry and Windows Phone versions is another possible future improvement.

Providing the app in Spanish for Puerto Rican volunteers is an important improvement the author would like to incorporate as soon as reasonably possible. Providing an additional .kml file that aggregates the Puerto Rican nesting data to show only polygons for beaches in Puerto Rico and list the number of nests on each beach is a mapping product that Robert Mayer would find useful for public outreach. By aggregating the data at the beach level, private data can be shared with the public to encourage people to become volunteers, but does not provide enough information to put the nests at risk from poachers. Another feature that could be added is a

mapping view that uses a cached vector-based map that could be used offline to allow users to compare where they are to the coastline on the cached map. This feature would be available even when the device has no Internet connection.

If the volunteer organizations continue to use the application, moving the database to a different server will likely be needed since there is a data and traffic limit to the Parse.com free account. Additionally, switching to a MySQL or similar database on a Duke server may be desirable as a step toward integration with the SeaTurtle.org database if that integration is deemed a worthwhile endeavor.

Incorporating the capability to record data on simple observations of a sea turtle by the general public could also be added with the goal of merging that data with the International Sea Turtle Observation Registry (iSTOR)¹⁵ database. Others have suggested that including turtle identification information could help reduce that number of sea turtle misidentifications in addition to a side benefit of providing educational material in the app. Finally, expanding the app to cover other states and/or countries could be a future enhancement that promotes increased sea turtle conservation over a much larger geographic area.

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APPENDIX A. DATA COLLECTION FIELDS

Stranding Database Fields	
<u>Field Name</u>	<u>Example Data</u>
recordID	14484
STSSN	WPT2012010401
programID	
user_id	15511
program	1
Name	William P Thompson
Affiliation	NPS
email	hatteras.resource@gmail.com
Address	P.O. Box 190 Buxton, NC 27920
Phone	(252) 216-9237
Date	1/4/12
NumberByDay	1
Notified	email
Species	CM
Photos	Y
VerifiedByCoord	Y
Sex	F
LifeStage	J
Tail	
SexDetermined	N
TailLength	
IncidentalCapture	N
StrandSite	I
StrandState	NC
County	Dare
Beach	Hatteras Island (NPS)
StrandLocation	Haulover Soundside Area.
NMFSzone	35
Latitude	35.29179
Longitude	-75.51546
LatLon_Method	
Condition	FD
RehabTurtle	N
RehabDescription	
RehabDisposition	

RehabDispositionDate	
ReleaseTagNumbers	
ReleasePITtagNo	
ReleaseSLCL_NotchTip	
ReleaseSLCL_NotchNotch	
ReleaseSLCL_Width	
ReleaseCCL_NotchTip	
ReleaseCCL_NotchNotch	
ReleaseCCL_Width	
ReleaseMass	
ReleaseLatitude	
ReleaseLongitude	
FlipperTags	Y
TagNumbers	None found
PITscan	Y
PITtagNo	None found
CodedWireScan	N
WireLocation	
LivingTag	Y
ScuteLocation	None found
FinalDisposition	BOnB
Salvaged	
DispositionUnknown	
Painted	N
Color	
PartsSamplesTaken	Y
SampleDescription	Left front flipper for aging purposes
SLCL_NotchTip	25.3
SLCL_NotchNotch	24.7
SLCL_Width	20.4
CCL_NotchTip	27
CCL_NotchNotch	26.3
CCL_Width	22.9
Mass	
Necropsied	Y
NecropsyDate	1/4/12
ProbableCauseStrand	Cold Stunning
DeathDescription	
Watercraft	N

Notes	Deep pink around the base of the appendages. Large amount of vegetation and barnacles growing on the carapace. Scavenged at the neck and front flippers. The heart and liver both looked good. Lungs were inflated with frozen bloody foam inside. Vegetation found throughout the GI tract and esophagus. Cold stun.
date_entered	1/4/12 14:00
last_modified	1/11/12 6:15
NMFS_date	
status	1
Prop_SL	
Prop_CL	
Prop_Width	
Prop_Depth	
Prop_Distance	
bid	1
beach_program	1
beach_name	Hatteras Island (NPS)
beach_admin	
beach_viewer	5,087,801,015,511
Owner	Cape Hatteras Hatteras Biotech
Year	2012
Month	1
Week	1

Nesting Database Fields	
<u>Field Name</u>	<u>Example Data</u>
UID	12892
Beach	Caswell Beach
County	Brunswick
Activity #	67
Activity	UN
Nest #	23
Ref #	
Activity Date	2010-00-00
Year	2010
Month	0
Week	
Dayofyear	
JulianDate	

Activity Comments	Eggs found at bottom of escarpment uncovered by tide. Relocated eggs do not look viable. No DNA sample taken
Encountered?	N
Species	Un
Latitude	33.8909
Longitude	-78.0331
Location	Marker 58.8
Nest Management	metal cage
Light Management	
Relocation	relocated
Total Eggs Laid By Female	25
Relocations	1
Relocation Date	6/24/10
Relocation Reason	tide
Relocation Latitude	33.8914
Relocation Longitude	-78.0331
Relocation Location	Marker 58.8
Washovers	0
Loss Reports	0
Prerelocations	0
Total Lost Eggs	0
Total Lost Hatchlings	0
Lost Nest	
Emerge Date	
Inventory Date	8/15/10
Incubation (days)	
Clutch Count	25
Shells>50%	0
Unhatched Eggs	25
Dead Hatchlings	0
Live Hatchlings	0
Final Status Unknown	
Exclude From Calc	
Hatch Success	0
Emergence Success	0
Inventory Comments	
Data Entry	Everett Smith
Inventorier	
Locator	Everett Smith
submitted	6/24/10 8:15

modified	8/15/10 8:17
Program	North Carolina

APPENDIX B. SURVEY GIVEN TO SEA TURTLE VOLUNTEERS AND STAFF

Holly Davis
715 9th St. Apt. 26
Durham, NC 27705

2/28/2013

Dear Sea Turtle Volunteer or Staff Member,

I am Holly Davis, a graduate student at Duke University, and I am working with Matthew Godfrey, Sea Turtle Biologist, NC Sea Turtle Project, NC Wildlife Resources Commission and Robert J. Mayer, Associate Professor, Director, University of Puerto Rico - Center for Coastal Conservation and Restoration.

We are looking into how mobile devices could be used to aid sea turtle conservation efforts and would like to understand better your use of mobile devices and social media services.

The survey below should take about 5 minutes or less to complete. You are not required to fill out the survey if you do not want to. If you decide to complete the survey, you do not need to answer every question that applies to you, however the more information you provide, the more helpful it will be.

Note: There are no right or wrong answers, and since we are not collecting any personally identifiable information, your answers will be anonymous. The information will be summarized in my master's project and may be used in aggregate form in future research proposals.

By filling out this survey, you are consenting to being included in my research. Though this survey may be distributed to you via email, your email address will not be stored with your completed survey, in the interest of keeping everyone's answers anonymous.

If you have any questions about this survey or my master's project, please feel free to contact me at holly.davis@duke.edu or 206-883-5877.

Thank you for taking the time to fill out this survey.

Best regards,
Holly Davis

The Survey

1a) Do you own, or have access to, a cell phone, smart phone and/or tablet (iPad, kindle, nook, etc)?

Yes

No

1b) If you use a cell phone, smart phone and/or tablet, please check all the devices you use and list the model (e.g. iPhone 3G or a first generation iPad) on the line to the right:

Regular cell phone (not a smart phone) _____

Blackberry _____

iPhone _____

Android phone _____

Windows phone _____

iPad _____

Kindle _____

Nook _____

Other tablet: what kind? _____

2a) If you do not have access to a smart phone or tablet, are you thinking of purchasing one?

Yes

No

Maybe

2b) If you do not have access to a smart phone or tablet AND you are thinking of possibly purchasing one, when to do you think you might make that purchase?

Within the next 3-4 months

Within the next 7-8 months

Within the next 12 months

3a) If you already have access to a smart phone and/or tablet, how do you use it?

Phone:

- Making calls
- Checking email
- Texting
- Using social media services (Twitter, Flickr, YouTube, Facebook, etc.)
- Mapping and directions
- Surfing the Internet
- Playing games
- Other (please describe) _____

Tablet:

- Reading eBooks or other documents
- Checking email
- Texting
- Using social media services (Twitter, Flickr, YouTube, Facebook, etc.)
- Mapping and directions
- Surfing the Internet
- Playing games
- Other (please describe) _____

3b) If you use a tablet, do you use (and pay for) cellular services (3G, for example) or do you get new content on your tablet only when you are near a wifi hotspot?

- Pay for cellular services
- Do not pay for cellular services and therefore connect only when wifi is available

4a) Do you have an account with any social media services? Please check all that apply:

- None
- Flickr (for photos)
- YouTube (for videos)

___ Twitter (for posting comments/tweets)

___ Other (please list) _____

4b) If you have accounts with social media services, are any of them private accounts?

___ Yes

___ No

4c) If you have private accounts with any social media services, and you are willing to comment, could you list the services where you have a private account? _____

(The intent of the question above is to understand how many users would need to obtain private accounts for specific social media services that might be used to collect sensitive sea turtle data that would need to be kept private.)

5) When collecting data in the field, how interested are you in using an electronic device such as a smart phone or tablet to collect that data?

___ Very interested

___ Interested only if appropriate training were provided on how to use the device

___ Not interested – I prefer to use paper and pencil to record information

Comments

Thank you, again, for your time!

APPENDIX C. RELEVANT TWITTER TERMS OF SERVICE CLAUSES

From general terms of service website: <https://twitter.com/tos>

8. "NOTE: crawling the Services is permissible if done in accordance with the provisions of the robots.txt file, however, scraping the Services without the prior consent of Twitter is expressly prohibited."

The robots.txt file is located here (<https://twitter.com/robots.txt>) and is mainly for search engines, however we have been talking about scraping the data and storing it in a database.

From Developers Terms of Service website: <https://dev.twitter.com/terms/api-terms>

I. Twitter Content

4. A. (second bullet) in part reads: "Exporting Twitter Content to a datastore as a service or other cloud based service, however, is not permitted."

4. E. "You will not attempt or encourage others to: use or access the Twitter API to aggregate, cache (except as part of a Tweet), or store place and other geographic location information contained in Twitter Content."

5. F. "You must: not use Twitter Content or other data collected from end users to create or maintain a separate status update or social network database or service."

II. Principles

3. Respect user privacy

D. Do not facilitate or encourage the publishing of private or confidential information.

Twitter has some best practices for using location data located here:

<https://dev.twitter.com/terms/geo-developer-guidelines>