JOURNAL OF Management and Development Studies
University of the Philippines Open University

POPULATION SURVEY OF MARINE TURTLES IN BORACAY ISLAND, PHILIPPINES USING A CITIZEN SCIENCE APPROACH

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ABSTRACT – In recent years, an increasing number of research projects involved non-scientist members of the community as 'citizen scientists' in science research projects. This study was done with the following objectives: 1) to identify individual marine turtles in Boracay Island; 2) to identify specific areas around Boracay island where marine turtles were sighted; and 3) to demonstrate the application of citizen science as a participatory approach for studying the marine turtle population in a specified location. Invitations to participate in the turtle identification project were sent to dive shops and disseminated through social media. Divers contributed photos used for photo identification of individual marine turtles using the unique pattern of scutes on the left side of the marine turtle's head. Through citizen science, this study was able to identify ten resident marine turtles (nine live and one dead) over a three-month period (February – April 2016). Eight turtles were encountered underwater during dives and two were found stranded. In total, five green turtles (*Chelonia mydas*) and five Hawksbill turtles (*Eretmochelys imbricate*) were identified. Most of the turtle encounters were in Baling-Hai Reef, suggesting that this reef has an important role as a possible habitat or feeding ground. Considering the recent move taken by the government to temporarily close Boracay to tourists to allow rehabilitation and restoration of the island, the identification of marine turtles in certain locations underscores the importance of restoring and protecting not only the beaches but also the reefs and surrounding areas for the protection of the marine turtle population. Through information provided by citizen science and evidence generated through photo-identification of marine turtles, proof of existence of the marine turtles in Boracay should spur the LGU and the community to initiate and sustain conservation efforts such as the creation and implementation of Marine Protected Areas (MPA) in areas where marine turtles abound.

Keywords: marine turtles, Boracay Island, citizen science, photo identification

INTRODUCTION

Marine turtles are air-breathing reptiles that spend most of their lives in the ocean after hatching, especially the males that stay underwater for the entirety of their lives. For marine turtles, their long flippers are used for swimming, unlike freshwater turtles (terrapins) that use legs or webbed claws. Population ecology research on sea turtles around the world primarily

To cite this paper: Madera, B. S. & Habito, C. dL. (2019). Population Survey of Marine Turtles in Boracay Island, Philippines Using a Citizen Science Approach. Journal of Management and Development Studies Volume Number 8 Issue 2, 1-15.

focuses on nesting beaches where female turtles lay eggs and on population growth. Other researches focus on turtle's foraging grounds but rarely on their movement and behavior in the open sea.

There are seven existing species of marine turtles in the world that have been identified, with five of these species found in the Philippines. These include the green turtle (*Chelonia mydas*), hawksbill turtle (Eretmochelys imbricata), olive ridley turtle (Lepidochelys olivacea), leatherback turtle (Dermochelys coriacea), and loggerhead turtle (Caretta caretta) (MWWP, 2014). Among the five marine turtles, three species of turtles are widely distributed throughout the archipelago namely green, hawksbill, and olive ridley turtles (MWWP, 2014). The International Union of Conservation of Nature (IUCN) lists green turtles as endangered, hawksbill turtles as critically endangered, and the loggerhead, leatherback and olive ridley turtles as vulnerable (IUCN, 2016).

Marine turtle conservation in the Philippines is quite challenging given that marine turtles are spread across the archipelago, divided by seas and different coastal areas and communities. Effective ways for management and conservation of wildlife population, particularly marine turtles, requires baseline data on the population demographics (Caughley, 1996). Ecological and conservation research starts with the ability to identify individuals within the population (Thompson et al., 2000). Mark-recapture techniques on sea turtles are done through tagging to identify individuals. This entails cost and requires trained individuals to attach tags. Moreover, tagging is an invasive method that may cause disturbance and discomfort in turtles (Shanker et al. 2003).

An alternative technique for identifying individual marine turtles is through visual identification or photo identification (photo ID). In contrast to tagging, the photo ID method used to visually identify the individual turtles through scale patterns is non-invasive to the animals, minimizing the chances of stressing the animals (Schofield et al. 2008). The method utilizes the facial scute patterns of different species of sea turtles: hawksbill, green and loggerhead turtles (Chassagneux et al., 2013; Feliz et al., 2013; Jean et al., 2010; Lloyd et al., 2012; Reisser et al., 2008; Schofield et al., 2008). The primary assumptions underlying the photo ID are (i.) the unique pattern characteristic of each individual is different and (ii.) the unique pattern is stable over time (Chew et al., 2015). Compared to expensive and stress-inducing tagging methods, photo identification method through citizen science reduces cost and are relatively stress-free when done according to appropriate guidelines, as it only depends on the natural markings on the head that are photographically captured to identify the individual and track for future re-sightings (Reisser et al., 2008).

In recent years, an increasing number of research projects have employed ordinary members of the community as 'citizen scientists'. In Maldives and Koh Tao in Thailand, a citizen science project on marine turtles is active among the diving community using social media - Facebook Group where they could upload their photos for photo ID. In the Philippines, individual identification of marine turtles through photo ID has been initiated by a non-government organization (NGO) called Large Marine Vertebrate (LAMAVE) Research Institute Project in Oslob, Central Visayas through trained volunteers.

In this study, the diving community became citizen scientists. They become significantly helpful and cost-effective monitoring agents for research (Ecocean, 2016). Any individual can help the research by photographing and submitting to the researcher the photographs of the turtle's head with the unique scale patterns useful for its identification.

In December 2015 within a span of just one week, nine dead marine turtles were reported

at different sites in Boracay Island (Maiquila-Asis, 2015). On two separate instances, there were two marine turtle strandings in which one of them was found dead and the other one was weak and struggling. In April 2016, another dead marine turtle was found in a state of decomposition with a broken carapace (Figure 1), suspected to have been caused by a water vessel strike (MWWP, 2016). These reports of turtle mortality highlight the importance of establishing a baseline on the marine turtle population in Boracay. It will also, in the long run, help to conserve the turtles of Boracay by increasing the awareness of the stakeholders (divers, tourists, government, academe, researcher, non-government organization, etc.) in the conservation of marine turtles in the island. The research is also a chance for the diving community on the island to get involved in the conservation of Boracay's marine resources. Their involvement coupled with available technology and the power of social media can be a start for sustainable citizen science initiatives in Boracay Island. Data from trained volunteers or seasoned divers will be an important contribution to monitor the presence of marine turtles in Boracay Island.

Figure 1. Screen capture of Marine Wildlife Watch of the Philippines (2016) report on marine turtle stranding with broken carapace.

The research study has the following objectives:

1. to identify individual marine turtles in Boracay Island;
2. to identify specific areas in Boracay island where marine turtles were sighted;
3. to demonstrate the application of citizen science as a participatory approach for studying the marine turtle population.

METHODOLOGY

A. Study Site

Boracay is an island (Fig. 2) 315 km south of Manila (the capital of Philippines) situated in the municipality of Malay, in the province of Aklan, Philippines. Its geographical coordinates are N11o56'- 12o 00 North, E121o54 – 121o57' East (CLUP, 2008). With an area slightly more than 1000 hectares and only 7 kilometers long, Boracay is a small island famous for the powdery white sand of its Long Beach (also known as White Beach). Uplifted remnants of

two ancient reef platforms covering the shallower areas of Sibuyan Sea explains the features of Boracay's physical environment. Continental shelves were formed connecting the two separate islets together from the uplifting and deposition of calcium carbonate thus forming the shape of Boracay Island. Since the late 1980s, Boracay has become a popular destination for local and international tourists. The rapid development of tourism, unrestrained building construction and poor waste and sewage disposal, together with widespread construction of boat moorings as well as illegal and unsustainable fishing methods to cater to the increasing demand for seafood for tourists has contributed to the degradation of its coral reefs (Rowan, 2011). While Boracay is known world-wide as a top island/beach destination in the world (Senate of the Philippines, 2014), the national government finally recognized the dire environmental situation in the island and undertook the drastic step of completely closing the island to tourists for most of 2018.

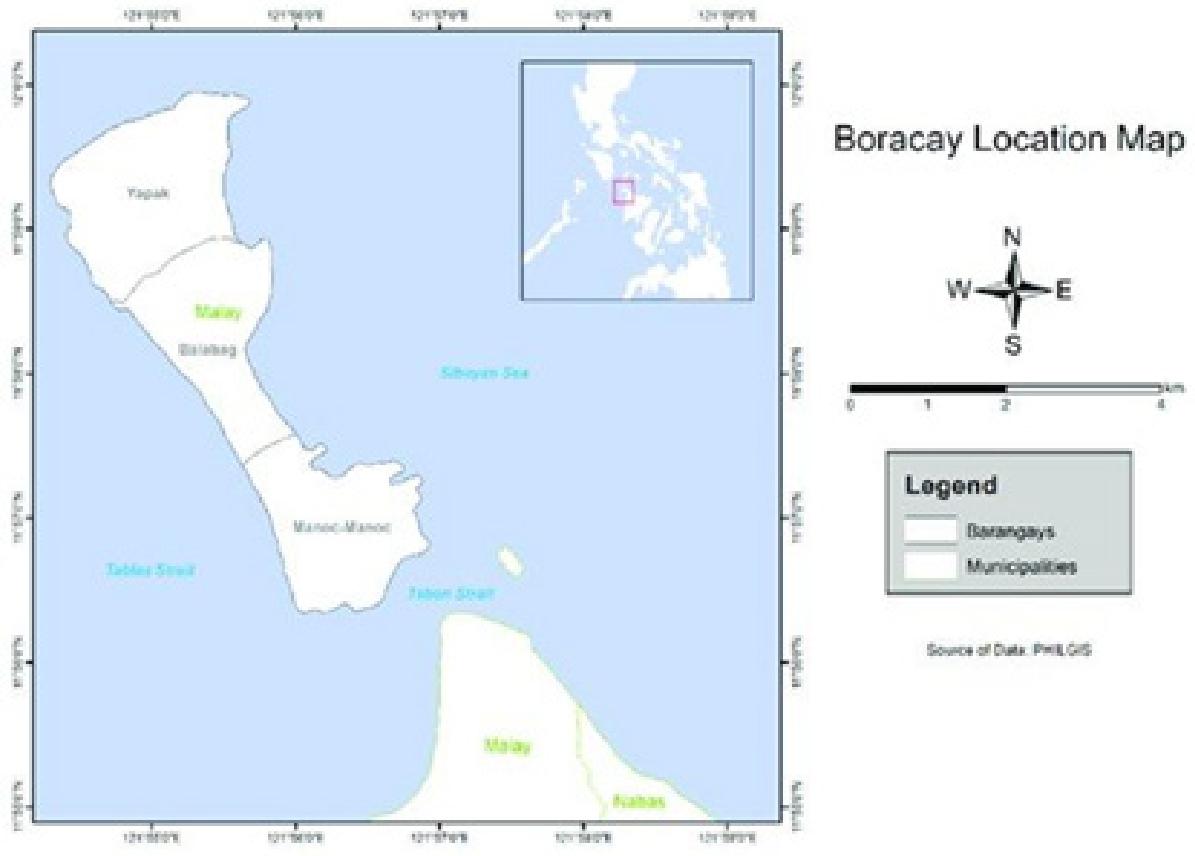


Figure 2. Map of the Philippines showing the location of Boracay island.

B. Data Collection

Data gathering involved getting the help of the diving community in Boracay Island. An extensive information campaign was done in different dive shops on the island to promote the project and gain the participation of the diving community. Social media was also used to promote the campaign. Archived photographs taken by the divers and social media photos posted on divers' Facebook accounts were used in this research. Divers either sent the file via Facebook messaging or sent directly to the primary investigator using an online link of the photos. Data collection was conducted during the months of February to April 2016. As the time stamp from photos downloaded from Facebook could not be retrieved, the time and date records of each photo were excluded. However, for future submissions, time and date information will be requested.

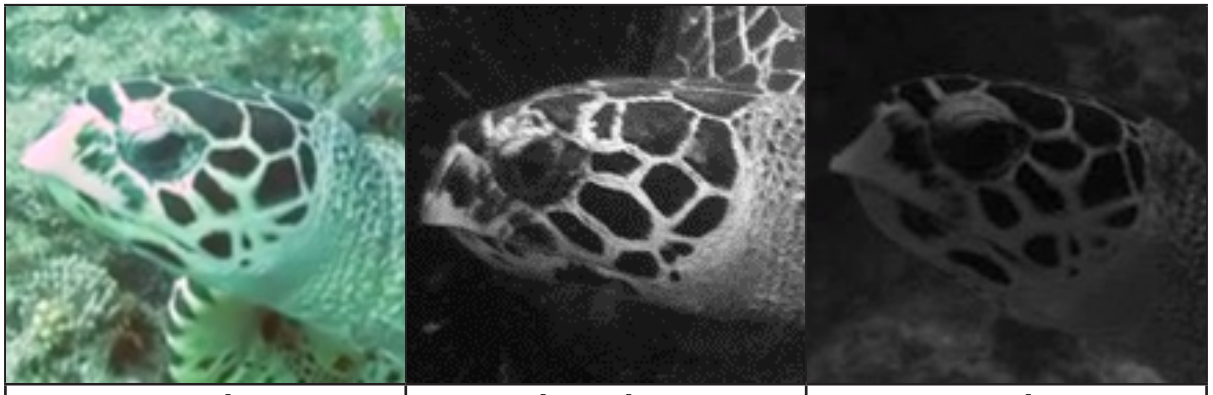
Photos of the left side of the head of marine turtles were obtained from the diving community and used for the study. Letters of request were personally sent to the dive shops, together with the printed poster of the study guidelines. Photographs were collected from different sources and transmitted to the researcher electronically. Two divers sent photos directly using Facebook messenger, one posted on the Facebook group, and most of the other files were gathered from the dive shops' Facebook pages or divers' Facebook pages.

Turtle photos were taken during the dive using an underwater camera or a regular camera fitted with underwater housing. The ideal photos used for the photo ID were those taken on the left side of the marine turtles' body that allowed adequate visualization of the scutes on the side of the turtle's head.

The guidelines for photo submissions specified that ideally, photos of the left and right sides of the head of the marine turtles in turtle encounters will be collected and used for the study. However, due to the incomplete photos of both left and right sides of the turtles that were eventually obtained, a decision was made during the analysis that only the photos of the left side of the head will be used to standardize the photo ID of the individual turtles.

C. Individual Photo Identification

Each turtle photo was compared manually to see if there were matches (i.e. duplicate images of the same turtle). The matching of the individuals was standardized using only the left side of a turtle's head to avoid duplication in the database. The position, shape and markings of the scutes were used to match the individuals (Figure 3, turtle 1 is matched to turtle 3). Unmatched photos were assigned as a new individual in the photo identification database. To establish the photo ID of each individual marine turtle, the shape and arrangement of facial scutes were compared (Reisser, 2008). The results were then verified by a team of scientists from the Large Marine Vertebrate Research Institute Philippines. These photos could then be used in the future where additional citizen science photos can be matched to the existing database



a. Turtle 1	b. Turtle 2	c. Turtle 3

Figure 3. Photos of marine turtles matched using the shape and arrangement of the scutes.

D. Species Identification

A marine turtle species identification key was used (National Oceanic and Atmospheric Administration, 2014) to identify the species of a submitted marine turtle photo. The turtle's head was also used for photo ID of individual marine turtles.

RESULTS

A. Identification of Individual Marine Turtles

Through the participation of the diving community, photos posted on diver's social media pages or submissions received via Facebook from divers were accessed. In total, 18 photographs of individual turtles' heads were gathered, 7 photographs of the right side and 11 photographs of the left side. For this study only 11 left side photos were considered for consistency. The same individual turtle was sighted and documented twice (Table 1).

B. Submitted & Collected Photos

A total of eighteen marine turtle photographs from social media (Facebook page) of the divers or dive shops were submitted/collected. In the compiled photographs of the turtles, there were differences in the angles or profiles in the way the turtles' heads were visible for identification. Given this challenge, the investigator decided to use only the photographs that clearly showed the left side of the turtles' heads, of which there were a total of 11 photographs. The distinct shape and arrangement of facial scutes enabled the identification of 10 unique turtles using the method described by Reisser (2008). Table 2 shows the sources and tally of the turtles included in the analysis. This included one turtle found stranded and dead by a non-diver while the remaining nine turtles were photographed underwater The dead turtle was identified and included in the database for reference of future submissions from previous diving encounters. A photo of a marine turtle was submitted by a non-diver who was present at a stranding in Boat Station 3 (Table 2). In total, the study was able to identify ten turtles (nine live and one dead) based on the photographs.

Table 1. Tally of marine turtles (*Chelonia mydas* & Eretmochelys imbricata) sightings used for individual photo ID and species identification.

Assigned ID No.	Species ID	Source of Photo	Location
BMT 01	*Chelonia mydas*	Dive Shop's Face-book Page	(Not provided)
BMT 02	*Eretmochelys imbricata*	Dive Shop's Face-book Page	(Not provided)
BMT 03	*Eretmochelys imbricata*	Diver	Baling-Hai Reef
BMT 04	*Chelonia mydas*	Diver	Baling-Hai Reef
BMT 05	*Eretmochelys imbricata*	Dive Shop's Face-book Page	(Not provided)
BMT 06	*Chelonia mydas*	Researcher (Strand-ing on beach, dead)	Bulabog Beach
BMT 07	*Chelonia mydas*	Non-diver (Stranding on beach, alive)	Boat Station 3
BMT 05	*Eretmochelys imbricata*	Diver	(Not provided)
BMT 08	*Eretmochelys imbricata*	Diver	(Not provided)
BMT 09	*Chelonia mydas*	Diver	Baling-Hai Reef
BMT 10	*Eretmochelys imbricata*	Diver	Baling-Hai Reef
Total	*C. mydas = 5,* *E. imbricata = 5*		

Table 2. Tally of marine turtle photo submission, ID and source with tally of source (D=Diver, R=Researcher and ND=Non-diver).

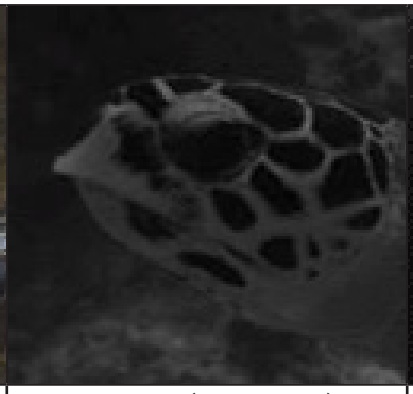
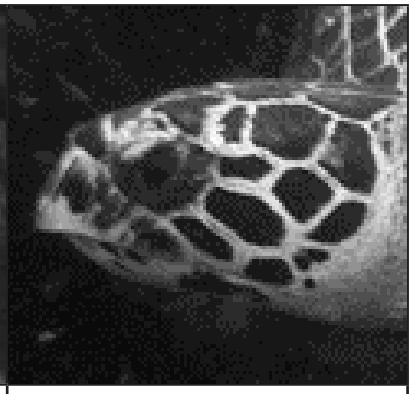
	Total Submissions Analyzed	**11**
Source	Diver	9
	Researcher	1
	Non-diver	1

The visual comparison of the left side of the head photo showed that the turtles' database (Table 3) have unique and specific facial scute patterns of both shape and arrangement, which allowed reliable and easy recognition of individuals. The unique scute patterns on each of the turtles that were photographed provided the information that at least ten marine turtles inhabit the study site.

Table 3. Photos gathered through citizen science were used to create databases.

		
BMT 01 *Chelonia mydas* **Retrieved from Scotty's Dive Facebook** **Location (not provided)**	**BMT 02** *Eretmochelys imbricata* **Retrieved from Calypso Dive Facebook** **Location (not provided)**	**BMT 03** *Eretmochelys imbricata* **Submitted by Eric Estrada** **Location Baling-Hai Reef**
		
BMT 04 *Chelonia mydas* **Submitted by Eric Estrada** **Location Baling-Hai Reef**	**BMT 05 (sighting 1)** *Eretmochelys imbricata* **Retrieved from Calypso Dive Facebook** **Location (not provided)**	**BMT 06** *Chelonia mydas* **Photo by researcher** **Bulabog (Stranding)**

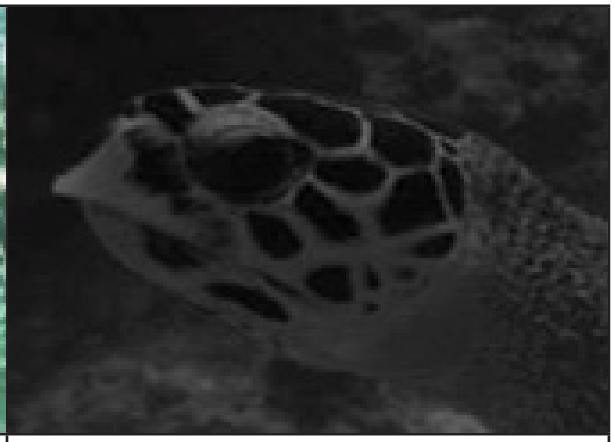
Table 3. Photos gathered through citizen science were used to create databases(cont'd...)

		
BMT 07 *Chelonia mydas* **Submitted by Guinting (Non-Diver)** **Station 3 (Stranding)** **Location (not provided)**	**BMT 05 (sighting 2)** *Eretmochelys imbricata* **Submitted by Raswan Sock-ol** **Location (not provided)**	**BMT 08** *Eretmochelys imbricata* **Submitted by Raswan Sock-ol** **Location (not provided)**
		
BMT 09 *Chelonia mydas* **Submitted by Domingo Villete** **Location Baling-Hai**	**BMT 10** *Eretmochelys imbricata* **Submitted by Junell Duapa** **Date April 22, 2016** **Location Baling-Hai**	

C. Matched Individual Turtles

Two submitted photos matched and were determined to be from the same individual (Table 4).

Table 4. Two submitted photos of the same individual marine turtle.

	
BMT 05 (sighting 1) *Eretmochelys imbricata* Retrieved from Calypso Dive Facebook Location (not provided)	BMT 05 (sighting 2) *Eretmochelys imbricata* Submitted by Raswan Sockol Location (not provided)

D. Identified Species

Guided by a marine turtle species identification key, five individuals were identified as C. mydas and five individuals were identified as E. imbricata from all the 10 photo submissions analyzed. From the divers' submissions, three were identified as C. mydas and six were E. imbricata. Two other individuals were identified as C. mydas (Table 4). Two photos of E. imbricata were found to be from the same individual. Thus, the study found a total of five E. imbricata and five C. mydas in Boracay Island.

Table 4. Tally of marine turtle photo submission according to species identification and tally of source (D=Diver, R=Researcher and ND=Non-diver).

	Species ID	*Chelonia mydas*	**Eretmochelys imbricata**
Source	Diver	3	5
	Researcher	1	0
	Non-Diver	1	0
	Total Species ID	**5**	**5**

E. Location of Identified Individual Turtles

Through citizen science, the study determined six different turtle locations, while five submissions had no locations provided. Turtles were spotted in the Baling-Hai Reef Wall while the other two were strandings on Bulabog Beach and Boat Station 3.

DISCUSSION

A. Significance of Citizen Science in Biodiversity Conservation

Global threats to biodiversity have underscored the importance of the need to generate historical and current data on as many species as possible – whether plant or animal; marine, freshwater or terrestrial. Information on the status and distribution of species diversity are essential for assessing changes, designing and monitoring environmental management and conservation efforts, and evaluating overall progress in biodiversity conservation (Boakes et al, 2010). Clearly, the task of collecting and managing such a massive database of information is fraught with numerous technical and operational challenges. The cost and technical skills required; the sources, availability and timeliness of information, and data quality are just a few important considerations in building such a database. The sheer magnitude of this effort dictates that government agencies, non-government organizations, academic and research institutions, and local communities work together and utilize all possible sources of data and information. This includes tapping into citizen science, described as the participation of volunteers in "some or all aspects of environmental assessments" (Chandler et al, 2017).

In the Philippines, citizen science has contributed to building the information database in biodiversity assessment and monitoring. Citizen science has been instrumental in the identification of new plant and animal species, assessing ecosystem services, for environmental education and generating greater involvement of local communities in natural resource management (Barcelona et al, 2014; Ateneo de Manila University, 2018; Schroter et a,l 2017; Danielsen et al, 2006). An impressive digital database of Philippine flora has been established and is a testament to the contribution of noted Filipino botanists and the role of citizen science in identifying and documenting plant biodiversity in the country (Pelser, Barcelona & Nickrent, 2011). Similarly, citizen science has been applied in marine biology studies. For example, data and information obtained from the application of citizen science and photo-identification in whale sharks in Leyte and Cebu waters has fed into the global database for this endangered species and the identification of global hotspots (Norman et al, 2017).

B. Citizen Science and Marine Turtles

Photo-identification of marine turtles (*Chelonia mydas*) at a site in Oslob, Cebu, Philippines has been previously done by Araujo and colleagues (2016). The authors found that photo-identification of facial scutes in individual turtles is a valid minimally invasive technique for identification and analysis in C. mydas species. The data generated by their study also made it possible to identify the site as an important developmental habitat – information that is clearly crucial for protection and conservation efforts.

This marine turtle citizen science project in Boracay relied on the contributions of the diving community since they had the unique skills and equipment that enable them to have direct access to the diving sites where individual marine turtles had been sighted in the past. Prior to the study, marine turtle encounters were common in Baling-Hai Reef. This was confirmed in this study, since four marine turtle encounters at Baling-Hai Reef were reported during the study period. Based on past studies (León, 2002; Blumenthal et al, 2009), it is possible that the turtles encountered in Baling-Hai reef could be residential turtles or foraging due to the availability of food sources in the reef. In the long run, divers can be encouraged to share more turtle photos, together with information on the location or dive site, as well as information on the depth and time of the marine turtle sighting. In the future, software photo identification or laser photogrammetry (Araujo et al, 2016) could also be used to enhance the

accuracy of the findings.

Starting up this project in collaboration with the diving community was initially a challenge since the divers have other work commitments. Poster guidelines on how to get the proper photos for photo ID were developed, posted online and printed for posting in the dive shops for wider information dissemination about the project and to generate support from volunteer divers. The information poster also invited divers to send previous photos taken before the study period as long as they met the criteria for photo ID.

C. Utilizing Marine Turtle Data and Information Derived from Citizen Science

This was a small study that sought to generate preliminary data on marine turtles in Boracay island. The findings were able to validate the existence of a small turtle population in this highly popular tourist attraction. The number of turtle encounters proximate to Baling-Hai reef also suggest the important ecological importance of the reef for the marine turtles. Information derived from citizen science initiatives such as this study can be used to create a sense of ownership and stewardship not only among divers but also with the local government and the wider community. These initial findings can be built upon and updated over time, with the possibility of attracting more citizen scientists to become actively involved, not only as collectors or documenters of marine turtle photographs and information, but as community conservation advocates as well. In Boracay's local communities, information about the existence of marine turtles and their habitats as well as environmental threats can be disseminated to enhance knowledge and understanding about the importance of protecting and supporting the marine turtle population among fisherfolk, children and adult residents, as well as tourists in the island.

Two marine turtle species were identified in this study: the green turtle (*Chelonia mydas*) is listed as endangered and the hawksbill turtle (Eretmochelys imbricata) is critically endangered (IUCN, 2018). Marine turtles are distributed across the globe and are increasingly under threat from a variety of environmental factors that include climate change, overdevelopment, pollution, and uncontrolled utilization of eggs, meat or turtle products (Mast et al., 2005). Having a database that describes the status, population sizes, morphology, reproduction, trends, habitat conditions and specific environmental threats is critical for site-specific risk assessment and for mounting effective conservation efforts. An online platform called the “State of the World’s Turtles” (SWOT) developed by the Marine Geospatial Laboratory in Duke University USA is a prime example (Kot et al., 2015). Clearly, the task of compiling and maintaining a database of such size and dynamicity is difficult to achieve by a single research or survey initiative. Citizen science presents an opportunity to contribute data and information to this database that serves as the foundation for local or global conservation efforts. For this reason, the ten individual turtles identified in this study can be tracked by future citizen scientists. Even the dead marine turtle was also included in the photo ID and in the database of this study for future reference for previous marine turtle sightings in Boracay as it may match a photo taken before it died. In the future, repeated sightings and records of the marine turtles identified in this study and any new additional individuals at specific dive sites might also help give information on reproductive patterns, trends, or environmental threats.

CONCLUSION

Through citizen science it was possible to validate the presence of individual marine turtles in Boracay using photo-identification. This study utilized the unique pattern of facial scutes found on the turtles’ heads to identify individual turtles and duplicate photographs of the

same turtle could thus be determined. The unique facial scute patterns of each turtle were determined using a taxonomic species identification key. In addition, results were verified by a team of scientists from the Large Marine Vertebrate Research Institute Philippines. Using this minimally-invasive technique to document individual marine turtles, the study was able to identify ten resident marine turtles in the waters off Boracay island. Unfortunately, one of the ten turtles was found dead as it was stranded. This highlighted the perils and threats to survival of the local marine turtle population in a rapidly developing and popular tourist area. The findings also showed the existence of at least two different species of marine turtles – the green turtle and the hawksbill turtle – listed globally as endangered and critically endangered, respectively. Most turtle sightings were in Baling-Hai reef, thus underscoring the importance of protecting and sustaining this ecosystem as part of the overall restoration and rehabilitation efforts being undertaken by the government in Boracay.

This study has demonstrated that involving community volunteers and the collection of turtle photographs for photo identification using the citizen science approach can contribute to the generation of information, knowledge and support for the broader area of marine conservation. In the future, the availability of additional data (e.g. photos of both sides of the head, location/ dive site, depth, and time) would be helpful for this effort in addition to the photos already collected. Species identification could be facilitated and enhanced with the help of turtle experts in the field. To create a more comprehensive marine turtle database through citizen science, more volunteer divers can be recruited and trained on the nuances of correct photo identification of the turtles' carapace and the left and right sides of the head. The unique features of each turtle in these photographs can then be used by a turtle expert for identification. While this study is preliminary, there is good potential for additional research in the future that builds upon the initial findings and expands the utility of the database for conservation efforts. Lastly, modern technology and the internet give an opportunity to widen the reach of information about marine turtles of Boracay and how to be involved in the citizen science project of Boracay Island. This approach can also provide information about environmental threats, status and issues, as well as stakeholders initiatives to help minimize the anthropogenic impact on Boracay's vulnerable and finite natural resources. Ultimately, greater involvement of the citizens in making updated information available on marine turtles and their habitats should spur the LGU and the community to initiate and sustain conservation efforts in the creation and enforcement of Marine Protected Areas (MPAs) in Boracay where marine turtle populations are found.

REFERENCES

Abreu-Grobois, A. & Plotkin, P. (IUCN SSC Marine Turtle Specialist Group) (2008). Lepidochelys olivacea. The IUCN Red List of Threatened Species 2008: e.T11534A3292503.http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T11534A3292503.en. Downloaded on 16 May 2016.

Ateneo de Manila University (2018). International citizen science project leads to new species discoveries. http://ateneo.edu/ls/biology/news/features/international-citizen-science-project-leads-new-species-discoveries

Araujo, G., Montgomery, J., Pahang, K., Labaja, J., Murray, R., & Ponzo, A. (2016). Using minimally invasive techniques to determine green sea turtle *Chelonia mydas* life-history parameters. Journal of Experimental Marine Biology and Ecology, 483, 25–30. https://doi.org/10.1016/j.jembe.2016.06.004

Barcelona J.F., Manting M.M.E, Arbolonio R.B., Caballero R., and Pelser P.P. (2014). Rafflesia mixta (Rafflesiaceae), a new species from Surigao del Norte, Mindanao, Philippines. Phytotaxa 174 (5):272-278. https://biotaxa.org/Phytotaxa/article/view/phytotaxa.174.5.3

Boakes E.H., McGowan P.J.K., Fuller R.A., Chang-qing D., Clark N.E., et al. (2010) Distorted Views of Biodiversity: Spatial and Temporal Bias in Species Occurrence Data. PLoS Biol 8(6): e1000385. doi:10.1371/journal.pbio.1000385

Blumenthal, J.M., Austin, T.J., Bothwell, J.B., Broderick, A.C., Ebanks-Petrie, G., Olyik, J.R., Orr, M.F., Solomon, J.L., Witt, M.J., and Godley, B.J. (2009). Diving behavior and movements of juvenile hawksbill turtles Eretmochelys imbricata on a Caribbean coral reef.Coral Reefs 28:55–65.

Caughley G, and Gunn A. (1996). Conservation Biology in Theory and Practice. Cambridge, MA., Blackwell Science.

Chandler M., See L., Copas K., Bonde A. M. Z., López B. C., Danielsen F., Legin J.F., Masinde S., Miller-Rushing A.J., Newman G., Rosemartin A., Turak E. (2017). Contribution of citizen science towards international biodiversity monitoring. Biological Conservation, 213, 280–294. https://doi.org/10.1016/j.biocon.2016.09.004

Chew, V. Y. C., Liew, H.-C. & Joseph, J. (2015). Photographic Identification of Green Turtles (*Chelonia mydas*) at Redang Island, Malaysia. Institute of Oceanography and Environment, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Malaysia

Chassagneux, A., Jean, C., Bourjea, J., & Ciccione., S.. (2013). Unraveling behavioral patterns of foraging hawksbill and green turtles using photo-identification. Marine Turtle Newsletter 137:1-5.

Comprehensive Land Use Plan (CLUP) (2008). Municipality of Malay, Aklan, Philippines.

Danielsen, F., Mendoza, M. M., Tagtag, A., Alviola, P. A., Balete, D. S., Jensen, A. E., Enghof M., Poulsen, M. K. (2007). Increasing Conservation Management Action by Involving Local People in Natural Resource Monitoring. AMBIO: A Journal of the Human Environment, 36(7), 566–570. https://doi.org/10.1579/0044-7447(2007)36[566:ICMABI]2.0.CO;2

Ecocean. (2016). Citizen Science. http://www.whaleshark.org.au/education/citizen-science/

Feliz, P., Revuelta, O., Leon, Y., Aucion, S., & Sofia, D. (2013). Photo-identification of juvenile hawksbill sea turtles using facial scales. In: Blumenthal, J., A. Panagopoulou & A.F. Rees (Comps). Proceedings of the 30th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech Mem NMFS-SEFSC-640. p. 110.

IUCN (2018). The IUCN Red List of Threatened Species. Version 2018-1. <http://www.iucnredlist.org>

Jean, C., Ciccione, S., Talma, E., Ballorain, K., & Bourjea, J. (2010). Photo-identification method for green and hawksbill turtles – first results from Reunion. Indian Ocean Turtle Newsletter 11: 8-12.

Kot, C.Y., E. Fujioka, A. DiMatteo, B. Wallace, B. Hutchinson, J. Cleary, P. Halpin and R. Mast. (2015). The State of the World's Sea Turtles Online Database: Data provided by the SWOT Team and hosted on OBIS-SEAMAP. Oceanic Society, IUCN Marine Turtle Specialist Group (MTSG), and Marine Geospatial Ecology Lab, Duke University. http://seamap.env.duke.edu/swot.

León, Y. and Bjorndal, K. (2002). Selective feeding in the hawksbill turtle, an important predator in coral reef ecosystems. Marine Ecology Progress Series 245:249–258.

Lloyd, J.R., Maldonado, M.A. & Stafford, R. (2012). Methods of developing user-friendly keys to identify green sea turtles (*Chelonia mydas* L.) from photographs. International Journal of Zoology, Article ID 317568, 7p.

Marine Wildlife Watch Philippines. 2016. Facebook post. https://web.facebook.com/marinewildlifewatchofthephilippines/photos/a.206074589000.130523.201382544000/10153600970949001/?type=3

Maiquila-Asis, A. T. personal communication, December 14, 2015.

National Oceanic and Atmospheric Administration. 2014. Draft Stranding Report Definitions of terms for U.S. West Coast Sea Turtle Stranding Report. https://swfsc.noaa.gov/textblock.aspx?Division=PRD&ParentMenuId=211&id=19162

Norman, B. M., Holmberg, J. A., Arzoumanian, Z., Reynolds, S. D., Wilson, R. P., Rob, D., … Morgan, D. L. (2017). Undersea Constellations: The Global Biology of an Endangered Marine Megavertebrate Further Informed through Citizen Science. BioScience, 67(12), 1029–1043. https://doi.org/10.1093/biosci/bix127

Pelser, P.B., J.F. Barcelona & D.L. Nickrent (eds.) (2011 onwards). Co's Digital Flora of the Philippines. https://tropicalbiology.org/cos-digital-flora-of-the-philippines/

Reisser, J., Proietti, M., Kinas, P., & Sazima, I. 2008. Photographic identification of sea turtles: method description and validation, with an estimation of tag loss. Endangered Species Research 5: 73-82.

Rowan, T. S. 2001. Revisiting Boracay Island, the Philippines: An Integrated Coastal Zone Management Perspective.

Schroter M., Kraemer R., Mantel M., Kabisch N., Hecker S., Richter A., Neumeier V., and Bonn A. (2017). Citizen science for assessing ecosystem services: Status, challenges and opportunities. Ecosystem Services 28:80-94. https://doi.org/10.1016/j.ecoser.2017.09.017

Shanker, K., Pandav, B. & Andrews, H.V.. 2003. Sea turtle conservation: research and management techniques. A GOI – UNDP Project Manual, Centre for Herpetology/ Madras Crocodile Bank Trust, Mamallapuram, Tamil Nadu, India. http://seaturtlesofindia.org/?page_id=26

Schofield, G., Katselidis, K.A., Dimopoulos, P. & Pantis, J.D.. 2008. Investigating the viability of photo-identification as an objective tool to study endangered sea turtle populations. Journal of Experimental Marine Biology and Ecology 360: 103-108.

Senate of the Philippines. 2014. Tourism at a Glance. Senate Economic Planning Office https://www.senate.gov.ph/publications/AAG%20Tourism_Final_15oct%202014.pdf

Thompson, P.M., Wilson, B., Grellier, K., Hammond, P.S. 2000. Combining power analysis and population viability analysis to compare traditional and precautionary approaches to conservation of coastal cetaceans. Conserv. Biol. 14, 1253–1263.