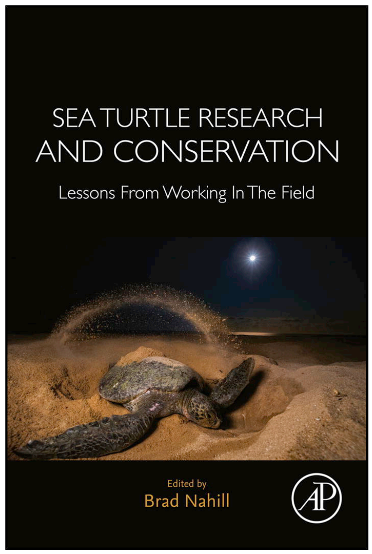

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Applications of Photo Identification in Sea Turtle Studies

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Introduction

Photographic identification (PID) is a technique used to identify individual animals in a population and track them over time from natural marks on the body. For sea turtles, it relies on capturing photographs of the unique patterns on scutes on the turtle's face. PID can be used as a noninvasive alternative to tagging. Indeed, they can be individually identified based on the arrangement of facial scutes [1−5]. These markings are stable over the long term, allowing for population studies over long periods [1].

PID can be used as a noninvasive alternative to tagging [4] and data may be analyzed through Capture-Mark-Recapture (CMR) methods. A photograph is used as the "capture," the pattern of scutes is the "mark," and a subsequent photo is the "recapture." This technique allows researchers to conduct longitudinal studies of individuals, yielding information about home range, survival rate, migration patterns, and life cycle. It also provides the opportunity to gather information on populations that are less studied than nesting females, such as juveniles and males.

PID is an important emerging tool in sea turtle research because it has the potential to provide information in areas where regular research is, and is not, taking place. For example, through the remote collection of images from citizen scientists, PID can help us improve our understanding of turtle home ranges, growth rates, onset of diseases, and reproductive outputs of individuals in places where there is a lack of active research.

The collection of images for a PID program requires little training, and image collections can be generated in both marine and terrestrial settings. In marine settings, all that is typically required is the ability to snorkel or SCUBA dive and to take a clear photo. Terrestrial settings are represented by nesting beach habitats, and simply require the photographer to comply with lighting and flash photography regulations of the managing authorities.

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However, the challenge comes in understanding how to use this opportunistic data effectively. The use of tourists and local community members as citizen scientists increases the workforce and data coverage immensely, although the quality and consistency of data can vary considerably [6].

We present three case studies that demonstrate some of the practical uses of PID in sea turtle research and conservation. These case studies from different regions of the world are focused on foraging populations at different life-history stages. However, they represent only a fraction of practical studies to which PID may be applied.

Reunion Island

Reunion Island is a French department of 2512 km^2 located in the southwest Indian Ocean about 700 km east of Madagascar and 170 km southwest of Mauritius. The island was discovered in the 17th century by the first navigators and described at that time as an important nesting ground for sea turtles. In the years following settlement, sea turtle harvesting for meat consumption on-board ships was so important that the first laws appeared only after 30 years of exploitation. During the following decades and centuries, the introduction of predators and coastal urbanization, in addition to continued harvest, contributed to drastic declines in sea turtle populations.

Things changed in the 1980s, after the establishment of international conventions (CITES, Nairobi) followed by regulations put in place by the French government, and when local associations implemented conservation and awareness-raising actions. These actions contributed to a gradual return of sea turtles at sea and on nesting beaches [7]. Since the 1990s, populations have been monitored by aerial surveys that have revealed population increases on the west coast of the island, particularly since 2007 [8−10].

In 2007 a citizen science program for individual resident green and hawksbill turtle identification by PID was implemented by Kelonia based on the opportunistic collection of images from SCUBA divers and snorkelers, with the goal of increasing knowledge and studying population structure and individual behaviors. These volunteers sent images by email to a dedicated email address or through a web application allowing anyone to search for the turtle they photographed inside the database and access part of its history. The program was also a way to develop a new form of public awareness by including divers in scientific monitoring while providing them with information on sea turtles and facilitating a turtle sponsorship program for the general public.

This citizen science program is based on a PID method developed locally by sea turtle experts from Kelonia [11], applied in a semi-automated recognition software developed with the help of computer developers, and integrated into a database called TORSOOI (www.torsooi.com). This method uses both face profiles (left and right) of individuals to generate an identification code based on facial scute shapes and positions inside the profiles. A major advantage of this program is that there are no required standards for a photo to be usable, with the exception that the scute edges and all post-ocular and bottom-central scutes must be clearly visible.

This program demonstrated that this method can be applied to monitor individuals from birth to adulthood, and is therefore a reliable tool for long-term identification of green turtles [1]. This method was tested and validated for three species: green, hawksbill [11,12], and loggerhead turtles [6]. Although TORSOOI was formalized in 2010, many images were collected in the years prior to its development and integrated into the program after it was launched, including those collected when the citizen science program began in 2007.

Results

Since the start of the program in 2007, Kelonia has collected 2795 images (some integrated into the system from as far back as 2003), with 2061 of greens and 734 of hawksbills. These images have facilitated the identification of 549 individuals (416 greens and 133 hawksbills) and the re-sighting of 182 greens and 54 hawksbills. The duration of individual monitoring was highly variable with an average of 1155 days (±1024). For seven individuals, the time between the first and last sightings exceeded 10 years, with two individuals monitored for 15 years (2004−2019) with several re-sightings during this period.

All of the turtles sighted were typically distributed around popular SCUBA diving sites on the west coast, mainly inside the marine reserve. In this study, the population is mainly composed of juveniles, with very few adults, feeding mainly on red algae on reef slopes (greens and hawksbills), seagrasses (greens), or the corallimorph, *Rhodactis rhodostoma* (hawksbills) on the reef flats [13]. Turtles in this population demonstrated strong spatial fidelity [12] with restricted home ranges of around 1.5 km, and short-term explorations of less than 3.5 km. This has been observed for most of the individuals monitored, including those known for up to 15 years who were systematically sighted at the same dive sites. This strong spatial attachment was also observed over shorter time, and at finer spatial scales through telemetry [14], thus confirming the high fidelity of these individuals to small foraging areas.

The TORSOOI PID software and database have been used in multiple countries in the Indian Ocean region and in other parts of the world. Recent data input revealed for the first time a regional re-sighting between Reunion Island and Tromelin of an adult male green turtle. In the near future, it is expected that with increasing PID data collection and the use of TORSOOI in the southwest Indian Ocean more re-sightings will occur in the region.

Lessons Learned

The number of participants in the citizen science program for Reunion Island varied over time and was highly dependent on how feedback from scientists was communicated to participants on the identity and history of turtles. Images have been contributed by a total of 265 citizen scientists, of which 15 have been regular contributors. The program has been very well received and people have been excited to contribute valuable data to scientific research.

However, one drawback to the program is that since any person trained or untrained may participate, there is the potential risk that overzealous participants may engage in behaviors that disrupt and negatively impact turtles. Although turtles appeared to become accustomed to human presence after approximately 6 months of residence, a contrary effect can be observed in some individuals after residing in the area for several years. In Reunion, interfering behaviors toward marine turtles by swimmers appear to be increasing in the back reef depression, suggesting that special instructions for appropriate sea turtle observation techniques should be provided to citizens who wish to participate in sea turtle monitoring through PID.

Roatán, Honduras

In the western Caribbean, the Bay Islands are nestled 50 km offshore of the north coast of mainland Honduras. At the western edge of Roatán, the largest of the three islands, the Sandy Bay West End Marine Reserve (SBWEMR) hugs approximately 13 km of coastline and extends just 0.5 km away from shore. Established in 1989 [15] to protect a small area of marine ecosystem for the economic interests of hotel and dive operations benefiting from the burgeoning tourism industry, the reserve is the only well-patrolled protected area in the island chain.

In 2014, despite a lack of any actual research on the sea turtle population in the past, the Protective Turtle Ecology Center for Training, Outreach, and Research, Inc. (ProTECTOR, Inc.) recognized that juvenile turtles were recruiting into the reserve area and that the number of resident juvenile hawksbill turtles appeared to be increasing. During 2015, in an effort to begin assessing the population in the reserve, Baumbach and Dunbar [16] developed a web-based map for divers to upload and map in-water sighting records, minimal metadata, and photographs of sea turtles throughout the SBWEMR. This mapping system provided a platform to gather in-water sea turtle photographs, which could then be used within a computer-automated sea turtle PID system.

Advantages of this web-based map platform were that it was freely accessible to anyone who had images of turtles from within the mapped region to upload their images with minimal effort, and it provided a mechanism by which those same sightings could be mapped by the citizen scientists who uploaded them. An added advantage was that researchers could then collect photographs in large numbers via the web-based map, even at times when they were unable to be on location at the marine reserve. Through this process, we devised a novel approach to both remotely collect valuable photographic information on resident turtles, and also engage the public in ecological research on the species.

Although this wasn't the first PID effort to engage the public, making a web-based map available for the public to upload and map their own sea turtle sightings and photographs represents a novel step forward in the evolving development of PID use within the sea turtle research community. In the evolution of PID to engage more citizen scientist involvement on a larger spatial scale, Baumbach and Dunbar further developed the concept of the web-based sightings map into the Turtles Uniting Researchers and

Tourists (TURT) smartphone app [17], which was the first-ever smartphone application for gathering sea turtle sightings on a global scale. The TURT app was developed to allow the input of sea turtle sightings from any mobile smartphone or tablet, providing a convenient method for gathering turtle sightings data from divers or tourists at nesting beaches. Baumbach et al. [17] then advertised the app through the Cturtle listserve run by the University of Florida, and sent messages to dive shops around the world [17].

As sightings data continued to increase, Baumbach and Dunbar began to ask if it was possible to remotely establish specific movement patterns and home range sizes of individual juvenile hawksbill turtles using only photographs and metadata submitted through the web-based GIS map and the TURT app. They also wondered if these home ranges were comparable to home ranges based on radio telemetry studies done in a nearby area of Roatán by Berube et al. [18].

To investigate home range sizes by PID, Baumbach et al. [17] first needed to identify individual turtles through PID. Photographs for each turtle were collected at dive sites throughout the marine reserve via the web-map. The computer-based HotSpotter program [19] was then used to build a database of photographs of individual turtles and match new photographs for each individual as described in Dunbar et al. [20]. Using flipper tags as a means to positively identify individuals matched by the HotSpotter program, a time series of photographs was selected for four separate turtles that were present over the previous 3 years and had been sighted and photographed at least 10 times over that time period. Using flipper tags and PID to identify each individual, sightings were plotted in ArcGIS Online in 2-week periods from July 2014 to December 2017. ArcMap was then used to map individual turtles at different dive sites and home range areas were calculated in ArcGIS Pro using minimum bounding convex geometry with convex hull [17].

Results

Over the period of 2014−17, 347 in-water sightings were mapped on the web-based Roatán map and in the TURT app. During this same period, 1479 images were placed in HotSpotter for identifying individual hawksbills. These sightings facilitated mapping the home ranges of four juvenile turtles within the SBWEMR using ArcGIS. In three of the four cases, home ranges were less than 1 km^2 and appeared to cluster around an area of the marine reserve that had a high abundance of the main hawksbill prey item in this area, the sponge *Geodia neptuni*.

These home range sizes fit well with previous home range analyses for juvenile hawksbills at the eastern end of Roatán using the direct tracking method of radio telemetry to estimate home range sizes [18]. In the fourth case, one juvenile hawksbill in the marine reserve had a home range slightly larger than the others, at 1.44 km^2. The home range for this turtle also overlapped the ranges of the other three in the area where *G. neptuni* had the highest abundance. Baumbach et al. [17] suggested the larger home range was likely due to the relative lack in abundance of the sponge prey to the northernmost area of this turtle's home range and that its larger home range was required to find sufficient sponge prey in the area of the reserve where sponges were most abundant.

Lessons Learned

From these studies, it can be seen that the use of PID in sea turtle research extends beyond the ability to simply identify individual turtles, to using remote re-sightings to track individuals and evaluate their home ranges. What Baumbach and Dunbar [16] learned from the web-based mapping process was that both keeping past divers engaged and recruiting new participants would be neither automatic nor easy. Keeping contributors engaged requires that they see the results of their contributions and are recognized as valued data providers to the process of science. Additionally, if divers are only partially committed, or are only engaged in the process for the initial stimulation of contributing to research, contributors will often reach a low level of input saturation and will quickly abandon the process, no matter how noble or worthy the project may appear.

Republic of Maldives

The Republic of Maldives is an archipelago of approximately 1200 islands spread over an area greater than 87,000 km^2, including 4500 km^2 of reef serving as important habitat for sea turtles. As of April 2016, all species of sea turtles, their eggs, and habitats have been legally protected in the Maldives. However, enforcement remains challenging, particularly in the remote northern and southern atolls. Various direct and indirect threats to these animals and their habitats are creating an uncertain future for sea turtles in the Maldives.

To inform conservation policy in this vast area, robust assessments of population abundance, distribution, and trends over time are necessary. Obtaining such information can be both expensive and logistically challenging, particularly for nations with limited capacity and resources. The evaluation of the conservation status of nesting and foraging sea turtle populations in the Republic of Maldives has been hindered by lack of data for all species.

For the 2008 IUCN assessment for the Maldives, a nesting population of 460−767 green turtles per year was calculated based on what little data were available from 1983 to 1995 [21,22], which represents an approximately 96% decline from historic numbers in the country [23]. The Maldives population for hawksbills is also listed as declining, although the Maldives is considered one of the most important areas for hawksbills in the Indian Ocean [23].

The Olive Ridley Project (ORP) began collecting new and historical photographs of foraging and nesting turtles in 2014. This PID project aims to help fill the gaps in scientific knowledge by providing detailed information on the abundance, distribution, population growth rate, apparent survival, and nesting frequency of hawksbill and green sea turtles in the Maldives. Since more information leads to less uncertainty, there is a need in the Maldives to create a consistent, long-term dataset of sea turtle information in order to inform government policy and management at local and national scales.

Data collection involved no handling of animals and caused no harm to, or harassment of, sea turtles. Data were collected ad hoc from marine biologists and dive guides stationed in resorts, guest houses, and on live-aboards, as well as from community members, ex-patriots, and tourists. When a turtle was sighted, data collectors approached the turtles slowly and took as many photographs as possible, aiming to capture at least one photograph of each side of the face and one of the carapace with a digital camera.

In CMR studies, populations of animals are often modeled as either open (movement in and out of the population) or closed (no movement in or out of the population). Pollock's robust design (RD) [24] offers a different approach. It relies on primary sampling occasions that are each comprised of secondary sampling occasions. For a more detailed description of RD, see Kendall and Pollock [24].

In this case study, an RD approach was applied to foraging hawksbill PID data to determine abundances and apparent survival at six reefs in the Maldives between 2013 and 2016. For the RD analyses, six months were chosen as the primary interval (aligning with the country's monsoons) to test seasonality, and one month for the secondary interval. The analysis tested 30 different models in R (package RMark [25]) in order to explore different ways capture probability, survival, emigration, and immigration changed over time.

Results

As of the end of 2019, this dataset has recorded almost 25,000 sightings of sea turtles in the country. Photos have been collected from approximately 46% of the country's waters and involved over 350 individual submitters. Thanks to a network of citizen scientists and biologists, an average of 15 sightings per day have been collected (spread across the country), making it extremely cost effective over a broad geographic area.

There were large differences in survey effort around the country and high turnover of staff at many locations, which limited the data that could be analyzed. Similar to case studies from Reunion and Roatán, high individual fidelity was observed. Hawksbill abundance increased at all but one site over the four years (2013−16). The mean abundance for the six reefs was 28 turtles while survival of turtles in the six reefs ranged from 77% to 90%, with a mean of 85%.

Out of the six reefs, four fit the same model: one that indicated a strong association with home reefs and heterogeneous detection rates independent of survey effort. One reef fit a model that indicated a more transient association with the home reef. The final reef fit a model that indicated that once a turtle has left its home reef, it is less likely to return, which may be an early warning sign of population decline and may signify the importance of keeping turtles on their home reefs and reducing disturbances to the animals and their habitat.

Annual hawksbill population growth rates were positive (>100%) at five of the six reefs, while one had reef habitats showing advanced decline. Several of the populations within these reefs are growing at 150% to 222% per year, indicating that many new recruits are arriving at the reefs, and that these reefs may not yet have reached carrying capacity.

Sites with high turtle growth rates generally had the lowest variability, suggesting these sites are the most stable, with turtles immigrating and remaining at these sites. Sites with low turtle growth rates had higher variability indicating either greater instability or that habitats became unsuitable. Combined high growth rates and high variability indicated high recruitment, although turtles did not remain in the area.

Lessons Learned

This study has shown that opportunistically collected PID data can be used to create real-time views of turtle abundances and survival in local reefs, and can begin to fill gaps in scientific data. This PID project has harnessed a large workforce for a cost-effective, noninvasive research project to study turtle population dynamics and growth. This project has also given us an opportunity to increase environmental awareness among community members and tourists and to inspire both groups to protect turtles by increasing their economic value. Based on preliminary analyses, populations are stable or growing at many reefs, and the Maldives appears to provide excellent habitats for recruiting juvenile hawksbills.

The lack of robust abundance baseline data from the archipelago makes the detection of a decline challenging. However, this work underlines the importance of simple, long-term monitoring programs that contribute reliable information to help assess the conservation status and efficacy of management strategies. Data such as these can feed into the Maldivian government's management plans, inform future marine protected area creation, and highlight areas of concern where intense monitoring should be focused.

Conclusion

Despite the differences in the three studies presented, some commonalities have emerged. All three studies showed that PID can be a cost-effective and noninvasive way of gathering a great deal of information on the study of animals. However, care must be taken to inform participants about the possibility of disturbing the animals and changing their behavior. Because all three studies were in-water investigations, we determined that for the PID data to be meaningful and useful in this context, a minimum amount of information is required including the dive site name, information about the turtle (approximate size, sex if distinguishable, flipper tag number, life stage), submitter name and email, and the submission of as high-quality photographs as possible.

The number of participants in these citizen science—based studies was variable over time, and required substantial (although different) efforts from the research teams in following-up with contributors to ensure data consistency. If divers are only partially committed or are only engaged in the process for the initial stimulation of contributing to research, contributors will often reach a low level of input saturation, and will quickly abandon the process, no matter how noble or worthy the project may appear.

This situation may lead to sporadic data inputs (whether in time or space), which may then be difficult to analyze, as long time series are needed to determine survival, emigration, growth rates, and other important factors for species conservation and recovery.

In sea turtle research, PID extends beyond the ability to identify individual turtles within their marine habitats. Relatively new developments and tools in the realm of PID are allowing researchers to use remote re-sightings provided by citizen scientists to track individuals and evaluate their home ranges, as well as understand population dynamics of selected groups that reside in specific reef or sea grass habitats. However, when we consider the ability to collect data through smartphone and web-based applications, we begin to imagine new ways in which PID could be used to further sea turtle research.

One example might be to use photo data to track individual turtles along their migration routes wherever they come in proximity to SCUBA diving activities. These data could provide detailed information on turtle activities while on their migrations to and from their nesting grounds. Another example is in identifying individuals through a global image database that actively crawls the internet mining images that could then be used to identify individual turtles around the world [26] whenever the database is queried from a mobile phone or other electronic device [26]. In this case, the idea is to develop portfolios on individual turtles and provide real-time metadata information on everything from laying history and migration routes to disease exposure and genetic links to other turtles. The field and laboratory applications for PID in sea turtle research are still in their relative infancy, but are an emerging tool to improve sea turtle research and conservation on a global scale.

References

[1] A.S. Carpentier, C. Jean, M. Barret, A. Chassagneux, S. Ciccione, Stability of facial scale patterns on green sea turtles *Chelonia mydas* over time: a validation for the use of a photo-identification method, Journal of Experimental Marine Biology and Ecology 476 (2016) 15−21.

[2] S.G. Dunbar, H.E. Ito, Picture Perfect: Photography for Hands-Off Turtle Monitoring the State of the World's Sea Turtles (SWOT), X, 2015, pp. 10−11.

[3] S.G. Dunbar, H.E. Ito, K. Bahjri, S. Dehom, L. Salinas, Recognition of juvenile hawksbills *Eretmochelys imbricata* through face scale digitization and automated searching, Endangered Species Research 26 (2014) 137−146.

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

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

[6] J.L. Williams, S.J. Pierce, M. Fuentes, M. Hamann, Effectiveness of recreational divers for monitoring sea turtle populations, Endangered Species Research 26 (2015) 209−219.

[7] S. Ciccione, J. Bourjea, Nesting of green turtles in Saint Leu, Reunion Island, Marine Turtle Newsletter 112 (2006) 1−3.

[8] H. Sauvignet, A. Pavitrin, S. Ciccione, D. Roos, Premiers résultats des campagnes de dénombrements aériens des tortues marines sur la côte ouest de La Réunion, Bulletin Phaeton 11 (2000) 8−12.

[9] C. Michalowski, Étude de l'indice d'abondance et des facteurs de répartition d'une population de tortues vertes, *Chelonia mydas*, par la méthode du transect aérien sur la côte ouest de l'ıle de la Réunion (Océan Indien), Biologos 6 (2007) 15−28.

[10] C. Jean, S. Ciccione, K. Ballorain, J.-Y. Georges, J. Bourjea, Ultralight aircraft surveys reveal marine turtle population increases along the west coast of Reunion Island, Oryx 44 (2010) 223−229.

[11] C. Jean, S. Ciccione, E. Talma, K. Ballorain, J. Bourjea, Photo-identification method for green and hawksbill turtles − first results from Reunion, Indian Ocean Turtle Newsletter 11 (2010) 8−13.

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

[13] K. Ballorain, Écologie trophique de la tortue verte *Chelonia mydas* dans les herbiers marins et algueraies du sud-ouest de l'océan Indien, 2010.

[14] P. Chambault, M. Dalleau, J.-B. Nicet, P. Mouquet, K. Ballorain, C. Jean, S. Ciccione, J. Bourjea, Contrasted habitats and individual plasticity drive the fine scale movements of juvenile green turtles in coastal ecosystems, Movement Ecology 8 (2020) 1−15.

[15] S. Colwell, Entrepreneurial MPAs: dive resorts as managers of coral reef marine protected areas, InterCoast Newsletter (1999) 4−5.

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

[17] D.S. Baumbach, E.C. Anger, N.A. Collado, S.G. Dunbar, Identifying sea turtle home ranges utilizing citizen-science data from novel web-based and smartphone GIS applications, Chelonian Conservation and Biology 18 (2) (2019) 133−144.

[18] M.D. Berube, S.G. Dunbar, K. Rützler, W.K. Hayes, Home range and foraging ecology of juvenile Hawksbill sea turtles (*Eretmochelys imbricata*) on inshore reefs of Honduras, Chelonian Conservation and Biology 11 (1) (2012) 33−43.

[19] J.P. Crall, C.V. Stewart, T.Y. Berger-Wolf, D.I. Rubenstein, S.R. Sundaresan, HotSpotter − patterned species instance recognition, in: 2013 IEEE Workshop on Applications of Computer Vision (WACV), 15−17 Jan. 2013, 2013, pp. 230−237.

[20] S.G. Dunbar, D.S. Baumbach, M.K. Wright, C.T. Hayes, J. Holmberg, J.P. Crall, T.Y. Berger-Wolf, C.V. Stewart, HotSpotter: less manipulating, more learning, and better vision for turtle photo identification, in: 37th Annual Symposium on Sea Turtle Biology and Conservation, 15−20 April, 2017, Las Vegas, NV, 2017, p. 77.

[21] H. Zahir, A. Hafiz, Sea turtles in the Maldives, in: National Report for the IUCN MTSG Northern Indian Ocean Sea Turtle Workshop and Strategic Planning Session, 13−18 January, Bhubaneswar, India, 1997, p. 16.

[22] J. Frazier, S. Salas, D. N.T.H, Marine Turtles in the Maldives Archipelago, Ministry of Fisheries and Agriculture, Malé, Maldives, 1984, p. 53.

[23] J.A. Mortimer, M. Donnelly, Eretmochelys imbricata . The IUCN Red List of Threatened Species 2008: e.T8005A12881238 (IUCN SSC Marine Turtle Specialist Group), 2008, p. 121.

[24] W.L. Kendall, K.H. Pollock, The robust design in capture-recapture studies: a review and evaluation by Monte Carlo simulation, in: D.R. McCullough, R.H. Barrett (Eds.), Wildlife 2001: Populations, Springer Netherlands, Dordrecht, 1992, pp. 31−43.

[25] J.L. Laake, RMark: an R Interface for Analysis of Capture-Recapture Data with MARK, 2013.

[26] A. Leslie, C. Hof, D. Amoraocho, T.Y. Berger-Wolf, J. Holmberg, C.V. Stewart, S.G. Dunbar, C. Jean, The Internet of Turtles, The State of the World's Sea Turtles (SWOT), XI, 2015, pp. 12−13.