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Olive ridley arribada on Gahirmatha beach, Odisha, India, with the nearby Maipura river delta in the background. See pages 1-2. Photo: M. Muralidharan.

Articles

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Using Social Media and Photo-Identification for Sea Turtles of New Caledonia

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In the last decade, the arrival of Web 2.0 and the rise of social media have opened a new window of opportunistic data collection. Social media is a new type of internet-based media that allows individuals to share photographs, videos, and thoughts and opinions with the world. Multiple social media platforms are available; Instagram is one of the many that allows users to document elements of their everyday lives in a visual context using a smartphone application. Instagram had over one million users within two months of its initial release and steadily increased to over 800 million users, to date (Everson 2017).

Even though most species of sea turtle are Endangered or Critically Endangered on the IUCN Red List (www.iucnredlist.org), and many questions still need to be addressed in order to implement beneficial conservation actions (Hamann *et al.* 2010), funding can be hard to obtain. Alternative methods must be developed in order to collect data for these in-water animals. Photo-identification (Photo-ID or PID) has been used widely to identify individual cetaceans and orectolobiformes (*e.g.*, whale sharks). For whale sharks, the spots on the body of individuals have been used to differentiate between individuals (Arzoumanian *et al.* 2005; Meekan *et al.* 2006; Bradshaw *et al.* 2007). Similarly, photos of cetacean dorsal fins and tail flukes have been photographed to differentiate individuals (Mizroch *et al.* 1990; Wursig & Jefferson 1990; Jujiwara & Caswell 2011; Weller *et al.* 2012). In 2008, two studies addressed the use of photo-identification as an alternative method to flipper tagging for the identification of individual sea turtles (Reisser *et al.* 2008) and Schofield *et al*. (2008) validated this technique by using individuals that also had flipper tags. Photo-identification of sea turtles has been published in multiple papers in more recent years using citizen science sightings. Home ranges of four individual turtles were calculated in Caribbean Honduras using photographs collected by citizen scientists and a smart-phone application that geo-located all uploaded photographs (Baumbach *et al*. 2019). A different study mapped the distribution of 199 individual sea turtles with the help of diver tourists at La Reunion Island (Chassagneux *et al.* 2013). Citizen science (recreational scuba divers) has also been successfully used in monitoring the composition, size and distribution of sea turtles in Mozambican waters (Williams *et al.* 2015), while Papafitsoros *et al.* (in press) used photos posted on social media to document individual sea turtle behavior in Greece.

New Caledonia is a French territory located in the South Pacific (Fig. 1) that is famous for its white sand beaches as well as the world's longest continuous barrier reef. It also has six areas classified on the World Heritage List for its reef diversity and associated ecosystems (UNESCO 2008). As of 2019, New Caledonia is home to a total of 271,407 inhabitants (ISEE 2019a) and has an average of 120,000 tourists that transit through the international airport each year (ISEE 2019b). Cruise ships also provide another type of tourism in New Caledonia and these visitors spend a day independently sightseeing or joining organized day tours. As of 2019, 300 cruise ships had stopped in New Caledonia, carrying over 500,000 tourists (https://la1ere.francetvinfo.fr/nouvellecaledonie/tourisme-croisiere-pleine-expansion-783863.html).

Photo-identification programs have been conducted for multiple species in New Caledonia. The first study was started in 1991 to identify the migration of humpback whales (Garrigue & Gill 1994) and is still ongoing (Garrigue *et al.* 2004, Orgeret *et al.* 2014). A second study obtained sea snake sightings from a group of retirees and it was discovered that there were 140 individual snakes in a coastal area of the capital of New Caledonia (Goiran & Shine 2019). Although these studies conducted were PID, they were done without the use of automated software. A study using photo-identification and the software FinBase reported the migration of tiger sharks in the waters south of New Caledonia (Clua *et al.* 2013). In this study, we documented photographs of sea turtles foraging in New Caledonia that were posted on Instagram between 2013 and 2019 and analyzed them using a program called TORSOOI (Jean *et al.* 2010). We found photographs on Instagram through a search for the keywords: *#seaturtle* in three languages (French, English and Japanese), *#newcaledonia*, popular diving sites of New Caledonia

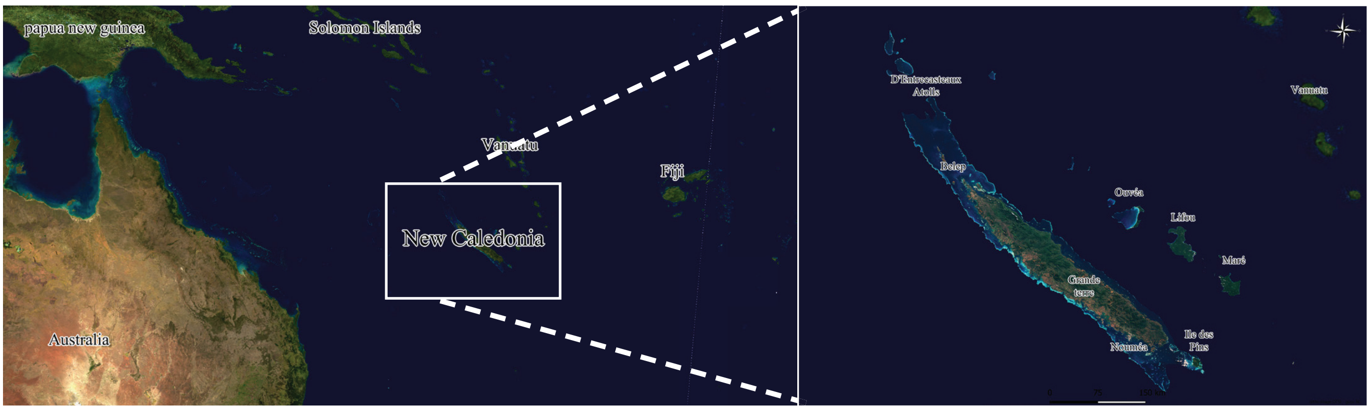

Figure 1. Map of New Caledonia (DTSI-Gouv NC).

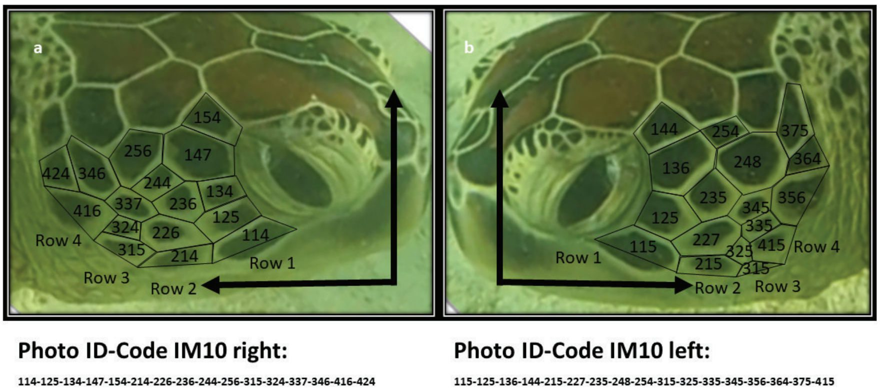

Figure 2. Viewpoint for scute analysis of an individual green turtle's right facial profile (a) and left facial profile (b), based on the position and the shape of the scutes.

#noumea, *#amedeeisland*, *#maitreisland* and words such as *#barrierreef*, *#lagoon*, *#dive*, and *#underwaterphotography*.

Once photographs were collected, we analyzed the profiles for individual turtles using the photo-ID software TORSOOI with all the metadata related to the sighting (date, place where the photograph was taken, species, life-stage, sex, particular physical characteristics such as missing limbs, etc.). The first step consists of manually drawing outlines of the scales on the facial profile by clicking on the vertices around the scutes. This automatically generates a series of codes (one for each scale), which are then used in the recognition process to order match results (Fig. 2). These codes indicate the position of the scale on the profile: first digit corresponds to the row, second digit to the line and the third digit equals the number of sides that each scute has. These scales have been studied and remain stable throughout the life of the individual (Carpentier *et al.* 2016). Match results are ordered according to the number of matched codes to photos (Jean *et al.* 2010). Finally, we visually matched photographs from the query. If a match was validated, the history of the profile was completed: the photograph was added to the record belonging to the matched profile (with all the metadata associated) and recorded as a "recapture." This allows us to monitor the movements of individuals and to note how many times an individual was seen. We recorded any turtle as a new individual if the photograph did not have a match in the database. When the right and left profiles of the same turtle were available, they were linked and the record for that individual was complete.

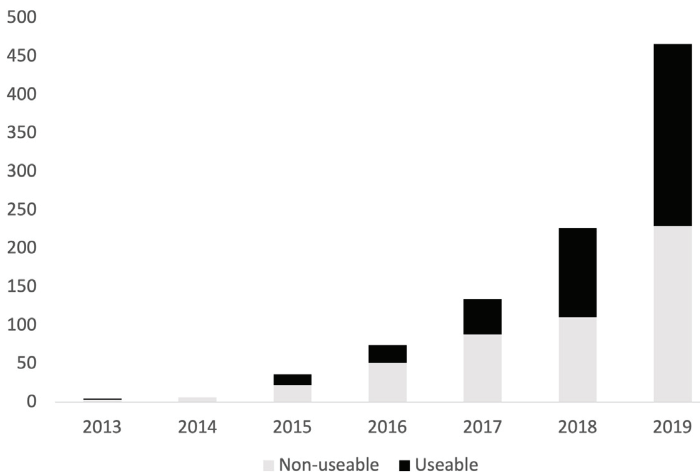

Figure 3. Number of photographs of sea turtles uploaded on Instagram between 2013 and 2019 in New Caledonia. Black bars represent useable photos, whereas grey bars represent non-useable photos.

Our search revealed that 946 sea turtle photographs were uploaded to Instagram between 2013 and 2019 and were referenced as having been taken in New Caledonia. Forty-six percent (n = 437) of these photographs were useable on the program TORSOOI (Fig. 3). We uploaded each of the useable photographs to TORSOOI and identified 276 profiles. Three species of sea turtles were photographed: *Chelonia mydas* (90%), *Caretta caretta* (5%) and *Eretmochelys imbricata* (5%). Our data showed *C. mydas* as the dominant species in New Caledonian waters; this was previously reported by Read (2015). Fourteen different locations within New Caledonia were included in the photograph metadata. They varied from the whole territory to specific islands (Table 1).

We found TORSOOI recognized profiles that already had matches in our database, and these profiles were then recorded as "recaptures." In this study, 164 recaptures were found with each profile being sighted on average 1.8 ±1.4 (SD) times (range of recaptures per profile: 1-9) and with a mean of 277 ±346 (SD) days between each recapture. All recaptures were of *C. mydas* profiles. Recaptures were recorded in seven locations but the highest rate of recapture was at Amedee and Signal Islands. Amedee Island is the primary tourist attraction listed on Tripadvisor (tripadvisor.com) and is directly linked to cruise ship tourism, while a snorkeling company on Signal Island advertises a "Noumea turtle tour" for tourists. These tourist attractions may explain why most recaptures were recorded at these two locations. Our data show that only one individual was photographed at two different locations. A single *C. mydas* named "Flo" was photographed at Duck Island on 31 October 2017 and was subsequently photographed on 16 November 2017 at Maitre Island (Fig. 4). Other studies support our results that sea turtles show high fidelity to their feeding areas (Limpus *et al.* 1992; Musick & Limpus 1997; Chaloupka & Limpus 2005; Broderick *et al.* 2007; Limpus 2009; Hart & Fujisaki 2010; Read *et al.* 2014).

Scientific data are harder to collect for juvenile and male sea turtles as they are rarely observed. Opportunistic PID allows the gathering of information for individual foraging sea turtles that would otherwise be difficult to obtain. Previous research has shown that in New Caledonia, the majority of green turtles present in foraging grounds are juveniles (Read *et al.* 2020). Our data does not allow us to estimate the number of individuals per feeding ground, however, citizen science data collection may aid future studies in providing these types of estimates.

In this study, the photographers had no particular training and no

New Caledonia	Noumea	Poé	Koumac	Lifou	Mare	Ouvéa	Ile des Pins	Duck Isld	Maitre Isld	Signal Isld	Laregnere Isld	Amedee Isld	Tenia Isld
48	6	2	2	10	3	6	13	7	58	25	6	85	5

Table 1. Number of useable sea turtle photographs that were uploaded to Instagram and their geographic locations.

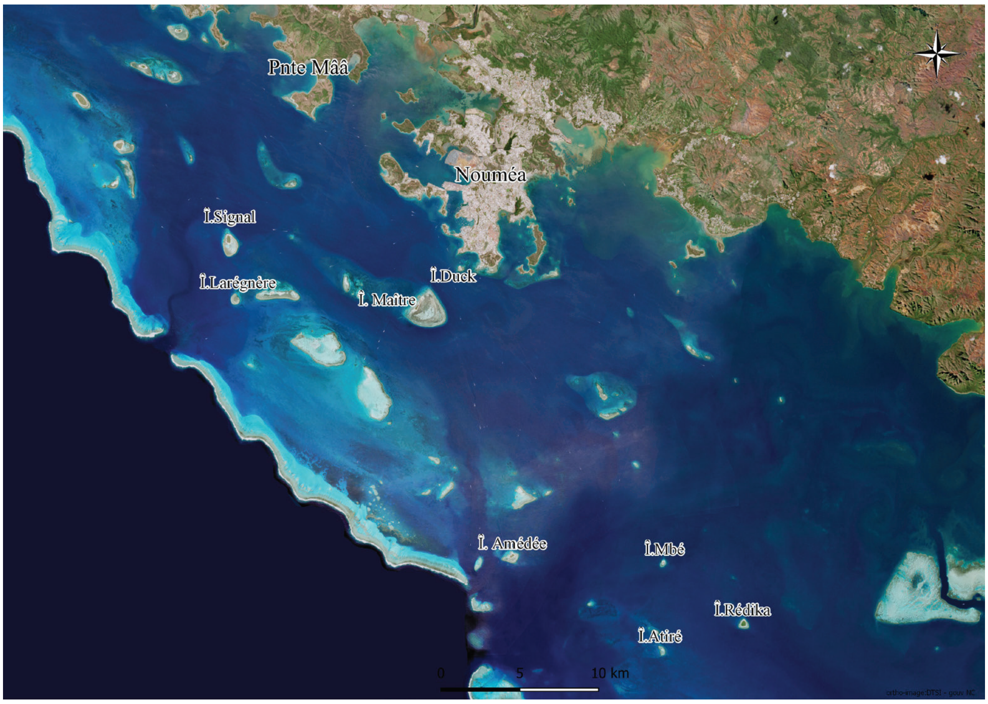

Figure 4. Map of islands of Noumea (DTSI-Gouv NC).

knowledge of participating in a citizen science project. The citizen scientists that provide the best data are the ones that are trained over time; this has been demonstrated in several studies (Williams *et al.* 2015; Baumbach *et al.* 2019). By also giving guidelines to people who want to participate in PID studies, it may also prevent some natural behavior disruption or harassment of the sea turtles (or other species studied). We witnessed instances of this disruption in some of the photographs from Instagram. In the Maldives, a citizen science study has allowed for data to be collected by dive and snorkel guides, marine biologists, and tourists (Hudgins *et al.* 2017). Their study was able to show that a citizen science project is an effective way of collecting data and that it also helps engagement of the general public toward the conservation of endangered species (Hudgins *et al.* 2017). Scuba divers represent an adequate population to participate in citizen science but there is a drawback of a lack of long-term involvement (Lucrezi *et al*. 2018). A previous study conducted by Santori *et al.* (2020) had observed this kind of behavior with users of TurtleSAT, a program designed to record any sightings of freshwater turtles in Australia. Their study showed direct contact with volunteers is needed and may be implemented through a hotline for technical issues (Santori *et al.* 2020).

The majority of the photos of sea turtles that were uploaded only showed one side of the head of the individuals. The number of scales and their disposition changes from one side to the other, which represents a bias in the data since the right facial profile is different from the left facial profile (as per Fig. 2). Therefore, individuals may be counted twice if the facial profile photographs cannot be matched to other photographs in the database. The use of videos or guidelines for citizens willing to provide data is essential in order to get a complete individual (Newman *et al.* 2010).

Not all photographs uploaded on social medias are useable (distance, angle, photo quality, etc.). Creating a hashtag dedicated to your study and giving some guidelines into what type of photographs is needed will allow for a non-negligible gain of time and of data. However, launching a campaign to collect some data can have some negative impact on the natural behavior of sea turtles. The race for the perfect picture can sometimes impede the precautions usually taken to protect these endangered species that may also be against the law in some countries. For example, in New Caledonia, approaching sea turtles at a distance <10 m is against the law.

The impact of whale watching on the behavior of humpback whales was studied in New Caledonia, in which 80% of the individuals showed a clear deviation from their trajectory when boats approached (Schaffar *et al.* 2013). A similar study was done on sea turtles in Honduras and showed that the number of sightings did not vary with the pressure from divers but the time spent feeding, investigating and breathing decreased with the presence of divers (Hayes *et al.* 2017).

This study describes an innovative method for data collection and explores the quality of citizen science photos for use in PID. This type of project could be undertaken in other areas where tourists are in close proximity to sea turtles, but rules should be put in place to make sure that sea turtles are not negatively impacted more than what is gained for their survival.

Acknowledgements. The photographs used for this study follow the fair use provision, Section 107 of the U.S. Copyright Act. Only a subset of the photographs was used and the data corresponding to the photographers were not stored. A special thank you to the volunteers who spent hours looking for photographs on social media for this project.

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