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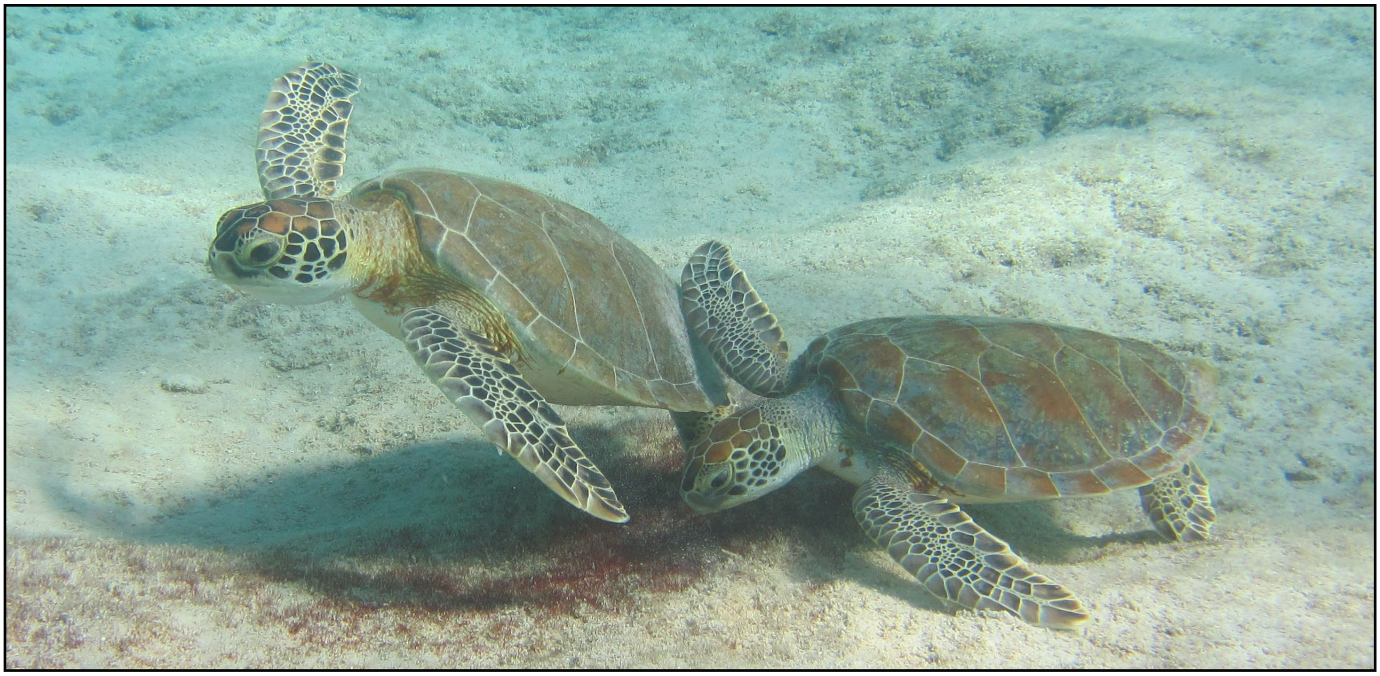

Green turtles "SAF" on left and "SX" on right at Salt Pier Bonaire, Dutch Caribbean.
See pages 1-8. Photo by Kevin Pursley

Articles

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In-water Computer Aided Photo-ID of Juvenile Green Turtles (*Chelonia mydas*) using Flipper Scales and Affine Transformations

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Photo identification (Photo-ID) has been used as a cost-effective method for mark-recapture of manta rays (Town *et al.* 2013), salamanders (Bendik *et al*. 2013, wildebeest (Morrison & Bolger 2014), giraffes (Bolger *et al.* 2012) and sea turtles. Previous sea turtle research has proven the effectiveness of sea turtle head scale patterns for Photo-ID (Schofield *et al.* 2008; Reisser *et al.* 2008; Lloyd *et al.* 2012; Hall & McNeill 2013; Dunbar *et al.* 2014; Chassagneux *et al.* 2013; Valdès *et al.* 2014; Su *et al.* 2015). Photo-ID has become a popular alternative to flipper tagging for reasons including: permit restrictions (Hall & McNeill 2013), capture stress, entanglement, hydrodynamic drag, risk of predation (de Urioste *et al.* 2016), risk of injury, cost-effectiveness (Araujo *et al*. 2016) and tag loss (Reisser *et al.* 2008). De Urioste *et al.* (2016) recommended flipper tagging be discontinued worldwide from the suggested tagging protocols for marine turtles based on the above concerns.

Methods used for computer aided sea turtle photo-ID include matching of head scales using numerically coded scale shape patterns (Jean *et al*. 2010; Valdés *et al.* 2014), Interactive Individual Identification System (I^3S) Classic (Dunbar *et al.* 2014) and subjective pattern matching (Bennett & Bennett 2001). Stability of facial scale arrangement and shape has been shown to be stable for up to 11 years (Carpentier *et al*. 2016). Facial scale Photo-ID does have significant drawbacks for in-water acquired images. To obtain a useful image the turtle should be approached from the side and parallel to the turtle with less than a 20° viewing angle (Araujo *et al.* 2016) limiting the use of citizen scientist snorkelers. Tumors can also obscure the facial scales (www.turtles.org/identify.htm).

Few examples of investigating flipper scale patterns for Photo-ID exist (Caillouet *et al*. 1985; Gatto *et al.* 2018; www.turtles.org/identify.htm). The front flippers of sea turtles form semi-rigid hydrofoils (Walker 1971; Font *et al*. 2011), which provide nearly flat areas that allow the use of mathematical algorithms that match planar surfaces**.** The National Advisory Committee for Aeronautics (NACA) 0014 airfoil has been used to model the turtle's front flipper (Font *et al*. 2011). Posterior of the maximum thickness the profile provides a nearly flat surface. The proposed method has been used when areas of the flipper are obscured while the turtle is resting in and under coral. Matches might also be possible on the uninjured portions of an injured flipper, which should match similarly to partially visible flippers. To the author's knowledge this is the first systematic in-water Photo-ID study using sea turtle flippers.

Photos of juvenile green sea turtles were obtained using Canon SX280HS digital cameras (12MP) with a WP-DC42 waterproof housing while snorkeling and SCUBA diving during one to three week annual summer trips to Bonaire from 2012 to 2016. Bonaire is an island in the Caribbean Sea approximately 80 km from Venezuela. Details on sea turtle density, nesting and other information can be found in the STCB (Sea Turtle Conservation Bonaire) annual reports (www.bonaireturtles.org/wp/explore/publications). A set of 64 images of left flippers of 30 individual green turtles were selected from the dive sites Karpata, Andrea I, Cliff, and Salt Pier. Left front flippers were used for no other reason than the author had more left front flipper pictures than right front flippers. Images captured while SCUBA diving and snorkeling with different illumination, viewing angles and quality were selected to test the capabilities of the prototype application. Included in the author's dataset are eleven turtles encountered only once, eleven photographed intra-year and eight in multiple years.

I^3S Classic (den Hartog & Reijns 2014) was explored for computer assisted flipper matching because of its successful prior use with sea turtle facial matching. The user manual advises viewing angles of no more than 30°. The program requires three reference points that are visible in all pictures and their exact location must be consistently and clearly distinguishable. The author could find no such landmarks defined for sea turtle flippers. Usable reference points were discovered after self-study of sea turtle flipper

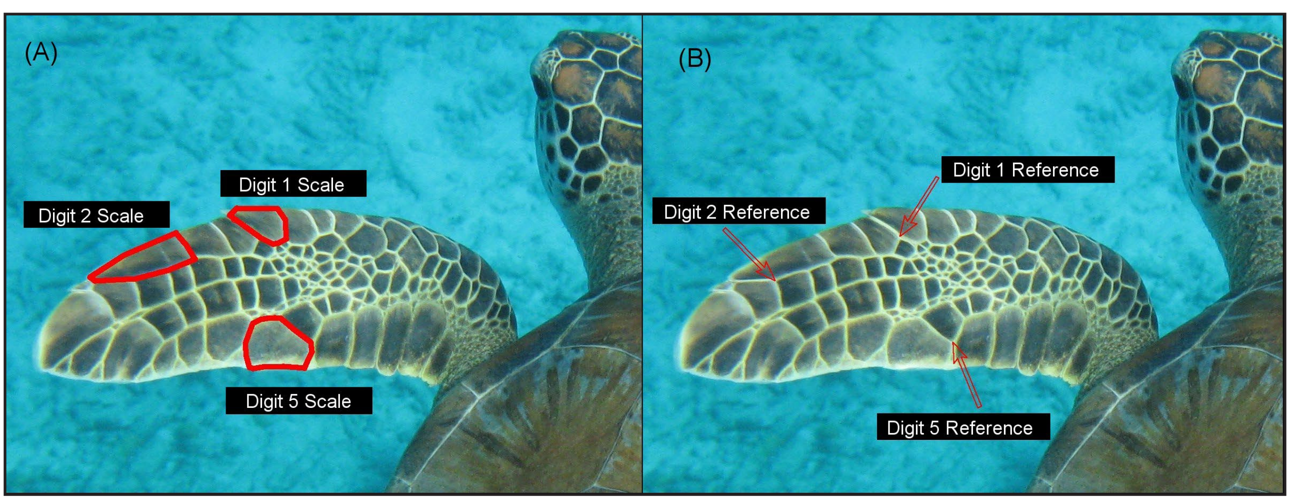

Figure 1. Left front flipper imager of "Hook" showing (A) outlined digit scales and (B) reference points.

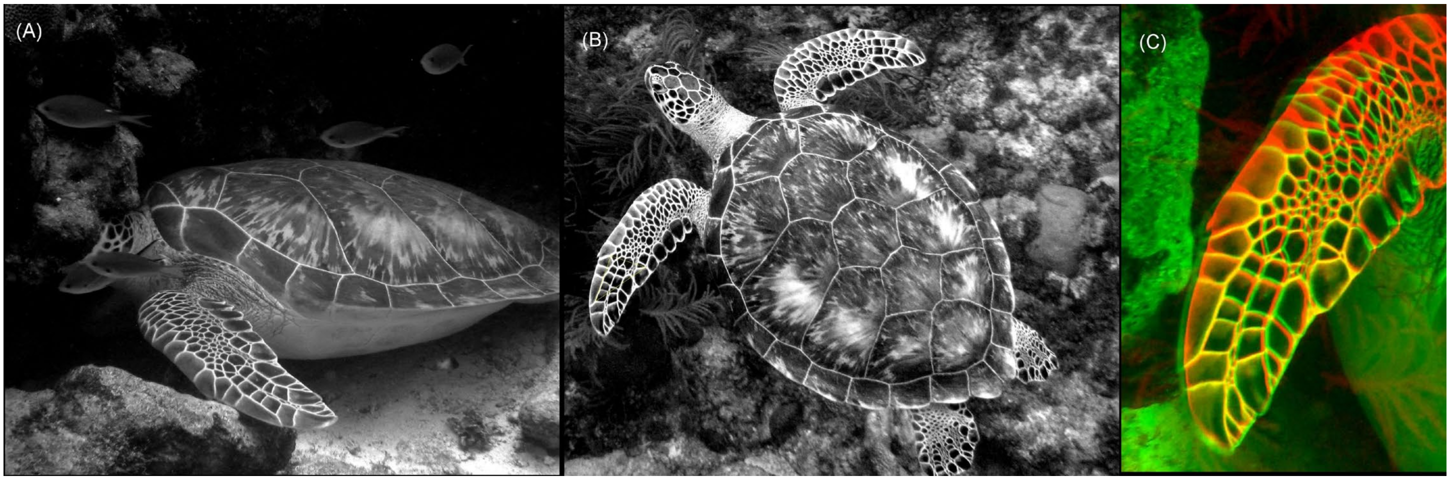

Figure 2. (A) Bonaire green turtle on 13 August 2014, courtesy Erik van der Zijden; (B) author's photo;(C) flipper from 2A affine transformed in to flipper from 2B. (C) Affine mapping of flippers from (A), colored red, and (B), colored green, and yellow indicates overlap.

photographs and consulting a sea turtle flipper anatomical diagram (www.fairmanstudios.com/turtle-flipper-anatomy). The reference points selected are the first scale intersection proximal of digit one, first scale intersection proximal to where digit two would emerge and the most proximal intersection of the scale covering digit five (Fig 1). Other spot points, which are typically scale intersection points, also need to be picked which can consume some time and may be inconsistent even when chosen by a single individual. The author abandoned I^{3}S Classic because the three reference points are not always visible, may be missing in the case of an injured turtle and the time and difficulty involved in consistently picking spot points.

Because the three reference points define a plane, the author employed ImageJ with a geometric mapping plugin (http://ij.ms3d.de/geometric_mappings.php) that provides an affine transform. Verification of both the usefulness of these reference points with different flipper poses could be matched was tested. Two images of the same turtle on a single dive taken by two divers with different cameras, angles and lighting show the efficacy of this method (Fig. 2).

The areas surrounding the reference point may also be used to classify flippers into groups similar to head scales (Schofield *et al.* 2008; Lloyd *et al.* 2012). Figs. 3B, 3C and 3D have been affine transformed using the reference points to match the Fig. 3A view. The author uses these classifications when manual matching. Table 1 contains the digit two pattern number which is coded as the number of scales directly posterior to the digit two reference scale. Partial scales are usually encoded as an additional 0.5 (see Fig. 3). The pattern of scales around digit five has also been used by the author for quickly confirming or rejecting a match while manually searching images and verifying weak computer-generated matches. Reference points were only used to verify that affine transformations are a suitable method of matching flippers and are not used for the prototype application.

Having established that affine transformations can allow for matching flippers, Affine Scale-Invariant Feature Transformation (ASIFT) (Yu & Morel 2011) was tested as a tool to match sea turtle flipper images. ASIFT leverages Scale-Invariant Feature Transform (SIFT) (Lowe 2004) and is designed to match images with much wider viewing angle differences than SIFT. This aids in matching in-water photos where the viewing angle of the turtle cannot be controlled. ASIFT models six viewing parameters instead of four for SIFT. SIFT has been used previously for Photo-ID of leatherback turtles (Buonantony 2008) and manta rays (Town *et al.* 2013).

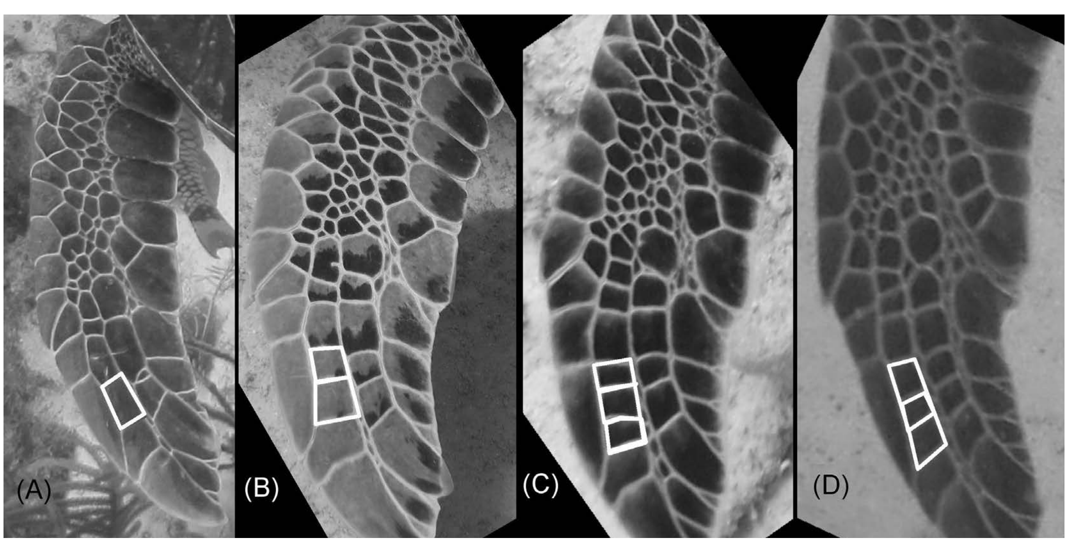

Figure 3. Illustration of simple grouping based on number of scales posterior from the digit two scale. (A) One scale and a partial coded at 1.5 (B) two scales and a partial as 2.5 (C) Three scales as 3.0 (D) Three scales and a partial as 3.5.

Turtle	Site	2012	2013	2014	2015	2016	Digit 2 pattern	Min Match Score	Max non-match Score	Non-match Turtle
AA	Andrea I					2	2.5	1694	19	K2
Algae	Andrea I					2	1.5	946	38	Jellyman
Alice	Andrea I	1					2.5		16	Night
Damsel	Andrea I					2	2.5	226	18	Mirjam
Dot	Salt Pier			1		2	2.5	35	21	G
E	Salt Pier					3	2.5	109	25	Flyer
Earl	Karpata			1	1	1	2.5	27	18	Damsel
Flyer	Cliff			1	1	3	2.5	73	33	K2
G	Salt Pier					2	2.5	1612	21	Dot
H	Salt Pier					3	2.5	77	18	Tres
Harry	Salt Pier					2	2.0	1323	16	Parker
Hook	Andrea I		1				2.5		20	Ursula
J	Salt Pier					2	1.5	1186	36	Parker
Jellyman	Karpata					2	1.5	502	52	K2
Joan	Salt Pier					1	1.5		13	Algae
K2	Karpata			1			1.5		52	Jellyman
Melvin	Karpata				1	1	1.5	430	19	G
Mirjam	Karpata				1	1	2.5	57	27	Jellyman
Night	Cliff			1	1	1	2.5	47	25	TwoTone
Notch	Salt Pier					2	2.5	888	15	AA
Parker	Cliff				1		2.5		36	J
Peter	Andrea I		1				2.5		15	Flyer
Plant	Cliff				1		2.0		22	Ursula
Tick	Salt Pier			1			2.5		17	Flyer
Tie	Salt Pier				1	1	2.5	233	17	G
Tres	Cliff				1	2	3.0	134	32	Parker
TwoTick	Andrea I					2	1.5	29	18	Flyer
TwoTone	Salt Pier			1			2.5		29	J
U1	Cliff			1			2.5		17	Miram
Ursula	Andrea I		1				2.5		23	Flyer

Table 1. Details and matching results of author-provided turtle flipper dataset.

A prototype application based on ASIFT was built by the author. Reference implementations of ASIFT can be found in OpenCV (Bradski 2000) and Yu & Morel (2011). Frames from a movie of a green turtle in "flight" near Little Cayman compared to a reference image using the prototyped program and recombined into a movie (www.youtube.com/watch?v=ubcwmCG1ZWM) illustrates that flippers may be matched successfully in a variety of poses during active swimming and validates that regions of the flipper can be treated as planar surfaces. Unlike other methods (den Hartog & Reijns 2014; Dunbar *et al.* 2014), no manual point/intersection picking is required. The preprocessing of images consisted of rectangular cropping the flipper from the raw images and optionally adjusting brightness/contrast and rotation using ImageJ (Schneider *et al.* 2012). Better images are taken against a plain background such as blue water or white sand. This can eliminate the false matching of similar objects in the background of both images. Rotation before cropping can eliminate much of the background if needed. Using the author's dataset the prototype application scales large images reducing computer resources. Other modifications were made to the algorithm to reduce computer resources because ASIFT is typically 13.5 times the computational effort of SIFT (Yu & Morel 2011). The cropped images may be of different sizes so the matching process is repeated with the image order swapped. The match score used by the author is the sum of matches in both directions. The minimum match scores for all images of an individual are reported in the Min Match Score column of Table 1. In all true match cases the minimum match scores were greater than any non-matching image scores, which are provided in Table 1 as the Max non-match Score column. The highest scoring non-match turtle name is also included in Table 1 as column Non-match turtle. Turtles appearing

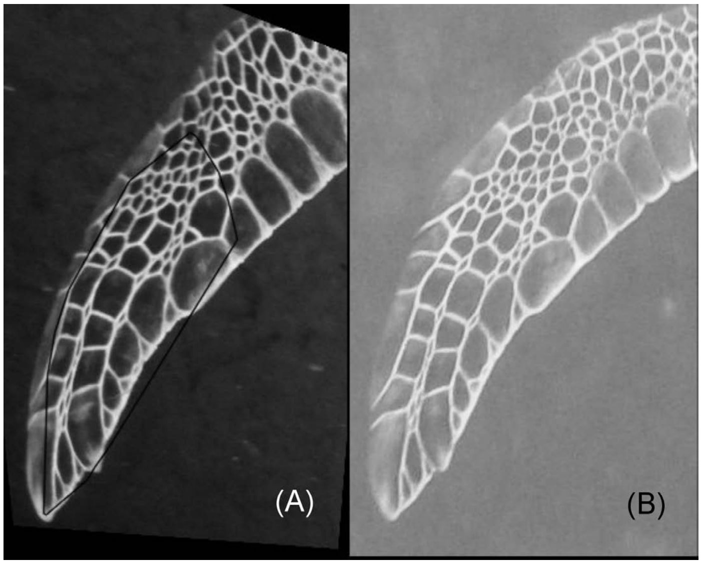

Figure 4. Visual matching results for green turtle image pair. Convex hull match area shown on image (A) that has been transformed to view of (B).

several times as non-matching indicate that they have at least a small region that is similar to several other turtles as in the case of "Flyer" which has the highest false match score for five turtles. A visual example of the prototype application is illustrated by Fig. 4. Fig. 4A is a cropped image of Fig. 5A that has been transformed by the application into the view of 4B which is a cropped image of Fig.5B. The application, when run interactively, draws the convex hull of the matching points on the first image to highlight the area where matches were made. This aids the user in verifying whether the image pair is a weak match or a false positive. The application has been in use by the author for several years to validate uniqueness and stability of flipper scale patterns over time. Table 2 details 183 encounters with 34 turtles near the Red Slave and Salt Pier dive sites that were successfully Photo-IDed multiple times for periods up to 1,477 days. Thirteen turtles were tracked for more than 1,000 days. One turtle "J" was recaptured after 1,333 days. Turtle "OC" has been followed via Photo-ID from before getting an external tag (Fig. 6A), after tagging (Fig. 6B) and finally after tag loss (Fig. 6C). Salt Pier is an industrial and heavily used recreational site so this data may be useful for studying the health and population dynamics of the resident turtle population.

Further research could explore other scoring methods and criteria for matching key points as well as algorithm optimization. Vacationing and resident snorkelers and divers can be leveraged to acquire useful Photo-ID images as part of their normal aquatic activities while following local conservation laws and guidelines. Fig. 5B shows a nearly ideal image while snorkeling clearly showing both flippers and includes both the carapace and the top of the head that can also be useful in identification. Photos used in Photo-ID can be taken from a distance to minimize barrel, perspective and other possible distortions in the image. Turtle flipper scale patterns can be used as a low cost, non-invasive matching technique while turtles are actively swimming, resting or foraging. The author suggests this method can be applied to the juvenile stage turtles of other species that have visible scale flipper patterns. As an example, Fig. 7 shows the technique applied to a hawksbill turtle (*Eretmochelys imbricata*) recaptured after 1,868 days. In that time period the turtle was tagged. Photo-ID extends the turtle's recorded life history. From the author's volunteer work photographing captive juvenile loggerhead turtles (*Caretta caretta*) could also benefit from this technique. The reference points and groupings may be useful for both hawksbill and loggerhead turtles. The method has been shown to be useful for periods up to 1,477 days for *Chelonia mydas* and 1,868 days for *Eretmochelys imbricata.*

The source code for the prototype application is available for non-commercial use from the author. Fig. 8 shows an example of the prototype application when run in interactive mode. The standard ASIFT algorithm can be accessed on the Image Processing On Line website (<http://ipol.im).

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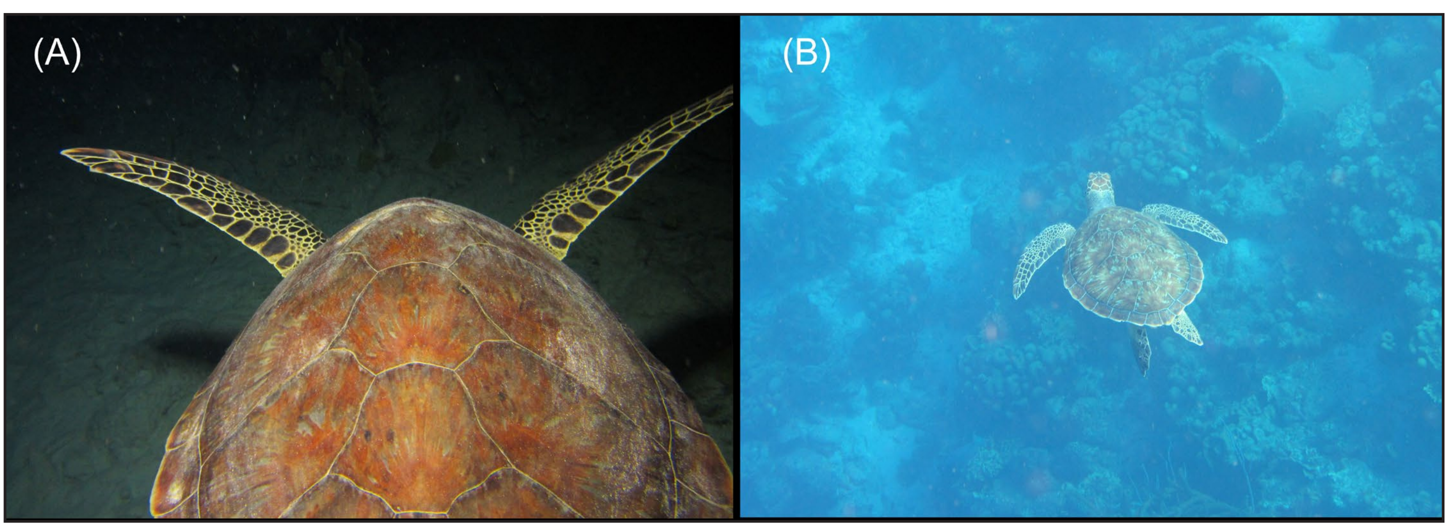

Figure 5. Original uncropped images for results shown in Figure 4. (A) "Flyer" on 01 August 2016 night snorkel. (B) "Flyer" on 23 August 2014 day snorkel.

van der Zijden for a photograph; Cathleen and David Whillock for photographs; Julia Reisser and Maíra Proietti for turtle head image dataset; Sue Willis and Sea Turtle Conservation Bonaire (STCB) staff and volunteers; Coral Paradise Resort, Dive Friends Bonaire, Captain Don's Habitat, Sea Sports SCUBA and Sheila Shelton for dive support; and Peter and Ursula Bennett for pioneering Photo-ID of sea turtles. The author also thanks the reviewers of this study.

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Turtle ID	Site	First encounter	Last Encouter	Total encounters	Max days between encounters	Days from first to last enounter
AC	RS	10 Aug 2017	14 Aug 2020	5	855	1100
BC	RS	28 Jul 2017	22 Aug 2020	8	532	1121
CC	RS	01 Dec 2019	22 Aug 2020	9	148	265
DC	RS	28 Jul 2017	05 Jul 2020	9	458	1073
EC	RS	29 Jun 2018	28 May 2020	9	519	699
FC	RS	01 Aug 2017	27 Aug 2020	9	851	1122
GC	RS	30 Nov 2019	30 Dec 2019	2	30	30
HC	RS	11 Jan 2019	27 Aug 2020	5	336	594
IC	RS	13 Dec 2019	04 Jan 2020	2	22	22
JC	RS	31 May 2019	27 Aug 2020	7	213	454
KC	RS	10 Aug 2017	27 Aug 2020	4	872	1113
LC	RS	30 Dec 2019	18 Jul 2020	5	125	201
MC	RS	28 Jul 2017	21 Aug 2020	9	471	1120
NC	RS	11 Aug 2016	27 Aug 2020	5	855	1477
OC	RS	01 Aug 2017	29 Aug 2020	8	852	1124
PC	RS	22 Aug 2014	10 Aug 2017	3	1071	1084
RC	RS	30 Dec 2019	22 Aug 2020	5	176	236
Harry	SP	01 Aug 2016	05 Apr 2020	6	537	1343
I	SP	13 Aug 2016	25 Apr 2020	5	604	1351
J	SP	07 Aug 2016	05 Apr 2020	3	1333	1337
SAA	SP	27 Mar 2020	13 Jun 2020	4	49	78
SD	SP	09 Feb 2019	27 Mar 2020	2	412	412
SE	SP	15 Jul 2018	13 Aug 2020	8	412	760
SF	SP	06 Apr 2019	13 Mar 2020	2	342	342
SG	SP	06 Apr 2019	12 Jul 2019	3	76	97
SH	SP	29 Jul 2017	05 Apr 2020	5	399	981
SK	SP	15 Jul 2018	02 Jul 2020	5	344	718
SM	SP	01 Feb 2018	13 Aug 2020	8	378	924
SO	SP	15 Jul 2018	15 Mar 2019	2	243	243
SS	SP	09 Feb 2019	01 Aug 2020	5	421	539
ST	SP	09 Feb 2018	22 Feb 2020	3	409	743
SU	SP	06 Aug 2017	13 Aug 2020	7	456	1103
SX	SP	22 Feb 2020	13 Aug 2020	8	49	173
SZ	SP	15 Jul 2018	25 Apr 2020	3	441	650

Table 2. Turtle encounters verified by prototype photo-ID application. Site abbreviations: RS = Red Slave SP = Salt Pier.

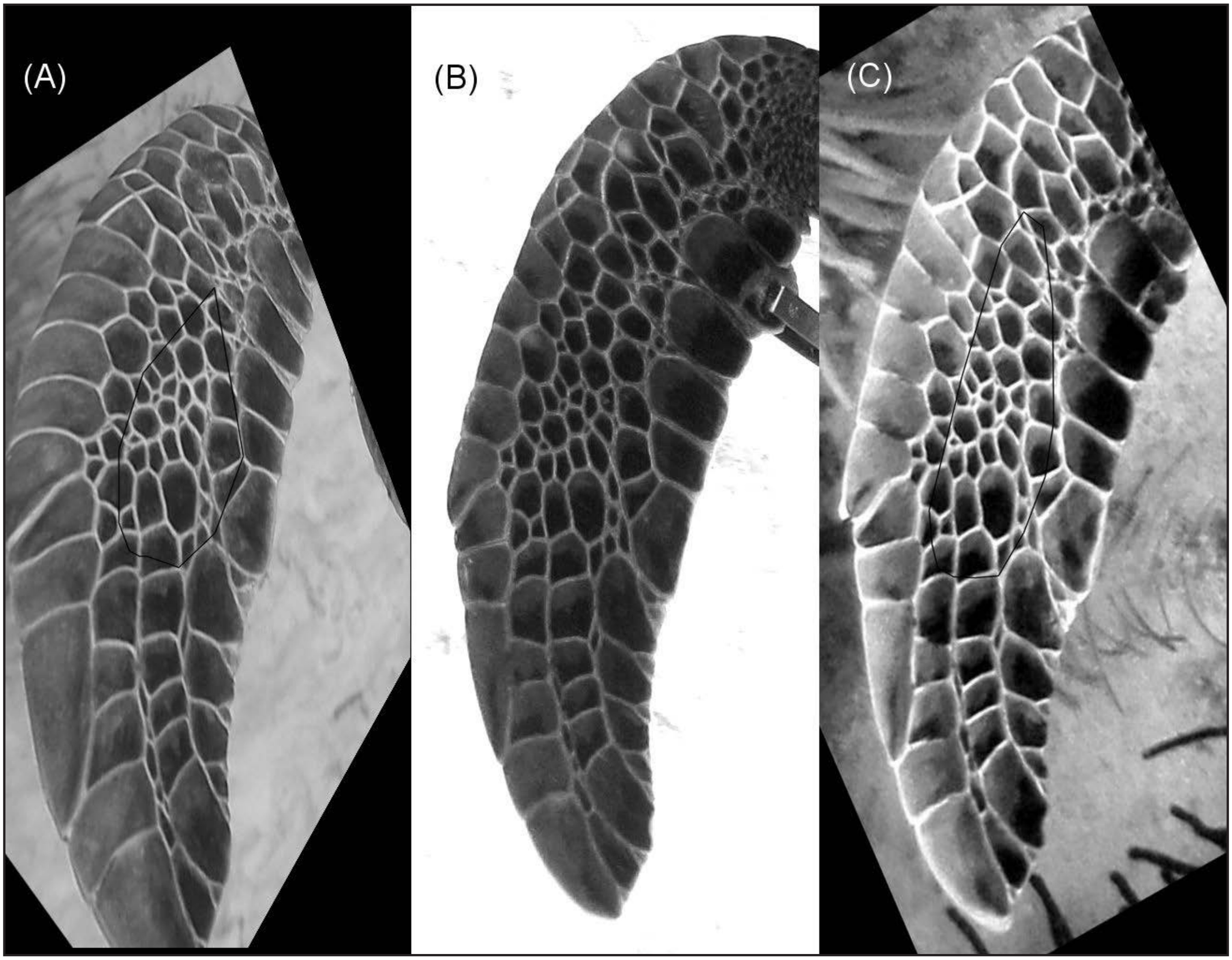

Figure 6. Turtle "FC" tag history: (A) 01 August 2017, (B) 30 December 2019, (C) 28 May 2020.

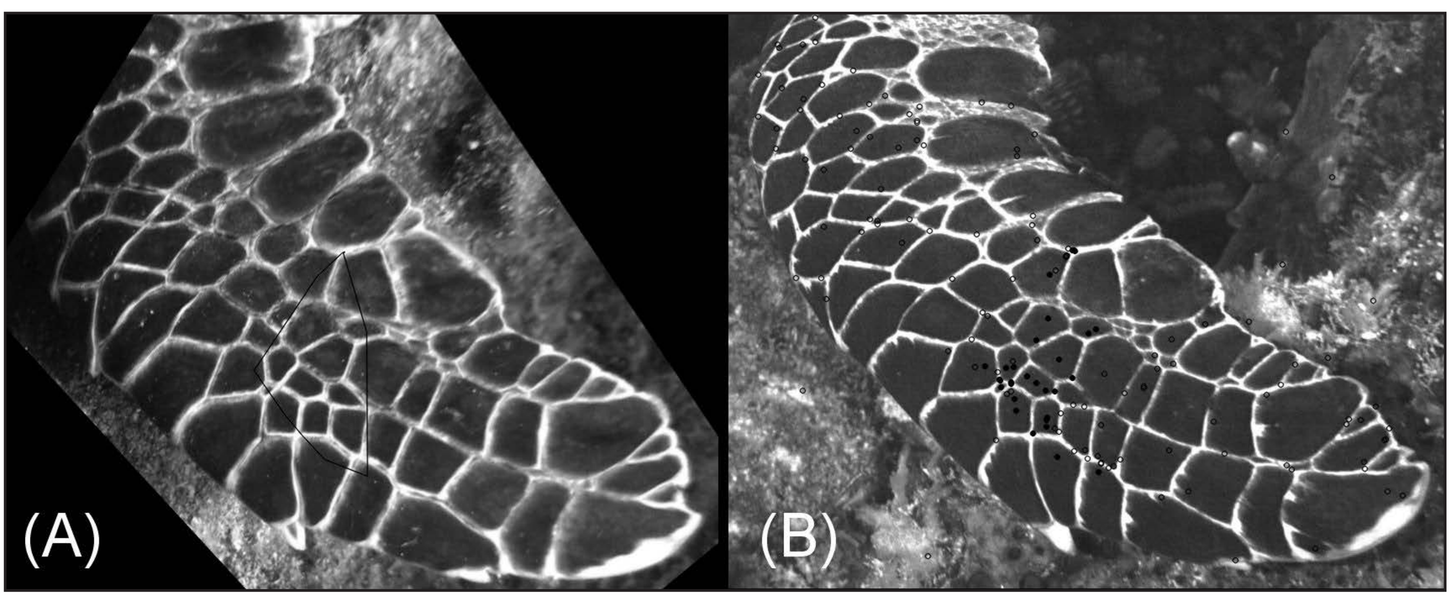

Figure 7. Hawksbill turtle. (A) 14 August 2015 affine transformed to (B) 24 September 2020 (Courtesy David Whillock).

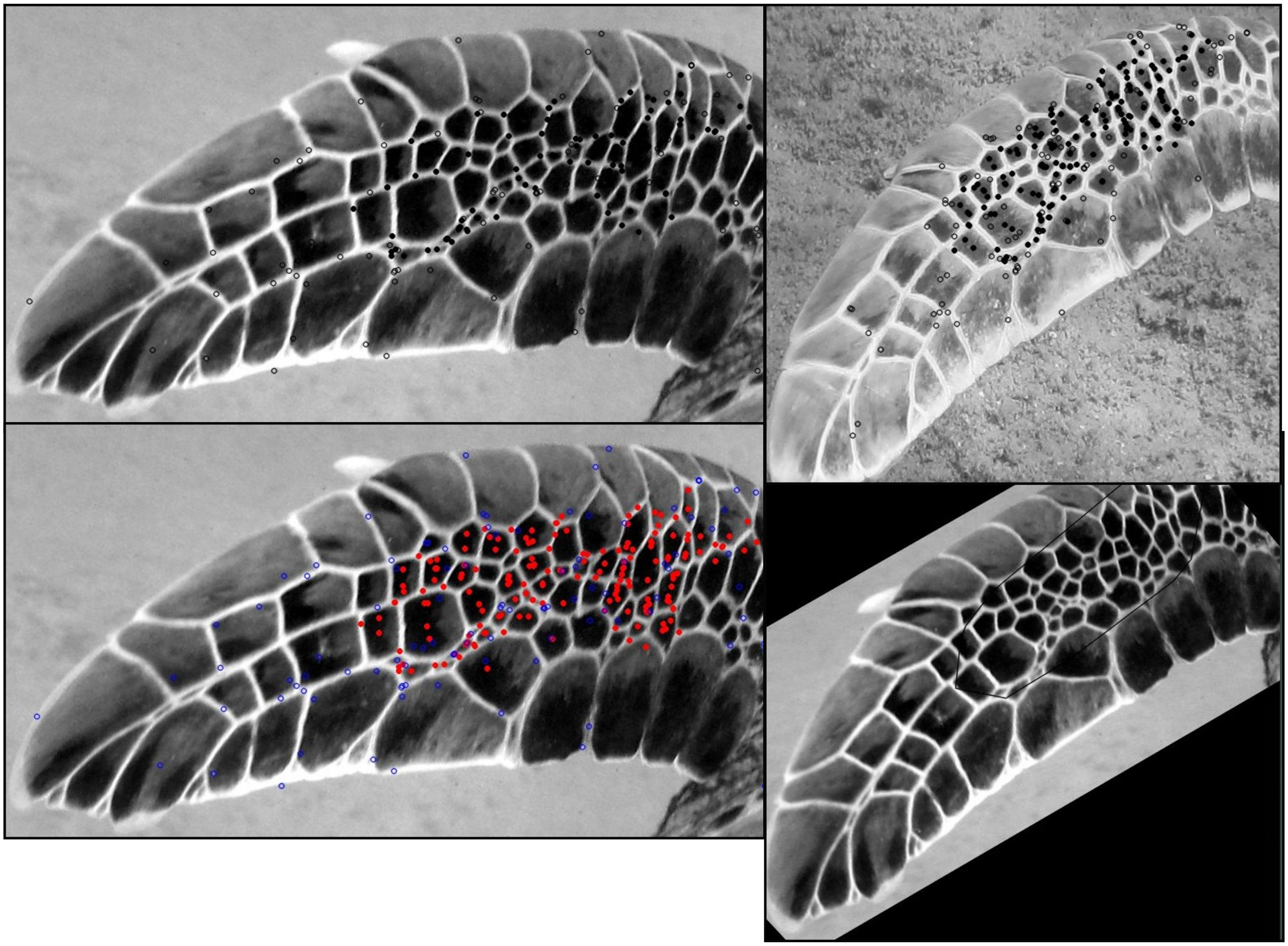

Figure 8. Application display. Matching images upper and lower right. Detail of match points from bottom right image on left.

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Kemp's Ridley Sea Turtle Emigration and Immigration Between The Gulf Of Mexico And North Atlantic Ocean Should Not Be Ignored In Age-Structured Population Modeling

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An annually dominant proportion of Kemp's ridley sea turtle (*Lepidochelys kempii*) reproduction occurs along the western Gulf of Mexico (GoM) coast of Tamaulipas, Mexico, so most of this endangered species' hatchlings enter the GoM from Tamaulipas beaches, primarily near Rancho Nuevo (Márquez Millan *et al*. 1989; Marquez-M. 1994; Márquez M. 2001; Heppell *et al*. 2005, 2007; Márquez-M. *et al*. 2005, 2018; Morreale *et al*. 2007; Rostal 2007; Putman *et al*. 2010; NMFS *et al*. 2011; Márquez-Millán *et al*. 2014; NMFS and USFWS 2015; Valverde & Holzwart 2017). In declining order, much smaller proportions reproduce along the coasts of Veracruz (Mexico), Texas (US), other states bordering the GoM, and some states bordering the eastern coast of the US (Caillouet *et al*. 2015, 2016a, 2018; Caillouet 2019).

Upon reaching the surf, hatchlings swim toward favorable offshore habitat (Putman *et al*. 2010). Thereafter, those in the oceanic (surface pelagic) life stage for 1-3 yrs (Ramirez 2019; Ramirez *et al*. 2020) are dispersed throughout the GoM by surface circulation, and some are also swept through the Florida Straits into the western North Atlantic Ocean (NAO) by the Loop Current, then northward by the Gulf Stream, as well as eastward via the North Atlantic Gyre to European waters (Carr 1963, 1967, 1980, 1986; Hendrickson 1980; Ogren 1989; Collard & Ogren 1990; Marquez-M. 1994; Brongersma 1995; Hildebrand 1995; Marquez M. 2001; Putman *et al*. 2010, 2013, 2019; NMFS *et al*. 2011; Witherington *et al*. 2012; NMFS & USFWS 2015; Putman & Mansfield 2015; Putman *et al*. 2019; Botterell *et al*. In press). They also orient and swim in patterns that can alter their direction of travel, and this behavior appears to promote their numerically greater retention within the GoM (Putman & Mansfield 2015). In experiments of swimming performance of captive-reared oceanic stage Kemp's ridleys, individuals swam against artificially produced currents (Stabenau *et al.* 1992).

Hendrickson (1980) explained that when the Atlantic Ocean and Pacific Ocean systems were connected, westward flow of the Atlantic North Equatorial Current presumably entered the Pacific system. Kemp's ridley did not exist as a species at that time, but it diverged later from olive ridley (*L. olivacea*) after emergence of the Panamanian isthmus (Bowen *et al*. 1991; Bowen & Karl 2007). With emergence of the Panamanian isthmus, flows of the Loop Current and Gulf Stream became more powerful (Schmidt 2007), and increased the potential for transporting oceanic stage sea turtles from the GoM to the NAO (Hendrickson 1980). Hendrickson (1980) considered this to be "a gigantic leak" that continually extracted an important fraction of the Kemp's ridley population from the GoM. Putman *et al.* (2013) used dispersal modeling to predict that 5.1 - 28.4% of oceanic stage Kemp's ridleys were transported annually from the GoM into the NAO during 2003-2010. Thus, "emigration" of significant portions of oceanic stage Kemp's ridleys from the GoM to the NAO is a natural annual occurrence. The Atlantic coast of North America is considered important developmental habitat for Kemp's ridleys (TMTRT 1984; Collard and Ogren 1990; TKRRT 1992; Schmid & Witzell 1997; Witzell 1998; Schmid & Woodhead 2000; Morreale & Standora 2005; Ramirez 2019; Ramirez *et al*. 2020). Evidence that Kemp's ridleys reproduce in the NAO is provided by rare nesting events from Florida to New York (Shigetomo 2014; Caillouet *et al*. 2016a; Rafferty *et al*. 2019). Although the fate of hatchlings from such nestings is unknown (*ibid*.), it is unlikely that they survive within the NAO (Ramirez, M.D., pers. comm.). Kemp's ridleys that do not return to the GoM from the NAO cannot contribute to population growth and recovery within the GoM. However, GoM and NAO ecosystems both provide important developmental habitat in the context of ecological roles of Kemp's ridley as predator, prey, carrion, scavenger, etc. (Lovich *et al*. 2018; Caillouet 2019).

Neritic Kemp's ridleys seasonally migrate and forage in waters within the 50-m depth contour on continental shelves of the GoM and western NAO (NMFS *et al*. 2011; NMFS & USFWS 2015; Hart *et al*. 2018; Ramirez *et al*. 2020). However, the continental shelf along the western NAO coast is generally narrower than that along the GoM coast. Neritic Kemp's ridleys in the western NAO exhibit seasonal migrations up and down the U.S. east coast (Carr 1980; Hendrickson 1980; Henwood and Ogren 1987; Ogren 1989; Collard & Ogren 1990; Renaud 1995; Gitschlag 1996; Marquez M. 2001; Bernardo & Plotkin 2007; Pritchard 2007; Putman *et al*. 2010, 2019; NMFS *et al*. 2011; Bovery & Wyneken 2013; Putman & Mansfield 2015). Water depths <100 m occur between the shoreline and 2 km to the east along Florida's southeast coast, so the southward migration corridor for neritic Kemp's ridleys within 50 m is the narrowest there (Land & Paull 2000; Fig. 3 in Pernas *et al*. 2001; Correa *et al*. 2012). Southward flow on the western flank of the Florida Current was characterized by Soloviev *et al*. (2017).

Until recently (Ramirez 2019; Ramirez *et al*. 2020), emigration and immigration have generally been ignored in age-structured modeling of the Kemp's ridley population (Heppell *et al*. 2007). According to Heppell *et al*. (2007), "Simply stated, population growth occurs when births exceed deaths and/or immigration exceeds emigration. We can ignore the latter for Kemp's because we have data for the entire species."

Yet, limited numbers of neritic stage Kemp's ridleys have been documented to have returned to the GoM from the NAO (Márquez-M. *et al*. 1995; Heppell *et al*. 1996; Heppell & Crowder 1998; TEWG 1998, 2000; Heppell *et al*. 2005, 2007; Crowder & Heppell 2011; NMFS *et al*. 2011; Bovery & Wyneken 2013; NMFS & USFWS 2015; Gallaway *et al*. 2016a,b; Kocmoud *et al*. 2019). Numbers of neritic stage Kemp's ridleys that remain in, survive to maturity and reproduce within the GoM are likely higher than those that mature and reproduce in the NAO or after returning to the GoM. Migration distances to western GoM nesting beaches are greater from the NAO than from within the GoM. Therefore, it is likely that much higher numbers of each year-class (cohort) of Kemp's ridleys enter the NAO in the oceanic life stage (Putman *et al*.

2010, 2013, 2019) than return to the GoM in any life stage or at any age. Fewer than 20 neritic Kemp's ridleys have been documented to have returned from the NAO to the GoM, although most were reported nesting at Tamaulipas (Schmid 1995; Witzell 1998; Schmid & Woodhead 2000; Renaud & Williams 2005; Schmid & Witzell 2005; Bovery & Wyneken 2013; Caillouet *et al*. 2015). This paucity of evidence that Kemp's ridleys return to the GoM from the NAO could result from inadequate numbers tagged and satellite-tracked in the NAO, or inadequate focus of monitoring NAO-tagged and NAO-tracked individuals around the Florida Straits and southwest Florida (Ramirez, M.D., pers. comm.). Yet, numbers of neritic Kemp's ridleys documented as having been caught or found stranded, with or without tags or transmitters, along the coasts of eastern North America and the GoM have been adequate for evaluations of somatic growth and seasonal migrations (Snover *et al*. 2007; NMFS *et al*. 2011; Bovery & Wyneken 2013; NMFS & USFWS 2015). Returns to western GoM nesting beaches of Kemp's ridley tagged or fitted with transmitters and tracked within the GoM dwarf those for conspecifics tagged or fitted with transmitters in the NAO (*ibid*.). Unless substantially more evidence is amassed to the contrary, it will continue to appear that most Kemp's ridleys that nest in the Gulf of Mexico have not spent time in the NAO. The dearth of evidence to the contrary begs the question of whether Kemp's ridley immigration from NAO to GoM has had or can have a measurable effect on growth of the population within the GoM. Additional tagging and tracking of neritic immature and adult Kemp's ridleys on the continental shelf along the southeast coast of Florida and Florida Straits may be necessary to resolve questions regarding the magnitude of their immigration from NAO to GoM (Ramirez, M.D., pers. comm.).

Avens *et al*. (2017) recommended integration of skeletochronology with stable isotope and trace element analyses to increase understanding of long-term changes in trophic ecology and movements of Kemp's ridleys between GoM and NAO foraging habitats and the relative contributions of these regions to the reproductive population. Ramirez (2019) used complementary lead isotopes (^{208}Pb:^{206}Pb) in humeri collected from dead-stranded Kemp's ridleys to distinguish, with exceptional accuracy (94.1%), those found in the NAO from those found in the GoM. Perhaps this isotopic tracer methodology could be used to identify Kemp's ridleys that spent time in the NAO then returned to the GoM (Ramirez, M.D., pers. comm.). Ramirez (2019) also used a spatially explicit, age-structured matrix model to examine habitat-specific demographic rates and variable ontogenetic shifts (oceanic to neritic). Although his model simulations showed that NAO to GoM transition influenced the population during its 1990-2009 period of rapid growth, they suggested that Kemp's ridleys in the western NAO were not strong contributors to growth of the Kemp's ridley population during that period, and were unlikely to influence population recovery time, even under the most extreme scenario evaluated that was based on annual emigration of 30% of Kemp's ridleys in the oceanic stage from the GoM to the NAO, and no immigration to the GoM of survivors in the NAO before age 7.

Over the years, annual numbers of Kemp's ridleys found stranded alive or dead from natural and anthropogenic causes have increased along GoM and NAO shores (TMTRT 1984; Meylan & Sadove 1986; Witherington & Ehrhart 1989; CSTC 1990; Tomás *et al*. 2003; Still *et al*. 2005; Witt *et al*. 2007; Insacco & Spadola 2010; NMFS *et al*. 2011; Caillouet *et al*. 2015; Nicolau *et al*. 2016; Avens & Dell'Amico 2018; Liu *et al*. 2018; Griffin *et al*. 2019; Innis *et al*. 2019). Those related to shrimp trawling and cold-stunning have received considerable attention (CSTC 1990; NMFS & USFWS 2015). Substantial effort and resources have been expended toward rescue, resuscitation, rehabilitation and release of live-stranded Kemp's ridleys. For US rehabilitation programs, Innis *et al*. (2019) reported that at least 5,137 Kemp's ridleys found stranded alive were rehabilitated and released during 1997-2016, and 61 were rehabilitated and released by those programs before 1997. They have contributed in various ways to Kemp's ridley conservation (NMFS *et al*. 2011; Innis *et al*. 2019), but their contribution to population growth and recovery has not been evaluated (Caillouet *et al*. 2015; Caillouet 2016b). It is noteworthy that oceanic stage Kemp's ridleys that enter Cape Cod Bay apparently are unable to navigate and swim their way out of it before temperatures drop and they become cold-stunned and stranded (Still *et al*. 2005; Liu *et al*. 2018; Griffin *et al*. 2019). This warrants further investigation in the context of their navigational and swimming abilities.

Heppell *et al*. (1996) and Heppell & Crowder (1998) set the precedent for using age-structured modeling to estimate the probability that a given Kemp's ridley conservation intervention contributed to Kemp's ridley population growth, and the use and improvement of age-structured models for such purposes has continued since then. We therefore recommend that age-structured modeling be used to determine the contribution made by Kemp's ridleys in the NAO to population growth in the GoM (Caillouet *et al*. 2015; Caillouet 2016b). The negative differences between annual numbers that "emigrate" in the oceanic stage from the GoM to the NAO and those that return to the GoM in any life stage should be included in age-structured modeling of the population in the GoM. They represent natural losses to the population in the GoM, and could be treated as natural mortality. If these differences were included in modeling, estimated total mortalities in the GoM would thereby be increased, and the proportion of total mortality represented by anthropogenic mortality would thereby be decreased. Results could have implications for Kemp's ridley conservation actions and interventions going forward. Therefore, emigration and immigration of Kemp's ridleys between the GoM to the NAO should no longer be ignored in age-structured modeling of the Kemp's ridley population in the GoM. However, as climate warms and sea level rises (NMFS *et al*. 2011; Pike 2013a,b), Kemp's ridleys in the NAO may become more important to population recovery and resilience if they adapt to such changes and establish new nesting colonies along the NAO coast (Caillouet 2012; Bevan *et al*. 2019; Butler 2019).

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Hatching Events of the Loggerhead Turtle in Corsica, France

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In the Mediterranean Sea, the nesting sites of loggerheads are mainly located in the eastern and central basin (Margaritoulis *et al.* 2003). However, in the western Mediterranean, rare nesting events have been reported in Spain, France and Italy (Casale *et al.* 2018). In recent years, several nesting events have been observed on the French beaches of St. Tropez in 2006 (Senegas *et al.* 2009), St. Aygulf in 2016 and Villeneuves-lès-Maguelones in 2018 (RTMMF, unpublished data). Moreover, since 2016, the necropsies of several adult female loggerheads on the mainland have revealed eggs, in different developmental stages, in their reproductive systems (RTMMF, unpublished data; http://gtmf.mnhn.fr/5-aout-2016-decouverte-dune-ponte-de-caouanne-sur-la-cote-dazur).

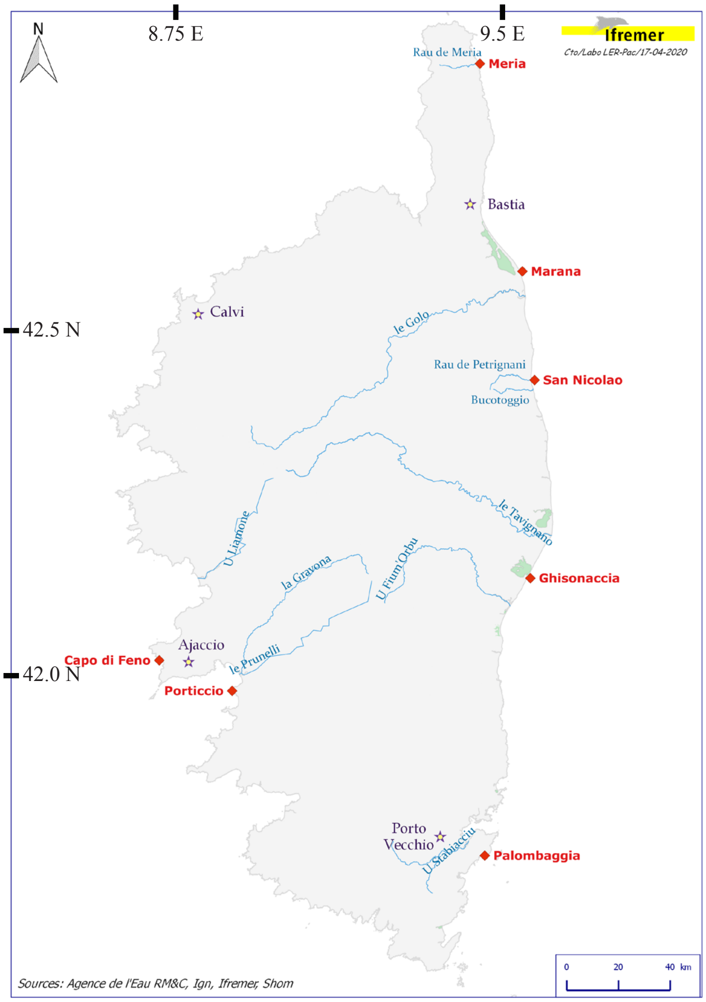

Figure 1. Locations of egg-laying and hatching events of loggerhead turtles in Corsica (red diamond).

In Corsica, a French island located 164 km southeast of mainland France, and 83 km south of mainland Italy, nesting evidence had been reported until the 1950s (Casale *et al.* 2018; Pascal *et al.* 2003), but after this period, there were no accounts of nesting or nesting attempts, suggesting that turtles had abandoned Corsica's beaches for nesting. For the first time in 50 years, a nest was discovered in 2002, on the Palombaggia beach in southeastern Corsica (Fig. 1) where eggshells were found and remaining embryos sampled (Delaugerre & Cesarini 2004). In 2014, one individual turtle was observed twice (recognized by its shell and scale patterns) attempting to climb onto the San Nicolao and Meria beaches in the northeastern part of Corsica on two occasions in July and August (Gerigny *et al.* 2016). Unfortunately, human disturbances (touching and lights) probably led the turtle to return to the sea and no egg deposition was observed (Fig. 1). In June 2016 in Palombaggia, a night watchman of a beach restaurant took pictures of a female crawling past the beach furniture during the night. In July and August 2016 three events were reported on the western Corsican coast located near Ajaccio (Fig. 1). On 30 July 2016, on the private beach of a hotel (Plage du Maquis - Porticcio), a turtle was observed attempting to climb on the upper beach among the sunbeds (Fig. 2a) and it started digging in the sand, but no nest was found. The beach furniture may have been a disturbance in this instance (RTMMF, unpublished data). The same day on a nearby beach (Pointe Sud - Porticcio), tracks were observed that indicated another female emergence. Eventually, on 16 August further north of Ajaccio on a very short sandy and rocky beach (Capo di Feno), members of the RTMMF observed three tracks (Fig. 2b), that were probably several days old. One of these tracks resulted in a nesting attempt, but it was possibly aborted due to rocks in the nesting substrate (http://gtmf.mnhn.fr/16-aout-2016-trois-nouvelles-traces-de-montee-en-corse/). In 2017 and 2018, no marine turtle nesting activity was reported in Corsica.

On 18 August 2019 at 8:17 pm, the emergence of a *Caretta caretta* hatchling (Figs. 3a-b) was reported to the RTMMF by a local resident, in Pinia, close to Ghisonaccia (42.0337 °N, 9.4844 °E) (Fig. 1). The nest was located 3 m above sea level on the upper-beach section that was characterized by a moderate slope at the edge of a littoral pine tree and a juniper forest (Natura 2000 site, https://inpn.mnhn.fr/collTerr/commune/2B123/tab/natura2000, code FR9400580). There were tire tracks of an ATV (All Terrain Vehicle) over the nest, representing a potential danger to the nest and hatchlings. Protection of the nest with natural material (driftwood) was implemented to prevent destruction from further ATV use while

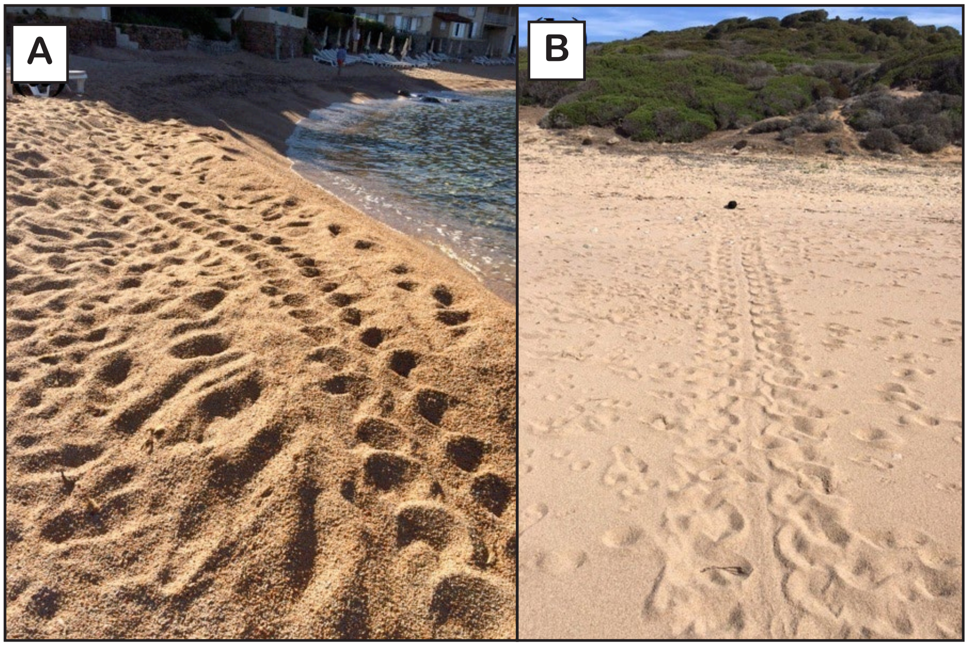

Figure 2. Marine turtle nesting tracks observed on the sand on (A) 30 July 2019 on Plage du Maquis and (B) 16 August 2019 on Capo di Feno beach. Photos by P. Moisson.

allowing the emergence of hatchlings. Appropriate surveillance was organized during the following days to keep the nest safe.

Later on 18 August 2019, 23 hatchlings were observed leaving the nest and going to the sea, while 64 hatched egg shells were collected, suggesting that another 41 turtles emerged before the observer arrived. Furthermore, 56 eggs, whose hatching was estimated to be pending, and four unfertilized or non-mature eggs were also counted in the nest (Fig. 3c). The unhatched eggs were left in the nest.

On 19 August, no emergence activity was observed by the guards. However, a hatchling with an unabsorbed yolk sac, which had been observed out of the nest the night before, was found dead near the nest. On 20 August, fragments of eggs were found around the nest, probably due to the action of predators such as foxes or dogs. On 21 August, the nest was observed to have been dug up, probably by a fox according to the prints on the sand, and egg remains were found up to three meters around the nest. Tracks of hatchlings were also observed. On 22 and 23 August, no signs of emergence or predation were observed, and on 24 August, the nest was excavated and inventoried by RTMMF members. They observed that the bottom of the central chamber was positioned 55 cm deep, and 31 eggs (unfertilized or undeveloped) were counted but due to the predator disruption there may have been more than 31 unhatched eggs. Eighty-nine hatched eggs were found, but there may have been some that were consumed by predators. All remaining eggs were sampled for genetic analysis and as odorous print sources for the turtle nest detection program by sniffing dogs, recently launched by Centre d'Etude et de Sauvegarde des Tortues marines de Méditerranée - Center for the Study and Protection of Mediterranean Sea Turtles (CESTMed) and RTMMF, on selected French Mediterranean beaches (Gambaiani & Senegas, pers. comm. 2019). Indeed, dogs can be trained to detect species for conservation purposes (Smith *et al.* 2001; Hurt & Smith 2009) and appear to be effective in detecting sea turtle nests (Witherington *et al.* 2017). In 2018, CESTMed and RTMMF carried out a survey using a sniffing dog to find sea turtle nests on two Natura 2000 beaches of the Mediterranean coast of mainland France. Before surveying French beaches, the sniffing dog was trained by the Rogue Detection Teams, thanks to the collaboration of ARCHELON, on nesting beaches of Greece.

On 01 October 2019, there was an observation of a hatchling lost in the littoral vegetation of a western beach in Corsica. Over the last 15 years, the three successful hatched nests confirm that Corsican beaches are still adequate nesting habitats for loggerheads. Furthermore, the single October 2019 hatchling event suggests that nests and emergences may be overlooked. Moreover, no systematic beach monitoring is carried out on Corsican beaches and observations depend on public alerts received on the RTMMF permanent "green line," which is a hotline for reporting environmental observations.

While sandy beaches are present all around the island, the eastern coast might be more suitable than other areas of Corsica, as it has more documented nesting and topography that features very long sandy beaches. The eastern beaches of Corsica were regularly used for sea turtle nesting until the beginning of the 20th century (Fretey in Pascal *et al.* 2003). For example, eggs that are currently stored in the collections of the Oceanographic Museum in Monaco, were collected in Cervione, Moriani and Aleria between 1923 and 1932. Moreover, there are records of egg harvesting taking place between 1935 and 1940 in Aleria and Favone (Fretey in Pascal *et al.* 2003).

Habitat degradation along with the fragmentation of the long sandy eastern shores as a result of anthropogenic development and urbanization might explain the lack of documented nesting events for 50 years in Corsica. The disturbances may also explain the decline of nesting in the Mediterranean until recent times (Casale 2015).

The recent occurrence of nesting events on Corsica may be explained by several factors, such as an increase in loggerhead population size, or environmental changes. The International Union for the Conservation of Nature (IUCN) has changed the conservation status of *Caretta caretta* from Vulnerable to Least Concern (LC) for the Mediterranean subpopulation. However, the current population status is conservation-dependent and results from decades of intense conservation programs (Casale 2015). The population increase could explain changes in the geographic distribution of nesting females and the recent nesting events in Corsica. Also, the effects of climate change on the phenology and distribution of loggerhead

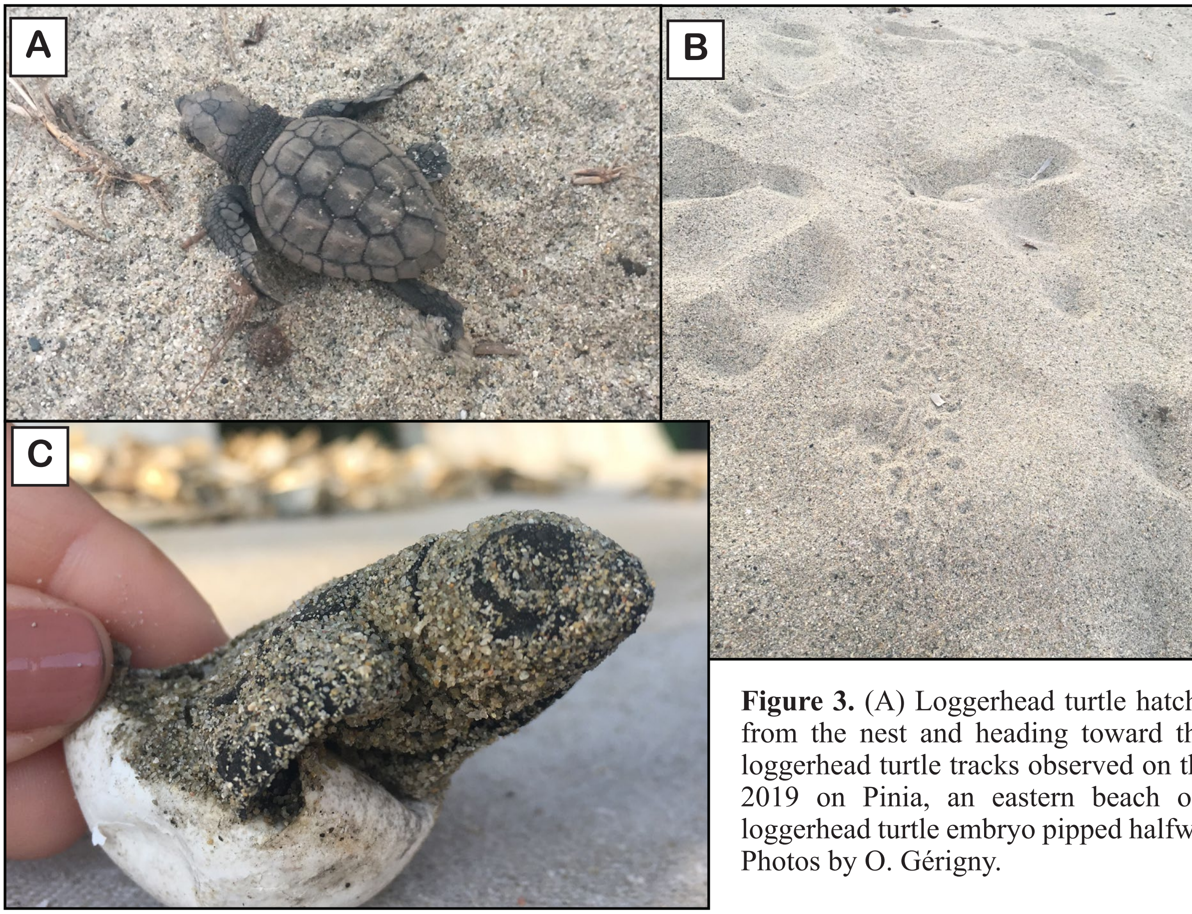

Figure 3. (A) Loggerhead turtle hatchling after emergence from the nest and heading toward the sea; (B) hatchling loggerhead turtle tracks observed on the sand on 18 August 2019 on Pinia, an eastern beach of Corsica; (C) dead loggerhead turtle embryo pipped halfway out of its eggshell. Photos by O. Gérigny.

nesting are being investigated in the Mediterranean (Mazaris *et al.* 2009; Mazaris *et al.* 2017; Almpanidou *et al.* 2018). Those studies indicated that the phenological and latitudinal adjustment of nesting to warming conditions could be the most effective short-term adaptation to climate change. However, in the western Mediterranean Sea, oceanic conditions would not favor hatchling survival (Maffucci *et al.* 2016).

It would be interesting to investigate if climate change (e.g., sand temperatures and moisture levels, sea surface temperatures, beach profiles, etc.) could make the habitat of Corsica more suitable for nesting loggerheads than in past years. For other Mediterranean regions, habitat may become less suitable.

In France, sea turtle species and their habitats are protected by law (Ministerial decree of 14 October 2005). The revised IUCN LC status of *Caretta caretta* in the Mediterranean includes in its definition that this status remains dependent of maintaining current conservation efforts.

The *Caretta caretta* nesting and hatching observations in the western Mediterranean summarized here emphasize that conservation measures should not only be maintained at the eastern Mediterranean major nesting sites, but must also be initiated or reinforced in the western basin where rare reproductive activity is reported, for example, in Corsica.

The measures that should be implemented should at least consist of: i) monitoring selected beaches during the nesting and hatching periods; ii) informing the adjacent coastal cities; iii) reducing anthropogenic pressures (e.g., prohibiting ATVs, night-lighting, and removing beach furniture at night on nesting beaches during the nesting/hatching season, etc.); iv) raising public awareness (e.g., through informative signs describing sea turtle tracks and respectful observer behavior (e.g., no flash cameras, touching, or moving turtles, etc.); and v) using predator cages over nests.

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Key to Living Tags for Northwestern Atlantic Loggerhead Turtles (*Caretta caretta*)

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Living tags are one of several mark-recapture methods used to identify sea turtles (Henderickson & Henderickson 1980; Schwartz 1981; Balazs 1985; Rowe & Kelly 2005; Dutton & Stewart 2013; Limpus *et al.* 2019). Living tags are a kind of xenograft, meaning that the graft and host are from the same individual. The reciprocal xenografting procedure involves excising and transplanting a small piece of scute and living epidermis between selected carapace and plastron scutes (Henderickson & Henderickson 1980). The tissue grafts provide a permanent specific pattern to identify the particular year-class of turtles. The living tags are strips of tissue fully contained within a single carapacial scute and a single plastron scute for each year-class and should be distinctive from barnacle scars. Once grafted, the carapace tag is yellow to white and the plastron tag is brown to tan. The plastron tag tissue tends to spread slightly so may fade with age and as the turtle grows. Occasionally the transplanted tissue is rejected and dies, and the site does not leave a clear scar. Consequently, a few turtles may have just a single tag. The Florida Atlantic University Marine Research Laboratory has systematically tagged small juvenile Northwestern Atlantic loggerhead sea turtles (*Caretta caretta*) from 2003 - 2004 and 2009 - 2019. Each year-class has a distinctive living tag pattern on the carapace and plastron (Fig. 1). In 2003 and 2004, loggerheads received different living tag patterns to distinguish between turtles that hatched on Florida's east and west coasts. East coast turtles in 2003 were further distinguished into northern and southern (peninsular Florida) subpopulations with different plastron tag locations. The procedure of using different patterns to distinguish coasts was abandoned after 2004, so that in all other years (2009 - 2019) all loggerheads from the same year-class received the same living tag pattern. Fig. 2 shows an example of a turtle from the 2017 year-class at the time that the living tags were applied and the same turtle two years later.

All turtles were released into the Northwest Atlantic offshore, except for a few turtles that were retained by local environmental education facilities. These turtles are released coastally after reaching a standard carapace length of at least 45 cm. We expect that, at the time of publication, turtles may be old enough to be recognized in live captures, sightings, or if health status becomes compromised, as strandings. All turtles were photographed immediately prior to release for the purpose of future identification. The goal of identifying the turtles observed with living tags is to better understand the ages of turtles that recruit to certain habitats and the length of time between hatching and maturity using verified durations rather than estimates (Mrosovsky & Godfrey 2003). For each turtle released, we have hatch date, location of the nest, growth rate in the lab, sex identification confirmed with laparoscopy, and incubation conditions. We request that anyone who sees a loggerhead with a living tag please contact us and please send clear photos of the carapace, plastron, and dorsal and lateral head if possible. Contact information: (wynekenatwork@gmail.com or jwyneken@fau.edu) and copy information to current stranding coordinators.

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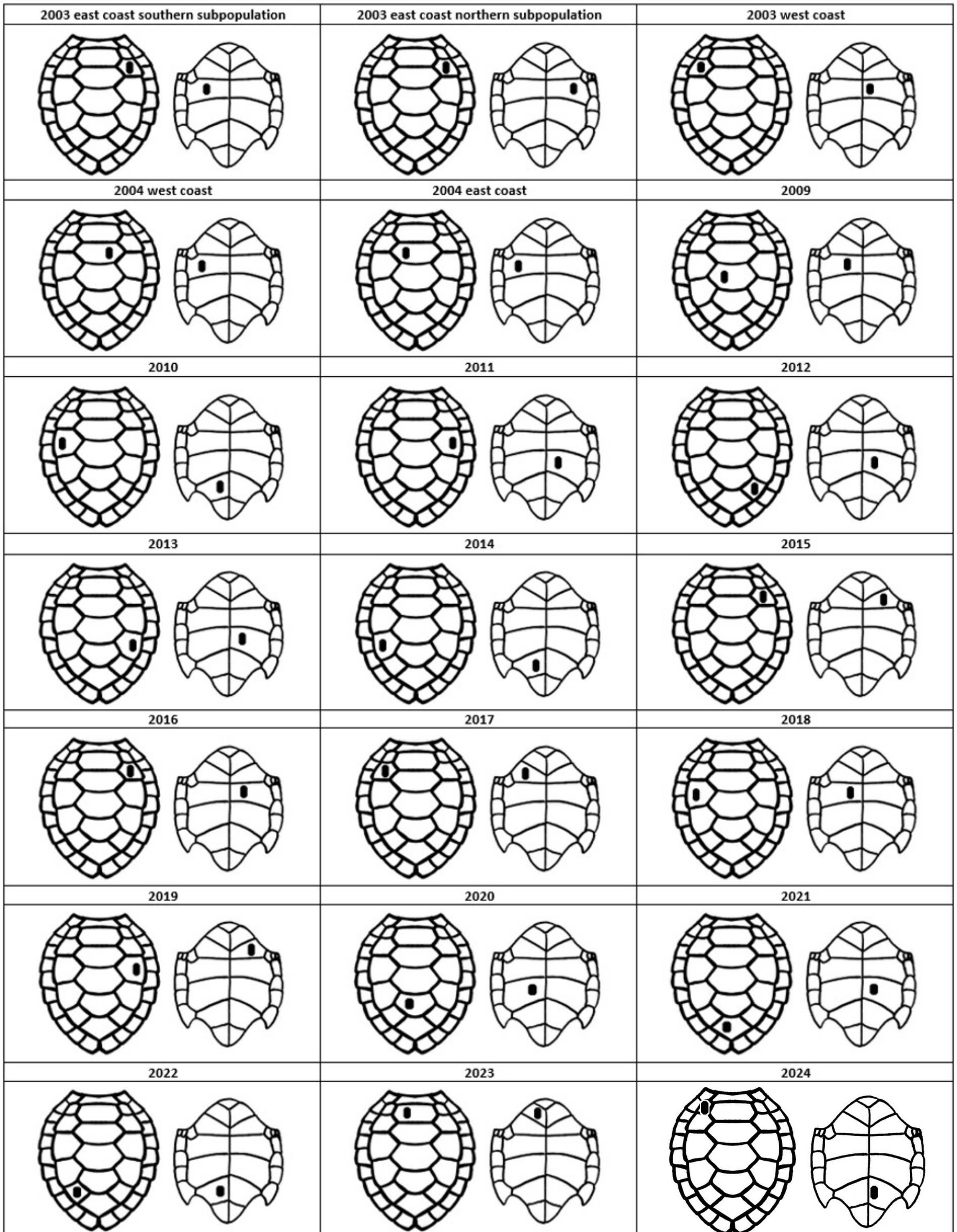

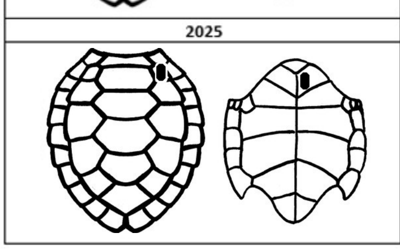

Figure 1. Living tag patterns for each year-class. Small strips of tissue from the carapace and plastron were reciprocally transplanted in a particular pattern for each year-class. This figure includes patterns for future years.

Figure 2. (Top) Carapace and plastron of a loggerhead from the 2017 year-class immediately after receiving living tags. (Bottom) Carapace and plastron of the same turtle two years later. This loggerhead was transferred to an environmental education center until his release in coastal waters. Photo credit: Samantha Arner, Conservancy of Southwest Florida, Naples, FL.

Carapace Tag Recaptures From the 1980s

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A nocturnal intensive tagging project has been underway on Casey Key (27.1411 °N, 82.4767 °W) in Nokomis, Florida to document and apply flipper tags and passive integrated transponder (PIT) tags on nesting sea turtles since 1982. In 2016, Mote Marine Laboratory (MML) researchers observed a metal tag attached to the left rear marginal carapacial scute of a loggerhead sea turtle (*Caretta caretta*) (Fig. 1A) nesting on Casey Key. After carefully removing the biofouling, the number stamp "203" was revealed. A review of MML data archives indicated that researchers on Casey Key had observed this tag type on eight occasions between 1986 and 2016, representing four individual loggerhead turtles (Table 1). In each case, the turtles sighted on Casey Key had no flipper tags; so new flipper tags were applied. If not for the carapace tags, the individuals would have been considered neophytes with no prior tag history.

From 1979 to 1991, carapace tags were used as an alternative to Monel flipper tags to improve tag retention and continuity of individual sea turtle identification prior to the introduction of less corrosive Inconel flipper tags. The carapace tags consisted of two $1\frac{7}{16}$ inch 18/8 stainless steel fender washers attached to the dorsal and ventral sides of a posterior left (or right) marginal scute (Hopkins 1979; LeBuff 1990). The washers were attached with a $1\frac{1}{4}$ - $1\frac{1}{2}$ inch long hex-headed machine bolts through a $\frac{1}{4}$ inch diameter hole drilled though the thinnest part of the carapace and secured with a nylon insert 18/8 stainless steel locking hex nut (Hopkins 1979; LeBuff 1990). Each tag was stamped with a unique number (LeBuff 1990; Murphy 2019). Tags were applied to nesting loggerhead sea turtles on Sanibel Island, Florida and on South Island, South Carolina in the United States, as well as on flatback turtles (*Natator depressus*) in Queensland, Australia (LeBuff 1990; Murphy 2019). Carapace tags were applied to both returning and newly sighted turtles in addition to a new or existing Monel flipper tag applied to the trailing edge of one front flipper (Hopkins 1979; LeBuff 1990). At least 102 individual loggerheads were tagged on Sanibel Island in 11 years starting in 1980. Tags were applied sequentially with the series starting at 101 (LeBuff pers. comm. 2020). Forty-eight tags were attached on South Island, South Carolina in 1979 (Hopkins 1979). The two series had notably different number stamps (Fig. 1B & 1C) and Sanibel Island tags carried a prefix "SAN" on one washer, while the South Island tags had a return address (Hopkins 1979; LeBuff 1990).

Turtles with carapace tags sighted on Casey Key were originally tagged on Sanibel Island, which is a loggerhead sea turtle nesting

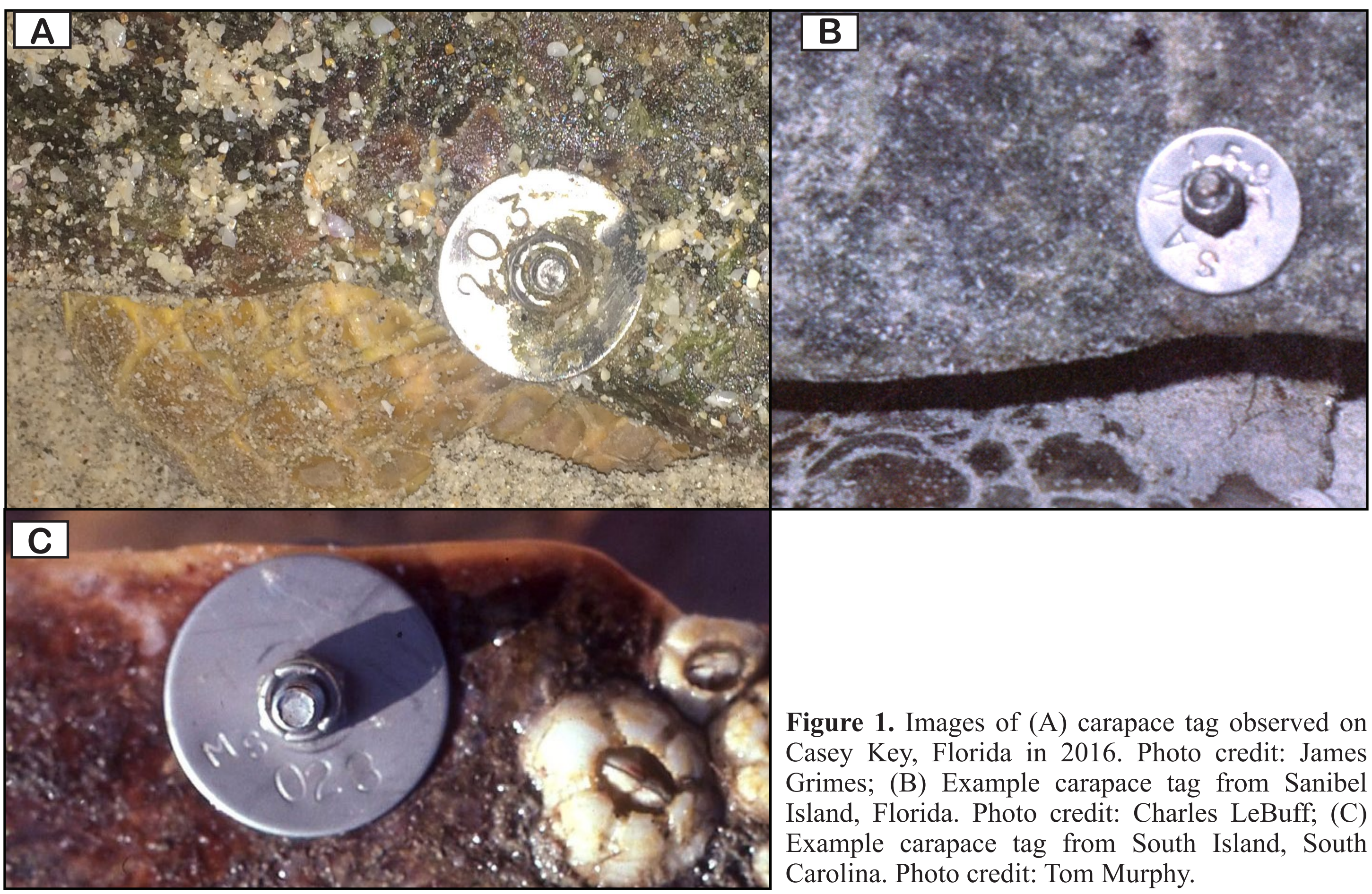

Figure 1. Images of (A) carapace tag observed on Casey Key, Florida in 2016. Photo credit: James Grimes; (B) Example carapace tag from Sanibel Island, Florida. Photo credit: Charles LeBuff; (C) Example carapace tag from South Island, South Carolina. Photo credit: Tom Murphy.

Carapace tag number	Year applied	First date recaptured on Casey Key	Years seen on Casey Key (# of encounters)	Tag retention
SAN132	6/15/1986	7/11/1986	1986 (1)	26 days
SAN170	1986-1991	6/17/1992	1992 (3)	1-6 years
SAN180	1986-1991	6/30/1993	1993 (1)	min. 2 years
203	1986-1991	6/30/1992	1992 (2) 1997 (3) 2001 (3) 2016 (4)	min. 26 years

Table 1. Original and recapture data from four carapace tags observed on Casey Key Florida. Tags were originally applied sequentially on Sanibel Island, Florida between 1980 and 1991 but original tag data were lost. Tagging dates and tag retention are estimated based on first recapture.

beach located approximately 80 km south of Casey Key. Exchange of nesting turtles between Casey Key and Sanibel Island has been documented on other occasions based on flipper and PIT tag recaptures (Mazzarella K.T. unpubl. data). Historical tag records from Sanibel Island were lost (LeBuff pers. comm. 2020); thus, original tag dates are not available for all individuals from that period. An archived letter from Caretta Research, Inc. dated 28 July 1986, provided documentation that one turtle had received a carapace tag "SAN132," and a Monel flipper tag "CR5142" on Sanibel Island approximately one month prior to being sighted on Casey Key. The turtle was identified on Casey Key by the carapace tag and the flipper tag was missing. Two additional carapace-tagged loggerheads, "SAN170" and "SAN180," were sighted on Casey Key on one to three occasions, in 1992 and 1993, respectively. Based on the tag sequence, these sightings are estimated to be one to six years after their original tagging on Sanibel Island. Loggerhead sea turtle "203" was sighted on Casey Key in 1992, 1997, 2001 and 2016. This turtle's carapace tag lacked the "SAN" identifier but matched the "3" stamp of the Sanibel Island tags. The lack of the "SAN" prefix on this tag may be due to an error in application such that the "SAN" washer was applied to the ventral side of the carapace. This tag documents carapace tag retention of at least 26 years (Table 1).

Nocturnal tagging projects may not identify the presence of a carapace tag due to tag location on the carapace and high potential to be concealed by epibionts. In 2016, epibionts were removed from the "203" tag in order to read the tag number, which was still legible after 26 years. On nine additional Casey Key encounters of carapace tagged turtles, individuals were identified by flipper tag or PIT tag number, but no carapace tag was noted. A characteristic notch or hole in the posterior marginal scute may indicate the loss of a carapace tag (LeBuff pers. comm. 2020). In addition, tags may loosen over time and create an enlarged hole (Murphy 2019). Tagging projects are encouraged to remain alert for evidence of carapace tags, whether the tag remains in place or the notch is observed.

The value of a long-term tagging dataset is dependent upon the recapture and proper identification of tagged individuals. Thus, tagging projects should conduct thorough examinations of nesting turtles for all possible tags, even when some tags are evident. Researchers are encouraged to locate and communicate with historic tagging programs in their region. Identification of historic tags may lead to discovery of longer recapture times than previously documented. This investigation of historic tags highlights the importance of utilizing multiple tag types to improve likelihood of recapture and backing up data to prevent loss and ensure effective use by future scientists.

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Bacterial Dermatitis Affecting the Carapace of Nesting Green Turtles (*Chelonia mydas*)

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Green turtle (*Chelonia mydas*) nesting in mainland Florida was first documented in 1957 and typically occurs on the Atlantic coast (Carr & Ingle 1959). Nesting on Florida's Gulf of Mexico southwest coast was first recorded in 1992 and occurs at a much lower density than on the Atlantic coast (Foley 1997). On Casey Key, a southwest Florida beach in Sarasota County (27.1411 °N, 82.4767 °W), green turtle nesting densities range from 0.1-11.4 nests per kilometer.

Sea turtle nesting on Casey Key is monitored by morning nest surveys and a nighttime tagging program. Turtles encountered on nighttime tagging surveys are inspected for existing identification tags and, if none are found, metal flipper tags and a Passive Integrated Transponder (PIT) tag are applied for future identification. Tagging and standard measurements are taken immediately following egg deposition. After completing the nesting process, green turtles selected for satellite tagging are detained in a corral where the carapace is cleaned and a satellite tag is bonded to the second vertebral scute using construction epoxy (Coyne *et al.* 2008). Turtles are released when the epoxy is dry.

On 18 June 2019, two nesting green turtles were observed with skin lesions involving the carapace. The lesions were characterized by multiple scute anomalies, including erosions, easy exfoliation, prominent variation in thickness, and formation of inflammatory exudate (Fig. 1A). The carapace condition precluded satellite tag application due to attachment and permit protocols, including concerns related to the health of the skin and potential for exacerbating disease. Studies conducted on curing temperatures of epoxies indicate that the heat of the exothermic curing process can transmit through a turtle carapace (Mazzarella *et al.* 2009; Evans N. & D. Evans pers. comm. 2016). Although the moderate heat produced by the epoxy (DeWalt Powers Pure 50+™) is acceptable for use on a healthy carapace, application to potentially ulcerated skin or epidermis lacking its normal keratin risks potential physical harm. In addition, the epoxy would not adhere well to non-keratinized surfaces, thus increasing the probability of premature tag loss. Finally, Florida Fish and Wildlife Conservation Commission (FWC) Marine Turtle Permit conditions require that telemetry devices not be attached to injured or compromised turtles. Thus, a conservative approach was taken and affected individuals were immediately released without satellite tag application.

In 2019, 11 of the 37 green turtles (29.7%) encountered were observed with the described carapacial lesions. It is possible that more turtles had this condition, but went undetected. Similar lesions have been documented in captive animals where temperature and water quality are possible contributory factors (Chuen-Im *et al.* 2010; Muñoz *et al.* 2013). To our knowledge, this carapacial condition has not been characterized in the wild nesting population. Therefore, although it was not the original intention of the study, an investigation into the cause of the carapacial lesions in nesting green sea turtles was undertaken.

After the condition was first observed, a thorough visual examination of the carapace was consistently conducted during the egg-laying phase of nesting to identify affected individuals. Carapace assessments were added to the existing tagging protocol to avoid unnecessary corralling of affected individuals. Carapace lesions were photographed, when possible, after shielding the turtle's head with a dark towel.

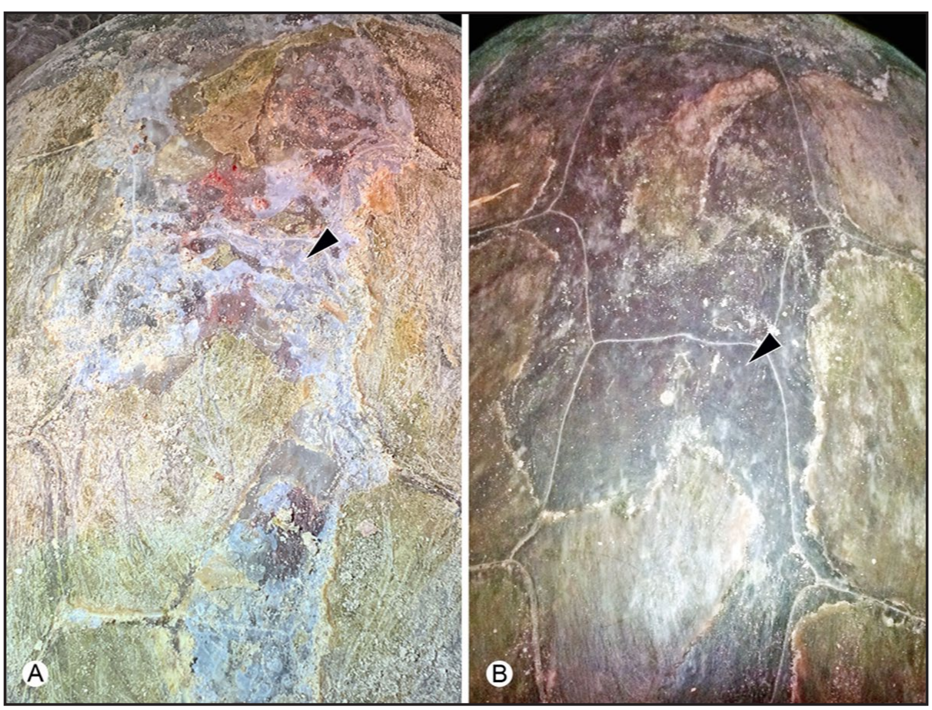

Figure 1. Green turtle, carapacial dermatitis. At initial presentation (A), the scutes were roughened, exhibited irregular exfoliation, and, in some areas, were absent, exposing an abnormally pale, mottled epidermis. Forty-four days later (B), inflammation is largely resolved and the skin has regained a more normal green color and surface texture. The arrowheads point to the same area of vertebral scute in each image to illustrate partial resolution of the skin lesions.

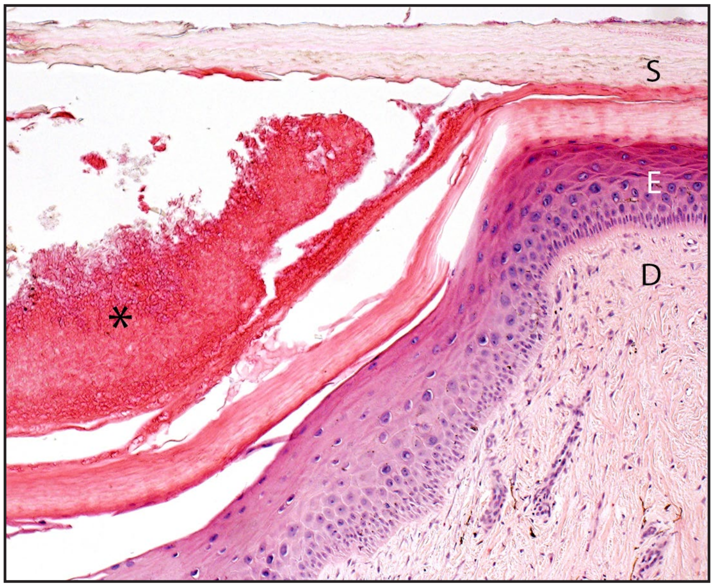

Figure 2. Green turtle, carapacial dermatitis. Degenerate heterophils (*) associated with bacteria separate the keratin layers of the scute (S). Also visible are the deeper layers of the epidermis (E) and underlying dermis (D). Hematoxylin and eosin stains used.

A permit modification (FWC Marine Turtle Permit #19-155) was obtained to allow collection of cytology and histology samples and cultures from affected green turtles. When an individual with lesions was identified, the carapace was rinsed with sterile water prior to collecting two superficial 6 mm scute biopsies at the junction of normal and abnormal skin. One biopsy was placed into a cryovial filled with neutral phosphate-buffered formalin; the other was kept on ice and later frozen at 0° C. Histological examinations of scute biopsies were conducted at NOAA/NMFS/Office of Protected Resources Pathology Laboratory. Once authorized, each biopsy site was additionally swabbed with a rayon-tipped BD BBL™ CultureSwab™ Plus. Biopsy sites were subsequently cleaned with betadine and triple antibiotic ointment was applied to prevent further infection. Culture swabs were stored at room temperature and submitted for aerobic culture (Sarasota Memorial Hospital) using Tryptic Soy Agar with 5% Sheep Blood, Chocolate Blood Agar, MacConkey Agar, and Tryptic Soy Broth incubated at 35°C in CO_2. Bacteria species were identified using the VITEK® 2 (bioMérieux, Inc.) microbial identification system.

Eleven affected green turtles, including nine neophytes and two remigrants, were observed between 16 July and 1 August 2019. Scute biopsies were collected from nine turtles. The most consistent histopathological finding (n = 6 individuals) was predominantly heterophilic, superficial dermatitis associated with Gram-negative bacteria (Fig. 2). Fungal colonization of the scute surface was observed in one individual with no evidence of bacteria. Two individuals showed no sign of fungal hyphae or bacteria. There was no histomorphological evidence of viral infection in any individuals.

Culture swab results were obtained from biopsy sites of four turtles and pooled by individual for identification of bacteria. A total of 12 different bacteria were identified (Table 1), each unique to individual turtles except for *Bacillus spp*., which was found on all individuals. The identified bacteria were primarily Gram-negative species that naturally inhabit marine and soil environments, some of which are previously reported opportunistic pathogens of sea turtles and other reptiles, including *Pseudomonas*, *Vibrio*, and *Bacillus spp*. (Pasmans *et al.* 2020). A fecal bacterium (*Enterobacter cloacae*) was identified on one turtle.

Of the 11 green turtles observed with carapacial lesions, all were visually examined and ten were photographed. The severity and distribution of lesions ranged from diffuse, superficial involvement of the carapacial scutes (n = 8), to a few discrete, round ulcers (1-2 cm diameter) exposing bone (n = 1). The lesions were most commonly observed on vertebral (V2 and V3) scutes (n = 8) and in scute margins (n = 5). Six individuals were re-evaluated photographically on subsequent encounters and exhibited partial resolution of the carapacial lesions after 12-44 days (Fig. 1B). With the exception of the carapacial lesions, all turtles were in robust body condition and appeared otherwise healthy based on external examination.

Post-hatch nest inventories were conducted for all green turtle nests to determine clutch size, hatch success, and emergence success. A Wilcoxon rank-sum test (R version 3.6.1) was used to determine if these factors differed between affected turtles (n = 11 individuals, 28 nests) and other green turtles (n = 22 individuals,

Bacteria	Classification	Reported Sources
Achromobacter denitrificans	Gram-negative	fresh and marine water, soil
Acinetobacter lwoffii	Gram-negative	skin flora
Bacillus spp.	Gram-positive	ubiquitous
Corynebacterium spp.	Gram-positive	soil, water, plants, skin flora
Enterobacter cloacae	Gram-negative	feces
Photobacterium damselae	Gram-negative	fish
Pseudomonas aeruginosa	Gram-negative	soil, water, skin flora
Pseudomonas putida	Gram-negative	soil, water
Sphingomonas paucimobilis	Gram-negative	land, water
Stenotrophomonas maltophilia	Gram-negative	water, soil, plants
Vibrio alginolyticus	Gram-negative	marine water
Vibrio parahaemolyticus	Gram-negative	brackish and marine water

Table 1. Bacteria identified from areas of carapacial dermatitis affecting four nesting green turtles (*Chelonia mydas*). *Bacillus spp*. was found on all individuals while other species were unique to each individual.

	Turtles	Nests	Median CCLnt (cm)	Median Clutch Size	Median Incubation Duration (days)	Median Hatch Success	Median Emergence Success
Affected green turtles	11	28	104.0	101.5	56.5	90.6%	84.0%
Other green turtles	22	29	104.0	104.0	57.0	87.8%	85.6%
Wilcoxon rank-sum test			W=301	W=456	W=330	W=420.5	W=442
Significance			p=0.8608	p=0.4292	p=0.9169	p=0.8231	p=0.5709

Table 2. Comparison of nesting parameters of green turtles encountered by tagging personnel between 29 May and 01 Aug 2019. CCLnt = Curved carapace length from notch to tip.

29 nests). No difference was observed for any parameter (Table 2). Affected turtles also did not differ from other green turtles in size as measured by curved carapace length (notch to tip) or nest incubation duration (Table 2).

Based on our findings, we characterized the carapace condition as bacterial dermatitis ranging from multifocal to diffuse in terms of the extent to which the carapace was affected. The abnormal gross appearance of the carapace resulted from erosion and loss of scutes, associated infiltration by leukocytes (inflammation), and proliferation of bacteria within affected scutes. The lack of histological evidence of bacterial dermatitis in three of the nine individuals with gross lesions is likely due to the superficial nature of the infections and loss of affected scute during sampling.

Culture results yielded multiple isolates, which was unsurprising given that abnormal skin is easily colonized by bacteria (Glazebrook & Campbell 1990; Aguirre *et al.* 1994; Boylan *et al.* 2017). Our results are similar to a study by Santoro *et al.* (2006), which found a wide variety of beneficial and pathogenic bacteria on healthy, wild nesting green turtles in Costa Rica. It is important to note that we did not culture the skin of unaffected individuals for comparison and thus did not characterize the fauna of normal skin during our observations.

Bacterial dermatitis in sea turtles and other reptiles typically results from abrasions or lacerations of the skin, environmental conditions that favor bacterial growth, or an underlying condition that alters the skin and/or its defenses against microbial infection (Boylan *et al.* 2017). Therefore, we considered potential underlying causes that may have contributed to carapacial infections on green turtles in our study.

Green sea turtles mate immediately prior to nesting season. Mating behavior is characterized by the male mounting the female, plastron to carapace, with the male using claws to grasp the female carapace (Booth & Peters 1972). Evidence of claw marks and bites have been observed on female carapaces during nesting season (Booth & Peters 1972; Mazzarella, K.T., unpubl. data), and may be associated with secondary infection of the skin (Boylan *et al.* 2017). We did not find the lesions in this study to be concentrated near the shoulders where males typically take hold, but some degree of more generalized damage to the scutes during mating cannot be completely ruled out.

Several species of barnacles have been documented attached to and sometimes embedded in the skin of sea turtles, including that of the carapace (Frick & Pfaller 2013). Attachment or removal of such epibionts can damage the skin to the degree that secondary infection occurs (Stacy *et al.* 2017). We did not find any epibionts on affected nesting turtles or see any residual marks suggestive of prior epibiont attachment; however, surface organisms may have detached or been removed by grooming prior to our observations.

Warm water temperatures and daily rain events may contribute to conditions favorable for bacterial growth and poor water quality in the Gulf of Mexico during sea turtle nesting season. Heavy summer rains lead to transport of nutrients into the Gulf of Mexico via surface runoff, overflows of sewage treatment plants, and riverine transport. The Florida Healthy Beaches Program conducts routine bacterial monitoring of beaches and coastal waters (www.floridahealth.gov/environmental-health/beach-water-quality/index.html). Poor water quality indicators were not documented on the beach or in coastal waters adjacent to the study site prior to or during the study. As the turtles exhibited the dermatitis while nesting, it is possible they encountered poor water quality at their foraging ground or during migration. Investigation into the foraging ground of affected individuals will be further pursued via stable isotope analysis.

Another consideration in this region is exposure to brevetoxins, algal toxins produced by the red tide organism *Karenia brevis*. It is hypothesized that brevetoxins may have sublethal effects on health and immune function (Perrault *et al.* 2016; Perrault *et al.* 2017). FWC hosts statewide red tide (*Karenia brevis*) status reports (https://myfwc.com/research/redtide/statewide/). Southwest Florida experienced a long-term major harmful algal bloom in the form of red tide between November 2017 and February 2019 (https://myfwc.com/media/21885/bloom-historic-database.pdf) with low to medium levels recorded in the Marquesas Keys, a known adult green turtle foraging ground (Hart *et al.* 2013; Herren *et al.* 2018). *Karenia brevis* was either not detected or was found at very low (>10,000-100,000 cells/liter) concentrations in Florida during March through June 2019 (www.flickr.com/photos/myfwc/sets/72157635398013168/with/25508900517/), thus there is no environmental evidence to suggest brevetoxin exposure, particularly high-level exposure, in the months immediately prior to nesting.

The underlying cause(s) of the carapacial infections reported here remains unknown. Although the condition resolved during the course of our study and was not believed to jeopardize survival of affected females; skin infections can be life-threatening in sea turtles as evidenced by observations in stranded animals (Boylan *et al.* 2017). Continued monitoring is recommended to follow the occurrence of carapace disease in subsequent years. Further study may benefit from more comprehensive sampling of the area nesting aggregation from the start of nesting season in order to better document prevalence and follow progression of carapace disease in more individuals. Furthermore, the addition of hematology and blood chemistry would provide more information about the health status of affected turtles beyond that evident from external examination and reproductive metrics.

Abnormalities affecting skin are an important aspect of aquatic wildlife health monitoring because the skin can reflect injurious external factors, such as water quality, as well as a host of systemic factors, such as diet, immune function, other organ function, and disease states. Emergence of conditions as described here merit attention given myriad concerns related to climate, pollution, and other changes in the marine environment that can affect sea turtle health. In addition, although the primary objective of tagging projects is mark/recapture documentation and tracking animal movements, the health of individual turtles should always be considered when conducting field studies. Thorough examination of turtles during tagging encounters may prevent unnecessary detainment of individuals ineligible for studies, avoid unintended negative effects on individuals with health problems, and may help reveal concerns otherwise undetected.

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Twenty-two Years Later: A Long Distance Recapture of a Green Turtle *(Chelonia mydas)* Tagged in Cuba and Found in Puerto Rico

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On 09 November 2019, an adult green turtle (*Chelonia mydas*), bearing a monel tag (#1039) on the trailing edge of its right front flipper, was found stranded dead at Icacos Beach, on the southeast coast of Vieques, Puerto Rico. Vieques is an adjacent island off the east coast of the main island of Puerto Rico. The recovered tag was in good condition (Fig. 1). At the time of stranding, the turtle's curved carapace length (CCL) was 115 cm, and curved carapace width (CCW) was 79 cm.

This turtle had been originally tagged more than 20 years earlier, on 06 November 1997, by the Sea Turtle Tagging Program of the Cuban Fisheries Research Center (CIP) in the feeding grounds of Laguna Agustin Hall, off the southern coast of Isla de la Juventud (Fig. 2), which is located along the southwestern coast of Cuba. In 1997, the harvesting of sea turtles was legal in Cuba (the legal fishery for sea turtles ended in 2008). However, this captured green turtle was released because it did not meet the minimum size for harvesting, according to the Cuban fisheries regulation, which specified that all turtles <50 cm CCL must be released. At the time of first capture, the turtle measured 46.0 cm CCL and 40.3 cm CCW.

When the turtle was found stranded at Vieques Island (Icacos Beach) in 2019, a necropsy was not conducted, but an external examination of the body did not reveal any wounds or entangling material such as ropes or bags on the body or extremities. The animal was buried at the same site where it was found. Due to the stage of decomposition of the animal, it is estimated that the animal had died within two or three days before it was found stranded on Icacos Beach. The turtle's tail did not extend beyond the carapace, and its carapace length was 115 cm CCL, therefore we concluded that it was an adult female. There are reports of green turtle nesting on this beach, but there was no evidence that this animal was nesting.

The time interval between the tagging date on this turtle in Cuba and when it was found in Puerto Rico was almost 22 years (8,030 days), which indicates that the turtle survived for almost two decades bearing the tag and reaching its sexual maturity within that time period. An estimated growth rate of 5.2 cm/yr was calculated for this turtle from the time of first capture (1997) and the last encounter (2020). This growth rate is similar to those reported for Puerto Rico and other places in the Caribbean (Patricio *et al.* 2014). It is estimated that green turtles can reach sexual maturity at a size ranging from 83 cm to 114 cm SCL, (Patricio *et al*. 2014; Goshe *et al*. 2010) or 87 cm to 118 cm CCL (according to conversion from CCL length to SCL by Bjorndal and Bolten 1989). .

Long distance recaptures of juvenile green turtles tagged in Cuban coastal waters have been reported previously from only two areas: Nicaragua's feeding grounds and Costa Rica (Moncada *et al*. 2006). This current report not only confirms the connectivity between different areas in the Caribbean for green turtle migratory patterns (Moncada *et al.* 2006; Patricio *et al.* 2017), but also is the oldest recapture for a turtle tagged in Cuba by CIP. More molecular studies should be conducted at a wider scale to include smaller green turtle nesting rookeries like the one in Vieques, to fill the gaps of the origins of various important green turtle foraging areas in the

Figure 1. Monel tag 1039 of a green turtle from Cuba, found on green turtle stranded at Vieques, Puerto Rico, 22 years after tagging.

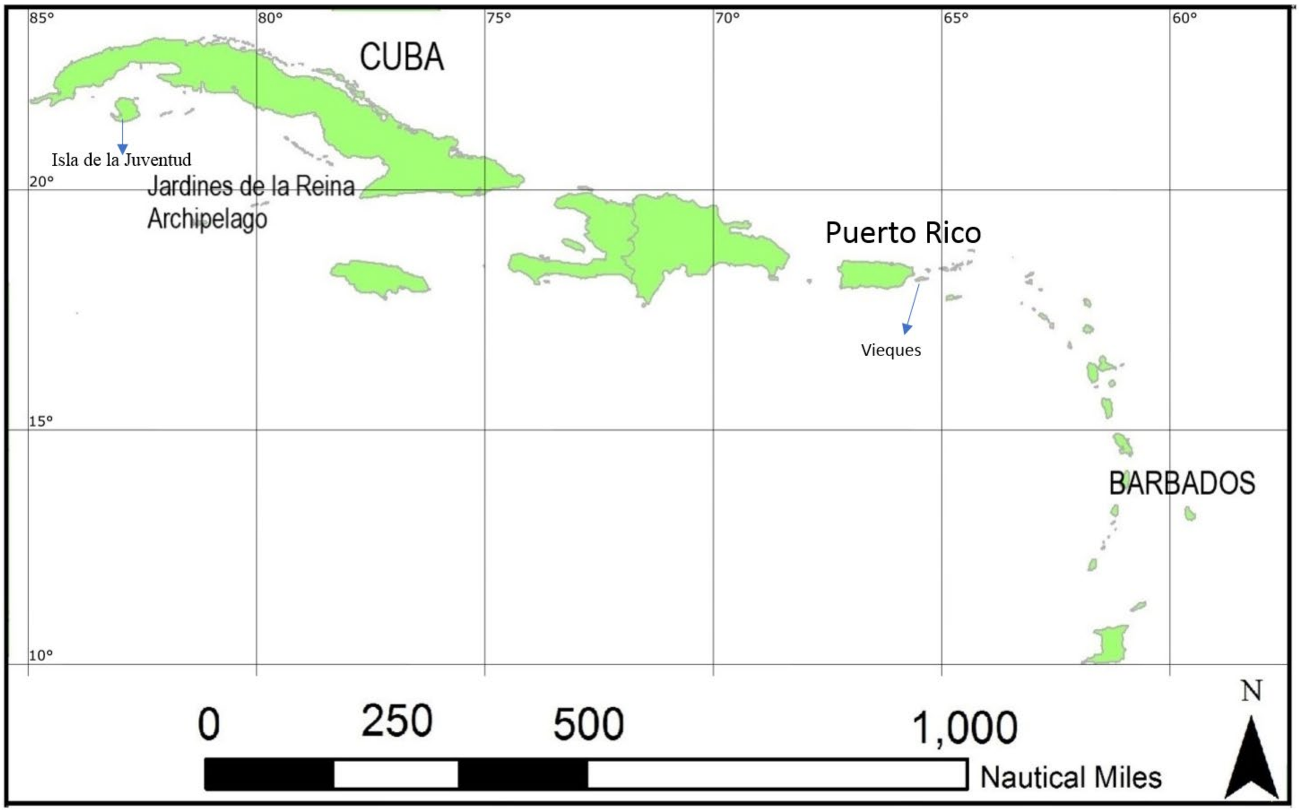

Figure 2. Location of initial tagging of a green turtle captured in its foraging area south of Isla de la Juventud, Cuba, and its stranding location 22 years later, in Vieiques, Puerto Rico.

Caribbean, such as the one in Laguna Agustin Hall, Cuba. This type of information highlights and strengthens the importance of regional conservation networks.

***Acknowledgements*.** From Cuba, we thank the staff members of the Fisheries Research Center, Cuba, who have been tagging sea turtles for many years. From Puerto Rico, we thank Y. de la Cruz from TICATOVE and J. Vargas from PR-DNER, who assisted in the field. Finally, we thank M. Godfrey for the review of this manuscript.

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Albino Green Turtle (*Chelonia mydas*) Hatchlings Documented at Cayo Largo (Canarreos Archipelago), Cuba

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On 20 July 2019, 15 green turtle albino hatchlings (*Chelonia mydas*) were discovered in Lindamar Beach, Cayo Largo (Canarreos Archipelago) in the southwestern region of Cuba. The hatchlings emerged from their nest after 47 days of incubation; the nest contained 112 eggs and had a hatching success of 88%.

The 15 hatchlings were transferred to the Marine Turtle Rescue Center (Cayo Largo) for captive-rearing. They are currently supplied with an alternating diet consisting of crushed fresh fish and an artificial diet (pellets), and are systematically observed by the staff of the center. After 40 days of captive care, 12/15 (80%) of the albino hatchlings had survived. These hatchlings will continue to be monitored, weighed, and measured monthly.

Albinism in sea turtle hatchlings continues to be a rare phenomenon and few known reports exist. Twenty-two loggerhead hatchlings (*Caretta caretta*) were born in Brazil (Marcovaldi *et al*. 1995), olive ridleys (*Lepidochelys olivacea*) were observed in Mexico by Barcenas & Maldonado (2009), two green turtles were reported in Turkey (Sonmez & Yalcin 2011), and most recently, 23 green turtle hatchlings emerged from a single clutch in Florida (Perrault & Coppenrath 2019).

Figure 1. Green turtle hatchlings (*Chelonia mydas*) hatched in Cayo Largo (Cuba). Photo: Leonardo Valido.

Godfrey & Mrosovsky (1995) hypothesized that orientation ability could be impacted in sea turtle hatchlings with pigmentation disorders, as retinal pathways to the brain are known to be abnormally routed in some albino organisms; however, this has not yet been confirmed (Perrault & Coppenrath 2019).

Acknowledgements. We thank Justin Perrault for reviewing early stages of this manuscript draft.

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Rare Observation of Hawksbill Turtle (*Eretmochelys imbricata*) Nesting Activity in Khor Fakkan, Eastern Coast of Sharjah, United Arab Emirates

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It is known that the waters of the United Arab Emirates provide a significant feeding and nesting habitat for marine turtles (Pilcher *et al.* 2014). Of the seven extant species that occur globally, there are five species of marine turtles that are known to occur in the waters of the UAE. Of these, green sea turtles (*Chelonia mydas*) and hawksbill sea turtles (*Eretmochelys imbricata*) are the most common (Baldwin & Gardner 2005). Globally, all marine turtles are listed in the International Union for the Conservation of Nature's Red List of Threatened Species; however, hawksbill sea turtles are listed as Critically Endangered (NMFS & USFWS 1993; Meylan & Donnelly 1999). This is in large part due to the loss of over 80% of important hawksbill turtle nesting sites in recent decades (www.redlist.org).

In the Arabian Gulf Coast of the UAE, hawksbill turtles are known to nest on numerous islands and beaches in the territorial waters of Dubai, Abu Dhabi and Sharjah (Pilcher *et al.* 2014). However, with the exception of one green turtle nest in 2014 and one hawksbill turtle nest in 2015 from Khor Kalba, Sharjah, there are no known contemporary records of marine turtle nesting activity on the Gulf of Oman coast of the UAE since marine turtle nesting has gradually diminished between the 1960s to the 1980s (Hebbelmann *et al.* 2016). Here we report an observation of hawksbill sea turtle nesting activity on Luluyah Beach, Khorfakkan, UAE.

On 16 May 2019 during a routine clean up of the beaches of the city of Khorfakkan, environmental inspectors observed a turtle on Luluyah Beach (25.38176 °N, 56.35952 °E) crawling toward the water (Fig. 1A). Video evidence of the encounter was captured and sent to Environment and Protected Areas Authority researchers. Observations of carapace morphology from the acquired video and the track morphology (track width = 66.1 cm) from site observations are consistent with hawksbill turtles. Observations of the tracks (Fig. 1B) show that, after emerging from the sea, the turtle crawled up the beach and attempted two digs before turning back toward the sea (Fig. 1C). Inspections of both excavations concluded that both attempts were not successful. This is believed to be due to the mix of rocks and coral fragments in the sand, making digging difficult. It is also possible that an approaching observer had frightened the turtle causing her to abandon her nesting attempt.

Although the exact reason for sporadic sea turtle nesting activity on the east coast of the UAE remains unknown, the observation of a nesting attempt, even an unsuccessful one, by a critically endangered marine turtle is an important finding. The observation of present and recent nesting activities in the area demonstrates the importance of identifying and conserving beaches that have characteristics of suitable nesting beaches, especially when considering the history of turtles nesting in the region.

Acknowledgements. The authors express their gratitude for the support of His Highness Sheikh Dr Sultan bin Mohammed Al Qasimi, Supreme Council Member and Ruler of Sharjah. The authors also acknowledge the support of her Excellency Hana Saif Al Suwaidi, chairperson of Sharjah Environment and Protected Areas Authority, and Awatif Al Naqbi, EPAA Khorfakkan office manager. The authors extend their gratitude to Ibrahim Bin Masoud, head of the EPAA Environmental Inspection Department and EPAA Environmental inspectors Najat Khalifa, Shaima Ali and Esra Ibrahim for their continued valued reports and operational support.

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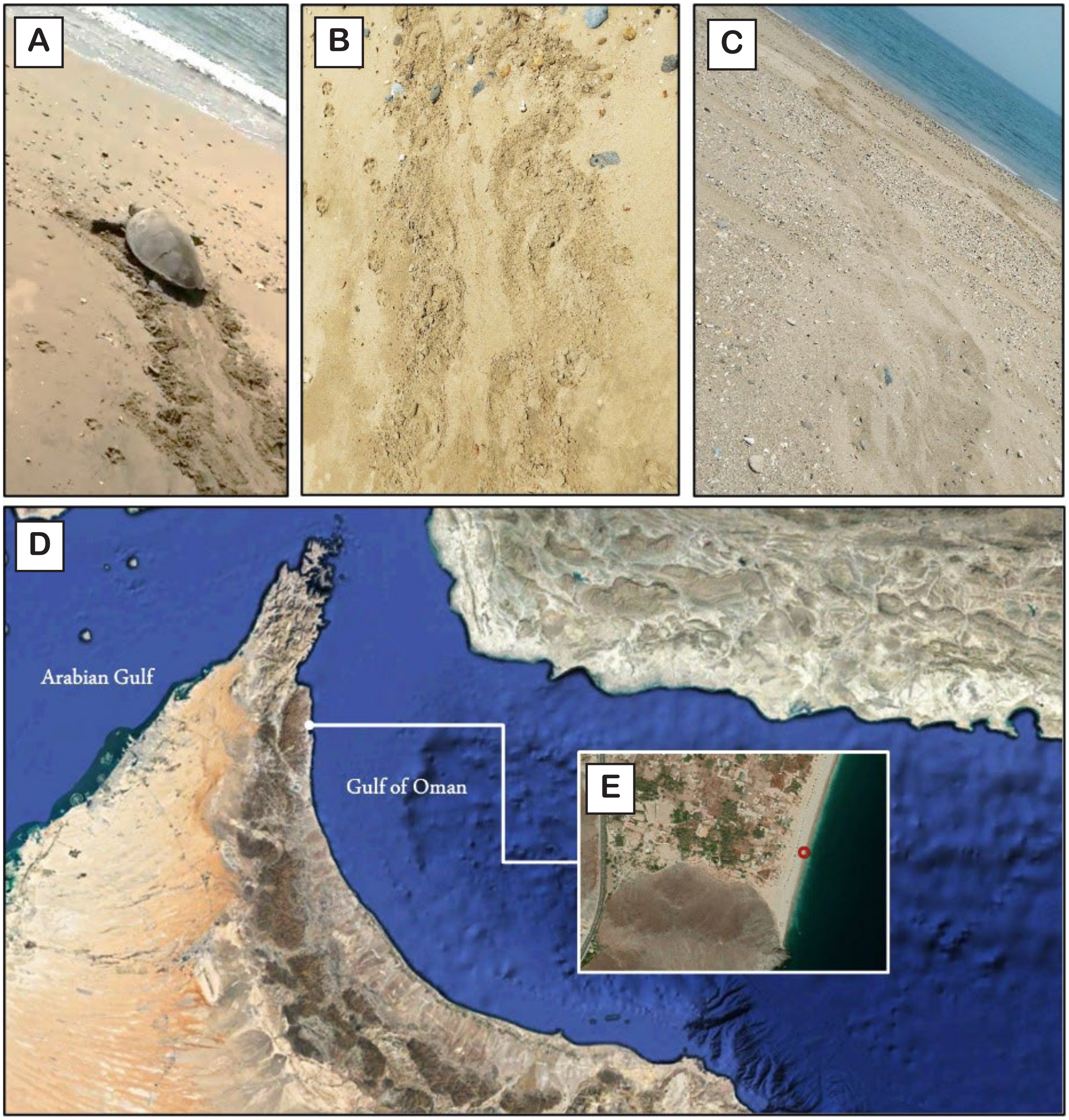

Figure 1. Hawksbill sea turtle (*Eretmochelys imbricata*) nesting attempt from Luluyah Beach (16 May 2019). [A] turtle crawling to the sea after its nesting attempt (Photo: Mohammed Mustafa); [B] turtle tracks; [C] turtle tracks and nesting attempt; [D] location of Luluyah Beach in the east coast of UAE; [E] stretch of Luluyah beach depicting point of encounter with turtle [Red circle: 25.38176 °N, 56.35952 °E]. Map Images courtesy of Google Earth, earth.google.com/web/

BOOK REVIEWS

Title: From Soup To Superstar: The Story Of Sea Turtle Conservation Along The Indian Coast
Year: 2015
Author: Kartik Shanker
Publisher: HarperCollins Litmus
ISBN: 9789351772323
Pages: 360 pages
Price: $24.99 (hardcover)

This book provides a detailed account of the path to sea turtle conservation in India, from sea turtles as a fishery to highly protected species. How sea turtle conservation grew in India develops though the book as it describes the different groups in various places around the country that have unique trajectories to protecting sea turtles. The author highlighted two contrasting programs, the more state-centered conservation action in Odisha and the local non-government organization efforts in Chennai, both of which were important to the development of sea turtle conservation in India. It was interesting to compare how conservation developed in different locations, but it would have been beneficial to include some sort of map when referring to sea turtle nesting beaches to help orient the reader to the geography of India.

Once a need for conservation of sea turtles was identified at various nesting locations, the author did an excellent job summarizing all the opposing opinions on how conservation should be conducted and what different groups thought the major threats were. India faced many similar conflicts over sea turtle conservation that other parts of the world encountered, including fishery interactions, TED use and whether to allow sustainable use. The book highlights several examples of when conflict arose, including physical violence in the case of trawling fishermen and the forest department on the Odisha coast and rhetoric battles between activists, organizations, and researchers.

This book does a thorough and excellent job synthesizing many articles and publications covering sea turtle monitoring or research in India, ranging from historical documents to scientific publications and newsletter opinion pieces. The author even identified inflated writing that people sometimes used when discussing the need for sea turtle conservation. The author includes many anecdotes and quotations from various researchers when discussing their work and contributions to the field, adding colorful details as the factual information was presented. By adding the element of storytelling throughout the book, the author was able to include many field-work tales which are often interesting and exciting yet left out of more formal scientific publications. The inclusion of stories about how various researchers, the author included, became fascinated with sea turtles helps the readers connect with the people and understand how the culture shift around turtles began. The inclusion of stories also allowed the author to acknowledge the dedication of many researchers to protecting the turtles, by rccounting their adventures during long monitoring efforts and dangerous encounters with disease and natural disasters.

There is a strong focus on the people and organizations involved with sea turtle conservation, and the book successfully identifies the many influential researchers and conservationists involved and often how they worked with and met one another. Identifying various connections between people was interesting but often led to many people being re-introduced several times throughout the book. I appreciated that the author included himself among the various connections and doesn't exclude himself from the story. Both large NGOs and small sea turtle conservation groups were identified, and it was interesting to read the author's reflections on the pros and cons of their various approaches. The author suggested some combination of national level interest groups combined with small local efforts as the best way to conserve sea turtles in India, and I found myself wanting to hear more of the authors thoughts on the future of sea turtle conservation in India.

The main critique of this book is the lack of an organized structure and that it could use rearranging of the material, either chronologically or geographically. The author reintroduces groups, people and events many times making logical flow difficult and sometimes repetitive. However, I think this book is incredibly informative while maintaining entertaining storytelling elements and successfully captures the interesting story of sea turtle conservation in India. It is an enjoyable read for anyone interested in learning more about these charismatic creatures and the people who love them in this part of the world!

Reviewed by Courtney Swink, Nicholas School of the Environment, Duke University Marine Laboratory, Beaufort, NC 28516, USA (E-mail: courtney.swink@duke.edu).

Title: Merlin: The Mind of a Sea Turtle
Year: 2017
Author: Ila France Porcher
Publisher: Ila France Porcher
ISBN: 1521543909
Pages: 59 pages
Price: $9.99 (paperback)
To order: www.amazon.com/Merlin-Turtle-Ila-France-Porcher-ebook/dp/B072WD4K7M

Merlin: The Mind of a Sea Turtle by Ila France Porcher follows the story of a sick green turtle, Merlin, and the efforts of Porcher to rehabilitate the animal in her home. It is an emotional tale of the connection that can develop between humans and wild animals. This book is written in the first person and takes you all the way to a small island in French Polynesia where Porcher lives and makes you feel as if you were the one feeding and caring for Merlin yourself. She evokes feelings of love, wonder, outrage, and hope, all in this short 59 page personal story.

The Tahitians have a long history of consumptive use of sea turtles in their waters and this conflicting image of turtles as a species to be preserved or to be eaten comes up right away in this book. The islanders do not understand why Porcher would go to such great lengths to protect and rehabilitate one sea turtle. This makes the story even more engaging because of the obstacles she must overcome to save this curiously humanized animal. Porcher does a good job of presenting the views of the other islanders in a way that is understandable and not overly influenced by emotion. Still, she must protect Merlin from the other islanders and figure out how to rehabilitate a sea turtle with little to no help or prior experience with this species, or any sea turtle for that matter. Her ability to connect with Merlin means it is easy for the reader to feel an attachment to him as well. I found myself drawn into the story and emotionally invested right from the start.

Porcher's world is beautiful and full of wonder. She has an astounding eye and ability to describe the underwater world that she gets to discover through caring for Merlin. This book is about more than just the rehabilitation of one sick turtle, it is about being in touch with nature and seeing the things that are right in front of you and not taking them for granted. I will say that because this is a true story there is not a nice, neat ending to the story of Merlin, but it is still a tale that deserves to be shared with anyone with a heart. I would recommend this book to anyone looking to add some wonder to their life. It is an easy read and requires no prior knowledge of sea turtle biology or conservation, just a love of nature and a desire to protect wild animals.

Reviewed by Audrey White, Nicholas School of the Environment, Duke University, Beaufort, NC 28516, USA (email: audrey.white@duke.edu).

Title: The Rise of Reptiles: 320 Million Years of Evolution
Year: 2019
Author: Hans-Dieter Sues
Publisher: Johns Hopkins University Press
ISBN: 9781421428673
Pages: 385 pages
Price: $84.95 (hardcover)

Don't be fooled by the appearance of this book: although it is oversized and looks like it belongs on your coffee table, it is a meticulously detailed look into the current understanding of the evolution of reptiles largely based on the fossil record. Extensive photographs and diagrams facilitate the reader's understanding of the various concepts, and Sues takes particular care to highlight linkages between ancient and modern reptiles. For example, on page 118, a photo of a fossil of *Geiseltaliellus maarius* from the Eocene is presented above a photo of a modern plumed basilisk, and allows the reader to see how anatomically similar the two species are, despite being separated by at least 30 million years.

The first two chapters anchor the rest of the book by reviewing key concepts in anatomy, fossilized bones and their relation to phylogeny. Readers of the Marine Turtle Newsletter are likely to be drawn to chapter five, which focuses on the phylogeny of turtles. The chapter has an excellent summary describing the changing phylogenetic position of turtles relative to other reptiles, based on various anatomical features, and Sues is careful to note as new data and analyses are published, the position of turtles relative to other reptiles will also change. In this and other chapters, I greatly appreciated the succinct style of expressing information that, in the hands of others, can be made overly complex or difficult to understand. For example, on page 43, to describe the difference between turtles and tortoises, Sues deftly writes "The vernacular 'turtle' is used here for Testudines and 'tortoise' specifically refers to members of Testudinidae." It can't be simpler than that!

The book ends with a short chapter on the conservation status of turtles, and the various threats they currently face, including habitat degradation, climate change, invasive species, pollutants, disease and parasites, and collection for consumption and the pet trade. Sues clearly states his position as skeptical of sustainable use of reptiles, although he does acknowledge that ranching and farming of some crocodilian species has improved their conservation status. It seems likely that Sues kept the chapter short, to avoid delving into complicated matters such as global vs. regional classification of sea turtles in the IUCN Red List, but it might have been better to add a few more references that highlight some of the more complicated conservation issues surrounding (sea) turtles. However, this does not detract from the overall excellence of this book, and it is highly recommended to anyone studying reptiles, with or without a background in phylogeny.

Reviewed by Matthew H. Godfrey, NC Wildlife Resources Commission, Beaufort, NC 28516, USA (email: mgodfrey@seaturtle.org).

REPORT

The First Gulf of Thailand Sea Turtle Nesting Recovery Network Workshop: 13-15 November, 2019, Koh Talu, Thailand

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The country of Thailand is an important cultural, economic, and environmental center in Southeast Asia (Lim *et al.* 2011; Suanmali 2014), and as such, has a strong history of tourism and trade throughout Asia-Pacific and the West. Additionally, Thailand has an influential role in both the traditional and contemporary outlooks on the development of conservation initiatives for endangered species in the region (Nijman & Shepherd 2007; Steinmetz *et al.* 2014), as well as the conservation education of millions within both local community and tourism sectors of the country (Sujarittanonta 2014).

Of the seven species of sea turtles, five have historically been sighted in the waters of Thailand (Phasuk & Rongmuansart 1973; Chantrapornsyl 1992), although by 1995, Settle (1995) suggested the loggerhead (*Caretta caretta*) had likely been extirpated from Thai waters, and soon after, Chantrapornsyl (2000) reports that only the hawksbill (*Eretmochelys imbricata*), green (*Chelonia mydas*), olive ridley (*Lepidochelys olivacea*), and the leatherback (*Dermochelys coriacea*) species remained throughout Thailand.

Nesting along the Andaman coast is mainly undertaken by olive ridleys (Settle 1995; Chantrapornsyl 1996; Aureggi 2010), although occasional reports of nesting leatherbacks, and more rarely hawksbills and greens, are provided to government agencies by local community members along this coast (Chantrapornsyl 1992; Chantrapornsyl 2000). Of all Thai waters, the Gulf of Thailand (GoT) (Fig. 1) is the area where the majority of hawksbill and green sea turtle nesting has historically occurred and been recorded

Figure 1. Map of the Gulf of Thailand bordering Cambodia on the southeast, and Malaysia on the southwest. Inset: Thailand regional view.

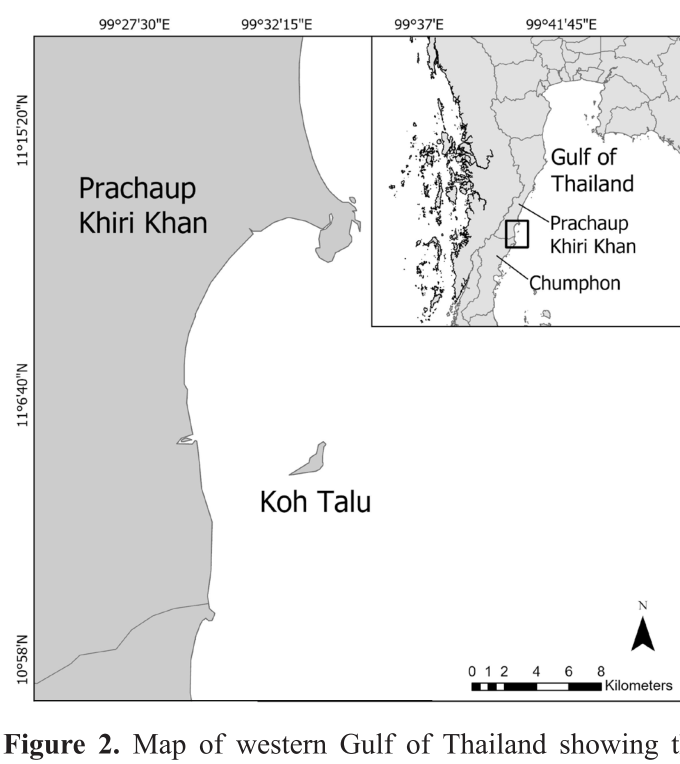

Figure 2. Map of western Gulf of Thailand showing the location of Koh Talu Island.

Figure 3. Dr. Nantarika Chansue (Chulalongkorn University, Thailand) provides opening remarks regarding the purpose and goals of the GoT NRN Workshop.

Figure 4. Mr. Preeda Charoenpak, owner of Koh Talu Island Resort, providing a historical background for the Siam Marine Rehabilitation Foundation, the only privately run, government authorized sea turtle head-starting program in the Gulf of Thailand.

even prior to a preliminary study report of sea turtles in this area by Commander Penyapol (1957) of the Royal Thai Navy. Despite the majority of nesting by three of the four species in Thailand taking place in the GoT, the majority of studies published have taken place in the area of southern Thailand on the Andaman coast (Aureggi & Chantrapornsyl 2003; Aureggi 2006; Aureggi 2010).

In July 2018, supported by funds from the United States Fish and Wildlife Service-Marine Turtle Conservation Fund (USFWS-MTCF), we initiated a rapid assessment for nesting hawksbills along the entire GoT, and began connecting small communities and government agencies along this area into the Gulf of Thailand Sea Turtle Nesting Recovery Network (GoTNRN) (Dunbar *et al.* 2019).

Our purpose here is to provide a brief report of the first Gulf of Thailand Sea Turtle Nesting Recovery Network workshop held 13-15 November, 2019 on Koh Talu Island (Fig. 2) at the Koh Talu Island Resort. The purpose of the workshop was to bring together key community leaders, government agency officers, and sea turtle researchers, to establish the need for a collective network of communities throughout the GoT that would work together in a coordinated fashion to develop common goals, standard beach monitoring and data collection methods, and to forge a growing sense of comradery and pride for community-based sea turtle conservation efforts in the GoT. Another goal of the workshop was to facilitate capacity building for representatives of local communities where sea turtle nesting is currently taking place, and to dispel some misconceptions regarding sea turtle life history stages, turtle movements, potentially injurious head-starting practices, and turtle health. Additionally, the workshop was to provide a venue for GoT community representatives who attended the Regional Training Workshop for Sea Turtle Conservation in Kep, Cambodia from 29 October-02 November 2018, to present information they had garnered from that workshop that was applicable to hawksbill nesting recovery in the GoT.

The team of facilitators (the authors) arrived on Koh Talu on 13 November to set up for the workshop and prepare seating, tables, and audio-visual arrangements under a roofed, but wall-less open seating area at the northern end of the resort property. On the morning of 14 November, the facilitators awoke to a monsoonal downpour and rain blowing into the area where the workshop was to be held. Working quickly with the help of resort staff, we were able to move

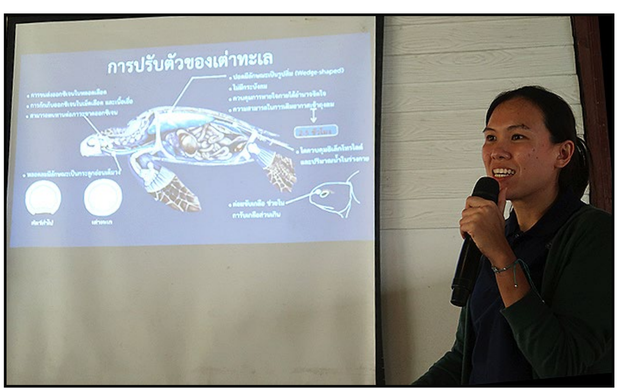

Figure 5. Department of Marine and Coastal Resources (DMCR) veterinarian, Dr. Chawanya Chiakwathanyu, explains the basic anatomy of sea turtles to workshop participants, and discusses the role of DMCR during reported stranding events throughout the Gulf of Thailand.

Figure 6. With many years of marine mammal and sea turtle rescue experience, Dr. Suwan Pitaksinthorn (Marine Scientist, Department of National Parks, Wildlife, and Plant Conservation, Trat Province) discusses how to foment opportunities to work in partnership with local communities.

Figure 7. Workshop participants practice decision-making regarding relocating nests to higher-shore locations.

Figure 8. During a practice night beach patrol, accurate data recording with standard nesting beach data sheets was stressed in different night-time scenarios.

Content and speakers	1	2	3	4	5
The contents were informative and useful	0%	0%	0%	42.9%	57.1%
The contents were interesting	0%	0%	0%	28.6%	71.4%
The speakers submitted clear and appropriate questions	0%	0%	0%	50%	50.0%
The speakers answered the questions	0%	0%	0%	21.4%	78.6%
The activities were useful	0%	0%	0%	21.4%	78.6%
The knowledge was applicable	0%	0%	7.1%	21.4%	71.4%
I can distribute what I have learned from the workshop	0%	0%	7.1%	28.6%	64.3%

Table 1. A Likert-scale (from 1= strongly disagree to 5 = strongly agree) survey of participants on the workshop contents and speakers.

Nesting recovery network	1	2	3	4	5
The workshop is useful for establishing the network	0%	0%	7.1%	35.7%	57.1%
The network needs to expand	0%	0%	0%	21.4%	78.6%

Table 2. A Likert-scale (from 1= strongly disagree to 5 = strongly agree) survey for workshop participants to gauge the establishment of the Nesting Recovery Network.

Nesting recovery network participation	Yes	No
Another nesting and rescue workshop should be done in the future	100%	0%
I would like to participate in the activities in the network	100%	0%

Table 3. A survey to gauge participation and need for future Nesting Recovery Network workshops.

	Comment by participant
1	"The workshop was too short"
2	"The weather was bad"
3	"There should be more participants in the workshop"
4	"The activities should be expanded"

Table 4. Comments provided by workshop participants to the open-ended survey question requesting feedback on any aspect of the overall workshop.

Figure 9. The group of participants in the first Gulf of Thailand Nesting Recovery Network Workshop.

the workshop set-up to a larger roofed area with walls on two sides with two sides open to the elements, yet far enough inside that blowing rain showers were of minimal impact. Workshop attendees arrived to the island by charter boat at approximately 8:30 AM amid another monsoonal downpour. Shortly after attendees settled in, we opened the workshop with introductions of all attendees and the opening ceremonies, with Dr. Nantraika Chansue describing the purpose, goals, and general flow of the workshop (Fig. 3). In addition, Chansue introduced the owner of Koh Talu Island Resort, Mr. Preeda Charoenpak (Fig. 4). Charoenpak introduced how his previous activities as a commercial fisher in the GoT influenced him to take a personal interest in ensuring sea turtles continued to survive in the region. He shared how he developed a vision to protect nesting turtles on Koh Talu Island, and became the initiator of the Koh Talu Island sea turtle conservation program (now called the Siam Marine Rehabilitation Foundation), which is currently the only non-governmental facility in the GoT with permission from the Department of Marine and Coastal Resources (DMCR) to be directly involved with head-starting turtles.

Once opening ceremonies had been completed, speakers began to provide their presentations. Presenters included faculty from the Marine Veterinary Department at Chulalongkorn University, a sea turtle expert, several staff veterinarians from regional offices of the DMCR (Figs. 5 & 6), and staff of the Koh Talu Siam Marine Rehabilitation Foundation (SMRF) turtle project. Presenters provided insights on a range of topics, including sea turtle life-history stages, species identification and tagging, nesting beach protocols and techniques, data management and education outreach, necropsy and sample collection, community stakeholders, and turtle bycatch management and rescue. All five Thai representatives who attended the Regional Training Workshop for Sea Turtle Conservation in Kep, Cambodia in 2018, presented regional information gathered from that workshop with applications to sea turtles in the GoT.

In addition to presentations, we held practical sessions in which all workshop participants used standard techniques for identifying nesting species from simulated beach tracks, practiced the translocation of eggs from a low-tide nest area, and recorded standard data during a nighttime beach patrol (Figs. 7 & 8). These practical exercises provided opportunities to dispel misconceptions, clarify proper techniques, and develop best-practice strategies for nesting protocols. Over the short timeframe of the workshop, we facilitated 16 presentations, three practical working sessions, and two breakout discussion and reporting sessions.

Prior to the conclusion of the workshop we assembled for a group photograph to commemorate the workshop (Fig. 9), then provided participants with an opportunity to provide feedback to the workshop organizers in the form of a Likert-scale (from 1= strongly disagree to 5 = strongly agree) workshop evaluation survey. We requested responses from participants in five areas of the workshop; Contents and Speakers (Likert), Accommodations and Travel (Likert), Nesting Recovery Network (Likert), Nesting Recovery Network Participation (Yes/No), and Suggestions (open ended). Responses to surveys were very positive (Tables 1-4; we have omitted the comments regarding the accommodations for this report), with 100% of participants agreeing there should be another GoTNRN workshop in the future, and 100% of participants stating their interest in participating in future GoTNRN workshop activities.

We recognized the limited past and current research-directed conservation efforts for all species of sea turtles in the GoT, and the need to develop strategies for the recovery of nesting and foraging populations in the region. Such strategies for sea turtle conservation may only be successful if there is commitment to these efforts by local communities, local and federal government agencies, national tertiary educational institutions, and research collaborators. It is our stated goal to work with all such stakeholders in further establishing and expanding the GoTNRN, and to work in collaboration with interested agencies to collect information throughout the GoT that may be used to improve recovery and conservation outcomes for all sea turtle species in this area of Southeast Asia.

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Juvenile loggerhead sea turtle released on the beach on South Core Banks, North Carolina, USA, after successful rehabilitation from cold-stunning. Photo by MH Godfrey.

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