Marine Turtle Newsletter

Issue Number 163 *April/July 2021*

Pacific green turtle observed nesting on Hermosa Beach, Uvita de Osa, Costa Rica. See pages 25-27.
Photo: Felipe Thomas.

Articles

ISSN 0839-7708

Editors:

Kelly R. Stewart
The Ocean Foundation
c/o Marine Mammal and Turtle Division
Southwest Fisheries Science Center, NOAA-NMFS
8901 La Jolla Shores Dr.
La Jolla, California 92037 USA
E-mail: mtn@seaturtle.org

Matthew H. Godfrey
NC Sea Turtle Project
NC Wildlife Resources Commission
1507 Ann St.
Beaufort, NC 28516 USA
E-mail: mtn@seaturtle.org

On-line Assistant:

ALan F. Rees
University of Exeter in Cornwall, UK

Managing Editor:

Michael S. Coyne
SEATURTLE.ORG
1 Southampton Place
Durham, NC 27705, USA
E-mail: mcoyne@seaturtle.org

MTN Online - The *Marine Turtle Newsletter* is available at the MTN web site: http://www.seaturtle.org/mtn/.

Subscriptions and Donations - Subscriptions and donations towards the production of the MTN should be made online at http://www.seaturtle.org/mtn/ or c/o SEATURTLE.ORG (see inside back cover for details).

Contact mtn@seaturtle.org to become a sponsor of the Marine Turtle Newsletter
or visit http://www.seaturtle.org/mtn/donate.shtml

The MTN-Online is produced and managed by ALan Rees and Michael Coyne.

Substantial Reduction in Annual Production of Kemp's Ridley Sea Turtle Hatchlings on Beaches of Tamaulipas, Mexico May Allow Abundance of Adults to Increase

Charles Wax Caillouet, Jr.
Montgomery, Texas 77356, USA (E-mail: caillouetcw2@gmail.com)

This perspective urges Mexico's Comisión Nacional de Áreas Naturales Protegidas (CONANP), US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) to consider possible negative effects of continuing annual translocations of most Kemp's ridley sea turtle (*Lepidochelys kempii*) nests (clutches of eggs laid) to protective hatcheries (corrals and polystyrene boxes) on western Gulf of Mexico (GoM) beaches of Tamaulipas, Mexico. Such translocations, combined with reductions in at-sea mortality of neritic (post-pelagic) juveniles and adults, appear to have led unintentionally to excessive abundance of neritic juveniles (Caillouet 2019). Excessive abundance of neritic juveniles, combined with reduced carrying capacity for the Kemp's ridley population within the GoM, may have contributed in part to the 2010-2020 nesting setback and prevented post-2009 increase in abundance of adults, especially females (Caillouet *et al*. 2018; Caillouet 2019). Because of Tamaulipas's coastal waters and beaches predominance in Kemp's ridley reproductive effort and output (Caillouet *et al*. 2016a; Caillouet & Gallaway 2020), their contribution to excessive abundance of neritic juveniles may also have suppressed nesting of secondary (Veracruz, Mexico) and tertiary (Padre Island National Seashore, Texas) nesting colonies. There has been close correspondence between trends in annual nests in Tamaulipas and Texas (Dixon & Heppell 2015; Shaver et al. 2016b). Despite providing evidence of pre-2010 slowing of the rate of increase in the Kemp's ridley population, Caillouet *et al*. (2016a) stated that conservation practices that enhance annual hatchling production on nesting beaches of Tamaulipas, Veracruz, and Texas probably would be the most expedient ways to restore population growth. Caillouet (2019) nuanced that suggestion by concluding instead that such practices are essential to maintenance and enhancement of secondary and tertiary nesting colonies on the coasts of Veracruz and Texas, respectively, which contribute to the population's diversity and resilience, while being essential on Tamaulipas beaches "at a level to be determined".

To test the hypothesis of excessive abundance of neritic juvenile Kemp's ridleys, Caillouet (2019) recommended that age-structured modeling be used to estimate post-1984 annual numbers of neritic juveniles and adults, so that a post-1984 time series of the quotient derived from annual number of adults divided by annual number of neritic juveniles could be examined. If this quotient declined, the decline would support the hypothesis. However, even if such analyses supported the hypothesis and annual hatchling production on Tamaulipas beaches were reduced substantially, it could take 10 yrs or more before effects could be detected, because of the time lag related to age at sexual maturity (Avens *et al*. 2017, 2020; Caillouet 2019). This lends urgency to implementing the as-yet unfulfilled age-structured modeling and examination of the post-1984 time series of the quotient. Recommendations by Caillouet (2019) are consistent with previous extensive uses of age-structured modeling to assess effects of conservation interventions and other factors affecting status and trends of the Kemp's ridley population (Márquez-M. *et al*. 1982; Heppell *et al*. 1996, 2005, 2007; Heppell & Crowder 1998; TEWG 1998, 2000; Crowder & Heppell 2011; NMFS *et al.* 2011; Gallaway *et al*. 2013, 2016a, b; NMFS & USFWS 2015; Kocmoud *et al*. 2019; Ramirez 2019). Theoretical papers by Schröder *et al*. (2014) and DeRoos (2018) discuss juvenile versus adult abundances and their effects on population dynamics.

Translocation of nests to on-beach hatcheries is considered highly manipulative (Meylan & Ehrenfeld 2000), but it was necessary, in combination with conservation interventions that reduced at-sea mortality of neritic life stages, to prevent Kemp's ridley's extinction and to put this species on a course toward recovery (Marquez-M. 1994; Heppell *et al*. 2005, 2007; Márquez-M. *et al*. 2005; Gallaway *et al*. 2013, 2016a, b; Márquez-Millán & Garduño-Dionate 2014; Burchfield & Peña 2015; Caillouet *et al*. 2015, 2016a; Kocmoud *et al*. 2019; Wibbels & Bevan 2019). Egg-to-hatchling survival is lower for nests left *in situ*, even when in *situ nests* are protected in various ways (Marquez M. 1987; Pritchard 1990, 2007; TKRRT 1992; Marquez-M. 1994; Márquez *et al*. 1999; Márquez-M. *et al*. 2005; Bevan *et al*. 2014, 2016; Márquez-Millán & Garduño-Dionate 2014; Burchfield & Peña 2015; Burchfield *et al*. 2020).

Pritchard (2007) questioned whether "the more turtles the better" conservation philosophy applied to Kemp's ridleys on Tamaulipas beaches should be abandoned. By 2004, the annual number of nests had increased to levels exceeding capabilities to translocate most of them to on-beach hatcheries (Bevan *et al.* 2014; Caillouet *et al.* 2016a; Gallaway *et al*. 2016a, b; Kocmoud *et al*. 2019). Therefore, a decision was made to reduce numbers of nests translocated to on-beach hatcheries and thus increase annual numbers of nests left *in situ*. However, *in situ* nests have continued to be protected in various ways on Tamaulipas beaches (Burchfield *et al*. 2020) and annual hatchling production has not been substantially reduced.

Arribada nesting on Tamaulipas beaches is the biogeographical norm for Kemp's ridley (Hildebrand 1963, 1982; Pritchard 2007; Wibbels & Bevan 2019). In the distant past, Kemp's ridley arribadas overwhelmed predators with ephemeral oversupplies of food, thereby perpetuating the species (Pritchard 2007). However, arribada nesting was disrupted primarily by exploitation of eggs on Tamaulipas beaches and mortality in neritic juveniles and adults caught unintentionally in shrimp trawls (Carr 1963, 1967, 1977; Hildebrand 1963; Marquez-M. 1994; Heppell *et al*. 2005, 2007; Gallaway *et al*. 2013, 2016a, b; Márquez-Millán & Garduño-Dionate 2014; Burchfield & Peña 2015; Caillouet *et al*. 2015, 2016a; Kocmoud *et al*. 2019; Wibbels & Bevan 2019).

Kemp's ridley population status and trends have been measured by annual numbers of nests (N_t, where t is calendar year) and

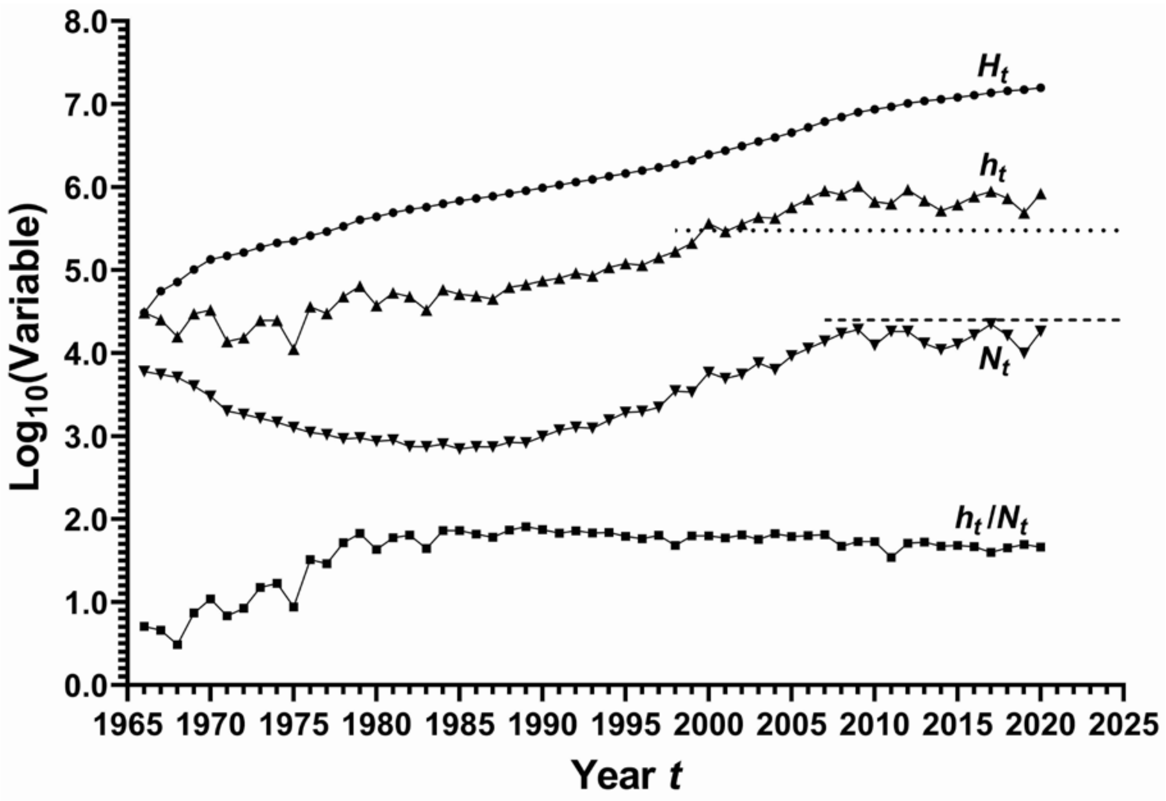

Figure 1. Trends in Log_{10}-transformed H_t, h_t, N_t and h_t/N_t (where t = calendar year) on the index beach, Tamaulipas, Mexico, 1966-2020, compared to Log_{10}-transformed downlisting thresholds for h_t (horizontal dotted line) and N_t (horizontal dashed line).

hatchlings released (h_t) into the GoM from the Tamaulipas index beach (Rancho Nuevo, Tepehuajes and Playa Dos beach segments combined) (Fig. 1; NMFS *et al*. 2011; NMFS & USFWS 2015). I emphasize that N_t and h_t comprise most but not all of the nests and hatchlings documented annually on Tamaulipas beaches (Heppell *et al*. 2007; Burchfield *et al*. 2020). The US-Mexico recovery plan (NMFS *et al*. 2011; NMFS & USFWS 2015) provided N_t and h_t thresholds for downlisting Kemp's ridley from endangered to threatened status; *viz.*, N_t = 25,000 nests (equivalent to 10,000 adult females nesting in a season) and h_t = 300,000 hatchlings released in a season (Fig.1). The downlisting threshold for h_t was exceeded during 2000-2020, except for 2001 when it was 291,268, while N_t remained below its downlisting threshold (Fig. 1).

Also shown in Fig. 1 are trends in two derived variables; viz., cumulative numbers of hatchlings released (H_t; Caillouet *et al.* 2016a) and numbers of hatchlings released per nest (h_t/N_t; Caillouet 2014). The variable H_t reflects total numbers of hatchling ever released from Tamaulipas beaches, beginning in 1966. The variable h_t/N_t reflects annual fecundity of nesters and hatch rates, which are influenced by many factors (Caillouet 2014; Caillouet *et al*. 2016a). In any year, h_t is determined for the most part by N_t, but it has also been affected by the post-1989 decline in h_t/N_t (Caillouet 2014; Caillouet *et al*. 2016a). Fecundity of nesters declined as the annual proportion of neophyte (first time) nesters increased (Marquez-M. 1994; Heppell *et al*. 2005, 2007; Witzell *et al*. 2005; Caillouet 2014; Caillouet *et al*. 2016a, 2018; Shaver *et al*. 2016b), and this may have contributed to the decline in h_t/N_t. Intentional increases in numbers of nests left in situ (Bevan *et al*. 2014) also could have contributed to the post-2003 decline in h_t/N_t. A mark-recapture study of Tamaulipas nesters during 2014-2015 found that 86% were putative neophytes (Burchfield & Peña 2015).

For years 1986–2014, Caillouet *et al*. (2016a) detected pre-2010 slowing of rates of increase in (1) the relationship between N_t and H_{t-10}, and (2) the times series of N_t/H_{t-10}. Caillouet *et al*. (2018) detected pre-2010 slowing of the rate of increase in N_t (Fig. 1). The finite multiplication rate (N_t/N_{t-1}) reached a temporary peak in 2000 (Fig. 2; see also Fig. 1B in Caillouet *et al*. 2018) and its maximum level in 2020 (Fig. 2). Assuming 10 yrs to maturity, its most recent surge may be a response to the 2009 hatchling release (indexed by h_t = 1,025,027), which was the highest on record (Fig. 1). This recent surge may also provide optimism that population growth has resumed; however, the highest N_t within the 1966-2020 time series was 22,415 in 2017, which is 4,239 (23%) higher than its 18,176 level in 2020. Only time will tell whether the nesting setback has ended.

Five years before the Deepwater Horizon (DWH) oil spill occurred in the northern GoM, Heppell *et al*. (2005) raised concerns that carrying capacity had changed and could prevent Kemp's ridley from reaching original levels. In 2006, Peter C.H. Pritchard suggested that carrying capacity might be exceeded because of intensive conservation efforts applied over the years (Caillouet 2014). GoM ecosystem alteration and degradation were underway long before the DWH oil spill (Heppell *et al*. 2007; Jackson 2008; Peterson *et al*. 2011; Walker *et al*. 2012; Yasuhara *et al*. 2012; Karnauskas *et al*. 2013; Shepard *et al*. 2013; Benitez *et al*. 2014; DWH NRDA Trustees 2016; Davis 2017; Hu *et al*. 2017; Scavia *et al*. 2017; Ward 2017; Wallace *et al*. 2020). Gallaway *et al*. (2013) mentioned the possibility that the assumption of density-independent

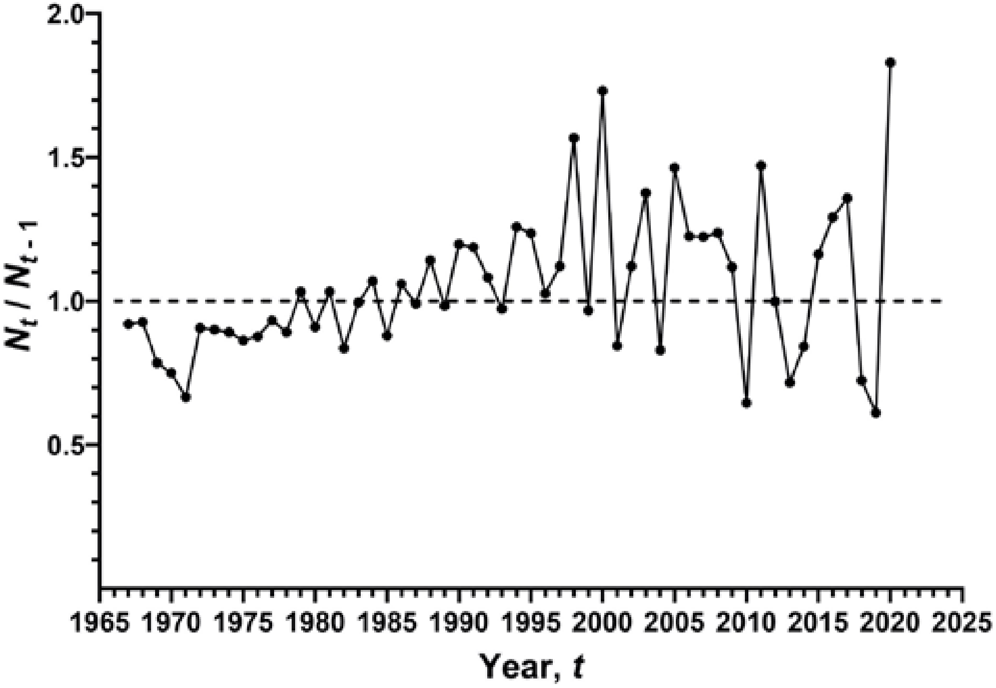

Figure 2. Trend in finite multiplication rate, $N_t / N_{t\text{-}1}$, for the Kemp's ridley index beach, Tamaulipas, Mexico, 1967-2020. The horizontal dashed represents $N_t = N_{t\text{-}1}$ (no change between consecutive years t-1 and t). Values of $N_t / N_{t\text{-}1}$ above the horizontal dashed line indicate increases ($N_t > N_{t\text{-}1}$), and those below the line indicate decreases ($N_t < N_{t\text{-}1}$).

mortality in age-structured modeling of the Kemp's ridley population may no longer be valid due to limits imposed by carrying capacity, but Gallaway *et al*. (2016b) considered density-dependent mortality unlikely for benthic-stage (neritic) Kemp's ridleys. Kocmoud *et al*. (2019) suggested that environmental factors caused the remigration interval for nesting females to increase. Avens *et al.* (2017, 2020) and Ramirez *et al*. (2020, 2021) compared Kemp's ridleys in the GoM and western North Atlantic Ocean with regard to age, growth, and maturity as related to environmental factors.

If age-structured modeling shows abundance of neritic immatures to be excessive, then consideration should be given to translocating excess clutches from Tamaulipas to other beaches throughout the northern GoM, to bolster the existing nesting colony on the coast of Padre Island National Seashore, and to establish new ones. Nesting on GoM beaches north and east of Tamaulipas, and along the eastern coast of North America may eventually become more important to Kemp's ridley population growth, recovery, resiliency, diversity and sustainability as climate warms and sea level rises (Heppell *et al*. 2007; Poloczanska *et al*. 2009; Putman *et al*. 2010a, b; Caillouet 2012, 2019; Pike 2013a, b; Shaver *et al*. 2013; 2016a, b; Caillouet *et al*. 2016b, 2018; Bevan *et al*. 2019; Butler 2019; Fuentes *et al*. 2019; Griffin *et al*. 2019; Innis *et al.* 2019; Reid *et al*. 2019; Dubois *et al*. 2020). However, Kemp's ridley may not be capable of adjusting rapidly enough to climate warming and sea level rise because of its fidelity to reproducing predominantly along the Tamaulipas coast (*ibid*.). Currently, it is unlikely that many if any Kemp's ridley hatchlings that enter the western NAO from rare nestings on the US east coast survive (Ramirez, M.D., pers. comm.; Caillouet & Gallaway 2020). Coastal currents and configurations and widths of continental shelves of the GoM and western NAO also influence locations of Kemp's ridley reproductive and foraging areas (Carr 1980; Rudloe & Rudloe 2005; Putman *et al*. 2010a, b; Shaver *et al*. 2013, 2016b; Caillouet & Gallaway 2020). In addition, river inflows (especially that of the Mississippi River) are greater along the GoM coast than along the east coast of North America, and they are essential to sustaining coastal estuaries that support life cycles of key Kemp's ridley prey species such as blue crab (*Callinectes sapidus*) (Hildebrand 1982; Vanderkooy 2013; Perry & Vanderkooy 2015; Gallaway *et al*. 2016b; O'Connell *et al*. 2019). In addition, restoration of the GoM ecosystem should increase carrying capacity for the Kemp's ridley population (Caillouet *et al*. 2018; Caillouet 2019).

Kemp's ridley's largest documented single-day arribada occurred on 18 June 1947, and it has been adopted as a benchmark for this species' recovery (Bevan *et al*. 2016; Wibbels & Bevan 2019). Therefore, consideration should be given by CONANP, USFWS and NMFS to examining existing daily nest counts during 1966-2020 to find the largest single-day nest count in each of those seasons. The trend in largest single-day nest counts would be informative as an index of single-day arribada size and progress toward recovery. My guess is that it would show the Kemp's ridley population to be far from recovery, even though its downlisting criterion for females nesting in a season has been approached, while that for hatchlings has been exceeded in 20 of the last 21 years (Fig. 1).

Acknowledgements. This review would not have been possible without availability of N_t and h_t data pairs for 1966-2020, which are maintained by CONANP and Gladys Porter Zoo, Brownsville, Texas. N_t and h_t data pairs for 1966-2014 were obtained from NMFS & USFWS (2015), and those for 2015-2020 were obtained from Jaime Peña and Patrick Burchfield, Gladys Porter Zoo. I thank Alberto Abreu-Grobois, Larisa Avens, Benny Gallaway, Nathan Putman, and Matthew Ramirez, as well as anonymous peer reviewers and Matthew Godfrey for reviewing various drafts of the manuscript. I commend CONANP and its predecessor agencies, National Park Service, USFWS, NMFS and Texas Parks and Wildlife Department, as well as other federal, state and local government agencies, corporations, businesses, universities, conservation organizations, local communities, and individuals in Mexico and the US, for their roles in Kemp's ridley conservation. This review is dedicated to the memories of Peter C.H. Pritchard (who died on 25 February 2020), Henry H. Hildebrand, Archie F. Carr, and Andrés Herrera. It is also dedicated to René Márquez-Millán.

AVENS, L., L.R. GOSHE, L. COGGINS, D.J. SHAVER, B. HIGGINS, A.M. LANDRY, JR. & R. BAILEY. 2017. Variability in age and size at maturation, reproductive longevity, and long-term growth dynamics for Kemp's ridley sea turtles in the Gulf of Mexico. PLoS ONE 12: e0173999.

AVENS, L., M.D. RAMIREZ, A.G. HALL, M.L. SNOVER, H.L. HAAS, M.H. GODFREY, L.R. GOSHE, M. COOK & S.S. HEPPELL. 2020. Regional differences in Kemp's ridley sea turtle growth trajectories and expected age at maturation. Marine Ecology Progress Series 654: 143-161.

BENITEZ, J.A., R.M. CERÓN-BRETÓN, J.G. CERÓN-BRETÓN & J. RENDÓN-VON-OSTEN. 2014. The environmental impact of human activities on the Mexican coast of the Gulf of Mexico: review of status and trends. WIT Transactions on Ecology and the Environment 181: 37-50.

BEVAN, E., T. WIBBELS, B.M.Z. NAJERA, M.A.C. MARTINEZ, L.A.S. MARTINEZ, D.J.L. REYES, M.H. HERNANDEZ, D.G. GAMEZ, L.J. PENA & P.M. BURCHFIELD. 2014. *In situ* nest and hatchling survival at Rancho Nuevo, the primary nesting beach of the Kemp' ridley sea turtle, *Lepidochelys kempii*. Herpetological Conservation & Biology 9: 563-577.

BEVAN, E., T. WIBBELS, B.M.Z. NAJERA, L. SARTI, F.I. MARTINEZ, J.M. CUEVAS, B.J. GALLAWAY, L.J. PENA & P.M. BURCHFIELD. 2016. Estimating the historic size and current status of the Kemp's ridley sea turtle (*Lepidochelys kempii*) population. Ecosphere 7: e01244

BEVAN, E.M., T. WIBBELS, D. SHAVER, J.S. WALKER, F. ILLESCAS, J. MONTANO, J. ORTIZ, J.J. PEÑA, L. SARTI, B.M.Z. NAJERA & P. BURCHFIELD. 2019. Comparison of beach temperatures in the nesting range of Kemp's ridley sea turtles in the Gulf of Mexico, Mexico and USA. Endangered Species Research 40: 31-40.

BURCHFIELD, P.M., C.H. ADAMS & J.L. DÁVILA GUERRERO. 2020. Mexico/United States of America binational population restoration program: U.S. 2020 report for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coast of Tamaulipas, Mexico. Gladys Porter Zoo, Brownsville, Texas. 58 p.

BURCHFIELD, P.M. & L.J. PEÑA. 2015. Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, Mexico 2011-2015. Five Year Report for the Natural Resource Trustees for the State of Texas. 57p. https://bit.ly/2Rf5mM8

BUTLER, C.J. 2019. A review of the effects of climate change on chelonians. Diversity 11: 138.

CAILLOUET, C.W. JR. 2012. Editorial: Do male-producing Kemp's ridley nesting beaches exist north of Tamaulipas, Mexico? Marine Turtle Newsletter 134: 1-2.

CAILLOUET, C.W., JR. 2014. Interruption of the Kemp's ridley population's pre-2010 exponential growth in the Gulf of Mexico and its aftermath: one hypothesis. Marine Turtle Newsletter 143: 1-7.

CAILLOUET, C.W., JR. 2019. Excessive annual numbers of neritic immature Kemp's ridleys may prevent population recovery. Marine Turtle Newsletter 158: 1-9.

CAILLOUET, C.W., JR. & B.J. GALLAWAY. 2020. 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. Marine Turtle Newsletter 161: 9-14.

CAILLOUET, C.W., JR., B.J. GALLAWAY & N.F. PUTMAN. 2016a. Kemp's ridley sea turtle saga and setback: novel analyses of cumulative hatchlings released and time-lagged annual nests in Tamaulipas, Mexico. Chelonian Conservation & Biology 15: 115-131.

CAILLOUET, C.W., JR., N.F. PUTMAN, D.J. SHAVER, R.A. VALVERDE, E.E. SENEY, K.J. LOHMANN, K.L. MANSFIELD, B.J. GALLAWAY, J.P. FLANAGAN & M.H. GODFREY. 2016b. A call for evaluation of the contribution made by rescue, resuscitation, rehabilitation, and release translocations to Kemp's ridley sea turtle (*Lepidochelys kempii*) population recovery. Herpetological Conservation & Biology 11: 486-496.

CAILLOUET, C.W., JR., S.W. RABORN, D.J. SHAVER, N.F. PUTMAN, B.J. GALLAWAY & K. L. MANSFIELD. 2018. Did declining carrying capacity for the Kemp's ridley sea turtle population within the Gulf of Mexico contribute to the nesting setback in 2010-2017? Chelonian Conservation & Biology 17: 123-133.

CAILLOUET, C.W., JR., D.J. SHAVER & A.M. LANDRY, JR. 2015. Kemp's ridley sea turtle (*Lepidochelys kempii*) head-start and reintroduction to Padre Island National Seashore, Texas. Herpetological Conservation & Biology 10: 309-377.

CARR, A. 1963. Panspecific reproductive convergence in *Lepidochelys kempi*. Ergebnisse der Biologie 26: 298-303.

CARR, A. 1967. So Excellent a Fishe: A Natural History of Sea Turtles. The Natural History Press, Garden City, NY. 248pp.

CARR, A. 1977. Crisis for the Atlantic ridley. Marine Turtle Newsletter 4: 2-3.

CARR, A. 1980. Some problems of sea turtle ecology. American Zoologist 20: 489-498.

COLEMAN, A.T., E.E. PULIS, J.L. PITCHFORD, K. CROCKER, A.J. HEATON, A.M. CARRON, W. HATCHETT, D. SHANNON, F. AUSTIN, M. DALTON, C.L. CLEMONS-CHEVISI & M. SOLANGI. 2016. Population ecology and rehabilitation of incidentally captured Kemp's ridley sea turtles (*Lepidochelys kempii*) in the Mississippi Sound, USA. Herpetological Conservation & Biology 11: 253-264.

CROWDER, L. & S. HEPPELL. 2011. The decline and rise of a sea turtle: how Kemp's ridleys are recovering in the Gulf of Mexico. Solutions 2: 67-73.

DAVIS, J.E. 2017. The Gulf: The Making of an American Sea. New York: Liveright Publishing Corporation. 592pp.

DEROOS, A.M. 2018. When individual life history matters: conditions for juvenile-adult stage structure effects on population dynamics. Theoretical Ecology 11: 397-416.

DIXON, P.M. & S.S. HEPPELL. 2015. Statistical analysis of Kemp's ridley nesting trends. Administrative Record for the Deepwater Horizon Oil Spill, Preassessment/Assessment, Sea Turtle Injury, Technical Report DWH-AR0088000. 42pp.

DUBOIS, M.J., N.F. PUTMAN & S.E. PIACENZA. 2020. Hurricane frequency and intensity may decrease dispersal of Kemp's ridley sea turtle hatchlings in the Gulf of Mexico. Frontiers in Marine Science 7: 301.

DWH NRDA TRUSTEES (DEEPWATER HORIZON NATURAL RESOURCE DAMAGE ASSESSMENT TRUSTEES). 2016. Deepwater Horizon oil spill: final programmatic damage assessment and restoration plan and final programmatic environmental impact statement. www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan/

FUENTES, M.M.P.B., M.H. GODFREY, D. SHAVER, S. CERIANI, C. GREDZENS, R. BOETTCHER, D. INGRAM, M. WARE & N. WILDERMANN. 2019. Exposure of marine turtle nesting grounds to named storms along the continental USA. Remote Sensing 11: 2996.

GALLAWAY, B.J., C.W. CAILLOUET, JR., P.T. PLOTKIN, W.J. GAZEY, J.G. COLE & S.W. RABORN. 2013. Kemp's ridley stock assessment project. Final Report from LGL Ecological Research Associates, Inc. to Gulf States Marine Fisheries Commission, Ocean Springs, MS. 291pp.

GALLAWAY, B.J., W,J. GAZEY, C.W. CAILLOUET, JR., P.T. PLOTKIN, F.A. ABREU GROBOIS, A.F. AMOS, P.M. BURCHFIELD, R.R. CARTHY, M.A. CASTRO MARTÍNEZ, J.G. COLE, A.T. COLEMAN, M. COOK, S. DIMARCO, S.P. EPPERLY, M. FUJIWARA, D. GOMEZ GAMEZ, G.L. GRAHAM, W.L. GRIFFIN, F. ILLESCAS MARTÍNEZ, M.M. LAMONT, R.L. LEWISON, K.J. LOHMANN, J.M. NANCE, J. PITCHFORD, N.F. PUTMAN, S.W. RABORN, J.K. RESTER, J.J. RUDLOE, L. SARTI MARTÍNEZ, M. SCHEXNAYDER, J.R. SCHMID, D.J. SHAVER, C. SLAY, A.D. TUCKER, M. TUMLIN, T. WIBBELS & B.M. ZAPATA NAJERA. 2016a. Development of a Kemp's ridley sea turtle stock assessment model. Gulf of Mexico Science 33: 138-157.

GALLAWAY, B.J., W.J. GAZEY, T. WIBBELS, E. BEVAN, D.J. SHAVER & J. GEORGE. 2016b. Evaluation of the status of the Kemp's ridley sea turtle after the 2010 Deepwater Horizon oil spill. Gulf of Mexico Science 33: 192-205.

GRIFFIN, L.P., C.R. GRIFFIN, J.T. FINN, R.L. PRESCOTT, M. FAHERTY, B.M. STILL & A.J. DANYLCHUK. 2019. Warming seas increase cold-stunning events for Kemp's ridley sea turtles in the northwest Atlantic. PLoS ONE 14: e0211503.

HARVEY, V.L., M.J. LEFEBVRE, S.D. DEFRANCE, C. TOFTGAARD, K. DROSOU, A.C. KITCHENER & M. BUCKLEY. 2019. Preserved collagen reveals species identity in archaeological marine turtle bones from Caribbean and Florida. Royal Society Open Science 6: 191137.

HEATON, A.J., E.E. PULIS, J.L. PITCHFORD, W.L. HATCHETT, A.M. CARRON & M. SOLANGI. 2016. Prevalence and transience of ingested fishing hooks in Kemp's ridley turtles. Chelonian Conservation & Biology 15: 257-264.

HEPPELL, S.S., P.M. BURCHFIELD & L.J. PEÑA. 2007. Kemp's ridley recovery: how far have we come, and where are we headed? In: Plotkin, P.T. (Ed.). Biology and Conservation of Ridley Sea Turtles. The Johns Hopkins University: Baltimore. pp. 325-335.

HEPPELL, S.S., D.T. CROUSE, L.B. CROWDER, S.P. EPPERLY, W. GABRIEL, T. HENWOOD, R. MÁRQUEZ & N.B. THOMPSON. 2005. A population model to estimate recovery time, population size, and management impacts on Kemp's ridley sea turtles. Chelonian Conservation & Biology 4: 767-773.

HEPPELL, S.S. & L.B. CROWDER. 1998. Prognostic evaluation of enhancement programs using population models and life history analysis. Bulletin of Marine Sciences 62: 405-507.

HEPPELL, S.S., L.B. CROWDER & D.T. CROUSE. 1996. Models to evaluate headstarting as a management tool for long-lived turtles. Ecological Applications 6: 556-565.

HILDEBRAND, H.H. 1963. Hallazgo del area de anidacion de la tortuga marina, "lora", *Lepidochelys kempi* (Garman) en la costa occidental del Golfo de Mexico. Ciencia, México 22: 105-112.

HILDEBRAND, H.H. 1982. A historical review of the status of sea turtle populations in the western Gulf of Mexico. In: Bjorndal, K.A. (Ed.). Biology and Conservation of Sea Turtles. Smithsonian Institution Press: Washington, D.C. pp. 447-453.

HU, X., Q. LI, W.-J. HUANG, B. CHEN, W.-J CAI, N.N. RABALAIS & R.E. TURNER. 2017. Effects of eutrophication and benthic respiration on water column carbonate chemistry in a traditional hypoxic zone in the Northern Gulf of Mexico. Marine Chemistry 194: 33-42.

INNIS, C.J., S. FINN, A. KENNEDY, E. BURGESS, T. NORTON, C.A. MANIRE & C. HARMS. 2019. A summary of sea turtles released from rescue and rehabilitation programs in the United States, with observations on re-encounters. Chelonian Conservation & Biology 18: 3-9

JACKSON, J.B.C. 2008. Ecological extinction and evolution in the brave new ocean. Proceedings of the National Academy of Sciences of the United States of America 105 (Supplement 1):11458-11465.

KARNAUSKAS, M., M.J. SCHIRRIPA, C.R. KELBLE, G.S. COOK & J.K. CRAIG. 2013. Ecosystem status report for the Gulf of Mexico. NOAA Tech Memo NMFS-SEFSC-653. 52pp.

KOCMOUD, A.R., H.-H. WANG, W.E. GRANT & B.J. GALLAWAY. 2019. Population dynamics of the endangered Kemp's ridley sea turtle following the 2010 oil spill in the Gulf of Mexico: simulation of potential cause-effect relationships. Ecological Modelling 392: 159-178.

MARQUEZ M., R. 1987. Status Report of the Kemp's Ridley Turtle. In: Ogren, L., F. Berry, K. Bjorndal, H. Kumpf, R. Mast, G. Medina, H. Reichart & R. Witham (Eds.), Proceedings of the Second Western Atlantic Turtle Symposium. NOAA Tech Memo NMFS-SEFC-226. pp. 159-174.

MARQUEZ-M., R. 1994. Synopsis of biological data on the Kemp's ridley turtle, *Lepidochelys kempi* (Garman, 1880). NOAA Tech Memo NMFS-SEFSC-343. 91pp.

MÁRQUEZ-M., R., P.M. BURCHFIELD, J. DÍAZ-F., M. SÁNCHEZ-P., M. CARRASCO-A., C. JIMÉNEZ-Q., A. LEO-P.,

R. BRAVO-G. & J. PEÑA-V. 2005. Status of the Kemp's ridley sea turtle, *Lepidochelys kempii*. Chelonian Conservation & Biology 4: 761-766.

MÁRQUEZ, R., J. DÍAZ, M. SÁNCHEZ, P. BURCHFIELD, A. LEO, M. CARRASCO, J. PEÑA, C. JIMÉNEZ & R. BRAVO. 1999. Results of the Kemp's ridley nesting beach conservation efforts in México. Marine Turtle Newsletter 85: 2-4.

MÁRQUEZ-M., R., J. DÍAZ-F., V. GUZMÁN-H., R. BRAVO-G. & M. DEL C. JIMENEZ-Q. 2018. Marine turtles of the Gulf of Mexico: abundance, distribution and protection. In: Withers, K. & M. Nipper (Eds.). Environmental Analysis of the Gulf of Mexico. Harte Research Institute for Gulf of Mexico Studies Special Publication Series No. 1. pp. 89-107.

MÁRQUEZ-MILLÁN, R. & M. GARDUÑO-DIONATE (Compiladores). 2014. Tortugas marinas. México City, México: Instituto Nacional de Pesca. 94pp.

MÁRQUEZ MILLAN, R., D. RÍO OLMEDA, J.M. SÁNCHEZ P. & J. DÍAZ, J. 1989. Mexico's contribution to Kemp's ridley sea turtle recovery. In: Caillouet, C.W., Jr. & A.M. Landry, Jr. (Eds.). Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management. Texas A&M University TAMU-SG-89-105. pp. 4-6.

MÁRQUEZ-M., R., A. VILLANUEVA O. & M. SANCHEZ PEREZ. 1982. The population of the Kemp's ridley sea turtle in the Gulf of Mexico-*Lepidochelys kempii*. In: Bjorndal, K.A. (Ed.). Biology and Conservation of Sea Turtles. Smithsonian Institution Press: Washington, D.C. pp. 159-164

MEYLAN, A.B. & D. EHRENFELD. 2000. Conservation of marine turtles. In: Klemens, M.W. (Ed.). Turtle Conservation. Smithsonian Institution Press: Washington, D.C. pp. 96-125.

NMFS (NATIONAL MARINE FISHERIES SERVICE) & USFWS (US FISH AND WILDLIFE SERVICE). 2015. Kemp's Ridley Sea Turtle (*Lepidochelys kempii*) 5-Year Review: Summary and Evaluation. NMFS & USFWS. 63pp.

NMFS (NATIONAL MARINE FISHERIES SERVICE), USFWS (US FISH AND WILDLIFE SERVICE) & SEMARNAT (SECRETARIAT OF ENVIRONMENT AND NATURAL RESOURCES MEXICO). 2011. Bi-national Recovery Plan for the Kemp's Ridley Sea Turtle (*Lepidochelys kempii*) - Second Revision. NMFS-OPR, Silver Spring, MD. 177pp.

O'CONNELL, M.T., M.S. PETERSON, S.P. POWERS, A.M. UZEE-O'CONNELL, E.J. ANDERSON & J. R. HENDON. 2019. Assessing nearshore nekton abundance, substrate, and environmental conditions in the northern Gulf of Mexico: are there differences among three adjacent coastal areas and have there been changes over three decades (1986–2015)? Estuaries and Coasts 42: 2139-2169.

PEÑA, L.J., J. MONTAÑO CUEVAS, F. ILLESCAS MARTÍNEZ, R. NUÑEZ LARA, J.G. MARÍN ÁLVAREZ, E.E. NAVARRO ANG, M. ROSAS COLMENARES, T. WIBBELS, E. BEVAN & A. BONKA. 2015. Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, Mexico. Gladys Porter Zoo, Brownsville, Texas. 48pp.

PERRY, H.M. & S.J. VANDERKOOY. 2015. The Blue Crab Fishery of the Gulf of Mexico, United States: A Regional Management Plan 2015 Revision. Gulf States Marine Fisheries Commission: Ocean Springs, Mississippi. 159pp.

PETERSON, C.H., F.C. COLEMAN, J.B.C. JACKSON, R.E. TURNER, G.T. ROWE, R.T. BARBER, K.A. BJORNDAL, R.S. CARNEY, R.K. COWEN, J.M. HOECKSTRA, J.T. HOLLIBAUGH, S.B. LASKA, R.A. LUETTICH, JR., C.W. OSENBERG, S.E. ROADY, S. SENNER, J.M. TEAL & P. WANG. 2011. A once and future Gulf of Mexico ecosystem: restoration recommendations of an expert working group. Pew Environment Group, Washington DC. 112pp.

PIKE, D.A. 2013a. Climate influences the global distribution of sea turtle nesting. Global Ecology and Biogeography 22: 555-566.

PIKE, D.A. 2013b. Forecasting range expansion into ecological traps: climate-mediated shifts in sea turtle nesting beaches and human development. Global Change Biology 19: 3082-3092.

POLOCZANSKA, E.S., C.J. LIMPUS & G.C. HAYS. 2009. Vulnerability of marine turtles to climate change. Advances in Marine Biology 56: 151-211.

PRITCHARD, P.C.H. 1990. Kemp's ridleys are rarer than we thought. Marine Turtle Newsletter 49: 1-3.

PRITCHARD, P.C.H. 2007. Arribadas I have known. In: Plotkin, P.T. (Ed.), Biology and Conservation of Ridley Sea Turtles. John Hopkins University Press: Baltimore. pp. 7-21.

PUTMAN, N.F., J.M. BANE & K. J. LOHMANN. 2010a. Sea turtle nesting distributions and oceanographic constraints on hatchling migration. Proceedings of the Royal Society B: 3631-3637.

PUTMAN, N.F., J. HAWKINS & B.J. GALLAWAY. 2020. Managing fisheries in a world with more sea turtles. Proceedings of the Royal Society B 287: 20200220.

PUTMAN, N.F. & K.L. MANSFIELD. 2015. Direct evidence of swimming demonstrates active dispersal in the sea turtle "lost years." Current Biology 25: 1-7.

PUTMAN, N.F., T.J. SHAY & K.J. LOHMANN. 2010b. Is the geographic distribution of nesting in the Kemp's ridley turtle shaped by migration needs of offspring? Integrative and Comparative Biology 50: 305-314.

RAMIREZ, M.D. 2019. It's in their bones: ecological drivers of Kemp's ridley sea turtle (*Lepidochelys kempii*) somatic growth and population dynamics. PhD Dissertation, Oregon State University, Corvallis, Oregon. 299pp.

RAMIREZ, M.D., L. AVENS, L.R. GOSHE, M.L. SNOVER, M. COOK & S.S. HEPPELL. 2020. Regional Variation in Kemp's ridley sea turtle diet composition and its potential relationship with somatic growth. Frontiers in Marine Science 7: 253.

RAMIREZ, M.D., T. POPOVSKA & E.A. BABCOCK. 2021. Global synthesis of sea turtle von Bertalanffy growth parameters through Bayesian hierarchical modeling. Marine Ecology Progress Series 657: 191-207.

REID, B.N., E. NARO-MACIEL, A. TORRES HAHN, N.N. FITZSIMMONS & M. GEHARA. 2019. Geography best explains global patterns of genetic diversity and postglacial co-expansion in marine turtles. Molecular Ecology 28: 3358-3370.

RUDLOE, A. & J. RUDLOE. 2005. Site specificity and the impact of recreational fishing activity on subadult endangered Kemp's ridley sea turtles in estuarine foraging habitats in the northeastern Gulf of Mexico. Gulf of Mexico Science 23: 186-191.

SCAVIA, D., I. BERTANI, D.R. OBENOUR, R.E. TURNER, D.R. FORREST & A. KATIN. 2017. Ensemble modeling informs hypoxia management in the northern Gulf of Mexico. Proceedings of the National Academy of Sciences of the United States of America 144: 8823-8828.

SCHRÖDER, A., A. VAN LEEUWEN & T.C. CAMERON. 2014. When less is more: positive population-level effects of mortality. Trends in Ecology & Evolution 29: 614-624.

SHAVER, D.J., K. HART, I. FUJISAKI, C.Y. RUBIO, A.R. SARTAIN, J. PEÑA, P.M. BURCHFIELD, D. GOMEZ GAMEZ & J. ORTIZ. 2013. Foraging area fidelity for Kemp's ridleys in the Gulf of Mexico. Ecology and Evolution 3: 2002-2012.

SHAVER, D.J., K.M. HART, I. FUJISAKI, C. RUBIO, K.M. HART, A.R. SARTAIN-IVERSON, J. PEÑA, D. GOMEZ GAMEZ, R. DE JESUS GONZALES DIAZ MIRON, P.M. BURCHFIELD, H.J. MARTINEZ & J. ORTIZ. 2016a. Migratory corridors of adult female Kemp's ridley turtles in the Gulf of Mexico. Biological Conservation 194: 158-167.

SHAVER, D.J., C. RUBIO, J.S. WALKER, J. GEORGE, A.F. AMOS, K. REICH, C. JONES & T. SHEARER. 2016b. Kemp's ridley sea turtle (*Lepidochelys kempii*) nesting on the Texas coast: geographic, temporal, and demographic trends through 2014. Gulf of Mexico Science 33: 158-178.

SHEPARD, A.N., J.F. VALENTINE, C.F. D'ELIA, D.W. YOSKOWITZ & D.E. DISMUKES. 2013. Economic impact of Gulf of Mexico ecosystem goods and services and integration into restoration decision-making. Gulf of Mexico Science 2013: 10-27.

TEWG (Turtle Expert Working Group). 1998. An assessment of the Kemp's ridley (*Lepidochelys kempii*) and loggerhead (*Caretta caretta*) sea turtle populations in the western North Atlantic. NOAA Tech Memo NMFS-SEFSC-409. 105pp.

TEWG (Turtle Expert Working Group). 2000. Assessment update for the Kemp's ridley and loggerhead sea turtle populations in the western North Atlantic. NOAA Tech Memo NMFS-SEFSC-444. 115pp.

TKRRT (The Kemp's Ridley Recovery Team). 1992. Recovery Plan for the Kemp's Ridley Sea Turtle (*Lepidochelys kempii*). Southwest Region U.S. Fish and Wildlife Service, Albuquerque, NM and National Marine Fisheries Service, Washington, DC. 48pp.

VANDERKOOY, S. 2013. GDAR 01 Stock Assessment Report: Gulf of Mexico Blue Crab. GSMFC Number 215. Gulf States Marine Fisheries Commission, Ocean Springs, MS. 291pp.

WALKER, S., A. DAUSMAN & D. LAVOIE. 2012. Gulf of Mexico Ecosystem Science Assessment and Needs. A Product of the Gulf Coast Ecosystem Restoration Task Force Science Coordination Team. 72pp.

WALLACE, B.P., B.A. STACY, E. CUEVAS, C. HOLYOAKE, P.H. LARA, A.C.J. MARCONDES, J.D. MILLER, H. NIJKAMP, N.J. PILCHER, I. ROBINSON, N. RUTHERFORD & G. SHIGENAKA. 2020. Oil spills and sea turtles: documented effects and considerations for response and assessment efforts. Endangered Species Research 41: 17-37.

WARD, C.H. (Ed.). 2017. Habitats and Biota of the Gulf of Mexico: Before the Deepwater Horizon Oil Spill. Volume 2. New York: Springer Nature. 948pp.

WIBBELS, T. & E. BEVAN. 2019. *Lepidochelys kempii (errata version published in 2019).*The IUCN Red List of Threatened Species 2019: e.T11533A155057916.

WITZELL, W.N., A. SALGADO-QUINTERO & M. GARDUNO-DIONTE. 2005. Reproductive parameters of the Kemp's ridley sea turtle (*Lepidochelys kempii*) at Rancho Nuevo, Tamaulipas, Mexico. Chelonian Conservation & Biology 4: 781-787.

YASUHARA, M., G. HUNT, D. BREITBURG, A. TSUJIMOTO & K. KATSUKI. 2012. Human-induced marine ecological degradation: micropaleontological perspectives. Ecology and Evolution 2: 3242-3268.

War on Polyethylene Terephthalate. Liechtenstein Post's Anti-plastic Campaign

Indraneil Das

Institute for Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak
94300 Kota Samarahan, Sarawak, Malaysia (E-mail: idas@unimas.my)

Landlocked Liechtenstein, a Central European nation located in the Alps, is renowned as a winter sport destination. Thus, conservation biologists looked on with interest when, on 7 September 2020, the Principality issued an unusual stamp, as part of the philatelic issues by Liechtensteinische Post AG, the official postal authority of the country (Fig. 1). The stamp draws attention to the dangers posed by plastic pollution on marine life, as highlighted on the cover (Fig. 2), and a marine turtle consuming a piece of plastic is depicted in the maximum card (Fig. 3).

Plastic pollution in natural environments has been widely documented, and by one estimate, of the 275 million metric tonnes of waste generated in 2010, 4.8 to 12.7 million metric tonnes were released into the world's oceans (Jambeck *et al.* 2015). The accumulation of plastic material, often symbolised by the Polyethylene Terephthalate (PET) bottle, is known to have affected ecosystems and species for decades. Harm brought to marine turtles has been suggested to include mortality following ingestion (Nelms *et al.* 2015), with pelagic stages of species more prone to consuming plastic (Clukey *et al.* 2017).

The goal of the new issue from Liechtenstein is to draw attention to environmental protection and the recovery of recyclable materials. The stamp was embroidered by the firm, Hämmerle & Vogel in Lustenau, Austria from polyester yarn thread derived from 3,100 recycled Polyethylene Terephthalate (PET) bottles of 600 ml volume. The three million meters of recycled polyester thread used is sufficient to encircle the border of Liechtenstein forty times. Hämmerle & Vogel is familiar to many for its other innovative stamps, such as the cotton-embroidered issues from Austria, including "Petit Point" (Eidelweiss flowers) issued 17 September 2010 (Stanley Gibbons catalog number, SG 3054), "Dirndl" (showing traditional Austrian ladies wear) issued 22 September 2016 (SG 3417), and the merino sheep wool thread used in the manufacture of the "Styrian Hat," issued 22 September 2018 (SG 3533). The firm also produced two souvenir sheets for Liechtenstein, issued to commemorate 300 Years of the Principality, on 12 January 2019. Shaped like crowns, they are cloth-embroidered, the special edition with a 24 carat gold thread, in addition to showing eight embedded Swarovski crystals. The 2,019 units (representing the year of issue) issued were distributed via a lottery (the catalog number SG 1864 was attributed to the regular version).

The current issue of interest is a near-circular, self-adhesive, blue (water) and green (land) stamp, of face value €6.30, and shows an embroidered globe in the center and three green leaves to the left, thus incorporating a natural motif. Not only can it be used as a postage stamp, the same can be attached to clothes and other accessories as an appliqué. The embroidered letterings (also from recycled plastic) indicate "Fürstentum Liechtenstein," or 'Principality of Liechtenstein,' on the outer edge of the globe, with the face value indicated within. The unusual stamp was produced using an automated process (Fig. 4).

Figure 1. A mint, plastic thread embroidered stamp from the 'PET Recycling' issue from 7 September 2020 (SG 1917).

Figure 2. A stamp on a first day cover, showing a Vaduz, Liechtenstein, cancellation.

The value of postage stamps in public education is recognized widely, topics as diverse as the social sciences (Kirman & Jackson 2000), medicine (Andrews 1956), politics (Raento 2006), and other fields. Yeung (2018) argued the cost-efficiency of postage stamps for conservation education, nature-themed stamps having the potential as a powerful tool for advocacy.

Figure 3. A stamp on a maximum card, showing one possible effect of plastic in marine environments.

Acknowledgements. I thank Christine Böhmwalder, Leiterin Philatelie, Liechtensteinische Post AG (Philatelie Liechtenstein) for information, images, and permission to reproduce the images, and Genevieve V.A. Gee for comments.

ANDREWS, M.J. 1956. Medical history as portrayed on postage stamps. Journal of the National Medical Association 48: 1-9.

CLUKEY, K.E., C.A. LEPCZYK, G.H. BALAZS, T.M. WORK & J.M. LYNCH. 2017. Investigation of plastic debris ingestion by four species of sea turtles collected as bycatch in pelagic Pacific longline fisheries. Marine Pollution Bulletin 120: 117-125.

JAMBECK, J.R., R. GEYER, C. WILCOX, T.R. SIEGLER, M. PERRYMAN, A. ANDRADY, R. NARAYAN & K.L. LAW. 2015. Plastic waste inputs from land into the ocean. Science 347: 768-771.

KIRMAN, J.M. & C. JACKSON. 2000. The use of postage stamps to teach social studies topics. The Social Studies 91: 187-190.

NELMS S.E., E.M. DUNCAN, A.C. BRODERICK, T.S. GALLOWAY, M.H. GODFREY, M. HAMANN, P.K. LINDEQUE & B.J. GODLEY. 2015. Plastic and marine turtles: a review and call for research. ICES Journal of Marine Science doi: 10.1093/icesjms/fsv165.

RAENTO, P. 2006. Communicating geopolitics through postage stamps: the case of Finland. Geopolitics 11: 601-629.

YEUNG, A.C. 2018. Promoting environmental conservation one stamp at a time. Biodiversity and Conservation 27: 3843-3844.

Figure 4. Production of the PET-bottle-based embroidered stamp required over a million revolutions to produce the output of 40,000 sheetlets. On the other hand, a single embroiderer, using manual tools, would take an estimated 25 years to produce these.

Occurrence of Sea Turtles on Niterói City Beaches, Rio de Janeiro, Brazil

Beatriz Guimarães Gomes[1], Alícia Bertoloto Tagliolatto[2] & Suzana Machado Guimarães[3]

[1]Universidade Federal do Rio de Janeiro, Instituto de Biologia, Departamento de Biologia Marinha, Av. Carlos Chagas Filho, 373, Edifício do Centro de Ciências da Saúde, Sala A1-050 - Bloco A, Rio de Janeiro, RJ, Brazil (E-mail: bggomes@id.uff.br); [2]Projeto Aruanã - Tartarugas Marinhas da Baía de Guanabara e adjacências, Universidade Federal Fluminense, Niterói, Rio de Janeiro, Brazil (E-mail: aliciabertoloto28@hotmail.com); [3]Laboratório ECOPESCA - Biologia do Nécton e Ecologia Pesqueira, Departamento de Biologia Marinha, Universidade Federal Fluminense, Niterói, Rio de Janeiro, Cx. Postal 100.644, Brazil (E-mail: suzanamgr@hotmail.com)

Sea turtles have been threatened throughout their existence, with the main threats being caused by anthropogenic factors, such as bycatch in fisheries, urban beach development, reduction of coastal nesting areas, and chemical or debris pollution/litter (Wyneken *et al.* 1988; Epperly *et al.* 1996; Lutcavage *et al.* 1997; Gallo 2001; Domingo *et al.* 2006). Currently, all species are included in the IUCN Red List of Endangered Species (www.redlist.org), as well as in the Brazilian Ministry of Environment Red List (ICMBIO 2018). These threats create an imbalance in sea turtle populations, in which replacement rates occur below mortality rates, causing decreases in population viability (Lutz & Musick 1996; Lutz *et al.* 2002).

Green sea turtles (*Chelonia mydas*, Linnaeus 1758) inhabit many coastal habitats, entering bays and estuaries and, consequently, are highly vulnerable to anthropogenic pressures (Bugoni *et al.* 2001; Rodrigues 2012). As coastal juveniles, they display a preference for an herbivorous diet, and they begin to look for areas with the presence of rocky shores, where they can find their preferred food (Balazs 1980; Hirth 1997; Rodrigues 2012). In Brazil, this species' feeding areas are distributed along the coast. However, priority nesting areas are located on the oceanic islands of Atol das Rocas, in the state of Rio Grande do Norte, Fernando de Noronha, in the state of Pernambuco, and Ilha de Trindade, in the state of Espirito Santo (Almeida *et al.* 2011).

A first step in identifying important areas of sea turtle occurrence is using the head counting technique through observations carried out from a fixed point. This technique is used in several activities that have the potential risk of interacting with sea turtles, such as in oil and gas exploration. It is also common in management plans for port dredging operations, in which the observation regarding the presence of marine animals is necessary both before and during operations (Gitschlag & Herczeg 1994; Santos *et al.* 2011; Goldberg *et al.* 2015; Santos *et al.* 2015; Sforza *et al.* 2017). In Brazil, studies that documented the occurrence of sea turtles in regions undergoing seismic surveys have also applied this methodology (Gurjão *et al.* 2005; Parente *et al.* 2006). In the city of Niterói, Brazil, studies carried out by the Aruanã Project have used this methodology as an auxiliary tool to identify periods with the highest number of sightings and thus to inform conservation strategies. In this methodology, the exact number of individuals cannot be estimated, but relative abundance indicates the main areas of occurrence.

Considering there have been regular sightings of these animals by the local community in several beaches in Guanabara Bay and surrounding areas, our study goal was to identify the areas of greatest sea turtle occurrence along the coast in the municipality of Niterói, in the state of Rio de Janeiro. We also wanted to analyze if there temporal variation in daily observations of turtles. These results are important for providing information that could be used in local conservation actions and could contribute to the development of future management plans for the protection of the sea turtles that live in the region.

The observations were carried out at the beaches of Itaipu (22.97083 ºS, 43.04638 ºW), Icaraí (22.90548 ºS, 43.11972 ºW), Jurujuba (22.92750 ºS , 43.11803 ºW), Adão (22.92771 ºS, 43.12285 ºW) and Eva (22.93000 ºS, 43.12277 ºW), located in Niterói, Rio de Janeiro, Brazil. The selection of these beaches was based on sea turtle occurrence reports from the local community. Except for Itaipu, the beaches are located within the Guanabara Bay, and are characterized as semi-enclosed coastal ecosystems, with an entrance that protects its waters from waves (Amador 1980). As an estuarine system, it presents a complex environment with high environmental variability, determined by factors like salinity and variations in the wave height and water circulation patterns, mainly governed by tides (Amador 1997). The bay's central region exhibits greater oceanic circulation, reflecting water quality and sediment type and aquatic biota distribution (Mayr *et al.* 1989; Amador 1997; Soares 2010; Amador 2012).

Due to its central and strategic location in the metropolitan region of the state of Rio de Janeiro, the second largest metropolis in the country, Guanabara Bay is used for various commercial activities. It is surrounded by large port centers, landfills, fishing piers, public roads, fishing activities, and several domestic sewage and industrial effluents dumping sites. Thus, the region suffers from the intense anthropogenic activity, being considered one of the most polluted bays along the Brazilian coast (Amador 1997; Valentin *et al.* 1999).

Icaraí beach is located inside Guanabara Bay, and it is approximately 1,400 m long. Adão and Eva are small nearby beaches, adjacent to each other, 250 m and 150 m long, respectively (Guia de Niterói 2014). Jurujuba beach is about 300 m long and is characterized by calm waters with significant influence of pollution ejected from Guanabara Bay (Guia de Niterói 2014). At Jurujuba beach, there is a traditional community of fishermen who, due to the collapse of artisanal fishing, organized and implemented mussel farms in the region to increase their income and reduce dependence on fishing (Capello & Brotto 2016).

Itaipu Beach, by contrast, is the only oceanic beach included in this study (Fig. 1), although the Bay may influence it due to its proximity. It is approximately 700 m long and continuously receives contributions from continental waters, through Itaipu Lagoon (Salvador & Silva 2002). Itaipu beach is located in a cove that is characterized by its fairly calm waters and has a set of three coastal islands that act as partial protection from waves; it also serves as a port for numerous boats that come from the city of Rio de Janeiro (Salvador & Silva 2002; Monteiro-Neto *et al.* 2008). Moreover, there is the presence of rocky banks, a rocky slab in the middle

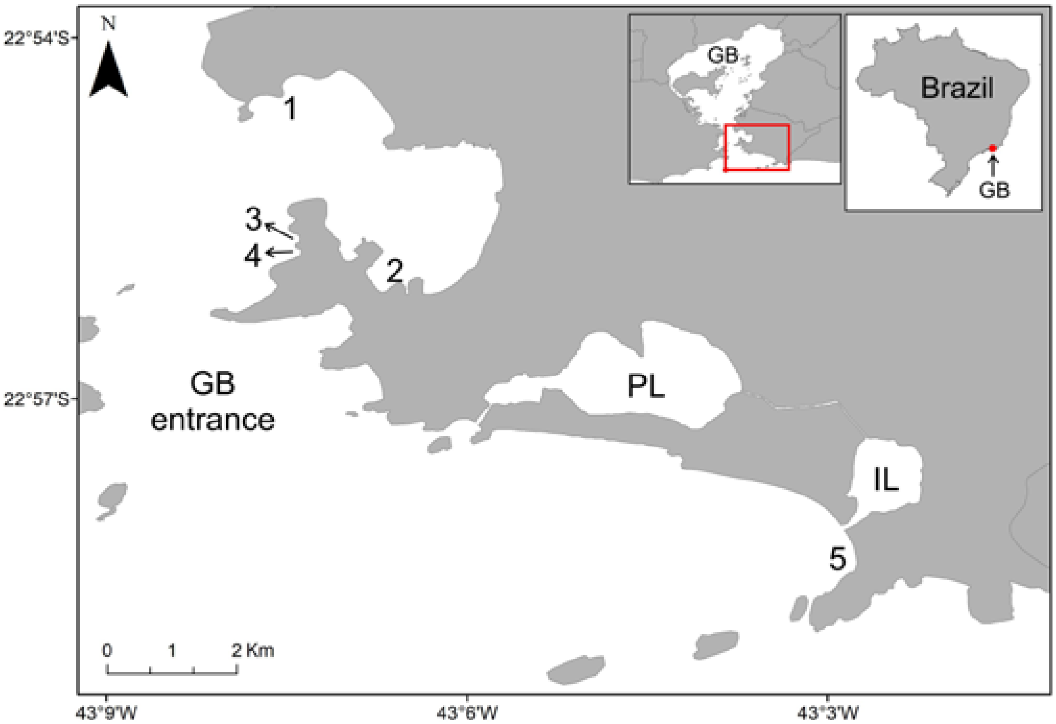

Figure 1. Map of the study area showing the five beaches in the municipality of Niterói, in the state of Rio de Janeiro, Brazil. 1: Icaraí Beach, 2: Jurujuba Beach, 3: Adão Beach, 4: Eva Beach and 5: Itaipu Beach. GB: Guanabara Bay; PL: Piratininga Lagoon; IL: Itaipu Lagoon.

part closest to the beach, and an artificial canal constructed with rocks in which algae are abundant (Braga *et al.* 2014; Nunes 2016).

Data were collected from August 2016 to February 2017, through *in situ* observations, by Projeto Aruanã trainees at Itaipu, Icaraí, Jurujuba, Adão and Eva Beaches in Niterói, Rio de Janeiro, Brazil. During this time, the same group of trainees collected the field data. Six months was considered a long enough timeframe for the purpose of the study. A total of 31 weeks and 276 observation days were carried out from August 2016 to February 2017 (57 days in Itaipu, 72 in Icaraí, 73 in Jurujuba, 45 in Adão and 20 in Eva).

The observations took place once a week at each beach from 08:00 to 16:00 h, divided into shifts and the same shifts were not necessarily completed on the same day. The morning shift was covered from 08 to 11 h and the afternoon shift was covered from 13 to 16 h. Except for Adão, the beaches were sectioned in smaller areas to reduce the chances of not seeing a turtle when it came up to breathe. These sections were made according to the beach size. Eva beach had two sections, Itaipu and Jurujuba beaches had three sections and Icaraí beach had four sections. The extension of each volunteer's observing area was subjective. Each section had the same designated trainees to avoid observer errors. Each trainee carried out headcounts at a fixed observation point at each beach. The maximum distance for observation was approximately 50 m from the observation point. As the animals emerged to breathe, one sighting was counted for each turtle head observed, with no effort to identify individual animals. For this study, the total number of sightings per beach was considered. Analysis of differences between sectors was not conducted.

To compile a descriptive analysis, an average index of heads counted by the number of hours per month at each beach was calculated. The analysis was also made per shift, considering the data that took exactly one hour of turtle sightings to maintain the effort and to make it possible to compare the number of turtle heads themselves. Data for December, January and February for Eva Beach were excluded due to a lack of observations in the afternoon shift.

To standardize the turtle observation effort between the beaches, we considered the corresponding median monthly observation index using the following formula:

$$\text{Average index} = \frac{\text{Number of sea turtle heads counted}}{\text{Number of hours per month}}$$

To standardize the turtle observation effort between the shifts at each beach, the analysis considered variables of four periods (8h-10h, 10h-12h, 12h-14h and 14h-16h).

The normality of the data was verified by the Shapiro Wilk test and Kruskal Wallis non-parametric test. The significance of the monthly observation between the beaches and the difference between the day shift by each beach (morning and afternoon) was verified using the Kruskal-Wallis non-parametric test and the Dunn *post hoc* test. The analyses were carried out using the statistical software R (version 3.4.1, R Core Team 2020).

The average index of turtle observations on each beach with standard deviations is shown in Table 1. In the Kruskal-Wallis test, the average index differed significantly between beaches ($p < 0.05$). In Dunn's *post hoc* test, the average index of turtle observations recorded in Icaraí differed significantly from that recorded in Adão, Itaipu and Jurujuba ($p < 0.05$), but did not differ significantly from the index recorded in Eva ($p = 0.0543$). Despite the test showing that Icaraí and Eva do not differ in terms of number of sightings, the index found Eva beach had a similar value to other beaches, with a *p*-value almost equal to 0.05.

The considerable number of sightings at Icaraí may be due to the plentiful presence of rocks with ample algae cover, used by green turtles as a food source. Moreover, the area features calm and warm waters, which is typical of bays (Nunes 2016; Guimarães 2017). This demonstrates the importance of this beach for these animals. Although Icaraí exhibits several factors that favor the presence of these animals, the area suffers from high pollution

Beach	Average index	Standard deviation
Itaipu	9.12	4.38
Icaraí	56.79	23.56
Jurujuba	6.99	3.93
Adão	4.25	1.58
Eva	13.84	7.15

Table 1. The average index of turtle observations on each beach (turtles per hour) with standard deviation.

rates from pipes that release raw sewage directly onto the beach. During the observations, several individuals were sighted with fibropapillomatosis, a disease caused by a type of herpesvirus that has pollution as one of the promoting agents. Even though studies on the presence of sea turtles at Guanabara Bay are scarce, it is known that juvenile green turtles widely use this estuary as a foraging and developmental area (Rodrigues 2012; Projeto Aruanã 2017 pers. comm.).

In the Kruskal-Wallis test, the median number of turtle observations differed significantly between hours ($p < 0.05$) at all beaches, but with the Dunn's test, we found that the period of 12-14 h did not differ significantly from 14-16 h($p = 0.1305$) and the 8-10 h period did not differ significantly from the 10-12 h ($p = 0.3320$). The period of 8-12 h (morning) differed in the number of sightings compared to the period of 12-16 h (afternoon), at all beaches, except for Itaipu. The period of 12-16 h was the peak time for turtles in Adão, Eva, Icaraí, and Jurujuba beaches. At Itaipu beach, the Dunn's test shows that the 12-14 h period did not differ significantly from 14-16 h ($p = 0.1335$) and that 10-12 h did not differ significantly from 8-10 h ($p = 0.0631$) or 12-14 h ($p = 0.0735$). Therefore, the period of 10-16 h was the peak time for turtles in Itaipu.

Araújo (2008) reported the highest occurrence of sea turtles in the afternoon at Arraial do Cabo, Rio de Janeiro. The greatest sea turtle occurrence in the afternoon shift may be explained by the physiology of the food items. Large herbivores have a longer period of activity in the afternoon, and this is related to the higher nutritional value (starch) of algae in this period. Zemke-White *et al.* (2002) corroborated this hypothesis, showing that the content of starch and floridoside, that are main sources of edible energy for herbivorous fishes, gradually increases after the initiation of photosynthesis in the morning and reaches high values in the afternoon. It has been observed that most herbivorous coral-reef fish feed more slowly in the morning than in the afternoon. This may be due to the selectivity in feeding on green algae that are rarely found, which increases energy expenditure on demand, resulting in lower bite rates. This behavior may also explain the more significant number of green turtles feeding in the afternoon. (Khait *et al.* 2013). In Itaipu, we observed no peak time; rather the turtles are always there. The Itaipu beach has been previously reported as a feeding, foraging, development, and residence area for juvenile turtles (Guimarães *et al.* 2009; Nunes 2016). According to Guimarães *et al.* (2009), this environment attracts many green turtle individuals due to good foraging habitats and due to its location in a coastal environment protected by islands and enriched by the presence of a lagoon complex. The study carried out by Nunes (2016) in Itaipu beach reported that the high number of turtles located near the shoreline may be due to the disposal of fish thrown into the water by fishermen during fish cleaning. This activity starts after the arrival of fishermen, which occurs in the late morning, between 10 and 12 hours, coinciding with the beginning of turtle peak observations near the beach. Other studies reported that greater resource availability in certain areas leads to individuals prioritizing these areas for certain activities, such as food and rest (Bjorndal 1980; Mendonça 1983; Ogden 1983; Fuentes *et al.* 2006; Makowski *et al.* 2006; Seminoff & Jones 2006; Mendonça 2009). Previous studies indicate that certain locations have higher sea turtle occurrence due to both presence and abundance of food and physical conditions, such as bathymetry (Mendonça *et al.* 1982; Bjorndal 1997). This may be happening at Itaipu, as there was no significant difference in activity between 10-12 and 12-14 hours, as observed on the other beaches.

In the present study, only green turtles were observed. The results of this study thus encourage the implementation of management plans and actions to raise awareness among the local population and to stimulate sea turtle conservation and protection, as well as preserve their habitat and the bay ecosystem. The creation of extractive reserves (RESEX), as in the case of Itaipu beach, could be one of the solutions. The RESEX use plan was introduced with two rules of use regarding sea turtles. There is an area of exclusion of fishing around a slab of stones that occurs about 50 meters from the beach and there is also removal of nets along the rocky shore to avoid the incidental capture of sea turtles. By understanding peak times for sea turtles in the region, perhaps it would be possible to include a time restriction for fishing in the future. At Icaraí beach, the practice of gillnet fishing is common. With the confirmation of the presence of sea turtles and their peak times at that beach, a mitigation plan with areas and times for fishing exclusion may be proposed.

We identified areas of significant sea turtle occurrence throughout Niterói beaches, Rio de Janeiro, with the highest number of sightings recorded at Icaraí. The time the day was correlated with sea turtle sightings at the beaches of Icaraí, Jurujuba, Adão and Eva. These results provide scientific knowledge for conservation actions and the continuity of these surveys can serve as tools for developing future sea turtle management and protection plans in the region, with the goal of conserving this habitat and the species that make use of it.

Acknowledgements. We thank all the volunteers of the Projeto Aruanã for collaborating with this study by carrying out field observations.

ALMEIDA, A.P, A.J.B. SANTOS, J.C.A. THOM, C. BELINI, C. BAPTISTOTTE, M.Â. MARCOVALDI, A.S. SANTOS & M. LOPEZ. 2011. Avaliação do estado de conservação da tartaruga marinha *Chelonia mydas* (Linnaeus, 1758) no Brasil. *In:* Perez, M.B., R.A. Magris & K.T. Ribeiro (Eds.). Avaliação do estado de Conservação das Tartarugas Marinhas. Biodiversidade Brasileira pp. 12-19.

AMADOR, E.S. 1980. Assoreamento da Baía de Guanabara - taxas de sedimentação. Anais da Academia Brasileira de Ciências 52: 723-742.

AMADOR, E.S. 1997. Baía de Guanabara e ecossistemas periféricos: Homem e Natureza. Rio de Janeiro, Retroarte Gráfica e Editora.

AMADOR, E.S. 2012. Bacia da Baía de Guanabara: características geoambientais e ecossistemas. Rio de Janeiro: Interciência.

ARAÚJO, C.R.S. 2008. Ocorrência de tartarugas marinhas na enseada da Prainha, Arraial do Cabo (RJ) - frequência de padrões de comportamento. Cabo Frio: FERLAGOS / ISE.

BALAZS, G.H. 1980. Synopsis of biological data on the green turtle in the Hawaiian Islands. NOAA Tech Memo NOAA-TM-NMFS-SWFS-7. 148pp.

BJORNDAL, K.A. 1980. Nutrition and grazing behavior of the green turtle *Chelonia mydas*. Marine Biology 56: 147-154.

BJORNDAL, K.A. 1997. Foraging ecology and nutrition of sea turtles. *In:* Lutz P.L. & J.A. Musick (Eds.). The Biology of Sea Turtles. Volume 1. CRC Press: Boca Raton, Florida. pp. 199-231.

BRAGA, A.C., D.A. SILVA, F.T.S. TÂMEGA, A.G. PEDRINI & R.A.D. MUNIZ. 2014. Composição e estrutura da comunidade fitobentônica do infralitoral da praia de Itaipu, Niterói, Brasil: subsídios para monitoramento e conservação. Iheringia Série Botânica 69: 267-276.

BUGONI, L., L. KRAUSE & M.V. PETRY. 2001. Marine debris and human impacts on sea turtles in southern Brazil. Marine Pollution Bulletin 42: 1330-1334.

CAPELLO, M.E. & D.S. BROTTO. 2016. Avaliação da capacidade de suporte dos bancos naturais de sementes do mexilhão *Perna perna*, em Jurujuba, Niterói - Rio de Janeiro. Arquivos de Ciências do Mar, Fortaleza 49: 33-40.

DOMINGO, A., L. BUGONI, L. PROSDOCIMI, P. MILLER, M. LAPORTA, D.S. MONTEIRO, A. ESTRADES & A. ALBAREDA. 2006. The impact generated by fisheries on sea turtles in the Southwestern Atlantic. WWF Progama Marino para Latinoamérica y el Caribe, San José, Costa Rica. 70pp.

EPPERLY, S.P., J. BRAUN, A.J. CHESTER, F.A. CROSS, J.V. MERRINER, P.A. TESTER & J.H CHUCHILL. 1996. Beach strandings as an indicator of at-sea mortality of sea turtles. Bulletin of Marine Science 59: 289-297.

FUENTES, M.M.P.B., I.R. LAWLER & E. GYURIS. 2006. Dietary preferences of juvenile green turtles (*Chelonia mydas*) on a tropical reef flat. Wildlife Research 33: 671-678.

GALLO, B. 2001. Ubatuba - entre a mata e o oceano. Revista do TAMAR 4: 13-14.

GOLDBERG, D.W., D.T. ALMEIDA, F. TOGNIN, G.G. LOPEZ, G.T. PIZETTA, N.O.L. JUNIOR & R. SFORZA. 2015. Hopper dredging impacts on sea turtles on the northern coast of Rio de Janeiro State, Brazil. Marine Turtle Newsletter 147: 17.

Guia de Niterói: Praias de Niterói. 2017. www.guiadeniteroi.com/praias-de-niteroi.

GUIMARÃES, S.M., H.M. GITIRANA & A.W. VIDAL. 2009. Região costeira de Itaipu, Niterói: uma estação de alimentação e desenvolvimento de tartarugas marinhas da espécie *Chelonia mydas* (tartaruga verde) no litoral Estado do Rio de Janeiro. Proceedings of the 2nd Congresso Brasileiro De Biologia Marinha, Búzios, Rio de Janeiro, Búzios.

GUIMARÃES, S.M. 2017. Ecologia populacional de juvenis de tartaruga-Vverde (*Chelonia mydas*, Linnaeus 1758) da área de alimentação da região costeira de Itaipu, Niterói - RJ. Niterói (RJ): Universidade Federal Fluminense.

GURJÃO, L.M., J.E.P. FREITAS & D.S. ARAÚJO. 2005. Observations of marine turtles during seismic surveys off Bahia, northeastern Brazil. Marine Turtle Newsletter 108: 8-9.

GITSCHLAG, R.G. & B.A. HERCZEG. 1994. Sea turtle observations at explosive removals of energy structures. Marine Fisheries Review 56: 1-8.

HIRTH, H.F. 1997. Synopsis of the biological data on green turtle *Chelonia mydas* (Linnaeus 1758). U.S. Fish and Wildlife Service, Washington, D.C. 126pp.

INSTITUTO CHICO MENDES DE CONSERVAÇÃO DA BIODIVERSIDADE. 2018. Livro Vermelho da Fauna Brasileira Ameaçada de Extinção: Volume IV - Répteis. In: Instituto Chico Mendes de Conservação da Biodiversidade. (Org.). Livro Vermelho da Fauna Brasileira Ameaçada de Extinção. Brasília: ICMBio. 4: 22-48.

KHAIT, R., U. OBOLSKI, L. HADANY & A. GENIN. 2013. Food selectivity and diet switch can explain the slow feeding of herbivorous coral-reef fishes during the morning. PLoS ONE 8(12): e82391.

LUTCAVAGE, M.E., P. PLOTKIN, B. WITHERINGTON & P.L. LUTZ. 1997. Human impacts on sea turtle survival. *In*: Lutz P.L., J.A. Musick (Eds.). The Biology of Sea Turtles. CRC Press, Boca Raton, FL. pp. 387-409.

LUTZ, P.L. & J. A. MUSICK. 1996. The Biology of Sea Turtles. Volume 1. CRC Press, Boca Raton, Florida. 432pp.

LUTZ, P.L., J.A. MUSICK & J. & WYNKEN. 2002. The Biology of Sea Turtles. Volume 2. CRC Press, Boca Raton, Florida. 472pp.

MAKOWSKI, C.J.A. & M. SALMON. 2006. Home range and habitat use of juvenile Atlantic turtles (*Chelonia mydas*) on reef habitats in Palm Beach, Florida, Marine Biology 148: 1167-1179.

MAYR, L., D. TENENBAUM, M.C. VILLAC, R. PARANHOS, C. NOGUEIRA, S. BONECKER & A. BONECKER. 1989. Hydrobiological characterization of Guanabara Bay. Coastlines of Brazil: 124-138.

MENDONÇA, M.T. & L.M. EHRHART. 1982. Activity, population size, and structure of immature *Chelonia mydas* and *Caretta caretta* in Mosquito Lagoon, Florida. Copeia 1982: 161-167.

MENDONÇA, M. 1983. Movements and feeding ecology of immature green turtles (*Chelonia mydas*) in a Florida Lagoon. Copeia 1983: 1014-1023.

MENDONÇA, P. 2009. Análise comportamental de juvenis de tartarugas marinhas (*Chelonia mydas* & *Eretmochelys imbricata*) em um ambiente recifal de águas rasas do parque nacional marinho de Fernando de Noronha Pernambuco, Brasil. MSc thesis, Universidade Federal do Rio Grande.

MONTEIRO-NETO, C., R.A. TUBINO, L.E.S. MORAES, J.P.M. NETO, G.V. ESTEVES & W.L. FORTES. 2008. Associações de peixes na região costeira de Itaipu, Niterói, RJ. Iheringia, Séries Zoológicas, Porto Alegre 98: 50-59.

NUNES, L.A. 2016. Ecologia alimentar de juvenis de tartaruga-verde (*Chelonia mydas,* Linnaeus, 1758) da Baía de Guanabara e adjacências MSc. Thesis, Universidade Federal Fluminense.

OGDEN, J.C., L. ROBINSON, K. WHITLOCK, H. DAGANHARDT & R. CEBULA. 1983. Diel foraging patterns in juvenile green turtles (*Chelonia mydas*) in St. Croix United States Virgin Islands.

Journal of Experimental Marine Biology 66: 199-205.

PARENTE, C.L., J.D. LONTRA & M.E. ARAÚJO. 2006. Occurrence of sea turtles during seismic surveys in Northeastern Brazil. Biota Neotropica 1(6): 2006000100004

R DEVELOPMENT CORE TEAM. 2020. R: A language and environment for statistical computing. version 3.4.1. Vienna, Austria. www.R-project.org.

RODRIGUES, M.F. 2012. Ocorrência de tartarugas marinhas na praia das Flechas, Niterói, Rio de Janeiro – Brasil. Niterói, Rio de Janeiro: Faculdades Integradas Maria Thereza.

SALVADOR, M.V.S. & M.A.M. SILVA. 2002. Morphology and sedimentology of Itaipu embayament - Niterói/RJ. Anais da Academia Brasileira de Ciências 74: 127-134.

SANTOS, A.S., A.P. ALMEIDA, A.J.B. SANTOS, B. GALLO, B. GIFFONI, C. BAPTISTOTTE, C.A. COELHO, E.H.S.M. LIMA, G. SALES, G.G. LOPEZ, G. STAHELIN, H. BECKER, J.C. CASTILHOS, J.C.S.A. THOMÉ, J. WANDERLINDE, M.A. MARCOVALDI, M.M. LÓPEZ-MENDILAHARSU, M.T. DAMASCENO, P.C.R. BARATA & R. SFORZA. 2011. Plano de Ação Nacional para a conservação das tartarugas marinhas. *In*: Marcovaldi MA, Santos AS, Sales G, editores. Brasília: Instituto Chico Mendes de Conservação da Biodiversidade, ICMBio. Série Espécies Ameaçadas p. 25.

SANTOS, F.S. & J.H.A. SANTOS & R.A LOPES. 2015. Dragagem no porto de Santos: a ampliação do calado no porto de Santos – Análise Ambiental.

SEMINOFF, J.Á. & T.T. JONES. 2006. Diel movements and activity ranges of green turtles (*Chelonia mydas*) at a temperate foraging area in the Gulf of California, Mexico. Herpetological Conservation Biology 1: 81-86.

SFORZA, R., A.C.J. MARCONDES & G.T. PIZETTA. 2017. Guia de licenciamento tartarugas marinhas - diretrizes para avaliação e mitigação de impactos de empreendimentos costeiros e marinhos. Brasília: ICMBio 130pp.

SOARES, D.L. 2010. Os impactos ambientais no geossistema da Baia de Guanabara. Proceedings of XVI Encontro Nacional Dos Geógrafos, Porto Alegre.

VALENTIN, J., D. TENENBAUM, A. BONECKER, S. BONECKER, C.E. NOGUEIRA & M. VILLAC. 1999. O sistema plânctônico da Baía de Guanabara: síntese do conhecimento. Ecologia dos Ambientes Costeiros do Estado do Rio de Janeiro. Série Oecologia Brasiliensis. PPGEUFRJ, Rio de Janeiro, RJ, Brazil VII: 35-39.

WYNEKEN, J., T.J. BURKE, M. MSOLOMON & D.K. PEDERSEN. 1988. Egg failure in natural and relocated sea turtle nests. Journal of Herpetology 22**:** 88-96.

ZEMKE-WHITE, W.L., J.H. CHOAT & K.D. CLEMENTS. 2002. A re-evaluation of the diurnal feeding hypothesis for marine herbivorous fishes. Marine Biology 141: 571-579.

Juvenile Loggerhead (*Caretta caretta*) Head-started in Cuba Recaptured in Florida

Felix Moncada[1], Gonzalo Nodarse[2], Leonardo Valido[2], Lynne Byrd[3],
Gretchen Lovewell[3], Jess Blackburn[3] & Amber Lea Kincaid[3]
[1]Centro de Investigaciones Pesqueras. 248 No. 0603, e/5ª ave y mar, Santa Fe, Playa, La Habana, Cuba (E-mail: fmoncada@cip.alinet.cu);
[2]Marina Marlin, Cayo Largo, Isla de la Juventud, Cuba (E-mail: gnodarse@gmail.com);
[3]Mote Marine Laboratory and Aquarium, Florida, USA (E-mail: akincaid@mote.org)

Captive breeding of juvenile sea turtles for a specific period of time with the goal of releasing the turtles after they have developed (*i.e.*, are no longer hatchlings) and are better able to escape natural predators is a common conservation technique used for these imperiled species (Mrosovsky 1981). This technique, commonly referred to as head-starting, removes the dangers hatchlings face with the hope that the juvenile sea turtles will grow to adulthood, increasing the overall wild sea turtle population (Burke 2015). A head-started juvenile loggerhead (*Caretta caretta*) was tagged and released on 31 March 2020 at Cayo Largo (Canarreos Archipelago), Cuba. The turtle was observed a few months later in southwest Florida (Fig. 1) and reported to Mote Marine Laboratory's Stranding Investigations Program (SIP) on 12 July 2020. The loggerhead was originally tagged with a Monel tag # CB373 by the Tagging Program (subsequently referred to as the Program) of the Fisheries Research Center (CIP-Cuba). The Program has been tagging sea turtles since 1989 at different nesting and foraging areas around the Cuban Archipelago. The Program also head-starts hatchlings born in hatcheries. CB373 was raised for nineteen months from a hatchling, tagged, and released on Cayo Largo (21.3723 °N, 81.3347 °W) on 31 March 2020.

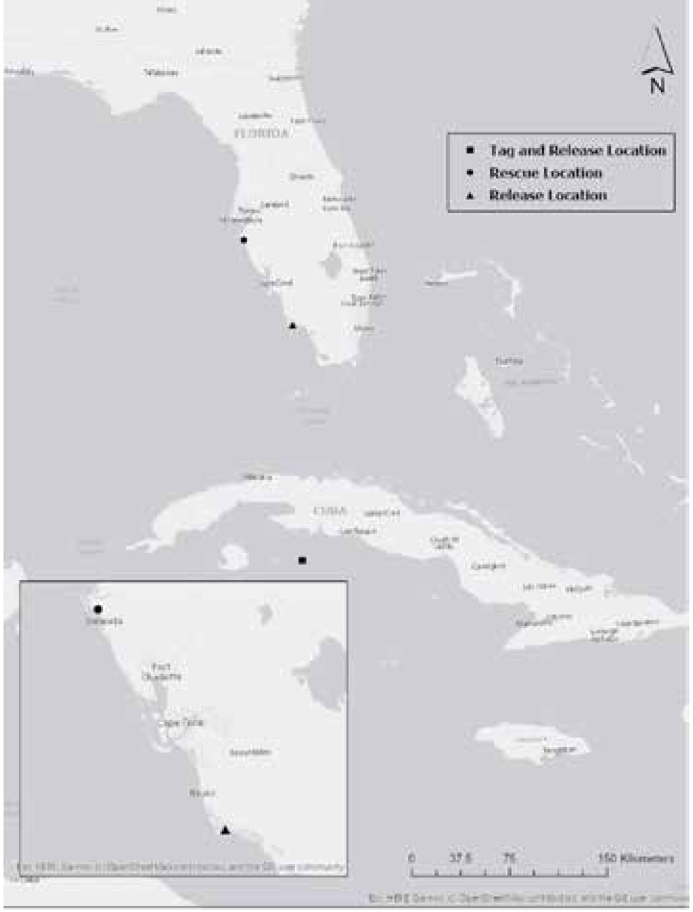

Figure 1. Initial tag and release (Cayo Largo, Cuba), rescue (Sarasota Bay, FL), and release (Ten Thousand Islands, FL) locations.

Cayo Largo is located at the eastern end of the Canarreos Archipelago. It is the most important nesting site for green (*Chelonia mydas*) and loggerhead turtles in the Cuban Archipelago and is one of the main nesting sites in the Caribbean Sea (Medina *et al*. 2009; Nodarse *et al*. 2010). The Marine Turtle Rescue Center head-starts between 50 and 100 green and loggerhead hatchlings (mostly green turtles) per year. Hatchlings are reared under human care and released before they reach two years of age (Fig. 2). The recaptured loggerhead came from a clutch that hatched on 5 July 2018 at Cayo Largo. When released, the loggerhead measured 39.5 cm curved carapace length from notch to tip (CCLnt; Bolten 1999) and weighed 6.8 kg.

A citizen first reported a lethargic sea turtle occupying a residential canal off Sarasota Bay (27.421781 °N, 82.584880 °W) for a week. The nearshore waters of Sarasota are not typical habitat for loggerheads of this age class, which raised significant concern (Witherington 2002; Witherington *et al.* 2012). Upon arrival of the SIP staff at the reported location, the turtle could not be located. Subsequent reports described a possible missing flipper and anecdotal evidence that the turtle had been seen in the area for one month, although whether it was CB373 could not be confirmed. The

Figure 2. Hatchling sea turtles at the Marine Turtle Rescue Center. Cayo Largo.

Figure 3. Intake photos of Mango at Mote Marine Laboratory.

Figure 4. Mango interacting with a rock from its tank.

turtle was re-sighted on 15 July 2020 by SIP staff, who noted that it was not missing any flippers but had a small barnacle load (Fig. 3), which is common in healthy loggerhead sea turtles. The turtle was eating mangos that had fallen from a tree overhanging the canal and the turtle was also approaching vessels. These two behaviors are not typically seen in juvenile sea turtles. The turtle was positively buoyant, especially in the caudal section. Rescue attempts on 15 July 2020 were unsuccessful. Two days later, SIP received a report of a turtle in the same canal system swimming in circles. Recent data published by Narazaki *et al*. (2021) indicated that sea turtles may swim in circles as a navigational aid. The SIP team successfully caught the turtle on 17 July 2020 and transported it back to Mote's Sea Turtle Rehabilitation Hospital for evaluation. A patch of blue paint was on the carapace, suggesting that the turtle had been hit by a boat. The turtle's CCLn-t measured 42.6 cm and its weight was 8.4 kg on arrival at Mote, indicating that it had grown 3.1 cm and gained 1.6 kg in the few months since release from Cuba on 31 March 2020. Based on these growth data, the estimated annual growth rate for this turtle was 10.5 cm/yr in the wild, after growing 35.4 cm under human care. For comparison, Bjorndal *et al.* (2000) reported an average growth rate of 12 cm/yr in the first six months from six loggerhead turtles in the Atlantic, and Casale *et al.* (2009) a growth rate of about 11 cm in the first 1.5 years of life in early juvenile loggerhead sea turtles in the Mediterranean. Bolten *et al.* (1990) reported a much lower growth rate of 5.1 cm /yr (SCL) for a loggerhead released from captivity in Brazil recaptured in Azores.

The turtle (nicknamed Mango), was rehabilitated at Mote for 24 days and was released on 10 August 2020. During the rehabilitation period, Mango was observed carrying rocks in its mouth (Fig. 4). This is a common behavior that has been witnessed previously at Mote as sea turtle patients, across species and age class, explore and interact with their environment. On the day before release (9 August 2020), Mango measured 43.3 cm CCLn-t and weighed 8.6 kg, indicating growth of 0.7 cm and a weight gain of 0.2 kg in the less than a month that it had been at Mote. A passive integrated transponder (PIT) tag was inserted intramuscularly in the left front flipper prior to release. Mango was released in the Ten Thousand Islands (25.88830° N, 81.62937° W), Collier County, Florida. The Florida Fish and Wildlife Conservation Commission (FWC) determines the release site for all rehabilitated sea turtles in the state and chose this site because of its remote nature and cleanliness of the water.

The time interval between the release in Cuba and the capture in Florida was 108 days, which indicated that the turtle traveled between the Cuban Archipelago and Florida in a very short time, moving at an average speed of 9.6 km/day. It is important to note that two other loggerheads from the same age class tagged and released from Cayo Largo, Cuba in 2017 also swam outside of the Cuban shelf but to the south. One was recaptured after 59 days in Colombian waters (Moncada *et al*. 2019). The other had been fitted with a satellite tag by the National Company for the Protection of Flora and Fauna in Cuba and traveled near the Nicaraguan coast. These two loggerheads that were hatched, head-started and released at the same location appear to have migrated in opposite directions with different travel durations in relation to Mango. Sizes and weights of the three suggest that they were not adversely affected by being reared under human care, although two were found to have buoyancy problems. By contrast, the different behavior patterns throw into question whether head-started sea turtles are able to continue their life cycle as wild animals, including their migration patterns and/or survivorship in the wild (Allen 1981; Woody 1991; Mortimer 1995). Although Okuyama *et al.* (2010) found that head-started hawksbill turtles (*Eretmochelys imbricata*), after adjusting to feeding in the wild, had less predictable dispersal directions than wild turtles. It is possible that the dispersal behavior of the two head-started loggerheads from Cayo Largo had been similarly impacted by human care. Mango's arrival in Florida may also have been due to it becoming entrained in the Gulf of Mexico current, taking into account that turtles migrating in oceanic waters of that area may be influenced by eddies of the Loop Current (Foley *et al*. 2013). To date, only loggerheads (post-nesting) tagged in Florida recaptured in Cuba waters were known (Moncada *et al*. 2010). Therefore, Mango constitutes the first recapture of loggerhead from Cuba recaptured in Florida waters.

Similar to other recent reports of turtles tagged in Cuba and recaptured in areas far from nesting and release sites (Moncada *et al*. 2019, 2020), this new recapture indicates the importance of cooperative regional and international efforts for conservation and management of sea turtles in the Wider Caribbean. In addition, this confirms the practical value of tagging sea turtles prior to release as an indispensable complement to other tools, such as genetic analyses and satellite tracking, to enhance our understanding of these species' movements over time.

Acknowledgements. We thank the workers of Marina Marlin (Cayo Largo, Cuba), who have been tagging sea turtles for decades at Cayo Largo through the "Tagging Program" of the Fisheries Research Center. Thank you to Tina Ravior from Turtles of the Caribbean for support and video footage. Thank you to Jill Schmid from Rookery Bay National Estuarine Research Reserve for her assistance in the release at Ten Thousand Islands. Thank you to the Mote Marine Laboratory and Aquarium staff, Dr. Whitney Greene, Jenna Rouse, Weston Spoon, and Courtney Hessell, Mote interns and volunteers, especially Lindsey Reisz for making the GIS map. We also thank Dr. Cathi Campbell and Cynthia Lagueux, from the Archie Carr Center for Sea Turtle Research and Cooperative Marine Turtle Tagging Program, for facilitating communication among the authors. Finally, we thank J.A. Horrocks for the review and suggestions to this manuscript.

ALLEN, K. 1981. Head-starting: The problems of imprinting and tagging. Marine Turtle Newsletter 19: 2.

BJORNDAL, K.A., A.B. BOLTEN & H.R. MARTINS. 2000. Somatic growth of juvenile loggerhead sea turtles *Caretta caretta*: duration of pelagic stage. Marine Ecology Progress Series 202: 265-272.

BOLTEN, A.B., H.R. MARTINS, M.L. NATALI, J.C.THOMÉ & M.A. MARCOVALDI. 1990. Loggerhead released in Brazil recaptured in Azores. Marine Turtle Newsletter 48: 24-25.

BOLTEN, A.B. 1999. Techniques for measuring sea turtles. *In*: K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois & M. Donnelly (Eds.), Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4, pp. 110-114.

BURKE, R.L. 2015. Head-starting turtles: learning from experience. Herpetological Conservation & Biology 10: 299-308.

CASALE, P., P. D'ASTORE & R. ARGANO. 2009. Age at size and growth rates of early juvenile loggerhead sea turtles (*Caretta caretta*) in the Mediterranean based on length frequency analysis. Herpetological Journal 19: 29-33.

FOLEY, A., B. SCHROEDER, R. HARDY, S. MACPHERSON, M. NICHOLAS & M. COYNE. 2013. Postnesting migratory behavior of loggerhead sea turtles *Caretta caretta* from three Florida rookeries. Endangered Species Research 21: 129-142.

MEDINA, Y.F., F. MONCADA & G. NODARSE. 2009. Anidación de la tortuga verde (*Chelonia mydas*) y caracterización de las playas en Cayo Largo, Cuba. Revista Cubana de Investigaciones Pesqueras 26: 66-72.

MONCADA, F., F.A. ABREU, D. BAGLEY, K.A. BJORNDAL, A.B. BOLTEN, J.A. CAMIÑAS, L. EHRHART, A. MUHLIA-MELO, G. NODARSE, B.A. SCHOROEDER, J. ZURITA & L.A. HAWKES. 2010. Movement patterns of loggerhead turtles *Caretta caretta* in Cuban waters inferred from flipper tag recaptures. Endangered Species Research 11: 61-68.

MONCADA F., C. RAMÍREZ-GALLEGO, J. CAMERO, M. GONZALEZ, G. NORDARSE & K.G. BARRIENTOS-MUÑOZ. 2019. A juvenile loggerhead turtle (*Caretta caretta*) tagged in Cuba is recaptured in Colombian waters. Marine Turtle Newsletter 156: 30-32.

MONCADA, F., C. DANIEL, G. NODARSE, O. REVUELTA, C. BARROW, N. BREWSTER, T. CALLENDER & J.A. HORROCKS. 2020. Hawksbill turtle (*Eretmochelys imbricata*) tagged as a juvenile in Cuba observed nesting in Barbados 14 years later. Marine Turtle Newsletter 160: 23-25.

MORTIMER, J.A. 1995. Headstarting as a management tool. Bjorndal, K.A. (Ed.), Biology and Conservation of Sea Turtles. Smithsonian Institutions Press, Washington, DC. pp. 613-615.

MROSOVSKY, N. 1981. Conserving Sea Turtles. British Herpetological Society, London. 176pp.

NARAZAKI, T., I. NAKAMURA, K. AOKI, T. IWATA, K. SHIOMI, P. LUSCHI, H. SUGANUMA, C.G. MEYER, R. MATSUMOTO, C.A. BOST, Y. HANDRICH, M. AMANO, R. OKAMOTO, K. MORI, S. CICCIONE, J. BOURJEA & K. SATO. 2021. Similar circling movements observed across marine megafauna taxa. iScience 24: 102221.

NODARSE, G., F. MONCADA, Y. MEDINA, C. RODRÍGUEZ, F. HERNÁNDEZ, R. BLANCO & E. ESCOBAR. 2010. Comportamiento de la anidación de tortugas marinas en los Cayos San Felipe y Archipiélago de los Canarreos, Cuba (2001-2006). Revista Cubana de Investigaciones Pesqueras 27: 67-71.

OKUYAMA, J., T. SHIMIZU, O. ABE, K. YOSEDA & N. ARAI. 2010. Wild versus head-started hawksbill turtles *Eretmochelys imbricata*: post-release behaviour and feeding adaptations. Endangered Species Research 10: 181-190.

WITHERINGTON, B.E. 2002. Ecology of neonate loggerhead turtles inhabiting lines of downwelling near a Gulf Stream front. Marine Biology 140: 843-853.

WITHERINGTON, B., S. HIRAMA & R. HARDY. 2012. Young sea turtles of the pelagic *Sargassum*-dominated drift community: habitat use, population density, and threats. Marine Ecology 463: 1-22.

WOODY, J. 1991. Guest Editorial: It's time to stop head-starting Kemp's ridleys. Marine Turtle Newsletter 54: 7-8.

Southernmost Record of an Immature Green Turtle *Chelonia mydas* in the Maracaibo Lake System, Venezuela

Ninive Espinoza-Rodriguez[1,2] **& Héctor Barrios-Garrido**[1,2,3]

[1]*Grupo de Trabajo en Tortugas Marinas del Golfo de Venezuela (GTTM-GV), Urb. Villa Venecia, Calle 40B #15A-41, Maracaibo 4001, Venezuela (E-mail: espinozaninive@gmail.com);* [2]*Laboratorio de Ecología General, Centro de Modelado Científico (CMC), Facultad Experimental de Ciencias, La Universidad del Zulia, Apartado 526, Maracaibo 4001, Venezuela (E-mail: hbarriosg@fec.luz.edu.ve)*
[3]*College of Marine and Environmental Sciences, Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER), James Cook University, Townsville, Queensland 4811, Australia (E-mail: hector.barriosgarrido@my.jcu.edu.au)*

The Maracaibo Lake System, which is an extensive coast depression (9-12º N, 70-72º W) in the west of Venezuela (Rodriguez 2001), covers four interconnected aquatic ecosystems: (1) the Gulf of Venezuela, (2) "El Tablazo" Bay, (3) The Maracaibo Strait, and (4) Maracaibo Lake (Rodriguez 2000a, 2001) (Fig. 1). Historically, records of marine turtles were restricted to the Gulf of Venezuela and "El Tablazo" Bay (Viloria & Barros 2000), which have unique environmental conditions and ecosystems such as seagrass beds, coral reef patches, sandy grounds, and rocky shores, that support both marine and estuarine fauna (Espinoza-Rodriguez *et al*. 2015, 2019; Barrios-Garrido *et al*. 2020a). Contrarily, the Maracaibo Strait and Maracaibo Lake are predominantly freshwater ecosystems, where muddy bottoms, coastal lagoons, floodplain and mangrove forests cover most of its coastline (Medina & Barboza 2003, 2006). Both estuarine and freshwater animals are commonly found in the previously mentioned ecosystems (Montiel-Villalobos & Barrios-Garrido 2005; De Turris *et al*. 2010).

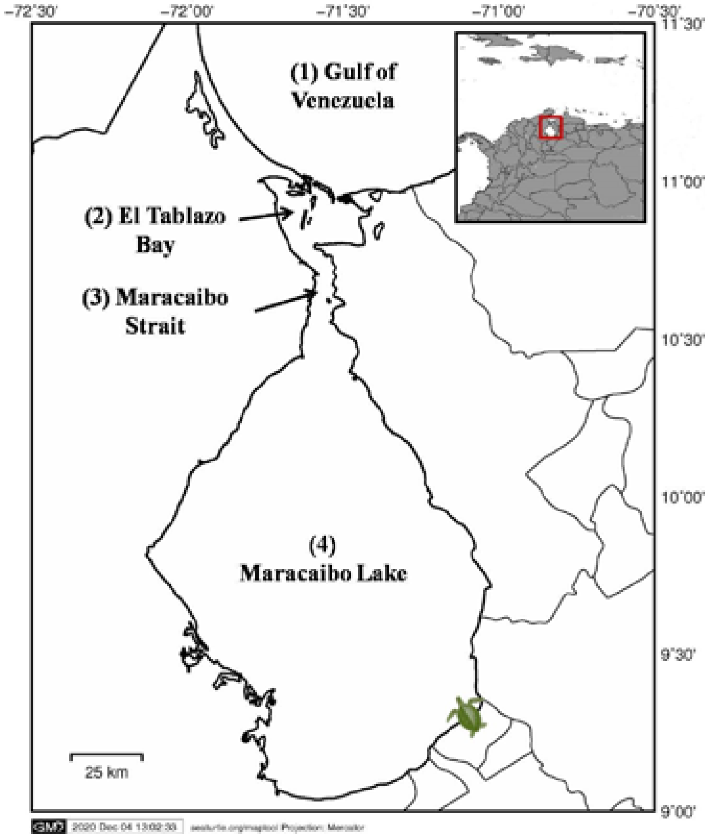

Figure 1. Maracaibo Lake System indicating its four aquatic ecosystems. The marine turtle icon indicates the location where the juvenile green turtle was found and rescued (Source: MapTool - seaturtle.org).

The Gulf of Venezuela is largely influenced by salt water supplied from the Caribbean Sea (Rodriguez 2000a). Previous studies have shown the presence of five marine turtle species in the Gulf of Venezuela, where the green turtle (*Chelonia mydas*) is the most frequently observed with more than 80% of the total observations including direct sightings, incidental by-catch, direct fishing, strandings, among others (Barrios-Garrido *et al*. 2020a; Rojas-Cañizales *et al*. 2020). It is also common to find a wide distribution of sizes (juveniles, sub-adults, to adults) all year-round (Barrios-Garrido *et al*. 2020a,b). Previous authors have indicated through tag reports and genetic studies, that marine turtles from different populations (such as Isla de Aves-Venezuela, Tortuguero-Costa Rica, Panama, Florida, etc.) use the Gulf of Venezuela as a feeding and development area (Barrios-Garrido *et al*. 2020a,b; Rojas-Cañizales *et al*. 2020). This note reports on the southernmost record of an immature green turtle, *Chelonia mydas*, in the Maracaibo Lake System, Venezuela.

Records and reports on marine megafauna in the Maracaibo Lake System have been documented following the Opportunistic Notification Network (RAO, by its Spanish acronym) methodology (Barrios-Garrido *et al*. 2012). In the case of marine turtles, when an individual is captured or is found stranded by community members and documented in the RAO protocol, it is measured for curved carapace length (CCL), curved carapace width (CCW), weighed (kg), and head profiles are photographed when possible. If the turtle is alive, the attending veterinarian has to conduct a preliminary examination, and decide whether the turtle needs rehabilitation or not (Barrios-Garrido *et al*. 2012; Espinoza-Rodriguez & Barrios-Garrido 2012; Conde *et al*. 2019).

On 6 November 2008, an immature green turtle was captured by artisanal fishers in Boscan village (9.301444 °N, -71.083611 °W) (Fig. 1). Biometric measurements of the specimen were made using a flexible measuring tape graduated in millimeters and it was weighed using a portable 110lb/50kg hanging scale. The specimen had a total curved carapace length of 24.9 cm, curved carapace width of 21.5 cm, and weighed 1.7 kg (Fig. 2). The turtle was then transported to a rehabilitation facility and kept under observation for two days, due to its poor body condition and signs of physical fatigue, which might be due to the time it spent in the area before being captured by local fishers (Thomson *et al*. 2009). Once the turtle's physical appearance showed improvement and the veterinarian approved its release, the turtle was released on 8 November 2008.

Figure 2. Immature green turtle (*Chelonia mydas*) recorded on the 8 November 2008, Southern Maracaibo Lake, Venezuela. Photos taken by: N. Espinoza-Rodriguez 2008.

This is the first and only record of a marine turtle inside Maracaibo Lake in our database. We confirmed the identification of the specimen by the number and arrangement of lateral scutes in the carapace, the number of prefrontal scales, and the characteristic color patterns for the species. This event was considered an unusual record and might have occurred due to various causes such as the local currents in the Maracaibo Strait, changes in the salinity concentration while foraging, or some other unexpected situation preventing the individual to return to the marine ecosystem northern Maracaibo Lake System.

These unusual records are important in order to understand green turtle's habitat use of the Maracaibo Lake System (Barrios-Garrido *et al*. 2020a,b). During informal interviews to several local fishers regarding green turtle presence in the area, they affirmed that they know of this species but it is rarely seen, with one or two individuals per year maybe found deceased in their nets, and only during the rainy season (July-November). They also indicated that there is no local consumption of this species. They believe that its presence in the area is a consequence of the navigation channel opened in 1958 (Morillo Diaz & Salas Cohen 2009), which marine fauna use to enter Maracaibo Lake (Febres & Masciangioli 2000; Morillo Diaz & Salas Cohen 2009).

It is known that marine turtles occur in tropical and subtropical saltwater or brackish environments (Meylan & Meylan 2000; Bolten 2003). However, there is little research about marine turtles using freshwater bodies like delta rivers and estuarine lagoons (Carr 1965; Costas Campos *et al*. 2013). The area where the specimen was found is characterized by low salinities (ranging between 1-4 psu), calm waters, average depths not more than 5 m, with muddy substrates (Febres & Masciangioli 2000; Medina & Barboza 2003). In addition, this region is a very important oil reserve, and has caused several environmental disruptions due to daily small oil spills and frequent use by vessels and oil ships (Rodriguez 2000b). These conditions are not considered as healthy settings for the recruitment and development of marine turtles (Carr 1965; Bjorndal & Jackson 2003). This record of an immature green turtle inside the Maracaibo Lake might indicate their tolerance to lower salinity systems, and how this species potentially uses the navigation channel that would allow local migrations to these freshwater and /or estuarine areas (Carr 1965; Costas Campos *et al*. 2013). Nevertheless, we cannot confirm the latter suggestions mainly because it is impossible for us to know the specimen's exact trajectory before the encounter and if it was an active or passive migration toward this southern region. It still remains unclear how and if green turtles use all four water bodies that make up the Maracaibo Lake System.

Acknowledgements. The authors acknowledge the inhabitants of the fishing port in Boscan village in Maracaibo Lake, who contributed to the conservation work in the region. Thanks to the students and professors of the Ecology Laboratory from the Biology Department of the Experimental Faculty of Science at the University of Zulia who collaborated during this event either collecting the specimen or collaborating during its rehabilitation period; as well as every helping hand from the Research Division at the Post-grade Department and the Dean office of this distinguish faculty. We thank editor and reviewers' comments to improve our manuscript. This research was authorized by Venezuela's Environmental Ministry (Ministerio del Poder Popular para el Ambiente) via scientific hunting licenses 0916 and 1224. Figure 1 was prepared using MapTool, via seaturtle.org.

BARRIOS-GARRIDO, H., N. WILDERMANN, N. ESPINOZA, J. PALMAR & L. MORÁN. 2012. New techniques for the rescue of sea turtles and field data assessment to estimate their population status in the Gulf of Venezuela. In: Jones, T.T. & B.P. Wallace (Comps.). Proceedings of the 31st Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech Memo NMFS-SEFSC-631, pp. 81-82.

BARRIOS-GARRIDO, H., P. BECKER, K.A. BJORNDAL, A.B. BOLTEN, C.E. DIEZ, N. ESPINOZA-RODRIGUEZ, M. FASTIGI, J. GRAY, E. HARRISON, K.A. HART, A. MEYLAN, P. MEYLAN, M.G. MONTIEL-VILLALOBOS, F. MORALES, M. NAVA, J. PALMAR, M.J. PETIT-RODRIGUEZ, P. RICHARDSON, K.M. RODRIGUEZ-CLARK, D. ROJAS-CAÑIZALES, M.G. SANDOVAL, R.A. VALVERDE, R. VAN DAM, J.T. WALKER, N. WILDERMANN & M. HAMMAN.

2020a. Sources and movements of marine turtles in the Gulf of Venezuela: Regional and local assessments. Regional Studies in Marine Science 36: 101318.

BARRIOS-GARRIDO, H.A., M.G. MONTIEL-VILLALOBOS, J. PALMAR & K.M. RODRÍGUEZ-CLARK. 2020b. Wayuú capture of green turtles, *Chelonia mydas*, in the Gulf of Venezuela: A major Caribbean artisanal turtle fishery. Ocean & Coastal Management 188: 105123.

BJORNDAL, K.A. & J.B.C. JACKSON. 2003. Roles of sea turtles in marine ecosystems: Reconstructing the past. In: Lutz, P.L., J.A. Musick & J. Wyneken (Eds.). Biology of Sea Turtles Volume 2. CRC Press, Boca Raton, FL. pp. 259-274.

BOLTEN, A.B. 2003. Variation in sea turtle life history patterns: neritic vs. oceanic developmental stages. In: Lutz, P., J.A. Musick & J. Wyneken (Eds.). Biology of Sea Turtles. Volume 2. CRC Press, Boca Raton, FL. pp. 243-258.

CARR, A. 1965. The navigation of the green turtle. Scientific American 212(5): 78-87.

CONDE, B., M.C. ALVARADO, N. ESPINOZA-RODRIGUEZ & H. BARRIOS-GARRIDO. 2019. Primer reporte de coccidiosis en tortugas verdes (*Chelonia mydas*) del Golfo de Venezuela. Caldasia 42: 278-288.

COSTAS CAMPOS, C.E., R. CABRAL DOS SANTOS, A. SILVA ARAUJO & N.N. GUEDES PAES. 2013. First record of an immature green turtle *Chelonia mydas* (Linnaeus, 1758) (Testudines: Cheloniidae) on a fluvial island, Reserva Biológica do Parazinho, Amazonas river, Brazil. CheckList 9: 434–435.

DE TURRIS-MORALES, K., G. DELGADO-ORTEGA, N. ESPINOZA-RODRIGUEZ, M.G. MONTIEL-VILLALOBOS & H. BARRIOS-GARRIDO. 2010. Nota sobre el comportamiento alimenticio del delfin estuarino (*Sotalia guianensis*) en la costa occidental del Lago de Maracaibo. Ecotropicos 23: 114-116.

ESPINOZA-RODRIGUEZ, N. & H. BARRIOS-GARRIDO. 2012. Tag recovery and photographic identification: tools to validate residency and recapture of sea turtles in the Gulf of Venezuela. In: Jones, T.T. & B.P. Wallace (Comps.). Proceedings of the 31st Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech Memo NMFS-SEFSC-631, pp. 245.

ESPINOZA-RODRIGUEZ, N., J. CARRASQUERO, K. DE TURRIS-MORALES, G. DELGADO-ORTEGA & H. BARRIOS-GARRIDO. 2015. Asociaciones entre aves marinas y *Sotalia guianensis* en el sur del Golfo de Venezuela. Caldasia 37: 309-318.

ESPINOZA-RODRÍGUEZ N., K. DE TURRIS-MORALES, T. SHIMADA & H. BARRIOS-GARRIDO. 2019. Guiana dolphin (*Sotalia guianensis*) in the Southern Gulf of Venezuela: Seasonal distribution, group size, and habitat use. Regional Studies in Marine Science 32: 100874.

FEBRES, G. & P. MASCIANGIOLI. 2000. Hidrografía del sistema de Maracaibo. In: Rodríguez G. (Ed). El Sistema de Maracaibo. Caracas, Venezuela: Instituto Venezolano de Investigaciones Científicas (IVIC). pp. 33-59.

MEDINA, E. & F. BARBOZA. 2003. Manglares del sistema del Lago de Maracaibo: caracterización fisiográfica y ecológica. Ecotropicos 16: 75-82.

MEDINA, E. & F. BARBOZA. 2006. Lagunas costeras del Lago de Maracaibo: distribución, estatus, y perspectivas de conservación. Ecotropicos 19: 128-139.

MEYLAN, A. & P. MEYLAN. 2000. Introducción a la evolución, historias de vida y biología de las tortugas marinas. *In*: Eckert, K.L., K.A. Bjorndal, F.A. Abreu-Grobois & M. Donnelly (Eds.). Técnicas de Investigación y Manejo para la Conservación de las Tortugas Marinas. UICN/CSE Grupo Especialista en Tortugas Marinas Publicación No. 4. pp. 3-5.

MONTIEL-VILLALOBOS, M.G. & H. BARRIOS-GARRIDO. 2005. Obsevaciones sobre la distribución y situación actual del manati *Trichechus manatus* (Sirenia: Trichechidae) en el Sistema del Lago de Maracaibo. ANARTIA. Publicaciones Ocasionales del Museo de Biología de la Universidad del Zulia. Facultad Experimental de Ciencias 18: 1-12.

MORILLO DIAZ, G. & G. SALAS COHEN. 2009. La cuenca del lago de Maracaibo como unidad geohistorica. Agenda Social 3: 78-99.

RODRÍGUEZ, G. 2000a. Fisiografía del sistema de Maracaibo. *In*: Rodriguez, G. (Ed.) El Sistema de Maracaibo. Instituto Venezolano de Investigaciones Científicas (IVIC) Caracas, Venezuela. pp. 7-20.

RODRÍGUEZ, G. 2000b. El manejo de los recursos naturales del sistema de Maracaibo. *In*: Rodriguez, G. (Ed.) El Sistema de Maracaibo. Instituto Venezolano de Investigaciones Científicas (IVIC) Caracas, Venezuela. pp. 91-109.

RODRÍGUEZ, G. 2001. El lago de Maracaibo como cuenca anaeróbica natural: Uso de líneas de base históricas en estudios de impacto ambiental. Interciencia 26: 450-456.

ROJAS-CAÑIZALES, D., N. ESPINOZA-RODRIGUEZ, M.J. RODRIGUEZ-PETIT, J. PALMAR, C. MEJIAS-BALSALOBRE, N. WILDERMANN, T. BARROS & H. BARRIOS-GARRIDO. 2020. Marine turtle mortality in a southern Caribbean artisanal fishery: A threat for immature green turtles. Regional Studies in Marine Science 38: 101380.

THOMSON, J.A., D. BURKHOLDER, M.R. HEITHAUS & L.M. DILL. 2009. Validation of a rapid visual-assessment technique for categorizing the body condition of green turtles (*Chelonia mydas*) in the Field. Copeia 2009: 251-255.

VILORIA, A. & T. BARROS. 2000. La fauna estuarina: otros vertebrados. *In*: Rodríguez, G. (Ed.). El Sistema de Maracaibo. Instituto Venezolano de Investigaciones Científicas (IVIC) Caracas-Venezuela. pp. 243-245.

Evaluation of Marine Debris Ingestion in Sea Turtles around Okinawa Island, Japan

Takahide Sasai[1,2,3], Masakatsu Kino[1], Kei Miyamoto[3], Haruna Okabe[3], Konomi Maeda[3], Shingo Fukada[1], Ken Maeda[1], Nozomi Kobayashi[3], Takahiro Kobuchi[1], Masae Makabe[1] & Isao Kawazu[1,3]

[1]Okinawa Churaumi Aquarium, 424 Ishikawa, Motobu, Okinawa 905-0206, Japan (E-mail: s-isa@hotmail.co.jp);
[2]Graduate School of Engineering and Science, University of the Ryukyus, 1, Senbaru, Nishihara-cho, Okinawa 903-0213, Japan;
[3]Okinawa Churashima Research Center, 888 Ishikawa, Motobu, Okinawa 905-0206, Japan

Green turtles (*Chelonia mydas*), loggerhead turtles (*Caretta caretta*), and hawksbill turtles (*Eretmochelys imbricata*) nest on the sandy beaches of Okinawa Island (Kikukawa *et al.* 1999; Komesu *et al.* 2016). These species are recognized as facing extinction in the wild by the International Union for Conservation of Nature (IUCN 2020). Due to several challenges, including loss of suitable nesting habitat (Crain *et al.* 1995) and bycatch in fisheries (Lewison *et al*. 2004), these species continue to decline at many locations. In Okinawa Island, any surveys (*e.g.*, nesting, stranding, bycatch) of sea turtles have been vigorously conducted, including by private volunteers. Therefore, the ecology of populations inhabiting around the Okinawa Island is becoming clear (*e.g.*, Kawazu *et al*. in press). On the other hand, a number of sea turtles have been affected by human life, such as nesting on sandy beaches that are lost sand by construction of coastline (Komesu *et al*. 2016) and being caught any number of times by set net at mating season (Takahashi *et al.* 2016). Therefore, it is necessary to consider a long-term conservation plan for these sea turtles.

Marine debris is a global problem and has been shown to affect many marine animals (Gall & Thompson 2015). Some previous studies on sea turtles have reported that accidental ingestion of marine debris may prevent survival and growth by causing perforations or blockages of the digestive system (Schuyler *et al*. 2012), reducing nutrient absorption (McCauley & Bjorndal 1999), and increasing absorption of harmful substances into the body (Teuten *et al*. 2009). Moreover, it suggests that higher concentrations of plastic items in the gastro-intestinal tract leads to a higher probability of mortality (Wilcox *et al*. 2018). Therefore, it is important to characterize the current levels of marine debris ingested by sea turtles to formulate an effective conservation plan for these species (Hamann *et al*. 2010). The extent of marine debris ingestion in sea turtles has been studied in the main islands and Yaeyama Islands in Japan (Kameda & Ishihara 2009; Fukuoka *et al*. 2016); however, there is a paucity of data from around Okinawa Island. In this study, we dissected the gastrointestinal tracts of stranded, dead sea turtles to determine the extent of marine debris ingestion by sea turtles around Okinawa Island, through analysis of frequency and type of marine debris ingested.

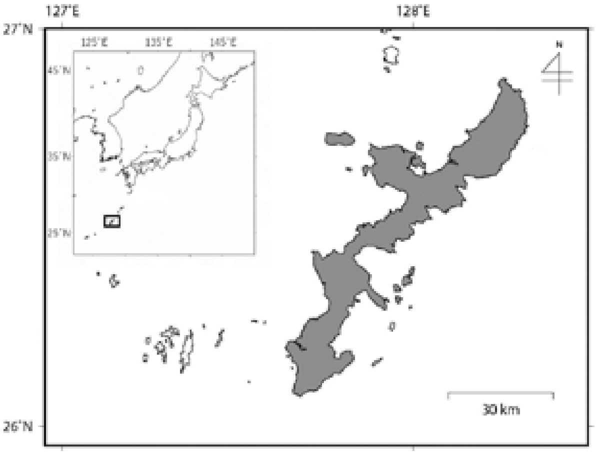

Figure 1. A map of Okinawa Island and small islands in its periphery. We collected samples from the islands shaded gray.

Between October 1990 and July 2019, 383 specimens of green turtles, 63 specimens of hawksbill turtles, and 38 specimens of loggerhead turtles were found on the beaches of Okinawa Island and the small islands at its periphery (Fig. 1). The mean (±SD) for the standard carapace length (SCL) of turtles were measured; the SCL was 572.2 ±180.6 mm (range: 309-1020 mm) for green turtles, 424.1 ±161.8 mm (201-800 mm) for hawksbill turtles and 821.3 ±78.3 mm (655-955 mm) for loggerhead turtles.

The marine debris found in the gut was removed from all specimens, and classified as hard plastic, soft plastic, Styrofoam, fishing line/rope, fishing hook, rubber, or other (Fig. 2), as described by Fukuoka *et al.* (2016). The occurrence rate of ingestion (%) for each category of marine debris in each turtle species were calculated using the following equation, as described by Schuyler *et al.* (2012):

$$\left(\frac{\text{Turtles that ingested a particular type of marine debris}}{\text{Turtles that ingested any marine debris}}\right)*100$$

A total of 17.4% (n = 84) of the examined specimens were found to have ingested marine debris. The percentage of specimens with marine debris in their guts was 14.9% for green turtles, 28.6% for hawksbill turtles, and 23.7% for loggerhead turtles (Table 1). The most common categories of ingested debris were soft plastic (54.4%) and fishing line/ rope (36.8%) for green turtles, hard plastic (44.4%) and soft plastic (33.3%) for hawksbill turtles, and hard plastic (44.4%) and Styrofoam (33.3%) for loggerhead turtles (Table 2).

To the best of our knowledge, the present study is the first to provide viable information on marine debris ingested by sea turtles distributed around Okinawa Island. These findings will aid in formulating conservation programs and improving our understanding about the feeding ecology of sea turtles. In particular, approximately 15% to 30% of green turtles, hawksbill turtles, and loggerhead turtles accidentally ingested marine debris. This rate was assessed to be relatively low when compared with other rates worldwide. For example, the frequency of marine debris ingestion is 60.5% for green turtles in southern Brazil (Bugoni *et al.* 2001), 68.8% for hawksbill turtles in northern Brazil (Macedo *et al.* 2015), and 79.6% for loggerhead turtles in the Western Mediterranean (Tomas *et al.* 2002). Some previous studies have reported high ingestion rates of soft plastic and fishing line/ rope in green turtles

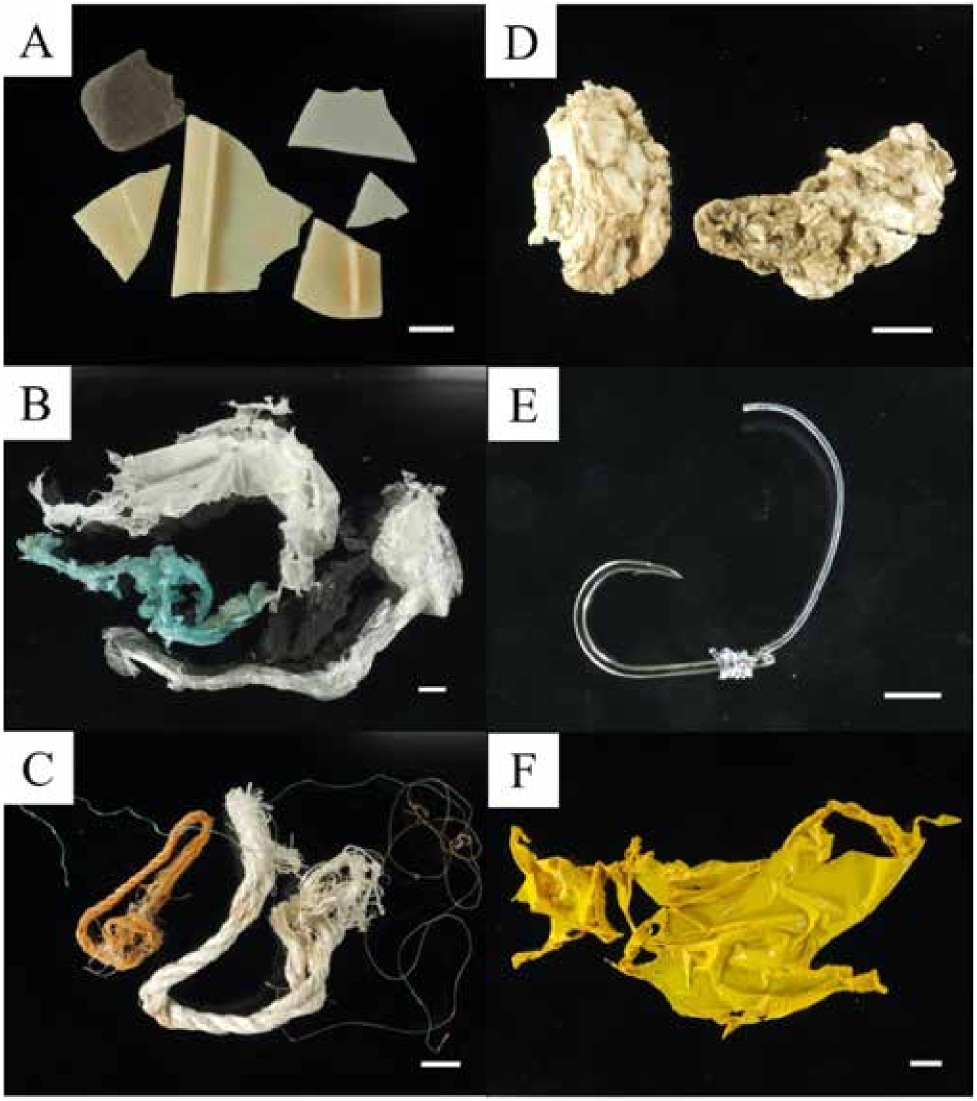

Figure 2. Marine debris ingested by sea turtles; A: Hard plastic, B: Soft plastic, C: Fishing line/rope, D: Styrofoam, E: Fishing hook, F: Rubber. White bars represent 10 mm.

	N	NTD	Occurrence (%)
Chelonia mydas	383	57	14.9
Eretmochelys imbricata	63	18	28.6
Caretta caretta	38	9	23.7
Total	484	84	17.4

Table 1. Occurrence of marine debris ingestion by sea turtles. N is the number of turtles examined, NTD is the number of turtles found with ingested debris, and occurrence is the percentage of individuals that had ingested marine debris.

	N	Hard plastic	Soft plastic	Fishing line/rope	Styrofoam	Fishing hook	Rubber	Others
Chelonia mydas	57	17 (29.8)	31 (54.4)	21 (36.8)	4 (7.0)	5 (8.8)	2 (3.5)	3 (5.3)
Eretmochelys imbricata	18	8 (44.4)	6 (33.3)	6 (33.3)	3 (16.7)	1 (5.6)	1 (5.6)	1 (5.6)
Caretta caretta	9	4 (44.4)	2 (22.2)	2 (22.2)	3 (33.3)	1 (11.1)	1 (11.1)	1 (11.1)
Total	84	30 (35.7)	40 (47.6)	28 (33.3)	10 (11.9)	3 (3.6)	3 (3.6)	9 (10.7)

Table 2. Number (and percentage) of sea turtles that ingested different categories of debris.

(Bugoni *et al*. 2001; Fukuoka *et al*. 2016). A similar trend was observed among the green turtles of Okinawa Island in this study.

In some previous studies on the main islands of Japan, the occurrence of marine debris in green turtles showed high rates; 100% for the Japan Sea (Kameda & Ishihara 2009) and the Iwate coast (Fukuoka *et al*. 2016), and 52.3% for Shikoku and Kii (Kameda & Ishihara 2009). However, the occurrence of marine debris ingested by green turtles in the Yaeyama Islands was extremely low (2.8%) (Kameda & Ishihara 2009). The frequency of marine debris in green turtles in Okinawa Island (14.9%) is closest to that of the Yaeyama Islands. Hence, the frequency of marine debris in green turtles was lower in the southern region, including around Okinawa Island and Yaeyama Islands, and higher in the northern region, including the main islands of Japan. Such differences between regions in Japan could be attributed to differences in feeding ecology, and feeding preferences may also affect the types of debris that turtles encounter (Schuyler *et al.* 2014).

Foraging green turtles are distributed around the Yaeyama Islands in a small area between their feeding grounds and a neighboring rest point (Okuyama *et al.* 2013). Kameda *et al.* (2013) reported that during a foraging period, green turtles were distributed in a narrow area of approximately 16.3 km^2 near the Yaeyama Islands, based on a mark-recapture method. On Okinawa Island, additional studies using the mark-recapture method have recorded some migrations between the east and west coasts of Okinawa Island (Hayashi & Nishizawa 2015; Nakanishi *et al.* 2017). In contrast, green turtles found in the Iwate Coast visit to forage during summer only, when they seasonally migrate a few hundred kilometers (Fukuoka *et al*. 2015). Fukuoka *et al*. (2016) demonstrated that green turtles confuse marine debris with gelatinous prey near the water surface during long-term migrations. Consequently, we suggest that the migration area for foraging has an effect on the encounter and ingestion rates of marine debris within sea turtle populations. These findings support the hypothesis that pelagic and neritic sea turtles exhibit significant differences in their likelihood of ingesting debris (Schuyler *et al*. 2012).

The gut contents of loggerhead turtles in Japanese Pacific temperate waters were recently studied by Fukuoka *et al*. (2016). Fukuoka and colleagues reported that 11 of the 13 loggerhead turtles found off the coast of Iwate of mainland Japan had marine debris. In contrast, 23.7% of the loggerhead turtles from Okinawa Islands had marine debris in their guts. Such variation in the occurrence of marine debris in gut contents might be explained by the difference in sexual maturity and appetite of loggerheads. Adult sea turtles reduce food intake during the reproductive season (Bjorndal 1985). The loggerhead turtles captured in Okinawa waters (nesting area) were mostly mature (Kawazu *et al.* 2013), while those in Iwate (foraging area) were immature (Fukuoka *et al*. 2016). Hence, we suggest that the frequency of marine debris ingestion is driven by appetite, which is related to sexual maturity.

We evaluated the levels of marine debris ingested by sea turtles distributed around Okinawa Island. This rate was assessed to be relatively low compared to certain other regions Japan and around the world. In recent years, ocean contamination by microplastics has become an increasingly global concern (Caron *et al*. 2018), requiring further study to improve our understanding of marine debris impacts on sea turtles.

Acknowledgments. Field sampling was financially supported by the members of the Okinawa Churashima Research Center and the Okinawa Churaumi Aquarium. Special thanks to T. Fukuoka of The University of Tokyo for his great assistance and discussions. And finally, we thank two anonymous reviewers for their detailed comments on the manuscript.

BJORNDAL, K.A. 1985. Nutritional ecology of sea turtles. Copeia 1985: 736-751.

BUGONI, L., L.KRAUSE & M.V. PETRY. 2001. Marine debris and human impacts on sea turtles in Southern Brazil. Marine Pollution Bulletin 42: 1330-1334.

CARON, A.G.M., C.R. THOMAS, K.L. BERRY, C.A. MOTTI, E. ARIEL & J.E. BRODIE. 2018. Ingestion of microplastic debris by green sea turtles (*Chelonia mydas*) in the Great Barrier Reef: validation of a sequential extraction protocol. Marine Pollution Bulletin 127: 743-751.

CRAIN D. A., A.B. BOLTEN & K.A. BJORNDAL. 1995. Effects of beach nourishment on sea turtles: review and research initiatives. Restoration Ecology 3: 95-104.

FUKUOKA, T., T. NARAZAKI & K. SATO. 2015. Summer-restricted migration of green turtles *Chelonia mydas* to a temperate habitat of the northwest Pacific Ocean. Endangered Species Research 28: 1-10.

FUKUOKA, T., M. YAMANE, C. KINOSHITA, T. NARAZAKI, G.J. MARSHALL, K.J. ABERNATHY, N. MIYAZAKI & K. SATO. 2016. The feeding habit of sea turtles influences their reaction to artificial marine debris. Scientific Reports 6: 28015.

GALL, S.C. & R.C. THOMPSON. 2015. The impact of marine debris on marine life. Marine Pollution Bulletin 92: 170-179.

HAMANN, M., M.H. GODFREY, J.A. SEMINOFF, K. ARTHUR, P.C.R. BARATA, K.A. BJORNDAL, A.B. BOLTEN, A.C. BRODERICK, L.M. CAMPBELL, C. CARRERAS, P.

CASALE, M. CHALOUPKA, S.K.F. CHAN, M.S. COYNE, L.B. CROWDER, C.E. DIEZ, P.H. DUTTON, S.P. EPPERLY, N.N. FITZSIMMONS, A. FORMIA, M. GIRONDOT, G.C. HAYS, C. I-JIUNN, J. KASKA, R. LEWISON, J.A. MORTIMER, W.J. NICHOLS, R.D. REINA, K. SHANKER, J.R. SPOTILA, J. TOMAS, B.P. Wallace, T.M. WORK, J. ZBINDEN & B.J. GODLEY. 2010. Global research priorities for sea turtles: informing management and conservation in the 21st century. Endangered Species Research 11: 245-269.

HAYASHI, R. & H. NISHIZAWA. 2015. Body size distribution demonstrates flexible habitat shift of green turtle (*Chelonia mydas*). Global Ecology and Conservation 3: 115-120.

KAMEDA, K. & T. ISHIHARA. 2009. Gut contents analysis of green turtles (*Chelonia mydas*) in Japan. Umigame Newsletter of Japan 81: 1723.

KAMEDA, K., M. WAKATSUKI & N. KAMEZAKI. 2013. Population structure and growth rate of the green turtle *Chelonia mydas*, on feeding grounds at Kuroshima Island, of Yaeyama group, Ryukyu Archipelago. The Biological Magazine Okinawa 51: 93-100.

KAWAZU I., K. KOMESU, M. KAYO, N. INOUE, M. KINO, K. MAEDA, S. FUKADA & T. SASAI. In press. Nesting and reproductive ecology of hawksbill turtles on Okinawajima Island, Japan. The Biological Magazine Okinawa.

KAWAZU, I., K. MAEDA, M. KINO & S. OKA. 2013. Structure of the loggerhead turtle assemblage in Okinawan waters estimated from variation in body size and blood profile. Current Herpetology 32: 190-196.

KIKUKAWA, A., N. KAMEZAKI & H. OTA. 1999. Current status of the sea turtles nesting on Okinawajima and adjacent islands of the central Ryukyus, Japan. Biological Conservation 87: 149-153.

KOMESU, K., M. KOGACHI, M. KAYOU & I. KAWAZU. 2016. Record of a hawksbill turtle with regular reproductive cycle in Ogimi of Okinawa Island, Japan. Umigame Newsletter of Japan 103: 6-10.

LEWISON R.L., L.B. CROWDER, A.J. READ & S.A. FREEMAN. 2004. Understanding impacts of fisheries bycatch on marine megafauna. Trends in Ecology & Evolution 19: 598-604.

MACÊDO, G.R., T.B. TARANTINO, I.S. BARBOSA, T.T. PIRES, G. ROSTAN, D.W. GOLDBERG, L.F.B. PINTO, M.G.A. KORN & C.R. FRANKE. 2015. Trace elements distribution in hawksbill turtle (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) tissues on the northern coast of Bahia, Brazil. Marine Pollution Bulletin 94: 284-289.

MCCAULEY S.J. & K.A. BJORNDAL. 1999. Conservation implications of dietary dilution from debris ingestion: sublethal effects in post-hatchling loggerhead sea turtles. Conservation Biology 13: 925-929.

NAKANISHI, Y., R. MIYAGI, H. TANABE, Y. TAKAHASHI & I. KAWAZU. 2017. Local movement of green turtle (*Chelonia mydas*) within the waters around Okinawajima Island, Japan. Umigame Newsletter of Japan 106: 3-5.

OKUYAMA, J., K. NAKAJIMA, T. NODA, S. KIMURA, H. KAMIHATA, M. KOBAYASHI, N. ARAI, S. KAGAWA, Y. KAWABATA & H. YAMADA. 2013. Ethogram of immature green turtles: behavioral strategies for somatic growth in large marine herbivores. PLoS ONE 8(6): e65783.

SCHUYLER, Q., B.D. HARDESTY, C. WILCOX & K. TOWNSEND. 2012. To eat or not to eat? Debris selectivity by marine turtles. PLoS ONE 7(7): e40884.

SCHUYLER, Q., B.D. HARDESTY, C. WILCOX & K. TOWNSEND. 2014. Global analysis of anthropogenic debris ingestion by sea turtles. Conservation Biology 28: 129-139.

TAKAHASHI, Y., K. FURUZUTSUMI, Y. NAKANISHI, & I. KAWAZU. 2016. Repeated recapture as an indicator of the mating area of loggerhead turtles. Case study in the set-net of western waters of Okinawa Island, Japan. Umigame Newsletter of Japan 103: 10-12.

TEUTEN, E.L., J.M. SAQUING, D.R. KNAPPE, M.A. BARLAZ, S. JONSSON, A. BJORN, S.J. ROWLAND, R.C. THOMPSON, T.S. GALLOWAY, R. YAMASHITA, D. OCHI, Y. WATANUKI, C. MOORE, P.H. VIET, T.S. TANA, M. PRUDENTE, R. BOONYATUMANOND, M.P. ZAKARIA, K. AKKHAVONG, Y. OGATA, H. HIRAI, S. IWASA, K. MIZUKAWA, Y. HAGINO, A. IMAMURA, M. SAHA & H. TAKADA. 2009. Transport and release of chemicals from plastics to the environment and to wildlife. Philosophical Transactions of the Royal Society of London B 364: 2027-2045.

TOMAS, J., R. GUITART, R. MATEO & J.A. RAGA. 2002. Marine debris ingestion in loggerhead sea turtles, *Caretta caretta* from the Western Mediterranean. Marine Pollution Bulletin 44: 211-216.

WILCOX, C., M. PUCKRIDGE, Q.A. SCHUYLER, K. TOWNSEND & B.D. HARDESTY. 2018. A quantitative analysis linking sea turtle mortality and plastic debris ingestion. Scientific reports 8: 1-11.

First Nesting Report for Pacific Green Turtle (*Chelonia mydas*) in Hermosa Beach, Uvita de Osa, Puntarenas, Costa Rica

Oscar Brenes Arias, Felipe Thomas Álvarez & Graciela Pulido Petit

Fundación Reserva Playa Tortuga, Ojochal de Osa, Puntarenas, Costa Rica
(Email: oscarbreari@gmail.com, felipe@felipethomas.com, gracieladcpp@gmail.com)

The green sea turtle (*Chelonia mydas*) is a highly migratory species found in tropical waters across the globe. Their populations are classified as Endangered on the IUCN Red List (IUCN 2020). In the Eastern Pacific, this species is commonly known as the black turtle (*Chelonia mydas agassizii*) because of their phenotypic, geographic, and reproductive differences compared to the green turtle in other parts of the world (Pritchard 1999); but genetic studies demonstrate that both the green and black turtle are members of one species (Karl & Bowen 1999).

Chelonia mydas is distributed along the west coast of the American Continent, in Eastern Pacific waters, from Baja California (Eguchi *et al.* 2010; Macdonald *et al*. 2012) to Chile (Guerra-Correa, 2007; Quiñones *et al.* 2010), including the Revillagigedo Islands (Juarez-Ceron *et al.* 2002) and Galapagos Islands (Green 1984). Major rookeries in Mexico are found in Michoacán (Raygadas-Torres & Delgado-Trejo 2008) and the Islas Revillagigedo Archipelago (Awbrey 1984; Juarez-Ceron *et al.* 2002; Holroyd & Trefry 2010). In the Eastern Pacific, two major rookeries have been described; the Galapagos Islands (Green 1984; Zarate *et al.* 2002) and the Pacific coast of Costa Rica at Cabuyal (Santidrián Tomillo *et al.* 2014), Isla San José beaches (Fonseca *et al*. 2014) and Nombre de Jesús beach. Recently, Fonseca *et al.* (2018) indicated that San José Island is the most important nesting site for Pacific green sea turtles in Central America.

Hermosa Beach is located on the south Pacific coast of Costa Rica, in the canton of Osa, in the northern sector of the Osa Conservation Area (9.182243 °N, 83.76671 °W). The site is located between the Ballena Marine National Park (PNMB) to the south and Puerto Nuevo Beach to the north. Hermosa Beach currently is 5.88 km long (Fig. 1). It is characterized by having moderate to heavy rainfall, with an annual rainy season between 3000-3500 mm, and a dry season from December to March. Average temperatures range from 23-27 °C (Alvarado *et al.* 2005).

Sea turtle nest monitoring efforts began at Hermosa Beach in August 2020. No conservation research related to sea turtles had been undertaken on this beach before this date. Monitoring efforts consisted of walking the beach four days per week, starting at 05:00 h. The entire length of beach, from Punta Achiote in north to the Morete River in the south, was surveyed for nesting activity once per patrol. Morning surveys were led by a variety of individuals, including Reserva Playa Tortuga staff, lifeguards, local volunteers, and PNMB Rangers.

Nesting activity by a single green turtle was documented twice in December 2020. The turtle first laid 77 eggs on 06 December, then 26 days later on 31 December laid 82 eggs 100 m south of the first nest. Eggs from both nests were collected in a clean, disinfected bucket and transferred to the Reserva Playa Tortuga hatchery. During the first encounter, the female was making the body pit (9.191525 °N, 83.777323 °W; see front cover).

The curved carapace length measured notch to notch was 86.6 cm and the curved carapace width measured 84.5 cm. Once the turtle finished the first nesting process, a metal tag was attached

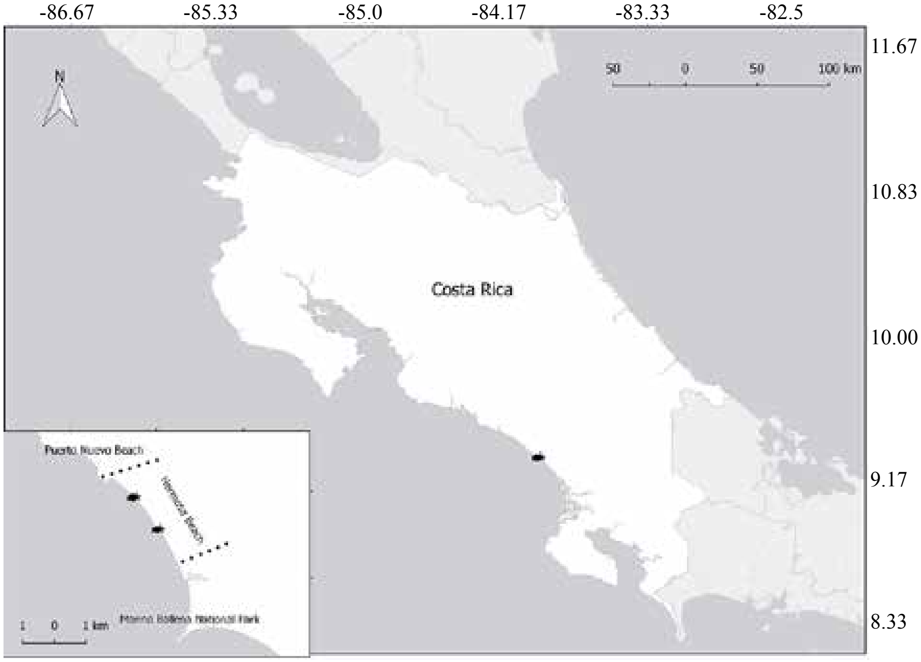

Figure 1. Map of Costa Rica and location of Hermosa Beach, Uvita de Osa. Inset map is of Hermosa Beach showing the location of *Chelonia mydas* nest locations.

Figure 2. Metal tag on the left front flipper of *Chelonia mydas*.

to the trailing edge of each front flipper, with the following codes: TGD0623 (right flipper) and TGD0622 (left flipper; Fig. 2).

Although green sea turtle nesting in Pacific Costa Rica has been documented since the late 1970s (Cornelius 1982), there is still much to learn about the species nesting preferences in the country. Chacón *et al.* (2007) indicated that the nesting period for *C. mydas* in the Pacific coast of Costa Rica lasts from September to March. There have been a few recent publications relating to green turtle nesting in the northwestern province of Guanacaste (Blanco *et al.* 2012b; Santidrián Tomillo *et al.* 2014). Fonseca *et al.* (2018) reported a nesting population of East Pacific green turtles in northwest Costa Rica at San José Island, Murciélago Archipelago. They observed year-round nesting; the lowest nest totals were observed in May and highest nesting occurred from November to February, with a distinct peak in January. On the Osa Peninsula, nesting has been described from July to December. (Govan 1998; Barquero-Edge 2013). Our report of a nesting green turtle at Hermosa Beach coincides with the nesting pattern observed in northwestern Costa Rica, but more efforts are needed to determine the temporal distribution of nesting on Hermosa Beach.

Long term conservation efforts have shown a positive impact in the nesting population trend of the green turtle nesting on the Caribbean coast of Costa Rica (Troëng & Rankin 2004). The continuity of monitoring nesting beaches is key to understanding the use of habitat, the seasonality and periodicity of nesting. Knowing the temporal and spatial distribution of nesting is important for establishing timely management measures and advising monitoring and conservation efforts. Finally, the participation of the community is essential in order to maintain the monitoring program. Without community support, the information needed to manage and conserve green sea turtles would not exist.

ALVARADO, J., J.J. CORTES, C. FERNANDEZ & J. NIVIA. 2005. Comunidades y arrecifes coralinos del Parque Nacional Marino Ballena, costa del Pacífico de Costa Rica. Ciencias Marinas 31: 641-651.

AWBREY, F.T, S. LEATHERWOOD, E.D. MITCHELL & W. ROGERS. 1984. Nesting green sea turtles (*Chelonia mydas*) on Isla Clarión, Islas Revillagigedos, Mexico. Bulletin of the Southern California Academy of Sciences. 83: 69-75.

BARQUERO-EDGE, P.S. 2013. Trends in marine turtle nesting and egg predation on the Osa Peninsula, Costa Rica. Marine Turtle Newsletter 138: 7-10.

BLANCO, G.S, S.J. MORREALE, E. VELEZ, R. PIEDRA, W.M. MONTES, F.V. PALADINO & J.R. SPOTILA. 2012. Reproductive output and ultrasonography of an endangered population of East Pacific green turtles. Journal of Wildlife Management 76: 841-846.

CHACÓN, D., J. SÁNCHEZ, J. CALVO & J. ASH. 2007. Manual para el manejo y la conservación de las trotugas marinas en Costa Rica; con énfasis en la operación de proyectos en playa y viveros. Sistema Nacional de Áreas de Conservación (SINAC), Ministerio de Ambiente y Energía (MINAE). Gobierno de Costa Rica. San José. 103pp.

EGUCHI, T., J.A. SEMINOFF, R.A. LEROUX, P.H. DUTTON & D.L. DUTTON 2010. Abundance and survival rates of green turtles in an urban environment: coexistence of humans and an endangered species. Marine Biology 157: 1869-1877.

FONSECA, L.G., P. SANTIDRIÁN TOMILLO, W.N. VILLACHICA, W.M. QUIRÓS, M. PESQUERO, M. HEIDEMEYER, F. JOYCE, P.T. PLOTKIN, J.A. SEMINOFF, E.R. MATARRITA & R.A. VALVERDE. 2018. Discovery of a major East Pacific green turtle (*Chelonia mydas*) nesting population in Northwest Costa Rica. Chelonian Conservation & Biology 17: 169-176.

FONSECA, L.G, W. QUIRÓS, W.N. VILLACHICA, M. HEIDEMEYER & Y. ARGÜELLO. 2014. Anidación de tortugas marinas en la Isla San José, Área de Conservación Guanacaste, Costa Rica (Temporada 2013-2014). Informe Técnico. Área de Conservación Guanacaste.

GOVAN, H. 1998. Community turtle conservation at Río Oro on the Pacific coast of Costa Rica. Marine Turtle Newsletter 80: 10-11.

GREEN, D. 1984. Long-distance movements of Galapagos green turtles. Journal of Herpetology 18: 121-130.

GUERRA-CORREA, C. 2007. Sea turtles situation is critical in Mejillones del Sur Bay in Northern Chile. In: Letter to Marman Listserve. Antofagasta. 02 August 2007.

HOLROYD, G.L. & H.E. TREFRY. 2010. The importance of Isla Clarion, Archipelago Revillagigedo, Mexico, for green turtle (*Chelonia mydas*) nesting. Chelonian Conservation & Biology 9: 305-309.

JUAREZ-CERON, J.A, A.L. SARTI-MARTINEZ & P.H. DUTTON. 2002. First study of the green/black turtles of the Revillagigedo Archipelago: a unique nesting stock in the Eastern Pacific. In: Seminoff, J.A. (Comp.). Proceedings of the 22nd Annual Symposium on Sea Turtle Biology and Conservation NOAA Tech Memo NMFS-SEFSC 503. p. 70.

KARL, S.A. & B.W. BOWEN. 1999. Evolutionary significant units versus geopolitical taxonomy: molecular systematics of an endangered sea turtle (Genus *Chelonia*). Conservation Biology 13: 990-999.

MACDONALD, B.D., R.L. LEWISON, S.V. MADRAK, J.A. SEMINOFF & T. EGUCHI. 2012. Home ranges of East Pacific green turtles *Chelonia mydas* in a highly urbanized temperate foraging ground. Marine Ecology Progress Series 461: 211-22.

PRITCHARD, P.C.H. 1999. Status of the black turtle. Conservation Biology 13: 1000-1003.

QUIÑONES, J., V. GONZALEZ CARMAN, J. ZEBALLOS, S. PURCA & M. HERMES. 2010. Effects of El Niño-driven environmental variability on black turtle migration to Peruvian foraging grounds. Hydrobiologia 345: 69-79.

RAYGADAS-TORRES, B.S. & C. DELGADO-TREJO. 2008. Estado de conservación de la población de tortuga negra (*Chelonia agassizii*) en Michoacán. MSc Thesis. Universidad Michoacána de San Nicolas de Hidalgo. Mexico.

SANTIDRIÁN TOMILLO, P., S.A. ROBERTS, R. HERNÁNDEZ, J.R. SPOTILA & F.V. PALADINO. 2014. Nesting ecology of East Pacific green turtles at Playa Cabuyal, Gulf of Papagayo, Costa Rica. Marine Ecology 36: 506-516.

TROËNG, S, & E. RANKIN. 2005. Long-term conservation efforts contribute to positive green turtle *Chelonia mydas* nesting trend at Tortuguero, Costa Rica. Biological Conservation 121: 111-116.

ZARATE, P, A. FERNIE & P. DUTTON. 2002. First results of the East Pacific green turtle, *Chelonia mydas*, nesting population assessment in the Galapagos Islands. In: Seminoff, J.A. (Comp.). Proceedings of the 22nd Annual Symposium on Sea Turtle Biology and Conservation NOAA Tech Memo NMFS-SEFSC 503. pp. 70-73.

Establishment of Mersin University Sea Turtle Application and Research Center (Me.U.DEKUYAM) in Mersin, Turkey

Serap Ergene[1,2], Yasemin Kaçar[1,2], Aşkın Hasan Uçar[1,2],
Cemil Aymak[3], Mahmut Ergene[1,2] & Oğuzhan Demir[1]
[1]Mersin University Sea Turtles Application and Research Center (Me.U.DEKUYAM), Çitlikköy Campus, Mersin, Turkey
(E-mail: serapergene@gmail.com, ykacar@gmail.com, askinhasanucar@gmail.com, mahmutergene@hotmail.com,
ouzhandemir@gmail.com); [2]Mediterranean Turtles and Nature Conservation Association (AKKAP), Mersin, Turkey;
[3]Bulancak Science High School, Bulancak, Giresun, Turkey (E-mail: cemil.aymak@gmail.com)

Mersin University, located on the eastern Mediterranean coast of Turkey, first began its sea turtle research projects when two members of the Department of Biology, with support from the RAC/SPA (Regional Activity Center/Special Protected Areas), established the green turtle nesting monitoring programme during the 2001 nesting season in Kazanlı beach, Mersin (Aureggi 2001). In later years, subsequent studies on marine turtles were conducted at other beaches, inlcuding Kazanlı, Davultepe 100. Yıl, Alata, Göksu Delta and Anamur beaches around Mersin. In 2009, a proposal was made to bring all sea turtle research activities the region of Mersin under a single corporate roof, called the Mersin University Sea Turtle Application and Research Center (Me. Ü. DEKUYAM). On 26 May 2009, the Higher Educational Council of Turkey officially recognized the application and the research center, and its constitution was published in the Official Gazette of Turkey (numbered: 27239).

The principal objectives of Me. Ü. DEKUYAM include (a) research, (b) conservation, (c) education (especially environmental awareness), and (d) supporting of rehabilitation efforts of marine turtles. In 2015, a complementary group named Mediterranean Turtles and Nature Conservation Association (Akdeniz Kaplumbağaları ve Doğa Koruma Derneği - AKKAP) was established in Mersin. Currently, Me. Ü. DEKUYAM and AKKAP work together. There are other centers working on sea turtles in Turkey, including at Mustafa Kemal University (in Hatay), Pamukkale University (in Denizli) and Çanakkale Onsekiz Mart University (in Çanakkale). Additional, there is Mersin Sea Turtle Rescue, Rehabilitation and Information Center which is supported by the Republic of Turkey Ministry of Agriculture and Forestry.

Along the Mediterranean coast of Turkey, important nesting grounds for both *Caretta caretta* (loggerhead turtle) and *Chelonia mydas* (green turtle) sea turtles have been identified by various studies conducted on the beaches (Türkozan & Kaska 2010) (Fig.1). In the Mersin region, the important nesting beaches include Alata (Aymak 2004; Aymak *et al.* 2005; Ergene *et al.* 2006a, 2009; Türkozan & Kaska 2010), and Davultepe 100. Yıl (Ergene *et al.* 2010; Ergene *et al.* 2016a). The beaches of Mersin are important sites because both green and loggerhead turtle regularly nest here (Fig.1).

One of our priority actions is to survey marine turtle nesting activity along the Mersin coasts. Since 2002, our research team in Mersin University has conducted studies on green turtle, loggerhead turtle and Nile soft-shelled turtle (*Trionyx triunguis*) on several beaches around Mersin, except for 2006, when survey data were collected only in Demre (Kale) beach, Antalya (Ergene 2006c; Ergene *et al.* 2007a).

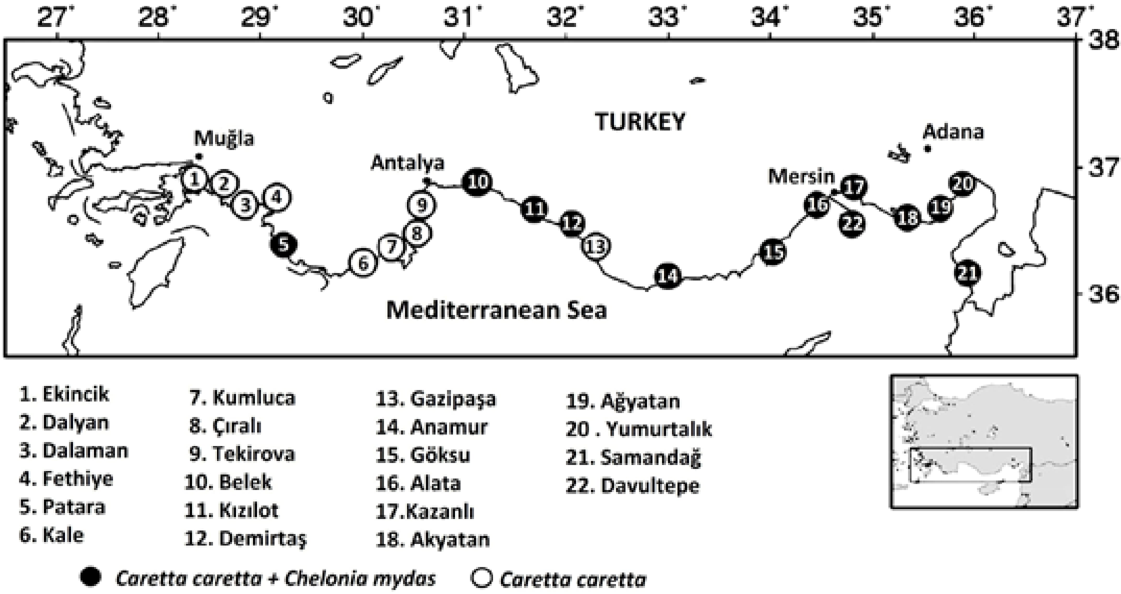

Figure 1. The important nesting beaches for marine turtles in Turkey (modified from Türkozan & Kaska 2010).

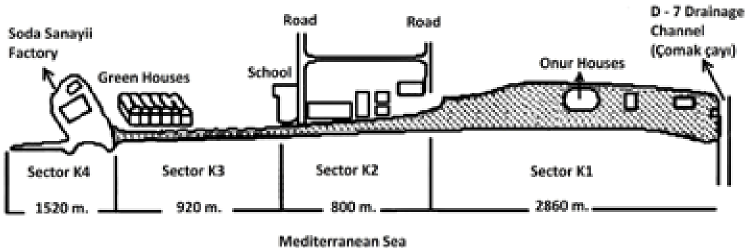

Figure 2. A sketch map of Kazanlı Beach with its sectors and the back structure (modified from Elmaz & Kalay 2006; not to scale).

Beaches regularly surveyed for nesting activities

Kazanlı beach: This 6.1 km long beach is an important site for green turtle nests in Turkey (Fig. 1). Additionally, loggerhead turtles regularly nest in small numbers here, and this beach is designated as a Natural SIT (protected) area (Türkozan & Kaska 2010). This beach is in the southern Mediterranean coast of Turkey, approximately 12 km from the center of Mersin. D-7 Drainage channel (Çomak) (36.8044 °N, 34.7882 °E) is located at the most eastern part of Kazanlı beach and Soda Sanayii A.Ş. and Kromsan Factory (36.8113 °N, 34.7238 °E) at the western end of the beach (Fig. 2). The most suitable part of the beach for sea turtle nesting is the eastern 4.7 km portion (Uçar *et al.* 2020; Aymak *et al.* 2020). We started monitoring and conservation studies on sea turtles in 2006 during the nesting season (Ergene *et al.* 2006b, 2013). Then, between 2009 and 2016, our studies continued for eight nesting seasons without interruption (Şengezer 2012; Ergene *et al.* 2012b, 2015, 2016b; Uçar *et al.* 2018a). Additional studies include: the age distributions of dead stranded loggerhead turtles collected from Kazanlı beach, determined by skeletochronology (Yaşar 2010); the haematological, biochemical and genotoxic properties of loggerhead and green turtles (Kaya 2011); and invertebrate infestation on green turtle nests on this beach (Aymak *et al.* 2020).

Davultepe 100. Yıl beach: This beach, 2.8 km in length, is another important nesting area for green turtles in Turkey, and also has a small number of loggerhead turtle nests laid annually (Ergene *et al.* 2010, 2012a, 2016a,b; Ergene 2014) (Fig. 3). Davultepe is located between Kandak Stream (36.7241 °N, 34.5056 °E) in the northeast and Onur Resort (36.7089 °N, 34.4735 °E) in the southwest of Mersin, and includes Davultepe public beach, the picnic area and Gümüşkum (100. Yıl) Natural Park (Ergene *et al.* 2016a, Fig. 3). The Gümüşkum Natural Park, designated on 7 November 2011, is 1.8 km long and located between Kandak Stream in the northeast and Kuğu Resort (36.7168 °N, 34.4882 °E) in the southwest (Fig. 3). The Park is administered by Mersin Sea Turtle Rescue, Rehabilitation and Information Center and the Republic of Turkey Ministry of Forestry and Water Affairs, 7th Regional Directorate, Section of Mersin (Ergene *et al.* 2016a). Initial surveys began in 2006, when 23 nests were documented on this beach (Ergene 2006). Subsequently, seasonal surveys on green and loggerhead turtle nestss have been conducted since 2009 without interruption (Ergene *et al*. 2010; 2012a,b; 2016a,b; Ergene 2014). As a result of the our monitoring studies, the Sea Turtles Science Commission in Turkey declared this beach as a sea turtle nesting area in 2019.

Alata beach: This beach is another important nesting site for green turtles, and also has a small number of loggerhead turtle nests laid annually (Fig. 1). This beach is 30 km from the center of Mersin and is located within the borders of Alata Horticultural Research Institute, which is a 1st degree natural site. It extends over 3 km from the marine resorts in the east of the Research Institute (36.6322 °N, 34.3531 °E) to the Topraksu camping site, which belongs to the Research Institute (36.6145 °N, 34.3285 °E), at the western end of the beach (Aymak *et al.* 2017; Fig. 4). Alata nesting beach was first surveyed in 2002, and was subsequently registered as an official sea turtle nesting beach of Turkey in 2005. Monitoring and conservation studies on green and loggerhead sea turtles have conducted since 2002 by our research team (Aymak 2004; Aymak *et al.* 2005; Ergene *et al.* 2006a,b, 2009, 2012b, 2016b). Other research projects based on this study beach include: genetic polymorphism of green turtle hatchlings using mtDNA-RFLP analysis (Hançer 2010); microsatelite locus analysis omn green turtles (Kaçar 2011); age distributions of dead stranded loggerhead turtle individuals using skeletochronology (Yaşar 2010); haematological, biochemical and genotoxic properties of loggerhead and green turtles (Kaya 2011); carapacial scute variation of green and loggerhead turtle hatchlings (Ergene *et al.* 2011); and invertebrate infestation in green and loggerhead turtles nests (Aymak *et al.* 2017).

Göksu Delta beach: The Göksu Delta, nearly 35 km in length, is an important nesting area for loggerhead turtles in Turkey (Fig. 1) and the beach is designated as Special Environmental Protection Area (Durmuş *et al.* 2011). This area is recognized as a 'Reproduction and Conservation Zone for Water Birds' as well as included in RAMSAR and 1st degree Natural Site (Durmuş *et al.* 2011). The Göksu Delta (36.2647 °N, 33.9766 °E) is located at 80 km west of Mersin (Durmuş *et al.* 2011) (Fig. 5). The Turkish Authority for the Specially Protected Areas coordinates regular monitoring of the Göksu Delta for nesting activities of sea turtles by providing financial support for researchers from different Turkish universities. We participated in field studies on sea turtle nests during 2004 nesting season. Subsequently, nesting activity of loggerhead

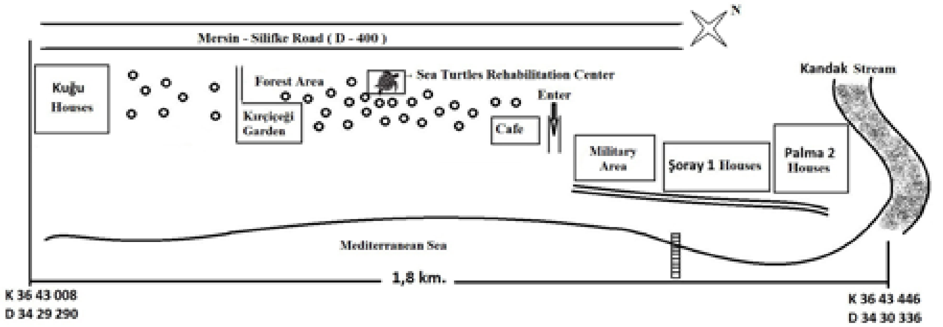

Figure 3. A sketch map of Gümüşkum Natural Park of Davultepe 100. Yıl Beach with its sectors and the back structure (not to scale, modified from Ergene et al. 2010).

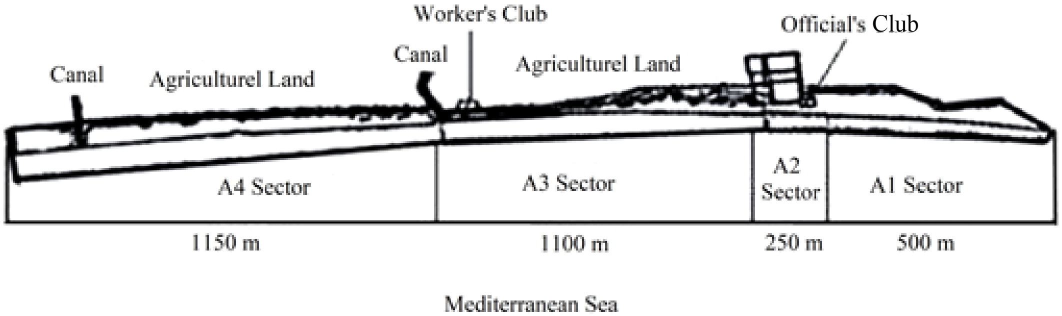

Figure 4. A sketch map of Alata beach with its sectors and the back structure (Aymak *et al.* 2017; not to scale).

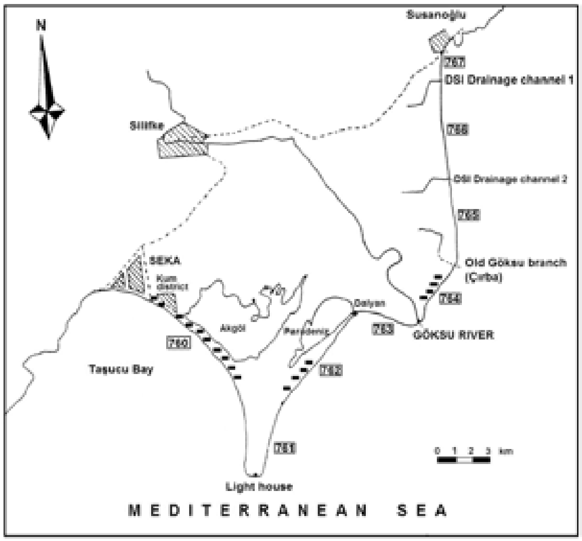

Figure 5. A sketch map of Göksu Delta with its subsections of dense nesting sites (from Durmuş *et al.* 2011).

turtles has been observed in cooperation with Dokuz Eylül and Mersin Universities in this beach.

<u>Anamur beach</u>: Anamur Beach, 12.7 km long, is located in the south of Anamur, Mersin, Turkey and is an important nesting area for loggerhead turtles. The historic town of Ören (Anamurium) (36.0200 °N, 32.8036 °E) is located at the most western part of the beach and Pullu Forest Camp (36.0877 °N, 32.9145 °E) at the eastern end of the beach. The beach is divided into 5 sectors from southeast to northeast by Sultansuyu (Sultançayı, rivulet), İskele (the wharf), Dragonçayı (Kocaçay, rivulet) and Mamure Castle (Uçar 2009; Fig. 6). During the 2006 and 2007 nesting seasons, the populations of loggerhead turtle, green turtle and Nile soft-shelled turtle, which all nest on Anamur beach, were investigated (Uçar 2009). In addition, estimates of loggerhead hatchling sex ratios were generated, based on gonad histology of dead hatchlings and late stage embryos collected from this beach (Uçar *et al.* 2012).

<u>Demre (Kale) beach</u>: This beach, located between Beymelek lagoon and Kale town in Antalya province, is almost 8.5 km in length and consists of five subsections: Çayağzı (36.2300 °N, 29.9398 °E), Sülüklü, Taşdibi, Beymelek-Sıfat beach and Beymelek-Dalyan beach (36.2593 °N, 30.0697 °E) (Ergene *et al.* 2007a; Fig. 7). The nesting activity of loggerhead turtles on this beach was investigated only during 2006 by our group (Ergene 2006c; Ergene *et al.* 2007a).

To successfully monitor the Mersin beaches for sea turtle nesting activities, Me.U.DEKUYAM accepts volunteers from different departments of our university and all other universities. Additionally, the center conducts public awareness campaigns in Mersin. Towards this end, our center participates in various public events, including science festivals, nature education and science support programs at public schools, various activities with different associations such as the annual Caretta bicycle festival, beach cleaning campaigns, etc. Furthermore, our center participated in "Social Responsibility Activities" program of the Introduction to University Life (ÜYG) course, which targeted students from different departments who were newly enrolled in the university, in order to inform both them about studies on research, conservation, education on sea turtles and nesting beaches. The center hopes to raise awareness of sea turtle conservation needs in fishermen, and perhaps recruit them in protection and data collection activities. In terms of postgraduate education at Mersin University Institute of Science that focused on sea turtles, four M.Sc. theses (Aymak 2004; Yaşar 2010; Kaya 2011; Şengezer 2012) and one Ph.D. dissertation (Uçar 2009) were completed under the supervision of Prof. Dr. S. Ergene and two M.Sc. theses (Hançer 2010; Ergene 2014) were completed under the supervision of Prof. Dr. Y. Kaçar and Prof. Dr. B. Cicik, respectively.

In addition to our efforts in research, conservation, education on sea turtles in Mersin, we also participate in rehabilitation efforts. We started in 2007 when we received an injured loggerhead turtle with large-scale fractures and fragment loss on its skull. We engaged specialists from Mersin University, including a veterinarian, a doctor from the Department of Orthopedics and Traumatology, a doctor from the Department of Neurosurgery, and three biologists from Department of Biology to treat and care for this turtle. Despite our best efforts, it was unable to recover from its injuries and died after 41 days (Ergene *et al.* 2007b; Fig. 8).

Later, in 2010, the Mersin Sea Turtles Rescue, Rehabilitation and Information Center was established in Gümüşkum Natural Park of Davultepe Beach, with initial support from the Republic of Turkey Ministry of Environment and Forestry, Section of Mersin and subsequently from the Republic of Turkey Ministry of Agriculture and Forestry. This rehabilitation center and Me. Ü. DEKUYAM work in collaboration. When injured sea turtles are found on the beach during regular field observations in the nesting seasons, initial interventions are performed at the beach, then the injured turtles are taken to the rehabilitaiton center in Davultepe 100. Yıl beach for further medical treatment and rehabilitation.

Overall, Me. Ü. DEKUYAM greatly benefits from being located close to nesting beaches in Mersin and coordinates

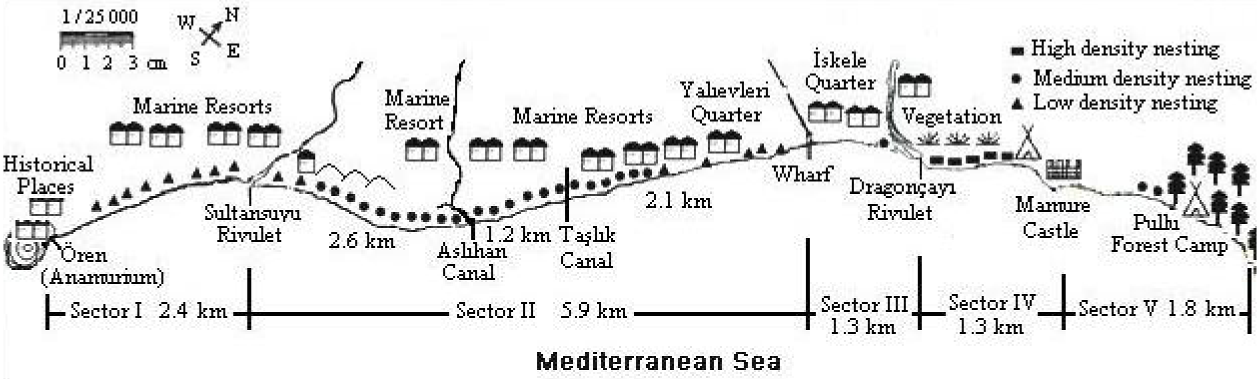

Figure 6. A sketch map of Anamur Beach showing the sub-sectors, beachstructures, and nest density (from Uçar *et al.* 2012; not to scale).

Figure 7. A satellite imagine of Demre (Kale) beach showing the sub-sectors: 1. Demre Çayağzı Beach, 2. Demre Sülüklü Beach, 3. Demre Taşdibi Beach, 4. Beymelek-Sıfat Beach, 5. Beymelek-Dalyan Beach (modified from Google Earth Pro, 29 October 2020).

Figure 8. The operation from the head trauma of loggerhead sea turtle in veterinary clinic.

regular monitoring of beaches in Mersin for nesting activities, engaging volunteers from Turkey and all around the world. Me. Ü. DEKUYAM has also engaged in collaborative research (Güçlü *et al.* 2009; Türkozan *et al.* 2013, 2018; Uçar *et al.* 2018b), and is interested in pursuing more collaborative projects with both national and international researchers. Organizations interested in receiving information about Me. Ü. DEKUYAM and AKKAP may follow us on the our social media addresses below:

Me. Ü. DEKUYAM:

www.mersin.edu.tr/akademik/deniz-kaplumbagalari-uygulama-ve-arastirma-merkezi
www.instagram.com/dekuyam/

AKKAP:

www.facebook.com/groups/998103066896385

Acknowledgements. During different sea turtle nesting seasons, our studies were supported by the Mersin University Scientific Research Fund, Şişecam Group and the Republic of Turkey Ministry of Agriculture and Forestry, Directorate General for Nature Conservation and National Parks. Additionally, since 2002 the wire cages and warning plates for the protection of sea turtle nests on all beaches were provided by the Ministry. In Alata beach, the support of personal accommodation was provided by the Republic of Turkey Ministry of Agriculture and Forestry, Directorate of Alata Horticultural Research Institute since 2002. In addition, we thank everyone who has helped to realize the projects and the local community of Mersin and non-governmental organizations, for their voluntary works.

AUREGGI, M. 2001. Green turtle monitoring programme Kazanli beach, Turkey. UNEP, Mediterranean Action Plan, Regional Activity Centre for Specially Protected Areas-Boulevard de l'Environnement, BP 337-1080 Cedex-Tunisia.

AYMAK, C. 2004. Alata sahillerindeki deniz kaplumbağaları (*Caretta caretta* ve *Chelonina mydas*)'nın biyolojik özellikleri . M.Sc. Thesis, Mersin University, Mersin, Turkey. 87pp.

AYMAK, C., S. ERGENE GÖZÜKARA & Y. KASKA. 2005. Reproductive ecology of *Caretta caretta* and *Chelonia mydas* during 2002 and 2003 nesting seasons in Alata, Mersin, Turkey. In: Demetropoulos, A. & O. Türkozan (Eds.). Proceeding of the Second Mediterranean Conference on Marine Turtles. pp. 44.

AYMAK, C., S. ERGENE, Y. KATILMIŞ & A.H. UÇAR. 2017. Invertebrate infestation in green turtle (*Chelonia mydas* (Linnaeus, 1758)) and loggerhead turtle (*Caretta caretta* (Linnaeus, 1758)) nests on Alata Beach, Mersin, Turkey. Turkish Journal of Zoology 41: 753-761.

AYMAK, C., A.H. UÇAR, Y. KATILMIŞ, E. BAŞKALE & S. ERGENE. 2020. The effect of invertebrate infestation on green turtle (*Chelonia mydas*) nests on Kazanlı beach, Mersin, Turkey. Russian Journal of Herpetology 27: 245-256.

DURMUŞ, S.H., Ç. ILGAZ, A. ÖZDEMİR & S.V. YERLİ. 2011. Nesting activity of loggerhead turtles (*Caretta caretta*) at Göksu Delta, Turkey during 2004 and 2008 nesting seasons. Ecologia Balcanica 3: 95-106.

ELMAZ, Ç. & M. KALAY. 2006. *Chelonia mydas* (L. 1758) ve *Caretta caretta* (L. 1758)'nın Kazanlı kumsalındaki üreme başarısı. Ekoloji 58: 28-32.

ERGENE, S. 2006a. Davultepe (100. Yıl) sahil kenarında yapılması istenen yürüyüş yolu ile ilgili görüş. Unpublished report.

ERGENE, S. 2006b. Antalya İli, Kale-Demre kumsalı deniz kaplumbağası (*Caretta caretta*, *Chelonia mydas*) ve yumuşak Kabuklu Nil kaplumbağası (*Trionyx triunguis*) populasyonlarının araştırılması, izlenmesi ve korunması faaliyeti hizmet alım işi. Final Report to Ministry of Environment and Forestry. 53pp.

ERGENE, M. 2014. Mersin, Davultepe yuvalama kumsalındaki deniz kaplumbağaları [*Chelonia mydas* (Linnaeus, 1758) *Caretta caretta* (Linnaeus, 1758)] populasyonlarının biyolojik özelliklerinin incelenmesi. M.Sc. thesis. Mersin University, Turkey. 107pp.

ERGENE, S., C. AYMAK & Y. KASKA. 2006a. Alata kumsalı (Mersin)'nda deniz kaplumbağa (*Caretta caretta* ve *Chelonia mydas*) populasyonlarının incelenmesi. Birinci Ulusal Deniz Kaplumbağaları Sempozyumu. İstanbul, WWF-Turkiye. 4-5 December 2003. pp. 82-90.

ERGENE, S., C. AYMAK & A.H. UÇAR. 2006b. Mersin İli Alata, Kazanlı ve Anamur kumsalı deniz laplumbağası (*Caretta caretta*, *Chelonia mydas*) ve yumuşak kabuklu Nil kaplumbağası (*Trionyx triunguis*) populasyonlarının araştırılması, izlenmesi ve korunması faaliyeti hizmet alım işi. Final Report to Ministry of Environment and Forestry. 113pp.

ERGENE, S., A.H. UÇAR & C. AYMAK. 2007a. Demre (Kale) kumsalı'nda yuva yapan *Caretta caretta* populasyonunun araştırılması. E.U. Journal of Fisheries & Aquatic Sciences 24: 239-246.

ERGENE, S., C. AYMAK, A.H. UÇAR, C. FIRAT, V. ÖZTUNA, Y. KAÇAR & C. BAĞDATOĞLU. 2007b. Kafa travması bulunan ergin *Caretta caretta* ile ilgili vaka takdimi. II. Ulusal Deniz Kaplumbağaları Sempozyumu Bildiriler Kitabı. Dalyan, Muğla, Türkiye. 25-27 October 2007. p.158.

ERGENE, S., C. AYMAK, A.H. UÇAR & Y. KAÇAR. 2009. 2005 Üreme aezonunda Alata kumsalı'na (Mersin) yuva yapan *Chelonia mydas* ve *Caretta caretta* populasyonlarının araştırılması. E.U. Journal of Fisheries & Aquatic Sciences 26: 187-196.

ERGENE, S., C. AYMAK, A.H. UÇAR, Y. KAÇAR & S.N. ŞENGEZER. 2010. Davultepe 100. Yıl Kumsalı'nda (Mersin) deniz kaplumbağası yuvalama potansiyelinin belirlenmesi üzerine bir ön çalışma. E.U. Journal of Fisheries and Aquatic Sciences 27: 7-13.

ERGENE, S., C. AYMAK & A.H. UÇAR. 2011. Carapacial scute variation in green turtle (*Chelonia mydas*) and loggerhead turtle (*Caretta caretta*) hatchlings in Alata, Mersin, Turkey. Turkish Journal Of Zoology 35: 343-356.

ERGENE, S., A.H. UÇAR, C. AYMAK, S.N. ŞENGEZER, M. ERKEK, M. ERGENE, H. KORKMAZ & A. ELÇİ. 2012a. Mersin İli, Davultepe 100. Yıl kumsalı'na yuvalayan deniz kaplumbağaları (*Chelonia mydas* ve *Caretta caretta*) populasyonlarının 2009-2012 üreme sezonlarında araştırılması. IV. Ulusal Deniz Kaplumbağaları Sempozyumu. Çanakkale, Turkey. 11-13 October 2012. p. 31.

ERGENE, S., A.H. UÇAR & C. AYMAK. 2012b. Mersin bölgesi deniz kaplumbağaları üreme alanları. 2012 Biyolojik Çeşitlilik Sempozyumu. The Republic of Turkey Ministry of Forestry and

Water Affairs, Directorate General for Nature Conservation and National Parks, Department of Biological Diversity, Ankara. 22-23 May 2012. pp. 127-134.

ERGENE, S., C. AYMAK, A.H. UÇAR & Y. KAÇAR. 2013. Kazanlı Kumsalı'na (Mersin) yuva yapan *Chelonia mydas* ve *Caretta caretta* populasyonlarının 2006 üreme sezonunda araştırılması. Ege Journal of Fisheries and Aquatic Sciences 30: 51-59.

ERGENE, S., A.H. UÇAR, C. AYMAK, S.N. ŞENGEZER, Y. KAÇAR, M. ERGENE, M. ERKEK & E. SAĞALTICI. 2015. Nesting activity of green sea turtles (*Chelonia mydas*) and loggerhead sea turtles (*Caretta caretta*) over 6 nesting seasons (2009-2014) at Kazanlı beach, Mersin, Turkey. In: Kaska, Y., B. Sönmez, O. Türkecan & Ç. Sezgin (Comps.). Book of Abstracts for the 35th Annual Symposium on Sea Turtle Biology & Conservation. Dalaman, Muğla, Turkey. 18-24 April 2015. pp. 209.

ERGENE, S., M. ERGENE, A.H. UÇAR, C. AYMAK & Y. KAÇAR. 2016a. Identification of a new nesting beach in Mersin, Turkey: Nesting activity of green and loggerhead sea turtles over 6 nesting seasons (2009-2014) at Davultepe Beach. Marine Turtle Newsletter 149: 6-9.

ERGENE, S., A.H. UÇAR, Y. KAÇAR & M. ERGENE. 2016b. Türkiye'nin doğu akdeniz bölgesi deniz kaplumbağaları üreme kumsallarının 2015 üreme sezonunda Mersin bölgesi potansiyeli. In: Şerifoğlu, Y. & İ. Akış (Eds.). Uluslararası Türk Dünyası'nda İlmi Araştırmalar Sempozyumu. İktisat ve Girişimcilik Üniversitesi, Celalabat-Kırgızistan. 29-31 May 2016. pp. 1002-1014.

GÜÇLÜ, Ö., C. ULGER, O. TÜRKOZAN, R. GEMEL, M. REİMANN, Y. LEVY, S. ERGENE, A.H. UÇAR & C. AYMAK. 2009. First assessment of mitochondrial DNA diversity in the Endangered Nile softshell turtle, *Trionyx triunguis*, in the Mediterranean. Chelonian Conservation & Biology 8: 222-226.

HANÇER, T. 2010. Alata kumsalı *Chelonia mydas* (Linnaeus, 1758) bireylerinde mtDNA-RFLP analizi. M.Sc. thesis. Mersin University, Turkey. 42pp.

KAÇAR, Y. 2011. Alata üreme kumsalında bulunan yeşil deniz kaplumbağaları (*Chelonia mydas*)'nın mikrosatellit lokus analizi. Gazi Eğitim Fakültesi Dergisi 31: 247-260.

KAYA, Ş. 2011. Kazanlı ve Alata yuvalama kumsalında *Caretta caretta* ve *Chelonia mydas*'ın hematolojik, biyokimyasal ve genotoksik özelliklerinin incelenmesi. M.Sc. thesis. Mersin University, Turkey. 79pp.

ŞENGEZER, S.N. 2012. Kazanlı yuvalama kumsalındaki deniz kaplumbağaları [*Chelonia mydas* (Linnaeus, 1758) ve *Caretta caretta* (Linnaeus, 1758)] populasyonlarının biyolojik özelliklerinin incelenmesi. M.Sc. thesis. Mersin University, Turkey. 164pp.

TÜRKOZAN, O. & Y. KASKA. 2010. Turkey. In: Casale, P. & D. Margaritoulis (Eds.). Sea turtles in the Mediterranean: distribution, threats and conservation priorities. IUCN/SSC Marine Turtle Specialist Group, Switzerland: Gland, pp. 257-293.

TÜRKOZAN, O., Ş. YALÇIN ÖZDİLEK, S. ERGENE, A.H. UÇAR, B. SÖNMEZ, C. YILMAZ, Y. KAÇAR & C. AYMAK. 2013. Strandings of loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtles in the eastern Mediterranean coast of Turkey. Herpetological Journal 23: 11-15.

TÜRKOZAN, O., C. YILMAZ, A.H. UÇAR, C. CARRERAS, S. ERGENE, C. AYMAK & S. KARAMAN. 2018. Local differentiation in the origin of stranded loggerhead turtles, *Caretta caretta*, within an eastern Turkey foraging area. Ocean & Coastal Management 153: 70-75.

UÇAR, A.H. 2009. Anamur yuvalama kumsalındaki deniz kaplumbağaları [(*Caretta caretta* (Linnaeus, 1758) ve *Chelonia mydas* (Linnaeus, 1758)] ve yumuşak kabuklu nil kaplumbağası [*Trionyx triunguis* (Forskal, 1775)] populasyonlarının biyolojik özelliklerinin ve kumsal özelliklerinin incelenmesi. Ph.D. thesis. Mersin University, Mersin, Turkey. 239pp..

UÇAR, A.H., Y. KASKA, S. ERGENE, C. AYMAK, Y. KAÇAR, A. KASKA & P. İLİ. 2012. Sex ratio estimation of the most eastern main loggerhead sea turtle nesting site: Anamur beach, Mersin-Turkey. Israel Journal of Ecology and Evolution 58: 87-100.

UÇAR, A.H., M. ERGENE, Y. KAÇAR, C. AYMAK, H.E. ÇETE & S. ERGENE. 2018a. Nesting activity of sea turtles (*Chelonia mydas* and *Caretta caretta*) in Kazanlı Beach (Mersin) in 2016. In: Canbulat, S., N. Gültepe & A. Türkyılmaz (Eds.). International Ecology 2018 Symposium. Kastamonu, Turkey. 19-23 June 2018. pp. 942.

UÇAR A.H., F. MAFFUCCI, S. ERGENE, M. ERGENE, Y. KATILMIŞ, E. BAŞKALE, Y. KASKA & S. HOCHSCHEID. 2018b. A stranded loggerhead turtle tracked by satellite in Mersin Bay, Eastern Mediterranean Sea, Turkey. Marine Turtle Newsletter, 155: 12-14.

UÇAR, A.H., E. SAĞALTICI, M. ERKEK, M. ERGENE & S. ERGENE. 2020. First report of *Herpestes ichneumon* predation on *Chelonia mydas* hatchlings in Turkey. Marine Turtle Newsletter 160: 14-18.

YAŞAR, Ü. 2010. Türkiye Doğu Akdeniz sahillerinde bulunan ölü ve genç caretta caretta bireylerinin yaş dağılımı. M.Sc. thesis. Mersin University, Turkey. 72pp.

RECENT PUBLICATIONS

This section consists of publications, books, reports, and academic theses that feature subject material relevant to marine turtles. Most references come from major search engines, and the editors encourage authors to submit their publications directly by email to the Recent Publications editor: mtnrecentpubs@gmail.com.

AFONSO, A.S., B. MOURATO, H. HAZIN & F.H. HAZIN. 2021. The effect of light attractor color in pelagic longline fisheries. Fisheries Research 235: 105822.

AGOSTINHO, K.F.F., L.R. MONTEIRO & A.P.M. DI BENEDITTO. 2021. Individual niche trajectories in nesting green turtles on Rocas Atoll, Brazil: an isotopic tool to assess diet shifts over time. Biota Neotropica 21: e20201099.

AGOSTINHO, K.F.F., I.A. PESTANA, C.E.V. DE CARVALHO & A.P.M. DI BENEDITTO. 2021. Trace elements and stable isotopes in egg yolk of green turtles on Rocas Atoll, Brazil. Marine Pollution Bulletin 162: 111821.

ALVAREZ-VARAS, R., M. HEIDEMEYER, C. RIGINOS, H.A. BENITEZ, E. RESENDIZ, M. LARA-UC, D.A. GODOY, J.P. MUNOZ-PEREZ, D.E. ALARCON-RUALES, G.M. VELEZ-RUBIO, A. FALLABRINO, S. PIOVANO, J. ALFARO-SHIGUETO, C. ORTIZ-ALVAREZ, J.C. MANGEL, D. ESQUERRE, P. ZARATE, C. MEDRANO, F.L. MIRANDA, F. GUERRERO, J.A. VIANNA & D. VELIZ. 2021. Integrating morphological and genetic data at different spatial scales in a cosmopolitan marine turtle species: challenges for management and conservation. Zoological Journal of the Linnean Society 191: 434-453.

ARANGO, B.G., D.C. ENSMINGER, M. HARFUSH-MELENDEZ, E.M. LOPEZ-REYES, J.A. MARMOLEJO-VALENCIA, H. MERCHANT-LARIOS, D.E. CROCKER & J.P. VAZQUEZ-MEDINA. 2021. Oxidative stress is a potential cost of synchronized nesting aggregations in olive ridley sea turtles. Integrative and Comparative Biology 61: E24.

ARENCIBIA, A., A. MELIAN & J. OROS. 2021. Anatomic interactive atlas of the loggerhead sea turtle (*Caretta caretta*) head. Animals 11: 198.

ARREOLA CAMACHO, C., N. UNDA-DÍAZ & A. FUENTES FARÍAS. 2021. Incubación en nidos de vivero y su efecto sobre el reflejo de enderezamiento en crías de tortuga golfina *Lepidochelys olivacea*. Milenaria, Ciencia y Arte 17: 24-26.

ATTUM, O. & B. RABIA. 2021. Green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) habitat use of the most environmentally extreme sea turtle feeding ground in the Mediterranean basin. Journal of Coastal Conservation 25: 4.

AVENS, L., M.D. RAMIREZ, L.R. GOSHE, J.M. CLARK, A.B. MEYLAN, W. TEAS, D.J. SHAVER, M.H. GODFREY & L. HOWELL. 2021. Hawksbill sea turtle life-stage durations, somatic growth patterns, and age at maturation. Endangered Species Research 45: 127-145.

BANERJEE, S.M., J.A. STOLL, C.D. ALLEN, J.M. LYNCH, H.S. HARRIS, L. KENYON, R.E. CONNON, E.J. STERLING, E. NARO-MACIEL, K. MCFADDEN, M.M. LAMONT, J. BENGE, N.B. FERNANDEZ, J.A. SEMINOFF, S.R. BENSON, R.L. LEWISON, T. EGUCHI, T.M. SUMMERS, J.R. HAPDEI, M.R. RICE, S. MARTIN, T.T. JONES, P.H. DUTTON, G.H. BALAZS & L.M. KOMOROSKE. 2021. Species and population specific gene expression in blood transcriptomes of marine turtles. BMC Genomics 22: 346.

BARCELO, L.P., J.A. SEMINOFF, H.B. VANDER ZANDEN, T.T. JONES, K.A. BJORNDAL, A.B. BOLTEN, W. MUSTIN, G. BUSQUETS-VASS & S.D. NEWSOME. 2021. Hydrogen isotope assimilation and discrimination in green turtles. Journal of Experimental Biology 224: 231431.

BARCELOS, L.M.D., G. MICHIELSEN, B. SÉRGIO, S. OLIVEIRA & J.P. BARREIROS. 2021. First record of the olive ridley sea turtle, *Lepidochelys olivacea* (Eschscholtz, 1829), in the Azores Islands, northeastern Atlantic Ocean (Testudines, Cheloniidae). Herpetology Notes 14: 371-373.

BARRETO, J., L. CAJAIBA, J.B. TEIXEIRA, L. NASCIMENTO, A. GIACOMO, N. BARCELOS, T. FETTERMANN & A. MARTINS. 2021. Drone-monitoring: improving the detectability of threatened marine megafauna. Drones 5: 14.

BERNHARD, M.C., S.E. HIRSCH, J.P. PERRAULT & J.A. LASALA. 2021. Impacts of a geotextile container on loggerhead sea turtle nesting in the Gulf of Mexico. Integrative and Comparative Biology 61: E54.

BESSESEN, B.L. & M. GONZALEZ-SUAREZ. 2021.The value and limitations of local ecological knowledge: Longitudinal and retrospective assessment of flagship species in Golfo Dulce, Costa Rica. People and Nature 3: 627-638.

BIAGI, E., M. MUSELLA, G. PALLADINO, V. ANGELINI, S. PARI, C. RONCARI, D. SCICCHITANO, S. RAMPELLI, S. FRANZELLITTI & M. CANDELA. 2021. Impact of plastic debris on the gut microbiota of *Caretta caretta* from Northwestern Adriatic Sea. Frontiers in Marine Science 8: 637030.

BLACKBURN, N.B., A.C. LEANDRO, N. NAHVI, M.A. DEVLIN, M. LEANDRO, I.M. ESCOBEDO, J.M. PERALTA, J. GEORGE, B.A. STACY, T.W. DEMAAR, J. BLANGERO, M. KENIRY & J.E. CURRAN. 2021. Transcriptomic profiling of fibropapillomatosis in green sea turtles (*Chelonia mydas*) from south Texas. Frontiers in Immunology 12: 630988.

BLUMENTHAL, J.M., J.L. HARDWICK, T.J. AUSTIN, A.C. BRODERICK, P. CHIN, L. COLLYER, G. EBANKS-PETRIE, L. GRANT, L.D. LAMB, J. OLYNIK, L.C.M. OMEYER, A. PRAT-VARELA & B.J. GODLEY. 2021. Cayman Islands sea turtle nesting population increases over 22 years of monitoring. Frontiers in Marine Science 8: 663856.

BOJORQUEZ-TAPIA, L.A., G. PONCE-DIAZ, D. PEDROZA-PAEZ, A.J. DIAZ-DE-LEON & F. ARREGUIN-SANCHEZ. 2021. Application of exploratory modeling in support of transdisciplinary inquiry: regulation of fishing bycatch of loggerhead sea turtles in Gulf of Ulloa, Mexico. Frontiers in Marine Science 8: 643347.

BOLDROCCHI, G., J.V. SCHMIDT & D.P. ROBINSON. 2021. First documented record of the leatherback turtle (*Dermochelys coriacea*) from Djibouti waters. Marine Biodiversity Records 14: 3.

BOMFIM, A.D., D.S.D. DE FARIAS, F. SILVA, S. ROSSI, S.A. GAVILAN, V. SANTANA & C.S. PONTES. 2021. Long-term monitoring of marine turtle nests in northeastern Brazil. Biota Neotropica 21: e20201159.

BOUSQUET, O., G. BARRUOL, E. CORDIER, C. BARTHE, S. BIELLI, R. CALMER, E. RINDRAHARISAONA, G. ROBERTS, P. TULET, V. AMELIE, F. FLEISCHER-DOGLEY, A. MAVUME, J. ZUCULE, L. ZAKARIASY, B. RAZAFINDRADINA, F. BONNARDOT, M. SINGH, E. LEES, J. DURAND, D. MEKIES, M. CLAEYS, J. PIANEZZE, C. THOMPSON, C.L. TSAI, R. HUSSON, A. MOUCHE, S. CICCIONE, J. CATTIAUX, F. CHAUVIN & N. MARQUESTAUT. 2021. Impact of tropical cyclones on Inhabited Areas of the SWIO Basin at Present and Future Horizons. Part 1: Overview and Observing Component of the Research Project RENOVRISK-CYCLONE. Atmosphere 12: 544.

BRISCOE, D.K., C.N.T. TOMASZEWICZ, J.A. SEMINOFF, D.M. PARKER, G.H. BALAZS, J.J. POLOVINA, M. KURITA, H. OKAMOTO, T. SAITO, M.R. RICE & L.B. CROWDER. 2021. Dynamic thermal corridor may connect endangered loggerhead sea turtles across the Pacific Ocean. Frontiers in Marine Science 8: 630590.

BRUNO, D.D., I.Q. WILLMER, L. PEREIRA, R.C.C. ROCHA, T.D. SAINT'PIERRE, P. BALDASSIN, A.C.S. SCARELLI, A.D. TADEU, F.V. CORREIA, E.M. SAGGIORO, L.S. LEMOS, S. SICILIANO & R.A. HAUSER-DAVIS. 2021. Metal and metalloid contamination in green sea turtles (*Chelonia mydas*) found stranded in Southeastern Brazil. Frontiers in Marine Science 8: 608253.

CAKIRLAR, C., F.J. KOOLSTRA & S. IKRAM. 2021. Tracking turtles in the past: zooarchaeological evidence for human-turtle interactions in the ancient Eastern Mediterranean. Antiquity 95: 125-141.

CANDAN, A.Y., Y. KATILMIS & C. ERGIN. 2021. First report of *Fusarium* species occurrence in loggerhead sea turtle (*Caretta caretta*) nests and hatchling success in Iztuzu Beach, Turkey. Biologia 76: 565-573.

CANZANELLA, S., A. DANESE, M. MANDATO, G. LUCIFORA, C. RIVERSO, G. FEDERICO, P. GALLO & M. ESPOSITO. 2021. Concentrations of trace elements in tissues of loggerhead turtles (*Caretta caretta*) from the Tyrrhenian and the Ionian coastlines (Calabria, Italy). Environmental Science and Pollution Research 28: 26545-26557.

CASSILL, D.L. 2021. Multiple maternal risk-management adaptations in the loggerhead sea turtle (*Caretta caretta*) mitigate clutch failure caused by catastrophic storms and predators. Scientific Reports 11: 2491.

CERIANI, S.A., B. BROST, A.B. MEYLAN, P.A. MEYLAN & P. CASALE. 2021. Bias in sea turtle productivity estimates: error and factors involved. Marine Biology 168: 41.

CERRITELLI, G., S. BENHAMOU & P. LUSCHI. Evaluating vector navigation in green turtles migrating in a dynamic oceanic environment. Ethology Ecology & Evolution 33: 290-306.

CHABOT, R.M., R.C. WELSH, C.R. MOTT, J.R. GUERTIN, B.M. SHAMBLIN & B.E. WITHERINGTON. 2021. A sea turtle population assessment for Florida's Big Bend, northeastern Gulf of Mexico. Gulf and Caribbean Research 32: 19-33.

CHAMBAULT, P., T. HATTAB, P. MOUQUET, T. BAJJOUK, C. JEAN, K. BALLORAIN, S. CICCIONE, M. DALLEAU & J.M. BOURJEA. 2021. A methodological framework to predict the individual and population-level distributions from tracking data. Ecography 44: 766-777.

CHATTERJI, R.M., M.N. HUTCHINSON & M.E.H. JONES. 2021. Redescription of the skull of the Australian flatback sea turtle, *Natator depressus*, provides new morphological evidence for phylogenetic relationships among sea turtles (Chelonioidea). Zoological Journal of the Linnean Society 191: 1090-1113.

CHATTING, M., S. HAMZA, J. AL-KHAYAT, D. SMYTH, S. HUSREVOGLU & C.D. MARSHALL. 2021. Feminization of hawksbill turtle hatchlings in the Twenty-First century at an important regional nesting aggregation. Endangered Species Research 44: 149-158.

CHRISTIANEN, M.J.A., M.M. VAN KATWIJK, B.I. VAN TUSSENBROEK, J.F. PAGES, K. BALLORAIN, N. KELKAR, R. ARTHUR & T. ALCOVERRO. 2021. A dynamic view of seagrass meadows in the wake of successful green turtle conservation. Nature Ecology and Evolution 5: 553-555.

COOK, M., J.L. RENEKER, R.W. NERO, B.A. STACY, D.S. HANISKO & Z. WANG. 2021. Use of drift studies to understand seasonal variability in sea turtle stranding patterns in Mississippi. Frontiers in Marine Science 8: 659536.

CORTES-GOMEZ, A.A., D. ROMERO, J. SANTOS, J.R. RIVERA-HERNANDEZ & M. GIRONDOT. 2021. Inorganic elements in live vs dead nesting olive ridley marine turtles in the Mexican Pacific: introducing a new statistical methodology in ecotoxicology. Science of the Total Environment 761: 143249.

CRUCIANI, B., M. BARRET, F. SCHNEIDER & C. VERGNEAU-GROSSET. Surgical repair of a chronic traumatic injury of the right carpal joint in a juvenile hawksbill sea turtle (*Eretmochelys imbricata*). Veterinary Record Case Reports 9: e22.

DE OLIVEIRA, R.E.M., F.L.N. ATTADEMO, J.S. GALVINCIO, A.C.D. FREIRE, A.S. DA SILVA, J.M.D. PIRES, L.R.P. DE LIMA, J.M.F. AGUIAR, A.B. MOREIRA, L.I.D. MELO, S.A. GAVILAN, S.A. LIMA, M.A. LIMA, F.J.D. SILVA & M.F. DE OLIVEIRA. 2021. Successful rehabilitation of an oiled sea turtle (*Lepidochelys olivacea*) affected by the biggest oil spill disaster in Brazil. Veterinarni Medicina 66: 313-319.

DE OLIVEIRA, R.E.M., S. ROSSI, F.L.N. ATTADEMO, T.A. SANTORO, R.A. REVOREDO, D.S.D. DE FARIAS, M.A. LIMA, J.S. BATISTA, F.J.D. SILVA, S.A. GAVILAN & M.F. DE OLIVEIRA. 2021. Colocolic intussusception associated with *Octangium* sp. (Digenea: Microscaphidiidae) in a green sea turtle *Chelonia mydas*. Journal of Aquatic Animal Health 33: 17-23.

DEGENFORD, J.H., D. LIANG, H. BAILEY, A.L. HOOVER, P. ZARATE, J. AZÓCAR, D. DEVIA, J. ALFARO-SHIGUETO, J.C. MANGEL, N. DE PAZ, J.Q. DAVILA, D.S. BARTUREN, J.M. RGUEZ-BARON, A.S. WILLIARD, C. FAHY, N. BARBOUR

& G.L. SHILLINGER. 2021. Using fisheries observation data to develop a predictive species distribution model for endangered sea turtles. Conservation Science and Practice 3: e349.

DELGADO-CANO, D., L. MARINO-RAMIREZ & J. HERNANDEZ-FERNANDEZ. 2021. Detection of high heteroplasmy in complete loggerhead and hawksbill sea turtles mitochondrial genomes using RNAseq. Mitochondrial DNA Part A 32: 106-114.

DI RENZO, L., G. MASCILONGO, M. BERTI, T. BOGDANOVIC, E. LISTES, M. BRKLJACA, V. NOTARSTEFANO, G. GIOACCHINI, E. GIORGINI, V. OLIVIERI, C. SILVESTRI, M. MATIDDI, N. D'ALTERIO, N. FERRI & F. DI GIACINTO. 2021. Potential impact of microplastics and additives on the health status of loggerhead turtles (*Caretta caretta*) stranded along the central Adriatic Coast. Water Air and Soil Pollution 232: 98.

DIMATTEO, A., G. LOCKHART & S. BARCO. 2021. Normalizing home ranges of immature Kemp's ridley turtles (*Lepidochelys kempii*) in an important estuarine foraging area to better assess their spatial distribution. Marine Biology Research 17: 57-71.

DUBOIS, M.J., N.E. PUTMAN & S.E. PIACENZA. 2021. A global assessment of the potential for ocean-driven transport in hatchling sea turtles. Water 13: 757.

DUNBAR, S.G., E.C. ANGER, J.R. PARHAM, C. KINGEN, M.K. WRIGHT, C.T. HAYES, S. SAFI, J. HOLMBERG, L. SALINAS & D.S. BAUMBACH. 2021. HotSpotter: using a computer-driven photo-id application to identify sea turtles. Journal of Experimental Marine Biology and Ecology 535: 151490.

EDWARDS, J.J., V.A. AMADI, E. SOTO, M.T. JAY-RUSSEL, P. AMINABADI, K. KENELTY, K. CHARLES, G. ARYA, K. MISTRY, R. NICHOLAS, B.P. BUTLER & D. MARANCIK. 2021. Prevalence and phenotypic characterization of *Salmonella enterica* isolates from three species of wild marine turtles in Grenada, West Indies. Veterinary World 14: 222-229.

ESCOBAR-FLORES, J.G. & S. SANDOVAL. 2021. Unmanned aerial vehicle (UAV) for sea turtle skeleton detection in the Mexican Pacific. Remote Sensing Applications-Society and Environment 22: 100501.

ESPINOZA, E.O., M.K. MOORE, B.C. HAMLIN, B.W. BAKER & A.J. ESPINOZA. 2021. Forensic characterization of sea turtle oil by ambient ionization mass spectrometry: Car*etta caretta, Chelonia mydas, Dermochelys coriacea, Eretmochelys imbricata, Lepidochelys kempii*, and *Lepidochelys olivacea*. Forensic Science International: Animals and Environments 1: 100008.

FAJIRI, A.M., E.F. JASJFI, D. DODY SETIANTO & T.H. PRIHATANTO. 2021. Video mapping for sea turtle preservation education campaign. Turkish Journal of Computer and Mathematics Eduction 12: 3076-3084.

FARRELL, J.A., K. YETSKO, L. WHITMORE, J. WHILDE, C.B. EASTMAN, D.R. RAMIA, R. THOMAS, P. LINSER, S. CREER, B. BURKHALTER, C. SCHNITZLER & D.J. DUFFY. 2021. Environmental DNA monitoring of oncogenic viral shedding and genomic profiling of sea turtle fibropapillomatosis reveals unusual viral dynamics. Communications Biology 4: 565.

FERREIRA, R.L., F.R. CEIA, T.C. BORGES, J.A. RAMOS & A.B. BOLTEN. 2021. Size-based differences in isotopic niche width (delta C-13 and delta N-15) of green turtles (*Chelonia mydas*) nesting on Principe Island, Gulf of Guinea. Marine Ecology 42: e12636.

FERREIRA, L.C., M. THUMS, S. FOSSETTE, P. WILSON, T. SHIMADA, A.D. TUCKER, K. PENDOLEY, D. WAAYERS, M.L. GUINEA, G. LOEWENTHAL, J. KING, M. SPEIRS, D. ROB & S.D. WHITING. 2021. Multiple satellite tracking datasets inform green turtle conservation at a regional scale. Diversity and Distribution 27: 249-266.

FILIPPOS, L.S., S. TANIGUCHI, P. BALDASSIN, T. PIRES & R.C. MONTONE. 2021. Persistent organic pollutants in plasma and stable isotopes in red blood cells of *Caretta caretta*, *Chelonia mydas* and *Lepidochelys olivacea* sea turtles that nest in Brazil. Marine Pollution Bulletin 167: 112283.

FINLAYSON, K.A., F.D.L. LEUSCH, C.A. VILLA, C.J. LIMPUS & J.P. VAN DE MERWE. 2021. Combining analytical and in vitro techniques for comprehensive assessments of chemical exposure and effect in green sea turtles (*Chelonia mydas*). Chemosphere 274: 129752.

FITZPATRICK, D.M., M.A. TETNOWSKI, T.G. ROSSER, R.D. PINCKNEY, D.P. MARANCIK & B.P. BUTLER. 2021. Genetic and morphologic characterization of *Diaschistorchis pandus* (Digenea: Pronocephalidae) trematodes extracted from hawksbill turtles, *Eretmochelys imbricata* (Testudines: Cheloniidae), in Grenada, West Indies. Journal of Parasitology 107: 267-274.

FOSSETTE, S., G. LOEWENTHAL, L.R. PEEL, A. VITENBERGS, M.A. HAMEL, C. DOUGLAS, A.D. TUCKER, F. MAYER & S.D. WHITING. 2021. Using aerial photogrammetry to assess stock-wide marine turtle nesting distribution, abundance and cumulative exposure to industrial activity. Remote Sensing 13: 1116.

GAJDZIK, L., A.L. GREEN, J.E.M. COCHRAN, R.S. HARDENSTINE, L.K. TANABE & M.L. BERUMEN. 2021. Using species connectivity to achieve coordinated large-scale marine conservation efforts in the Red Sea. Marine Pollution Bulletin 166: 112244.

GARCÍA-GRAJALES, J., J.F. MERAZ-HERNANDO, J.L. ARCOS GARCÍA & E. RAMÍREZ-FUENTES. 2021. Influence of nest temperature on morphology of leatherback turtle (*Dermochelys coriacea*) hatchlings incubated in hatcheries in Oaxaca, Mexico. Canadian Journal of Zoology 99: 369-379.

GATTO, C.R., B. MATTHEWS & R.D. REINA. 2021. Role of incubation environment in determining thermal tolerance of sea turtle hatchlings. Endangered Species Research 44: 397-408.

GENTILE, A., T. AMATO, A. GUSTINELLI, M.L. FIORAVANTI, D. GAMBINO, V. RANDAZZO, G. CARACAPPA, D. VICARI & M. ARCULEO. 2021. Helminth infection of the loggerhead sea turtle *Caretta caretta* along the Coasts of Sicily and the North West Adriatic Sea. Animals 11: 1408.

GIRARD, A., N. BREHERET, G. BAL, J.G. MAVOUNGOU, J.F. TCHIBINDA, F. MAKAYA & M. GIRONDOT. 2021. Unusual sexual dimorphism and small adult size for olive ridley sea turtles are linked to volumetric geometric constraints. Marine Biology 168: 7.

GONZALEZ, A.N., F.M.C. GONZALEZ, R.M.C. DAGOSTINO &

O.N. GONZALEZ. 2021. Methodological process for assessing the suitability of the territory for alternative tourism activities: case study Miramar-Playa Tortugas, Riviera Nayarit, Mexico. Investigaciones Turisticas 256-277.

GRAVELLE, J.M. & J. WYNEKEN. 2021. The effects of multiple environmental factors on the hatching and emergence success of loggerhead sea turtles (*Caretta caretta*). Integrative and Comparative Biology 61: E1128-E1129.

GUNNER, R.M., R.P. WILSON, M.D. HOLTON, R. SCOTT, A. ARKWRIGHT, A. FAHLMAN, M. ULRICH, P. HOPKINS, C. DUARTE & C. EIZAGUIRRE. 2021. Activity of loggerhead turtles during the U-shaped dive: insights using angular velocity metrics. Endangered Species Research 45: 1-12.

HANNA, M.E., E.M. CHANDLER, B.X. SEMMENS, T. EGUCHI, G.E. LEMONS & J.A. SEMINOFF. 2021. Citizen-sourced sightings and underwater photography reveal novel insights about green sea turtle distribution and ecology in Southern California. Frontiers in Marine Science 8: 671061.

HARMS, C.A., L.K. RUTERBORIES, N.I. STACY, E.F. CHRISTIANSEN, M.G. PAPICH, A.M. LYNCH, A. BARRATCLOUGH & M.E. SERRANO. 2021. Safety of multiple-dose intramuscular ketoprofen treatment in loggerhead turtles (*Caretta caretta*). Journal of Zoo and Wildlife Medicine 52: 126-132.

HARNINO, T.Z.A.E., I.N.Y. PARAWANGSA, L.A. SARI & D.S. ARSAD. 2021. Effectiveness of sea turtle conservation management at the Turtle Conservation and Education Center of Serangan, Denpasar Bali. Journal of Marine and Coastal Science 10: 18-34.

HARRISON, C.S., J.Y. LUO, N.F. PUTMAN, Q.F. LI, P. SHEEVAM, K. KRUMHARDT, J. STEVENS & M.C. LONG. 2021. Identifying global favourable habitat for early juvenile loggerhead sea turtles. Journal of the Royal Society Interface 18: 20200799.

HART, K.M., J.C. GUZY & B.J. SMITH. 2021. Drivers of realized satellite tracking duration in marine turtles. Movement Ecology 9: 1.

HATAKENAKA, T., K. MIYAKE, K. TAKADA, T. SASAI, S. FUKADA, M. KAYOU, T. OBUCHI, K. MAEDA, M. MAKABE, I. KAWAZU & T. SAITO. 2021. Influence of retention conditions and duration on the swim frenzy in green sea turtle hatchlings. Kuroshio Science 14: 103-112.

HAYS, G.C., W.J. CHIVERS, J.O. LALOE, C. SHEPPARD & N. ESTEBAN. 2021. Impact of marine heatwaves for sea turtle nest temperatures. Biology Letters 17: 20210038.

HAYS, G.C., J.O. LALOE, A. RATTRAY & N. ESTEBAN. Why do Argos satellite tags stop relaying data? Ecology and Evolution 11: 7093-7101.

HEMELIKOVA, A., P. ZOUBEK, T. OUHEL, A. AWALUDDIN & T.R. FERASYI. 2021. Conservation of hawksbill turtle (*Eretmochelys imbricata*) in Indonesia: lessons learned and future challenges. Advances in Biological Sciences Research 12: 44-47.

HERNANDEZ-FERNANDEZ, J., A. PINZON-VELASCO, E.A. LOPEZ, P. RODRIGUEZ-BECERRA & L. MARINO-RAMIREZ. 2021. Transcriptional analyses of acute exposure to methylmercury on erythrocytes of loggerhead sea turtle. Toxics 9: 70.

HOLTZE, S., E. GORSHKOVA, S. BRAUDE, A. CELLERINO, P. DAMMANN, T.B. HILDEBRANDT, A. HOEFLICH, S. HOFFMANN, P. KOCH, E.T. TOZZINI, M. SKULACHEV, V.P. SKULACHEV & A. SAHM. 2021. Alternative animal models of aging research. Frontiers in Molecular Biosciences 8: 660959.

HOUNSLOW, J.L., O.J.D. JEWELL, S. FOSSETTE, S. WHITING, A.D. TUCKER, A. RICHARDSON, D. EDWARDS & A.C. GLEISS. 2021. Animal-borne video from a sea turtle reveals novel anti-predator behaviors. Ecology 102: e03251.

HOWELL, L.N. & D.J. SHAVER. 2021. Foraging habits of green sea turtles (*Chelonia mydas*) in the Northwestern Gulf of Mexico. Frontiers in Marine Science 8: 658368.

JAMES, A., A. PAGE-KARJIAN, K.E. CHARLES, J. EDWARDS, C.R. GREGORY, S. CHEETHAM, B.P. BUTER & D.P. MARANCIK. 2021. Chelonid alphaherpesvirus 5 prevalence and first confirmed case of sea turtle fibropapillomatosis in Grenada, West Indies. Animals 11: 1490.

JEANTET, L., V. VIGON, S. GEIGER & D. CHEVALLIER. 2021. Fully Convolutional Neural Network: A solution to infer animal behaviours from multi-sensor data. Ecological Modelling 450: 109555.

JIAN, L., R. GUO, X.B. ZHENG, H.T. SHI & J.C. WANG. 2021. Trace elements in green turtle eggshells and coral sand sediments from the Xisha Islands, South China Sea. Marine Pollution Bulletin 164: 112036.

JUALAONG, S., H. KANGHAE, K. THONGPRAJUKAEW, S. SAEKHOW, N. AMARTIRATANA & P. SOTONG. 2021. Optimal feeding frequency for captive hawksbill sea turtle (*Eretmochelys imbricata*). Animals 11: 1252.

KINOSHITA, C., T. FUKUOKA, T. NARAZAKI, Y. NIIZUMA & K. SATO. 2021. Analysis of why sea turtles swim slowly: a metabolic and mechanical approach. Journal of Experimental Biology 224: 236216.

KISHIDA, T. 2021. Olfaction of aquatic amniotes. Cell and Tissue Research 383: 353-365.

KITAYAMA, C., K. UEDA, M. OMATA, T. TOMITA, S. FUKADA, S. MURAKAMI, Y. TANAKA, A. KAJI, S. KONDO, H. SUGANUMA, Y. AIKO, A. FUJIMOTO, Y.K. KAWAI, M. YANAGAWA & D. KONDOH. 2021. Morphological features of the nasal cavities of hawksbill, olive ridley, and black sea turtles: comparative studies with green, loggerhead and leatherback sea turtles. PLoS ONE 16: e0250873.

KONDOH, D., C. KITAYAMA & Y.K. KAWAI. 2021. The nasal cavity in sea turtles: adaptation to olfaction and seawater flow. Cell and Tissue Research 383: 347-352.

KRESTOFF, E.S., J.P. CREECY, W.D. LORD, M.L. HAYNIE, J.A. COYER & K. SAMPSON. 2021. Mitochondrial DNA evaluation and species identification of Kemp's ridley sea turtle (*Lepidochelys kempii*) bones after a 3-year exposure to submerged marine and terrestrial environments. Frontiers in Marine Science 8: 646455.

KUDO, H., H. NISHIZAWA, K. UCHIDA & K. SATO. 2021. Boldness-exploration behavioral syndrome in wild sub-adult green sea turtles caught at Oita, Japan. Applied Animal Behaviour Science 236: 105216

LACASELLA, E.L., M.P. JENSEN, C.A.M. HOF, I.P. BELL, A. FREY & P.H. DUTTON. 2021. Mitochondrial DNA profiling to combat the illegal trade in tortoiseshell products. Frontiers in Marine Science 7: 595853.

LAMB, G. 2021. Spectacular sea turtles: circuits of a wildlife ecotourism discourse in Hawai'i. Applied Linguistics Review 12: 93-121.

LALOË J.-O., J.N. TEDESCHI, D.T. BOOTH, I. BELL, A. DUNSTAN, R.D. REINA & G.C. HAYS. 2021. Extreme rainfall events and cooling of sea turtle clutches: Implications in the face of climate warming. Ecology and Evolution 11: 560-565

LAMBIASE, S., F.P. SERPE, M. PILIA, F. FIORITO, D. IACCARINO, P. GALLO & M. ESPOSITO. 2021. Polychlorinated organic pollutants (PCDD/Fs and DL-PCBs) in loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) turtles from Central-Southern Tyrrhenian Sea. Chemosphere 263: 128226.

LAMONT, M.M. & D. JOHNSON. 2021. Variation in species composition, size and fitness of two multi-species sea turtle assemblages using different neritic habitats. Frontiers in Marine Science 7: 1187.

LAMONT, M.M., D. JOHNSON & D.J. CATIZONE. 2021. Movements of marine and estuarine turtles during Hurricane Michael. Scientific Reports 11: 1577.

LASALA, J.A., M.C. BERNHARD & K.T. MAZZARELLA. 2021. Longitudinal study of sea turtle nesting behavior on a large Gulf of Mexico rookery. Integrative and Comparative Biology 61: E500.

LEI, J., D.T. BOOTH, M.U. RUSLI & Z.W. ZHANG. 2021. Spatial ecology of Asian water monitors adjacent to a sea turtle nesting beach. Zoological Science 38: 1-7.

LIAO, C.P., J.Y. HSU, S.P. HUANG, R.W. CLARK, J.W. LIN, H.Y. TSENG & W.S. HUANG. 2021. Sum of fears among intraguild predators drives the survival of green sea turtle (*Chelonia mydas*) eggs. Proceedings of the Royal Society B 288: 20202631.

LILES, M.J., M.N. PETERSON, K.T. STEVENSON & M.J. PETERSON. 2021. Youth wildlife preferences and species-based conservation priorities in a low-income biodiversity hotspot region. Environmental Conservation 48: 110-117.

LIN, L., S. LI, M. CHEN, J.F. PARHAM & H. SHI. 2021. Sea turtle demand in China threatens the survival of wild populations. iScience 24: 102517.

LOISIER, A., M.P. SAVELLI, V. ARNAL, F. CLARO, D. GAMBAIANI, J.B. SENEGAS, C. CESARINI, J. SACCHI, C. MIAUD & C. MONTGELARD. 2021. Genetic composition, origin and conservation of loggerhead sea turtles (*Caretta caretta*) frequenting the French Mediterranean coasts. Marine Biology 168: 52.

MADDUPPA, H., S. BAHRI, A.T. GHOZALI, A.S. ATMADIPOERA, B. SUBHAN, P. SANTOSO, I.N.M. NATIH & D. ARAFAT. 2021. Population genetic structure of olive ridley (*Lepidochelys olivacea*) across Indonesian archipelago revealed by mitochondrial DNA Implication for management. Regional Studies in Marine Science 41: 101600.

MANEJA, R.H., J.D. MILLER, W.Z. LI, R. THOMAS, H. EL-ASKARY, S. PERERA, A.V.B. FLANDEZ, A.U. BASALI, J.F.A. ALCARIA, J. GOPALAN, S. TIWARI, M. AL-JEDANI, P.K. PRIHARTATO, R.A. LOUGHLAND, A. QASEM, M.A. QURBAN, W. FALATH & D. STRUPPA. 2021. Multidecadal analysis of beach loss at the major offshore sea turtle nesting islands in the northern Arabian Gulf. Ecological Indicators 121: 107146.

MANSFIELD, K.L., J. WYNEKEN & J.G. LUO. 2021. First Atlantic satellite tracks of 'lost years' green turtles support the importance of the Sargasso Sea as a sea turtle nursery. Proceedings of the Royal Society B-Biological Sciences 288: 20210057.

MARANCIK, D.P., J.R. PERRAULT, L.M. KOMOROSKE, J.A. STOLL, K.N. KELLEY & C.A. MANIRE. 2021. Plasma proteomics of green turtles (*Chelonia mydas*) reveals pathway shifts and potential biomarker candidates associated with health and disease. Conservation Physiology 9: coab018.

MARCH, D., E. ARIEL, D. BLYDE, L. CHRISTIDIS & B.P. KELAHER. 2021. Influence of exercise and fasting on blood parameters in juvenile green turtles (*Chelonia mydas*): implications for health assessments. Comparative Exercise Physiology 17: 181-187.

MARTIN-DEL-CAMPO, R., M.F. CALDERON-CAMPUZANO, I. ROJAS-LLEONART, R. BRISENO-DUENAS & A. GARCIA-GASCA. 2021. Congenital malformations in sea turtles: puzzling interplay between genes and environment. Animals 11: 444.

MARTINEZ-ESTEVEZ, L., J.P. CUEVAS AMADOR, F. CUEVAS AMADOR, K.M. ZILLIACUS, A. MARTINEZ PACHECO, J.A. SEMINOFF, J. LUCERO, K. OCEGUERA, B.R. TERSHY & D.A. CROLL. 2021. Spatial ecology of hawksbill sea turtles (*Eretmochelys imbricata*) in foraging habitats of the Gulf of California, Mexico. Global Ecology and Conservation 27: e01540.

MASHKOUR, N., K. JONES, W. WIRTH, G. BURGESS & E. ARIEL. 2021. The concurrent detection of Chelonid alphaherpesvirus 5 and *Chelonia mydas* papillomavirus 1 in tumoured and non-tumoured green turtles. Animals 11: 697.

MAZZARELLA, K.T. & M.C. BERNHARD. 2021. To cage or not to cage? Effectiveness of caging sea turtle nests on Gulf of Mexico beaches. Integrative and Comparative Biology 61: E588-E589.

MCNALLY, K.L., C.J. INNIS, A. KENNEDY & J.L. BOWEN. 2021. Characterization of oral and cloacal microbial communities in cold-stunned Kemp's ridley sea turtles (*Lepidochelys kempii*) during the time course of rehabilitation. PLoS ONE 16: e0252086.

MCNALLY, K.L., C.R. MOTT, J.R. GUERTIN & J.L. BOWEN. 2021. Microbial communities of wild-captured Kemp's ridley (*Lepidochelys kempii*) and green sea turtles (*Chelonia mydas*). Endangered Species Research 45: 21-36.

MEAZA, I., J.H. TOYODA & J.P. WISE. 2021. Microplastics in sea turtles, marine mammals and humans: a one environmental health perspective. Frontiers in Environmental Science 8: 575614.

MEJIAS-BALSALOBRE, C., J. RESTREPO, G. BORGES, R. GARCIA, D. ROJAS-CANIZALES, H. BARRIOS-GARRIDO & R.A. VALVERDE. 2021. Local community perceptions of sea turtle egg use in Tortuguero, Costa Rica. Ocean & Coastal Management 201: 105243.

MELVIN, S.D., D.T. MARCH, K. MARSHALL, A.R. CARROLL

& J.P. VAN DE MERWE. 2021. Improving rehabilitation outcomes using metabolomics: health, recovery and biomarkers of mortality in sick and injured green turtles (*Chelonia mydas*). Biological Conservation 254: 108943.

MERCHANT-LARIOS, H. 2021. Developmental biology in Mexico. International Journal of Developmental Biology 65: 59-70.

MONDRAGON, M.E., O.P. LUZARDO, M. ZUMBADO, A. RODRIGUEZ-HERNANDEZ, C.R. BERRIEL, H.V. RAMIREZ-GOMEZ, C.G.R. ISLAS, R.F.A. FISHER & J.R.R. MARTINEZ. 2021. Incidence of 49 elements in the blood and scute tissues of nesting hawksbill turtles (*Eretmochelys imbricata*) in Holbox Island. Regional Studies in Marine Science 41: 101566.

MORA, N.E., C.M. ORREGO & D.A. ALVARADO. 2021. Estimación del área y el número máximo de turistas para observar la anidación de tortugas marinas protegidas. Ecología Austral 31: 289-300.

MORALES-ZARATE, M.V., J.A. LOPEZ-RAMÍREZ & C.A. SALINAS-ZAVALA. 2021. Loggerhead marine turtle (*Caretta caretta*) ecological facts from a trophic relationship model in a hot spot fishery area: Gulf of Ulloa, Mexico. Ecological Modelling 439: 109327.

MULOCHAU, T., C. JEAN, P. GOGENDAU & S. CICCIONE. 2021. Green sea turtle, *Chelonia mydas*, feeding on *Synapta maculata* (Holothuroidea: Synaptidae) on a seagrass bed (*Syringodium isoetifolium*) at Reunion Island, western Indian Ocean. SPC Beche-de-Mer Infomation Bulletin 41: 37-39.

MUSTIKA, P.L.K., E. WONNEBERGER, K. ERZINI & N. PASISINGI. 2021. Marine megafauna bycatch in artisanal fisheries in Gorontalo, northern Sulawesi (Indonesia): An assessment based on fisher interviews. Ocean & Coastal Management 208: 105606.

NARAZAKI, T., I. NAKAMURA, K. AOKI, T. IWATA, K. SHIOMI, P. LUSCHI, H. SUGANUMA, C.G. MEYER, R. MATSUMOTO, C.A. BOST, Y. HANDRICH, M. AMANO, R. OKAMOTO, K. MORI, S. CICCIONE, J. BOURJEA & K. SATO. 2021. Similar circling movements observed across marine megafauna taxa. iScience 24: 102221.

NORTON, T.M., T. CLAUSS, R. SOMMER, S. STOWELL, M. KAYLOR, C. THISTLE & S. COX. 2021. Pharmacokinetic behavior of Meloxicam in loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempii*), and green (*Chelonia mydas*) sea turtles after subcutaneous administration. Journal of Zoo and Wildlife Medicine 52: 295-299.

OKOH, G.R., P.F. HORWOOD, D. WHITMORE & E. ARIEL. 2021. Herpesviruses in reptiles. Frontiers in Veterinary Science 8: 642894.

OKUYAMA, J., S.R. BENSON, P.H. DUTTON & J.A. SEMINOFF. 2021. Changes in dive patterns of leatherback turtles with sea surface temperature and potential foraging habitats. Ecosphere 12: e03365.

OLIVEIRA, R.E.M., F.L.N. ATTADEMO, J.S. GALVINCIO, A.C.B. FREIRE, A.S. SILVA, J.M.L. PIRES, L.R.P. LIMA, J.M.F. AGUIAR, A.B. MOREIRA, L.I.S. MELO, S.A. GAVILAN, S.A. LIMA, M.A. LIMA, F.J.L. SILVA & M.F. OLIVEIRA. 2021. Successful rehabilitation of an oiled sea turtle (*Lepidochelys olivacea*) affected by the biggest oil spill disaster in Brazil. Veterinarini Medicina 66: 313-319.

ONATE-CASADO, J., D.T. BOOTH, K. VANDERCAMERE, S.P. SAKHALKAR & M.U. RUSLI. 2021. Offshore dispersal and predation of sea turtle hatchlings I: a study of hawksbill turtles at Chagar Hutang Turtle Sanctuary, Malaysia. Ichthyology and Herpetology 109: 180-187.

OROS, J., M. CAMACHO, P. CALABUIG, C. RIAL-BERRIEL, N. MONTESDEOCA, S. DENIZ & O.P. LUZARDO. 2021. Postmortem investigations on leatherback sea turtles (*Dermochelys coriacea*) stranded in the Canary Islands (Spain) (1998-2017): evidence of anthropogenic impacts. Marine Pollution Bulletin 167: 112340.

OSLAND, M.J., P.W. STEVENS, M.M. LAMONT, R.C. BRUSCA, K.M. HART, J.H. WADDLE, C.A. LANGTIMM, C.M. WILLIAMS, B.D. KEIM, A.J. TERANDO, E.A. REYIER, K.E. MARSHALL, M.E. LOIK, R.E. BOUCEK, A.B. LEWIS & J.A. SEMINOFF. 2021. Tropicalization of temperate ecosystems in North America: the northward range expansion of tropical organisms in response to warming winter temperatures. Global Change Biology 27: 3009-3034.

PAEZ-ROSAS, D., P. SALINAS-DE-LEON, A. PROANO, L. VACA-PITA & J. SUAREZ-MONCADA. 2021. Multi-tissue stable isotope analyses reveal temporal changes in the feeding patterns of green turtles in the Galapagos Marine Reserve. Journal of Experimental Zoology Part A 335: 319-328.

PATEL, S.H., M.V. WINTON, J.M. HATCH, H.L. HAAS, V.S. SABA, G. FAY & R.J. SMOLOWITZ. 2021. Projected shifts in loggerhead sea turtle thermal habitat in the Northwest Atlantic Ocean due to climate change. Scientific Reports 11: 8850.

PATRICIO, A.R., L.A. HAWKES, J.R. MONSINJON, B.J. GODLEY & M. FUENTES. 2021. Climate change and marine turtles: recent advances and future directions. Endangered Species Research 44: 363-395.

PERRAULT, J.R., M.D. ARENDT, J.A. SCHWENTER, J.L. BYRD, K.A. TUXBURY & N.I. STACY. 2021. Comparison of 2 glucose analytical methodologies in immature Kemp's ridley sea turtles: dry chemistry of plasma versus point-of-care glucometer analysis of whole blood. Journal of Veterinary Diagnostic Investigation 33: 595-599.

PERRAULT, J.R., M. LEVIN, C.R. MOTT, C.M. BOVERY, M.J. BRESETTE, R.M. CHABOT, C.R. GREGORY, J.R. GUERTIN, S.E. HIRSCH, B.W. RITCHIE, S.T. WEEGE, R.C. WELSH, B.E. WITHERINGTON & A. PAGE-KARJIAN. 2021. Insights on immune function in free-ranging green sea turtles (*Chelonia mydas*) with and without fibropapillomatosis. Animals 11: 861.

PETRY, M.V., L.D. ARAUJO, A.C. BRUM, V.R.F. BENEMANN & J.V.G. FINGER. 2021. Plastic ingestion by juvenile green turtles (*Chelonia mydas*) off the coast of Southern Brazil. Marine Pollution Bulletin 167: 112337.

PHILLIPS, K.F., D.S. ADDISON, C.R. SASSO & K.L. MANSFIELD. 2021. Postnesting migration routes and fidelity to foraging sites among loggerhead turtles in the western North Atlantic. Bulletin of Marine Science 97: 1-18.

PILCHER, N.J., M.A. ANTONOPOULOU, C.J. RODRIGUEZ-

ZARATE, D. MATEOS-MOLINA, H.S. DAS, I. BUGLA & S.M. AL GHAIS. 2021. Movements of green turtles from foraging areas of the United Arab Emirates: regional habitat connectivity and use of marine protected areas. Marine Biology 168: 10.

PINYA, S., E. RENGA, G. FERNANDEZ, G. MATEU-VICENS, S. TEJADA, X. CAPO & A. SUREDA. 2021. Physiological biomarkers in loggerhead turtles (*Caretta caretta*) as a tool for monitoring sanitary evolution in marine recovery centres. Science of the Total Environment 757: 143930.

POORNIMA, P. 2021. Nesting and hatching behaviour of olive ridley turtles *Lepidochelys olivacea* (Eschscholtz, 1829) (Reptilia: Cryptodira: Cheloniidae) on Dr. Abdul Kalam Island, Odisha, India. Journal of Threatened Taxa 13: 18122-18131.

PROKIC, M.D., B.R. GAVRILOVIC, T.B. RADOVANOVIC, J.P. GAVRIC, T.G. PETROVIC, S.G. DESPOTOVIC & C. FAGGIO. 2021. Studying microplastics: lessons from evaluated literature on animal model organisms and experimental approaches. Journal of Hazardous Materials 414: 125476.

QUESADA-RODRIGUEZ, C., C. ORIENTALE, J. DIAZ-OROZCO & B. SELLES-RIOS. 2021. Impact of 2020 COVID-19 lockdown on environmental education and leatherback sea turtle (*Dermochelys coriacea*) nesting monitoring in Pacuare Reserve, Costa Rica. Biological Conservation 255: 108981.

RAJANGAM, K. & A. SUNDAR. 2021. Reading the entanglements of nature-culture conservation and development in contemporary India. Journal of South Asian Development 16: 7-32.

RAMESH, M. 2021. Frenemies: marine turtle conservation and economic development in the Rushikulya Coast, eastern India. Journal of South Asian Development 16: 33-53.

RAMIREZ, H., V. VALVERDE-CANTILLO & P.S. TOMILLO. 2021. El Nino events and chlorophyll levels affect the reproductive frequency but not the seasonal reproductive output of East Pacific green turtles. Marine Ecology Progress Series 659: 237-246.

RAMIREZ, M.D., T. POPOVSKA & E.A. BABCOCK. 2021. Global synthesis of sea turtle von Bertalanffy growth parameters through Bayesian hierarchical modeling. Marine Ecology Progress Series 657: 191-207.

RAMOS, A.V.V., A.V.M. SILVA, J.L.A. DIAS, E.A. DEUS & V.P.C. VIEIRA. 2021. Helmintos gastrinestinais de *Chelonia mydas* (Tartarugas-verdes) resgatadas no litoral sul de São Paulo, Brasil. Archives of Veterinary Science 26: 39-50.

RAMOS-RIVERA, B.S., H. CASTRO-MONDRAGON, J.G. KUK-DZUL, P. FLORES-RODRÍGUEZ & R. FLORES-GARZA. 2021. Diversity of epibionts associated with *Lepidochelys olivacea* (Eschscholtz 1829) sea turtles nesting in the Mexican South Pacific. Animals 11: 1734.

RANGEL, B.D., N. HAMMERSCHLAG, J.A. SULIKOWSKI & R.G. MOREIRA. 2021. Dietary and reproductive biomarkers in a generalist apex predator reveal differences in nutritional ecology across life stages. Marine Ecology Progress Series 664: 149-163.

REBOUL, I., D. BOOTH & U. RUSLI. 2021. Artificial and natural shade: implications for green turtle (*Chelonia mydas*) rookery management. Ocean & Coastal Management 204: 105521.

RESENDIZ, E. & H. FERNANDEZ-SANZ. 2021. Biochemical identification of potentially pathogenic and zoonotic bacteria in black turtles (*Chelonia mydas*) from the Mexican Pacific. Abanico Veterinario 11: 1-13

RESENDIZ, E., H. FERNANDEZ-SANZ, J.F. DOMINGUEZ-CONTRERAS, A.H. RAMOS-DIAZ, A. MANCINI, A.A. ZAVALA-NORZAGARAY & A.A. AGUIRRE. 2021. Molecular characterization of chelonid alphaherpesvirus 5 in a black turtle (*Chelonia mydas*) fibropapilloma from Baja California Sur, Mexico. Animals 11: 105.

REZAIE-ATAGHOLIPOUR, M., F. IMANI, P. GHEZELLOU & J.A. SEMINOFF. 2021. Feeding ecology of juvenile green turtles in food-poor habitats of the Persian Gulf. Marine Biology 168: 4.

RICE, N., S. HIRAMA & B. WITHERINGTON. 2021. High frequency of micro- and meso-plastics ingestion in a sample of neonate sea turtles from a major rookery. Marine Pollution Bulletin 167: 112363.

RITTENBURG, L.T., J.R. KELLEY, K.L. MANSFIELD & A.E. SAVAGE. 2021. Marine leech parasitism of sea turtles varies across host species, seasons, and the tumor disease fibropapillomatosis. Diseases of Aquatic Organisms 143: 1-12.

RIZGALLA. J. 2021. Can social media platforms play a role in sea turtle conservation efforts in Libya in times of war and political/economic instability? Journal of the Black Sea/Mediterranean Environment 27: 1-23.

ROBERTS, K.E., B.J. SMITH, D. BURKHOLDER & K.M. HART. 2021. Evaluating the use of marine protected areas by endangered species: a habitat selection approach. Ecological Solutions and Evidence 2: e12035.

ROBINSON, D.P., K. HYLAND, G. BEUKES, A. VETTAN, A. MABADIKATE, R.W. JABADO, C.A. ROHNER, S.J. PIERCE & W. BAVERSTOCK. 2021. Satellite tracking of rehabilitated sea turtles suggests a high rate of short-term survival following release. PloS ONE 16: e0246241.

RODGERS, E.M., C.E. FRANKLIN & D.W.A. NOBLE. 2021. Diving in hot water: a meta-analytic review of how diving vertebrate ectotherms will fare in a warmer world. Journal of Experimental Biology 224: jeb228213.

ROJAS-CANIZALES, D., N. ESPINOZA-RODRIGUEZ, M.A. RODRIGUEZ, J. PALMAR, M.G. MONTIEL-VILLALOBOS, N.E. WILDERMANN & H. BARRIOS-GARRIDO. 2021. Leatherback turtles (*Dermochelys coriacea*) in the Gulf of Venezuela: an updated stranding assessment 2001-2014. Marine and Fishery Sciences 34: 113-119.

RUBERG, E.J., T.D. WILLIAMS & J.E. ELLIOTT. 2021. Review of petroleum toxicity in marine reptiles. Ecotoxicology 30: 525-536.

RUMAIDA, M.Y., S.A. PUTRA, A. MULYADI & S. NASUTION. 2021. Nesting habitat characteristics of green sea turtle (*Chelonia* mydas) in the Tambelan archipelago, Indonesia. Journal of Coastal Conservation 25: 6.

SOLAZZO, C., J. SOULAT & T. CLELAND. 2021. Creation of a peptide database of corneous beta-proteins of marine turtles for the identification of tortoiseshell: archaeological combs as case study. Royal Society Open Science 8: 201857.

SANTOS, B.S. & L.B. CROWDER. 2021. Online news media coverage of sea turtles and their conservation. Bioscience 71: 305-313.

SARKER, S., C. HANNON, A. ATHUKORALA & H. BIELEFELDT-OHMANN. 2021. Emergence of a novel pathogenic poxvirus infection in the endangered green sea turtle (*Chelonia mydas*) highlights a key threatening process. Viruses-Basel 13: 219.

SASSO, C.R., P.M. RICHARDS, S.R. BENSON, M. JUDGE, N.F. PUTMAN, D. SNODGRASS & B.A. STACY. 2021. Leatherback turtles in the Eastern Gulf of Mexico: foraging and migration behavior during the autumn and winter. Frontiers in Marine Science 8: 660798.

SHAMBLIN, B.M., M.G. DODD, S.M. PATE, M.H. GODFREY, J.B. PFALLER, K.L. WILLIAMS, B.L. ONDICH, D.A. STEEN, E.S. DARROW, P. HILLBRAND, R. BOETTCHER, M.S. COYNE & C.J. NAIRN. 2021. In search of the "missing majority" of nesting loggerhead turtles: improved inter-seasonal recapture rates through subpopulation-scale genetic tagging. Marine Biology 168: 16.

SHAMBLOTT, K.M., J.L. RENEKER & S.J. KAMEL. 2021. The thermal impacts of beach nourishment across a regionally important loggerhead sea turtle (*Caretta caretta*) rookery. Ecosphere 12: e03396.

SHAVER, D.J., C. GREDZENS, J.S. WALKER, C.A.J. GODARD-CODDING, J.E. YACABUCCI, A. FREY, P.H. DUTTON & C.J. SCHMITT. 2021. Embryo deformities and nesting trends in Kemp's ridley sea turtles *Lepidochelys kempii* before and after the Deepwater Horizon oil spill. Endangered Species Research 44: 277-289.

SIEGFRIED, T.R., M. FUENTES, M. WARE, N.J. ROBINSON, E. ROBERTO, J.R. PIACENZA & S.E. PIACENZA. Validating the use of stereo-video cameras to conduct remote measurements of sea turtles. Ecology and Evolution 11: 8226-8237.

SINAEI, M., R. ZARE, M.T. MATIN & J. GHASEMZADEH. 2021. Marine debris and trace metal (Cu, Cd, Pb, and Zn) pollution in the stranded green sea turtles (*Chelonia mydas*). Archives of Environmental Contamination and Toxicology 80: 634-644.

SMITH, J.A., D. TOMMASI, H. WELCH, E.L. HAZEN, J. SWEENEY, S. BRODIE, B. MUHLING, S.M. STOHS & M.G. JACOX. 2021. Comparing dynamic and static time-area closures for bycatch mitigation: a management strategy evaluation of a swordfish fishery. Frontiers in Marine Science 8: 630607.

SMITH, J.R., R.J. LINDBORG, V. HERNANDEZ, E.A. ABNEY & B.E. WITHERINGTON. 2021. Using behavior indices and vital rates to determine the conservation impact of wildlife tourism: Guided sea turtle watch programs in Florida. Global Ecology and Conservation 27: e01537.

SMULDERS, F.O.H., O.R. O'SHEA & M.J.A. CHRISTIANEN. 2021. Animal-borne video reveals atypical behaviour in provisioned green turtles: a global perspective of a widespread tourist activity. Global Ecology and Conservation 25: e01417.

SOARES, L.S., K.A. BJORNDAL, A.B. BONEN, M.L. WAYNE, J.C. CASTILHOS, M.I. WEBER, M. LOPEZ-MENDILAHARSU, M.A. MARCOVALDI, S.T. VILACA & E. NARO-MACIEL. 2021. Reproductive output, foraging destinations, and isotopic niche of olive ridley and loggerhead sea turtles, and their hybrids, in Brazil. Endangered Species Research 44: 237-251.

SOLAZZO, C., J. SOULAT & T. CLELAND. 2021. Creation of a peptide database of corneous beta-proteins of marine turtles for the identification of tortoiseshell: archaeological combs as case study. Royal Society Open Science 8: 201857.

SQUIRES, D., L.T. BALLANCE, L. DAGORN, P.H. DUTTON & R. LENT. 2021. Mitigating bycatch: novel insights to multidisciplinary approaches. Frontiers in Marine Science 8: 613285.

STACY, B.A., A.M. FOLEY, D.J. SHAVER, C.M. PURVIN, L.N. HOWELL, M. COOK & J.L. KEENE. 2021. Scavenging versus predation: shark-bite injuries in stranded sea turtles in the southeastern USA. Diseases of Aquatic Organisms 143: 19-26.

SUÁREZ-DOMÍNGUEZ, E.A. 2021. Caracterizacion del microhabitat de *Chelonia mydas* (Chelonidae) en la costa central de Veracruz, Mexico. Revista Latinoamericana de Herpetología 4: 190-198.

TANABE, L.K., M. STEENACKER, M.U. RUSLI & M.L. BERUMEN. 2021. Implications of nest relocation for morphology and locomotor performance of green turtle (*Chelonia mydas*) hatchlings. Ocean & Coastal Management 207: 105591.

TAYLOR, B.K., M.K. BERNISH, S.A. PIZZUTI & C.E. KEHL. 2021. A bioinspired navigation strategy that uses magnetic signatures to navigate without GPS in a linearized northern Atlantic Ocean: a simulation study. Bioinspiration & Biomimetics 16: 4.

TAYLOR, B.K., K.J. LOHMANN, L.T. HAVENS, C.M.F. LOHMANN & J. GRANGER. 2021. Long-distance transequatorial navigation using sequential measurements of magnetic inclination angle. Journal of the Royal Society Interface 18: 20200887.

THOMSON, R.C., P.Q. SPINKS & H.B. SHAFFER. 2021. A global phylogeny of turtles reveals a burst of climate-associated diversification on continental margins. Proceedings of the National Academy of Sciences of the United States of America 118: e2012215118.

TOL, S.J., M. HARRISON, R. GROOM, J. GILBERT, D. BLAIR, R. COLES & B.C. CONGDON. 2021. Using DNA to distinguish between faeces of *Dugong dugon* and *Chelonia mydas*: non-invasive sampling for IUCN-listed marine megafauna. Conservation Genetics Resources 13: 115-117.

TRAIL, S.E. & M. SALMON. 2021. Evidence for the independent evolution of visual perception during seafinding by hatchling leatherback sea turtles (*Dermochelys coriacea*). Integrative and Comparative Biology 61: E904-E905.

TROTTA, A., M. CIRILLI, M. MARINARO, S. BOSAK, G. DIAKOUDI, S. CICCARELLI, S. PACI, D. BUONAVOGLIA & M. CORRENTE. 2021. Detection of multi-drug resistance and AmpC beta-lactamase/extended-spectrum beta-lactamase genes in bacterial isolates of loggerhead sea turtles (*Caretta caretta*) from the Mediterranean Sea. Marine Pollution Bulletin 164: 112015.

TSAI, M.A., C.C. CHANG & T.H. LI. 2021. Antimicrobial-resistance profiles of gram-negative bacteria isolated from green turtles (*Chelonia mydas*) in Taiwan. Environmental Pollution 277: 116870.

TURAN, C., B. SÖNMEZ, M. GÜRLEK, S.A. DOGDU, D. AYAS, A. ERGENLER, A. UYAN & M. TÜRKMANI. 2021. The investigations of the nesting status of the green turtle

Chelonia mydas on Yeniyurt Beach (Hatay) in the northeastern Mediterranean, Turkey. Ecological Life Science 16: 40-47.

TURNER, R.C., C.J. INNIS, B.A. STACY, J.A. HERNANDEZ, R.C. HILL, K.C. SCOTT, S. FRASCA, M.M. GARNER, R.E. BURNS, M.D. ARENDT, J. BRISSON, T.M. NORTON, S.R. WILLIAMS, A. KENNEDY, A.B. ALEXANDER & N.I. STACY. 2021. Steatitis in cold-stunned Kemp's ridley sea turtles (*Lepidochelys kempii*). Animals 11: 898.

USATEGUI-MARTIN, A., A. LIRIA-LOZA, R.A. VALVERDE, J. PINOS-CROSAS, F. TUYA, A. CARBAJAL, M. LOPEZ-BEJAR & D. MONTERO. 2021. Assessment of captive rearing conditions on loggerhead hatchlings: effect of handling frequency and stocking density. Journal of Experimental Zoology Part A-Ecological and Integrative Physiology 335: 489-498.

VASQUEZ-BULTRON, O.S., D.E. MORENO-ESPINOZA, L.T. HERNANDEZ-SALAZAR & J.E. MORALES-MAVIL. 2021. Rapid stress response in post-nesting Kemp's ridley turtle (*Lepidochelys kempii*). Salamandra 57: 146-150.

VASQUEZ-CARRILLO, C. & M. PELAEZ-OSSA. 2021. Insights into the ecology of sea turtles and the fisheries of eastern Guajira from the traditional knowledge of fishermen. Fisheries Research 238: 105915.

WANG, J.Q., C.X. GAO, F. WU, X.D. GAO, J. CHEN, X.J. DAI, S.Q. TIAN & Y. CHEN. 2021. The discards and bycatch of Chinese tuna longline fleets in the Pacific Ocean from 2010 to 2018. Biological Conservation 255: 109011.

WEI, Y.Y., B.J. SONG & S.L. YUAN. 2021. Dynamics of a ratio-dependent population model for green sea turtle with age structure. Journal of Theoretical Biology 516: 110614

WELTMEYER, A., G. DOGRUER, H. HOLLERT, J.D. OUELLET, K. TOWNSEND, A. COVACI & L. WEIJS. 2021. Distribution and toxicity of persistent organic pollutants and methoxylated polybrominated diphenylethers in different tissues of the green turtle *Chelonia mydas*. Environmental Pollution 277: 116795.

WERNECK, M.R., L.M. CONTI & D. BLAIR. 2021. *Desmogonius baldassinae* n. sp. (Digenea: Pronocephalidae) collected in a green sea turtle-*Chelonia mydas*-from Brazil. Parasitology Research 120: 2281-2285.

WILSON, P., M. THUMS, C. PATTIARATCHI, S. WHITING, M. MEEKAN & K. PENDOLEY. 2021. Nearshore wave characteristics as cues for swimming orientation in flatback turtle hatchlings. Journal of Experimental Marine Biology and Ecology 535: 151475.

WINTER, R.M., W. DE KOCK, P.J. PALSBOLL & C. CAKIRLAR. 2021. Potential applications of biomolecular archaeology to the ecohistory of sea turtles and groupers in Levant coastal antiquity. Journal of Archaeological Science-Reports 36: 102872.

WOOD, C., G.H. BALAZS, M. RICE, T.M. WORK, T.T. JONES, E. STERLING, T.M. SUMMERS, J. BROOKER, L. KURPITA, C.S. KING & J.M. LYNCH. 2021. Sea turtles across the North Pacific are exposed to perfluoroalkyl substances. Environmental Pollution 279: 116875.

YAGHMOUR, F. & C.J. RODRÍGUEZ-ZÁRATE. 2021. First record of olive ridley sea turtle *Lepidochelys olivacea* (Eschscholtz, 1829) nesting in the United Arab Emirates. Herpetology Notes 14: 353-356.

YAMAMURA, Y., K. TAKEDA, Y.K. KAWAI, Y. IKENAKA, C. KITAYAMA, S. KONDO, C. KEZUKA, M. TANIGUCHI, M. ISHIZUKA & S.M.M. NAKAYAMA. 2021. Sensitivity of turtles to anticoagulant rodenticides: Risk assessment for green sea turtles (*Chelonia mydas*) in the Ogasawara Islands and comparison of warfarin sensitivity among turtle species. Aquatic Toxicology 233: 105792.

YETSKO, K., J.A. FARRELL, N.B. BLACKBURN, L. WHITMORE, M.R. STAMMNITZ, J. WHILDE, C.B. EASTMAN, D.R. RAMIA, R. THOMAS, A. KRSTIC, P. LINSER, S. CREER, G. CARVALHO, M.A. DEVLIN, N. NAHVI, A.C. LEANDRO, T.W. DEMAAR, B. BURKHALTER, E.P. MURCHISON, C. SCHNITZLER & D.J. DUFFY. 2021. Molecular characterization of a marine turtle tumor epizootic, profiling external, internal and postsurgical regrowth tumors. Communications Biology 4: 152.

ZARDUS, J.D. 2021. Global synthesis of the correspondence between epizoic barnacles and their sea turtle hosts. Integrative Organismal Biology 3: obab002.

ZINENKO, O., K.A. VISHNYAKOVA, L. STOYANOV & P.E. GOL'DIN. 2021. The northernmost record of the loggerhead sea turtle, *Caretta caretta* (Testudines, Cheloniidae), in the Black Sea with the review of the species occurrence in the region. Zoodiversity 55: 127-132.

Nesting crawl made by leatherback sea turtle, Culebra Island, Puerto Rico. Photo: M. Godfrey.

The MTN was founded in 1976 by Nicholas Mrosvosky
at the University of Toronto, Canada

SUBSCRIPTIONS AND DONATIONS

The Marine Turtle Newsletter (MTN) is distributed quarterly to more than 2000 recipients in over 100 nations world-wide. In order to maintain our policy of free distribution and free access to colleagues throughout the world, the MTN relies heavily on donations. We appeal to all of you, our readers and contributors, for continued financial support to maintain this venture. All donations are greatly appreciated and will be acknowledged in a future issue of the MTN. Typical personal donations have ranged from $25-100 per annum, with organisations providing significantly more support. Please give what you can. Donations to the MTN are handled under the auspices of SEATURTLE.ORG and are fully tax deductible under US laws governing 501(c)(3) non-profit organisations. Donations are preferable in US dollars as a Credit Card payment (MasterCard, Visa, American Express or Discover) via the MTN website <http://www.seaturtle.org/mtn/>. In addition we are delighted to receive donations in the form of either a Personal Cheque drawn on a US bank, an International Banker's Cheque drawn on a US bank, a US Money Order, an International Postal Money Order, or by Direct Bank Wire (please contact mcoyne@seaturtle.org for details). Please do not send non-US currency cheques.

Please make cheques or money orders payable to **Marine Turtle Newsletter** and send to:

Michael Coyne (Managing Editor)
Marine Turtle Newsletter
1 Southampton Place
Durham, NC 27705, USA

Email: mcoyne@seaturtle.org