Hawksbill Turtle (*Eretmochelys imbricate)* 2013-2020

Bibliography

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Background & Scope

The hawksbill sea turtle is wide-ranging with multiple populations using many nesting beaches world-wide and foraging and migrating in the Atlantic Ocean (East, Southwest, West, Western Caribbean), Pacific Ocean (Southwest, West, Southeast Asia, East, North Central, Southwest, West Central, West), and the Indian Ocean (Southeast, Southwest, Northeast, Northwest).

This bibliography focuses on any relevant hawksbill sea turtle literature (peer-reviewed, technical reports, memos, Regional Fisheries Management Council reports, biological opinions) since 2013. It is intended as a reference resource for ESA staff of the NOAA Fisheries Office of Protected Resources and the U.S. Fish and Wildlife Service when compiling and summarizing any relevant new (i.e. 2013-present) information for this marine turtle. It is organized into four sections: Biology (life history), Ecology (interaction with the environment), Population Abundance and Trends, and Threats.

Section I – Biology

Section one is intended to provide an overview of the life history of the hawksbill turtle. The research in this area includes a compilation of diet, lifespan and habitat, migration patterns, behavior, feeding, and reproduction as well as any current literature on hawksbill turtle biology.

Section II – Ecology

Section two is intended to provide an overview of how the hawksbill turtle interacts with the environment. The research in this area includes a compilation of feeding ecology, food resources, prey composition and how climate change affects the hawksbill turtle.

Section III – Population Abundance and Trends

Section three is intended to provide an overview of the latest population estimates and trends for hawksbill turtles in all known populations specially nesting. It is divided into three main areas (Atlantic Ocean, Pacific Ocean, and Indian Ocean). In addition, any new information on the further subdivision of geographical populations within each of these three ocean basins is summarized as follows: Atlantic Ocean (East, Southwest, West, Western Caribbean), Pacific Ocean (Southwest, West, Southeast Asia, East, North Central, Southwest, West Central, West), and the Indian Ocean (Southeast, Southwest, Northeast, Northwest).

Section IV – Threats

A threat is defined as any factor that could represent an impediment to a species' recovery. Thus, section four is intended to provide an overview of any new and/or existing threats to the hawksbill turtle (i.e. poaching, coastal armoring, loss of nesting and foraging areas, bycatch, oil and gas activities, military activities, vessel interactions, disease, injury from marine debris, predation, directed hunts, trade, contaminants/pollutants, loss of prey base due to contamination and climate change, disturbance due to research, and any new threats that may be documented in the literature).

Sources Reviewed

The following databases were used to identify sources: Clarivate Analytics' Web of Science: Science Citation Index Expanded and Social Science Index; Science.gov; ProQuest's Science and Technology

including Aquatic Science Fisheries Abstracts; Elsevier's Science Direct; JSTOR; EBSCO's Academic Search Complete and Environment Complete; NOAA's Institutional Repository; the Biodiversity Heritage Library; BioOneComplete; and Google Scholar.

Section I: Biology

Barcenas-Ibarra, A., de la Cueva, H., Rojas-Lleonart, I., Abreu-Grobois, F., Lozano-Guzman, R. I., Cuevas, E., & Garcia-Gasca, A. (2015). First Approximation to Congenital Malformation Rates in Embryos and Hatchlings of Sea Turtles. *Birth Defects Research Part A: Clinical and Molecular Teratology, 103*(3), 203-224 https://doi.org/10.1002/bdra.23342

Background: Congenital malformations in sea turtles have been considered sporadical. Research carried out in the Mexican Pacific revealed high levels of congenital malformations in the olive ridley, but little or no information is available for other species. We present results from analyses of external congenital malformations in olive ridley, green, and hawskbill sea turtles from Mexican rookeries on the Pacific coast and Gulf of Mexico. METHODS: We examined 150 green and hawksbill nests and 209 olive ridley nests during the 2010 and 2012 nesting seasons, respectively. Olive ridley eggs were transferred to a hatchery and incubated in styrofoam boxes. Nests from the other two species were left in situ. Number of eggs, live and dead hatchlings, and eggs with or without embryonic development were registered. Malformation frequency was evaluated with indices of prevalence and severity. Results: Mortality levels, prevalence and severity were higher in olive ridley than in hawksbill and green sea turtles. Sixty-three types of congenital malformations were observed in embryos, and dead or live hatchlings. Of these, 38 are new reports; 35 for wild sea turtles, three for vertebrates. Thirty-one types were found in hawksbill, 23 in green, and 59 in olive ridley. The head region showed a higher number of malformation types. Malformation levels in the olive ridley were higher than previously reported. Conclusion: Olive ridleys seem more prone to the occurrence of congenital malformations than the other two species. Whether the observed malformation levels are normal or represent a health problem cannot be currently ascertained without long-term assessments.

Bell, I., & Jensen, M. P. (2018). Multinational Genetic Connectivity Identified in Western Pacific Hawksbill Turtles, *Eretmochelys imbricata*. *Wildlife Research, 45*(4), 307-315 https://doi.org/10.1071/wr17089

Context. An understanding of the genetic stock structure of wide-ranging marine species is necessary for sound conservation management. *Eretmochelys imbricata* is Critically Endangered globally, but is among the least studied marine turtles. Reduced population sizes, its long-distance migratory nature between feeding and nesting habitats and poor understanding of its stock structure, biology and anthropogenic impact(s) pose challenges to developing effective conservation strategies for regional conspecifics. Aims. Quantification of the population connectivity between specific feeding areas and regional nesting populations is needed for threat assessment and development of mitigation actions. Methods. Here, we sequenced the mitochondrial DNA (mtDNA) of 91 immature and adult foraging E. imbricata individuals captured at the Howick Group of islands in the far-northern section of the Great Barrier Reef (nGBR), Queensland, Australia. We used a Bayesian mixed-stock analysis (MSA) approach to determine the contribution of nine regional genetically characterised breeding populations to this feeding aggregation. Key results. The MSA estimated that a majority (83%; 95% CI = 70-92%) of feeding E. imbricata had originated from nesting beaches in the Bismarck-Solomon Sea region, whereas only 15% (95% CI = 6-25%) had originated from nGBR rookeries. International reproductive migrations were also corroborated by the return of 18 uniquely numbered titanium flipper tags that had been applied to E. imbricata found foraging in the Howick Group and had swum to rookeries within the Bismarck-Solomon Sea region. These 18 turtles represent 86% of all migration tag-recaptures from the Howick Group. Conclusions. We

postulate that recent increases in nesting populations within the Solomon Islands may be due to the high level of protection afforded to foraging turtles within the Great Barrier Reef.

Bellini, C., Santos, A. J. B., Patricio, A. R., Bortolon, L. F. W., Godley, B. J., Marcovaldi, M. A., . . . Colman, L. P. (2019). Distribution and Growth Rates of Immature Hawksbill Turtles *Eretmochelys imbricata* in Fernando De Noronha, Brazil. *Endangered Species Research, 40*, 41-52 https://doi.org/10.3354/esr00979

Knowledge of life history parameters is essential for the effective management of species of conservation concern. For migratory marine vertebrates such as hawksbill sea turtles *Eretmochelys imbricata*, feeding aggregations are important developmental habitats, allowing the study of population dynamics. Here, we used data from a 31 yr mark-recapture study of juvenile hawksbill sea turtles in the Fernando de Noronha Archipelago, Brazil, to estimate key demographic parameters. Turtles recruit to the neritic habitat at similar sizes to those of other Atlantic hawksbill aggregations. The curved carapace length (CCL) at the first capture ranged from 28 to 84 cm (mean +/- SD: 44.6 +/- 9.8 cm). Median minimum residence time of turtles captured at least twice was 3.2 yr, whilst long-term minimum residence of up to 14 yr was also observed, with turtles showing site fidelity within the archipelago. The mean size of turtles captured was constant throughout time. Turtles grew on average 3.4 +/- 2.2 cm yr(-1), with a monotonic expected growth rate function generally decreasing with increasing size. At these rates, hawksbill turtles in Fernando de Noronha would need to spend ca. 14-18 yr to reach minimum adult breeding size (similar to 74 cm CCL). This mark-recapture study has been essential to understanding the ecology and demographic parameters of this regional hawksbill turtle neritic foraging ground.

Camacho, M., Boada, L. D., Orós, J., López, P., Zumbado, M., Almeida-González, M., & Luzardo, O. P. (2014). Monitoring Organic and Inorganic Pollutants in Juvenile Live Sea Turtles: Results from a Study of *Chelonia mydas* and *Eretmochelys imbricata* in Cape Verde. *Science of The Total Environment, 481*, 303-310 https://doi.org/10.1016/j.scitotenv.2014.02.051

Despite the current environmental concern regarding the risk posed by contamination in marine ecosystems, the concentrations of pollutants in sea turtles have not been thoroughly elucidated. In the current study, we determined the concentrations of 18 organochlorine pesticides (OCPs), 18 polychlorinated biphenyls (PCBs), 16 polycyclic aromatic hydrocarbons (PAHs) and 11 inorganic elements (Cu, Mn, Pb, Zn, Cd, Ni, Cr, As, Al, Hg and Se) for the first time in two sea turtle species (*Chelonia mydas* and *Eretmochelys imbricata*). Only five of the 18 analyzed OCPs were detected in both species. The average total OCP concentration was higher in green turtles than in hawksbills (0.33ng/ml versus 0.20ng/ml). Higher concentrations of individual congeners and total PCBs were also detected in green turtles than in hawksbills (∑PCBs=0.73ng/ml versus 0.19ng/ml), and different PCB contamination profiles were observed in these two species. Concerning PAHs, we also observed a different contamination profile and higher levels of contamination in green turtles (∑PAHs=12.06ng/ml versus 2.95ng/ml). Di- and tri-cyclic PAHs were predominant in both populations, suggesting a petrogenic origin, rather than urban sources of PAHs. Additionally, all of the samples exhibited detectable levels of the 11 inorganic elements. In this case, we also observed relevant differences between both species. Thus, Zn was the most abundant inorganic element in hawksbills (an essential inorganic element), whereas Ni, a well-known toxicant, was the most abundant inorganic element in green turtles. The presence of contaminants is greater in green turtles relative to hawksbill turtles, suggesting a greater

exposure to hazardous chemical contaminants for green turtles. These results provide baseline data for these species that can serve for future monitoring purposes outlined in the EU's Marine Strategy Framework Directive.

Cazabon-Mannette, M., Browne, D., Austin, N., Hailey, A., & Horrocks, J. (2016). Genetic Structure of the Hawksbill Turtle Rookery and Foraging Aggregation in Tobago, West Indies. *Journal of Experimental Marine Biology and Ecology, 485*, 94-101 https://doi.org/10.1016/j.jembe.2016.09.002

Mitochondrial DNA control region haplotypes of immature hawksbills feeding in Tobago waters and adult females nesting on the beaches of Tobago were characterized. Eleven haplotypes were documented among foraging aggregations and six haplotypes among nesting females, including two which were previously of unknown natal origin. The Tobago rookery is genetically distinct from all other rookeries in the region characterized to date. Significant genetic differentiation was found between the foraging aggregations on the windward and leeward sides of Tobago. Within the rookery, greater diversity was detected among samples from the North-East coast compared to samples from the South-West coast, however no significant difference was detected based on pairwise FST. Mixed stock analysis was conducted to estimate the natal origins of immature hawksbills foraging in Tobago waters and the contribution of the Tobago rookery to regional foraging aggregations using rookery size as a constraint. The analysis estimated that the Tobago foraging aggregation is mostly composed of animals originating from Cuba, Barbados (Leeward Coast) and Puerto Rico, though this represents only a small fraction of the production from these rookeries. The impact of harvest of juveniles in Tobago is likely to be distributed across the region and not concentrated on any particular rookery. A significant proportion of individuals from the Tobago rookery contributes to the foraging aggregation of the Cayman Islands, and a large proportion of both the Cayman Islands and Puerto Rico foraging aggregations are derived from the Tobago rookery.

Correa, G. V. V., Ingels, J., Valdes, Y. V., Fonseca-Genevois, V. G., Farrapeira, C. M. R., & Santos, G. A. P. (2014). Diversity and Composition of Macro- and Meiofaunal Carapace Epibionts of the Hawksbill Sea Turtle (*Eretmochelys imbricata* Linnaeus, 1822) in Atlantic Waters. *Marine Biodiversity, 44*(3), 391-401 https://doi.org/10.1007/s12526-013-0189-9

The presence of macro-epibionts on turtle carapaces is a well-known phenomenon, whereby carapaces are occupied by dynamic and fully functional epibiont communities. However, meiofaunal organisms have been largely ignored in turtle shell studies despite their omnipresence and higher abundances and diversity than the macrofauna. Epifauna from the hawksbill sea turtle *Eretmochelys imbricata* was investigated during summer 2010 with the aim to advance our knowledge on meiofaunal epibiont communities on turtle carapaces and gain insights into their interaction with settled macrofauna. Eighteen epibiont higher taxa were found (17 meiofauna, 5 macrofauna), 5 of which are common for macro- and meiofauna. Meiofauna was present on all turtle carapaces, but macrofauna occurred on only 8 out of 19 investigated carapaces, suggesting that carapace colonization by meiofauna precedes macrofauna recruitment. In addition, the macrofauna embedded on the carapaces increased the microhabitat complexity, favoring richer and more abundant meiofauna communities. The significant positive correlations between meiofauna and macrofauna taxa (up to 90 %) suggests the presence of mutual facilitating processes and indicates the positive effects between meio- and macrofaunal epibionts important for their recruitment and establishment. The hawksbill sea turtle carapaces were

occupied by fully functional and active epifaunal communities, with adult and reproductive stages for most meiofaunal and macrofaunal taxa. Turtle carapaces can therefore be seen as a biological substrate that can serve as a platform for faunal dispersal, as has been observed for barnacles, enhancing the geographical distribution of several species through sea turtle migration. In addition to the main focus of this paper on meio- and macrofaunal epibiont communities, we provide an updated list of taxa found on carapaces of the hawksbill sea turtle and discuss the geographical scope and dispersion potential of some of these taxa.

Cortés-Gómez, A. A., Romero, D., & Girondot, M. (2017). The Current Situation of Inorganic Elements in Marine Turtles: A General Review and Meta-Analysis. *Environmental Pollution, 229*, 567-585 https://doi.org/10.1016/j.envpol.2017.06.077

Inorganic elements (Pb, Cd, Hg, Al, As, Cr, Cu, Fe, Mn, Ni, Se and Zn) are present globally in aquatic systems and their potential transfer to marine turtles can be a serious threat to their health status. The environmental fate of these contaminants may be traced by the analysis of turtle tissues. Loggerhead turtles (*Caretta caretta*) are the most frequently investigated of all the sea turtle species with regards to inorganic elements, followed by Green turtles (*Chelonia mydas*); all the other species have considerably fewer studies. Literature shows that blood, liver, kidney and muscle are the tissues most frequently used for the quantification of inorganic elements, with Pb, Cd, Cu and Zn being the most studied elements. *Chelonia mydas* showed the highest concentrations of Cr in muscle (4.8 ± 0.12), Cu in liver (37 ± 7) and Mg in kidney (17 µg g−1 ww), Cr and Cu from the Gulf of Mexico and Mg from Japanese coasts; *Lepidochelys olivacea* presented the highest concentrations of Pb in blood (4.46 5) and Cd in kidney (150 ± 110 µg g−1 ww), both from the Mexican Pacific*; Caretta caretta* from the Mediterranean Egyptian coast had the highest report of Hg in blood (0.66 ± 0.13 µg g−1 ww); and *Eretmochelys imbricata* from Japan had the highest concentration of As in muscle (30 ± 13 13 µg g−1 ww). The meta-analysis allows us to examine some features that were not visible when data was analyzed alone. For instance, Leatherbacks show a unique pattern of concentration compared to other species. Additionally, contamination of different tissues shows some tendencies independent of the species with liver and kidney on one side and bone on the other being different from other tissues. This review provides a general perspective on the accumulation and distribution of these inorganic elements alongside existing information for the 7 sea turtle species.

Daza-Criado, L., & Hernandez-Fernandez, J. (2014). Molecular Identification and First Report of Mitochondrial Coi Gene Haplotypes in the Hawksbill Turtle *Eretmochelys imbricata* (Testudines: Cheloniidae) in the Colombian Caribbean Nesting Colonies. *Genetics and Molecular Research, 13*(3), 7123-7132 https://doi.org/10.4238/2014.February.21.14

Hawksbill sea turtles *Eretmochelys imbricata* are found extensively around the world, including the Atlantic, Pacific, and Indian Oceans; the Persian Gulf, and the Red and Mediterranean Seas. Populations of this species are affected by international trafficking of their shields, meat, and eggs, making it a critically endangered animal. We determined the haplotypes of 17 hawksbill foraging turtles of Islas del Rosario (Bolivar) and of the nesting beach Don Diego (Magdalena) in the Colombian Caribbean based on amplification and sequencing of the mitochondrial gene cytochrome oxidase c subunit I (COI). We identified 5 haplotypes, including EI-A1 previously reported in Puerto Rico, which was similar to 10 of the study samples. To our knowledge, the remaining 4 haplotypes have not been described. Samples EICOI11 and EICOI3 showed 0.2% divergence from EI-A1, by a single nucleotide change, and were

classified as the EI-A2 haplotype. EICOI6, EICOI14, and EICOI12 samples showed 0.2% divergence from EI-A1 and 0.3% divergence from EI-A2 and were classified as EI-A3 haplotype. Samples EICOI16 and EICOI15 presented 5 nucleotide changes each and were classified as 2 different haplotypes, EI-A4 and EI-A5, respectively. The last 2 haplotypes had higher nucleotide diversity (K2P = 1.7%) than that by the first 3 haplotypes. EI-A1 and EI-A2 occurred in nesting individuals, and EI-A2, EI-A3, EI-A4, and EI-A5 occurred in foraging individuals. The description of the haplotypes may be associated with reproductive migrations or foraging and could support the hypothesis of natal homing. Furthermore, they can be used in phylogeographic studies.

de Macêdo, G. R., B. Tarantino, T., Barbosa, I. S., Pires, T. T., Rostan, G., Goldberg, D. W., . . . Franke, C. R. (2015). Trace Elements Distribution in Hawksbill Turtle (*Eretmochelys imbricata*) and Green Turtle (*Chelonia mydas*) Tissues on the Northern Coast of Bahia, Brazil. *Marine Pollution Bulletin, 94*(1), 284-289 https://doi.org/10.1016/j.marpolbul.2015.02.033

Concentrations of elements (As, Al, Ba, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sr, V, Zn) were determined in liver, kidneys and bones of *Eretmochelys imbricata* and *Chelonia mydas* specimens found stranded along the northern coast of Bahia, Brazil. Results showed that the concentrations of Cd, Cu, Ni and Zn in the liver and kidneys of juvenile C. mydas were the highest found in Brazil. We also observed a significant difference ($p<0.05$) on the bioaccumulation of trace elements between the two species: Al, Co, Mo, Na and Se in the liver; Al, Cr, Cu, K, Mo, Ni, Pb, Sr and V in the kidneys; and Al, Ba, Ca, Cd, Mn, Ni, Pb, Se, Sr and V in the bones. This study represents the first report on the distribution and concentration of trace elements in *E. imbricata* in the Brazilian coast.

dei Marcovaldi, M. A. G., Santos, A. J. B., Santos, A. S., Soares, L. S., Lopez, G. G., Godfrey, M. H., . . . Fuentes, M. M. P. B. (2014). Spatio-Temporal Variation in the Incubation Duration and Sex Ratio of Hawksbill Hatchlings: Implication for Future Management. *Journal of Thermal Biology, 44*, 70-77 https://doi.org/10.1016/j.jtherbio.2014.06.010

Climate change poses a unique threat to species with temperature dependent sex determination (TSD), such as marine turtles, where increases in temperature can result in extreme sex ratio biases. Knowledge of the primary sex ratio of populations with TSD is key for providing a baseline to inform management strategies and to accurately predict how future climate changes may affect turtle populations. However, there is a lack of robust data on offspring sex ratio at appropriate temporal and spatial scales to inform management decisions. To address this, we estimate the primary sex ratio of hawksbill hatchlings, *Eretmochelys imbricata*, from incubation duration of 5514 in situ nests from 10 nesting beaches from two regions in Brazil over the last 27 years. A strong female bias was estimated in all beaches, with 96% and 89% average female sex ratios produced in Bahia (BA) and Rio Grande do Norte (RN). Both inter-annual (BA, 88 to 99%; RN, 75 to 96% female) and inter-beach (BA, 92% to 97%; RN, 81% to 92% female) variability in mean offspring sex ratio was observed. These findings will guide management decisions in Brazil and provide further evidence of highly female-skew sex ratios in hawksbill turtles.

Delgado-Cano, D., Mariño-Ramirez, L., & Hernández-Fernández, J. (2020). Data on Heteroplasmic Mutations in Mitochondrial Genomes of Loggerhead and Hawksbill Sea Turtles: First Approach. *Data in Brief, 28*, 104882 https://doi.org/10.1016/j.dib.2019.104882

The populations of loggerhead (*Caretta caretta*) and hawksbill (*Eretmochelys imbricata*) sea turtles are suffering an exponential decline due to anthropic and environmental actions that threaten their survival. In these turtle populations, the degree of heteroplasmic mutations commonly related with pathologies, has not been studied. In this data report, the specifications of each heteroplasmic site (region, mutation, length) and the percentage of heteroplasmy of each gene for four mitochondrial genomes of turtles (loggerhead: Cc1, Cc2, Cc3 and hawksbill: Ei1) are presented. The highest value of heteroplasmy in tRNA was of 83.33% for the Cc2 turtle (tRNASer gene), in protein coding genes was 38.62% for Cc2 (ND5), and in rRNA genes of 0.74% for Ei1 turtle (rRNA-16S). The variability data obtained will be useful for further conservation projects, evolution studies and population health of these species. This is the first study of heteroplasmy in complete mitogenomes of loggerhead and hawksbill turtles.

dos Santos, G. A. P., Corrêa, G. V. V., Valdes, Y., Apolônio Silva de Oliveira, D., Fonsêca-Genevois, V. G., Silva, A. C., . . . Ingels, J. (2018). *Eretmochelys imbricata* Shells Present a Dynamic Substrate for a Facilitative Epibiont Relationship between Macrofauna Richness and Nematode Diversity, Structure and Function. *Journal of Experimental Marine Biology and Ecology, 502*, 153-163 https://doi.org/10.1016/j.jembe.2017.08.009

Although nematodes are the most abundant metazoans in marine environments and present an important biological and ecological model organism to assess marine ecosystem processes and functions, there are in fact very few studies that use nematodes to investigate ecological communities and relationships on “mobile” ecosystems. Arguably one of the most mobile or dynamic marine ecosystems is a sea turtle carapace, hosting tens to hundreds or even thousands of epibiotic organisms; and as the turtle breeds, feeds and migrates, provides an ecosystem that is continuously exposed to changes and potential colonizers. In this study we investigated the nematode communities associated with 19 Hawksbill sea turtle carapaces (*Eretmochelys imbricata*), and compared nematode structural (composition, richness and diversity) and functional (trophic types and gender/life stages) community parameters with those of other comparable epibiotic substrates (macrophytes, natural and artificial hard substrates) to see whether turtle carapaces are hotspots of nematode diversity and function among substrates suitable for epifauna. We also addressed potential epibiotic macrofauna-nematode interactions by looking at the relationships between macrofauna richness and nematode richness, diversity and community composition. Results suggest that the macrofauna play a bioconstructing role, creating several microenvironments, and thereby enhancing the richness and diversity of the associated nematode assemblages. This was supported by a direct and positive relationship between macrofauna and nematode richness, and implies a genera enrichment process across size classes and phyla. All heterotrophic nematode feeding guilds were recovered from the carapaces, with dominance of predators/omnivores and epistrate feeders. Nematode juveniles dominated in terms of abundance, and a female/male ratio of 1.11 was observed. Nematode richness and diversity were higher than found on other substrates, but feeding guild, gender and life stage structure did not differ compared to nematode communities from all other epibiotic substrates. As a result, we argue that turtle carapaces can be seen as hotspots for nematode biodiversity compared to other epibiotic substrates, but this is not reflected in the function of the nematode community. This study is the first to investigate in detail sea turtle carapace nematode communities, their richness, diversity, trophic and life cycle structure, and potential interactions with their co-epibionts, the macrofauna.

Eduardo, S. L., & Diaz, J. L. (2013). New Records of Four Digenean (Platyhelminthes) Species Parasitic in Sea Turtles (Reptilia: Chelonia) in the Philippines. *Philippine Journal of Veterinary Medicine, 50*(2), 112-115 Retrieved from https://ejournals.ph/article.php?id=3813

Four species of Digenea from sea turtles are reported for the first time in the Philippines constituting new locality record for the species. The species with their respective superfamilies and families are: Schizamphistomum scleroporum (Creplin, 1844) and S. erratum Blair, 1983; (Paramphistomatoidea, Cladorchiidae); Rhytidodes gelatinosus Looss, 1901 (Echinostomatoidea, Rhytidodidae) and Enodiotrema reductum Looss, 1901 (Plagiorchioidea: Plagiorchiidae). The first two species were from the stomach and intestines of *Chelonia mydas* (green sea turtle) and the latter two species were recovered from the intestines of *Eretmochelys imbricata* (hawksbill sea turtle). They are here discussed and photomicrographs of them are provided based on the present materials.

Ehsanpour, M., Afkhami, M., Khoshnood, R., & Reich, K. J. (2014). Determination and Maternal Transfer of Heavy Metals (Cd, Cu, Zn, Pb and Hg) in the Hawksbill Sea Turtle (*Eretmochelys imbricata*) from a Nesting Colony of Qeshm Island, Iran. *Bulletin of Environmental Contamination and Toxicology, 92*(6), 667-673 https://doi.org/10.1007/s00128-014-1244-3

This study was conducted to determine trace metal concentrations (Cd, Cu, Zn, Pb and Hg) in blood and three egg fractions from *Eretmochelys imbricata* nesting on Qeshm Island in Iran. The results showed detectable levels of all analytes in all fractions. Pb and Hg were detectable in the blood and eggs, reflecting a maternal transfer. With the exception of Cu and Pb, analyzed elements in eggs were concentrated in yolk. Only Zn in blood had a significant correlation with the body size and weight ($p < 0.01$). It appears that Hawksbill sea turtles can regulate Zn concentrations through homeostatic processes to balance metabolic requirements. The relatively low concentrations of metals in blood support the knowledge that E. imbricata feed mainly on the low trophic levels. All essential and non-essential elements were detectable in blood and in eggs of the hawksbill, reflecting a maternal transfer. Consequently, movement patterns, home ranges of foraging grounds, and availability of food could explain variations in trace element concentrations among female turtles.

Ehsanpour, M., Ahmadi, M. R., Bahri, A. H., Afkhami, M., & Reich, K. J. (2015). Plasma Biochemistry Values in Wild Female Hawksbill Turtles (*Eretmochelys imbricata*), During Nesting and Foraging Seasons in Qeshm Island, Persian Gulf. *Comparative Clinical Pathology, 24*(3), 561-566 https://doi.org/10.1007/s00580-014-1945-3

Normal reference ranges of biochemical parameters are considered important for assessing and monitoring the health status of sea turtles. For this study, plasma biochemistry determinations were analyzed in normal adult nesting and foraging hawksbill turtles (*Eretmochelys imbricata*). Blood samples were collected in March-April during (nesting season) and December-November (foraging season). Differences in plasma biochemistry values, except for creatinine and lipase, were statistically different ($P<0.05$) between the two periods. Glucose, cholesterol, triglycerides, ALP (alkaline phosphates), AST (aspartate aminotransferase), bilirubin, total protein, LDH (lactate dehydrogenize), CK (creatine kinase), and amylase were significantly higher in nesting season than foraging season ($P<0.05$). Whereas, urea, ALT (alanine aminotransferase), and albumin in the nesting season were significantly lower than during the foraging season ($P<0.05$). It was concluded that the nesting E. imbricata showed significant variation in their biochemical profile due to reproductive output. This study has produced working reference

intervals useful for hawksbill turtles for future conservation and rehabilitation projects in the Persian Gulf and may be of assistance in similar programs worldwide.

Gaos, A. R., Lewison, R. L., Liles, M. J., Gadea, V., Altamirano, E., Henriquez, A. V., . . . Dutton, P. H. (2016). Hawksbill Turtle Terra Incognita: Conservation Genetics of Eastern Pacific Rookeries. *Ecology and Evolution, 6*(4), 1251-1264 https://doi.org/10.1002/ece3.1897

Prior to 2008 and the discovery of several important hawksbill turtle (*Eretmochelys imbricata*) nesting colonies in the EP (Eastern Pacific), the species was considered virtually absent from the region. Research since that time has yielded new insights into EP hawksbills, salient among them being the use of mangrove estuaries for nesting. These recent revelations have raised interest in the genetic characterization of hawksbills in the EP, studies of which have remained lacking to date. Between 2008 and 2014, we collected tissue samples from 269 nesting hawksbills at nine rookeries across the EP and used mitochondrial DNA sequences (766bp) to generate the first genetic characterization of rookeries in the region. Our results inform genetic diversity, population differentiation, and phylogeography of the species. Hawksbills in the EP demonstrate low genetic diversity: We identified a total of only seven haplotypes across the region, including five new and two previously identified nesting haplotypes (pooled frequencies of 58.4% and 41.6%, respectively), the former only evident in Central American rookeries. Despite low genetic diversity, we found strong stock structure between the four principal rookeries, suggesting the existence of multiple populations and warranting their recognition as distinct management units. Furthermore, haplotypes EiIP106 and EiIP108 are unique to hawksbills that nest in mangrove estuaries, a behavior found only in hawksbills along Pacific Central America. The detected genetic differentiation supportsthe existence of a novel mangrove estuary reproductive ecotype that may warrant additional conservation attention. From a phylogeographic perspective, our research indicates hawksbills colonized the EP via the Indo-Pacific, and do not represent relict populations isolated from the Atlantic by the rising of the Panama Isthmus. Low overall genetic diversity in the EP is likely the combined result of few rookeries, extremely small reproductive populations and evolutionarily recent colonization events. Additional research with larger sample sizes and variable markers will help further genetic understanding of hawksbill turtles in the EP.

García-Besné, G., Valdespino, C., & Rendón-von Osten, J. (2015). Comparison of Organochlorine Pesticides and Pcb Residues among Hawksbill (*Eretmochelys imbricata*) and Green (*Chelonia mydas*) Turtles in the Yucatan Peninsula and Their Maternal Transfer. *Marine Pollution Bulletin, 91*(1), 139-148 https://doi.org/10.1016/j.marpolbul.2014.12.015

Organochlorine pesticides and PCB (POPs) concentrations were determined in the blood and eggs of green and hawksbill turtles. We compared concentrations between species, analyzed the relationship between turtle size and the POPs concentrations and the relationship between the concentrations in the blood of the nesting turtles and their eggs. We expected higher concentrations in the hawksbill turtle because of its higher trophic level, but concentrations were not higher in all the cases. Significant differences were found in δ-HCH blood concentrations. Lindane, heptachlor epoxide and PCB 101 concentrations were significantly higher in the hawksbill eggs. The relationship between the size of the turtles and the POP concentrations in the eggs of the hawksbills showed a negative correlation. No correlation was found between the size of the female and concentrations in the blood. In eggs, only the hawksbill turtles exhibited negative correlation in the concentration of mirex and PCB 44 and size.

Gleason, F. H., Allerstorfer, M., & Lilje, O. (2020). Newly Emerging Diseases of Marine Turtles, Especially Sea Turtle Egg Fusariosis (SEFT), Caused by Species in the *Fusarium solani* Complex (FSSC). *Mycology*, 1-11 https://doi.org/10.1080/21501203.2019.1710303

Sea turtles are presently considered severely endangered species that are historically threatened by many environmental factors. Recently, additional threats to sea turtles from two pathogenic species of fungi in the Fusarium solani species complex (F. falciforme and F. keratoplasticum) have been identified. These species infect marine turtle eggs, causing sea turtle egg fusariosis, and kill their embryos, with recent reports of hatch-failure in seven globally distributed species of endangered sea turtles (*Caretta caretta, Chelonia mydas, Dermochelys coriaceae, Eretmochelys imbricata, Lepidochelys olivacea, Lepidochelys kempi* and *Natator depressus*). Mycelia and spores of pathogenic species of Fusarium are produced in disturbed terrestrial soils and are transported to the ocean in coastal run off. We propose that these fungi grow on floating particles of plant tissues (leaves and wood), animal tissues, silt and plastics, which are carried by wind and currents and the turtles themselves to the beaches where the turtles lay their eggs.

Goldberg, D. W., Leitao, S. A. T., Godfrey, M. H., Lopez, G. G., Santos, A. J. B., Neves, F. A., . . . Bastos, V. (2013). Ghrelin and Leptin Modulate the Feeding Behaviour of the Hawksbill Turtle *Eretmochelys imbricata* During Nesting Season. *Conservation Physiology, 1*(1) https://doi.org/10.1093/conphys/cot016

Female sea turtles have rarely been observed foraging during the nesting season. This suggests that prior to their migration to nesting beaches the females must store sufficient energy and nutrients at their foraging grounds and must be physiologically capable of undergoing months without feeding. Leptin (an appetite-suppressing protein) and ghrelin (a hunger-stimulating peptide) affect body weight by influencing energy intake in all vertebrates. We investigated the levels of these hormones and other physiological and nutritional parameters in nesting hawksbill sea turtles in Rio Grande do Norte State, Brazil, by collecting consecutive blood samples from 41 turtles during the 2010-2011 and 2011-2012 reproductive seasons. We found that levels of serum leptin decreased over the nesting season, which potentially relaxed suppression of food intake and stimulated females to begin foraging either during or after the post-nesting migration. Concurrently, we recorded an increasing trend in ghrelin, which may have stimulated food intake towards the end of the nesting season. Both findings are consistent with the prediction that post-nesting females will begin to forage, either during or immediately after their post-nesting migration. We observed no seasonal trend for other physiological parameters (values of packed cell volume and serum levels of alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, gamma-glutamyl transferase, low-density lipoprotein, and high-density lipoprotein). The observed downward trends in general serum biochemistry levels were probably due to the physiological challenge of vitellogenesis and nesting in addition to limited energy resources and probable fasting.

Gonzalez-Garza, B. I., Stow, A., Sanchez-Teyer, L. F., & Zapata-Perez, O. (2015). Genetic Variation, Multiple Paternity, and Measures of Reproductive Success in the Critically Endangered Hawksbill Turtle (*Eretmochelys imbricata*). *Ecology and Evolution, 5*(24), S758-S769 https://doi.org/10.1002/ece3.1844

The Yucatan Peninsula in Mexico contains some of the largest breeding groups of the globally distributed and critically endangered hawksbill turtle (*Eretmochelys imbricata*). An improved understanding of the breeding system of this species and how its genetic variation is structured among nesting areas is required before the threats to its survival can be properly evaluated. Here, we genotype 1195 hatchlings and 41 nesting females at 12 microsatellite loci to assess levels of multiple paternity, genetic variation and whether individual levels of homozygosity are associated with reproductive success. Of the 50 clutches analyzed, only 6% have multiple paternity. The distribution of pairwise relatedness among nesting localities (rookeries) was not random with elevated within-rookery relatedness, and declining relatedness with geographic distance indicating some natal philopatry. Although there was no strong evidence that particular rookeries had lost allelic variation via drift, younger turtles had significantly lower levels of genetic variation than older turtles, suggesting some loss of genetic variation. At present there is no indication that levels of genetic variation are associated with measures of reproductive success such as clutch size, hatching success, and frequency of infertile eggs.

Gopper, B. M., Voogt, N. M., & Ganswindt, A. (2018). First Record of the Marine Turtle Leech (*Ozobranchus margoi*) on Hawksbill Turtles (*Eretmochelys imbricata*) in the Inner Granitic Seychelles. *Onderstepoort Journal of Veterinary Research, 85*(1) https://doi.org/10.4102/ojvr.v85i1.1604

Ozobranchus spp. are leeches that feed solely on turtle blood. They are common ectopara sites found on a range of marine turtle species, with some species of the leech being implicated as vectors of fibropapilloma-associated turtle herpesvirus (FPTHV). Green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles are the two commonly occurring species in the inner granitic islands of the Seychelles. Routine monitoring of nesting turtles on Cousine Island, Seychelles, allowed for opportunistic sightings of leeches on two hawksbill females. In both cases infestation was low, with three leeches collected off one female turtle and five off the other. No obvious signs of papillomas secondary to infection of FPTHV were seen. All of the turtle leeches collected were determined to be Ozobranchus margoi as they had five pairs of lateral digiform branchiae. The specimens were deposited in the Seychelles Natural History Museum on Mahe. To the best of our knowledge this is the first record of Ozobranchus margoi recorded in the inner granitic Seychelles on hawksbill turtles.

Gruber, D. F., & Sparks, J. S. (2015). First Observation of Fluorescence in Marine Turtles. *American Museum Novitates, 2015*(3845), 1-8, 8 https://doi.org/10.1206/3845.1

In recent years, biofluorescence has been observed in an increasing diversity of animals. Biofluorescence has been primarily examined in cnidarians, and it is also known to occur in other marine animal phyla, including Ctenophora, Annelida, Arthropoda, and Chordata. Most recently, the phenomenon has been shown to be phylogenetically widespread and phenotypically variable in cartilaginous and ray-finned fishes. Here we report on the first observation of fluorescence in a marine tetrapod, sea turtles.

Hawkes, L. A., McGowan, A., Broderick, A. C., Gore, S., Wheatley, D., White, J., . . . Godley, B. J. (2014). High Rates of Growth Recorded for Hawksbill Sea Turtles in Anegada, British Virgin Islands. *Ecology and Evolution, 4*(8), 1255-1266 https://doi.org/10.1002/ece3.1018

Management of species of conservation concern requires knowledge of demographic parameters, such as rates of recruitment, survival, and growth. In the Caribbean, hawksbill turtles (*Eretmochelys imbricata*) have been historically exploited in huge numbers to satisfy trade in their shells and meat. In the present study, we estimated growth rate of juvenile hawksbill turtles around Anegada, British Virgin Islands, using capture-mark-recapture of 59 turtles over periods of up to 649days. Turtles were recaptured up to six times, having moved up to 5.9km from the release location. Across all sizes, turtles grew at an average rate of 9.3cmyear(-1) (range 2.3-20.3cmyear(-1)), and gained mass at an average of 3.9kgyear(-1) (range 850g-16.1kgyear(-1)). Carapace length was a significant predictor of growth rate and mass gain, but there was no relationship between either variable and sea surface temperature. These are among the fastest rates of growth reported for this species, with seven turtles growing at a rate that would increase their body size by more than half per year (51-69% increase in body length). This study also demonstrates the importance of shallow water reef systems for the developmental habitat for juvenile hawksbill turtles. Although growth rates for posthatching turtles in the pelagic, and turtles larger than 61cm, are not known for this population, the implications of this study are that Caribbean hawksbill turtles in some areas may reach body sizes suggesting sexual maturity in less time than previously considered.

Hawkes, L. A., McGowan, A., Godley, B. J., Gore, S., Lange, A., Tyler, C. R., . . . Broderick, A. C. (2013). Estimating Sex Ratios in Caribbean Hawksbill Turtles: Testosterone Levels and Climate Effects. *Aquatic Biology, 18*(1), 9-19 https://doi.org/10.3354/ab00475

Evolutionary theory predicts that male and female offspring should be produced at a 1:1 ratio, but this may rarely be the case for species in which sex is determined during incubation by temperature, such as marine turtles. Estimates of primary sex ratio suggest that marine turtle sex ratios are highly skewed, with up to 9 females per male. We captured juvenile hawksbill turtles *Eretmochelys imbricata* in waters around Anegada, British Virgin Islands, a regionally important foraging aggregation, and analysed concentrations of plasma testosterone and oestradiol-1713 from 62 turtles to estimate sex ratio. There were 2.4 to 7.7 times more females than males. Testosterone concentrations correlated with sampling date and sea surface temperature (SST), with higher concentrations in the late summer when SST was highest, suggesting that assigning sex through threshold values of sex hormones must be carried out cautiously. The sex ratio in the juvenile foraging aggregation around Anegada is more male biased than at other locations, suggesting that turtles at Anegada have resilience against feminising effects of climate change. Future work should (1) integrate the relative contributions of different genetic stocks to foraging aggregations and (2) investigate the annual and seasonal cycles of sex hormones, and differences among individuals and life history stages.

Hernández-Fernández, J. (2017). Data of First De-Novo Transcriptome Assembly of a Non-Model Species, Hawksbill Sea Turtle, *Eretmochelys Imbricate*, Nesting of the Colombian Caribean. *Data in Brief, 15*, 573-576 https://doi.org/10.1016/j.dib.2017.10.015

The hawksbill sea turtle*, Eretmochelys imbricata*, is an endangered species of the Caribbean Colombian coast due to anthropic and natural factors that have decreased their population levels. Little is known about the genes that are involved in their immune system, sex determination, aging and others important functions. The data generated represents RNA sequencing and the first de-novo assembly of transcripts expressed in the blood of the hawksbill sea turtle. The raw FASTQ files were deposited in the NCBI SRA database with accession number SRX2653641. A total of 5.7Gb raw sequence data were

obtained, corresponding to 47,555,108 raw reads. Trinity was used to perform a first de-novo assembly, and we were able to identify 47,586 transcripts of the female hawksbill turtle transcriptome with an N50 of 1100bp. The obtained transcriptome data will be useful for further studies of the physiology, biochemistry and evolution in this species.

Hernandez-Fernandez, J., Beltran-Torres, G., & Marino-Ramirez, L. (2017). Complete Mitochondrial Genome of the Nesting Colombian Caribbean Hawksbill Turtle. *Mitochondrial DNA Part B-Resources, 2*, 128-129 https://doi.org/10.1080/23802359.2017.1292477

The hawksbill turtle, *Eretmochelis imbricata* (Linnaeus, 1766), is an endangered sea turtle in Colombian Caribbean beach. In this study, we report the complete mitochondrial DNA sequences of hawksbill turtle. The entire genome comprised 16,386 base pairs, and a nucleotide frequency of T: 25.6%, C: 26.9%, A: G 35.4% and 12.1%. The mitogenome sequence of hawksbill turtle would contribute to better understand population genetics, and evolution of sea turtles. Molecule was deposited at the GenBank database under the accession number KP221806.

Hill, J. E., King, C. M., Stewart, K. R., Paladino, F. V., & Dutton, P. H. (2018). Genetic Differentiation of Hawksbill Turtle Rookeries on St. Croix, US Virgin Islands. *Chelonian Conservation and Biology, 17*(2), 303-308 https://doi.org/10.2744/ccb-1293.1

We collected tissue samples from 41 nesting hawksbill turtles (*Eretmochelys imbricata*) at Sandy Point National Wildlife Refuge, St. Croix, US Virgin Islands, to characterize the genetic structure of this rookery in terms of mitochondrial DNA; we compared haplotype frequencies from this rookery to those from Buck Island, another hawksbill nesting beach on St. Croix. Pairwise F-ST comparisons showed that Sandy Point was demographically distinct from Buck Island (F-ST = 0.501, $p < 0.001$), a finding reinforced by significantly different haplotype frequencies (chi(2) = 51.76, $p < 0.001$) and a lack of interchange of nesting females between both sites based on mark- recapture data. Our results support the delineation of the nesting populations at Sandy Point and Buck Island into separate units for the purposes of management.

Ives, A. K., Antaki, E., Stewart, K., Francis, S., Jay-Russell, M. T., Sithole, F., . . . Soto, E. (2017). Detection of *Salmonella enterica* Serovar Montevideo and Newport in Free-Ranging Sea Turtles and Beach Sand in the Caribbean and Persistence in Sand and Seawater Microcosms. *Zoonoses and Public Health, 64*(6), 450-459 https://doi.org/10.1111/zph.12324

Summary Salmonellae are Gram-negative zoonotic bacteria that are frequently part of the normal reptilian gastrointestinal flora. The main objective of this project was to estimate the prevalence of non-typhoidal Salmonella enterica in the nesting and foraging populations of sea turtles on St. Kitts and in sand from known nesting beaches. Results suggest a higher prevalence of Salmonella in nesting leatherback sea turtles compared with foraging green and hawksbill sea turtles. Salmonella was cultured from 2/9 and identified by molecular diagnostic methods in 3/9 leatherback sea turtle samples. SalmonellaDNA was detected in one hawksbill turtle, but viable isolates were not recovered from any hawksbill sea turtles. No Salmonella was detected in green sea turtles. In samples collected from nesting beaches, Salmonella was only recovered from a single dry sand sample. All recovered isolates were positive for the wzx gene, consistent with the O:7 serogroup. Further serotyping characterized serovars

Montevideo and Newport present in cloacal and sand samples. Repetitive-element palindromic PCR (rep-PCR) fingerprint analysis and pulsed-field gel electrophoresis of the 2014 isolates from turtles and sand as well as archived Salmonella isolates recovered from leatherback sea turtles in 2012 and 2013, identified two distinct genotypes and four different pulsotypes, respectively. The genotyping and serotyping were directly correlated. To determine the persistence of representative strains of each serotype/genotype in these environments, laboratory-controlled microcosm studies were performed in water and sand (dry and wet) incubated at 25 or 35°C. Isolates persisted for at least 32 days in most microcosms, although there were significant decreases in culturable bacteria in several microcosms, with the greatest reduction in dry sand incubated at 35°C. This information provides a better understanding of the epizootiology of Salmonella in free-ranging marine reptiles and the potential public health risks associated with human interactions with these animals in the Caribbean.

Jeantet, L., Dell'Amico, F., Forin-Wiart, M. A., Coutant, M., Bonola, M., Etienne, D., . . . Chevallier, D. (2018). Combined Use of Two Supervised Learning Algorithms to Model Sea Turtle Behaviours from Tri-Axial Acceleration Data. *Journal of Experimental Biology, 221*(10) https://doi.org/10.1242/jeb.177378

Accelerometers are becoming ever more important sensors in animal-attached technology, providing data that allow determination of body posture and movement and thereby helping to elucidate behaviour in animals that are difficult to observe. We sought to validate the identification of sea turtle behaviours from accelerometer signals by deploying tags on the carapace of a juvenile loggerhead (*Caretta caretta*), an adult hawksbill (*Eretmochelys imbricata*) and an adult green turtle (*Chelonia mydas*) at Aquarium La Rochelle, France. We recorded tri-axial acceleration at 50 Hz for each species for a full day while two fixed cameras recorded their behaviours. We identified behaviours from the acceleration data using two different supervised learning algorithms, Random Forest and Classification And Regression Tree (CART). treating the data from the adult animals as separate from the juvenile data. We achieved a global accuracy of 81.30% for the adult hawksbill and green turtle CART model and 71.63% for the juvenile loggerhead, identifying 10 and 12 different behaviours. respectively. Equivalent figures were 86.96% for the adult hawksbill and green turtle Random Forest model and 79.49% for the juvenile loggerhead, for the same behaviours. The use of Random Forest combined with CART algorithms allowed us to understand the decision rules implicated in behaviour discrimination, and thus remove or group together some 'confused' or under-represented behaviours in order to get the most accurate models. This study is the first to validate accelerometer data to identify turtle behaviours and the approach can now be tested on other captive sea turtle species.

Jensen, M., LaCasella, E., Dutton, P., & Madden Hof, C. (2019). *Cracking the Code: Developing a Tortoiseshell DNA Extraction and Source Detection Method.* WWF-Australia Sydney, Australia. Retrieved from https://www.wwf.org.au/ArticleDocuments/353/pub-cracking-the-code-2019-21aug19.pdf.aspx

Aims of this Study

Here, we build on these previous efforts by developing a reliable method and protocol for extracting and sequencing mtDNA from hawksbill turtle carapace, by:

1. Piloting DNA extraction and sequencing from both tissue and shell samples from the same individual to serve as a positive control for accurately assigning mtDNA haplotypes between individual turtle tissue and turtle shell.

2. Using shell product (donated from Papua New Guinea and the Solomon Islands) to refine the DNA extraction and sequencing method from processed shell products, using:
    a. modified, yet commercially available, kits that can be easily replicated and upscaled in tortoiseshell trade countries
    b. higher quality and longer fragment of mtDNA (>770bp) to match genetic nesting data
    c. updated techniques that are safer to use and do not rely on traditional potentially harmful chemicals such as phenol/chloroform
3. Sequencing additional tissues samples from nesting beaches of Milman Island, Queensland and Arnavon Islands, Solomon Islands and foraging grounds of the Howick Group of Islands to add to the Shell Bank baseline dataset being established across Asia-Pacific for hawksbill rookeries.

This study forms part of a larger Initiative to address Marine Turtle Use and Trade in Asia-Pacific, coordinated by WWF-Australia. The overarching goal of this Initiative is to safeguard hawksbill turtle populations in the Asia-Pacific region, so they are no longer at risk of extinction, and no longer targeted for trade. This component of work aimed to develop a reliable method to extract DNA from turtle products to trace back which nesting turtle populations are being targeted along the use-trade chain from 'sale to source', and further our understanding of hawksbill turtle genetic stock boundaries for future management. This study provides the methodology and demonstrates the proof of concept that can be scaled up and trailed in other tortoiseshell demand and supply countries. Future iterations of this study, by Michael Jensen, NOAA collaborators and WWF include translating the DNA shell extraction and sequencing method into a scientific protocol detailing the use of this tool for future trials and use by decision-makers and forensic investigators.

Kawazu, I., Kino, M., Maeda, K., & Teruya, H. (2015). Age and Body Size of Captive Hawksbill Turtles at the Onset of Follicular Development. *Zoo Biology, 34*(2), 178-182 https://doi.org/10.1002/zoo.21190

The aim of this study was to record the age and body size of 23 captive female hawksbill turtles at the onset of follicular development. The age, straight carapace length (SCL), and body mass (BM) of the turtles were recorded between 2006 and 2014 at follicular development (determined via ultrasonography) these parameters were 17.7 plus or minus 1.7 years (range: 13-20 years), 77.7 plus or minus 3.3cm (73.3-83.5cm), and 61.1 plus or minus 8.0kg (48.2-76.1kg), respectively. When the year of the onset of follicular development was designated year 0, the increase in SCL in years -7-0 and 0-3 averaged 2.2cm and 1.0cm, respectively. Correspondingly, the increase in BM in years -7-0 and 0-3 averaged 5.0kg and 2.2kg, respectively. This is the first study to report the age and body size of captive female hawksbill turtles at the onset of follicular development, which indicates the beginning of sexual maturation. The reduction in growth after follicular development suggests that at the onset of sexual maturation, female hawksbills may utilize energy for follicular development rather than growth.

Kawazu, I., Kino, M., Maeda, K., Yamaguchi, Y., & Sawamukai, Y. (2014). Induction of Oviposition by the Administration of Oxytocin in Hawksbill Turtles. *Zoological Science, 31*(12), 831-835 https://doi.org/10.2108/zs140032

We set out to develop an oviposition induction technique for captive female hawksbill turtles *Eretmochelys imbricata*. The infertile eggs of nine females were induced to develop by the administration of follicle-stimulating hormone, after which we investigated the effects of administering oxytocin on oviposition. Seven of the turtles were held in a stationary horizontal position on a retention

stand, and then oxytocin was administrated (0.6-0.8 units/kg of body weight; 5 mL). The seven turtles were retained for a mandatory 2 h period after oxytocin administration, and were then returned to the holding tanks. As the control, normal saline (5 mL) was administered to the other two turtles, followed by the administration of oxytocin after 24 h. The eggs in oviducts of all nine turtles were observed by ultrasonography at 24 h after oxytocin administration. The control experiment validated that stationary retention and normal saline administration had no effect on egg oviposition. Eight of the turtles began ovipositing eggs at 17-43 min after oxytocin administration, while one began ovipositing in the holding tank immediately after retention. All turtles finished ovipositing eggs within 24 h of oxytocin administration. This report is the first to demonstrate successful induced oviposition in sea turtles. We suggest that the muscles in the oviducts of hawksbill turtles may respond to relatively lower doses of oxytocin (inducing contractions) compared to land and freshwater turtles (4-40 units/kg) based on existing studies.

Kawazu, I., Kino, M., Yanagisawa, M., Maeda, K., Nakada, K., Yamaguchi, Y., & Sawamukai, Y. (2015). Signals of Vitellogenesis and Estrus in Female Hawksbill Turtles. *Zoological Science, 32*(1), 114-118 https://doi.org/10.2108/zs140212

This study reports a viable means of identifying the vitellogenic cycle and limited estrus period in hawksbill turtles for the purposes of developing captive breeding program, based on the combination of blood metabolite parameters (triglyceride, total protein, and calcium levels), feeding status, and ovary condition. Follicle size of two focal captive females showed clear seasonal changes, with major development occurring between March and May (19.0-24.4 mm), and exceeding 25 mm between June and September. Triglyceride, total protein, and calcium levels dropped with follicular development and maintenance (March to October), and then began to rise when follicular retraction occurred from October onwards. The two focal turtles reduced food intake during intensive follicular development (April to May). These findings suggest that blood metabolite parameters and feeding conditions are inferred by the vitellogenic cycle. An additional 10 females exhibiting follicular development were mated with a single male for 7-day period between May and June. Follicle size was measured immediately prior to pairing, and a statistically significant difference in follicle size of 10 females was recorded between the seven failed (20.9 mm) and three successful (23.6 mm) mating events. This indicates follicle development is essential to successful mate and monitoring of vitellogenic cycle may help improve the success rates of captive hawksbill breeding programs.

Kawazu, I., Maeda, K., Koyago, M., Nakada, K., & Sawamukai, Y. (2014). Semen Evaluation of Captive Hawksbill Turtles. *Chelonian Conservation and Biology, 13*(2), 271-278 https://doi.org/10.2744/CCB-1064.1

This study presented information about the semen evaluation of captive male hawksbill sea turtles, *Eretmochelys imbricata*, based on an extended 15-mo study using the electro-ejaculation technique. In particular, we demonstrated that hawksbill sperm, which is underactive just after ejaculation, was activated by the presence of urine. The findings are useful for developing optimal semen collection techniques for future artificial insemination programs of hawksbill turtles.

Kawazu, I., Suzuki, M., Maeda, K., Kino, M., Koyago, M., Moriyoshi, M., . . . Sawamukai, Y. (2014). Ovulation Induction with Follicle-Stimulating Hormone Administration in Hawksbill Turtles *Eretmochelys imbricata*. *Current Herpetology, 33*(1), 88-93, 86 https://doi.org/10.5358/hsj.33.88

To develop ovulation induction techniques, we investigated the effects of follicle- stimulating hormone (FSH) administration on ovulation in captive hawksbill turtles *Eretmochelys imbricata*. Porcine FSH preparation was administered by intramuscular injection to four hawksbill turtles with fully-developed follicles (21.6–23.8 mm, measured using ultrasonography) in July or August 2009. Blood samples were obtained and subjected to plasma progesterone measurement, and ovaries and oviducts were observed by ultrasonography just before, and 1–6 days after, FSH administration. One day after the administraion, the plasma progesterone concentration significantly increased from the basal level (<0.01–0.3 ng/mL) to 0.8– 5.1 ng/mL and then dropped to nearly the basal level within 2–4 days. The formation of eggshells was observed two days after FSH administration. These data collectively indicate that in hawksbill turtles FSH administration effectively induces ovulation, progesterone secretion, and egg formation.

Kelez, S., Velez-Zuazo, X., & Pacheco, A. S. (2016). First Record of Hybridization between Green *Chelonia mydas* and Hawksbill *Eretmochelys imbricata* Sea Turtles in the Southeast Pacific. *PeerJ, 4* https://doi.org/10.7717/peerj.1712

Hybridization among sea turtle species has been widely reported in the Atlantic Ocean, but their detection in the Pacific Ocean is limited to just two individual hybrid turtles, in the northern hemisphere. Herein, we report, for the first time in the southeast Pacific, the presence of a sea turtle hybrid between the green turtle *Chelonia mydas* and the hawksbill turtle *Eretmochelys imbricata*. This juvenile sea turtle was captured in northern Peru (4 degrees 13'S; 81 degrees 10'W) on the 5(th) of January, 2014. The individual exhibited morphological characteristics of C. mydas such as dark green coloration, single pair of pre-frontal scales, four post-orbital scales, and mandibular median ridge, while the presence of two claws in each frontal flipper, and elongated snout resembled the features of E. imbricata. In addition to morphological evidence, we confirmed the hybrid status of this animal using genetic analysis of the mitochondrial gene cytochrome oxidase I, which revealed that the hybrid individual resulted from the cross between a female E. imbricata and a male C. mydas. Our report extends the geographical range of occurrence of hybrid sea turtles in the Pacific Ocean, and is a significant observation of interspecific breeding between one of the world's most critically endangered populations of sea turtles, the east Pacific E. imbricata, and a relatively healthy population, the east Pacific C. mydas.

Labastida-Estrada, E., Machkour-M'Rabet, S., Diaz-Jaimes, P., Cedeno-Vazquez, J. R., & Henaut, Y. (2019). Genetic Structure, Origin, and Connectivity between Nesting and Foraging Areas of Hawksbill Turtles of the Yucatan Peninsula: A Study for Conservation and Management. *Aquatic Conservation-Marine and Freshwater Ecosystems, 29*(2), 211-222 https://doi.org/10.1002/aqc.2999

Anthropogenic activities have resulted in declines in many marine turtle populations. Their complex life cycle (e.g. female philopatry, hatchling migration, adult movements between breeding and foraging areas) makes it difficult to fully understand some of the biological implications of human impacts on their populations, but genetic tools can play a major role in understanding population dynamics and thus improve conservation and management strategies. Using the mitochondrial DNA control region, this study examines the composition, population structure, and connectivity between rookeries and

foraging aggregations, in addition to their relationship with Atlantic rookeries and foraging areas of the hawksbill turtle in the Yucatan Peninsula. Haplotype composition of rookeries showed EiA22, EiA39, and EiA41 as endemic haplotypes and revealed a segregation between the Gulf of Mexico and the Yucatan and Quintana Roo rookeries, defining two management units. Foraging aggregations present 15 haplotypes, some common for Atlantic and others for Mexican rookeries. Considering the Gulf of Mexico versus the Mexican Caribbean, significant population genetic structure was revealed, inferring a differential recruitment of hawksbill turtles. Rookery-centric mixed-stock analysis reveals a high contribution of Mexican turtles to local foraging aggregations, principally in the Gulf of Mexico. Foraging-ground-centric mixed-stock analysis showed that the Gulf of Mexico foraging aggregation is predominantly composed of individuals from local rookeries, whereas Mexican Caribbean foraging groups have a mixed composition with individuals from Barbados, Brazil, and Puerto Rico rookeries. The connectivity between rookeries and foraging aggregations suggests that the ocean currents and swimming behaviour influence the distribution of hawksbill turtles. Our results highlighted the importance in identifying management units in nesting and foraging areas to develop monitoring and management programmes at appropriate geographic scales. In addition, understanding turtle habitat connectivity will allow for prioritized conservation actions considering particular threats, emphasizing the need for both national and international collaboration for conservation of this endangered species.

Laloee, J.-O., Esteban, N., Berkel, J., & Hays, G. C. (2016). Sand Temperatures for Nesting Sea Turtles in the Caribbean: Implications for Hatchling Sex Ratios in the Face of Climate Change. *Journal of Experimental Marine Biology and Ecology, 474*, 92-99 https://doi.org/10.1016/j.jembe.2015.09.015

A 200-year time series of incubation temperatures and primary sex ratios for green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and leatherback (*Dermochelys coriacea*) sea turtles nesting in St. Eustatius (North East Caribbean) was created by combining sand temperature measurements with historical and current environmental data and climate projections. Rainfall and spring tides were important because they cooled the sand and lowered incubation temperatures. Mean annual sand temperatures are currently 31.0 degree C (SD=1.6) at the nesting beach but show seasonality, with lower temperatures (29.1-29.6 degree C) during January-March and warmer temperatures (31.9-33.3 degree C) in June-August. Results suggest that all three species have had female-biased hatchling production for the past decades with less than 15.5%, 36.0%, and 23.7% males produced every year for greens, hawksbills and leatherbacks respectively since the late nineteenth century. Global warming will exacerbate this female-skew. For example, projections indicate that only 2.4% of green turtle hatchlings will be males by 2030, 1.0% by 2060, and 0.4% by 2090. On the other hand, future changes to nesting phenology have the potential to mitigate the extent of feminisation. In the absence of such phenological changes, management strategies to artificially lower incubation temperatures by shading nests or relocating nest clutches to deeper depths may be the only way to prevent the localised extinction of these turtle populations.

Lima, S. R., Barbosa, J. M. d. S., Saracchini, P. G. V., Padilha, F. G. F., Leite, J. d. S., & Ferreira, A. M. R. (2019). Gastric Lesions in Free-Living Sea Turtles: An Underestimated Disease That Reflects the Health of the Ecosystem. *Science of The Total Environment, 697*, 133970 https://doi.org/10.1016/j.scitotenv.2019.133970

Free-living marine turtles are constantly exposed to aggression factors and the gastrointestinal tract is one of the main gateways of entry. The objective of this study was to identify, and describe the anatomopathological alterations in the stomach of free-living marine turtles found dead on the beaches of the Microrregião dos Lagos, Rio de Janeiro, Brazil. Twenty-two sea turtles were necropsied, and stomach fragments were collected, fixed, and processed routinely. The presence of gastritis, parasitism, and adaptative morphological alteration of the cells were evaluated in a microscopic analysis. Descriptive statistics and Fisher's exact test were performed. Of the samples, 59.1% had stomach hyperemia. Microscopically, gastritis was found in 86.4% of cases, parasitism in 72.7%, and adaptive morphological alteration in 59.1%. There was an association between the presence of cellular adaptive morphological alteration and chronic inflammation. This the first report to describe the adaptive morphological changes observed in the stomach cells. The chronicity of the lesions was due to continuous aggressions to the tissue, with parasitism, garbage ingestion, and environmental pollutants as possible causes. The results obtained in this study demonstrate that the chronicity of the stomach lesions is due to continuous aggressions to this tissue, and the irritating factors have environmental origin, such as parasites, garbage, and toxic pollutants, including heavy metals, which are ingested by free-living sea turtles. This article demonstrates that stomach injuries in free-living marine turtles are frequent, severe, and possibly underdiagnosed; these lesions reflect the diseased ecosystem in which those animals live.

Maulida, F. F., Hadi, S., Imron, M. A., & Reischig, T. (2017). Geometry Morphometry and Health Status of Hawksbill Turtle (*Eretmochelys imbricata* Linnaeus, 1766) in Maratua Island, East Kalimantan-Indonesia. In *4th International Conference on Biological Science.* T. R. Nuringtyas, R. H. Setyobudi, J. Burlakovs, M. Mel, P. G. Adinurani, & Z. VincevicaGaile (Eds.), (pp. 100-110) https://doi.org/10.18502/kls.v3i4.693

Research on hawksbill turtles in the Maratua Island is still very few. Meanwhile, population of hawksbills was believed to decline due to human exploitation. The aim of this research was to study the morphology of hawksbill through geometric morphometric approach and health status which includes the existence of epibionts, mechanical damages and Body Condition Index. The survey was conducted from 5 to 18 September 2014. The method used was the hand-catching by snorkeling and diving for catching turtles, morphometric measurements and documentation of the turtle body parts using the camera. Morphological aspects were analyzed with linear regression and geometry approach with Microsoft Excel and ImageJ software. Health status was analyzed with observation of epibionts and mechanical damages through photos and calculation of Body Condition Index. There were 11 turtles that have been caught. The results indicated the growth of straight carapace length notch to tip affect the growth of the other body parts of hawksbill turtle and based approach to geometry, shape growth of hawksbill turtles that are found in Maratua not changed but only have added size. Based on the health status through observation epibionts, mechanical damages and analysis of Body Condition Index, hawksbill in Maratua still relatively healthy compared with studies elsewhere.

Monteiro, C. C., Carmo, H. M. A., Santos, A. J. B., Corso, G., & Sousa-Lima, R. S. (2019). First Record of Bioacoustic Emission in Embryos and Hatchlings of Hawksbill Sea Turtles (*Eretmochelys imbricata*). *Chelonian Conservation & Biology, 18*(2), 273-278 https://doi.org/10.2744/CCB-1382.1

Recordings were made in nests of *Eretmochelys imbricata* and 107 samples of 10-min recordings revealed 575 sounds that were classified manually into 4 categories. Our results show that hawksbill turtles vocalize within the nest, especially during and after eclosion, which suggests vocalizations are important for communication among hatchlings to synchronize emergence from the nest.

Munoz-Perez, J. P., Lewbart, G. A., Hirschfeld, M., Alarcon-Ruales, D., Denkinger, J., Castaneda, J. G., . . . Lohmann, K. J. (2017). Blood Gases, Biochemistry and Haematology of Galapagos Hawksbill Turtles (*Eretmochelys imbricata*). *Conservation Physiology, 5* https://doi.org/10.1093/conphys/cox028

The hawksbill turtle, *Eretmochelys imbricata*, is a marine chelonian with a circum-global distribution, but the species is critically endangered and has nearly vanished from the eastern Pacific. Although reference blood parameter intervals have been published for many chelonian species and populations, including nesting Atlantic hawksbills, no such baseline biochemical and blood gas values have been reported for wild Pacific hawksbill turtles. Blood samples were drawn from eight hawksbill turtles captured in near shore foraging locations within the Galapagos archipelago over a period of four sequential years; three of these turtles were recaptured and sampled on multiple occasions. Of the eight sea turtles sampled, five were immature and of unknown sex, and the other three were females. A portable blood analyzer was used to obtain near immediate field results for a suite of blood gas and chemistry parameters. Values affected by temperature were corrected in two ways: (i) with standard formulas and (ii) with auto-corrections made by the portable analyzer. A bench top blood chemistry analyzer was used to measure a series of biochemistry parameters from plasma. Standard laboratory haematology techniques were employed for red and white blood cell counts and to determine haematocrit manually, which was compared to the haematocrit values generated by the portable analyzer. The values reported in this study provide reference data that may be useful in comparisons among populations and in detecting changes in health status among Galapagos sea turtles. The findings might also be helpful in future efforts to demonstrate associations between specific biochemical parameters and disease or environmental disasters.

Muñoz, C. C., & Vermeiren, P. (2020). Maternal Transfer of Persistent Organic Pollutants to Sea Turtle Eggs: A Meta-Analysis Addressing Knowledge and Data Gaps toward an Improved Synthesis of Research Outputs. *Environmental Toxicology and Chemistry, 39*(1), 9-29 https://doi.org/10.1002/etc.4585

Maternal transfer of persistent organic pollutants (POPs) confronts developing embryos with a pollution legacy and poses conservation concerns due to its potential impacts unto subsequent generations. We conducted a systematic review focusing on: 1) processes of POP maternal transfer, 2) challenges and opportunities to synthesizing current knowledge on POP concentrations in eggs, and 3) a meta-analysis of patterns in current egg pollution data. Results suggest selective maternal transfer of individual compounds. These relate to biological factors such as the foraging and remigration behavior, and to the selective mobilization of POPs during vitellogenesis, such as increased diffusion limitation for lipophilic POPs and slower release and higher reabsorption of apolar POPs. A key gap relates to knowledge of further selective toxicokinetics during embryonic development, as research to date has mainly focused on initial uptake into eggs. Challenges in the synthesis of current data on egg contamination profiles relate to methodological differences, varying analytical approaches, restricted data access, and reporting transparency among studies. To increase opportunities in the use of current data, we propose

best practice guidelines, and synthesize a database on POP concentrations within sea turtle eggs. The meta-analysis revealed a geographical and taxonomic bias on the West Atlantic Ocean, including the Gulf of Mexico and Caribbean Sea, with most studies conducted on green turtles. Concentrations of POPs show temporal patterns related to trends in usage, production, release, and persistence in the environment, often with regional patterns. The trophic level has the potential to influence POP patterns with higher concentrations in loggerheads compared to other species, but this is confounded by temporal and geographic trends. We argue for more mechanistically process-focused and methodologically comparable research

Natoli, A., Phillips, K. P., Richardson, D. S., & Jabado, R. W. (2017). Low Genetic Diversity after a Bottleneck in a Population of a Critically Endangered Migratory Marine Turtle Species. *Journal of Experimental Marine Biology and Ecology, 491*, 9-18 https://doi.org/10.1016/j.jembe.2017.01.009

Hawksbill turtles (*Eretmochelys imbricata*), which are distributed throughout the world's oceans, have undergone drastic declines across their range, largely due to anthropogenic factors. Assessing sizes, genetic variability and structure of their populations at global and regional levels is critical to the development of conservation management strategies. Here, nuclear and mitochondrial markers were used to analyse patterns of parentage and population structure in hawksbill turtles in United Arab Emirates (UAE) waters, utilizing samples from two life stages (hatchlings and juveniles), and to compare the UAE population with neighboring populations. Weak genetic differentiation was detected between juveniles and hatchlings and between the nesting sites of Dubai and Sir Bu Nair. Parentage analysis suggested that only 53 females and 74–80 males contributed to the hatchlings from 67 nests across three nesting sites in UAE (Dubai, Sir Bu Nair, Abu Dhabi). No females were identified as nesting in more than one location. In Dubai and Abu Dhabi, single paternity was the norm (75%), whereas on Sir Bu Nair, multiple paternity was detected in the majority of nests (67%). Polygyny was also frequently detected on Sir Bu Nair (15% of the overall number of males), but not in the other nesting sites. Comparison of the UAE population with published data from other populations suggests that population structure exists both within the Gulf and between the Gulf and Indian Ocean populations, and that the UAE population has lower genetic variability than the Seychelles population. Finally, the data suggest that the UAE population, and the Gulf population overall, experienced a bottleneck/founder event. The observed overall low genetic variability, evidence of population structure in the Gulf, and strong differentiation between the Gulf and the Indian Ocean populations, raises concerns about the sustainability of this species in this near-enclosed basin. These results highlight the need for regional collaboration in the development of management measures for the long-term conservation of this Critically Endangered species.

Nezhad, S. R. K., Modheji, E., & Zolgharnein, H. (2013). Polymorphism Analysis of Mitochondrial DNA Control Region of Hawksbill Turtles (*Eretmochelys imbricata*) in the Persian Gulf. *Indian Journal of Geo-Marine Sciences, 42*(3), 300-303 Retrieved from http://nopr.niscair.res.in/handle/123456789/19656

To estimate the genetic diversity of the hawksbill turtle populations, the mitochondrial DNA control region was used as a matrilineal marker. Captured turtles (69 samples) were obtained from three different islands in the Persian Gulf. From all the samples DNA was isolated. Primers were selected based on a specific sequence in control region of mitochondrial genome. PCR products were restricted

by various restriction enzymes and four different haplotypes observed. Measurement of inter-population genetic diversity and evolutionary distance between genotypes showed a low diversity in mitochondrial genome of hawksbill turtle in the studied regions. Therefore, the similarity between these three populations was significant. Present results provide evidences showing that significant genetic variation was not observed between these distinct populations and there is not even enough evidence to show the separation and diversion in the studied populations in haplotype level.

Nishizawa, H., Joseph, J., & Chong, Y. K. (2016). Spatio-Temporal Patterns of Mitochondrial DNA Variation in Hawksbill Turtles (*Eretmochelys imbricata*) in Southeast Asia. *Journal of Experimental Marine Biology and Ecology, 474*, 164-170 https://doi.org/10.1016/j.jembe.2015.10.015

Mitochondrial DNA (mtDNA) polymorphisms provide useful information that can be used to estimate the phylogeographic relationships, historical demography, and migratory events of widely distributed animals. In this study, the spatio-temporal patterns of mtDNA polymorphisms were assessed in Indo-Pacific hawksbill turtles from Malaysian nesting rookeries and foraging aggregations sampled during 1996–2014. Clear genetic differences were observed between turtles from the Sabah Turtle Islands rookery in the Sulu Sea, and the rookeries of Melaka and Redang Island in the South China Sea off the Malay Peninsula; however, no temporal genetic changes were found to have occurred on a decadal time scale. Despite the descriptive evaluation of a few samples, Johor nesting turtles possessed different haplotypes from those at the proximate Melaka rookery, indicating the importance of conserving this small nesting population. Although continuous sampling efforts are needed to determine the relationships between specific rookeries and foraging aggregations, the presence of multiple haplotypes in Malaysian foraging aggregations, in combination with Lagrangian drifter buoy data, suggests that there have been migrations to foraging grounds in Southeast Asia from various rookeries. This study provides basic information for the conservation and management of hawksbill turtles in Southeast Asia.

Omeyer, L. C. M., Godley, B. J., & Broderick, A. C. (2017). Growth Rates of Adult Sea Turtles. *Endangered Species Research, 34*, 357-371 https://doi.org/10.3354/esr00862

Indeterminate growth, i.e. growth that persists throughout life, is common in longlived reptiles. Because fecundity and body size tend to be correlated in such species, individuals face a life-history trade-off at sexual maturity. Saturation tagging and intensive monitoring at nesting grounds can potentially provide opportunities to accumulate data on individual measurements and reproductive output. Until recently, however, shortcomings from these methods have prevented the testing of theories on resource allocation between growth and reproduction at sexual maturity in wild populations of sea turtles. Here, we review the state of knowledge of growth rates in adult sea turtles and potential life-history trade-offs. We found that post-maturity growth rates varied among ocean basins. They appeared highest in the Atlantic Ocean for both green turtles *Chelonia mydas* and hawksbill turtles *Eretmochelys imbricata*, and highest in the Mediterranean Sea for loggerhead turtles *Caretta caretta*. For other species, there are too few studies at present to allow for intraspecific comparison. Additionally, we found no significant difference in mean female compound annual growth rates among species and ocean basins. Although captive studies have provided great insight into changes in energy allocation at sexual maturity and life-history trade-offs, this review highlights the lack of data on wild animals regarding changes in post-maturity growth rates and reproductive output over time. Such data are desirable to further our understanding of energy allocation, growth and ageing in wild sea turtles. They are further required to

assess the status of species and to understand population dynamics for both conservation and management.

Phillips, K. P., Jorgensen, T. H., Jolliffe, K. G., Jolliffe, S.-M., Henwood, J., & Richardson, D. S. (2013). Reconstructing Paternal Genotypes to Infer Patterns of Sperm Storage and Sexual Selection in the Hawksbill Turtle. *Molecular Ecology, 22*(8), 2301-2312 https://doi.org/10.1111/mec.12235

Postcopulatory sperm storage can serve a range of functions, including ensuring fertility, allowing delayed fertilization and facilitating sexual selection. Sperm storage is likely to be particularly important in wide-ranging animals with low population densities, but its prevalence and importance in such taxa, and its role in promoting sexual selection, are poorly known. Here, we use a powerful microsatellite array and paternal genotype reconstruction to assess the prevalence of sperm storage and test sexual selection hypotheses of genetic biases to paternity in one such species, the critically endangered hawksbill turtle, *Eretmochelys imbricata*. In the majority of females (90.7%, N = 43), all offspring were sired by a single male. In the few cases of multiple paternity (9.3%), two males fertilized each female. Importantly, the identity and proportional fertilization success of males were consistent across all sequential nests laid by individual females over the breeding season (up to five nests over 75 days). No males were identified as having fertilized more than one female, suggesting that a large number of males are available to females. No evidence for biases to paternity based on heterozygosity or relatedness was found. These results indicate that female hawksbill turtles are predominantly monogamous within a season, store sperm for the duration of the nesting season and do not re-mate between nests. Furthermore, females do not appear to be using sperm storage to facilitate sexual selection. Consequently, the primary value of storing sperm in marine turtles may be to uncouple mating and fertilization in time and avoid costly re-mating.

Phillips, K. P., Jorgensen, T. H., Jolliffe, K. G., & Richardson, D. S. (2014). Potential Inter-Season Sperm Storage by a Female Hawksbill Turtle. *Marine Turtle Newsletter*(140), 13-14 Retrieved from http://www.seaturtle.org/mtn/archives/mtn140/mtn140-6.shtml

Phillips et al talk about the female hawksbill turtle. Female Testudines can store viable sperm for a long time. Among marine species, a single insemination is often enough to sire a female's entire reproductive output for a nesting season, extending to hundreds of offspring laid over a period exceeding two months. For some terrestrial species, the standard reproductive tactic is for females to mate prior to hibernation, store sperm over the winter, and then use this sperm to fertilize their eggs in the spring.

Phillips, K. P., Mortimer, J. A., Jolliffe, K. G., Jorgensen, T. H., & Richardson, D. S. (2014). Molecular Techniques Reveal Cryptic Life History and Demographic Processes of a Critically Endangered Marine Turtle. *Journal of Experimental Marine Biology and Ecology, 455*, 29-37 https://doi.org/10.1016/j.jembe.2014.02.012

The concept of ‘effective population size’ (Ne), which quantifies how quickly a population will lose genetic variability, is one of the most important contributions of theoretical evolutionary biology to practical conservation management. Ne is often much lower than actual population size: how much so depends on key life history and demographic parameters, such as mating systems and population connectivity, that often remain unknown for species of conservation concern. Molecular techniques

allow the indirect study of these parameters, as well as the estimation of current and historical Ne. Here, we use genotyping to assess the genetic health of an important population of the critically endangered hawksbill turtle (*Eretmochelys imbricata*), a slow-to-mature, difficult-to-observe species with a long history of severe overhunting. Our results were surprisingly positive: we found that the study population, located in the Republic of Seychelles, Indian Ocean, has a relatively large Ne, estimated to exceed 1000, and showed no evidence of a recent reduction in Ne (i.e. no genetic bottleneck). Furthermore, molecular inferences suggest the species' mating system is conducive to maintaining a large Ne, with a relatively large and widely distributed male population promoting considerable gene flow amongst nesting sites across the Seychelles area. This may also be reinforced by the movement of females between nesting sites. Our study underlines how molecular techniques can help to inform conservation biology. In this case our results suggest that this important hawksbill population is starting from a relatively strong position as it faces new challenges, such as global climate change.

Prichula, J., Pereira, R. I., Wachholz, G. R., Cardoso, L. A., Tolfo, N. C. C., Santestevan, N. A., . . . Frazzon, A. P. G. (2016). Resistance to Antimicrobial Agents among Enterococci Isolated from Fecal Samples of Wild Marine Species in the Southern Coast of Brazil. *Marine Pollution Bulletin, 105*(1), 51-57 https://doi.org/10.1016/j.marpolbul.2016.02.071

The purpose of this study was to evaluate species distribution, antimicrobial resistance profiles, and presence of resistance genes in enterococci isolated from fecal samples of wild marine species, including seabirds (n=12), sea turtles (n=8), and mammals (n=3) found alive or dead in southern coast of Brazil. Enterococci were classified based on phenotypic and genotypic characteristics, tested for antibiotic susceptibility, and the presence of tet(S), tet(M), tet(L), mrsC, and erm(B) genes by PCR. Enterococcus faecalis and Enterococcus faecium were the most common species. Single (37.09%), double (25.80%), and multiple (16.12%) antibiotic resistance patterns were observed. Resistance to rifampicin occurred most frequently. The msrC, tet(M), and/or tet(L) genes were detected in 60.15%, 73.07%, and 23.07% of the resistant strains, respectively. In conclusion, the presence of antibiotic resistant strains in these species could be related to food web interactions and aquatic pollutants or linked to environmental resistome.

Proietti, M. C., Reisser, J., Marins, L. F., Rodriguez-Zarate, C., Marcovaldi, M. A., Monteiro, D. S., . . . Secchi, E. R. (2014). Genetic Structure and Natal Origins of Immature Hawksbill Turtles (*Eretmochelys imbricata*) in Brazilian Waters. *PLoS One, 9*(2) https://doi.org/10.1371/journal.pone.0088746

Understanding the connections between sea turtle populations is fundamental for their effective conservation. Brazil hosts important hawksbill feeding areas, but few studies have focused on how they connect with nesting populations in the Atlantic. Here, we (1) characterized mitochondrial DNA control region haplotypes of immature hawksbills feeding along the coast of Brazil (five areas ranging from equatorial to temperate latitudes, 157 skin samples), (2) analyzed genetic structure among Atlantic hawksbill feeding populations, and (3) inferred natal origins of hawksbills in Brazilian waters using genetic, oceanographic, and population size information. We report ten haplotypes for the sampled Brazilian sites, most of which were previously observed at other Atlantic feeding grounds and rookeries. Genetic profiles of Brazilian feeding areas were significantly different from those in other regions (Caribbean and Africa), and a significant structure was observed between Brazilian feeding grounds grouped into areas influenced by the South Equatorial/North Brazil Current and those influenced by the

Brazil Current. Our genetic analysis estimates that the studied Brazilian feeding aggregations are mostly composed of animals originating from the domestic rookeries Bahia and Pipa, but some contributions from African and Caribbean rookeries were also observed. Oceanographic data corroborated the local origins, but showed higher connection with West Africa and none with the Caribbean. High correlation was observed between origins estimated through genetics/rookery size and oceanographic/rookery size data, demonstrating that ocean currents and population sizes influence haplotype distribution of Brazil's hawksbill populations. The information presented here highlights the importance of national conservation strategies and international cooperation for the recovery of endangered hawksbill turtle populations.

Putman, N. F., Abreu-Grobois, F. A., Broderick, A. C., Ciofi, C., Formia, A., Godley, B. J., . . . Williams, N. (2014). Numerical Dispersal Simulations and Genetics Help Explain the Origin of Hawksbill Sea Turtles in Ascension Island. *Journal of Experimental Marine Biology and Ecology, 450*, 98-108 https://doi.org/10.1016/j.jembe.2013.10.026

Long-distance dispersal and ontogenetic shifts in habitat use are characteristic of numerous marine species and have important ecological, evolutionary, and management implications. These processes, however, are often challenging to study due to the vast areas involved. We used genetic markers and simulations of physical transport within an ocean circulation model to gain understanding into the origin of juvenile hawksbill sea turtles (*Eretmochelys imbricata*) found at Ascension Island, a foraging ground that is thousands of kilometers from known nesting beaches. Regional origin of genetic markers suggests that turtles are from Western Atlantic (86%) and Eastern Atlantic (14%) rookeries. In contrast, numerical simulations of transport by ocean currents suggest that passive dispersal from the western sources would be negligible and instead would primarily be from the East, involving rookeries along Western Africa (i.e., Principe Island) and, potentially, from as far as the Indian Ocean (e.g., Mayotte and the Seychelles). Given that genetic analysis identified the presence of a haplotype endemic to Brazilian hawksbill rookeries at Ascension, we examined the possible role of swimming behavior by juvenile hawksbills from NE Brazil on their current-borne transport to Ascension Island by performing numerical experiments in which swimming behavior was simulated for virtual particles (simulated turtles). We found that oriented swimming substantially influenced the distribution of particles, greatly altering the proportion of particles dispersing into the North Atlantic and South Atlantic. Assigning location-dependent orientation behavior to particles allowed them to reach Ascension Island, remain in favorable temperatures, encounter productive foraging areas, and return to the vicinity of their natal site. The age at first arrival to Ascension (4.5–5.5years) of these particles corresponded well to estimates of hawksbill age based on their size. Our findings suggest that ocean currents and swimming behavior play an important role in the oceanic ecology of sea turtles and other marine animals.

Raweewan, N., Laovechprasit, W., Giorgi, M., Chomcheun, T., Klangkaew, N., Imsilp, K., . . . Poapolathep, S. (2019). Pharmacokinetics of Tolfenamic Acid in Hawksbill Turtles (*Eretmochelys imbricata*) after Single Intravenous and Intramuscular Administration. *Journal of Veterinary Pharmacology and Therapeutics* https://doi.org/10.1111/jvp.12823

To the best of our knowledge, limited pharmacokinetic information to establish suitable therapeutic plans is available for Hawksbill turtles. Therefore, the present study aimed to assess the pharmacokinetic features of tolfenamic acid (TA) in Hawksbill turtles, *Eretmochelys imbricata*, after single intravenous (i.v.) and intramuscular (i.m.) administration at dosage 4 mg/kg body weight (b.w.).

The study (parallel design) used 10 Hawksbill turtles randomly divided into equal groups. Blood samples were collected at assigned times up to 144 hr. The concentrations of TA in plasma were quantified by a validated liquid chromatography tandem mass spectrometry (LC-ESI-MS/MS). The concentration of TA in the experimental turtles with respect to time was pharmacokinetically analyzed using a noncompartment model. The C-max values of TA were 89.33 +/- 6.99 mu g/ml following i.m. administration. The elimination half-life values were 38.92 +/- 6.31 hr and 41.09 +/- 9.32 hr after i.v. and i.m. administration, respectively. The absolute i.m. bioavailability was 94.46%, and the average binding percentage of TA to plasma protein was 31.39%. TA demonstrated a long half-life and high bioavailability following i.m. administration. Therefore, the i.m. administration is recommended for use in clinical practice because it is both easier to perform and provides similar plasma concentrations to the i.v. administration. However, further studies are needed to determine the clinical efficacy of TA for treatment of inflammatory disease after single and multiple dosages.

Razaghian, H., Esfandabad, B. S., Hesni, M. A., Shoushtari, R. V., Toranjzar, H., & Miller, J. (2019). Distribution Patterns of Epibiotic Barnacles on the Hawksbill Turtle, *Eretmochelys imbricata*, Nesting in Iran. *Regional Studies in Marine Science, 27*, 100527 https://doi.org/10.1016/j.rsma.2019.100527

The hawksbill turtle (*Eretmochelys imbricata*,) is a critically endangered species of marine turtle that occurs in the Persian Gulf. The present study analyzed the frequency and distribution of epibiont barnacles residing on 122 the carapace and plastron of nesting hawksbill turtles (mean CCL = 70.22 ± 4.3 cm; mean CCW = 64.77 ± 3.2 cm) from the northern Persian Gulf in 2017. Barnacles frequency on the carapace, plastron, flippers, and head were studied in 29 turtles of the 122 turtles. 99.2 % of the nesting hawksbill turtles hosted barnacles and 72% carried between 1 and 20 barnacles (n= 122 turtles). The plastron, carapace, flippers, and head areas of the 29 turtles hosted 2804 836, 585 and 454 barnacles, respectively. The number of barnacles smaller than 0.5 cm on carapace represented 38.8% of the total of 836 barnacles. Based on the combined totals on the plastron, flippers, and head, barnacles smaller than 0.5 cm represented 69.2% of the barnacles counted on the turtles. There was a significant difference among the barnacle frequency on different scales of carapace, plastron, and four flippers ($P<0.05$). The presence of numerous barnacles may influence the hydrodynamic surface and water flow around the turtle's body. Moreover, the high density of barnacles may influence the health of the turtles. The number of barnacles residing on a hawksbill turtle may result from the foraging behavior and habitat of the turtles.

Rocha Júnior, J. C., Pfaller, J. B., Corbetta, R., & Veríssimo, L. (2015). Parasitic Isopods Associated with Sea Turtles Nesting in Brazil. *Marine Biological Association of the United Kingdom. Journal of the Marine Biological Association of the United Kingdom, 95*(5), 973-981 https://doi.org/10.1017/S0025315414001829

Studies of sea turtle epibiosis have focused on the diversity and ecology of facultative commensalisms and less attention has been given to parasitic associations, in which the epibiont species derives nutrients from the tissue of the host turtle. We present the first description and quantitative survey of the parasitic isopods Excorallana costata, Excorallana bicornis and Excorallana oculata on loggerhead (N = 79) and hawksbill turtles (N = 23), and E. costata on olive ridley turtles (N = 9), nesting on Praia do Forte, Bahia, Brazil during the 2009-2010 season. Excorallana costata was the most common isopod species (N = 651), followed by E. bicornis (N = 77) and E. oculata (N = 20). Patterns include: (1) E. costata

exhibited a higher frequency and intensity of parasitism than E. bicornis and E. oculata and (2) loggerheads hosted parasitic isopods at a higher frequency and intensity than hawksbills and olive ridleys. We also detected temporal shifts in the occurrence and intensity of parasitism across the nesting season, which strongly suggests that turtles were parasitized by all three isopod species during their internesting periods. Because parasitic isopods were observed only rarely prior to the 2009-2010 turtle-nesting season and have continued to be common in subsequent seasons, it is important to gain a better understanding of the basic biology of these interactions, the reasons for their recent emergence, and the potential biological impacts on turtle, as well as isopod, populations.

Salmon, M., Coppenrath, C., & Higgins, B. (2018). The Early Ontogeny of Carapace Armoring in Hawksbill Sea Turtles (*Eretmochelys imbricata*), with Comparisons to Its Close Relatives (Loggerhead, *Caretta caretta*; Kemp's Ridley, *Lepidochelys kempii*). *Journal of Morphology, 279*(9), 1224-1233 https://doi.org/10.1002/jmor.20844

In this study, we compare and contrast armoring strategies during early ontogeny among three related species of marine turtles: the hawksbill, a species that diverged about 29 mya from the loggerhead and Kemp's ridley, which diverged from one another about 16 mya. Our purpose was to determine whether there was a correlation between divergence time and the evolution of unique morphological armoring specializations among these species. To find out, we completed a more detailed analysis of shell morphology for all of the species that revealed the following patterns. First, each species has evolved a somewhat different armoring strategy, suggesting that shell morphological evolution is surprisingly flexible. Second, hawksbills possess armoring features that are unique among all marine turtle species, suggesting a correlation between divergence through time and divergence in morphology. However, hawksbills also frequent coral reefs and selection pressures promoting their survival in those habitats may also have shaped their unique morphology. In contrast, loggerhead and Kemp's ridley turtles share similar armoring features that differ primarily in when during ontogeny they appear and in their degree of expression. Third, the armoring adaptations shown generally by juvenile marine turtles resemble those found among marine fishes of comparable size, probably because both small turtles and fishes are exposed to similar predators that promote evolutionarily similar adaptations.

Salvarani, P. I., Morgado, F., Vieira, L. R., & Rendon-von Osten, J. (2019). Organochlorines Contaminants in Eggs of Hawksbill (*Eretmochelys imbricata*) and Green Sea Turtles (*Chelonia mydas*) from Mexico Coast. *Archives of Environmental Contamination and Toxicology, 76*(3), 425-434 https://doi.org/10.1007/s00244-018-00589-3

The investigation of organochlorine pesticides (OCPs) levels in sea turtles is an important issue in conservation research, due to the harmful effects of these chemicals. In the present study, OCPs concentrations were determined in the eggs of two sea turtle species (*Eretmochelys imbricata* and *Chelonia mydas*) collected from the Punta Xen and Isla Aguada (Mexican coast) in 2014 and 2015. Concentrations of 20 OCPs were analysed, including isomers of hexachlorocyclohexane, aldrin, chlordanes, endosulfans, methoxychlor, DDTs, and heptachlor. From the group of contaminants considered (analysed as families), the results revealed higher concentrations of sigma HCH and sigma Dienes on both selected species. We analysed the relationship between turtle size and the OCPs concentrations; no correlation was found between the size of the female and concentrations in the eggs. In addition, principal component analysis indicated pattern differences between species and years, in good agreement with concentrations differences.

Salvarani, P. I., Vieira, L. R., Ku-Peralta, W., Morgado, F., & Rendon-von Osten, J. (2018). Oxidative Stress Biomarkers and Organochlorine Pesticides in Nesting Female Hawksbill Turtles *Eretmochelys imbricata* from Mexican Coast (Punta Xen, Mexico). *Environmental Science and Pollution Research, 25*(24), 23809-23816 https://doi.org/10.1007/s11356-018-2404-5

Because of their vulnerable population status, assessing exposure levels and impacts of toxicants on the health status of Gulf of Mexico marine turtle populations is essential, and this study was aimed to obtain baseline information on oxidative stress indicators in hawksbill sea turtle (*Eretmochelys imbricata*). In order to evaluate the health status of sea turtles and the effect of organochlorine compounds (OC) in the southern part of the Gulf of Mexico, we searched for relationships between carapace size and the activity of antioxidant enzymes in the blood of the hawksbill sea turtle. The level of oxidative stress biomarkers such as the enzymes catalase (CAT), superoxide dismutase (SOD), glutathione reductase (GR), glutathione S-transferase (GST), and acetylcholinesterase (Ache) in the hawksbill sea turtle was analysed during nesting season in the years 2014-2015 at Punta Xen (Campeche, Mexico). The results of this study provide insight into data of antioxidant enzyme activities in relation to contaminant OCPs in hawksbill sea turtles and the possible health impacts of contaminant in sea turtles.

Santoro, M., Morales, J. A., Bolanos, F., Chaves, G., & De Stefano, M. (2015). Helminths of Hawksbill Turtle (*Eretmochelys imbricata*) from the Pacific Coast of Costa Rica. *Helminthologia, 52*(1), 67-70 https://doi.org/10.1515/helmin-2015-0012

Parasitological examination of a stranded hawksbill turtle (*Eretmochelys imbricata*) from Pacific coast of Costa Rica revealed the presence of a rich digenean fauna including Carettacola stunkardi (Spirorchiidae), Enodiotrema reductum (Plagiorchiidae), Cricocephalus albus, Adenogaster serialis, Epibathra crassa, Pleurogonius lobatus, P. trigonocephalus, P. linearis, and Pyelosomum posterorchis (Pronocephalidae). All helminths except C. albus and P. lobatus represent new geographical records for Costa Rica. Carettacola stunkardi is reported for first time in an Eastern Pacific hawksbill turtle and its pathological changes are here described. Histologically, nodular lesions on the serosal surface of intestine revealed a mixed infiltrate of heterophils, lymphocytes, and histiocytes within necrotic debris. Granulomas with spirorchiid eggs were observed in the mucosa, sub-mucosa and muscular layers of stomach and intestine, gallbladder and liver.

Shamblin, B. M., Berry, B. E., Lennon, D. M., Meylan, A. B., Meylan, P. A., Outerbridge, M. E., & Nairn, C. J. (2013). Tetranucleotide Microsatellite Loci from the Critically Endangered Hawksbill Turtle (*Eretmochelys imbricata*). *Conservation Genetics Resources, 5*(1), 23-26 https://doi.org/10.1007/s12686-012-9720-8

We describe isolation and characterization of 14 polymorphic tetranucleotide loci from the hawksbill turtle (*Eretmochelys imbricata*). We identified an average of 14.5 alleles per locus based on screening of 36 individuals captured on foraging grounds in Bocas del Toro Province, Panama, and 9.6 alleles in 13 individuals captured on foraging grounds in Bermuda. Observed heterozygosity ranged from 0.67 to 1.00, with a mean of 0.85 for the Panama foraging aggregation and 0.83 for the Bermuda foraging aggregation. This microsatellite suite has a combined non-exclusion probability of identity of 8.26 x 10-23. These markers should be informative in individual and population-focused analyses.

Sheil, C. A. (2013). Development of the Skull of the Hawksbill Seaturtle, *Eretmochelys imbricata*. *Journal of Morphology, 274*(10), 1124-1142 https://doi.org/10.1002/jmor.20167

The embryonic development of the cranium of the Hawksbill Seaturtle (*Eretmochelys imbricata*) is described on the basis of cleared and double-stained specimens. Illustrations and descriptions of the chondrocranium at Stage 25 form the basis of comparison with similar data for the Loggerhead Seaturtle, *Caretta caretta*. Morphological changes through prehatching ontogeny are described for all dermal and endochondral elements of the skull and jaws, and the sequence of appearance and ossification of these elements are compared with similar data for *Chelonia mydas*, Natator depressa, and Dermochelys coriacea. Comparisons among suggest that a possible remnant of the dorsal edge of the orbital cartilage remains and represents a portion of the posterior orbital cartilage in C. caretta, representing a novel pattern of development for the posterior orbital cartilage for this species. Anatomy of cartilages of the orbitotemporal region are described for E. imbricata and C. caretta.

Silva, M. A., Jerdy, H. L., Ribeiro, R. B., Medina, R. M., Petronilha, M., Shimoda, E., . . . Carvalho, E. C. Q. (2016). Histopathological Findings in Lungs of Hawksbill Turtles Collected on the Coasts of the States of Espirito Santo and Rio De Janeiro, Brazil. *Arquivo Brasileiro De Medicina Veterinaria E Zootecnia, 68*(5), 1267-1274 https://doi.org/10.1590/1678-4162-8949

The present work aimed to report the histopathological findings verified in lungs of hawksbill turtles (*Eretmochelys imbricata*) retrieved from the coasts of the states of Espirito Santo and Rio de Janeiro, Brazil. Between the years 2010 and 2014, 29 E. imbricata individuals were found stranded on the coasts, already dead or dying during treatment. Lung samples of all specimens were collected during necropsies, fixed in 10% neutral buffered formalin, subjected to routine histological processing and classified histomorphologically. The findings revealed that 37.93% of the specimens presented lung lesions. Of these, 90.91% were rescued alive and 9.09% were found dead; 63.63% were females and 36.37% were males. The mean weight was 5.44 Kg and the mean length 39 cm, characterizing young individuals. The animals originated from Sao Francisco de Itabapoana - RJ, Aracruz - ES, Sao Mateus - ES, Guarapari - ES, Linhares - ES, Itapemirim - ES, and Anchieta - ES. Macroscopic analysis revealed presence of foam, hyperemia, nodules in the parenchyma, cyst and caseous material. Microscopic examination evidenced heterophilic bronchopneumonia, parasitic granulomatous pneumonia caused by spirorchiids, bacterial granulomatous pneumonia, fungal granulomatous pneumonia, and congestion. It was concluded that juvenile specimens of *Eretmochelys imbricata*, females and males, originated from the states of Espirito Santo and Rio de Janeiro and found stranded both alive or dead, have significant lung lesions, mainly inflammatory ones, associated or not with infectious agents.

Snover, M. L., Balazs, G. H., Murakawa, S. K. K., Hargrove, S. K., Rice, M. R., & Seitz, W. A. (2013). Age and Growth Rates of Hawaiian Hawksbill Turtles (*Eretmochelys imbricata*) Using Skeletochronology. *Marine Biology, 160*(1), 37-46 https://doi.org/10.1007/s00227-012-2058-7

The Hawaiian hawksbill population has fewer than 20 females nesting per year; hence, there is a need to monitor this population closely and basic biological information on individual growth and age to maturity is critical. We present a skeletochronology analysis of Hawaiian hawksbills using humeri recovered from 30 dead stranded hawksbills, plus 10 dead hatchlings. Growth mark morphology shows readily distinguishable marks similar in appearance to other species, though some animals displayed more diffuse marks. Growth rates remained high (average 2.24-4.77 cm year(-1)) from 20 to 80 cm

straight carapace length (SCL). Hawksbills larger than 80 cm SCL had average growth rates of 0.3 cm year(-1). There were few adult turtles in the sample; however, results indicate hawksbills have faster growth rates than loggerhead or green turtles, with probable average age to maturity (at size 78.6 cm SCL) occurring between 17 and 22 years.

Soares, L. S., Bjorndal, K. A., Bolten, A. B., dei Marcovaldi, M. A. G., Luz, P. B., Machado, R., . . . Wayne, M. L. (2018). Effects of Hybridization on Sea Turtle Fitness. *Conservation Genetics, 19*(6), 1311-1322 https://doi.org/10.1007/s10592-018-1101-8

Sea turtle hybridization is a common phenomenon in Brazil between loggerheads (*Caretta caretta*) and hawksbills (*Eretmochelys imbricata*) as well as between loggerheads and olive ridleys (Lepidochelys olivacea). In a previous study we showed that the reproductive output of loggerhead/hawksbill hybrids is similar to that of parental species, suggesting no negative effect of hybridization at this life stage. In this study, we used pooled amplicon sequencing to assign species identity to dams and their progeny, and to investigate the fitness consequences of hybridization, using hatchling viability as a proxy for fitness. We genotyped 4829 hatchlings from egg clutches laid by 78 loggerheads, 13 hawksbills, seven loggerhead/hawksbill hybrids, and three loggerhead/olive ridley hybrids. The proportion of viable hybrid (heterozygous) hatchlings was similar to that of homozygous hatchlings (based on data at two loci), independent of the dam's genotype. Multiple species paternity was observed in 35.7% of the nests. Both hybrid males and females were fertile and produced viable offspring, and we found no evidence for hybrid breakdown. We suggest a genome-wide study of the hybrids and parental species to better characterize hybrids, as well as studies on additional demographic and ecological parameters to further assess the effects of hybridization and its consequences for sea turtles and their environment.

Soares, L. S., Bolten, A. B., Wayne, M. L., Vilaca, S. T., Santos, F. R., dei Marcovaldi, M. A. G., & Bjorndal, K. A. (2017). Comparison of Reproductive Output of Hybrid Sea Turtles and Parental Species. *Marine Biology, 164*(1), 1-10 https://doi.org/10.1007/s00227-016-3035-3

Globally, sea turtle hybridization has been reported at very low frequencies. However, in Brazil, a high incidence (>40% of morphologically assigned hawksbills) of hybridization between loggerheads and hawksbills has been reported. To the best of our knowledge, this is the first analysis of the effect of hybridization on the reproductive output of sea turtle hybrids. We used nuclear and mitochondrial markers to assign a status of hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), or hybrid to 146 females that deposited 478 nests. Hybrids do not appear to be at either a reproductive advantage or disadvantage relative to their parental species based on the parameters analyzed (female curved carapace length, clutch size, emergence success, incubation period, hatchling production, observed clutch frequency, and observed breeding frequency). Although emergence success is lower in hybrids, hatchling production per clutch, as well as clutch frequency and breeding frequency, is similar among the three groups. These results show that hybrids may persist in this region. Further research on hybrid survival rates at different life stages, as well as growth rates and their ecological roles, will be fundamental to predict the fate of hybrid turtles. Sea turtle populations that overlap with other sea turtle species in space and time on nesting beaches should be screened for hybridization with the appropriate genetic markers.

Takeshita, S., Matsuda, N., Kodama, S., Suzuki, K., & Watanabe, M. (2013). In Vitro Thermal Effects on Embryonic Cells of Endangered Hawksbill Turtle *Eretmochelys imbricata*. *Zoological Science, 30*(12), 1038-1043 https://doi.org/10.2108/zsj.30.1038

The hawksbill turtle is an ectotherm, whose sex is determined by temperature during embryonic development. This study aimed to determine whether embryonic hawksbill turtle cells respond differently to temperature than mammalian cells. Embryonic hawksbill turtle cells were established in culture, and thermal effects on these cells were investigated in vitro. Cells were maintained in Dulbecco's Modified Eagle Medium supplemented with non-essential amino acids, vitamin solution, sodium pyruvate, and 10% fetal bovine serum at 33 degrees C and cell proliferation occurred at 25-33 degrees C. When cells were incubated at 37 degrees C (the temperature of mammalian cell culture) for 24 h, cell growth was completely inhibited. This growth inhibition was evidently recovered by changing the incubation temperature back to 33 degrees C. Expression of heat shock protein was found to increase with elevating culture temperature from 25 to 33 degrees C.

Tremblay, N., Ortíz Arana, A., González Jáuregui, M., & Rendón-von Osten, J. (2017). Relationship between Organochlorine Pesticides and Stress Indicators in Hawksbill Sea Turtle (*Eretmochelys imbricata*) Nesting at Punta Xen (Campeche), Southern Gulf of Mexico. *Ecotoxicology, 26*(2), 173-183 https://doi.org/10.1007/s10646-016-1752-5

Data on the impact of environmental pollution on the homeostasis of sea turtles remains scarce, particularly in the Southern Gulf of Mexico. As many municipalities along the coastline of the Yucatan Peninsula do not rely on a waste treatment plant, these organisms could be particularly vulnerable. We searched for relationships between the presence of organochlorine pesticides (OCP) and the level of several oxidative and pollutant stress indicators of the hawksbill sea turtle (*Eretmochelys imbricata*) during the 2010 nesting season at Punta Xen (Campeche, Mexico). Of the 30 sampled sea turtles, endosulfans, aldrin related (aldrin, endrin, dieldrin, endrin ketone, endrin aldehyde) and dichlorodiphenyldichloroethylene (DDT) families were detected in 17, 21 and 26, respectively. Significant correlation existed between the size of sea turtles with the concentration of methoxychlor, cholinesterase activity in plasma and heptachlors family, and catalase activity and hexachlorohexane family. Cholinesterase activity in washed erythrocytes and lipid peroxidation were positively correlated with glutathione reductase activity. Antioxidant enzyme actions seem adequate as no lipids damages were correlated with any OCPs. Future studies are necessary to evaluate the effect of OCPs on males of the area due to the significant detection of methoxychlor, which target endocrine functioning and increases its concentration with sea turtles size.

Van Houtan, K. S., Andrews, A. H., Jones, T. T., Murakawa, S. K. K., & Hagemann, M. E. (2016). Time in Tortoiseshell: A Bomb Radiocarbon-Validated Chronology in Sea Turtle Scutes. *Proceedings of the Royal Society B-Biological Sciences, 283*(1822) https://doi.org/10.1098/rspb.2015.2220

Some of the most basic questions of sea turtle life history are also the most elusive. Many uncertainties surround lifespan, growth rates, maturity and spatial structure, yet these are critical factors in assessing population status. Here we examine the keratinized hard tissues of the hawksbill (*Eretmochelys imbricata*) carapace anduse bomb radiocarbondating to estimate growth andmaturity. Scutes have an established dietary record, yet the large keratin deposits of hawksbills evoke a reliable chronology. We sectioned, polished and imaged posterior marginal scutes from 36 individual hawksbills representing all

life stages, several Pacific populations and spanning eight decades. We counted the apparent growth lines, microsampled along growth contours and calibrated Delta C-14 values to reference coral series. We fit von Bertalanffy growth function (VBGF) models to the results, producing a range of age estimates for each turtle. We find Hawaii hawksbills deposit eight growth lines annually (range 5-14), with model ensembles producing a somatic growth parameter (k) of 0.13 (range 0.1-0.2) and first breeding at 29 years (range 23-36). Recent bomb radiocarbon values also suggest declining trophic status. Together, our results may reflect long-term changes in the benthic community structure of Hawaii reefs, and possibly shed light on the critical population status for Hawaii hawksbills.

Van Houtan, K. S., Francke, D. L., Alessi, S., Jones, T. T., Martin, S. L., Kurpita, L., . . . Baird, R. W. (2016). The Developmental Biogeography of Hawksbill Sea Turtles in the North Pacific. *Ecology and Evolution, 6*(8), 2378-2389 https://doi.org/10.1002/ece3.2034

High seas oceanic ecosystems are considered important habitat for juvenile sea turtles, yet much remains cryptic about this important life-history period. Recent progress on climate and fishery impacts in these so-called lost years is promising, but the developmental biogeography of hawksbill sea turtles (*Eretmochelys imbricata*) has not been widely described in the Pacific Ocean. This knowledge gap limits the effectiveness of conservation management for this globally endangered species. We address this with 30 years of stranding observations, 20 years of bycatch records, and recent simulations of natal dispersal trajectories in the Hawaiian Archipelago. We synthesize the analyses of these data in the context of direct empirical observations, anecdotal sightings, and historical commercial harvests from the insular Pacific. We find hawksbills 04 years of age, measuring 8-34 cm straight carapace length, are found predominantly in the coastal pelagic waters of Hawaii. Unlike other species, we find no direct evidence of a prolonged presence in oceanic habitats, yet satellite tracks of passive drifters (simulating natal dispersal) and our small sample sizes suggest that an oceanic phase for hawksbills cannot be dismissed. Importantly, despite over 600 million hooks deployed and nearly 6000 turtle interactions, longline fisheries have never recorded a single hawksbill take. We address whether the patterns we observe are due to population size and gear selectivity. Although most sea turtle species demonstrate clear patterns of oceanic development, hawksbills in the North Pacific may by contrast occupy a variety of ecosystems including coastal pelagic waters and shallow reefs in remote atolls. This focuses attention on hazards in these ecosystems - entanglement and ingestion of marine debris - and perhaps away from longline bycatch and decadal climate regimes that affect sea turtle development in oceanic regions.

Vargas, S. M., Jensen, M. P., Ho, S. Y. W., Mobaraki, A., Broderick, D., Mortimer, J. A., . . . FitzSimmons, N. N. (2016). Phylogeography, Genetic Diversity, and Management Units of Hawksbill Turtles in the Indo-Pacific. *Journal of Heredity, 107*(3), 199-213 https://doi.org/10.1093/jhered/esv091

Hawksbill turtle (*Eretmochelys imbricata*) populations have experienced global decline because of a history of intense commercial exploitation for shell and stuffed taxidermied whole animals, and harvest for eggs and meat. Improved understanding of genetic diversity and phylogeography is needed to aid conservation. In this study, we analyzed the most geographically comprehensive sample of hawksbill turtles from the Indo-Pacific Ocean, sequencing 766bp of the mitochondrial control region from 13 locations (plus Aldabra, n = 4) spanning over 13500 km. Our analysis of 492 samples revealed 52 haplotypes distributed in 5 divergent clades. Diversification times differed between the Indo-Pacific and Atlantic lineages and appear to be related to the sea-level changes that occurred during the Last Glacial Maximum. We found signals of demographic expansion only for turtles from the Persian Gulf region,

which can be tied to a more recent colonization event. Our analyses revealed evidence of transoceanic migration, including connections between feeding grounds from the Atlantic Ocean and Indo-Pacific rookeries. Hawksbill turtles appear to have a complex pattern of phylogeography, showing a weak isolation by distance and evidence of multiple colonization events. Our novel dataset will allow mixed-stock analyses of hawksbill turtle feeding grounds in the Indo-Pacific by providing baseline data needed for conservation efforts in the region. Eight management units are proposed in our study for the Indo-Pacific region that can be incorporated in conservation plans of this critically endangered species.

Velasco-Charpentier, C., Pizarro-Mora, F., Estrades, A., & Velez-Rubio, G. M. (2016). Epibiota of Juvenile Hawksbill Sea Turtles *Eretmochelys imbricata* Stranded in the Coast of Rocha Department, Uruguay. *Revista De Biologia Marina Y Oceanografia, 51*(2), 449-453 https://doi.org/10.4067/s0718-19572016000200022

The hawksbill turtle (*Eretmochelys imbricata*) is the most threatened sea turtle species in the world. An important aspect of the biology of sea turtles is the study of colonizing fauna, i.e., their epibiota. The aim of this study is a taxonomic determination on the epibiota found on 4 hawksbills turtles stranded in 2009 and 2011 on the coast of Rocha Department, Uruguay. The epibiota was composed by algae from the class Phaeophyceae (Sphacelaria sp. and Hincksia mitchelliae) and invertebrates from the classes Cirripedia (Platylepas hexastylos, Chelonibia testudinaria and Amphibalanus improvisus) and Hirudinea (Ozobranchus margoi), with greater predominance of P. hexastylos cirripeds (n = 365), a result that is consistent with other similar studies. Hincksia mitchelliae and A. improvisus are new reports as hawksbill turtles' epibiota.

Werneck, M. R., Baldassin, P., D'Azeredo, F., Trazi, A., & Berger, B. (2014). The Hawksbill Sea Turtle *Eretmochelys imbricata* Linnaeus 1758 (Testudines, Cheloniidae) as New Host of Hapalotrema Postorchis Rao, 1976 (Digenea: Spirorchiidae). *Comparative Parasitology, 81*(1), 75-78 https://doi.org/10.1654/4662.1

This note describes the first occurrence of Hapalotrema postorchis Rao, 1976 in the heart of Hawksbill sea turtle *Eretmochelys imbricata* Linnaeus, 1758, from Espirito Santo State, Brazil. This parasite has previously been reported only in *Chelonia mydas* from India, Australia, the United States, Costa Rica, and Taiwan. The note constitutes the first documented occurrence of this parasite in sea turtles from the western South Atlantic Ocean.

Werneck, M. R., Lima, E., Pires, T., & Silva, R. J. (2015). Helminth Parasites of the Juvenile Hawksbill Turtle *Eretmochelys imbricata* (Testudines: Cheloniidae) in Brazil. *Journal of Parasitology, 101*(4), 500-503 https://doi.org/10.1645/13-479.1

The helminth fauna of 31 juvenile specimens of *Eretmochelys imbricata* from the Brazilian coast was examined. Seventeen individuals were infected with helminths (54.8%). The helminths found were: Diaschistorchis pandus, Cricocephalus albus, Metacetabulum invaginatum, Pronocephalus obliquus (Pronocephalidae), Cymatocarpus solearis (Brachycoeliidae), Styphlotrema solitaria (Styphlotrematidae), Carettacola stunkardi, Amphiorchis caborojoensis (Spirorchiidae), Orchidasma amphiorchis (Telorchiidae), and Anisakis nematode larvae. This report is the first analysis of parasite communities in this host.

Werneck, M. R., Sousa, V. R., Trazi, A., & Berger, B. (2015). Monticellius Indicum Mehra, 1939 (Digenea: Spirorchiidae) in a Hawksbill Turtle, *Eretmochelys imbricata* Linnaeus 1766 (Testudines, Cheloniidae) from Brazil. *Comparative Parasitology, 82*(1), 155-157 https://doi.org/10.1654/4716.1

This note reports the first occurrence of Monticellius indicum Mehra, 1939, in the heart of the Hawksbill turtle, *Eretmochelys imbricata* Linnaeus, 1766, in the state of Espi ' rito Santo, Brazil. This parasite has only previously been reported, to our knowledge, in *Chelonia mydas* from India, Brazil, and Costa Rica.

Werneck, M. R., Velloso, R., Das Chagas, P. B. C., Leandro, H. J., & De Amorim, R. M. (2019). First Report of Pyelosomum Cochlear Looss 1899 (Digenea: Pronocephalidae) in a Hawksbill Turtle - *Eretmochelys imbricata* L. Found in Brazilian Coast. *Helminthologia, 56*(4), 334-337 https://doi.org/10.2478/helm-2019-0024

Pyelosomum cochlear Looss 1899 (Digenea: Pronocephalidae) is a parasite exclusive to sea turtles, having been described in the green turtle (*Chelonia mydas*) in Egypt, the USA, Panama, Costa Rica and Brazil as well as the olive ridley turtle (Lepidochelys olivacea) in Brazil. The present note describes the first occurrence of P. cochlear in a hawksbill turtle (*Eretmochelys imbricata*) found on the coast of Brazil.

White, E. M., Clark, S., Manire, C. A., Crawford, B., Wang, S., Locklin, J., & Ritchie, B. W. (2018). Ingested Micronizing Plastic Particle Compositions and Size Distributions within Stranded Post-Hatchling Sea Turtles. *Environmental Science & Technology, 52*(18), 10307-10316 https://doi.org/10.1021/acs.est.8b02776

From July 2015 to November 2016, 96 post-hatchling sea turtles were collected from 118 km of the Atlantic coastline in Florida, USA, including loggerhead, green, and hawksbill sea turtle species. Forty-five of the recovered turtles were rehabilitated and released, but the remaining 52 died and were frozen. At necropsy, the gastrointestinal tracts of most the turtles contained visible plastic, and collected particles of 27 individuals were chemically characterized by Raman microscopy as polyethylene, polypropylene, polyethylene terephthalate, and polystyrene. Mesoparticle plastic fragments 1.0-8.7 mm, microparticle fragments 20-1000 mu m, and nanoparticles 5-169 nm were identified in the turtles. Polyethylene and polypropylene were the most common plastics ingested from specimens representing 54.1 and 23.7% of the total observed mesoparticles and 11.7 and 21.0% of the total observed microparticles, respectively. A plastic-to-body mass ratio of 2.07 mg/g was determined for this group. The authors suggest that ingestion of micronizing plastic by post-hatchling sea turtles is likely a substantial risk to survival of these endangered and threatened species. This study also provides some of the first evidence for the formation of nanoscopic plastic particles that we theorize forms in the post-hatchling and juvenile environment and are present post-ingestion.

Whiting, S. D., Guinea, M. L., Fomiatti, K., Flint, M., & Limpus, C. J. (2014). Plasma Biochemical and Pcv Ranges for Healthy, Wild, Immature Hawksbill (*Eretmochelys imbricata*) Sea Turtles. *The Veterinary Record, 174*(24), 608 https://doi.org/10.1136/vr.101396

In recent years, the use of blood chemistry as a diagnostic tool for sea turtles has been demonstrated, but much of its effectiveness relies on reference intervals. The first comprehensive blood chemistry values for healthy wild hawksbill (*Eretmochelys imbricata*) sea turtles are presented. Nineteen blood chemistry analytes and packed cell volume were analysed for 40 clinically healthy juvenile hawksbill sea turtles captured from a rocky reef habitat in northern Australia. We used four statistical approaches to calculate reference intervals and to investigate their use with non-normal distributions and small sample sizes, and to compare upper and lower limits between methods. Eleven analytes were correlated with curved carapace length indicating that body size should be considered when designing future studies and interpreting analyte values.

Wise, S. S., Xie, H., Fukuda, T., Thompson, W. D., & Wise, J. P. (2014). Hexavalent Chromium Is Cytotoxic and Genotoxic to Hawksbill Sea Turtle Cells. *Toxicology and Applied Pharmacology, 279*(2), 113-118 https://doi.org/10.1016/j.taap.2014.06.008

Sea turtles are a charismatic and ancient ocean species and can serve as key indicators for ocean ecosystems, including coral reefs and sea grass beds as well as coastal beaches. Genotoxicity studies in the species are absent, limiting our understanding of the impact of environmental toxicants on sea turtles. Hexavalent chromium (Cr(VI)) is a ubiquitous environmental problem worldwide, and recent studies show it is a global marine pollutant of concern. Thus, we evaluated the cytotoxicity and genotoxicity of soluble and particulate Cr(VI) in hawksbill sea turtle cells. Particulate Cr(VI) was both cytotoxic and genotoxic to sea turtle cells. Concentrations of 0.1, 0.5, 1, and 5 mu g/cm(2) lead chromate induced 108, 79, 54, and 7% relative survival, respectively. Additionally, concentrations of 0, 0.1, 0.5, 1, and 5 mu g/cm(2) lead chromate induced damage in 4, 10, 15, 26, and 36% of cells and caused 4, 11, 17, 30, and 56 chromosome aberrations in 100 metaphases, respectively. For soluble Cr, concentrations of 0.25, 0.5, 1, 2.5, and 5 mu M sodium chromate induced 84, 69, 46, 25, and 3% relative survival, respectively. Sodium chromate induced 3, 9, 9, 14, 21, and 29% of metaphases with damage, and caused 3, 10, 10, 16, 26, and 39 damaged chromosomes in 100 metaphases at concentrations of 0, 025,0.5,1, 2.5, and 5 mu M sodium chromate, respectively. These data suggest that Cr(VI) may be a concern for hawksbill sea turtles and sea turtles in general.

Young, J. L., Wise, S. S., Xie, H., Zhu, C. R., Fukuda, T., & Wise, J. P. (2015). Comparative Cytotoxicity and Genotoxicity of Soluble and Particulate Hexavalent Chromium in Human and Hawksbill Sea Turtle (*Eretmochelys imbricata*) Skin Cells. *Comparative Biochemistry and Physiology C-Toxicology & Pharmacology, 178*, 145-155 https://doi.org/10.1016/j.cbpc.2015.09.013

Chromium is both a global marine pollutant and a known human health hazard. In this study, we compare the cytotoxicity and genotoxicity of both soluble and particulate chromate in human and hawksbill sea turtle (*Eretmochelys imbricata*) skin fibroblasts. Our data show that both soluble and particulate Cr(VI) induce concentration-dependent increases in cytotoxicity, genotoxicity, and intracellular Cr ion concentrations in both human and hawksbill sea turtle fibroblasts. Based on administered concentration, particulate and soluble Cr(VI) were more cytotoxic and clastogenic to human cells than sea turtle cells. When the analysis was based on the intracellular concentration of Cr, the data showed that the response of both species was similar. The one exception was the cytotoxicity of intracellular Cr ions from soluble Cr(VI), which caused more cytotoxicity in sea turtle cells (LC50 = 271 mu M) than that of human cells (LC50 = 471 mu M), but its clastogenicity was similar between the two species. Thus, adjusting for differences in uptake indicated that the explanation for the difference in

potency was mostly due to uptake rather than differently affected mechanisms. Overall these data indicate that sea turtles may be a useful sentinel for human health responses to marine pollution.

Zarate, P. M., Bjorndal, K. A., Seminoff, J. A., Dutton, P. H., & Bolten, A. B. (2015). Somatic Growth Rates of Green Turtles (*Chelonia mydas*) and Hawksbills (*Eretmochelys imbricata*) in the Galapagos Islands. *Journal of Herpetology, 49*(4), 641-648 https://doi.org/10.1670/14-078

Growth rates can be used as an indicator of overall turtle population health and provide a baseline against which to compare the quality of, or changes in, the conditions in foraging habitats. Previous studies of Green Turtles (*Chelonia mydas*) in the waters of the Galapagos Archipelago in the late 1970s revealed some of the slowest growth rates ever reported for immature Green Turtles. In this study, we evaluate whether growth rates have changed since the earlier study and the effects of color morph, body size, recapture interval, year, and site of capture on growth rates for Green Turtles at four key foraging grounds in the Galapagos Islands between 2003 and 2008. Results of this study confirm that somatic growth in Galapagos Green Turtles is very slow. In addition, somatic growth is significantly affected by morph, body size, and spatial variation. Mean growth rates generate implausibly long estimates of 133-200 yr for Galapagos Green Turtles to grow from 40-cm straight carapace length to sexual maturity. We also present some data for growth in Hawksbills (*Eretmochelys imbricata*), representing the first information of growth rates for Hawksbills in the Archipelago.

Zuñiga-Marroquin, T., & de los Monteros, A. E. (2017). Genetic Characterization of the Critically Endangered Hawksbill Turtle (*Eretmochelys imbricata*) from the Mexican Pacific Region. *Latin American Journal of Aquatic Research, 45*(3), 555-562 http://dx.doi.org/10.3856/vol45-issue3-fulltext-5

The hawksbill turtle (*Eretmochelys imbricata*) is a Critically Endangered species and has been a species of interest for decades. Only in recent years attention has been focused on the populations of the Eastern Pacific Ocean. We present a genetic characterization of this species in the Mexican Pacific, based on mitochondrial DNA sequences. Six localities were sampled along the Pacific Coast, from the Gulf of California to Chiapas, between 2002 and 2007. Seventeen individuals found in marine habitats at six localities and six nests laid at three nesting sites were sampled along the Mexican Pacific. Our results show five haplotypes of 766 bp, three previously identified and two that to date were not reported. Genetic diversity indices indicate moderate to low variation for this region. Even with the small sample size reported here, our results show important relationships between the Mexican Pacific hawksbills and nesting populations of Central America and foraging areas along the Eastern and Indo-Pacific. These results, along with updated information on ecology and behavior, are essential for the future approach to conservation and management programs resulting in the recovery of this species in the Eastern Pacific.

Section II: Ecology

Al-Mansi, A. M. A. (2016). Status and Ecology of Sirenian, Cetaceans and Marine Turtles in the Farasan Bank, Red Sea, Saudi Arabia. *Journal of King Abdulaziz University, 26*(1), 1-8 https://doi.org/10.4197/Mar.26-1.1

This paper presents preliminary data regarding the status, general distribution and habitat use of cetaceans, sirenian and marine turtle species inhabiting the Farasan Bank in the south-east of the Red Sea. The survey was conducted in April 2009 as part of a joint project by the Khaled Bin Sultan Living Ocean Foundation and the Saudi Wildlife Authority. With respect to habitat use of these species, the Common Dolphins, Delphinus delphius, were recognized in the offshore waters around the islands and the reefs; whereas the Bottlenose Dolphins, Tursiops truncatus, showed a preference for deeper waters. The Humpbacked Dolphins, Sousa chinensis, were sighted near an island with mangrove swamps and the Spinner Dolphins, Stenella longirostris, inhabited sheltered shallow water. The Bryde's whales, Balaenoptera edeni, were found in offshore waters which are of high productively. The Dugongs, Dugong dugon, used shallow water habitats characterized by seagrass meadows. The habitat use of the marine turtles found in the study area was also distinct. The Hawksbill turtles, *Eretmochelys imbricata*, were recorded within the coral reefs, whereas the Green Turtle, *Chelonia mydas*, were seen near the seagrass beds. The results of this study provide an important baseline data on the ranges and abundance of some endangered animals. These data along with a greater understanding of species distribution and habitat use will prove to be important for the proposing the Farasan Bank as Marine Protected Areas in this part of the Red Sea.

Almpanidou, V., Schofield, G., & Mazaris, A. D. (2017). Unravelling the Climatic Niche Overlap of Global Sea Turtle Nesting Sites: Impact of Geographical Variation and Phylogeny. *Journal of Biogeography, 44*(12), 2839-2848 https://doi.org/10.1111/jbi.13092

Aim Identifying processes that determine climatic niche dynamics is difficult, especially for wide-ranging species where niche conservatism might differ at different life stages. Evolutionary history shapes climatic niche, with populations of the same or phylogenetically close species occupying similar conditions. However, the geographical separation of populations also leads to niche evolution as an adaptive response to local conditions. Here, we use five sea turtle species (loggerhead, green, leatherback, hawksbill, olive ridley) to test whether short- (environmental adaptation) or long-term (phylogenetic separation) evolutionary events determined the level of niche conservatism among distinct groups of nesting populations (termed Regional Management Units; RMUs) distributed across different ocean basins. Location Global. Methods We estimated the climatic niche of 4,829 georeferenced nesting locations using air and sea surface parameters. We quantified niche overlap among RMUs of the same species at a global scale and examined how the geographical ranges of each RMU are correlated with niche similarity. We also investigated the extent of niche conservatism among RMUs of different species in the same ocean basin. Results We found limited within-species niche similarity of RMUs at a global scale, with geographical range having negligible impact (latitudinal overlap, range size asymmetries). We detected generally higher niche overlap between RMUs of different species located within the same ocean basin, where the geographical range had a stronger effect on niche similarity. Main conclusions We show that adaptation to local conditions potentially prevails over distant evolutionary events when considering the climatic niche of RMUs of the same species across different oceans. Because sea turtles, like other long-distance migratory animals, occupy distinct climatic niches, our findings support the importance of understanding this phenomenon for different life stages, populations and species to preserve unique adaptations to different environments that might enhance future viability under climate change, as well as help identify key conservation areas.

Anonymous. (2017). Hawksbill Turtles Thrive in Belizean Preserve. *The Science Teacher, 84*(1), 22-24 Retrieved from https://www.jstor.org/stable/44160042

A new generation of threatened hawksbill sea turtles is thriving in the protected waters of Glover's Reef Atoll, Belize, according to the Wildlife Conservation Society and the Belize Fisheries Department. In a recently published study in the journal Endangered Species Research, scientists have reported that the coral reefs surrounding the atoll are home to more than 1,000 juvenile hawksbill sea turtles.

Askari Hesni, M., Tabib, M., & Hadi Ramaki, A. (2016). Nesting Ecology and Reproductive Biology of the Hawksbill Turtle, *Eretmochelys imbricata*, at Kish Island, Persian Gulf. *Journal of the Marine Biological Association of the United Kingdom, 96*(7), 1373-1378 https://doi.org/10.1017/S0025315415001125

The ecology and reproductive biology of the hawksbill turtle, *Eretmochelys imbricata* were studied in Kish Island, Persian Gulf. The studied parameters include: environmental factors such as air temperature and humidity, soil types in different habitats during the breeding season; parameters related to the females' body and hatchlings biometrics i.e. weight, curved carapace length (CCL), straight carapace length (SCL), curved carapace width (CCW) and straight carapace width (SCW); and parameters related to reproductive biology, i.e. breeding time during diurnal, total eggs laid, the numbers of normal and abnormal eggs, weight and diameter of the eggs, incubation period and hatching success (HS). The temperature, humidity and soil size in different nest sites were 18.5-31 degree C, 70 to 88% and 0.063 to 4 mm, respectively. Means of weight, CCL, SCL, CCW and SCW of the females were 39.8 kg, 71.6, 65.1, 65.2 and 51.8 cm, respectively. The average of total egg numbers, normal and abnormal eggs by each individual female were 92.9, 75.2 and 17.7 respectively. Diameter and weight of every egg measured 38.4 mm and 33.6 g. Average of incubation period and HS were 60.9 days and 75.8%. According to the positive and significant correlation between CCL and CCW with weight took exponential regression models.

Bechhofer, J., & Henderson, A. C. (2018). Transient Nocturnal Site Fidelity in Juvenile Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) Sea Turtles on the Shallow Nearshore Coral Reefs of South Caicos, Turks and Caicos Islands. *Tropical Zoology, 31*(1), 44-54 https://doi.org/10.1080/03946975.2017.1403196

Opportunistic nocturnal catch-and-release turtle surveys were conducted on three nearshore, shallow coral reefs that fringe the main navigation channel to Cockburn Harbour, South Caicos, between 2005 and 2015. A total of 117 captures were made, representing 73 individual turtles (32 green, 41 hawksbill). Almost half of the green turtles were recaptured on at least one occasion, with a maximum time at liberty of 574 days (median = 94 days). Only 20% of hawksbill turtles were recaptured, with a maximum time at liberty of 587 days (median = 120 days). These data suggest that the study sites are utilised by a combination of transient visitors and short to medium-term resident turtles. However, no evidence of long-term nocturnal site fidelity was found. The size ranges observed in both species indicate that all turtles were immature, and the minimum sizes are consistent with previously reported settlement sizes from the region. Despite the lack of long-term fidelity, turtles were regularly encountered over the course of the study, indicating that these reefs are an important nocturnal refugium for local juvenile turtles in general.

Becking, L. E., Christianen, M. J. A., Nava, M. I., Miller, N., Willis, S., & van Dam, R. P. (2016). Post-Breeding Migration Routes of Marine Turtles from Bonaire and Klein Bonaire, Caribbean Netherlands. *Endangered Species Research, 30*, 117-124 https://doi.org/10.3354/esr00733

The management of small rookeries is key to conserving the regional genetic diversity of marine turtle populations and requires knowledge on population connectivity between breeding and foraging areas. To elucidate the geographic scope of the populations of marine turtles breeding at Bonaire and Klein Bonaire (Caribbean Netherlands) we examined the post-breeding migratory behavior of 5 female loggerheads *Caretta caretta*, 4 female green turtles *Chelonia mydas*, and 2 male and 13 female hawksbill turtles *Eretmochelys imbricata* during the years 2004-2013. After leaving Bonaire, the 24 tracked turtles frequented foraging grounds in 10 countries. The distances swum from Bonaire to the foraging areas ranged from 608 to 1766 km for loggerhead turtles, 198 to 3135 km for green turtles, and 197 to 3135 km for hawksbill turtles, together crossing the waters of 19 countries. Males represented the minority in this study, but we made 2 key observations that require further research: males remained in the vicinity of the breeding area for 3-5 mo, which is 2-5 times longer than females, and males migrated greater distances than previously recorded. Although the turtles dispersed widely across the Caribbean, there appeared to be 2 benthic foraging areas of particular importance to all 3 species of marine turtles breeding at Bonaire, namely the shallow banks east of Nicaragua and Honduras (n = 8 tracked turtles) and Los Roques, Venezuela (n = 3). Marine turtles breeding at Bonaire face threats from legal turtle harvesting, illegal take, and bycatch in the waters that they traverse across the Caribbean.

Bell, I. (2013). Algivory in Hawksbill Turtles: *Eretmochelys imbricata* Food Selection within a Foraging Area on the Northern Great Barrier Reef. *Marine Ecology, 34*(1), 43-55 https://doi.org/10.1111/j.1439-0485.2012.00522.x

This paper describes the food selection of hawksbill turtles, *Eretmochelys imbricata*, using reefs of the Far Northern Section of the Great Barrier Reef Marine Park (nGBR) during 2006 and 2007. A total of 467 gastric lavage and 71 buccal cavity ingesta items were collected from 120 individual E. imbricata, comprising adult female and immature turtles of both sexes. Nineteen E. imbricata that were captured in 2006 were recaptured and sampled again in 2007. Within the total pooled buccal and lavage sample (n=538), the occurrence of food items was dominated (72.7%) by only three algal taxonomic divisions: Rhodophyta (red algae; 53.7%, n=289); Chlorophyta (green algae; 11.0%, n=59) and algae from the division of Phaeophyceae (brown algae; 8.0%, n=43). The remaining total (buccal and lavage) ingesta sample comprised sponges (10.4%, n=56), soft corals and a wide variety of possibly nutritionally important invertebrate species (12.6%, n=68), and a small percentage (5.4%, n=22) of inorganic material. Generally, E. imbricata were considered to be primarily a sponge-feeding specialist and secondarily an omnivorous species; within coral reef habitats and in various parts of the world this is the case. However, this study has shown that E. imbricata found foraging on reefs of the nGBR are primarily algivorous and secondarily omnivorous. A feeding strategy that relies on a predominantly algal diet may infer important benefits to the species if the impacts of climate change and ocean acidification inhibit coral growth, while promoting algal density and distribution within the Great Barrier Reef ecosystem.

Bevan, E., Whiting, S., Tucker, T., Guinea, M., Raith, A., & Douglas, R. (2018). Measuring Behavioral Responses of Sea Turtles, Saltwater Crocodiles, and Crested Terns to Drone Disturbance to Define Ethical Operating Thresholds. *PLoS One, 13*(3) https://doi.org/10.1371/journal.pone.0194460

Drones are being increasingly used in innovative ways to enhance environmental research and conservation. Despite their widespread use for wildlife studies, there are few scientifically justified guidelines that provide minimum distances at which wildlife can be approached to minimize visual and auditory disturbance. These distances are essential to ensure that behavioral and survey data have no observer bias and form the basis of requirements for animal ethics and scientific permit approvals. In the present study, we documented the behaviors of three species of sea turtle (green turtles, *Chelonia mydas*, flatback turtles, Natator depressus, hawksbill turtles, *Eretmochelys imbricata*), saltwater crocodiles (Crocodylus porosus), and crested terns (Thalasseus bergil) in response to a small commercially available (1.4 kg) multirotor drone flown in Northern Territory and Western Australia. Sea turtles in nearshore waters off nesting beaches or in foraging habitats exhibited no evasive behaviors (e.g. rapid diving) in response to the drone at or above 20-30 m altitude, and at or above 10 m altitude for juvenile green and hawksbill turtles foraging on shallow, algae-covered reefs. Adult female flatback sea turtles were not deterred by drones flying forward or stationary at 10 m altitude when crawling up the beach to nest or digging a body pit or egg chamber. In contrast, flyovers elicited a range of behaviors from crocodiles, including minor, lateral head movements, fleeing, or complete submergence when a drone was present below 50 m altitude. Similarly, a colony of crested terns resting on a sand-bank displayed disturbance behaviors (e.g. flight response) when a drone was flown below 60 m altitude. The current study demonstrates a variety of behavioral disturbance thresholds for diverse species and should be considered when establishing operating conditions for drones in behavioral and conservation studies.

Bjorndal, K. A., Bolten, A. B., Chaloupka, M., Saba, V. S., Bellini, C., Marcovaldi, M. A. G., . . . Kenyon, L. (2017). Ecological Regime Shift Drives Declining Growth Rates of Sea Turtles Throughout the West Atlantic. *Global Change Biology, 23*(11), 4556-4568 https://doi.org/10.1111/gcb.13712

Somatic growth is an integrated, individual-based response to environmental conditions, especially in ectotherms. Growth dynamics of large, mobile animals are particularly useful as bio-indicators of environmental change at regional scales. We assembled growth rate data from throughout the West Atlantic for green turtles, *Chelonia mydas*, which are long-lived, highly migratory, primarily herbivorous mega-consumers that may migrate over hundreds to thousands of kilometers. Our dataset, the largest ever compiled for sea turtles, has 9690 growth increments from 30 sites from Bermuda to Uruguay from 1973 to 2015. Using generalized additive mixed models, we evaluated covariates that could affect growth rates; body size, diet, and year have significant effects on growth. Growth increases in early years until 1999, then declines by 26% to 2015. The temporal (year) effect is of particular interest because two carnivorous species of sea turtles-hawksbills, *Eretmochelys imbricata*, and loggerheads, *Caretta caretta*-exhibited similar significant declines in growth rates starting in 1997 in the West Atlantic, based on previous studies. These synchronous declines in productivity among three sea turtle species across a trophic spectrum provide strong evidence that an ecological regime shift (ERS) in the Atlantic is driving growth dynamics. The ERS resulted from a synergy of the 1997/1998 El Nino Southern Oscillation (ENSO)-the strongest on record-combined with an unprecedented warming rate over the last two to three decades. Further support is provided by the strong correlations between annualized mean growth rates of green turtles and both sea surface temperatures (SST) in the West Atlantic for years of declining growth rates (r = -.94) and the Multivariate ENSO Index (MEI) for all years (r = .74). Granger-causality analysis also supports the latter finding. We discuss multiple stressors that could reinforce and prolong the effect of the ERS. This study demonstrates the importance of region-wide collaborations.

Booth, D. T., Onate-Casado, J., Rusli, M. U., & Stewart, T. (2019). Towing a Float Decreases Swim Speed but Does Not Affect Swimming Behavior During Offshore Swimming in Sea Turtle Hatchlings. *Chelonian Conservation and Biology, 18*(1), 112-115 https://doi.org/10.2744/ccb-1350.1

Swimming behavior and speed of green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*) hatchlings swimming offshore were compared between individuals that were free swimming and the same individuals towing a float. Towing a float did not influence swimming behavior in either species, but decreased swimming speed by 20% in green turtles and 50% in hawksbill turtles.

Brei, M., Pérez-Barahona, A., & Strobl, E. (2016). Environmental Pollution and Biodiversity: Light Pollution and Sea Turtles in the Caribbean. *Journal of Environmental Economics and Management, 77*, 95-116 https://doi.org/10.1016/j.jeem.2016.02.003

We examine the impact of pollution on biodiversity by studying the effect of coastal light pollution on the sea turtle population in the Caribbean. To this end we assemble a panel data set of sea turtle nesting activity and satellite-derived measures of nighttime light. Controlling for the surveyor effort, the local economic infrastructure, and spatial spillovers, we find that nighttime light significantly reduces the number of sea turtle nests. According to data on replacement costs for sea turtles raised in captivity, our result suggests that the increase in lighting over the last two decades has resulted in the loss of close to 1800 sea turtles in the Caribbean, worth up to $288 million. Incorporating our empirical estimates into a stage-structured population model, we discover that the dynamic effect of nighttime light on future generations of sea turtles is likely to be much larger, with a cost of approximately $2.8 billion for Guadeloupe alone. More generally, our study provides a new approach to valuing the cost of environmental pollution associated with species extinction.

Carrión-Cortez, J., Canales-Cerro, C., Arauz, R., & Riosmena-Rodríguez, R. (2013). Habitat Use and Diet of Juvenile Eastern Pacific Hawksbill Turtles (*Eretmochelys imbricata*) in the North Pacific Coast of Costa Rica. *Chelonian Conservation and Biology, 12*(2), 235-245 https://doi.org/10.2744/CCB-1024.1

The hawksbill turtle (*Eretmochelys imbricata*) is critically endangered throughout its global range and is particularly threatened in the eastern Pacific, a region where our knowledge of the ecological traits is very limited. Understanding habitat preferences of hawksbills at different life stages is necessary to create effective local and regional conservation strategies. We studied habitat use and the diet of juvenile hawksbill sea turtles at Punta Coyote, a rocky reef located along the Nicoya Peninsula on the north Pacific coast of Costa Rica, along the northern boundary of the Caletas-Arío National Wildlife Refuge. We tracked 12 juvenile hawksbills (36-69-cm curved carapace length) with acoustic transmitters to study their habitat use. Turtles were on the rocky reef more frequently than the sandy bottoms (x^sup 2^^sub 1^ = 29.90, p = 0.00). The 95% fixed kernel density home range analysis revealed high-intensity use of the rocky reef, where hawksbills mainly dove in shallow waters (7.6 ± 3.3 m). Less than 5% of the 95% home range area overlapped with the Caletas-Arío National Wildlife Refuge. Hawksbills fed mainly on 2 invertebrate species regardless of season: a sponge (Geodia sp.) (mean volume = 67%) and a tunicate (Rhopalaea birkelandi) (mean volume = 51%). Our surveys along the Nicoya Peninsula suggested that use of rocky reefs by juvenile hawksbill turtles was common. To protect juvenile hawksbills in the study area, we recommend that this site be granted official protection status as part of the Caletas-Arío National Wildlife Refuge. We also suggest studying other discrete rocky reefs along the

Nicoya Peninsula to determine critical habitats for the hawksbill turtle to improve conservation and management policy.

Chacon-Chaverri, D., Martinez-Cascante, D. A., Rojas, D., & Fonseca, L. G. (2015). Golfo Dulce, Costa Rica, an Important Foraging Ground for the Pacific Hawksbill Turtle (*Eretmochelys imbricata*). *Revista De Biologia Tropical, 63*, 351-362 https://doi.org/10.15517/RBT.V6311.23114

Limited quantitative information is available for hawksbill turtles (*Eretmochelys imbricata*) at foraging grounds in the Eastern Tropical Pacific (ETP), where the species composes one of the most endangered marine turtle populations on the planet. Between August 2010 and March 2013 we captured individual hawksbill turtles using entanglement nets along the edges of mangroves and seagrasses of the Golfo Dulce, in southwest Pacific Costa Rica. A total of 62 hawksbills were captured, including 14 recaptures, of which 46 (74.19%) were juveniles (CCL<66cm) and 16 (25.81%) were adults. The catch per unit effort (1 unit: 100m of net for 7h) during the study ranged between 0.03 and 0.07. The Golfo Dulce is highly turbid during the rainy season (May-November), particularly at our study area, as high sediment loads due to intensive runoff lead to poor water clarity. The probability of detection of hawksbills was considerably higher in the dry season (December-April) compared to the rainy season, suggesting these turtles may prefer waters with higher clarity. None of the individuals captured had evidence of internal or external tags, making it possible to conclude that they had not been previously marked at other feeding or breeding sites. A total of 28 (45.16%) individuals were found to host the ectoparasitic barnacle Stephanolepas muricata, which in high concentrations can be harmful by limiting the mobility of organs and limbs. Although consistent in-water quantification of hawksbills in the ETP remains scant, this study represents the longest and most robust marine monitoring dataset for hawksbills in the region to date. Our findings highlight the relevance of the Golfo Dulce as an important foraging ground for hawksbill turtles in the ETP and emphasize the need to monitor and protect this habitat to aid efforts to recover this critically endangered marine turtle population.

Chatting, M., Smyth, D., Al-Maslamani, I., Obbard, J., Al-Ansi, M., Hamza, S., . . . Marshall, C. D. (2018). Nesting Ecology of Hawksbill Turtles, *Eretmochelys imbricata*, in an Extreme Environmental Setting. *PLoS One, 13*(9) https://doi.org/10.1371/journal.pone.0203257

Relatively few details of hawksbill turtle (*Eretmochelys imbricata*) nesting ecology exist within the Arabian Gulf. Moreover, little is known about how their nesting dynamics compare to nesting populations throughout the rest of the world. Due to the extreme environmental setting, nesting ecology of hawksbills in the Arabian Gulf is of significant interest to researchers and conservationists. The current research reports on a long-term tagging and monitoring program undertaken at Fuwairit beach, Qatar. To investigate nesting behavior, site surveys and tagging were employed from 2010 to 2016. Presence of nests and clutch sizes were confirmed by excavation. Over the entire study period, nesting hawksbills had a mean curved carapace length of 70.8 cm (SD +/- 2.8). A total 187 nests were confirmed, which contained a mean 78.9 eggs per clutch (SD +/- 17.1), over an annual nesting season that lasted an average of 52.2 days (SD +/- 6.3) from the start of April to the start of June. Meta-analysis with other global regions showed these characteristics to be significantly reduced when compared to nesting hawksbills from other populations. Meteorological data analysis showed air temperatures in the Arabian Gulf to increase on average 13.2 degrees C (SD +/- 0.26) from start to the end of nesting annually, which is significantly greater than other global nesting regions. Their smaller body size and reduced fecundity coupled with the extreme change in ambient air temperatures support the

hypothesis that hawksbills in the region are more at risk than the already critically endangered hawksbill populations elsewhere in the world.

Chevis, M. G., Godley, B. J., Lewis, J. P., Lewis, J. J., Scales, K. L., & Graham, R. T. (2017). Movement Patterns of Juvenile Hawksbill Turtles *Eretmochelys imbricata* at a Caribbean Coral Atoll: Long-Term Tracking Using Passive Acoustic Telemetry. *Endangered Species Research, 32*, 309-319 https://doi.org/10.3354/esr00812

Understanding the ecological interactions that underlie marine ecosystem functioning requires sufficient data describing habitat use by mobile species. Hawksbill turtles Eretmo-chelys imbricata are considered a key species in coral reef-associated communities, owing to their specific foraging preferences, yet new information is still revealing details of the spatial and temporal aspects of habitat use. We used passive acoustic telemetry to monitor the movements of 18 juvenile hawksbills (minimum curved carapace length: 32.0-59.7 cm, mean +/- SD = 43.9 +/- 6.7 cm) at a developmental foraging site in a Mesoamerican barrier reef, Lighthouse Reef Atoll in Belize (tracking duration 10-1414 d, mean +/- SD = 570 +/- 484 d). Although specific home ranges were difficult to quantify, several turtles showed high site fidelity over timescales of months to years, with occasional wide-ranging use of the atoll. Diel variation in the number of detections received strongly suggest nocturnal resting. Long-term tracking data reveal 3 degrees of site fidelity across the atoll, based on the number of detection days near individual stations: high residency(n = 4 turtles), equential residency (n = 5), and transient behavior (n = 4). These variations in movement raise questions about the differentiation of foraging habitats and degree of individual specialization within this population, as well as the influences of microhabitats and human disturbance.

de Oliveira Braga, H., & Schiavetti, A. (2013). Attitudes and Local Ecological Knowledge of Experts Fishermen in Relation to Conservation and Bycatch of Sea Turtles (Reptilia: Testudines), Southern Bahia, Brazil. *Journal of Ethnobiology and Ethnomedicine, 9*(1), 15 https://doi.org/10.1186/1746-4269-9-15

Background: The use of ethnoecological tools to evaluate possible damage and loss of biodiversity related to the populations of species under some degree of threat may represent a first step towards integrating the political management of natural resources and conservation strategies. From this perspective, this study investigates fishermen's ecological knowledge about sea turtles and attitudes towards the conservation and bycatch in Ilheus, Southern Bahia, Brazil. Methods: Fishermen experts semi-structured interviews were performed using snowball sampling method. The interviews consisted of a series of questions relating to the fishermen's profile, structure and work equipment, the local ecological knowledge of fishermen about sea turtles and bycatch, a projective test, attitudes towards turtle conservation and beliefs and taboos regarding turtles. Indicators for quantitative comparisons of respondents in terms of their broad knowledge and attitudes towards turtle conservation were created. Correlation analyses were made between indicators of knowledge and attitude as well as the relationship between education level and knowledge and attitudes. Results: Thirty experts were interviewed for the study. The local ecological knowledge and attitudes of fishermen towards the conservation of sea turtles were respectively medium (0.43) and moderate (0.69) according to experts (based on Likert scale and Cronbach's Alpha). Potential areas of spawning were reported from Barra Grande to Una covering the entire coast of Ilheus. Methods for identifying the animal, behavior, and popular names were described by fishermen. The most recent captures of turtles were attributed to fishing line, but according to the respondents, lobster nets and shrimp traps are more likely to capture

turtles. Knowledge and attitudes were weakly inversely correlated (r = -0.38, p = 0.04), and the education level of the respondent showed a positive correlation with positive attitudes towards turtle conservation (H = 8.33; p = 0.04). Life history, habitat, specific and exogenous taboos, beliefs and the use of hawksbill turtle to make glasses and other handcrafts are also reported in the study. Conclusions: Monitoring of spawning areas, preservation of traditional practices, strategies to moderate the use of fishery resources and the local ecological knowledge/attitudes can provide data to improve the conservation practices and management of sea turtles.

Delcroix, E., Bédel, S., Santelli, G., & Girondot, M. (2014). Monitoring Design for Quantification of Marine Turtle Nesting with Limited Effort: A Test Case in the Guadeloupe Archipelago. *Oryx, 48*(1), 95-105 https://doi.org/10.1017/S0030605311000792

The Guadeloupe archipelago hosts nesting of the threatened hawksbill *Eretmochelys imbricata*, green *Chelonia mydas* and leatherback Dermochelys coriacea marine turtles. There is a need to monitor the nesting of these species but, with > 150 beaches in the archipelago, exhaustive monitoring is infeasible. Using a new monitoring design and a new statistical tool we have been able to monitor one-third of the beaches. Seasonality and level of nesting were described for the three species for 2 years on > 50 beaches. For each species beaches were categorized as A- or B-beaches, with high and low nest density, respectively. A-beaches were monitored on 6-7 days per month before and after the peak nesting period and on 7-15 days during the peak, and the B-beaches on 14-22 days during the peak. The monitoring design and statistical tool are described in detail as they could be applied to any migratory species. Hawksbill turtles at Trois Ilets beach have been monitored for 9 years and a positive trend in nesting has been detected.

Esteban, N., van Dam, R. P., Harrison, E., Herrera, A., & Berkel, J. (2015). Green and Hawksbill Turtles in the Lesser Antilles Demonstrate Behavioural Plasticity in Inter-Nesting Behaviour and Post-Nesting Migration. *Marine Biology, 162*(6), 1153-1163 https://doi.org/10.1007/s00227-015-2656-2

Satellite transmitters were deployed on three green turtles, *Chelonia mydas*, and two hawksbill turtles, *Eretmochelys imbricata*, nesting in the Lesser Antilles islands, Caribbean, between 2005 and 2007 to obtain preliminary information about the inter-nesting, migratory and foraging habitats in the region. Despite the extremely small dataset, both year-round residents and migrants were identified; specifically, (1) two green turtles used local shallow coastal sites within 50 km of the nesting beach during all of their inter-nesting periods and then settled at these sites on completion of their breeding seasons, (2) one hawksbill turtle travelled 200 km westward before reversing direction and settling within 50 km of the original nesting beach and (3) one green and one hawksbill turtle initially nested at the proximate site, before permanently relocating to an alternative nesting site over 190 km distant. A lack of nesting beach fidelity was supported by flipper tag datasets for the region. Tagging datasets from 2002 to 2012 supported that some green and hawksbill individuals exhibit low fidelity to nesting beaches, whereas other females exhibited a high degree of fidelity (26 turtles tagged, 40.0 km maximum distance recorded from original nesting beach). Individual turtles nesting on St Eustatius and St Maarten appear to exhibit behavioural plasticity in their inter-nesting behaviour and post-nesting migration routes in the eastern Caribbean. The tracking and tagging data combined indicate that some of the green and hawksbill females that nest in the Lesser Antilles islands are year-round residents, whilst others may nest and forage at alternative sites. Thus, continued year-round protection of these islands

and implementation of protection programmes in nearby islands could contribute towards safeguarding the green and hawksbill populations of the region.

Fernandes, A., Bondioli, A. C. V., Sole, M., & Schiavetti, A. (2017). Seasonal Variation in the Behavior of Sea Turtles at a Brazilian Foraging Area. *Chelonian Conservation and Biology, 16*(1), 93-102 https://doi.org/10.2744/ccb-1200.1

This study was conducted in Sao Sebastiao Channel, along the Southern Brazil Platform, and describes the occurrence of 3 species of sea turtles in the area, their main behavioral patterns, and the anthropogenic-related threats. Green turtles (*Chelonia mydas*) showed a preference for a site covered by Halodule spp. seagrass and hawksbill turtles (*Eretmochelys imbricata*) showed a preference for a sheltered bay with little wave action and the presence of rocks covered with Palythoa caribaeorum. These sites exhibited different characteristics due to the presence of ocean currents and variable habitat types in the Channel. This study enabled the description of the Sao Sebastiao Channel as a foraging and resting area for sea turtles. We also suggest changing the category of the local marine protected area to enable better protection of turtles.

Ferreira, R. L., Ceia, F. R., Borges, T. C., Ramos, J. A., & Bolten, A. B. (2018). Foraging Niche Segregation between Juvenile and Adult Hawksbill Turtles (*Eretmochelys imbricata*) at Príncipe Island, West Africa. *Journal of Experimental Marine Biology and Ecology, 498*, 1-7 https://doi.org/10.1016/j.jembe.2017.10.005

Hawksbill sea turtles are the most tropical sea turtle species with one of the last remaining aggregations in West Africa found on Príncipe Island (1° 37′ N; 7° 23′ E). Here we present for the first time, data on the trophic and foraging ecology of both juvenile and adult hawksbill turtles found in the shallow waters of Príncipe, using stable isotope analyses of carbon (δ13C) and nitrogen (δ15N), and assess any isotopic niche segregation between these two life-stages. Hawksbill turtles were sampled from December 2012 to June 2014, complementary to a snorkeling survey conducted around the entire coastline (ca. 100 km). δ13C and δ15N values were measured in epidermal samples of 40 individuals and analyzed in the context of isotopic niche width and overlap (i.e. trophic and foraging niches). Juveniles hawksbills (n=29; <60cm curved carapace length (CCL)) occupy a significant smaller isotopic niche than adults (n=11; >75cm), especially in relation to δ13C values (i.e. habitat use) but also in δ15N values (i.e. trophic level). Variances between adults and juveniles were not homogenous for both isotopes and larger for adults, particularly for δ13C values. We found significant differences in δ13C values between the two groups, but not for δ15N, and a significant correlation between δ13C values and CCL for the pooled data. SIBER (stable isotopes Bayesian ellipses in R) outcomes support these results and, although niches are not completely segregated, it indicates spatial foraging segregation between juveniles and adults. The fact that Príncipe Island's shallow waters are constantly being patrolled by spearfishermen, together with the existence of a large insular platform and a superior dive capacity in larger hawksbills, might influence this segregation. Our results suggest that part of the adults may be originating from isotopically distinct areas. To have a better understanding on the distribution and abundance of the sea turtle populations in Príncipe, including their connectivity with other foraging and breeding areas, future in-water studies focused mainly on the entire insular platform of Príncipe, but also on the adjacent probable foraging areas of the Gulf of Guinea, are required.

Ferreira, R. L., & Martins, H. R. (2013). Nesting Hawksbill Turtle, *Eretmochelys imbricata*, Disorientation at a Beach Resort on Príncipe Island, West Africa. *Marine Turtle Newsletter*(136), 7-9 Retrieved from http://www.seaturtle.org/mtn/archives/mtn136/mtn136p7.shtml

Ferreira and Martins report an opportunistic observation of an unsuccessful nesting attempt by the Critically Endangered hawksbill turtle (*Eretmochelys imbricata*), at Coco Beach on Principe Island. The island, which is located on the Gulf of Guinea in West Africa, was recently nominated as a UNESCO Biosphere Reserve and today high level tourism investments are being planned and implemented. Sea turtle nesting is not monitored on the beach but animals are protected from poachers since only resort staff and tourists have access to it.

Finn, S. A., Thompson, W. P., Shamblin, B. M., Nairn, C. J., & Godfrey, M. H. (2016). Northernmost Records of Hawksbill Sea Turtle Nests and Possible Trans-Atlantic Colonization Event. *Marine Turtle Newsletter*(151), 27-29 Retrieved from http://www.seaturtle.org/mtn/archives/mtn151/mtn151-7.shtml

Unfortunately, no hatchling or embryo samples were collected from the hawksbill nests in North Carolina. [...]it is unknown whether the hatchlings were pure hawksbill or possibly hawksbill x loggerhead hybrids. The NC Sea Turtle Project is supported by the NC Wildlife Resource Commission Nongame & Endangered Wildlife Fund, the US Fish & Wildlife Service, the National Park Service, Cape Hatteras National Seashore Resource Management staff, in addition to other federal, state, local, and private institutions and individuals.

Gaos, A. R., Lewison, R. L., Jensen, M. P., Liles, M. J., Henriquez, A., Chavarria, S., . . . Dutton, P. H. (2017). Natal Foraging Philopatry in Eastern Pacific Hawksbill Turtles. *Royal Society Open Science, 4*(8) https://doi.org/10.1098/rsos.170153

The complex processes involved with animal migration have long been a subject of biological interest, and broad-scale movement patterns of many marine turtle populations still remain unresolved. While it is widely accepted that once marine turtles reach sexual maturity they home to natal areas for nesting or reproduction, the role of philopatry to natal areas during other life stages has received less scrutiny, despite widespread evidence across the taxa. Here we report on genetic research that indicates that juvenile hawksbill turtles (*Eretmochelys imbricata*) in the eastern Pacific Ocean use foraging grounds in the region of their natal beaches, a pattern we term natal foraging philopatry. Our findings confirm that traditional views of natal homing solely for reproduction are incomplete and that many marine turtle species exhibit philopatry to natal areas to forage. Our results have important implications for life-history research and conservation of marine turtles and may extend to other wide-ranging marine vertebrates that demonstrate natal philopatry.

Gaos, A. R., Lewison, R. L., Jensen, M. P., Liles, M. J., Henriquez, A., Chavarria, S., . . . Dutton, P. H. (2018). Rookery Contributions, Movements and Conservation Needs of Hawksbill Turtles at Foraging Grounds in the Eastern Pacific Ocean. *Marine Ecology Progress Series, 586*, 203-216 https://doi.org/10.3354/meps12391

Understanding the spatial ecology of wide-ranging marine species is fundamental to advancing ecological research and species management. For marine turtles, genetic studies using mitochondrial DNA (mtDNA) markers have proven invaluable to characterize movement, particularly between rookeries (i.e. nesting sites) and foraging grounds. Hawksbill turtles *Eretmochelys imbricata* are a globally threatened species whose conservation status is particularly precarious in the eastern Pacific Ocean. Recent research in the region has identified unique life history characteristics, including highly restricted movements, the use of mangrove estuaries for foraging and nesting, as well as a regional pattern of natal foraging philopatry (NFP). For this study, we used mtDNA sequences and mixed-stock analysis of hawksbills from 8 designated foraging grounds and 5 primary rookeries to evaluate stock composition at each foraging ground, assess how stock contributions are affected by the NFP life history strategy, and search for evidence of unidentified rookeries. Although we found evidence supporting the NFP pattern at most foraging grounds, results indicated important site-specific variability at particular foraging grounds. We also found discrepancies among the haplotype frequencies of several foraging grounds and rookeries, as well as the presence of several orphan haplotypes, suggesting undiscovered hawksbill rookeries likely remain in the eastern Pacific. Our findings contextualize the prevalence and scale of the NFP life history strategy and provide insights that can be directly applied to future ecological research and species management and conservation.

Gaos, A. R., Lewison, R. L., Liles, M. J., Henriquez, A., Chavarría, S., Yañez, I. L., . . . Dutton, P. H. (2018). Prevalence of Polygyny in a Critically Endangered Marine Turtle Population. *Journal of Experimental Marine Biology and Ecology, 506*, 91-99 https://doi.org/10.1016/j.jembe.2018.06.004

Genetic analyses of nuclear DNA (e.g., microsatellites) are a primary tool for investigating mating systems in reptiles, particularly marine turtles. Whereas studies over the past two decades have demonstrated that polyandry (i.e., females mating with multiple males) is common in marine turtles, polygyny (i.e., males mating with multiple females) has rarely been reported. In this study we investigated the mating structure of Critically Endangered hawksbill turtles (*Eretmochelys imbricata*) at Bahía de Jiquilisco in El Salvador, one of the largest rookeries in the eastern Pacific Ocean. We collected genetic samples from 34 nesting females and hatchlings from 41 clutches during the 2015 nesting season, including one nest from each of 27 females and two nests from seven additional females. Using six highly polymorphic microsatellite loci, we reconstructed the paternal genotypes for 22 known male turtles and discovered that seven (31.8%) sired nests from multiple females, which represents the highest polygyny level reported to date for marine turtles and suggests that this is a common mating structure for this population. We also detected multiple paternity in four (11.8%) clutches from the 34 females analyzed, confirming polyandrous mating strategies are also employed. The high level of polygyny we documented suggests there may be a limited number of sexually mature males at Bahía de Jiquilisco; a scenario supported by multiple lines of empirical evidence. Our findings highlight key management uncertainties, including whether polygynous mating strategies can compensate for potential ongoing feminization and the low number of adult males found for this and possibly other marine turtle populations.

Gaos, A. R., Liles, M. J., Gadea, V., de Niz, A. P., Vallejo, F., Miranda, C., . . . Seminoff, J. A. (2017). Living on the Edge: Hawksbill Turtle Nesting and Conservation Along the Eastern Pacific Rim. *Latin American Journal of Aquatic Research, 45*(3), 572-584 https://doi.org/10.3856/vol45-issue3-fulltext-7

Prior to 2007, efforts to monitor and conserve hawksbill turtles (*Eretmochelys imbricata*) in the eastern Pacific Ocean were opportunistic and records were virtually non-existent. The first abundance estimates were published in 2010, but contained limited data on the species. Ongoing research since that time has led to the identification of several rookeries, including sites containing large proportions of the overall hawksbill nesting currently known to occur in the region. Monitoring projects were established at several sites and have since provided substantial nesting data on the species. Here we summarize data collected between 1983 and March 2016 from all sites (n = 9) confirmed to host > 10 nests in any given season to provide an update on hawksbill nesting in the eastern Pacific. We documented a total of 3,508 hawksbill nests, 265,024 hatchlings and 528 individual nesting females in the region. The vast majority of these records (99.4%, 99.9% and 99.6%, respectively) were generated subsequent to 2007, coinciding with the discovery of eight of the nine rookeries included in this study and the organization of monitoring efforts at those sites, which led to the increased documentation conferred here. Our findings should not be misconstrued as increases in actual nesting or signs of recovery, which could diminish the ongoing need for conservation actions, but rather as optimism, that there is still an opportunity to restore the species in the eastern Pacific. The top three sites in terms of average annual number of nests were Estero Padre Ramos (Nicaragua; 213.2 +/- 47.6 nests), Bahia de Jiquilisco (El Salvador; 168.5 +/- 46.7 nests) and Aserradores (Nicaragua; 100.0 +/- 24.0 nests), and all three sites are located in mangrove estuaries in Central America, highlighting the importance of these rookeries/habitats for the survival and recovery of hawksbills in the region. The remaining six sites received between 6.9 +/- 7.3 nests (Costa Careyes, Mexico) and 59.3 +/- 17.7 nests (Los Cobanos, El Salvador) annually. By integrating data collected on nesting hawksbills with local conservation realities at the most important known hawksbill rookeries in the eastern Pacific, we provide a more holistic view of the conservation status and management needs of the species in this ocean region.

Gilman, E., Owens, M., & Kraft, T. (2014). Ecological Risk Assessment of the Marshall Islands Longline Tuna Fishery. *Marine Policy, 44*, 239-255 https://doi.org/10.1016/j.marpol.2013.08.029

To support implementing an ecosystem approach to fisheries management, ecological risk assessment (ERA) methods have recently been developed for the continuum of data-deficient to data-rich fisheries. A semi-quantitative ERA was conducted for the Marshall Islands longline bigeye tuna (Thunnus obesus) fishery. The study used information from analyses of observer data, surveys of captains and crew and inventories of gear and equipment. Relative risks were evaluated through a consideration of hylogenetic uniqueness, risk of population extirpation, risk of species extinction and importance in ecosystem regulation. The fishery presents a highest relative risk to leatherback (Dermochelys coriacea), hawksbill (*Eretmochelys imbricata*), green (*Chelonia mydas*) and olive Ridley (Lepidochelys olivacea) sea turtle Regional Management Units that overlap with the fishery, in that order. The next highest relative risk is to affected stocks of oceanic whitetip (Carcharhinus longimanus), blue (Prionace glauca), and silky (Carcharhinus falciformis) sharks, in that sequence. Seabird bycatch is likely not problematic. There was inadequate information to assess risks to cetacean populations. Risks to stocks of market and non-market species of marine fishes with r-selected life history characteristics were not assessed. This is because estimates of critical threshold levels of local and absolute abundance and current biomass are not known for many of these stocks. Several best practice gear technology methods to mitigate problematic catch of vulnerable species groups are currently employed: monofilament leaders, whole fish for bait, singlehooking fish bait, no lightsticks, and no fishing at shallow submerged features. Setting terminal tackle below 100 m and carrying and using best practice handling and release equipment were methods identified to reduce fishing mortality and injury of vulnerable species. More information is

needed to determine if weaker hooks should be prescribed to mitigate cetacean bycatch. The large benefit to sea turtles of replacing remaining j-shaped hooks with circle hooks 'might outweigh a possible small increase in elasmobranch catch rates. The consumption of 2024 I of fuel per tonne of landed catch, which is within the range of available estimated rates from similar fisheries, could be reduced, reducing greenhouse gas emissions, through more frequent maintenance and upgrading vessel equipment and materials. Observer data quality may be adequate to support a quantitative Level 3 ERA to determine the significance of the effect of various factors on standardized catch rates and to estimate population-level effects from fishing mortality.

Girondot, M. (2017). Optimizing Sampling Design to Infer the Number of Marine Turtles Nesting on Low and High Density Sea Turtle Rookeries Using Convolution of Negative Binomial Distribution. *Ecological Indicators, 81*, 83-89 https://doi.org/10.1016/j.ecolind.2017.05.063

Reliable monitoring of wildlife populations represents a non-negligible cost, and in a limited-resource world, resources allocated to monitoring are not devoted to actions to solve identified problems. I explore resource efficient survey designs based on a negative binomial distribution including variable survey intervals for marine turtles using track counts as an index of female activity. In the modified procedure, all new tracks between two monitoring patrols are recorded. These data are analyzed by statistical models that take advantage of the statistical properties of the sum of counts. The outputs of models with different lagged monitoring dates (3–10 days) are compared with the outputs of daily surveys using extrapolations from high and low density populations. Results show that the quality of the estimates is similar when total time series analysis is compared with situations in which only a fourth, a seventh, or a tenth of monitoring daily during the season are used. This solution permits the reallocation of funds from monitoring to other conservation activities. Furthermore, the efficient sampling design and the statistical methods allow getting similar information with less effort.

Gopar-Canales, K. L., & Miranda-Anaya, M. (2014). Circadian Clock and Sun Compass Orientation in Hatchlings of the Turtle *Eretmochelys imbricata* at Sisal, Yucatan, Mexico. *Biological Rhythm Research, 45*(3), 407-414 https://doi.org/10.1080/09291016.2013.830511

The sun compass orientation implies a circadian clock and the sun's azimuth in order to establish a direction. This behavior has been observed in a diversity of invertebrate and vertebrate species including reptiles. Shifting an organism's internal clock by a given period of time (via alterations in photoperiod) helps to demonstrate the presence of a sun compass and circadian clock mechanisms. This study aims to test whether a sun compass orientation mechanism exists in hatchlings of the hawksbill turtle *Eretmochelys imbricata* at the shore of Sisal, Yucatan, Mexico. In order to mask the magnetic sensitivity, turtles were observed with and without a neodymium magnet attached to their carapaces. One group of animals was held in regular LD, while another group was maintained for three days in a 6-h-delayed LD. Observations were made by photographs in an open circular arena near the shore. Results obtained from these observations indicate that hatchlings exposed to a 6- h-delayed LD show a difference in angular direction of near 60 degree and that magnets do not change such difference. Swimming activity recorded during the first four days after hatching indicates an organized crepuscular rhythm. The implications of multiple orientation mechanisms in these species and conservation efforts are discussed.

Gorham, J. C., Clark, D. R., Bresette, M. J., Bagley, D. A., Keske, C. L., Traxler, S. L., . . . Nairn, C. J. (2014). Characterization of a Subtropical Hawksbill Sea Turtle (Eretmocheyles imbricata) Assemblage Utilizing Shallow Water Natural and Artificial Habitats in the Florida Keys. *PLoS One, 9*(12) https://doi.org/10.1371/journal.pone.0114171

In order to provide information to better inform management decisions and direct further research, vessel-based visual transects, snorkel transects, and in-water capture techniques were used to characterize hawksbill sea turtles in the shallow marine habitats of a Marine Protected Area (MPA), the Key West National Wildlife Refuge in the Florida Keys. Hawksbills were found in hardbottom and seagrass dominated habitats throughout the Refuge, and on man-made rubble structures in the Northwest Channel near Cottrell Key. Hawksbills captured (N = 82) were exclusively juveniles and subadults with a straight standard carapace length (SSCL) ranging from 21.4 to 69.0cm with a mean of 44.1 cm (SD = 10.8). Somatic growth rates were calculated from 15 recaptured turtles with periods at large ranging from 51 to 1188 days. Mean SSCL growth rate was 7.7 cm/year (SD = 4.6). Juvenile hawksbills (<50 cm SSCL) showed a significantly higher growth rate (9.2 cm/year, SD = 4.5, N = 11) than subadult hawksbills (50–70 cm SSCL, 3.6 cm/year, SD = 0.9, N = 4). Analysis of 740 base pair mitochondrial control region sequences from 50 sampled turtles yielded 12 haplotypes. Haplotype frequencies were significantly different compared to four other Caribbean juvenile foraging aggregations, including one off the Atlantic coast of Florida. Many-to-one mixed stock analysis indicated Mexico as the primary source of juveniles in the region and also suggested that the Refuge may serve as important developmental habitat for the Cuban nesting aggregation. Serum testosterone radioimmunoassay results from 33 individuals indicated a female biased sex ratio of 3.3 females: 1 male for hawksbills in the Refuge. This assemblage of hawksbills is near the northern limit of the species range, and is one of only two such assemblages described in the waters of the continental United States. Since this assemblage resides in an MPA with intensive human use, basic information on the assemblage is vital to resource managers charged with conservation and species protection in the MPA.

Hardy, R. F., Hu, C. M., Witherington, B., Lapointe, B., Meylan, A., Peebles, E., . . . Hirama, S. (2018). Characterizing a Sea Turtle Developmental Habitat Using Landsat Observations of Surface-Pelagic Drift Communities in the Eastern Gulf of Mexico. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 11*(10), 3646-3659 https://doi.org/10.1109/jstars.2018.2863194

Compared with our understanding of most aspects of sea turtle biology, knowledge of the surface-pelagic juvenile life stages remains limited. Young North Atlantic cheloniids (hard-shelled sea turtles) are closely associated with surface-pelagic drift communities (SPDCs), which are dominated by macroalgae of the genus Sargassum. We quantified SPDCs in the eastern Gulf of Mexico, a region that hosts four species of cheloniids during their surface-pelagic juvenile stage. Landsat satellite imagery was used to identify and measure the areal coverage of SPDCs in the eastern Gulf during 2003-2011 (1323 images). Although the SPDC coverage varied annually, seasonally, and spatially, SPDCs were present year-round, with an estimated mean area of SPDC in each Landsat image of 4.9 km(2) (SD = 10.1). The area of SPDCs observed was inversely proportional to sea-surface wind velocity (Spearman's $r = -0.33$, $p < 0.001$). The SPDC coverage was greatest during 2005, 2009, and 2011 and least during 2004 and 2010, but the 2010 analysis was affected by the Deepwater Horizon oil spill, which occurred within the study region. In the eastern Gulf, the area of SPDC peaked during June-August of each year. Although the SPDC coverage appeared lower in the eastern Gulf than in other regions of the Gulf and the North Atlantic, surface-pelagic juvenile green, hawksbill, Kemp's ridley, and loggerhead turtles were found to be using this

habitat, suggesting that eastern Gulf SPDCs provide developmental habitats that are critical to the recovery of four sea turtle species.

Hart, K. M., Iverson, A. R., Benscoter, A. M., Fujisaki, I., Cherkiss, M. S., Pollock, C., . . . Hillis-Starr, Z. (2019). Satellite Tracking of Hawksbill Turtles Nesting at Buck Island Reef National Monument, Us Virgin Islands: Inter-Nesting and Foraging Period Movements and Migrations. *Biological Conservation, 229*, 1-13 https://doi.org/10.1016/j.biocon.2018.11.011

To conserve imperiled marine species, an understanding of high-density use zones is necessary prior to designing and evaluating management strategies that improve their survival. We satellite-tracked turtles captured after nesting at Buck Island Reef National Monument (BIRNM), St. Croix, US Virgin Islands to determine habitat-use patterns of endangered adult female hawksbills (*Eretmochelys imbricata*). For 31 turtles captured between 2011 and 2014, switching state-space modeling and home range analyses showed that inter-nesting (IN) core-use areas (i.e., 50% kernel density estimates [KDEs]) were 9.6 to 77.7 km2 in area, occupied for 21 to 85 days, and in shallow water (21 of 26 centroids > −10 m). The IN zones overlapped with areas both within the protected borders of BIRNM, and outside BIRNM (32% of turtle-tracking days outside during IN). Turtles migrated to their foraging grounds between July and October with path lengths ranging from 52 to 3524 km; foraging areas included 14 countries. Core-use foraging areas (50% KDEs) where turtles took up residence were 6.3 to 95.4 km2, occupied for 22 to 490 days, with mean centroid depth − 66 m. Our results show previously unknown habitat-use patterns and highlight concentrated areas of use both within and adjacent to a US protected area during the breeding season. Further, our results clearly demonstrate the need for international conservation to protect hawksbills, as migrating turtles crossed between two and eight different jurisdictions. Our results provide critical spatial and temporal information for managers charged with designing strategies to minimize human impact to and maximize survival for this globally imperiled species.

Hart, K. M., Sartain, A. R., Hillis-starr, Z.-m., Phillips, B., Mayor, P. A., Roberson, K., . . . Musick, S. (2013). Ecology of Juvenile Hawksbills (*Eretmochelys imbricata*) at Buck Island Reef National Monument, Us Virgin Islands. *Marine Biology, 160*(10), 2567-2580 https://doi.org/10.1007/s00227-013-2249-x

Surveys of juvenile hawksbills around Buck Island Reef National Monument, US Virgin Islands from 1994 to 1999 revealed distributional patterns and resulted in a total of 75 individual hawksbill captures from all years; turtles ranged from 23.2 to 77.7 cm curved carapace length (CCL; mean 42.1 ± 12.3 cm SD). Juveniles concentrated where Zoanthid cover was highest. Length of time between recaptures, or presumed minimum site residency, ranged from 59 to 1,396 days (mean 620.8 ± 402.4 days SD). Growth rates for 23 juveniles ranged from 0.0 to 9.5 cm year^sup -1^ (mean 4.1 ± 2.4 cm year^sup -1^SD). Annual mean growth rates were non-monotonic, with the largest mean growth rate occurring in the 30-39 cm CCL size class. Gastric lavages indicated that Zoanthids were the primary food source for hawksbills. These results contribute to our understanding of juvenile hawksbill ecology and serve as a baseline for future studies or inventories of hawksbills in the Caribbean.

Hernández-Cortés, J. A., NúÑez-Lara, E., Cuevas, E., & Guzmán-Hernández, V. (2018). Natural Beach Vegetation Coverage and Type Influence the Nesting Habitat of Hawksbill Turtles (*Eretmochelys*

imbricata) in Campeche, Mexico. *Chelonian Conservation and Biology, 17*(1), 94-103 https://doi.org/10.2744/CCB-1280.1

The hawksbill turtle (*Eretmochelys imbricata*) is a critically endangered species with a global distribution and is broadly distributed along the Yucatan Peninsula in the Gulf of Mexico. To complete its life cycle, this species uses sandy beaches with particular environmental conditions that facilitate nesting and hatching. This study aimed to identify if beach physical characteristics influence biological reproductive parameters (hatching and emergence success). Nesting activity was monitored along 18 km of beach in the state of Campeche, Mexico, during 2014. Seventy-eight nests were recorded, 12 physical and environmental variables were measured in the nests and contiguous areas, and the hatching and emergence success of each nest was determined. Beach slope and width had no significant relationship to nest site selection. Nest depth and nest distance to highest tide and vegetation, including vegetation type, did influence hatching and emergence success. Herbaceous and bushy plants were positively correlated with reproductive parameters, highlighting the importance of preserving beach vegetation cover. This parameter was a central structural component of hawksbill nesting habitat, possibly because it influenced nest shading, preventing egg overheating and possible embryo death. Preservation and restoration of vegetation structure on hawksbill nesting beaches is clearly vital to enhancing the reproductive success of this species.

Hill, J. E., Robinson, N. J., King, C. M., & Paladino, F. V. (2017). Diving Behavior and Thermal Habitats of Gravid Hawksbill Turtles at St. Croix, USA. *Marine Biology, 164*(1), 1-9 https://doi.org/10.1007/s00227-016-3050-4

Knowledge of an animal's behavior during particular life history stages can provide insights into habitat selection, and this can have important conservation implications. Gravid hawksbill turtles spend the internesting interval resting on the seafloor, but their diving behavior has only been previously examined in shallow-water habitats. We examined depth use of gravid hawksbills in a location of variable bathymetry to determine if hawksbills engage in deeper diving if deeper waters are available. We attached archival time-depth recorders onto hawksbills nesting at Sandy Point National Wildlife Refuge, St. Croix, US Virgin Islands, where the neritic zone ends within 500 m of the shoreline. We recorded seven internesting intervals from five individuals. Internesting intervals were characterized by long dives (mean 24.2 ± SD 22.3 min) to a constant depth, consistent with seafloor resting in a spatially restricted residence area. There was little variation in the water temperatures at all depths occupied (mean 29.06 ± SD 0.43 °C). Two turtles attained the deepest recorded dives for gravid hawksbills (95.1 and 84.4 m) and sometimes remained at depths greater than 60 m for up to 30 min. Although we recorded instances of relatively deep diving for the species, the overall pattern of seafloor resting and infrequent diving was consistent with hawksbills in other ocean basins with different offshore habitats. We propose that benthic resting is common behavior for gravid hawksbills globally, and protection of benthic habitats near the nesting beach should be a management priority.

Hochscheid, S. (2014). Why We Mind Sea Turtles' Underwater Business: A Review on the Study of Diving Behavior. *Journal of Experimental Marine Biology and Ecology, 450*, 118-136 https://doi.org/10.1016/j.jembe.2013.10.016

For most of their lifetime, sea turtles have to organize their underwater activities around the necessity to return to the surface to breathe. This group of animals has developed extraordinary diving capacities

(over 10h of single breath-hold dives and dive depths exceeding 1200m) that allow them to exploit oceanic and neritic habitats, and maintain their role in marine ecosystems, despite the numerous threats imposed on them by human activities. Understanding sea turtle behavior, and the extent of flexibility with which they respond to environmental changes, has been a key element of studies on sea turtle diving behavior for over 25years. Here, I review the major outcomes of these studies, summarizing published data on dive durations and depths, and identifying the factors that influence the shape and temporal patterns of sea turtle diving. By carefully assembling existing published information in this research field, some unique features emerged (such as the ability of some turtles to rest for extended periods in the middle of the water column), as well as knowledge gaps that require further investigations (such as the behavior and diving capacity of small juvenile turtles). In addition to simply collecting and presenting existing data, this review also highlights the needs for some level of minimum standardization, especially for studies involving electronic telemetry equipment, in addition to clarifying where future effort should be focused. Ultimately, this review is anticipated to serve as a reference guide for scientists and wildlife managers alike, who seek to mitigate threats to sea turtles through specific knowledge-based conservation strategies.

Hoenner, X., Whiting, S. D., Enever, G., Lambert, K., Hindell, M. A., & McMahon, C. R. (2016). Nesting Ecology of Hawksbill Turtles at a Rookery of International Significance in Australia's Northern Territory. *Wildlife Research, 43*(6), 461-473 https://doi.org/10.1071/wr16047

Context. Following centuries of intense human exploitation, the global stocks of hawksbill turtle have decreased precipitously and the species is currently considered Critically Endangered by the IUCN. Australia supports the largest breeding aggregations worldwide; however, there are no accurate estimates of population abundance and seasonality for hawksbill turtles at important nesting grounds in eastern Arnhem Land. Aims. This study was designed to fill in this lack of ecological information and assist with the conservation and management of hawksbill turtles. More specifically, our overarching goals were to assess nesting seasonality, habitat preferences and provide the first estimate of annual nesting population size at a Northern Territory rookery. Methods. In 2009 and 2010 we collected beach monitoring, satellite telemetry and sand temperature data over two nesting seasons at a group of three islands located 30 km off Groote Eylandt in the Gulf of Carpentaria, northern Australia. We subsequently analysed these data to unravel hawksbill nesting behaviour and reproductive outputs, and examined the vulnerability of this rookery to climate change. Key results. Hawksbill turtle nesting seasonality consistently started in mid-May, peaked in mid-August and ended in late November. Annual nesting abundance showed a near 3-fold increase between 2009 and 2010, with an average of 220 and 580 hawksbill females nesting on this island group respectively. Sand temperature at 50 cm reached more than 30 degrees C at all monitored sites during most of the peak of the incubation period. Conclusions. This remote and untouched group of islands constitutes a major hawksbill turtle rookery both nationally and globally. While anthropogenic impacts and predation are low year round, climate change threatens to skew hatchling sex ratios, eventually leading to an increase in hatchling mortality. Implications. Additional ground-based surveys are required to refine the accuracy of population estimates presented in this study. Given the paucity of data in the region, we recommend this island group off Groote Eylandt be used as a population-monitoring index site for the eastern Arnhem Land hawksbill turtle breeding aggregation.

Hoenner, X., Whiting, S. D., Hamann, M., Limpus, C. J., Hindell, M. A., & McMahon, C. R. (2016). High-Resolution Movements of Critically Endangered Hawksbill Turtles Help Elucidate Conservation

Requirements in Northern Australia. *Marine & Freshwater Research, 67*(8), 1263-1278 https://doi.org/10.1071/MF15013

Despite being critically endangered, the at-sea behaviour of hawksbill turtles (*Eretmochelys imbricata*) remains insufficiently understood to support a global conservation strategy. Habitat location and spatial use are poorly documented, which is particularly true for the globally important Australian hawksbill population. We equipped 10 adult female hawksbill turtles nesting on Groote Eylandt, northern Australia, with Fastloc GPS and Argos satellite transmitters. We quantified fine-scale habitat use and area-restricted search behaviour, and located potential feeding and developmental habitats by simulating hatchling turtle dispersal patterns by using a particle-tracking hydrological model. During the breeding season, females mostly remained near their nesting site. Post-breeding, all turtles migrated to foraging sites on the Australian continental shelf, primarily in the Gulf of Carpentaria in coastal seagrass pastures, but also offshore near coral-reef platforms. The distribution of adult foraging grounds was similar to simulated dispersal patterns of hatchling turtles from distant rookeries, thus highlighting the ecological significance of the Gulf of Carpentaria for hawksbill turtles. Although this hawksbill turtle population is likely to be endemic to Australian waters, national and international conservation initiatives are required to mitigate sources of anthropogenic mortality (e.g. illegal tortoise-shell trade, incidental captures in fishing gear, marine debris, seabed mining exploitation).

Honarvar, S., Fitzgerald, D. B., Weitzman, C. L., Sinclair, E. M., Echube, J. M. E., O'Connor, M., & Hearn, G. W. (2016). Assessment of Important Marine Turtle Nesting Populations on the Southern Coast of Bioko Island, Equatorial Guinea. *Chelonian Conservation and Biology, 15*(1), 79-89 https://doi.org/10.2744/CCB-1194.1

Bioko Island's southern beaches are important nesting sites for marine turtles in the Gulf of Guinea region. In this study, we present data on the 4 species of sea turtles nesting on 5 nesting beaches (19 km) of Bioko Island, from 2000 to 2014. A total of 43,860 leatherback (Dermochelys coriacea), 16,778 green (*Chelonia mydas*), 1731 olive ridley (Lepidochelys olivacea), and 85 hawksbill turtle (*Eretmochelys imbricata*) encounters, defined as the number of tracks, were recorded on Bioko's southern beaches. Since 2008, the estimated number of leatherback females ranged from 42 to 444, green turtles from 63 to 649, and olive ridley turtles from 22 to 53 annually. This study presents the first extensive tagging program on Bioko Island, where 790 leatherback turtles were tagged with Passive Integrated Transponder tags from 2008 to 2014. Only 6.1% of the tagged turtles returned to nest again with a remigration interval of 3-4 yrs. In addition, 279 green turtles were flipper-tagged in the 2013-2014 nesting season. Overall, the total number of leatherback turtle encounters decreased annually from 2000 to 2014. These declines may be attributed to adult turtle captures in commercial fisheries operating in the Gulf of Guinea and turtle take in local artisanal fisheries. On the other hand, olive ridley encounters increased from 2000 to 2014. The construction of a paved road from Luba, the second largest city on Bioko Island, directly to the nesting beaches is now set to dramatically alter human interaction with nesting turtles. These long-term data confirm the importance of Bioko Island's nesting beaches for the Southeast Atlantic and fill a critical need for sea turtle conservation in a data-deficient, yet globally significant, area.

I-Jiunn Cheng, Hua-Yan Wang, Wen-Yi Hsieh, & Chan, Y.-T. (2019). Twenty-Three Years of Sea Turtle Stranding/Bycatch Research in Taiwan. *Zoological Studies, 58*(44) https://doi.org/10.6620/ZS.2019.58-44

Coastal sea turtle stranding and bycatch are common phenomena worldwide and have received more attention in recent years. They are caused by both natural and anthropogenic factors. One thousand and seventy-two turtles were reported to be victims of these phenomena from March 1997 to November 2019 in Taiwan. Number of stranding/bycatch were variable and infrequent for the first 14 years, but increased each year after 2012 and peaked in 2019 with 217 cases. Most turtles were juveniles to subadults. All five of Taiwan's species were reported in stranding and bycatch records, and the green turtle was reported the most common. The main reported seasons lasted from winter to spring, when the weather changes dramatically. The sex ratio (female: male) ranged from 7 in the hawksbill turtle to 0.7 in the olive ridley, with an average of 2.4 for all species. Green turtles were the dominant stranded species, and more loggerhead turtles were by-caught. The hotspots were the towns of Dougou and Tochen in Yilan County, and Gongliao District in New Taipei City, located in NE coast of Taiwan respectively. Stranding was the more common of the two phenomena reported, and 80% of all stranded turtles were subadult green turtles. Eighty percent of all stranded/bycaught turtles were dead. Pond-nets were the fishing gear that accounted for the most bycatch, and captured mainly living young and subadult green turtles as well as subadult loggerhead turtles. The hotspots for bycatch were the towns of Dongou and Tochen in Yilan County. The Coast Guard and concerned citizen were the main sources of reports. This is the first study to analyze the long-term stranding/bycatch of sea turtles in Taiwan.

Iverson, A. R. S., Hart, K. M., Fujisaki, I., Cherkiss, M. S., Pollock, C., Lundgren, I., & Hillis-Starr, Z.-M. (2016). Hawksbill Satellite-Tracking Case Study: Implications for Remigration Interval and Population Estimates. *Marine Turtle Newsletter*(148), 2-7 Retrieved from http://www.seaturtle.org/mtn/archives/mtn148/mtn148-2.shtml

To aid in population recovery and protection, the Hawksbill Recovery Plan identified the need to determine demographic information for hawksbills, such as distribution, abundance, seasonal movements, foraging areas (sections 121 and 2211), growth rates, and survivorship (section 2213, NMFS & USFWS 1993). The National Park Service (NPS) has conducted a saturation-tagging sea turtle nesting and monitoring program at BIRNM for over 25 years (z. Hillis-Starr, unpubl. data).

Joseph, J., Nishizawa, H., Hassan, M., bin Zakariah, M. I., Jaaman, S. A., & Zhang, X. L. (2017). Utilization of Brunei Bay (Malaysia) as a Developmental and Foraging Habitat for Hawksbill Turtle (*Eretmochelys imbricata*). *Regional Studies in Marine Science, 16*, 304-307 https://doi.org/10.1016/j.rsma.2017.09.012

Malaysia provides nesting rookeries and foraging grounds for the critically endangered hawksbill turtle (*Eretmochelys imbricata*), and a number of important foraging grounds have been identified for hawksbill turtles in Malaysia to date. This study reports the first record of juvenile hawksbill turtle at Brunei Bay (a distance of 60 km from the nearest known foraging ground at Pulau Tiga, Sabah, Malaysia). Genetic analysis using mitochondrial DNA (mtDNA) control region sequences reveal the EilP122 haplotype (GenBank Accession no: KR706173), which was first reported from the hawksbill turtle foraging at Pulau Tiga. The confirmation of the presence of hawksbill turtle at Brunei Bay extends the known distribution of this species in Malaysia and highlights the need for further research at Brunei Bay to understand the developmental and foraging habitat for hawksbill turtle. This finding also highlights the importance of Brunei Bay as a foraging ground in South China Sea, not only for the green turtles but may be also for the hawksbill turtles.

Kamel, S. J. (2013). Vegetation Cover Predicts Temperature in Nests of the Hawksbill Sea Turtle: Implications for Beach Management and Offspring Sex Ratios. *Endangered Species Research, 20*(1), 41-48 https://doi.org/10.3354/esr00489

Whether a sea turtle embryo develops into a male or a female depends, as with many other reptiles, on the temperature during incubation of the eggs. With sea turtles, warm temperatures produce 100% females and, thus, increasing global temperatures have the potential to significantly alter offspring sex ratios. Nest-site selection provides a potential mechanism by which females might adjust the sex of their offspring, but necessitates a reliable cue which provides information about the thermal properties of a nest. Overstory vegetation cover was found to significantly predict temperatures in nests of the hawksbill sea turtle *Eretmochelys imbricata*. Nests placed under high vegetation cover are significantly cooler and remain within the male-producing range of temperatures throughout incubation. Interestingly, metabolic heating of the developing clutch is less pronounced under vegetation, further reinforcing the importance of this nesting habitat with respect to the production of males. This underscores the importance of preserving natural vegetation cover at hawksbill nesting beaches in order to maintain the thermal diversity of nesting sites and, potentially, mitigate the impacts of increasing global temperatures.

Kamrowski, R. L., Limpus, C., Jones, R., Anderson, S., & Hamann, M. (2014). Temporal Changes in Artificial Light Exposure of Marine Turtle Nesting Areas. *Global Change Biology, 20*(8), 2437-2449 https://doi.org/10.1111/gcb.12503

Artificial light at night poses a significant threat to multiple taxa across the globe. In coastal regions, artificial lighting close to marine turtle nesting beaches is disruptive to their breeding success. Prioritizing effective management of light pollution requires an understanding of how the light exposure of nesting areas changes over time in response to changing temporal and spatial distributions of coastal development. We analyzed multitemporal, satellite night-light data, in combination with linear mixed model analysis, to determine broadscale changes in artificial light exposure at Australian marine turtle nesting areas between 1993 and 2010. We found seven marine turtle management units (MU), from five species, have experienced significant increases in light exposure over time, with flatback turtles nesting in east Australia experiencing the fastest increases. The remaining 12 MUs showed no significant change in light exposure. Unchanging MUs included those previously identified as having high exposure to light pollution (located in western Australia and southern Queensland), indicating that turtles in these areas have been potentially exposed to high light levels since at least the early nineties. At a finer geographic scale (within-MU), nine MUs contained nesting areas with significant increases in light exposure. These nesting areas predominantly occurred close to heavily industrialized coastal areas, thus emphasizing the importance of rigorous light management in industry. Within all MUs, nesting areas existed where light levels were extremely low and/or had not significantly increased since 1993. With continued coastal development, nesting females may shift to these darker/unchanging 'buffer' areas in the future. This is valuable information that informs our understanding of the capacity and resilience of marine turtles faced with coastal development: an understanding that is essential for effective marine turtle conservation.

Levasseur, K. E., Stapleton, S. P., Fuller, M. C., & Quattro, J. M. (2019). Exceptionally High Natal Homing Precision in Hawksbill Sea Turtles to Insular Rookeries of the Caribbean. *Marine Ecology Progress Series, 620*, 155 https://doi.org/10.3354/meps12957

Marine turtles migrate back to their natal region during reproduction, but the precision of this homing behavior and how the precision varies among populations and across biogeographic regions are unclear. We hypothesize that marine turtles nesting on insular landmasses navigate to their rookeries with greater precision than those nesting on continuous coastlines. We analyzed new mitochondrial and microsatellite marker data from hawksbill turtles *Eretmochelys imbricata* at nesting sites across Antigua and Barbuda, West Indies, to assess the scale of natal homing in the highly insular Leeward Islands. We then used published data from 15 western Atlantic rookeries to examine regional patterns of rookery structure. Mitochondrial control region data showed weak to no partitioning among nesting sites within Antigua and strong partitioning between Antigua and Barbuda, suggesting natal homing at a scale of 50 km. Microsatellite data showed weak to no partitioning between sites, indicating male-mediated gene flow. Regionally, we found stronger population structuring among rookeries of insular landmasses than among those of larger landmasses with continuous coastlines, despite shorter average rookery separation for the former. We also found a positive relationship between a rookery's isolation index (a metric incorporating distances from larger landmasses) and its genetic divergence from proximate rookeries. These findings support our hypothesis, and we caution that insular rookeries that host marine turtles with extreme homing behavior have limited ability to colonize new nesting habitat. The unprecedented rates of development and increasing instability of present-day nesting habitat might therefore pose a greater and increasing threat to insular rookeries.

Liles, M. J., Peterson, T. R., Seminoff, J. A., Gaos, A. R., Altamirano, E., Henriquez, A. V., . . . Peterson, M. J. (2019). Potential Limitations of Behavioral Plasticity and the Role of Egg Relocation in Climate Change Mitigation for a Thermally Sensitive Endangered Species. *Ecology and Evolution, 9*(4), 1603-1622 https://doi.org/10.1002/ece3.4774

Anthropogenic climate change is widely considered a major threat to global biodiversity, such that the ability of a species to adapt will determine its likelihood of survival. Egg-burying reptiles that exhibit temperature-dependent sex determination, such as critically endangered hawksbill turtles (*Eretmochelys imbricata*), are particularly vulnerable to changes in thermal regimes because nest temperatures affect offspring sex, fitness, and survival. It is unclear whether hawksbills possess sufficient behavioral plasticity of nesting traits (i.e., redistribution of nesting range, shift in nesting phenology, changes in nest-site selection, and adjustment of nest depth) to persist within their climatic niche or whether accelerated changes in thermal conditions of nesting beaches will outpace phenotypic adaption and require human intervention. For these reasons, we estimated sex ratios and physical condition of hatchling hawksbills under natural and manipulated conditions and generated and analyzed thermal profiles of hawksbill nest environments within highly threatened mangrove ecosystems at Bahia de Jiquilisco, El Salvador, and Estero Padre Ramos, Nicaragua. Hawksbill clutches protected in situ at both sites incubated at higher temperatures, yielded lower hatching success, produced a higher percentage of female hatchlings, and produced less fit offspring than clutches relocated to hatcheries. We detected cooler sand temperatures in woody vegetation (i.e., coastal forest and small-scale plantations of fruit trees) and hatcheries than in other monitored nest environments, with higher temperatures at the deeper depth. Our findings indicate that mangrove ecosystems present a number of biophysical (e.g., insular nesting beaches and shallow water table) and human-induced (e.g., physical barriers and deforestation) constraints that, when coupled with the unique life history of hawksbills in

this region, may limit behavioral compensatory responses by the species to projected temperature increases at nesting beaches. We contend that egg relocation can contribute significantly to recovery efforts in a changing climate under appropriate circumstances.

Llamas, I., Flores, E. E., Abrego, M. E., Seminoff, J. A., Hart, C. E., Donadi, R., . . . Gaos, A. (2017). Distribution, Size Range and Growth Rates of Hawksbill Turtles at a Major Foraging Ground in the Eastern Pacific Ocean. *Latin American Journal of Aquatic Research, 45*(3), 597-605 https://doi.org/10.3856/vol45-issue3-fulltext-9

Hawksbill sea turtles (*Eretmochelys imbricata*) inhabiting the eastern Pacific Ocean are one of the world's most threatened marine turtle management units. Despite the fact that knowledge about the status of sea turtles at foraging grounds is a key element for developing the effective conservation strategies, comprehensive studies of hawksbills at foraging habitats in the eastern Pacific remain lacking. For many years anecdotal information indicated Coiba Island National Park in Panama as a potentially important hawksbill foraging ground, which led to the initiation of monitoring surveys in September 2014. Ongoing mark-recapture surveys to assess population status, generate demographic data and identify key foraging sites have been conducted every six months in the park since that time. To date, a total of six monitoring campaigns consisting of four days each have been conducted, leading to the capture and tagging of 186 hawksbills, 51 of which were recaptured at least once. The size range of captured individuals was 30.0 to 75.5 cm and largely comprised of juveniles. Somatic growth rates of individual hawksbills were highly variable, ranging from -0.78 to 7.1 cm year-1. To our knowledge, these are the first published growth rates for juvenile hawksbill turtles in the eastern Pacific Ocean. When these growth data are combined with information on hawksbill demography and distribution, our findings indicate Coiba Island National Park is one of the most important known foraging sites for hawksbill sea turtles in the eastern Pacific Ocean.

Lukowiak, M., Cramer, K. L., Madzia, D., Hynes, M. G., Norris, R. D., & O'Dea, A. (2018). Historical Change in a Caribbean Reef Sponge Community and Long-Term Loss of Sponge Predators. *Marine Ecology Progress Series, 601*, 127-137 https://doi.org/10.3354/meps12694

Sponges are an ecologically important component of modern Caribbean coral reefs. However, little is known about the structure of sponge communities prior to the large-scale degradation of Caribbean reef ecosystems. Here we explore changes in the sponge community over the past millennium by analyzing the composition of sponge spicules from a sediment core collected from a lagoonal reef within the archipelago of Bocas del Toro, Caribbean Panama. The analysis reveals a change in spicule composition that began approximately 400 yr ago. During this time, the share of monaxial spicules, belonging mostly to haplosclerid and axinellid sponges, decreased while the relative number of spherical spicules, found typically in Placospongia, Geodia, and some chondrillids, increased. These results were compared with previously published data on parrotfish, corals, and reef accretion rates obtained from the same core. The increased share of spherical spicules did not correlate with contemporaneous declines in the abundance of parrotfish (determined from fish teeth) or with trends in the relative abundance of dominant coral species (determined from coral skeletal remains) but was weakly correlated with reef accretion rates (determined from sediment accumulation rates). Spicule morphogroup diversity and evenness increased over the past similar to 400 yr, suggesting community changes were not due to reef environments becoming less habitable for reef sponges. Although not

tested directly, the increase in spherical spicules may be due to declines in the abundance of sea turtles that preferentially feed on sponges that contain these spicule types.

Majid Askari, H., Rezaie-Atagholipour, M., Zangiabadi, S., Mohammad Amin, T., Moazeni, M., Jafari, H., . . . Motlaghnejad, A. (2019). Monitoring Hawksbill Turtle Nesting Sites in Some Protected Areas from the Persian Gulf. *Acta Oceanologica Sinica, 38*(12), 43-51 https://doi.org/10.1007/s13131-019-1514-3

Iranian nesting populations of the critically endangered hawksbill turtle (Eretmochelys imbricate) are some of the most important in the Indian Ocean. In this study, four of the most important hawksbill nesting grounds in the Persian Gulf, situated within three Iranian marine protected areas, were surveyed during nesting season, including Nakhiloo, Ommolgorm and Kharko Islands and the mainland beaches of the Naiband Marine-Coastal National Park (NMCNP). We present GIS maps of these key nesting grounds and describe sand texture of key nesting zones, along with conservation recommendations. About 9.2 (28.3%) out of 32.5 km of all shores surveyed in this study were used by nesting hawksbill turtles follows: Nakhiloo: 1.4 km (52% of potential nesting area); Ommolgorm: 1.94 km (40%); Kharko: 3.4 km (28%), and NMCNP: 2.46 km (18.9%). The average nesting density was calculated as 131 nests/km at Nakhiloo, 76 nests/km at Ommolgorm, 7 nests/km at Kharko, and 15 nests per km at NMCNP. Highest nesting density was observed in Nakhiloo and Ommolgorm. It is thought that high hawksbill nesting density in these islands seems likely a result of limiting adequate nesting shores rather than the size of population, and also low density in Kharko and NMCNP more related to past and current pressures and low population density. With the exception of Ommolgorm Island, sands at the nesting grounds were well sorted. Grain size indicated that female hawksbill turtles in the Iranian Persian Gulf nest in sands that are generally mixed, with mean grain size ranging from coarse sands (0.4Φ; ~0.5-1 mm) to fine sands (2Φ; ~0.25 mm). We provide and discuss conservation recommendations and suggestions for future.

McDonald, T. L., Schroeder, B. A., Stacy, B. A., Wallace, B. P., Starcevich, L. A., Gorham, J., . . . Witherington, B. E. (2017). Density and Exposure of Surface-Pelagic Juvenile Sea Turtles to Deepwater Horizon Oil. *Endangered Species Research, 33*, 69-82 https://doi.org/10.3354/esr00771

The 2010 Deepwater Horizon (DWH) oil spill posed a severe threat to surface-pelagic sea turtles because the surface convergence zones, which provide vital habitat by aggregating pelagic Sargassum and other floating material, also aggregated floating oil. Following the DWH spill, turtle rescue operations between 17 May and 9 September 2010 documented 937 juvenile sea turtles in the spill area and examined 574 captured turtles. Of the captured turtles, 81% were visibly oiled. Transect searches in convergence zones found Kemp's ridleys (51% of individuals), green turtles (37%), loggerheads (7%), hawksbills (2%), and unidentified sea turtles (2%). Line-transect methods estimated the density of all surface-pelagic sea turtles in surface convergence zones to be 3.32 km(-2) (95% CI = 2.82-3.88), and the density of heavily oiled turtles to be 0.24 km(-2) (95% CI = 0.15-0.39). Turtle densities and the areal extent of heavy oiling probability were used to estimate total number of turtles exposed to DWH oil. We estimate approximately 402 000 surface-pelagic sea turtles were exposed, and of those, 54 800 were likely to have been heavily oiled. Our estimates formed the basis of surface-pelagic juvenile sea turtle mortality estimates included in the DWH natural resource damage assessment.

Méndez-Salgado, E., Chacón-Chaverri, D., Fonseca, L. G., & Seminoff, J. A. (2020). Trophic Ecology of Hawksbill Turtles (*Eretmochelys imbricata*) in Golfo Dulce, Costa Rica: Integrating Esophageal Lavage and Stable Isotope (Δ13c, Δ15n) Analysis. *Latin American Journal of Aquatic Research, 48*(1) https://doi.org/10.3856/vol48-issue1-fulltext-2230

Hawksbill turtles (*Eretmochelys imbricata*), considered Critically Endangered, have several small populations in the Eastern Pacific (EP). Knowledge about their diet and habitat use can aid in developing conservation strategies and promoting population recovery in the region. Although considered a spongivore in the Caribbean, data from the EP region indicate that hawksbills consume a wide array of prey species, including angiosperms. We used two approaches to study the diet of hawksbills at Golfo Dulce, Costa Rica: oesophageal lavage and stable isotope (δ13C, δ15N) analysis of bulk skin tissue and blood plasma. Lavage samples collected from 41 turtles revealed macroalgae as the predominant diet item (Rw = 20.22), followed by sea snails and excavating worms. Stable isotope values for blood plasma from 44 turtles ranged from -23.0‰ to -15.7‰ for δ13C and 6.9‰ to 10.4‰ for δ15N, whereas values for skin tissue were -20.4‰ to -13.9‰ and 9.3‰ to 11.0‰ for δ13C and δ15N, respectively. We compared these isotope values with those of five potential prey groups (sponge, sea snail, excavating worm, mangrove, macroalgae) using a multisource stable isotope mixing model analysis in R (SIAR). Our results indicated that multiple prey resources are important for hawksbills in Golfo Dulce, where sea snails, sponges and excavating worms contributed up to 63% of the assimilated diet per individual, and mangrove and macroalgae up to 50%. These data show that hawksbills in Golfo Dulce, and perhaps the wider EP region, are omnivorous, underscoring the importance for considering alternative habitats, aside of coral reefs, for its management and restoration.

Montero, N., Maria, A. G. d. M., Milagros, L. M., Santos, A. S., Santos, A. J. B., & Mariana, M. P. B. F. (2018). Warmer and Wetter Conditions Will Reduce Offspring Production of Hawksbill Turtles in Brazil under Climate Change. *PLoS One, 13*(11) https://doi.org/10.1371/journal.pone.0204188

Climate change is expected to impact animals that are heavily reliant on environmental factors, such as sea turtles, since the incubation of their eggs, hatching success and sex ratio are influenced by the environment in which eggs incubate. As climate change progresses it is therefore important to understand how climatic conditions influence their reproductive output and the ramifications to population stability. Here, we examined the influences of five climatic variables (air temperature, accumulated and average precipitation, humidity, solar radiation, and wind speed) at different temporal scales on hawksbill sea turtle (*Eretmochelys imbricata*) hatchling production at ten nesting beaches within two regions of Brazil (five nesting beaches in Rio Grande do Norte and five in Bahia). Air temperature and accumulated precipitation were the main climatic drivers of hawksbill hatching success (number of eggs hatched within a nest) across Brazil and in Rio Grande do Norte, while air temperature and average precipitation were the main climatic drivers of hatching success at Bahia. Solar radiation was the main climatic driver of emergence success (number of hatchlings that emerged from total hatched eggs within a nest) at both regions. Warmer temperatures and higher solar radiation had negative effects on hatchling production, while wetter conditions had a positive effect. Conservative and extreme climate scenarios show air temperatures are projected to increase at this site, while precipitation projections vary between scenarios and regions throughout the 21st century. We predicted hatching success of undisturbed nests (no recorded depredation or storm-related impacts) will decrease in Brazil by 2100 as a result of how this population is influenced by local climate. This study shows the determining effects of different climate variables and their combinations on an important and critically endangered marine species.

Nakamura, M. F., Santos, A. J. B., Lobao-Soares, B., & Corso, G. (2019). Lunar Phases and Hawksbill Sea Turtle Nesting. *Journal of Ethology, 37*(3), 307-316 https://doi.org/10.1007/s10164-019-00604-7

The behavior of sea turtle species can be influenced by the lunar cycle, possibly due to moonlight variability. We analyzed the relationship between nesting behavior and moon phase using nesting hawksbill turtle records for beaches in Northeast Brazil for the 2006-2007 to 2015-2016 seasons. The total number of records was 4807, while the total number with time point registration was 1031. The *Eretmochelys imbricata* inter-nesting period was approximately half the lunar cycle; we therefore expected nesting phase synchronization with lunar phases within each season. We computed the lunar angle for the hawksbill records, and the Kuiper test for uniformity indicated that the species shows some lunar phase preferences. We observed that oviposition at the first and last quarters of the moon is more frequent than at full moon or new moon phases. We also computed the lunar angle throughout several seasons for remigrant turtles and found an absence of preferential lunar phase across different seasons. This indicates that the hawksbill does not choose a lunar phase previously chosen in other nesting seasons. We analyzed the relationship between the presence of the moon in the sky and nesting turtles, and, in sequence, compared the records of false crawls and nest crawls; no relation was found between these variables.

Ng, C. K. Y., Gu, H. X., Li, T. H., Ye, M. B., Xia, Z. R., Zhang, F. Y., . . . Murphy, M. B. (2018). Insights into Identifying Habitat Hot Spots and Migratory Corridors of Green Turtles in the South China Region. *Aquatic Conservation-Marine and Freshwater Ecosystems, 28*(5), 1181-1191 https://doi.org/10.1002/aqc.2923

1. Sea turtles are globally endangered, and face daily anthropogenic threats, such as direct take, by-catch, and habitat degradation. Current research efforts on sea turtles in the South China region mainly focus on captivity and husbandry, haematology and blood chemistry, and nesting ecology. Published information on the marine habitat use of wild populations is limited. 2. This situation therefore creates a pressing need for scientific research on freeranging sea turtles as a foundation for habitat management and species protection in South China. In this study, habitat use and oceanic movement of nesting, and bycatch or stranded green turtles, were determined by satellite tracking combined with home-range analysis. 3. Coupled with previous findings, the foraging grounds of several sea turtle species (green turtle *Chelonia mydas*, hawksbill turtle *Eretmochelys imbricata* and loggerhead *Caretta caretta*) were mainly distributed along the coasts of Hainan Island Province and Guangdong Province, mainland China, as well as Taiwan and the Philippines, and the outlying islands in the South China Sea and East China Sea. 4. Habitat hot spots and migratory corridors of green turtles, in particular nesting turtles in South China, were identified. Coastal waters near Wanning City of Hainan Island, the eastern Leizhou Peninsula, Iriomote-jima and Ishigaki-shima of the Ryukyu Islands of Japan, and Dao Bach Long Vi of Vietnam serve as foraging grounds for nesting green turtles from different origins in South China. Moreover, the Paracel (Xisha) and the Pratas (Dongsha) Islands in the South China Sea, Huidong Gangkou, and its vicinity in mainland China, and Liouciou Island and Penghu Island of Taiwan contain both nesting sites and foraging grounds for green turtles. 5. The sites that are associated with migratory corridors, in particular Hainan Island, eastern Leizhou Peninsula, and Liouciou Island, which currently lack conservation plans for sea turtles, should be given higher priority for habitat and species protection.

Okuyama, J., Shimizu, T., Abe, O., Yoseda, K., & Arai, N. (2010). Wild Versus Head-Started Hawksbill Turtles *Eretmochelys imbricata*: Post-Release Behavior and Feeding Adaptions. *Endangered Species Research, 10*, 181-190 https://doi.org/10.3354/esr00250

To ensure the success of reintroduction programs, it is important to monitor the postrelease behavior and survival of released animals. In this study, the post-release movement and behavior of 5 wild and 5 head-started hawksbill turtles *Eretmochelys imbricata* were monitored using ultrasonic telemetry. Their dispersal directions and recaptures may indicate that wild turtles perform homing migrations. However, the head-started turtles showed non-uniform patterns in dispersal movements. Four head-started turtles moved out of the monitoring area in various directions, whereas one turtle stayed within the monitoring area for approx. 10 mo. These results might indicate that head-started turtles wander aimlessly in their new surroundings. Signal reception patterns indicated that wild turtles were active in the daytime and rested under the coral at night. Although the head-started turtles also rest at night, their resting places did not seem to be sheltered from hazardous sea conditions or adequate for efficient resting. Therefore, head-started hawksbill turtles appear to need pre-release training such as exposure to structures or ledges in the rearing tank so they can utilize similar structures in the wild for shelter during rest periods and maximize their dive duration by employing these as a roof to counteract the positive buoyant effect of inhaled air. Prey analysis of a head-started turtle captured incidentally demonstrates that these turtles can make feeding adaptations to adjust to the natural environment. These findings provide constructive information for the implementation and improvement of head-start programs.

Olivier, I. R. (2015). An Unusual Physical Interaction between Two Adult Hawksbill Turtles (*Eretmochelys imbricata*) in the Seychelles. *Marine Turtle Newsletter*(146), 13-15 Retrieved from http://www.seaturtle.org/mtn/archives/mtn146/mtn146-5.shtml

The hawksbill turtle is listed as Critically Endangered by the IUCN. Despite a substantial amount of research conducted on the biology of sea turtles, very little published information exists regarding their social and mating behaviors. Here, Olivier describe an unusual physical interaction between two adult hawksbill turtles observed offshore of Cousine Island in the Seychelles.

Parker, D. M., King, C., Rice, M., & Balazs, G. (2014). First Use of a Gps Satellite Tag to Track a Post-Nesting Hawksbill (*Eretmochelys imbricata*) in the Hawaiian Islands with an Indication of Possible Mortality. *Marine Turtle Newsletter*(142), 10-13 Retrieved from http://www.seaturtle.org/mtn/archives/mtn142/mtn142-4.shtml

Hawaiian hawksbills (*Eretmochelys imbricata*) have been satellite tagged in the main Hawaiian islands (MHI) with standard Argos tags since 1997. These turtles showed short inter-island migrations. However, the number and quality of transmissions for these tags were relatively poor with few positions with high accuracy resulting of hawksbills having short surface periods and longer dive times. Here, Parker et al describes the first use of a Global Positioning System satellite tag to track a post-nesting Hawksbills in the Hawaiian Islands with an indication of possible mortality.

Pawlik, J. R., Loh, T. L., & McMurray, S. E. (2018). A Review of Bottom-up Vs. Top-Down Control of Sponges on Caribbean Fore-Reefs: What's Old, What's New, and Future Directions. *PeerJ, 6* https://doi.org/10.7717/peerj.4343

Interest in the ecology of sponges on coral reefs has grown in recent years with mounting evidence that sponges are becoming dominant members of reef communities, particularly in the Caribbean. New estimates of water column processing by sponge pumping activities combined with discoveries related to carbon and nutrient cycling have led to novel hypotheses about the role of sponges in reef ecosystem function. Among these developments, a debate has emerged about the relative effects of bottom-up (food availability) and top-down (predation) control on the community of sponges on Caribbean fore-reefs. In this review, we evaluate the impact of the latest findings on the debate, as well as provide new insights based on older citations. Recent studies that employed different research methods have demonstrated that dissolved organic carbon (IDOC) and detritus are the principal sources of food fora growing list of sponge species, challenging the idea that the relative availability of living picoplankton is the sole proxy for sponge growth abundance. New reports have confirmed earlier findings that reef macroalgaer release labile DOC available for sponge nutrition. Evidence for top down control of sponge community structure by fish predation is further supported by gut content studies and historical population estimates of hawksbill turtles, which likely had a much greater impact on relative sponge abundances on Caribbean reefs of the past. Implicit to investigations designed to address the bottom-up vs. top down debate are appropriate studies of Caribbean fore-reef environments, where benthic communities are relatively homogeneous and terrestrial influences and abiotic effects are minimized. One recent study designed to test both aspects of the debate did so using experiments conducted entirely in shallow lagoonal habitats dominated by mangroves and seagrass beds. The top-down results from this study are reinterpreted as supporting past research demonstrating predator preferences for sponge species that are abundant in these lagoonal habitats, but grazed away in ore reef habitats. We conclude that sponge communities on Caribbean fore-reefs of the past and present are largely structured by predation, and offer new directions for research, such as determining the environmental conditions under which sponges may be food-limited (e.g., deep sea, lagoonal habitats) and monitoring changes in sponge community structure as populations of hawksbill turtles rebound.

Pazira, A., Moshtaghie, M., Tollab, M. A., Ahmadi, F., Rashidi, M., Faghih, H., . . . Malekpouri, P. (2016). Hatching Success of Hawksbill Sea Turtles (*Eretmochelys imbricata*) in a Protected Hatchery Site in Nakhiloo Island, Persian Gulf. *Regional Studies in Marine Science, 3*, 216-224 https://doi.org/10.1016/j.rsma.2015.11.001

Hawksbill sea turtle is one of the two important marine turtles, breeding and nesting regularly in the Iran beaches of the Persian Gulf. Hawksbill turtles are critically endangered and there is very little information regarding their Indian Northwest population. Thirty eight nests of *Eretmochelys imbricata* were monitored during the nesting season in Nakhiloo Island. Half of the nests were transferred into a protected hatchery site, in which there were no risk of predation and high-tide inundation. All nests were closely monitored during the incubation period. The pivotal duration was recorded between 48 and 52 days for all nests. During the incubation period, the mean of nest temperature were 34.7±1.3 and 34.4±1.5°C for hatchery site and in situ respectively, which led to female biased. Although there is no significant difference in total eggs between the hatchery site and in situ, other measured parameters were significantly higher in the hatchery site ($P<0.01$). An indirect relationship ($R2$ cubic = 0.842) between percentages of the hatch rate and healthy eggs was observed. The PCA biplots ordination revealed that 83.4% of overall variance was influenced by healthy eggs and live hatchlings which were

distributed in the hatchery site. In an opposite position, the nests at the in situ were mostly associated with either the axis of unhatched eggs (3.4% of overall variance) or dead hatchlings and unhealthy eggs (12.7% of overall variance). Obtained data implies that the selection of hatcheries can prevent the nests being destroyed by the sea waves, tides, other sea turtles and predators.

Pendoley, K. L., Whittock, P. A., Vitenbergs, A., & Bell, C. (2016). Twenty Years of Turtle Tracks: Marine Turtle Nesting Activity at Remote Locations in the Pilbara, Western Australia. *Australian Journal of Zoology, 64*(3), 217-226 https://doi.org/10.1071/zo16021

Little is known about the biology and ecology of marine turtles in the Pilbara region of Western Australia and most potential habitat is unconfirmed and, therefore, undescribed. Understanding basic biological parameters at a regional level is critically important for effective long-term management. We used the track census' methodology to identify reproductive habitat and assess species-specific abundance of adult flatback (Natator depressus), green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles at 154 locations in the Pilbara region of Western Australia. Between 1992 and 2012, potential nesting habitat was assessed via either ground or aerial snapshot' (single visit) or census' (more than one night) surveys and additional information obtained using the Expert Elicitation Method. Species-specific abundance (tracks night(-1)s.d.) was varied; green turtles were most abundant, nesting at fewer locations (n=47) but in greater numbers (1200.5 +/- 62.0) than flatback or hawksbill turtles and primarily (93%) at island locations. Flatback turtle nests were more widely distributed (n=77) than those of green or hawksbill turtles, yet abundance (877.4 +/- 29.5) was lower than that of green and greater than that of hawksbill turtles. Activity was primarily (76%) island-based and activity on the mainland coastline was concentrated close to Mundabullangana and Cemetery Beach. Hawksbill turtle abundance (314.1 +/- 17.1) was lowest and the least widespread (n=43), concentrated primarily in the Onslow and Dampier subregions with no activity recorded in the Port Hedland subregion or on the mainland coastline. The findings provide information with which the Federal government can meaningfully assess the status and distribution of EPBC Act-listed species where habitat overlaps with areas zoned for development. We highlight the urgent need for the Federal Government to regulate the process by which we accumulate data to support data quality and provide meaningful information to enhance efficacy in state and Federal management of species of concern.

Pike, D. A. (2013). Climate Influences the Global Distribution of Sea Turtle Nesting. *Global Ecology and Biogeography, 22*(5), 555-566 https://doi.org/10.1111/geb.12025

Aim: To understand whether climate limits current sea turtle nesting distributions and shapes the ecological niche of the terrestrial life-history stage of these wide-ranging marine vertebrates.
Location: Coastlines world-wide.
Methods: I predicted the spatial distributions of nesting habitat under current climatic conditions for seven sea turtle species using information criteria and maximum entropy modelling. I also compared niche similarity among species using three niche metrics: I, Schoener's D and relative rank.
Results: Sea turtles currently nest across their entire bioclimatic envelopes, with up to six species predicted to nest on a single beach. The Caribbean Sea, Gulf of Mexico and Australasia support high nesting diversity, with most regional areas supporting three to five species. Despite large overlap in nesting distributions among species, loggerhead and green turtles have the broadest environmental niches, while Kemp's ridley and flatback turtles have very narrow niches.

Main conclusions: The terrestrial nesting habitat of sea turtles is characterized by distinct climatic conditions, which are linked to the physical conditions necessary for eggs to hatch successfully and allow hatchlings to disperse from natal areas. Despite broad geographic patterns of overlap and similar embryonic tolerances to temperature and moisture among species, sea turtles partition habitat by nesting in different niche spaces. The tight link between current geographic patterns of nesting and climate, along with the dependence of developing embryos on nest microclimate, imply that regional or global changes in environmental conditions could differentially influence the distribution of sea turtle species under climate change. This could influence the adaptive potential of different populations, and predicting these responses before they occur will be important in mitigating the effects of climate change.

Pilcher, N. J., Antonopoulou, M., Perry, L., Abdel-Moati, M. A., Al Abdessalaam, T. Z., Albeldawi, M., . . . Willson, A. (2014). Identification of Important Sea Turtle Areas (Itas) for Hawksbill Turtles in the Arabian Region. *Journal of Experimental Marine Biology and Ecology, 460*, 89-99 https://doi.org/10.1016/j.jembe.2014.06.009

We present the first data on hawksbill turtle post-nesting migrations and behaviour in the Arabian region. Tracks from 90 post-nesting turtles (65 in the Gulf and 25 from Oman) revealed that hawksbills in the Arabian region may nest up to 6 times in a season with an average of 3 nests per turtle. Turtles from Qatar, Iran and the UAE generally migrated south and southwest to waters shared by the UAE and Qatar. A smaller number of turtles migrated northward towards Bahrain, Saudi Arabia and one reached Kuwait. Omani turtles migrated south towards Masirah island and to Quwayrah, staying close to the mainland and over the continental shelf. The widespread dispersal of hawksbill foraging grounds across the SW Gulf may limit habitat protection options available to managers, and we suggest these be linked to preservation of shallow water habitats and fishery management. In contrast, the two main foraging areas in Oman were small and could be candidates for protected area consideration. Critical migration bottlenecks were identified at the easternmost point of the Arabian Peninsula as turtles from Daymaniyat Islands migrate southward, and between Qatar and Bahrain. Overall, Gulf turtles spent 68% of the time in foraging ground with home ranges of 40–60km2 and small core areas of 6km2. Adult female turtles from Oman were significantly larger than Gulf turtles by ~11cm $\bar{x}$=81.4CCL and spent 83% of their time foraging in smaller home ranges with even smaller core areas (~3km2), likely due to better habitat quality and food availability. Gulf turtles were among the smallest in the world $\bar{x}$=70.3CCL and spent an average of 20% of time undertaking summer migration loops, a thermoregulatory response to avoid elevated sea surface temperatures, as the Gulf regularly experiences sustained sea surface temperatures >30°C. Fishery bycatch was determined for two of the 90 turtles. These spatio-temporal findings on habitat use will enable risk assessments for turtles in the face of multiple threats including oil and gas industries, urban and industrial development, fishery pressure, and shipping. They also improve our overall understanding of hawksbill habitat use and behaviour in the Arabian region, and will support sea turtle conservation-related policy decision-making at national and regional levels.

Pilcher, N. J., Perry, L., Antonopoulou, M., Abdel-Moati, M. A., Al Abdessalaam, T. Z., Albeldawi, M., . . . Willson, A. (2014). Short-Term Behavioural Responses to Thermal Stress by Hawksbill Turtles in the Arabian Region. *Journal of Experimental Marine Biology and Ecology, 457*, 190-198 https://doi.org/10.1016/j.jembe.2014.04.002

We present a previously unrecorded short-term behavioural response by hawksbill sea turtles to elevated sea surface temperatures in the Persian/Arabian Gulf. Surface waters typically exceed 30°C for sustained periods during the summer, and can be likened to a natural living laboratory for understanding thermoregulatory behaviour by marine species in the face of climate change and elevated global temperatures. We satellite-tracked 90 post-nesting hawksbill turtles between 2010 and 2013 as part of a larger programme to elucidate turtle foraging habitats and post-nesting behaviour. We used 66 of these datasets, where turtles clearly departed and returned to foraging grounds, for these analyses. Sea surface temperatures during the summer averaged 33.5°C and peaked at 34.9°C. During these elongated periods of elevated temperatures (June–August) the turtles temporarily migrated an average of 70km to deeper and cooler waters at northern latitudes, returning after 2–3months (September–October) back to original feeding grounds. Temperature differential TΔ between foraging and summer loop habitats was significantly different and approximated −2°C. Turtles undertaking summer migration loops generally moved in a north-easterly direction toward deeper water, returning in a south-westerly direction to the shallower foraging grounds. Swim speeds were significantly higher and orientation was less omnidirectional during the migrations than when foraging. The outbound migrations were significantly inversely correlated with temperature, but were not linked to chlorophyll-a, geostrophic currents or sea surface height. The turtles' preference for returning to the same foraging grounds suggests a lack of other substantial influences which might have precipitated the temporary summer migration loops. Our results indicate that Gulf hawksbills employ thermoregulatory responses which take them out of high temperature and potentially physiology-threatening conditions. These findings improve our overall understanding of hawksbill habitat use and behaviour in a climate-challenged environment, and support sea turtle conservation-related policy decision-making at national and regional levels.

Poonian, C. N. S., Ramilo, R. V., & Lopez, D. D. (2016). Diversity, Habitat Distribution, and Indigenous Hunting of Marine Turtles in the Calamian Islands, Palawan, Republic of the Philippines. *Journal of Asia-Pacific Biodiversity, 9*(1), 69-73 https://doi.org/10.1016/j.japb.2015.12.006

All of the world's seven species of marine turtle are threatened by a multitude of anthropogenic pressures across all stages of their life history. The Calamian Islands, Palawan, Philippines provide important foraging and nesting grounds for four species: green turtles (*Chelonia mydas*), hawksbill turtles (*Eretmochelys imbricata*), loggerheads (*Caretta caretta*), and leatherbacks (Dermochelys coriacea). This work aimed to assess the relative importance of turtle nesting beaches and local threats using a combination of social science and ecological research approaches. Endangered green turtles and critically endangered hawksbills were found to nest in the Calamianes. The most important nesting sites were located on the islands off the west of Busuanga and Culion, particularly Pamalican and Galoc and along the north coast of Coron, particularly Linamodio Island. Opportunistic hunting and egg collection, conducted legally by indigenous communities, is the most significant threat to sea turtles in the area. Sites particularly vulnerable to hunting were found to be Galoc Island, Pamalican Island, and Panlaitan Island. Raising awareness, community engagement, and understanding of socio-cultural drivers of sea turtle exploitation, particularly among indigenous communities, are essential to gain support for any effective conservation program. Additionally, more effective enforcement of laws related to the trade in sea turtle products is required to close the commercial and export markets.

Proietti, M. C., Reisser, J., Marins, L. F., Marcovaldi, M. A., Soares, L. S., Monteiro, D. S., . . . Secchi, E. R. (2014). Hawksbill X Loggerhead Sea Turtle Hybrids at Bahia, Brazil: Where Do Their Offspring Go? *PeerJ, 2* https://doi.org/10.7717/peerj.255

Hybridization between hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*) breeding groups is unusually common in Bahia state, Brazil. Such hybridization is possible because hawksbill and loggerhead nesting activities overlap temporally and spatially along the coast of this state. Nevertheless, the destinations of their offspring are not yet known. This study is the first to identify immature hawksbill x loggerhead hybrids (n = 4) from this rookery by analyzing the mitochondrial DNA (mtDNA) of 157 immature turtles morphologically identified as hawksbills. We also compare for the first time modeled dispersal patterns of hawksbill, loggerhead, and hybrid offspring considering hatching season and oceanic phase duration of turtles. Particle movements varied according to season, with a higher proportion of particles dispersing southwards throughout loggerhead and hybrid hatching seasons, and northwards during hawksbill season. Hybrids from Bahia were not present in important hawksbill feeding grounds of Brazil, being detected only at areas more common for loggerheads. The genetic and oceanographic findings of this work indicate that these immature hybrids, which are morphologically similar to hawksbills, could be adopting behavioral traits typical of loggerheads) such as feeding in temperate waters of the western South Atlantic. Understanding the distribution, ecology, and migrations of these hybrids is essential for the development of adequate conservation and management plans.

Rees, A. F., Papathanasopoulou, N., & Godley, B. J. (2019). Tracking Hawksbills in Kuwait: Contributions to Regional Behavioral Insights. *Chelonian Conservation and Biology, 18*(1), 86-90 https://doi.org/10.2744/ccb-1368.1

Hawksbill turtles from nesting areas in the south of the Arabian/Persian Gulf have been shown to migrate to numerous individual foraging sites across the region and undertake "summer migration loops" (SMLs) to avoid the most extreme sea temperatures. We tracked hawksbills nesting in Kuwait (n = 4) that migrated to hitherto undescribed foraging sites but showed no evidence of SMLs despite experiencing water temperatures greater than 33 degrees C. Increasing the sample size for Kuwait turtles, tracking males, and publishing results from other important hawksbill nesting areas in Saudi Arabia are recommended to get a fuller indication of potential behavioral plasticity in the region.

Reising, M., Salmon, M., & Stapleton, S. (2015). Hawksbill Nest Site Selection Affects Hatchling Survival at a Rookery in Antigua, West Indies. *Endangered Species Research, 29*(2), 179-187 https://doi.org/10.3354/esr00708

Nesting populations of Critically Endangered hawksbill sea turtles remain depleted across much of their range in the Caribbean. Some islands, however, including Jumby Bay (Pasture Bay) in Antigua, have shown a steady increase in the number of nesting females. Furthermore, in recent years nesting has occurred in particularly high densities within the remnant maritime forest on the northwestern side of the bay, concentrating the entry of emerging hatchlings into the sea along a small (160 m long) length of shoreline. Previous studies have shown that when many hatchlings enter the sea from a restricted location, aquatic predators may exploit that site. We followed 49 hatchlings by kayak at night as they swam offshore, and we determined that predation rates were significantly higher on the western than on the eastern side of the bay. At both locations, the turtles showed no obvious differences in offshore

orientation that might have increased their vulnerability to predators. We hypothesize that the greater predation rate was most likely caused by the presence of more predators. To reduce those predation pressures, we recommend a 2-pronged strategy: (1) 'risk-spreading' (releasing hatchlings at other locations adjacent to, and within, the bay), and (2) habitat restoration to expand the area of attractive nesting habitat.

Rocha, F., Nascimento, R. F. F., Barbosa, F. P., & Abessa, D. M. S. (2017). Monitoring Sea Turtles in an Estuary Altered by Human Use. *Marine Turtle Newsletter*(152), 20-24 Retrieved from http://www.seaturtle.org/mtn/archives/mtn152/mtn152-7.shtml

At each sampling station, reliable visualization of sea turtles was possible from a distance of up to approximately 30 m. We quantified the turtle breathing events within each viewing period as a proxy for relative abundance. Because the exact number of individuals present at each sampling could not be confirmed, the number of sightings represents how many times one turtle (or more) was seen breathing, not the number of specimens. Studies should take other approaches for detecting and quantifying sea turtles, including visual surveys, active captures, records of stranded animals and those incidentally captured by fishers, tagging animals, etc. Because greens and hawksbills are protected species in Brazil, stronger measures are required to minimize the potential threats to these animals and to monitor their population size and health status.

Salleh, S. M., Nishizawa, H., Sah, S. A. M., & Safri, M. F. (2018). Spatiotemporal Preferences in Nesting of the Hawksbill Turtle (*Eretmochelys imbricata*) in Melaka, Malaysia. *Journal of the Marine Biological Association of the United Kingdom, 98*(8), 2145-2152 https://doi.org/10.1017/s0025315417001734

Nesting of hawksbill turtles (*Eretmochelys imbricata*) was monitored in 2013 and 2014 at 20 nesting beaches along the shores of Melaka, Peninsular Malaysia. Total nest numbers found were 481 and 463 in 2013 and 2014, respectively. The mean clutch size in 2013 of 123.5 +/- 32.3 (SD) was similar to that in 2014 (118.5 +/- 39.7). The distributions of nests were not uniform among the 20 beaches, and a large number of nests were found in Padang Kemunting, Kem Terendak, and Pulau Upeh, where the beaches were not always long. The nest sites indicated that the hawksbill turtle preferred to build its nest within the woody vegetation zone. The preferred vegetation species was Scaevola taccada. The temporal nesting pattern was year-round in both years, but the peak nesting season was between May and August, in the south-west monsoon season, possibly due to the gentle winds during this period. The turtles tended to nest between 22:01 and 24:00 h. This study provides basic information about hawksbill turtle nesting and insights into their spatial and temporal nesting preferences, which will contribute towards the conservation of this endangered species.

Santos, A. J. B., Bellini, C., Bortolon, L. F. W., Outerbridge, B., Browne, D. C., Santos, A., . . . Marcovaldi, M. A. (2019). Long-Range Movements and Growth Rates of Brazilian Hawksbill Turtles: Insights from a Flipper-Tagging Program. *Chelonian Conservation and Biology, 18*(1), 75-81 https://doi.org/10.2744/ccb-1343.1

The understanding of developmental and reproductive migrations of sea turtles is essential for effective protection and conservation efforts. Flipper tags remain a valuable method for detecting movements

and migrations because they are cost-effective and conspicuous, allowing the detection of a tagged animal by any person worldwide. Here we report 13 flipper-tag recoveries for Brazilian hawksbill (*Eretmochelys imbricata*) turtles that augment the body of information on the migratory nature of this species and provide new growth-rate data.

Santos, A. J. B., Bellini, C., Vieira, D. H. G., Neto, L. D., & Corso, G. (2013). Northeast Brazil Shows Highest Hawksbill Turtle Nesting Density in the South Atlantic. *Endangered Species Research, 21*(1), 25-32 https://doi.org/10.3354/esr00505

To date, hawksbill turtle *Eretmochelys imbricata* nesting in Brazil has been estimated by recording clutch numbers. To better address conservation assessments and more reliably estimate the number of females, the Projeto TAMAR-ICMBio initiated a mark and recapture program of nesting females to gather data on critical parameters such as clutch frequency and remigration interval. The study area on the southern coast of Rio Grande do Norte was divided into 2 data-recording efforts: index (IA) and protected (PA) areas. Overall, 243 nesting hawksbill turtles were tagged along 42 km of nesting beach; 153 of these were within the 4 km area of intensive tagging. We estimated a remigration interval of 2.1 yr and a clutch frequency of between 2.3 and 2.6 clutches per female. Furthermore, the number of active breeding females was estimated to be between 705 and 791. The average number of clutches per kilometer was 21.1 in the IA and 20.7 in the PA (although some sections were as high as 37.5 and 48.5 nests km super(-1), respectively). This represents the highest density of hawksbill clutches per kilometer found so far for the South Atlantic, and highlights the importance of southern Rio Grande do Norte for the conservation of the Critically Endangered hawksbill turtle.

Santos, A. J. B., Neto, J. X. L., Vieira, D. H. G., Neto, L. D., Bellini, C., Albuquerque, N. D. S., . . . Soares, B. L. (2016). Individual Nest Site Selection in Hawksbill Turtles within and between Nesting Seasons. *Chelonian Conservation and Biology, 15*(1), 109-114 https://doi.org/10.2744/CCB-1136.1

We analyzed 410 nest locations from 150 individual nesting hawksbill turtles (*Eretmochelys imbricata*) on the northeastern Brazilian coast during 8 nesting seasons from 2006 to 2014 to evaluate individual nesting preferences. We determined the consistency of nest site choice within and between nesting seasons for open sand and vegetation nest microhabitats and also for nest site distances from the current waterline, highest spring tide, vegetation line, and position along the beach. We found that behavioral consistency within seasons was more robust than between seasons. This suggests that a decrease in the consistency of nest site choice may be related to progressive landscape changes in the nesting environment, driving behavioral flexibility in nesting preferences.

Selby, T. H., Hart, K. M., Smith, B. J., Pollock, C. G., Hillis-Starr, Z., & Oli, M. K. (2019). Juvenile Hawksbill Residency and Habitat Use within a Caribbean Marine Protected Area. *Endangered Species Research, 40*, 53-64 https://doi.org/10.3354/esr00975

Understanding the spatial ecology of highly mobile marine vertebrates is necessary for informing conservation and management strategies aimed at protecting such species. Buck Island Reef National Monument (BIRNM), off the coast of St. Croix, US Virgin Islands, harbors critical foraging habitat for Critically Endangered juvenile hawksbills *Eretmochelys imbricata* that exhibit high site fidelity until

sexual maturation. Using an array of fixed passive acoustic receivers that covered over 20.2 km(2) at its largest configuration and in-water biannual sampling, we analyzed residency patterns and habitat use of 29 hawksbills. High recapture rates allowed for long-term data collection for some individuals, with 1 individual being detected within the array 1952 d (mean +/- SD: 411 +/- 444 d). We used detection data to construct a resource selection function based on a generalized linear mixed model in order to determine relative habitat selection, or the use of different habitat types within an area proportional to the 'true' selection. Our covariates in the model were benthic structure, bathymetry, time of day, and year. Results showed selection by tagged individuals for shallow (< 20 m) depths in areas with high rugosity characterized by a high density of reef or rock. However, individuals also selected areas comprised primarily of sand interspersed with seagrass pastures. We also used the best supported model to predict relative selection across BIRNM and found that the total area of high relative selection decreased significantly at night. The information provided will help guide both future in-water surveys for cryptic hawksbills and management decisions about public area-use at BIRNM.

Simoes, T. N., da Silva, A. C., & Moura, C. C. D. (2017). Influence of Artificial Lights on the Orientation of Hatchlings of *Eretmochelys imbricata* in Pernambuco, Brazil. *Zoologia, 34* https://doi.org/10.3897/zoologia.34.e13727

Sea turtle hatchlings, in natural abiotic conditions, emerge from their nests at night and go directly to the sea, following the moonlight's reflection in the ocean. Increased human activities such as tourism and artificial lights on the coasts, however, have interfered with the ability of sea turtle neonates to find their correct destination, negatively affecting their survival rates. Here we endeavored to assess the influence of artificial lights on the hatchlings of the sea turtle *Eretmochelys imbricata* (Linnaeus, 1766) in the south coast of the state of Pernambuco, Brazil. To that end, 10 experiments were conducted with 15 hatchlings/test subjects. Five experiments took place in artificially illuminated areas and five in non-illuminated areas. Circles with a 2 m radius were drawn on the sand a small 2-3 cm depression was made at the center of each circles. The neonates were then placed in the depressions to simulate their coming from a nest. After the neonates crossed the edge of the circles, their tracks were photographed and drawn on a diagram. To ascertain if the trajectories of the neonates differed between the two groups (hatchlings from illuminated versus non-illuminated nests), the Rayleigh test was used. The significance of those differences was tested using ANOVA. To evaluate similarities and significance of clusters, a Multi-Dimensional Scaling was used. The tracks of 86.67% (N = 65) of the hatchlings from nests at illuminated areas departed from their correct trajectory. The distribution of trajectories was considered random (V = 19.4895, p > 0.05) only for tracks originating from artificially illuminated areas. The movement patterns of hatchlings from illuminated and non-illuminated areas differed significantly (F < 0.0001, p < 0.01). Consistent with this, two distinct groups were identified, one from illuminated and one from non-illuminated areas. Therefore, we conclude that artificial illumination impacts the orientation of hawksbill hatchlings. This suggests that in order to protect this species it is necessary to safeguard its nesting areas from artificial lights.

Smith, B. J., Selby, T. H., Cherkiss, M. S., Crowder, A. G., Hillis-Starr, Z., Pollock, C. G., & Hart, K. M. (2019). Acoustic Tag Retention Rate Varies between Juvenile Green and Hawksbill Sea Turtles. *Animal Biotelemetry, 7*(1) https://doi.org/10.1186/s40317-019-0177-3

Background: Biotelemetry has become a key tool for studying marine animals in the last decade, and a wide range of electronic tags are now available for answering a range of research questions. However,

comparatively, less attention has been given to attachment methods for these tags and the implications of tag retention on study design, especially when designing a comparative study looking at multiple species. Here, we reported our findings on acoustic tag retention rates for juveniles of two species of marine turtle: the green sea turtle (*Chelonia mydas*) and the hawksbill sea turtle (*Eretmochelys imbricata*). We captured both species twice annually (spring and fall) from 2012 through 2017, as part of a capture–mark–recapture study at Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands. We assessed tag retention rates using physical recaptures of turtles previously outfitted with an acoustic tag. Results: We deployed 72 acoustic tags on 60 juvenile greens and 37 acoustic tags on 29 hawksbills. We estimated the half-life for tags on greens to be 150 days (95% CI 117–188 days), whereas the half-life for tags on hawksbills was 1077 days (95% CI 870–2118 days), a marked difference. We observed that tag attachment holes, drilled into the posterior marginal scutes, migrated laterally towards the outer edge of the marginals in both species. Green turtles tended to exhibit tear-outs, as their attachment holes wore and/or tags grew near the edge of their scutes, whereas hawksbills tended to maintain the structure of these holes and did not exhibit these tear-outs. Conclusions: We conclude that hawksbills can be tagged with long-battery-life acoustic tags for long-term studies of habitat use and movement patterns, whereas greens are likely to shed their tags in the 1st year, making long-term studies difficult. This study is the first clear evidence that tagging protocols should vary between species of hardshelled turtles. Furthermore, shed tags on the seafloor continue to be detected by acoustic receivers, creating a challenge in data filtering before analysis. We encourage future research into an efficient method for filtering these data points prior to analysis.

Sterling, E. J., McFadden, K. W., Holmes, K. E., Vintinner, E. C., Arengo, F., & Naro-Maciel, E. (2013). Ecology and Conservation of Marine Turtles in a Central Pacific Foraging Ground. *Chelonian Conservation and Biology, 12*(1), 2-16 https://doi.org/10.2744/CCB-1014.1

Foraging grounds are critical to the survival of marine turtles, yet studies of these areas lag behind those of nesting sites. Our study represents the first data and discussion on marine turtle distribution, abundance, and health at a marine turtle foraging ground in the central Pacific, Palmyra Atoll National Wildlife Refuge, which constitutes a regionally important mixed-size-class foraging ground for green turtles (*Chelonia mydas*) and, to a lesser extent, for hawksbill turtles (*Eretmochelys imbricata*). Surveys and anecdotal reports suggest that nesting activity is rare, and we have confirmed the presence of limited suitable nesting habitat. During in-water activities from 2008 to 2011, we caught 211 green turtles ranging from postpelagic juveniles to adults (weight: mean = 44.6 kg, range = 7.2-146.3 kg; curved carapace length (CCL): mean = 69.7 cm, range = 41.0-113.6 cm) and 2 juvenile hawksbills (weight^sub 2009^ = 16.3 kg, CCL^sub 2009^ = 57.0; weight^sub 2011^ = 11.2 kg, CCL^sub 2011^ = 50.5 cm). Body condition indices did not significantly differ by year of capture. These indices, along with the absence of observed fibropapilloma tumors, indicated that turtles at Palmyra Atoll were on average in very good condition. We also conducted 11 relative abundance surveys from 2005 to 2011, a subset of which revealed an uneven distribution of turtles around Palmyra Atoll with 3 hot spots of turtle abundance off the flats to the north, south, and east. By linking several aspects of our research program with similar efforts at foraging grounds throughout the Pacific Basin, we can further our understanding of poorly known regional migratory connectivity.

Strindberg, S., Coleman, R. A., Perez, V. R. B., Campbell, C. L., Majil, I., & Gibson, J. (2016). In-Water Assessments of Sea Turtles at Glover's Reef Atoll, Belize. *Endangered Species Research, 31*, 211-225 https://doi.org/10.3354/esr00765

The decline of sea turtle populations in the Caribbean has led to intensive recovery efforts. In Belizean waters, hawksbill turtles are seemingly making a comeback. At Glover's Reef Atoll particularly, juvenile hawksbill turtles are found in the fore-reef habitat. The population status and dynamics of this foraging aggregation were assessed to inform conservation management and to ascertain the national and regional importance of this site. During 12 sampling periods from 2007 to 2013, turtles of all species were counted, captured, and tagged. For hawksbill turtles, the capture-recapture histories were combined with the counts using a mark-resight analysis under a robust design. This provided estimates of abundance as well as survival and transition rates. From 2009 onward, distance sampling was also used to estimate density and abundance of hawksbill turtles and the less frequently encountered green and loggerhead turtles. Distance sampling provided a more cost-effective estimation method for multiple species and another more precise source of abundance estimates for hawksbills. This is the first study known to use either mark-resight or distance sampling methods during snorkel surveys of sea turtles. It produced reasonably congruent abundance estimates of >1000 juvenile hawksbills and an order of magnitude less of green and loggerhead turtles. The mark-resight analysis estimated an apparent juvenile hawksbill survival probability of 0.975 (95% CI: 0.936-0.99), indicating that mortality factors are low. The Atoll provides important developmental habitat for juvenile hawksbills, contributing to the recovery of the species on the national and regional scale.

Stringell, T. B., Clerveaux, W. V., Godley, B. J., Kent, F. E. A., Lewis, E. D. G., Marsh, J. E., . . . Broderick, A. C. (2016). Taxonomic Distinctness in the Diet of Two Sympatric Marine Turtle Species. *Marine Ecology, 37*(5), 1036-1049 https://doi.org/10.1111/maec.12349

Marine turtles are considered keystone consumers in tropical coastal ecosystems and their decline through overexploitation has been implicated in the deterioration of reefs and seagrass pastures in the Caribbean. In the present study, we analysed stomach contents of green (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) harvested in the legal turtle fishery of the Turks and Caicos Islands (Caribbean) during 2008-2010. Small juveniles to adult-sized turtles were sampled. Together with data from habitat surveys, we assessed diet composition and the taxonomic distinctness (and other species diversity measures) in the diets of these sympatric marine turtle species. The diet of green turtles (n = 92) consisted of a total of 47 taxa: including three species of seagrass (present in 99% of individuals), 29 species of algae and eight sponge species. Hawksbill turtles (n = 45) consumed 73 taxa and were largely spongivorous (16 species; sponges present in 100% of individuals) but also foraged on 50 species of algae (present in 73% of individuals) and three species of seagrass. Plastics were found in trace amounts in 4% of green turtle and 9% of hawksbill turtle stomach samples. We expected to find changes in diet that might reflect ontogenetic shifts from small (oceanic-pelagic) turtles to larger (coastal-benthic) turtles. Dietary composition (abundance and biomass), however, did not change significantly with turtle size, although average taxonomic distinctness was lower in larger green turtles. There was little overlap in prey between the two turtle species, suggesting niche separation. Taxonomic distinctness routines indicated that green turtles had the most selective diet, whereas hawksbill turtles were less selective than expected when compared with the relative frequency and biomass of diet items. We discuss these findings in relation to the likely important trophic roles that these sympatric turtle species play in reef and seagrass habitats.

Summers, T. M., Jones, T. T., Martin, S. L., Hapdei, J. R., Ruak, J. K., & Lepczyk, C. A. (2017). Demography of Marine Turtles in the Nearshore Environments of the Northern Mariana Islands. *Pacific Science, 71*(3), 269-286 https://doi.org/10.2984/71.3.3

In the western Pacific, green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) sea turtles are listed as Endangered under the U. S. Endangered Species Act (ESA). Population data are limited for both species throughout the entire region and particularly in the Philippine Sea. This study characterizes size class distribution, growth rates, habitat use, behavior, diet, and site fidelity of foraging aggregations of green and hawksbill turtles in nearshore habitats of Saipan, Tinian, and Rota in the Commonwealth of the Northern Mariana Islands (CNMI). Between August 2006 and February 2014, we captured 642 turtles (493 green and 36 hawksbill turtles). Straight carapace length (SCL) ranged from 32.5 to 91.6 cm, with juveniles composing the majority of captures (mean SCL = 50.7 cm). Four of the green turtles were adults (SCL >= 81 cm), with SCLs of 84.2 to 91.6 cm. All 36 hawksbill turtles were juveniles (SCL < 78.6 cm). Most captures occurred in coral habitats where turtles were foraging and resting. Diet samples from 47 green turtles included Amansia sp., Gelidiella sp., Hypnea sp., and Ceramium sp. Green turtle growth rates ranged from 0.3 to 7.8 cm yr(-1). Estimated mean residency time was 17 yr. This is the first study within the CNMI to report on morphometric data and diet composition of marine turtles. These results provide an assessment of green and hawksbill turtle population demographics and habitat use in the CNMI.

Vilaça, S. T., Lara-Ruiz, P., Marcovaldi, M. A., Soares, L. S., & Santos, F. R. (2013). Population Origin and Historical Demography in Hawksbill (*Eretmochelys imbricata*) Feeding and Nesting Aggregates from Brazil. *Journal of Experimental Marine Biology and Ecology, 446*, 334-344 https://doi.org/10.1016/j.jembe.2013.06.004

We studied hawksbills from Brazilian feeding aggregates and nesting colonies to ascertain the origin and genealogical relationship of individuals in the largest southern Atlantic remnant population by using sequences of the mitochondrial (mtDNA) control region and five autosomal genes. A phylogeographic analysis of 246 hawksbills showed four distinct mtDNA haplogroups in the feeding grounds, while only one was found in Brazilian rookeries. We found significant differences among nesting sites in Brazil, and among them and other rookeries worldwide. Differences among Brazilian feeding aggregation sites and others around the world were also found. We were able to show that hawksbills from feeding aggregates at the Brazilian islands of Fernando de Noronha and Rocas Atoll were mainly derived from Brazilian and Caribbean rookeries, although some were related to individuals from the eastern Atlantic and Indo-Pacific, indicating large transoceanic migrations for this species. The nuclear data presented no structure and no signal of demographic change. Mixed stock analyses indicated that Brazilian rookeries contribute mostly to Brazilian feeding grounds, and in a smaller proportion to feeding aggregations in the Caribbean and eastern Atlantic. Finally, hybrids found frequently in rookeries of the Bahia State are not present in the feeding grounds, and thus, may display different feeding and migratory behaviors.

Voogt, N. M., & Göpper, B. M. (2017). Terrestrial Emergence Recorded for a Male Hawksbill (*Eretmochelys imbricata*) on Cousine Island, Seychelles. *Marine Turtle Newsletter*(153), 9-10 Retrieved from http://www.seaturtle.org/mtn/archives/mtn153/mtn153-4.shtml

Basking behavior (sea or land based) is one of the less understood behaviors in marine turtles. Land-basking is a widely documented behavior for green turtles (*Chelonia mydas*) in Hawaii and the

Galápagos (Whittow & Balazs 1982; Murakawa & Balazs 2005; Van Houtan *et al*. 2015). Possible reasons for land-basking include predator avoidance (Balazs 1980), energy conservation (Balazs 1980; Garnett *et al*. 1985), thermoregulation (Hughes 1974; Van Houtan *et al*. 2015), and females escaping unwanted attention from males (Booth & Peters 1972; Hughes 1974; Mortimer 1981). It has been suggested that the occasional beached male in the Galápagos occurs incidentally due to following females ashore (Green 1997). At-sea basking has been recorded in olive ridleys (*Lepidochelys olivacea*) (Hughes & Richard 1974) and loggerheads (*Caretta caretta*) (Green 1997). Murakawa & Balazs (2005) compiled a bibliography of all known terrestrial basking and non-nesting emergence publications for marine turtles, but there is no reference to basking behavior by hawksbills (*Eretmochelys imbricata*). Cousine Island (-4.350577 °S, 55.647527 °E) is a privately owned island, which features a resort and a nature reserve in the inner-granitic Seychelles. Its one kilometer stretch of beach is a nesting beach for both the diurnally nesting hawksbills (September - March) and the nocturnally nesting greens (rare, with one or two females observed nesting each year). The Cousine Island Marine Turtle Research and Monitoring Program began in the early 1990s, and during the hawksbill nesting season, hourly beach patrols are performed, tagging and reading tags of turtles that come ashore, and recording and monitoring nests and hatchlings. During the nesting season there are a few males observed lingering on the surrounding reef. On 21 September 2016, a hawksbill was observed on the beach at 17:00 h, exiting the wave wash. Initially, from a distance, the turtle was perceived to be a female emerging from the surf and coming ashore to nest. When the turtle did not continue crawling up the beach, as a female would do during exploration or nesting, we became concerned and moved to another vantage point to take a better look at the turtle. We viewed the turtle from the side, noticed an unusually long tail, and then realized it was a male. He had crawled just past the surf (Fig. 1) and showed very little movement, only twice lifting his head to make a gulping motion. Occasionally he would crawl forward if the waves washed over him. Once the sun began setting, he returned to the sea at 18:00 h. He was then caught in the shallows and brought back onshore whereupon we read his flipper tags and checked for injuries or signs of sickness. The external examination revealed no evidence of trauma, lesions, growths or ectoparasites, with the exception of a few small barnacles on the soft tissue of the hind flippers. He was very strong and healthy. The left flipper tag read SEY 6229 (on the second scale) while the right tag was missing. There was evidence of a flipper tag scar on the right second scale, therefore, the tag was presumed to have been pulled out. A replacement tag (SCA 7677), was placed in the skin adjacent to the first scale on the right flipper. From Cousine Island internal records, this turtle was originally tagged SEY 6229/6228 (second scales) and identified as a male on Cousine Island by P.M. Hitchins in October 2003. The record showed that the turtle was observed during a similar time of the year, with the same duration out of the water, and on the same area of beach as sighted in 2016. This rare case was published as a photo of "basking" and the "only record of a male emerging onto the beach in the Seychelles" in a book describing Cousine Island's restoration and conservation programs (Samway *et al*. 2010). These two terrestrial emergences by this one individual male are fascinating, and if these two incidents on Cousine Island were truly land-basking, they were incredibly rare occurrences. This is the first known recorded hawksbill male to demonstrate this behavior in the Seychelles.

Walcott, J., Eckert, S., & Horrocks, J. A. (2013). Diving Behaviour of Hawksbill Turtles During the Inter-Nesting Interval: Strategies to Conserve Energy. *Journal of Experimental Marine Biology and Ecology, 448*, 171-178 https://doi.org/10.1016/j.jembe.2013.07.007

Hawksbill sea turtles (*Eretmochelys imbricata*) nesting in Barbados were outfitted with time-depth recorders (TDRs) with temperature sensors to investigate the form and patterns of diving behaviour during the inter-nesting interval (INI; average 14.7days). All females, regardless of size, surfaced

infrequently during dives of average 56min duration, and the majority of dives (90%) were spent in the bottom phase at 15–25m depths, which corresponded to the depth of benthic habitat at each location. Diving activity was highest while commuting to and from the nesting beach (about 1–2days each way), with a level of quiescence during the intermediate period (i.e. the majority of the INI). Despite little thermal variation in seawater at this latitude (13.1°N), the length of the INI was influenced by ambient sea water temperature. Diving behaviour was consistent with females conserving energy reserves built up at foraging grounds prior to arrival at the nesting beach and minimising time spent in the water column away from safe refuge at night. The frequency of surfacing and the depths at which females spend most of their time varies between sites even within one species and may be crucial in managing the risks to animals temporarily residing offshore from important nesting beaches.

Walcott, J., Eckert, S., Oxenford, H. A., & Horrocks, J. A. (2014). Use of a Towed Camera System to Investigate Benthic Habitat Use by Inter-Nesting Female Hawksbill Sea Turtles. *Endangered Species Research, 24*(2), 159-170 https://doi.org/10.3354/esr00597

The types of marine benthic habitats utilised by hawksbill sea turtles *Eretmochelys imbricata* nesting at Needham's Point, Barbados, were investigated using an underwater drop camera. Habitats used preferentially (i.e. those within high-use areas) tended to be high relief and densely covered with biota, characterised by high abundance of hard corals and shallower than less frequented areas. These structurally complex habitats offered opportunities for rest and refuge, but not for foraging, with females showing no preference for sites with high sponge abundance. Females appeared to trade off site quality (i.e. based on benthic relief, cover and species composition) against the energy expended to get there, travelling long distances (up to 21.2 km) to higher-quality sites.

Walker, G., Cawley, B., Pepe, H., Robb, A., Livingstone, S., & Downie, R. (2015). The Creation of a Map of Hawksbill Turtle (*Eretmochelys imbricata*) Nesting in Tobago, West Indies. *Marine Turtle Newsletter*(144), 3-9 Retrieved from http://www.seaturtle.org/mtn/PDF/MTN144.pdf

The number of hawksbill turtles (*Eretmochelys imbricata*) using known globally important nesting sites has declined by over 80% in recent decades, resulting in the species being listed as Critically Endangered on the IUCN Red List of Threatened Species. However, it remains the case that not all hawksbill populations are well documented, because nesting often occurs on small dispersed beaches on islands where monitoring is logistically difficult. Walker et al provide an updated map of hawksbill turtle nesting for Tobago that can be compared with the findings of Dow et al (2007).

Weber, S. B., Weber, N., Godley, B. J., Pelembe, T., Stroud, S., Williams, N., & Broderick, A. C. (2017). Ascension Island as a Mid-Atlantic Developmental Habitat for Juvenile Hawksbill Turtles. *Journal of the Marine Biological Association of the United Kingdom, 97*(4), 813-820 https://doi.org/10.1017/s0025315414001258

Ascension Island in the South Atlantic Ocean is renowned for its globally-important nesting population of green turtles (*Chelonia mydas*) that has been the subject of long-term research. By comparison, very little is known about the apparently small population of hawksbill turtles (*Eretmochelys imbricata*) that have been recorded in its waters, thousands of kilometres from known nesting beaches. Here, we collate 10 years of in-water tagging data, opportunistic public sighting records and underwater

observations to provide a baseline for future research, and present preliminary data on habitat use derived from two individuals fitted with GPS transmitters. Although public sightings were inevitably biased towards popular recreation areas, the resulting distribution suggests that hawksbill turtles occur year round in Ascension Island's waters along the entire 65 km of coastline. Hawksbills were observed feeding on benthic algae and encrusting sponges, and were frequently seen scavenging on fish discards around the Island's pier at night aided by anthropogenic lighting. Between 2003 and 2013, 35 turtles were captured, measured, tagged and then released. Curved carapace lengths ranged from 33.5 to 85 cm (mean = 48.8 cm) indicating that most (if not all) individuals encountered around Ascension are post-pelagic juveniles. Four individuals were recaptured at least once giving a mean minimum residence time of 4.2 yr (range: 2.8-7.3 yr) and a mean growth rate of 2.8 cm yr(-1). Turtles fitted with FastlocTM GPS devices remained at Ascension Island for the duration of the study (> 90 days) and occupied restricted home ranges with an average area of 2.5 km(2) and an average 'core use area' (50% utilization distribution) of 0.05 km(2). Together, these results suggest that Ascension Island serves as a mid-Atlantic developmental habitat for benthic-feeding, juvenile hawksbill turtles on extended oceanic migrations before recruiting to their adult foraging grounds, likely to be located in Brazil or tropical West Africa.

Wood, L. D., Brunnick, B., & Milton, S. L. (2017). Home Range and Movement Patterns of Subadult Hawksbill Sea Turtles in Southeast Florida. *Journal of Herpetology, 51*(1), 58-67 https://doi.org/10.1670/15-133

Subadult Hawksbill Turtles (*Eretmochelys imbricata*) reside on the coral reefs of Palm Beach County, Florida, but their movements and patterns of habitat use are poorly understood. In this study, six subadult Hawksbills were tracked with global positioning system (GPS)-linked satellite telemetry for a span of 102-429 days Total home ranges and within-range areas of "core'' use were measured with minimum convex polygons (MCPs) and kernel density estimates (KDEs). Home-range estimates ranged 1.1-19.0 km(2) (X = 10.1 km(2)) using MCP and 0.01-1.2 km(2) (X = 0.49 km(2)) using the 95% KDE. Each turtle remained at or near the 15-25 m hard-bottom reef habitats of the area and exhibited strong site fidelity to centrally located core use areas (50% and 25% KDE >, 0.03 km(2)); this was especially true at night, suggesting the repeated use of familiar refuges (shipwrecks/caves) for nocturnal shelter. Likely driven by predator avoidance, competition for a limited number of preferred refuges, or "roosts,'' may restrict the extent of each turtle's home range and influence the abundance and distribution of the Hawksbill Turtles that occupy this site.

Wood, L. D., Hardy, R., Meylan, P. A., & Meylan, A. B. (2013). Characterization of a Hawksbill Turtle (*Eretmochelys imbricata*) Foraging Aggregation in a High-Latitude Reef Community in Southeastern Florida, USA. *Herpetological Conservation and Biology, 8*(1), 258-275 Retrieved from http://www.herpconbio.org/Volume_8/Issue_1/Wood_etal_2013.pdf

A foraging aggregation of Hawksbill Turtles (*Eretmochelys imbricata*) on the Southeast Florida Continental Reef Tract off Palm Beach County, Florida, is the first described within the waters of the continental United States. The aggregation is the second most northerly known in the western Atlantic; its existence may be due in part to the proximity of the Florida Current. We captured 146 individual hawksbills 181 times at 44 dive sites over 5.5 y. We captured turtles on five benthic habitat types. Individuals varied from 35.7 to 83.9 cm SCLn-t and > 95% were likely to be immature; thus the site serves primarily as developmental habitat. Captures and observations of tagged turtles indicate year-round presence; average observed residency was 24.9 mo (up to 73 mo). The average distance between

researcher dive initiation sites associated with sequential observations of individual turtles was 1345 m, indicating a high degree of site fidelity. Control region (mtDNA) sequences for 112 individuals showed a predominance (> 65%) of haplotypes associated with Mexican nesting beaches. The minimum size of hawksbills captured at the study site suggests that the turtles have already spent time in benthic developmental habitat elsewhere. Observation rates and growth rates were comparable to those at several Caribbean sites, indicating that this high-latitude reef system constitutes primary habitat for this species.

Wood, L. D., Milton, S. L., & Maple, T. L. (2017). Foraging Behavior of Wild Hawksbill Turtles (*Eretmochelys imbricata*) in Palm Beach County, Florida, USA. *Chelonian Conservation and Biology, 16*(1), 70-75 https://doi.org/10.2744/CCB-1242.1

Foraging behavior from 30 wild hawksbill turtles (*Eretmochelys imbricata*) was video-recorded by scuba divers on the coral reefs of Palm Beach County, Florida. A transition matrix was created to calculate the sequence and frequency of 5 behavioral categories leading to prey ingestion, and general observations associated with foraging behavior were described. Likely aided by olfaction, the hawksbills at this site employed a multistep process to preferentially locate and ingest well-concealed sessile invertebrates, notably poriferans of the class Demospongiae. Cumulatively, behavioral frequencies decreased as the sequence progressed toward prey consumption, and only a small proportion of the items handled were ingested. Highly exploratory foraging behavior may aid hawksbills to adaptively identify and prioritize dietary preferences within and among habitat types.

Section III: Population Abundance and Trends

Alvarez-Varas, R., Flores, M., Demangel, D., Garcia, M., & Sallaberry-Pincheira, N. (2015). First Confirmed Report of Hawksbill Sea Turtle *Eretmochelys imbricata* in Nearshore Waters of Easter Island (Rapa Nui). *Revista De Biologia Marina Y Oceanografia, 50*(3), 597-602 https://doi.org/10.4067/s0718-19572015000400018

The hawksbill turtle (*Eretmochelys imbricata*; Critically Endangered) has a circumtropical distribution. In Polynesia it inhabits the waters of a great number of islands; however, up to date there are no official records for Easter Island. We document the first report of E. imbricata in Easter Island and Chile based on underwater photographs and examination of one individual. The confirmation of the presence of hawksbills extends the known distribution range for the species, increases the number of sea turtle species recorded for Chile, and highlights the need for further research on potential threats to the species and the importance of Rapa Nui as developmental and foraging habitat for hawksbills.

Becker, S. L., Brainard, R. E., & Van Houtan, K. S. (2019). Densities and Drivers of Sea Turtle Populations across Pacific Coral Reef Ecosystems. *PLoS One, 14*(4) https://doi.org/10.1371/journal.pone.0214972

Sea turtle populations are often assessed at the regional to sub-basin scale from discrete indices of nesting abundance. While this may be practical and sometimes effective, widespread in-water surveys may enhance assessments by including additional demographics, locations, and revealing emerging population trends. Here, we describe sea turtle observations from 13 years of towed-diver surveys

across 53 coral islands, atolls, and reefs in the Central, West, and South Pacific. These surveys covered more than 7,300 linear km, and observed more than 3,400 green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) sea turtles. From these data, we estimated sea turtle densities, described trends across space and time, and modelled the influence of environmental and anthropogenic drivers. Both species were patchily distributed across spatial scales, and green turtles were 11 times more abundant than hawksbills. The Pacific Remote Island Areas had the highest densities of greens (3.62 turtles km-1, Jarvis Island), while American Samoa had the most hawksbills (0.12 turtles km-1, Ta'u Island). The Hawaiian Islands had the lowest turtle densities (island ave = 0.07 turtles km-1) yet the highest annual population growth ($\mu = 0.08$, $\sigma = 0.22$), suggesting extensive management protections can yield positive conservation results. Densities peaked at 27.5°C SST, in areas of high productivity and low human impact, and were consistent with patterns of historic overexploitation. Though such intensive surveys have great value, they are logistically demanding and therefore have an uncertain budget and programmatic future. We hope the methods we described here may be applied to future comparatively low-cost surveys either with autonomous vehicles or with environmental DNA.

Bell, I. P., Meager, J. J., Eguchi, T., Dobbs, K. A., Miller, J. D., & Madden Hof, C. A. (2020). Twenty-Eight Years of Decline: Nesting Population Demographics and Trajectory of the North-East Queensland Endangered Hawksbill Turtle (*Eretmochelys imbricata*). *Biological Conservation, 241*, 108376 https://doi.org/10.1016/j.biocon.2019.108376

Globally, hawksbill turtles (*Eretmochelys imbricata*) are listed as Critically Endangered, the cause of which is largely attributed to excessive historical take by the tortoiseshell industry. Yet few long-term data analyses describing population trend or survivorship exist. Here we analyse a long-term dataset for a globally significant western Pacific E. imbricata nesting population on Milman Island, northern Great Barrier Reef. Three demographic indicators were used: (1) number of egg clutches laid, (2) nester abundance and survival, and (3) the body-size distribution of nesters (curved carapace length, CCL). Models were developed for a time series from the 1990–91 to 2016–17 nesting season that included 21 years of sampling, with predicted trends evaluated against samples from the 2017–18 nesting season. The number of clutches laid and nester abundance rate of decline varied over the study period, but the decline was markedly similar with a 58 and 57% overall reduction, respectively. Annual survival rate was high (0.972, 95% CI = 0.965 to 0.977), but was not estimated separately for all years. Models predicted that the current rate of decline would lead to nesting extirpation by 2036 (95% CI: 2026–2058) and 2032–2037 (95% CI: from 2020 to increasing), for the models of nester abundance and number of eggs laid, respectively; and aligned with the observed values for the test dataset (2017–18 season). The rate of decline of E. imbricata nesting at Milman Island highlights the urgency to understand and mitigate risks faced by this endangered population and more broadly across the western Pacific.

Carreras, C., Godley, B. J., León, Y. M., Hawkes, L. A., Revuelta, O., Raga, J. A., & Tomás, J. (2013). Contextualising the Last Survivors: Population Structure of Marine Turtles in the Dominican Republic. *PLoS One, 8*(6) https://doi.org/10.1371/journal.pone.0066037

Nesting by three species of marine turtles persists in the Dominican Republic, despite historic threats and long-term population decline. We conducted a genetic survey of marine turtles in the Dominican Republic in order to link them with other rookeries around the Caribbean. We sequenced a 740bp fragment of the control region of the mitochondrial DNA of 92 samples from three marine turtle species [hawksbill (n = 48), green (n = 2) and leatherback (n = 42)], and incorporated published data from other

nesting populations and foraging grounds. The leatherback turtle (Dermochelys coriacea) in the Dominican Republic appeared to be isolated from Awala-Yalimapo, Cayenne, Trinidad and St. Croix but connected with other Caribbean populations. Two distinct nesting populations of hawksbill turtles (Eremochelys imbricata) were detected in the Dominican Republic and exhibited interesting patterns of connectivity with other nesting sites and juvenile and adult male foraging aggregations. The green sea turtle (*Chelonia mydas*) has almost been extirpated from the Dominican Republic and limited inference could be made from our samples. Finally, results were compared with Lagrangian drifting buoys and published Lagrangian virtual particles that travelled through the Dominican Republic and Caribbean waters. Conservation implications of sink-source effects or genetic isolation derived from these complex inter-connections are discussed for each species and population.

Esteban, N., Laloe, J. O., Mortimer, J. A., Guzman, A. N., & Hays, G. C. (2016). Male Hatchling Production in Sea Turtles from One of the World's Largest Marine Protected Areas, the Chagos Archipelago. *Scientific Reports, 6* https://doi.org/10.1038/srep20339

Sand temperatures at nest depths and implications for hatchling sex ratios of hawksbill turtles (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) nesting in the Chagos Archipelago, Indian Ocean are reported and compared to similar measurements at rookeries in the Atlantic and Caribbean. During 2012-2014, temperature loggers were buried at depths and in beach zones representative of turtle nesting sites. Data collected for 12,546 days revealed seasonal and spatial patterns of sand temperature. Depth effects were minimal, perhaps modulated by shade from vegetation. Coolest and warmest temperatures were recorded in the sites heavily shaded in vegetation during the austral winter and in sites partially shaded in vegetation during summer respectively. Overall, sand temperatures were relatively cool during the nesting seasons of both species which would likely produce fairly balanced hatchling sex ratios of 53% and 63% male hatchlings, respectively, for hawksbill and green turtles. This result contrasts with the predominantly high female skew reported for offspring at most rookeries around the globe and highlights how local beach characteristics can drive incubation temperatures. Our evidence suggests that sites characterized by heavy shade associated with intact natural vegetation are likely to provide conditions suitable for male hatchling production in a warming world.

Hamilton, R. J., Bird, T., Gereniu, C., Pita, J., Ramohia, P. C., Walter, R., . . . Limpus, C. (2015). Solomon Islands Largest Hawksbill Turtle Rookery Shows Signs of Recovery after 150 Years of Excessive Exploitation. *PLoS One, 10*(4) https://doi.org/10.1371/journal.pone.0121435

The largest rookery for hawksbill turtles in the oceanic South Pacific is the Arnavon Islands, which are located in the Manning Strait between Isabel and Choiseul Province, Solomon Islands. The history of this rookery is one of overexploitation, conflict and violence. Throughout the 1800s Roviana headhunters from New Georgia repeatedly raided the Manning Strait to collect hawksbill shell which they traded with European whalers. By the 1970s the Arnavons hawksbill population was in severe decline and the national government intervened, declaring the Arnavons a sanctuary in 1976. But this government led initiative was short lived, with traditional owners burning down the government infrastructure and resuming intensive harvesting in 1982. In 1991 routine beach monitoring and turtle tagging commenced at the Arnavons along with extensive community consultations regarding the islands' future, and in 1995 the Arnavon Community Marine Conservation Area (ACMCA) was established. Around the same time national legislation banning the sale of all turtle products was passed. This paper represents the first analysis of data from 4536 beach surveys and 845 individual turtle tagging histories obtained from the

Arnavons between 1991-2012. Our results and the results of others, reveal that many of the hawksbill turtles that nest at the ACMCA forage in distant Australian waters, and that nesting on the Arnavons occurs throughout the year with peak nesting activity coinciding with the austral winter. Our results also provide the first known evidence of recovery for a western pacific hawksbill rookery, with the number of nests laid at the ACMCA and the remigration rates of turtles doubling since the establishment of the ACMCA in 1995. The Arnavons case study provides an example of how changes in policy, inclusive community-based management and long term commitment can turn the tide for one of the most charismatic and endangered species on our planet.

Herren, R. M., Bagley, D. A., Bresette, M. J., Holloway-Adkins, K. G., Clark, D., & Witherington, B. E. (2018). Sea Turtle Abundance and Demographic Measurements in a Marine Protected Area in the Florida Keys, USA. *Herpetological Conservation and Biology, 13*(1), 224-239 Retrieved from http://www.herpconbio.org/Volume_13/Issue_1/Herren_etal_2018.pdf

We used vessel-based surveys to estimate sea turtle abundance and capture them in a 129 km(2) area within the Key West National Wildlife Refuge, USA, and adjacent waters. We measured captured turtles, externally examined them for disease and injuries, and analyzed diet in 62 Green Turtles (*Chelonia mydas*). Between 2003- 2012, we sighted 1,087 Green Turtles, 789 Loggerheads (*Caretta caretta*), 65 Hawksbills (*Eretmochelys imbricata*), one Kemp's Ridley (Lepidochelys kempii), and 12 unidentified turtles. We fitted the sighting data to a probability of detection model, which gave us an estimate of 46.4 turtles km(-2). Most sightings were clustered in four distinct areas that were in the lee of islands. Captured Loggerheads were significantly larger (mean straight carapace length [SCL +/- SD], 74.2 +/- 9.3 cm) than Green Turtles (54.3 +/- 21.8 cm) which were significantly larger than Hawksbills (46.7 +/- 11.3 cm). However, Green Turtles were a mixture of three size classes and exhibited significant size class partitioning with larger turtles found in deeper water (> 3 m) and smaller turtles found in shallower water (< 3 m). The majority of recaptures (79%) were found < 1 km from their initial location suggesting a high degree of site fidelity. The proportion of Green Turtles with fibropapillomatosis was 6%, while 13% of all species had boat propeller injuries. Green Turtles primarily consumed Turtle Grass, Thalassia testudinum (62%). Our results highlight the importance of this area and the return of Green Turtles to a place where they were once commercially harvested.

Kendall, W. L., Stapleton, S., White, G. C., Richardson, J. I., Pearson, K. N., & Mason, P. (2019). A Multistate Open Robust Design: Population Dynamics, Reproductive Effort, and Phenology of Sea Turtles from Tagging Data. *Ecological Monographs, 89*(1) https://doi.org/10.1002/ecm.1329

Understanding population dynamics, and how it is influenced by exogenous and endogenous factors, is important to the study and conservation of species. Moreover, for migratory species, the phenology and duration of use of a given location can also influence population structure and dynamics. For many species, breeding abundance, survival, and reproductive performance, as well as phenology of nesting, are often the most accessible, and therefore, practical elements of their life history to study. For a population of hawksbill sea turtles (*Eretmochelys imbricata*), we modeled population change for nesters and total adult females, survival, and breeding probability, from 25 yr of intensive tagging data. We modeled breeding probability as a function of the number of years since last breeding and tested for differences between neophyte and experienced nesters. For each year, we also estimated the number of clutches deposited per female, and phenology of use, for neophytes and experienced nesters. To implement the analysis, we developed a novel generalized multistate open robust design mark–

recapture modeling framework, with parameters for survival and transition probabilities, and for each primary period, state structure and arrival, persistence, and detection probabilities. Derived parameters included abundance of observable and unobservable components of the population, residence time, expected arrival and departure periods, and per-period intensity of study area use. Abundance of nesters increased over most of the time series. Survival probability was 0.935 ± 0.01 (estimate ± SE). Virtually all hawksbills skipped at least one year of nesting. Breeding probability increased by skipping a second year, but then decreased thereafter. Subsequent breeding probability was lower for neophyte nesters than for experienced nesters, but the effect was weaker than the effect of years since breeding. Clutch frequency varied by year, with no discernable pattern of differences between neophytes and experienced nesters. Mean arrival and departure dates also varied, with a slight shift of nesting activity to earlier in the season. The multistate open robust design model developed here provides a flexible framework for modeling the dynamics of structured migratory populations and the phenology and duration of their seasonal use of study areas.

Leite, T. C., Bondioli, A. C. V., Martins, J. K., Rodrigues, J., & Guitierrez, D. (2013). Record of a Hawksbill Sea Turtle (*Eretmochelys imbricata*, Linneaus 1766) Aggregation at Anchieta Island State Park, Ubatuba, Sao Paulo, Brazil. *Marine Turtle Newsletter*(139), 1-3 Retrieved from http://www.seaturtle.org/mtn/archives/mtn139/mtn139-1.shtml

Leite et al present a report on an aggregation of juvenile hawksbill turtles observed in the coastal waters of the state of Sao Paulo, Brazil. As part of a research project that focused the fishing activities of local indigenous populations on the coast of the state of Sao Paulo, an in-water surveys in Anchieta Island State Park on March 7-9, 2012 was conducted. During the monitoring, an aggregation of hawksbills concentrated in a small area, and opportunistically collected data are observed.

Lima, E. H. S. M., Melo, M. T. D., Godfrey, M. H., & Barata, P. C. R. (2013). Sea Turtles in the Waters of Almofala, Ceará, in Northeastern Brazil, 2001-2010. *Marine Turtle Newsletter*(137), 5-9 Retrieved from http://www.seaturtle.org/mtn/archives/mtn137/mtn137p5.shtml

Projeto Tamar-ICMBio (TAMAR), the Brazilian sea turtle conservation program, established a conservation and research station at Almofala Beach, northeastern Brazil in 1992. Almofala is a foraging area for sea turtles: green (*Chelonia mydas*), loggerhead (Careua careua), leatherback (Dennochelys coriacea), hawksbill (*Eretmochelys imbricata*) and olive ridley (Lepidochelys olivacea), the same five species that occur in other places in Brazil. About 85% of the sea turtles recorded at Almofala are green turtles, and both juvenile and adult-sized green turtles regularly occur there, which distinguishes Almofala from green turtle foraging areas in southern Brazil, where individuals of that species are generally juveniles. The central objective of TAMAR's conservation actions at Almofala is to deal with the incidental capture of sea turtles by artisanal fisheries; this is carried out through monitoring, research, educational activities with local communities and the development of economic alternatives for them. Here, Lima et al present an integrated summary of sea turtle data gathered by the Almofala station, focusing on the carapace size distribution of each species and connections between Almofala and other known nesting or foraging locations in the Atlantic Ocean.

Meylan, A. B., Meylan, P. A., & Espinosa, C. O. (2013). Sea Turtles of Bocas Del Toro Province and the Comarca Ngöbe-Buglé, Republic of Panamá. *Chelonian Conservation and Biology, 12*(1), 17-33 https://doi.org/10.2744/CCB-0948.1

The Bocas del Toro region of Panamá (Bocas del Toro Province and the Comarca Ngöbe-Buglé) has been known as an important area for sea turtles since at least the 17th century. Four species occur in the region: the hawksbill (Eretmochelys imbricala), green turtle (*Chelonia mydas*), loggerhead (*Caretta caretta*), and leatherback (Dermochelys coriacea). Multiple life stages of these species are supported by the diverse marine habitats and beaches in the region. We summarize the evidence for stages present and their known distributions in the Bocas region. Annual nest numbers, location, and monitoring status are given for 17 nesting beaches. These beaches support regionally significant numbers of leatherback and hawksbill nests, small numbers of green turtle nests and, rarely, loggerhead nests. We review the history of sea turtle use in the Bocas region and describe "velación," a government-organized system that facilitated the extraction of hawksbills from nesting beaches throughout the Bocas region during the 20th century to supply the market for tortoiseshell. Current threats to sea turtles in the Bocas area include an illegal directed take of turtles at sea and of eggs and turtles on nesting beaches, bycatch in lobster and shark fisheries, and habitat degradation. Coastal development and increasing tourism have gradually become concerns for sea turtle conservation as the economic focus of the region has changed. The history of conservation efforts on behalf of sea turtles in Bocas is also summarized. This contribution was originally written to provide data on sea turtles for a coastal management plan for the region.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. (2018). *Action Plan for Research and Management of Hawksbill Sea Turtles (Eretmochelys imbricata) in Hawai'I: 2018-2022*. Retrieved from http://www.hihawksbills.org/uploads/7/2/5/4/72549631/ei_hi_action_plan_2018-2022_final_april2018.pdf

No abstract

Pilcher, N. J., Al-Maslamani, I., Williams, J., Gasang, R., & Chikhi, A. (2015). Population Structure of Marine Turtles in Coastal Waters of Qatar. *Endangered Species Research, 28*(2), 163-174 https://doi.org/10.3354/esr00688

Knowledge of the interrelationships between habitats and life-stage development in marine turtles requires an understanding of recruitment, size and age at maturity, sex ratios, growth and sexual development rates, survivorship and nesting probabilities. These data may be used to determine the status and survival of turtle populations during earlier life stages and for the development of appropriate conservation strategies. We sampled in-water stocks of marine turtles in coastal waters of Qatar using rodeo-style captures, entrapments in an industrial cooling intake and opportunistic bycatch to determine species, size, gender and age class. Our results revealed that Qatar is home to a resident population of small juvenile green turtles (<40 cm curved carapace length, CCL) and a transient population of juvenile hawksbills (<25 cm CCL) at an approximate 7:3 ratio of green to hawksbill turtles. Hawksbills were male-biased (4M:1F) while green turtles were slightly female biased (2M:3F). Given the extreme high ambient and water temperatures in the Arabian Gulf, which may be considered a living laboratory for understanding climate change effects on marine species, our results are not conclusive that elevated temperatures have led to feminisation of marine turtle populations. We instead believe

that there may be a regional and/or evolutionary shift in the pivotal temperature that regulates ecologically appropriate sex determination, which requires further investigation. Our data provide, for the first time, a description of the foraging marine turtle population structure in Qatari waters, and point to a need for protection of seagrass beds, effective mitigation measures for sedimentation from coastal development and rehabilitation of coral-reef habitats.

Quimpo, F.-a. T. (2013). Sea Turtles of Macajalar and Gingoog Bays Mindanao, Philippines. *Asian Journal of Biodiversity, 4*, 169-189 https://doi.org/10.7828/ajob.v4i1.302

There are 4 species of sea turtles recorded in Macajalar and Gingoog Bays in Northern Mindanao. The hawksbill and the green turtle have the highest occurrence while casual and accidental occurrences are recorded for the olive ridley and leatherback turtle. Sea turtles are recorded in 22 barangays (the smallest geopolitical unit in the Philippines) of 11 municipalities in both bays, but only the hawksbill and green turtles are observed in in-water and boat surveys. Only the hawksbill turtle is confirmed to nest in 9 barangays of 5 municipalities. Nesting is all year round with peaks during the 1 super(st) quarter of the year. 22% of the nests have not reached hatching due to poaching (14%) and natural causes (8%). Nesting activity is within the range recorded for the species. Sea turtle-human interactions are generally positive with majority of accidental captured turtles released although poaching of eggs and deaths of sea turtles directly or indirectly manmade are still documented.

Varo-Cruz, N., Cejudo, D., Calabuig, P., Herrera, R., Urioste, J., & Monzón-Argüello, C. (2017). Records of the Hawksbill Sea Turtle (*Eretmochelys imbricata*) in the Canary Islands. *Marine Turtle Newsletter*(154), 1-6 Retrieved from http://www.seaturtle.org/mtn/archives/mtn154/mtn154-1.shtml

Five species of sea turtles have been recorded in the waters around the Canary Islands (López-Jurado 1992; Espino 1998; Varo-Cruz *et al*. 2015). The most frequent observations are of juvenile loggerheads (*Caretta caretta*, Linnaeus 1758), which are considered common and widespread in this archipelago (López-Jurado 1992); they occupy mainly pelagic waters (Varo-Cruz *et al*. 2016). It is also possible to find juvenile green turtles (*Chelonia mydas*, Linnaeus, 1758), but in this case they occupy shallow neritic waters (Monzón-Argüello *et al*. 2015). Although less frequently seen, the leatherback (*Dermochelys coriacea*, Vandelli, 1761) may be observed in pelagic waters, and both greens and leatherbacks, are considered common species in Canarian waters (López-Jurado 1992). Two other species are rarely seen in these waters, the olive ridley (*Lepidochelys olivacea*, Eschsholtz, 1829), with only three sightings recorded (Varo-Cruz *et al*. 2015), and the hawksbill (*Eretmochelys imbricata*, Linnaeus, 1766), with only two records published, one in Lanzarote (Camiñas 2002), and the other in La Palma (Brito-Hernández & Cruz-Simó 1982).

Walker, G., & Gibson, K. W. (2015). First Documented Evidence of a Rookery of the Critically Endangered Hawksbill Sea Turtle (*Eretmochelys imbricata*) in North East Tobago. *Chelonian Conservation and Biology, 14*(1), 95-99 https://doi.org/10.2744/ccab-14-01-95-99.1

In the context of declining global hawksbill sea turtle (*Eretmochelys imbricata*) populations, the wider Caribbean region is of global conservation importance. This study compiles and presents previously unpublished sea turtle nesting-activity data for North East Tobago (11 degree 19'13.53 double prime N, -

060 degree 33'1.57 double prime E) and reports the results of the first comprehensive survey of sea turtle nesting beaches at this southern Caribbean site. The results of this study quantify a previously undocumented, regionally important rookery for the globally critically endangered hawksbill sea turtle, consisting of untagged reproductive females.

Whelan, R., Clarke, C., Gubiani, R., & Muzaffar, S. B. (2019). Sea Turtle Observations on and around Siniya Island, Umm Al Quwain, United Arab Emirates. *Marine Turtle Newsletter*(156), 10-12 Retrieved from http://www.seaturtle.org/mtn/archives/mtn156/mtn156-4.shtml

Four species of sea turtles, all listed on the IUCN Red List, occur in the Arabian Gulf (Baldwin & Gardner 2005): the Endangered green (*Chelonia mydas*, Seminoff 2004), Critically Endangered hawksbill (*Eretmochelys imbricata*, Mortimer & Donnelly 2008), Critically Endangered loggerhead (*Caretta caretta*, NW Indian Ocean subpopulation, Casale 2015) and Vulnerable leatherback (Dermochelys coriacea, Wallace et al. 2013). Recent reports of nesting sea turtles include hawksbill and green turtle nests in Khor Kalba (Sharjah - Arabian Sea coastline, Hebbelmann et al. 2016), hawksbill and rare green turtle nests on Sir Bu Nair Island, Sharjah (within the Gulf, Al Suweidi et al. 2012), a few hawksbill nests on Saadiyat Island, Abu Dhabi (Willing pers. comm.) and other offshore islands in the Western Region of Abu Dhabi (Baldwin & Gardner 2005, Al Suweidi et al. 2012) and within the Jebel Ali Marine Sanctuary, Dubai (Emirates Marine Environmental Group). First contemporary record of green turtle (*Chelonia mydas*) nesting in the United Arab Emirates.

Whiting, S. D., Macrae, I., Thorn, R., Murray, W., & Whiting, A. U. (2014). Sea Turtles of the Cocos (Keeling) Islands, Indian Ocean. *Raffles Bulletin of Zoology*, 168-183 Retrieved from https://www.cms.int/iosea-turtles/en/publication/sea-turtles-cocos-keeling-islands-indian-ocean

The Cocos (Keeling) Islands support high density resident green and hawksbill turtles and low to moderate density nesting green turtles. Dedicated studies were conducted on resident foraging turtles of the southern atoll between 1999 and 2012 and opportunistic observations were conducted on nesting turtles on both atolls between 1999 and 2009. In-water capture surveys resulted in a species composition of 51% green and 49% hawksbill turtles while counts during boat-based strip transect surveys resulted in a composition of 93% and 7% respectively. Captured green turtles in the foraging grounds had a bimodal distribution with modal size classes at 45-50 and 105-110 cm curved carapace length (ccl) (mean size = 64.7 cm, sd = 20.0, range = 33.5-115.6 cm, n = 984) while hawksbill turtles had a modal size class of 50-60 cm ccl (mean size = 57.6 cm, sd = 13, range = 24.8-86.7 cm, n = 950). New recruits to the foraging grounds were observed annually. Green turtle diet was dominated by seagrass and algae while hawksbill turtle diet was dominated by algae and sponge. Blood chemistry values of both species captured on the foraging grounds were within the published reference ranges. Opportunistic beach surveys conducted on five islands between 1999 and 2012 revealed low density nesting by green turtles (highest: 10.2 tracks km(-1) night(-1)) with no other species recorded. Nesting success was low because of dry sand and natural and anthropogenic debris on the beaches. The mean size of nesting turtles was 107.2 cm ccl (sd = 3.7, range = 96.6-115.9 cm, n = 16). Sand temperatures at nest depth (50 cm) ranged between 25.0 and 29.1 degrees C between January and April.

Section IV: Threats

Adimey, N. M., Hudak, C. A., Powell, J. R., Bassos-Hull, K., Foley, A., Farmer, N. A., . . . Minch, K. (2014). Fishery Gear Interactions from Stranded Bottlenose Dolphins, Florida Manatees and Sea Turtles in Florida, U.S.A. *Marine Pollution Bulletin, 81*(1), 103-115 https://doi.org/10.1016/j.marpolbul.2014.02.008

Documenting the extent of fishery gear interactions is critical to wildlife conservation efforts, especially for reducing entanglements and ingestion. This study summarizes fishery gear interactions involving common bottlenose dolphins (Tursiops truncatus truncatus), Florida manatees (Trichechus manatus latirostris) and sea turtles: loggerhead (*Caretta caretta*), green turtle (*Chelonia mydas*), leatherback (Dermochelys coriacea), hawksbill (*Eretmochelys imbricata*), Kemp's ridley (Lepidochelys kempii), and olive ridley (Lepidochelys olivacea) stranding in Florida waters during 1997–2009. Fishery gear interactions for all species combined were 75.3% hook and line, 18.2% trap pot gear, 4.8% fishing nets, and 1.7% in multiple gears. Total reported fishery gear cases increased over time for dolphins ($p<0.05$), manatees ($p<0.01$), loggerheads ($p<0.05$) and green sea turtles ($p<0.05$). The proportion of net interaction strandings relative to total strandings for loggerhead sea turtles increased ($p<0.05$). Additionally, life stage and sex patterns were examined, fishery gear interaction hotspots were identified and generalized linear regression modeling was conducted.

Alfaro-Shigueto, J., Mangel, J. C., Darquea, J., Donoso, M., Baquero, A., Doherty, P. D., & Godley, B. J. (2018). Untangling the Impacts of Nets in the Southeastern Pacific: Rapid Assessment of Marine Turtle Bycatch to Set Conservation Priorities in Small-Scale Fisheries. *Fisheries Research, 206*, 185-192 https://doi.org/10.1016/j.fishres.2018.04.013

Bycatch of marine megafauna by small-scale fisheries is of growing global concern. The southeastern Pacific sustains extensive fisheries that are important sources of food and employment for millions of people. Mismanagement, however, jeopardizes the sustainability of ecosystems and vulnerable species. We used survey questionnaires to assess the impact of small-scale gillnet fisheries on sea turtles across 3 nations (Ecuador, Peru and Chile), designed to fill data gaps and identify priority areas for future conservation work. A total of 765 surveys from 43 small-scale fishing ports were obtained (Ecuador: n = 379 fishers, 7 ports; Peru: n = 342 fishers, 30 ports; Chile: n = 44 fishers, 6 ports). The survey coverage in study harbors was 28% for Ecuador, 37.0% for Peru, and 62.7% for Chile. When these survey data are scaled up across the fleets within surveyed ports, the resulting estimate of total annual bycatch across the study harbors is 46 478 turtles; where Ecuador is 40 480, Peru 5 828 and Chile 170 turtles. Estimated mortality rates vary markedly between countries (Ecuador: 32.5%; Peru 50.8%; Chile 3.2%), leading to estimated lethal takes of 13 225, 2 927, and 6 turtles for Ecuador, Peru, and Chile, respectively. These estimates are remarkably large given that the ports surveyed constitute only 16.4, 41, and 22% of the national gillnet fleets in Ecuador, Peru, and Chile, respectively. Limited data from observer-based surveys in Peru suggest that information from surveys are reliable and still informative. Information from surveys clearly highlight Ecuador and Peru as priority areas for future work to reduce turtle bycatch, particularly given the status of regional populations such as leatherback and hawksbill turtles.

Arroyo-Arce, S., & Salom-Perez, R. (2015). Impact of Jaguar Panthera Onca (Carnivora: Felidae) Predation on Marine Turtle Populations in Tortuguero, Caribbean Coast of Costa Rica. *Revista De Biologia Tropical, 63*(3), 815-825 https://doi.org/10.15517/rbt.v63i3.16537

Little is known about the effects of jaguars on the population of marine turtles nesting in Tortuguero National Park, Costa Rica. This study assessed jaguar predation impact on three species of marine turtles (*Chelonia mydas*, Dermochelys coriacea and *Eretmochelys imbricata*) that nest in Tortuguero beach. Jaguar predation data was obtained by using two methodologies, literature review (historical records prior the year 2005) and weekly surveys along the 29 km stretch of beach during the period 2005-2013. Our results indicated that jaguar predation has increased from one marine turtle in 1981 to 198 in 2013. Jaguars consumed annually an average of 120 (SD= 45) and 2 (SD= 3) green turtles and leatherbacks in Tortuguero beach, respectively. Based on our results we concluded that jaguars do not represent a threat to the population of green turtles that nest in Tortuguero beach, and it is not the main cause for population decline for leatherbacks and hawksbills. Future research should focus on continuing to monitor this predator-prey relationship as well as the factors that influence it so the proper management decisions can be taken.

Biological Opinion on Reinitiation of Esa Section 10(a)(1)(a) Permit by Regulation to Authorize Response to Stranded Endangered Sea Turtles. (2016). https://doi.org/10.7289/V5S75DH7

This biological opinion has been prepared in accordance with section 7 of the ESA, associated implementing regulations, and agency policy and guidance (50 CFR 402). It is based on information provided by participants in the sea turtle stranding and salvage networks, published and unpublished scientific information on the biology and ecology of endangered sea turtles within the action area, and other sources of information. A complete administrative record is on file with NMFS Office of Protected Resources, Marine Mammal and Turtle Conservation Division, Silver Spring, Maryland.

Biological Opinion on the Issuance of Permit No. 19697 for Scientific Research on Sea Turtles in the Coastal Waters of Puerto Rico. (2017). https://doi.org/10.7289/V5CN71ZP

The Permits Division proposes to issue scientific research Permit No. 19697 for the measuring, weighing, photographing/videoing, tagging (flipper, passive integrated transponder (PIT), and satellite), sampling (blood and tissue), ultrasound, and tumor removal of green and hawksbill sea turtles in the coastal waters of Puerto Rico, including Mona, Monito, and Desecheo Islands, and the Culebra Archipelago. This consultation, biological opinion, and incidental take statement, were completed in accordance with section 7(a)(2) of the statute (16 U.S.C. 1536 (a)(2)), associated implementing regulations (50 C.F.R. ''401-16), and agency policy and guidance was conducted by NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division (hereafter referred to as 'we').This biological opinion and incidental take statement were prepared by NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 C.F.R. '402
Consultation Tracking number: FPR-2017-9185.
Approved on: April 17, 2017.

Biological Opinion on the Issuance of Permit No. 20315 for Scientific Research on Sea Turtles in the United States Virgin Islands. (2017). https://doi.org/10.7289/V5QJ7FJB

The action agency for this consultation is the NMFS, Office of Protected Resources, Permits and Conservation Division (hereafter referred to as "the Permits Division") for its issuance of a scientific research permit (Appendix A) pursuant to section 10(a)(1)(A) of the ESA. The Permits Division proposes to issue scientific research Permit No. 20315 for the capture, measuring, weighing, photographing/videoing, tagging (flipper, passive integrated transponder (PIT), and satellite), sampling (blood, fecal, and tissue), and epibiota removal of green, hawksbill, and loggerhead sea turtles in the waters of the U.S. Virgin Islands
Consultation Tracking number: FPR-2017-9207.
Approved on: August 10, 2017.

Bjorndal, K. A., Milani, C., Saba, V. S., Diez, C. E., van Dam, R. P., Krueger, B. H., . . . Bolten, A. B. (2016). Somatic Growth Dynamics of West Atlantic Hawksbill Sea Turtles: A Spatio-Temporal Perspective. *Ecosphere, 7*(5) https://doi.org/10.1002/ecs2.1279

Somatic growth dynamics are an integrated response to environmental conditions. Hawksbill sea turtles (*Eretmochelys imbricata*) are long-lived, major consumers in coral reef habitats that move over broad geographic areas (hundreds to thousands of kilometers). We evaluated spatio-temporal effects on hawksbill growth dynamics over a 33-yr period and 24 study sites throughout the West Atlantic and explored relationships between growth dynamics and climate indices. We compiled the largest ever data set on somatic growth rates for hawksbills – 3541 growth increments from 1980 to 2013. Using generalized additive mixed model analyses, we evaluated 10 covariates, including spatial and temporal variation, that could affect growth rates. Growth rates throughout the region responded similarly over space and time. The lack of a spatial effect or spatio-temporal interaction and the very strong temporal effect reveal that growth rates in West Atlantic hawksbills are likely driven by region-wide forces. Between 1997 and 2013, mean growth rates declined significantly and steadily by 18%. Regional climate indices have significant relationships with annual growth rates with 0- or 1-yr lags: positive with the Multivariate El Niño Southern Oscillation Index (correlation = 0.99) and negative with Caribbean sea surface temperature (correlation = −0.85). Declines in growth rates between 1997 and 2013 throughout the West Atlantic most likely resulted from warming waters through indirect negative effects on foraging resources of hawksbills. These climatic influences are complex. With increasing temperatures, trajectories of decline of coral cover and availability in reef habitats of major prey species of hawksbills are not parallel. Knowledge of how choice of foraging habitats, prey selection, and prey abundance are affected by warming water temperatures is needed to understand how climate change will affect productivity of consumers that live in association with coral reefs.

Burt, A. J., Dunn, N., Mason-Parker, C., Antha, S., & Mortimer, J. A. (2015). Curieuse National Park, Seychelles: Critical Management Needs for Protection of an Important Nesting Habitat. *Marine Turtle Newsletter*(147), 6-11 Retrieved from http://www.seaturtle.org/mtn/archives/mtn147/mtn147-4.shtml

In most years, surveys at Curieuse were incomplete and provided only minimum estimates of numbers of egg clutches laid, except for hawksbills during 1981-1983 and 2001-2003, and more recently for both hawksbills and green turtles since 2010 when Seychelles National Parks Authority (SNPA) joined forces

with Global Vision International, a conservation and community development organization that now collects data on behalf of SNPA. Here, Burt et al assess the nesting of hawksbills during the 44 months between Sep 2010 and Apr 2014, and of green turtles during the 33 months from Sep 2012 to May 2015, using the following parameters: a) spatial distribution of nesting activity on seven beaches; b) seasonal distribution of green turtle nesting; c) numbers of egg clutches laid by each species; and d) estimated numbers of females nesting annually. Moreover, they recommend long term conservation management strategies for nesting turtles and their habitats at Curieuse National Park.

Butt, N., Whiting, S., & Dethmers, K. (2016). Identifying Future Sea Turtle Conservation Areas under Climate Change. *Biological Conservation, 204*, 189-196 https://doi.org/10.1016/j.biocon.2016.10.012

Species' response to climate change is already occurring and managers require scenario planning with tangible actions for effective conservation. We address this need by examining the impact of projected changes in maximum temperature and sea level rise (SLR), on the future suitability of current nesting sites for two globally endangered turtle species (*Eretmochelys imbricata*, hawksbill and *Caretta caretta*, loggerhead turtles). We parameterized the biophysical characteristics of nesting beaches in Western Australia (WA), Northern Territory (NT) and Queensland (Qld) and used climate change projections to assess future suitability. All current nesting beaches are predicted to experience increased maximum temperatures (up to 34.8°C in NT and 38.9°C in WA), sex ratios will become increasingly female-skewed, and embryo viability will be threatened at beaches in the north and west of Australia. Beaches in eastern Australia are less likely to flood than those in the west under sea level rise, although all beaches will experience increased flooding, with some sites projected to be below mean high water level by 2100. Many current beaches globally may become unsuitable for nesting under climate change and therefore other existing, or newly established, beaches will be critical for the persistence of turtle populations: thermally suitable climate space in Australia will undergo a southwards shift. This type of analysis can be repeated elsewhere to inform regional long-term conservation planning, such as implementation of protected areas. We demonstrate a valid approach to addressing the issue of conservation for species that use different habitats at different life stages in different parts of the world: by assessing future habitat suitability we highlight important areas for effective conservation planning and management.

Casale, P., Abitsi, G., Aboro, M. P., Agamboue, P. D., Agbode, L., Allela, N. L., . . . Formia, A. (2017). A First Estimate of Sea Turtle Bycatch in the Industrial Trawling Fishery of Gabon. *Biodiversity and Conservation, 26*(10), 2421-2433 https://doi.org/10.1007/s10531-017-1367-z

Gabon hosts nesting grounds for several sea turtle species, including the world's largest rookery for the leatherback turtle (Dermochelys coriacea), Africa's largest rookery for the olive ridley turtle (Lepidochelys olivacea) and smaller aggregations of the hawksbill turtle (*Eretmochelys imbricata*) and green turtle (*Chelonia mydas*). To assess the level of incidental captures of turtles by the Gabonese trawl fishery, an onboard observer program was conducted in the period 2012-2013. A total of 143 turtles were captured by 15 trawlers during 271 fishing days. The olive ridley turtle was the main species captured (80% of bycaught turtles), with mostly adult-sized individuals. The remaining 20% included green turtles, hawksbill turtles, leatherback turtles and undetermined species. Bycatch per unit of effort (BPUE) of olive ridley turtles varied greatly depending on the period of the year (range of means: 0.261-2.270). Dead and comatose turtles were 6.2 and 24.6% respectively (n = 65). By applying the available fishing effort to two BPUE scenarios (excluding or considering a seasonal peak), the total annual number

of captures was estimated as ranging between 1026 (CI 95% 746-1343) and 2581 (CI 95% 1641-3788) olive ridley turtles, with a mortality ranging from 63 (CI 95% 13-135) to 794 (CI 95% 415-1282) turtles per year depending on the scenario and on the fate of comatose turtles. Such a potential mortality may be reason for concern for the local breeding population of olive ridley turtles and recommendations in terms of possible conservation measures and further research are given.

Clemente, B., & Enrique, Q. T. (2019). Is a Small Sea Turtles Rookery Doomed to Local Extinction? Decreasing Nesting Trends at the Paria Gulf, Venezuela. *Marine Ecology, 40*(5) https://doi.org/10.1111/maec.12562

Small rookeries are rarely evaluated for marine turtles worldwide. Two species of sea turtles (Hawksbill, *Eretmochelys imbricata*; Leatherback, Dermochelys coriacea) nest on five main beaches of the northeast coast of the Paria Gulf in Venezuela. Population trends using generalized linear models at this rookery were assessed and compared with other small rookeries. Both species showed significant negative nesting trends: Nesting by critically endangered hawksbills decreased over nine seasons 2009–2017 (64–142 nests per year, General Linear Model Slope Value = −0.061; data pooled for five beaches); similarly, vulnerable leatherback nests decreased across the same period in the main beach Los Garzos (0–69 nests/year; GLMSV = −0.34). Besides human and natural predation of the nests, no significant environmental impacts affect the beaches except probably on Obispo Isthmus where a gas pipeline installation interrupted the nesting activity in 2014. Observed changes to the nesting trends in these small rookeries have a collective impact on broader conservation concerns for sea turtles in the region.

Cuevas, E., Guzmán-HernáNdez, V., Uribe-Martínez, A., Raymundo-SÂnchez, A., & Herrera-Pavon, R. (2018). Identification of Potential Sea Turtle Bycatch Hotspots Using a Spatially Explicit Approach in the Yucatan Peninsula, Mexico. *Chelonian Conservation and Biology, 17*(1), 78-93 https://doi.org/10.2744/CCB-1263.1

A spatially explicit participatory approach was used to collect fishing effort and sea turtle bycatch data from local fishers at 15 ports in the Yucatan Peninsula, Mexico. These data were combined with satellite telemetry data to define potential bycatch hotspots. This is the first participatory and spatially explicit study on sea turtle bycatch rates in the region. Hawksbill turtles (*Eretmochelys imbricata*) were the most frequently caught bycatch species, followed by loggerheads (*Caretta caretta*) and green turtles (*Chelonia mydas*). Gillnets were the most dangerous for sea turtles, with the greatest incidence of dead turtles caught. Three particular bycatch hotspots were identified at the northeast, northwest, and southwest coasts of the peninsula. Identification of bycatch hotspots is recognized worldwide as a key element for protecting these endangered species, particularly in a region such as the Yucatan Peninsula that harbors critical habitats for ≥ 4 sea turtle species, 2 of them categorized as critically endangered (hawksbills and Kemp's ridleys [Lepidochelys kempii]). The spatially explicit participatory approach is versatile, easy to implement, and strategic for generating information under marine spatial planning for endangered species conservation.

da Silva, P. F., Chaves, M. F., Santos, M. G., Santos, A. J. B., Magalhaes, M. D., Andreazze, R., & de Moura, G. J. B. (2016). Insect Infestation of Hawksbill Sea Turtle Eggs in Rio Grande Do Norte, Brazil. *Chelonian Conservation and Biology, 15*(1), 147-153 https://doi.org/10.2744/ccb-1133.1

We describe infestation of hawksbill turtle (*Eretmochelys imbricata*) nests by insects on Pipa beach in the municipality of Tibaudo Sul, Rio Grande do Norte, Brazil in January and June 2011. The mean number of live hatchlings (83.96 +/- 43.31) was higher in nests unassociated with vegetation, although it is important to consider that a number of parameters other than proximity to vegetation may also affect nest success.

Dewald, J. R., & Pike, D. A. (2014). Geographical Variation in Hurricane Impacts among Sea Turtle Populations. *Journal of Biogeography, 41*(2), 307-316 https://doi.org/10.1111/jbi.12197

Aim: Hurricanes bring wind and rainfall that can have dramatic effects on coastal ecosystems, which provide important nesting locations for some migratory species. We investigated the frequency with which hurricanes impact spatially and biologically distinct sea turtle nesting populations to understand whether the reproductive biology of sea turtles can buffer population-level impacts of these disturbances. Location: North-western Atlantic and north-eastern Pacific Oceans. Methods: Historical hurricane paths from 1970 to 2007 were combined into a spatial layer of seasonal storm frequency, which we used to quantify the frequency of impacts on sea turtle nesting sites. This was done by comparing spatio-temporal patterns of hurricane frequency among nesting sites used by different species and spatially/biologically distinct populations ('regional management units'). Results: Hurricanes affected 97% of sea turtle nesting beaches (n = 2444) over four decades, and the seasonal incidence of these storms overlapped substantially with sea turtle nesting and egg incubation periods. The spatial distribution of storms, in relation to the distribution of species and regional management units, determined relative exposure to large storm events. Green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and leatherback (Dermochelys coriacea) turtle nesting beaches experienced relatively frequent storms; loggerhead (*Caretta caretta*) and Kemp's ridley (Lepidochelys kempii) turtle nesting beaches experienced relatively fewer storms; and olive ridley turtle (Lepidochelys olivacea) nesting sites were least affected. Main conclusions: Extreme weather events are common features of coastal environments and may impact sea turtles by altering nesting habitat quality (through sand erosion and accretion) and lowering within-season reproductive success by drowning incubating embryos or eroding nests. The unique reproductive attributes of sea turtles (i.e. individual females reproduce at 2-5-year intervals, and when reproducing lay 2-7 clutches of c. 100 large eggs at c. 2-week intervals) may be uniquely suited to exploiting highly disturbed nesting habitats. The impacts of hurricanes on sea turtle populations may be limited because even in severe storm seasons only a proportion of adult females are reproducing, and only those eggs incubating at the time of storm impact will be directly affected. Understanding whether the frequency of large storms influences long-term population dynamics will aid in the development of effective local and regional management plans for sea turtle recovery efforts.

Duncan, E. M., Broderick, A. C., Fuller, W. J., Galloway, T. S., Godfrey, M. H., Hamann, M., . . . Godley, B. J. (2019). Microplastic Ingestion Ubiquitous in Marine Turtles. *Global Change Biology, 25*(2), 744-752 https://doi.org/10.1111/gcb.14519

Despite concerns regarding the environmental impacts of microplastics, knowledge of the incidence and levels of synthetic particles in large marine vertebrates is lacking. Here, we utilize an optimized enzymatic digestion methodology, previously developed for zooplankton, to explore whether synthetic particles could be isolated from marine turtle ingesta. We report the presence of synthetic particles in every turtle subjected to investigation (n = 102) which included individuals from all seven species of marine turtle, sampled from three ocean basins (Atlantic [ATL]: n = 30, four species; Mediterranean

(MED): n = 56, two species; Pacific (PAC): n = 16, five species). Most particles (n = 811) were fibres (ATL: 77.1% MED: 85.3% PAC: 64.8%) with blue and black being the dominant colours. In lesser quantities were fragments (ATL: 22.9%: MED: 14.7% PAC: 20.2%) and microbeads (4.8%; PAC only; to our knowledge the first isolation of microbeads from marine megavertebrates). Fourier transform infrared spectroscopy (FT-IR) of a subsample of particles (n = 169) showed a range of synthetic materials such as elastomers (MED: 61.2%; PAC: 3.4%), thermoplastics (ATL: 36.8%: MED: 20.7% PAC: 27.7%) and synthetic regenerated cellulosic fibres (SRCF; ATL: 63.2%: MED: 5.8% PAC: 68.9%). Synthetic particles being isolated from species occupying different trophic levels suggest the possibility of multiple ingestion pathways. These include exposure from polluted seawater and sediments and/or additional trophic transfer from contaminated prey/forage items. We assess the likelihood that microplastic ingestion presents a significant conservation problem at current levels compared to other anthropogenic threats.

Dyc, C., Covaci, A., Debier, C., Leroy, C., Delcroix, E., Thomé, J.-P., & Das, K. (2015). Pollutant Exposure in Green and Hawksbill Marine Turtles from the Caribbean Region. *Regional Studies in Marine Science, 2*, 158-170 https://doi.org/10.1016/j.rsma.2015.09.004

Despite their common occurrence in Guadeloupe, little is known about levels and effects of pollutants in free-ranging green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles. The aims of this study were (1) to evaluate levels of persistent organic pollutants and trace elements in Guadeloupian marine turtles, (2) to assess the risk for turtle embryo facing chemical exposure. Eggs and dermis were collected from 11 green and 4 hawksbill turtles and analysed for inorganic and organic pollutants. Chemical risks were evaluated for turtle embryos through a screening risk assessment (SRA). ∑PCBs and chlordecone were the main contaminant groups in green and hawksbill turtles. Contaminant levels were lower in the tissues of the Guadeloupean turtles compared to other geographic locations. p,p'-DDE, selenium, mercury and cadmium could affect the marine turtle embryos. This study is the first to provide levels of pollutants in marine turtles from Guadeloupe.

Foley, A. M., Stacy, B. A., Hardy, R. F., Shea, C. P., Minch, K. E., & Schroeder, B. A. (2019). Characterizing Watercraft-Related Mortality of Sea Turtles in Florida. *Journal of Wildlife Management, 83*(5), 1057-1072 https://doi.org/10.1002/jwmg.21665

Mortality from being struck by a motorized watercraft is considerable for many aquatic vertebrates around the world, including sea turtles. We studied stranded (i.e., dead, sick, or injured) sea turtles found in Florida, USA, during 1986–2014 and identified those with sharp force or blunt force injuries indicative of a vessel strike. About a third of stranded loggerheads (*Caretta caretta*), green turtles (*Chelonia mydas*), and leatherbacks (Dermochelys coriacea) had a vessel-strike injury (VSI). The frequency of this injury was lower but still substantial for stranded Kemp's ridleys (Lepidochelys kempii; 26.1%) and hawksbills (*Eretmochelys imbricata*; 14.8%). Over the study period, the annual number of stranded loggerheads, green turtles, and Kemp's ridleys with a VSI increased as did the annual number of vessels registered in Florida. Eighty-one percent of the stranded turtles with a VSI were found in the southern half of Florida and 66% of those were found along the southeast coast. By coastal county, the proportion of stranded sea turtles with a VSI was positively related to the mean annual number of registered vessels. The percentage occurrence of a VSI was highest for adult loggerheads, green turtles, and leatherbacks, and reproductively active individuals appeared to be particularly vulnerable to these injuries. We conducted necropsies on 194 stranded sea turtles with a VSI and concluded that this injury

was the cause of death or the probable cause of death in ≥92.8% of these cases. During 2000–2014, we estimate that the mean annual numbers of stranded sea turtles that died from a VSI were 142–229 loggerheads, 101–162 green turtles, 16–32 Kemp's ridleys, 4–6 leatherbacks, and 2–4 hawksbills. Considering that only about 10–20% of sea turtles that died likely washed ashore, the overall annual mortality may have been 5–10 times greater than that represented by strandings. Most of the significant clusters of stranded sea turtles with a VSI occurred at inlets or passes and the probability that a stranded sea turtle had a VSI decreased with increasing distance from inlets or passes, navigable waterways, and marinas. We suggest focusing initial management efforts on reducing watercraft-related mortality for all sea turtle species around 8 inlets in southeast Florida, reproductively active loggerheads and green turtles along the coast of southeast Florida, and Kemp's ridleys and adult male loggerheads at passes along the coast of southwest Florida.

Foley, A. M., Stacy, B. A., Schueller, P., Flewelling, L. J., Schroeder, B., Minch, K., . . . Landsberg, J. H. (2019). Assessing Karenia Brevis Red Tide as a Mortality Factor of Sea Turtles in Florida, USA. *Diseases of Aquatic Organisms, 132*(2), 109-124 https://doi.org/10.3354/dao03308

Data on Karenia brevis red tides (>= 10(5) cells I-1) and on dead or debilitated (i.e. stranded) Kemp's ridleys Lepidochelys kempii, loggerheads *Caretta caretta*, green turtles *Chelonia mydas*, hawksbills *Eretmochelys imbricata*, and leatherbacks Dermochelys coriacea documented in Florida during 1986-2013 were evaluated to assess red tides as a sea turtle mortality factor. Unusually large numbers of stranded sea turtles were found coincident with red tides primarily along Florida's Gulf coast but also along a portion of Florida's Atlantic coast. These strandings were mainly adult and large immature loggerheads and Kemp's ridleys, and small immature green turtles and hawksbills. Unusually large numbers of stranded leatherbacks never coincided with red tide. For the 3 most common species, results of stranding data modeling, and of investigations that included determining brevetoxin concentrations in samples collected from stranded turtles, all indicated that red tides were associated with greater and more frequent increases in the numbers of stranded loggerheads and Kemp's ridleys than in the number of stranded green turtles. The mean annual number of stranded sea turtles attributed to K. brevis red tide was 80 (SE = 21.6, range = 2-338). Considering typical stranding probabilities, the overall mortality was probably 5-10 times greater. Red tide accounted for a substantial portion of all stranded loggerheads (7.1%) and Kemp's ridleys (17.7 %), and a smaller portion of all stranded green turtles (1.6%). Even though K brevis red tides occur naturally, the mortality they cause needs to be considered when managing these threatened and endangered species.

Foran, D. R., & Ray, R. L. (2016). Mitochondrial DNA Profiling of Illegal Tortoiseshell Products Derived from Hawksbill Sea Turtles. *Journal of Forensic Sciences, 61*(4), 1062-1066 https://doi.org/10.1111/1556-4029.13062

The hawksbill sea turtle (*Eretmochelys imbricata*) is a highly endangered species, commonly poached for its ornate shell. "Tortoiseshell" products made from the shell are widely, although illegally, available in many countries. Hawksbills have a circumglobal distribution; thus, determining their origin is difficult, although genetic differences exist geographically. In the research presented, a procedure was developed to extract and amplify mitochondrial DNA from tortoiseshell items, in an effort to better understand where the species is being poached. Confiscated tortoiseshell items were obtained from the U.S. Fish and Wildlife Service, and DNA from 56 of them was analyzed. Multiple mitochondrial haplotypes were identified, including five not previously reported. Only one tortoiseshell item proved to be of Atlantic

origin, while all others corresponded to genetic stocks in the Indo-Pacific region. The developed methodology allows for unique, and previously unattainable, genetic information on the illegal poaching of sea turtles for the decorative tortoiseshell trade.

Frasier, K. E., Solsona-Berga, A., Stokes, L., & Hildebrand, J. A. (2020). Impacts of the Deepwater Horizon Oil Spill on Marine Mammals and Sea Turtles. In *Deep Oil Spills.* (pp. 431-462): Springer Retrieved from https://link.springer.com/chapter/10.1007/978-3-030-11605-7_26

The Gulf of Mexico (GOM) is one of the most diverse ecosystems in the world (Fautin et al. PLoS One 5(8):e11914, 2010). Twenty-one species of marine mammals and five species of sea turtles were routinely identified in the region by the end of the twenty-first century (Waring et al. NOAA Tech Memo NMFS NE 231:361, 2015), a decrease from approximately 39 species prior to intensive exploitation (Darnell RM. The American sea: a natural history of the Gulf of Mexico. Texas A&M University Press, College Station, TX, 2015). Life histories of these megafauna species range from hyperlocal residence patterns of bottlenose dolphins to inter-ocean migrations of leatherback turtles. All species are subject to direct and indirect impacts associated with human activities. These impacts have intensified with major development and extraction efforts since the 1940s. The Deepwater Horizon (DWH) oil spill represents a new type of injury to this system: Unlike previous large oil spills, it not only exposed marine megafauna to surface slicks, it also involved an unprecedented release of dispersed oil into deep waters and pelagic habitats, where effects are difficult to observe and quantify. This chapter synthesizes the research conducted following the DWH oil spill to characterize acute and chronic offshore effects on oceanic marine mammals and sea turtles. Marine mammals and sea turtles were exposed to unprecedented amounts of oil and dispersants. Local declines in marine mammal presence observed using passive acoustic monitoring data suggest that the acute and chronic population-level impacts of this exposure were likely high and were underestimated based on coastal observations alone. These population declines may be related to reduced reproductive success as observed in nearshore proxies. Long-term monitoring of oceanic marine mammals is a focus of this chapter because impacts to these populations have not been extensively covered elsewhere. We provide an overview of impacts to sea turtles and coastal marine mammals, but other more thorough resources are referenced for in depth reviews of these more widely covered species.

Fuentes, M., Pike, D. A., Dimatteo, A., & Wallace, B. P. (2013). Resilience of Marine Turtle Regional Management Units to Climate Change. *Global Change Biology, 19*(5), 1399-1406 https://doi.org/10.1111/gcb.12138

Enhancing species resilience to changing environmental conditions is often suggested as a climate change adaptation strategy. To effectively achieve this, it is necessary first to understand the factors that determine species resilience, and their relative importance in shaping the ability of species to adjust to the complexities of environmental change. This is an extremely challenging task because it requires comprehensive information on species traits. We explored the resilience of 58 marine turtle regional management units (RMUs) to climate change, encompassing all seven species of marine turtles worldwide. We used expert opinion from the IUCN-SSC Marine Turtle Specialist Group (n=33 respondents) to develop a Resilience Index, which considered qualitative characteristics of each RMU (relative population size, rookery vulnerability, and genetic diversity) and non climate-related threats (fisheries, take, coastal development, and pollution/pathogens). Our expert panel perceived rookery vulnerability (the likelihood of functional rookeries becoming extirpated) and non climate-related

threats as having the greatest influence on resilience of RMUs to climate change. We identified the world's 13 least resilient marine turtle RMUs to climate change, which are distributed within all three major ocean basins and include six of the world's seven species of marine turtle. Our study provides the first look at inter- and intra-species variation in resilience to climate change and highlights the need to devise metrics that measure resilience directly. We suggest that this approach can be widely used to help prioritize future actions that increase species resilience to climate change.

Gall, S. C., & Thompson, R. C. (2015). The Impact of Debris on Marine Life. *Marine Pollution Bulletin, 92*(1), 170-179 https://doi.org/10.1016/j.marpolbul.2014.12.041

Marine debris is listed among the major perceived threats to biodiversity, and is cause for particular concern due to its abundance, durability and persistence in the marine environment. An extensive literature search reviewed the current state of knowledge on the effects of marine debris on marine organisms. 340 original publications reported encounters between organisms and marine debris and 693 species. Plastic debris accounted for 92% of encounters between debris and individuals. Numerous direct and indirect consequences were recorded, with the potential for sublethal effects of ingestion an area of considerable uncertainty and concern. Comparison to the IUCN Red List highlighted that at least 17% of species affected by entanglement and ingestion were listed as threatened or near threatened. Hence where marine debris combines with other anthropogenic stressors it may affect populations, trophic interactions and assemblages.

Gomez, L., & Krishnasamy, K. (2019). *A Rapid Assessment on the Trade in Marine Turtles in Indonesia, Malaysia and Viet Nam.* TRAFFIC Petaling Jaya, Malaysia. Retrieved from https://www.traffic.org/site/assets/files/12524/se-asia-marine-turtle-trade.pdf

Six species of marine turtles are found in Southeast Asia. Generally, all six species are protected or regulated by national laws across the region. Furthermore, all marine turtle species (Family Cheloniidae and Dermochelys coriacea) are listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which prohibits the international trade of marine turtles, their parts and derivatives for commercial purposes. These species are also listed on Appendices I and II of the Convention on Migratory Species of Wild Animals, meaning that the Parties to the Convention including Indonesia, Malaysia and Viet Nam among other countries in the region have committed to strict protection of these species and to reducing threats to their survival both nationally and through international co-operation. These countries are also among the 35 Signatory States to the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia the goal of which is to enhance international co-operation on the conservation of marine turtles. Despite these efforts, marine turtles continue to be illegally exploited for trade and consumption, which is considered to be a threat to remaining wild populations already at risk from a range of reasons including continued habitat degradation, pollution of the marine environment, bycatch and disease.

Hayes, C. T., Baumbach, D. S., Juma, D., & Dunbar, S. G. (2017). Impacts of Recreational Diving on Hawksbill Sea Turtle (*Eretmochelys imbricata*) Behaviour in a Marine Protected Area. *Journal of Sustainable Tourism, 25*(1), 79-95 https://doi.org/10.1080/09669582.2016.1174246

The hawksbill sea turtle (*Eretmochelys imbricata*) is a critically endangered species encountered by recreational divers in marine protected areas (MPAs) circumtropically. Few studies, however, have examined the impacts of recreational diving on hawksbill behaviours. In 2014, we collected turtle sightings surveys and dive logs from 14 dive operations, and conducted in-water observations of 61 juvenile hawksbill turtles in Roatan, Honduras, to determine if differences in dive site use and diver behaviours affected sea turtle behaviours in the Roatan Marine Park. Sightings distributions did not vary with diving pressure during an 82-day study period. We found the amount of time turtles spent eating, investigating and breathing decreased when approached by divers. Our results suggest diver interactions may negatively impact sea turtle behaviours, however it is unknown if recreational diving has a cumulative effect on turtles over time. We recommend that MPA managers should implement monitoring programmes that assess the impacts of tourism on natural resources. We have established monitoring of hawksbills as representatives of the marine habitat in an MPA, which has the potential to be heavily impacted by dive tourism, and provide recommendations for continued monitoring of the resource.

Liles, M. J., Gaos, A. R., Bolaños, A. D., Lopez, W. A., Arauz, R., Gadea, V., . . . Peterson, M. J. (2017). Survival on the Rocks: High Bycatch in Lobster Gillnet Fisheries Threatens Hawksbill Turtles on Rocky Reefs Along the Eastern Pacific Coast of Central America. *Latin American Journal of Aquatic Research, 45*(3), 521-539 Retrieved from http://lajar.ucv.cl/index.php/rlajar/issue/view/60

Small-scale coastal fisheries can cause detrimental impacts to non-target megafauna through bycatch. This can be particularly true when high-use areas for such species overlap with fishing grounds, as is the case with hawksbill turtle (*Eretmochelys imbricata*) aggregations at lobster gillnet fishing sites in El Salvador and Nicaragua. We quantified hawksbill bycatch by partnering with local fishers to record data for 690 gillnet sets on rocky reefs at Los Cóbanos Reef Marine Protected Area (2008-2009) and Punta Amapala (2012-2014) in El Salvador, and La Salvia (2012-2014) in Nicaragua. Based on 31 observed hawksbill captures, the mean bycatch-per-unit-effort (0.0022; individuals per set = 0.0450) and mortality (0.74) are among the highest reported for the species across fishing gear types and oceanic regions worldwide, and we conservatively estimate that at least 227 juvenile hawksbill captures occurred in lobster gillnet fishing fleets at our sites during the study. Estimated mortality for the 227 hawksbills - which could approach the 74% observed mortality of total captures-from interactions with lobster gillnet fisheries at these sites during the study period may constitute the greatest single source of human-induced in-water mortality for juvenile, sub-adult, and adult hawksbills in the eastern Pacific, and is of grave concern to the population. Based on our findings, we discuss neritic habitat use by hawksbills during their 'lost years' and offer recommendations for bycatch reduction strategies, including community-based efforts to enhance sustainable self-governance via the establishment of locally crafted conservationist norms and marine protected areas at important developmental habitat.

Lynch, J. M. (2018). Quantities of Marine Debris Ingested by Sea Turtles: Global Meta-Analysis Highlights Need for Standardized Data Reporting Methods and Reveals Relative Risk. *Environmental Science & Technology, 52*(21), 12026-12038 https://doi.org/10.1021/acs.est.8b02848

Because of their propensity to ingest debris, sea turtles are excellent bioindicators of the global marine debris problem. This review covers five decades of research on debris ingestion in sea turtles from 131 studies with a novel focus on quantities. Previous reviews have focused solely on presence/absence

data. Past reviews have called for standardization and highlight biases in the literature, yet none thoroughly describe improvements needed at the data reporting stage. Consequences of three reporting choices are discussed: not reporting quantities of ingested debris (32% of sea turtle studies reported only frequency of occurrence), excluding animals that did not ingest debris (64%), and not normalizing quantities to animal size (95%). Ingestion quantities, corrected for these factors, allowed a first-ever global meta-analysis on the units of grams/kilogram, revealing that hawksbill and green turtles rank highest among sea turtle species, and that the Central and Northwest Pacific and Southwest Atlantic Oceans are hotspots. Furthermore, this review discovered that monitoring efforts are disproportionate to the magnitude of the problem. Large efforts are focused in the Mediterranean Sea where international policies are hotly discussed versus the Central Pacific that has 5-fold greater debris ingestion quantities but represents only 3% of the global research effort. Future studies are recommended to report quantities of ingested debris using units described herein and make use of the pilot database provided.

Matley, J. K., Eanes, S., Nemeth, R. S., & Jobsis, P. D. (2019). Vulnerability of Sea Turtles and Fishes in Response to Two Catastrophic Caribbean Hurricanes, Irma and Maria. *Scientific Reports, 9* https://doi.org/10.1038/s41598-019-50523-3

Extreme weather events (e.g., cyclones, floods, droughts) are capable of changing ecosystems and altering how animals obtain resources. Understanding the behavioural responses of animals being impacted by these natural events can help initiate and ameliorate conservation or management programs. This study investigated short- and long-term space-use of the critically endangered hawksbill sea turtle (*Eretmochelys imbricata*), as well as five species of fishes and stingrays, in response to two of the most destructive Caribbean hurricanes in known history- Irma and Maria, which were at their peak intensity when they passed the US Virgin Islands in September of 2017. Using passive acoustic telemetry in St. Thomas, US Virgin Islands, we show a variety of short-term behavioural patterns initiated across species to reduce exposure to the strong environmental conditions, such as moving to deeper habitats within the study area. Although short-term expansion of activity space was evident for several sea turtles, long-term impacts on space-use and body condition were limited. In contrast, southern stingrays (Hypanus americanus) left the study area shortly after the hurricanes, suggesting vulnerability stemming from altered habitat, prey availability, or temperature/oxygen profiles. This study shows the strong spatial resilience of several nearshore species despite exposure to two consecutive category 5 hurricanes.

Maurer, A. S., De Neef, E., & Stapleton, S. (2015). Sargassum Accumulation May Spell Trouble for Nesting Sea Turtles. *Frontiers in Ecology and the Environment, 13*(7), 394-395 https://doi.org/10.1890/1540-9295-13.7.394

Thigh-high mounds of sargassum seaweed line the northern section of a beach on Long Island, Antigua – an island in the West Indies – that hosts nesting hawksbill sea turtles (*Eretmochelys imbricata*) every summer. A meter offshore – although it is difficult to tell where the shore begins and the sea ends – the seaweed is crisp, even crunchy underfoot. We plod through it to skirt a mangrove tree during nightly patrols for nesting hawksbills, but the thick seaweed soup makes wading slow and difficult. The mass of seaweed varies with the prevailing winds and currents but often stretches over 10 m into the water. Closer to shore, it is a warm, fly-infested mush in various states of stinking decay. It collects on the

beach to form a low but substantial wall, at times approaching 1 m in height and well over 2 m in width (Figure 1). And the sargassum keeps coming.

Miller, E. A., McClenachan, L., Uni, Y., Phocas, G., Hagemann, M. E., & Van Houtan, K. S. (2019). The Historical Development of Complex Global Trafficking Networks for Marine Wildlife. *Science Advances, 5*(3) https://doi.org/10.1126/sciadv.aav5948

The complexity of trade networks is a major challenge to controlling wildlife trafficking and illegal, unreported, and unregulated (IUU) fishing. These networks may not be modern inventions, but have developed over centuries, from integrated global markets that preceded modern regulatory policies. To understand these linkages, we curated 150 years of tortoiseshell transactions and derived biologically informed harvest models to estimate the trade in critically endangered hawksbill sea turtles (*Eretmochelys imbricata*). We find that trade networks concentrated in Southeast Asia harvested 9 million turtles, over six times previous estimates. These networks spread from within the Pacific, to the Indian and Atlantic basins, and became markedly more complex after 1950. Our results further indicate that the magnitude and extent of the coastally restricted hawksbill exploitation parallel current patterns of IUU fishing. Policies to combat these interlinked illegal practices should assimilate the important role of small-scale, coastal fisheries in these increasingly complex global networks.

Muñoz, C. C., & Vermeiren, P. (2018). Profiles of Environmental Contaminants in Hawksbill Turtle Egg Yolks Reflect Local to Distant Pollution Sources among Nesting Beaches in the Yucatán Peninsula, Mexico. *Marine Environmental Research, 135*, 43-54 https://doi.org/10.1016/j.marenvres.2018.01.012

Knowledge of spatial variation in pollutant profiles among sea turtle nesting locations is limited. This poses challenges in identifying processes shaping this variability and sets constraints to the conservation management of sea turtles and their use as biomonitoring tools for environmental pollutants. We aimed to increase understanding of the spatial variation in polycyclic aromatic hydrocarbon (PAH), organochlorine pesticide (OCP) and polychlorinated biphenyl (PCB) compounds among nesting beaches. We link the spatial variation to turtle migration patterns and the persistence of these pollutants. Specifically, using gas chromatography, we confirmed maternal transfer of a large number of compounds (n = 68 out of 69) among 104 eggs collected from 21 nests across three nesting beaches within the Yucatán Peninsula, one of the world's most important rookeries for hawksbill turtles (*Eretmochelys imbricata*). High variation in PAH profiles was observed among beaches, using multivariate correspondence analysis and univariate Peto-Prentice tests, reflecting local acquisition during recent migration movements. Diagnostic PAH ratios reflected petrogenic origins in Celestún, the beach closest to petroleum industries in the Gulf of Mexico. By contrast, pollution profiles of OCPs and PCBs showed high similarity among beaches, reflecting the long-term accumulation of these pollutants at regional scales. Therefore, spatial planning of protected areas and the use of turtle eggs in biomonitoring needs to account for the spatial variation in pollution profiles among nesting beaches.

Nijman, V. (2015). Decades-Long Open Trade in Protected Marine Turtles Along Java's South Coast. *Marine Turtle Newsletter*(144), 10-13 Retrieved from http://www.seaturtle.org/mtn/archives/?dir=141

The island of Java, Indonesia, has long been recognized as globally important for marine turtle conservation. Over-exploitation of eggs and adults, especially of green and hawksbill turtles on Java have led to their decline with considerable decreases in population sizes. Nijman discusses the decades-long open trade in protected marine turtles along Java's South Coast.

Oliveira, M., Serrano, I., Santos, J. P., Bilocq, F., Pereira, N., Loureiro, N. D., . . . De Vos, D. (2017). Pseudomonads from Wild Free-Living Sea Turtles in Principe Island, Gulf of Guinea. *Ecological Indicators, 81*, 260-264 https://doi.org/10.1016/j.ecolind.2017.06.005

Dissemination of antibiotic resistance is a major concern, especially in aquatic environments, where pollution contributes for resistant bacteria selection. These strains may have serious health implications, especially for endangered species, including the sea turtles' hawksbill *Eretmochelys imbricata* and green turtles *Chelonia mydas*. We aimed to evaluate the presence of antibiotic resistant pseudomonads in wild sea turtles from Principe Island, Sao Tome and Principe, Guinea Gulf. Isolates were obtained from oral and cloacal swabs of free-living turtles by conventional techniques. Pseudomonads screening was performed by multiplex-PCR (*oprl/oprL*) and biochemical identification and antibiotic resistance profiling were achieved using Vitek2. All pseudomonad isolates were genotyped by Rep-PCR. Thirteen isolates were *oprl*-positive and classified as pseudomonads, eight from the genus Pseudomonas with the species P. aeruginosa, P. stutzeri, and P. mendocina, and five co-isolated Alcaligenes faecalis. The P. aeruginosa isolate was also *oprL*-positive. Regarding isolates susceptibility profile, 38.5% were susceptible to all antibiotics tested, and multidrug resistant (MDR) strains were not identified. DNA fingerprinting did not show any specific clonal-cluster similarity. Data on the worldwide incidence of antibiotic resistance among wildlife is still very scarce, especially concerning remote tropical areas. Since Pseudomonas genus has emerged as a group of increasingly reported opportunistic microorganisms in human and veterinary medicine with high resistance levels, it could be used as a tool for environmental resistance surveillance, particularly considering their ubiquity.

Pheasey, H., McCargar, M., Glinsky, A., & Humphreys, N. (2018). Effectiveness of Concealed Nest Protection Screens against Domestic Predators for Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) Sea Turtles. *Chelonian Conservation and Biology, 17*(2), 263-270 https://doi.org/10.2744/ccb-1316.1

Mammalian depredation of nests has been listed amongst the most significant threats to hatchling success in sea turtles. In 2013, at least 13% of green turtle (Cheloizia mydas) and 25% of hawksbill turtle (*Eretmochelys imbricata*) nests were lost to domestic dog predation on Playa Norte, Costa Rica. In 2014 and 2015, plastic and bamboo protective screens were deployed to protect nests. Screens were deployed at different stages of the incubation period and the success of the nests analyzed. Predation rates increased as the seasons progressed with October and November being the peak depredation months, as well as the peak for hatchling emergences. Eggs remaining in nests that had been partially depredated had a significantly lower percentage of hatching success than eggs in undisturbed nests. There was no significant difference between timing of deployment and likelihood of a screen being breached. The likelihood of a screen being breached was highly dependent on the type of material used; bamboo screens were ca. 153% more effective than plastic and successfully prevented the complete predation of ca. 48% of nests. Bamboo screening is an inexpensive, environmentally inert, yet labor-intensive method for reducing nest depredation by domestic dogs. This screening method does not impact the hatching or emerging success of the nest.

Pingo, S., Jiménez, A., Alfaro-Shigueto, J., & Mangel, J. C. (2017). Incidental Capture of Sea Turtles in the Artisanal Gillnet Fishery in Sechura Bay, Northern Peru. *Latin American Journal of Aquatic Research, 45*(3), 606-614 https://doi.org/10.3856/vol45-issue3-fulltext-10

Gillnets are recognized globally as one of the fishing gears with the highest levels of bycatch and mortality of sea turtles. Through onboard observer monitoring from July 2013 to June 2014 we assessed the bycatch of sea turtles by an artisanal gillnet fishery operating from Sechura Bay, Peru. One hundred and four sea turtles were incidentally caught in 53 observed fishing sets. The observed species composition of bycatch was green turtle *Chelonia mydas* (n = 100), hawksbill *Eretmochelys imbricata* (n = 3) and olive ridley Lepidochelys olivacea (n = 1). Bycatch occurred in 62.3% of monitored sets, with an average of 1.96 turtles caught per set. For all sea turtles combined, 28.8% of individuals were dead and 71.2% were alive at the time of retrieval. The majority of individuals caught were classified as juveniles and sub-adults, with an average carapace length (CCL) of 57.3 ± 0.9 cm for green turtles and 40.2 ± 2.4 cm for hawksbills. The mean annual catch per unit effort (CPUE) of sea turtles was 1.11 ± 0.31 turtles km-1 12 h-1), but varied by seasons. These results suggest that Sechura Bay is an important developmental habitat for juvenile and sub-adult green turtles and hawksbill turtles, but one subject to intense fishing interaction pressure. The development of monitoring programs, local awareness-raising activities, and enhanced management and protection of this critical foraging area and developmental habitat is recommended.

Poli, C., Lopez, L. C. S., Mesquita, D. O., Saska, C., & Mascarenhas, R. (2014). Patterns and Inferred Processes Associated with Sea Turtle Strandings in Paraiba State, Northeast Brazil/Padroes E Inferencias Associadas Com Encalhes De Tartarugas Marinhas No Estado Da Paraiba, Nordeste Do Brasil. *Brazilian Journal of Biology, 74*(2), 283 Retrieved from http://www.scielo.br/pdf/bjb/v74n2/1519-6984-bjb-74-02-283.pdf

This study analysed sea turtle strandings on the coast of Paraiba State, Northeastern Brazil, from August 2009 to July 2010. A total of 124 strandings were recorded in this period: green turtle *Chelonia mydas*, hawksbill *Eretmochelys imbricata*, olive ridley Lepidochelys olivacea and loggerhead *Caretta caretta*. Of all turtles for which the Curved Carapace Length was measured, only 12 individuals were adults. Twenty individuals had synthetic anthropogenic debris in the gastrointestinal tract. Other traces of human interactions were observed in 43 individuals, such as injuries caused by entanglement in fishing lines or nets, collisions with vessels, direct contact with oil spills and lesions caused by sharp or spiked objects. Moreover, in 28.5% of the stranded turtles, the presence of external tumors was noticed, suggestive of fibropapillomatosis and in 9.7%, shark bite marks were observed. The researchers found evidence of human interactions in half of the strandings, but in most cases it was not possible to determine if such interactions were the cause of death.

Poli, C., Mesquita, D. O., Saska, C., & Mascarenhas, R. (2015). Plastic Ingestion by Sea Turtles in Paraiba State, Northeast Brazil. *Iheringia Serie Zoologia, 105*(3), 265-270 https://doi.org/10.1590/1678-476620151053265270

Currently, plastics are recognized as a major pollutant of the marine environment, representing a serious threat to ocean wildlife. Here, we examined the occurrence and effects of plastic ingestion by sea turtles found stranded along the coast of Paraiba State, Brazil from August 2009 to July 2010.

Ninety-eight digestive tracts were examined, with plastic found in 20 (20.4%). Sixty five percent (n = 13) of turtles with plastic in the digestive tract were green turtles (*Chelonia mydas*), 25% (n = 5) were hawksbills (*Eretmochelys imbricata*), and 10% (n = 2) were olive ridley (Lepidochelys olivacea). More plastic was found in the intestine (85%) than in other parts of the gastrointestinal tract. We observed complete blockage of the gastrointestinal tract due to the presence of plastic in 13 of the 20 turtles that had ingested plastic. No correlation was found between the curved carapace length (CCL) and the number or mass of the plastic ingested items. Significant differences were found between the intake of hard and soft plastic and the ingestion of white/transparent and colored plastic, with soft and white/transparent plastics being more commonly ingested. This study reveals the serious problem of plastic pollution to sea turtles at the area.

Proietti, M. C., Marques, V. C., Marques, M. L., Repinaldo, F. P. M., Lacerda, A. L. F., & Barreto, J. (2015). Natural Death of a Hawksbill Turtle Due to Feeding Behavior. *Marine Turtle Newsletter*(146), 9-10 Retrieved from http://www.seaturtle.org/mtn/archives/mtn146/mtn146-3.shtml

The Abrolhos Archipelago, located within the Abrolhos National Marine Park, is an important feeding area for immature hawksbill turtles. This species is generally carnivorous and has been reported to feed on a wide range of prey, with preference for ingesting sessile benthic organisms such as sponges and zoanthids. Here, Proietti et al describe an odd and natural cause of death of an immature hawksbill turtle at a protected bay of Santa Barbara Island. While eating green sea mat, the hawksbill got its head irremovably lodged in the crevice, and subsequently drowned.

Quiñones, J., Quispe, S., & Galindo, O. (2017). Illegal Capture and Black Market Trade of Sea Turtles in Pisco, Peru: The Never-Ending Story. *Latin American Journal of Aquatic Research, 45*(3), 615-621 https://doi.org/10.3856/vol45-issue3-fulltext-11

The Pisco-San Andrés area (13°44'S, 76°13'W) in central Peru is known for a traditional historic sea turtle fishery. To determine if illegal captures and black market trade exist, we carried out bi-weekly sampling in dumpsites and coastal areas from 2009 to 2015. A total of 953 carapaces were encountered, which included mainly black turtles (*Chelonia mydas*, 92.2%) and to a lesser extent, olive ridley turtles (Lepidochelys olivacea, 4.3%), leatherback turtles (Dermochelys coriacea, 1.4%), and a single hawksbill turtle (Eretmochelys imbricate, 0.1%). The mean curved carapace length (CCL) was 59.1 for black turtles, 60.4 for olive ridleys and 113 cm for leatherbacks. For all species, most of turtles reported were juveniles and came largely from illegal captures (89%) and not from stranding reports (1.4%). Mean mortality was 8.1 carcasses km-1 year-1 at beaches and 160.2 carcasses year-1 at dumpsites. Main consumed prey items in black turtles were silverside fish eggs (47.9%), Chondracanthus seaweed (31.4%) and Paranthus sp., anemone (16.2%). Despite the big sampling effort, mortality estimates could be underestimated since big percentages are butchered and discarded at sea. Still, numbers remains high with almost 1000 turtles in a five-year period and an illegal trade persists. Urgent measures are needed to recover this endangered species.

Ramos, J., Pincetich, C., Adams, L., Santos, K. C., Hage, J., & Arauz, R. (2012). Quantification and Recommended Management of Man-Made Debris Along the Sea Turtle Nesting Beach at Playa Caletas, Guanacaste, Costa Rica. *Marine Turtle Newsletter, 134*, 12-17 Retrieved from http://www.seaturtle.org/mtn/archives/mtn134/mtn134p12.shtml?nocount

Sea turtle nesting activity in Playa Caletas has been monitored since 2002 by the Association for the Restoration of Sea Turtles, or Pretoma (<http://www.pretoma.org>), a Costa Rican grassroots conservation organization, in close collaboration with its sister organization Turtle Island Restoration Network of the United States (<http://www.seaturtles.org>) and the authorities of the Tempisque Conservation Area (ACT) of the Ministry of Environment.

Riskas, K. A., Tobin, R. C., Fuentes, M. M. P. B., & Hamann, M. (2018). Evaluating the Threat of Iuu Fishing to Sea Turtles in the Indian Ocean and Southeast Asia Using Expert Elicitation. *Biological Conservation, 217*, 232-239 https://doi.org/10.1016/j.biocon.2017.10.011

Illegal, unreported and unregulated (IUU) fishing is a pervasive issue that affects economic, social, regulatory and environmental systems in all ocean basins. Research on the ecological impacts of IUU fishing has been relatively underrepresented, with minimal investigation into how IUU fishing may negatively affect populations of marine megafauna, such as sea turtles. To address this knowledge gap and identify priority areas for future research and management, we evaluated IUU fishing as a threat to a marine megafauna species group (sea turtles) in the Indian Ocean and Southeast Asia region (IOSEA). We designed and distributed an online survey to experts in the fields of sea turtle research, marine conservation, fisheries management, consulting and NGOs throughout IOSEA. Our results reveal that IUU fishing is likely to have potentially significant impacts on sea turtle populations in IOSEA through targeted exploitation and international wildlife trafficking. Addressing domestic IUU fishing needs to be actioned as a high priority within the study area, as does the issue of patrolling maritime borders to deter illegal cross-border transhipment. There is a demonstrable need to strengthen MCS and employ regional coordination to help build capacity in less-developed nations. Future research requirements include evaluating IUU fishing as a threat to sea turtles and other threatened marine species at multiple scales, further investigation into market forces throughout IOSEA, and examination of potential barriers to implementing management solutions. We advocate for introducing sea turtle-specific measures into IUU fishing mitigation strategies to help maximize the opportunity for positive outcomes in creating healthy ecosystems and stable communities.

Rizzi, M., Rodrigues, F. L., Medeiros, L., Ortega, I., Rodrigues, L., Monteiro, D. S., . . . Proietti, M. C. (2019). Ingestion of Plastic Marine Litter by Sea Turtles in Southern Brazil: Abundance, Characteristics and Potential Selectivity. *Marine Pollution Bulletin, 140*, 536-548 https://doi.org/10.1016/j.marpolbul.2019.01.054

The ingestion of plastic marine litter (PML) by sea turtles is widespread and concerning, and the five species that occur in the southwestern Atlantic – green, loggerhead, olive ridley, leatherback and hawksbill – are vulnerable to this pollution. Here, we quantified and characterized PML ingested by these species in southern Brazil, and observed PML ingestion in 49 of 86 sampled individuals (~57.0%). Green turtles presented the highest rates and variety of ingested plastics, and such ingestion has been high at least since 1997. Omnivorous turtles presented higher PML ingestion than carnivorous ones. Loggerheads displayed a negative correlation between body size and number of ingested items. Green turtles ingested mostly flexible transparent and flexible/hard white plastics; loggerheads ate mainly flexible, hard and foam fragments, in white and black/brown colors. These results help us better understand PML ingestion by sea turtles, highlighting the seriousness of this threat and providing information for prevention and mitigation strategies.

Stringell, T. B., Clerveaux, W. V., Godley, B. J., Phillips, Q., Ranger, S., Richardson, P. B., . . . Broderick, A. C. (2015). Protecting the Breeders: Research Informs Legislative Change in a Marine Turtle Fishery. *Biodiversity & Conservation, 24*(7), 1775-1796 https://doi.org/10.1007/s10531-015-0900-1

Marine turtles are sensitive to harvesting because of life-cycle traits such as longevity, late maturity and natal philopatry. The take of nesting females is of conservation concern because they are key to population maintenance and has led to global efforts to protect this life stage. In the Turks and Caicos Islands (TCI; a UK Overseas Territory in the Caribbean), previous turtle fishery legislation protected nesting turtles on the beach but not in the water, where turtles over a minimum size were subject to legal take. In a 2-year study, we undertook nesting beach and in-water surveys, molecular analyses, satellite tracking and collation of fisheries landing data to investigate the populations of green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles in the TCI and its turtle fishery. Adults were frequently taken in one of the region's largest legal and artisanal turtle fisheries. We suggest that nesting populations in the TCI, which contain genetically unique haplotypes, have diminished since the 1980s, likely as a result of the harvest of adults. Using these multiple lines of evidence, we highlight the inadequacies of the former fishery regulations and propose specific legislative amendments, which, as a result of this study, were implemented on 1 July 2014 by the TCI government. With good enforcement, these measures will protect adults breeding in the TCI and those from nesting rookeries in the region that use the waters of the TCI, improve the management of this fishery, and safeguard fisher livelihoods.

Stringell, T. B., & et al. (2013). Marine Turtle Harvest in a Mixed Small-Scale Fishery: Evidence for Revised Management Measures. *Ocean and coastal management, 82*, 34-42 https://doi.org/10.1016/j.ocecoaman.2013.05.004

Small-scale fisheries (SSF) account for around half of the world's marine and inland fisheries, but their impact on the marine environment is usually under-estimated owing to difficulties in monitoring and regulation. Successful management of mixed SSF requires holistic approaches that sustainably exploit target species, consider non-target species and maintain fisher livelihoods. For two years, we studied the marine turtle fishery in the Turks and Caicos Islands (TCI) in the Wider Caribbean Region, where the main export fisheries are queen conch (Strombus gigas) and the spiny lobster (Panulirus argus); with fin-fish, green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) taken for domestic consumption. We evaluate the turtle harvest in relation to the other fisheries and recommend legislation and management alternatives. We demonstrate the connectivity between multi-species fisheries and artisanal turtle capture: with increasing lobster catch-per-unit-effort (CPUE), hawksbill catch increased whilst green turtle catch decreased. With increasing conch CPUE, hawksbill catch declined and there was no demonstrable effect on green turtle catch. We estimate 176-324 green and 114-277 hawksbill turtles are harvested annually in TCI: the largest documented legal hawksbill fishery in the western Atlantic. Of particular concern is the capture of adult turtles. Current legislation focuses take on larger individuals that are key to population maintenance. Considering these data we recommend the introduction of maximum size limits for both species and a closed season on hawksbill take during the lobster fishing season. Our results highlight the need to manage turtles as part of a broader approach to SSF management.

Velez-Rubio, G. M., Estrades, A., Fallabrino, A., & Tomas, J. (2013). Marine Turtle Threats in Uruguayan Waters: Insights from 12 Years of Stranding Data. *Marine Biology, 160*(11), 2797-2811 https://doi.org/10.1007/s00227-013-2272-y

We present the first study conducted in a wide spatio-temporal scale on marine turtles strandings (N = 1,107) over a 12-year period (1999-2010) in Uruguay. Five species were recorded *Chelonia mydas* (N = 643; 58.1 %), *Caretta caretta* (N = 329; 29.7 %), Dermochelys coriacea (N = 131; 11.8 %), *Eretmochelys imbricata* (N = 3; 0.3 %), and Lepidochelys olivacea (N = 1; 0.1 %). The first three species stranded throughout the Uruguayan coast, but differences in distribution patterns were detected among species. Although occurring year round, stranding records show a clear seasonal pattern with variation in monthly distribution among species, but with a peak of records in austral summer. Strandings provide indirect evidence of threats to marine turtles in Uruguayan and surrounding waters, particularly fisheries and marine debris. Our results demonstrate that Uruguayan coastal waters likely serve as a foraging or development area for at least three endangered marine turtle species in temperate waters.

Whytlaw, P. A., Edwards, W., & Congdon, B. C. (2013). Marine Turtle Nest Depredation by Feral Pigs (Sus Scrofa) on the Western Cape York Peninsula, Australia: Implications for Management. *Wildlife Research, 40*(5), 377-384 https://doi.org/10.1071/WR12198

Context: The west coast of the Cape York Peninsula (CYP) is a major nesting ground for three species of threatened marine turtle, namely, the flatback (Natator depressus), olive ridley (Lepidochelys olivacea) and hawksbill (Eretemochelys imbricata). Marine turtle nests in this area experience high rates of depredation and unpublished data from numerous studies have suggested that feral pigs are responsible for most nest losses. Aims: The aim of the present study was to identify the relative magnitude of nest mortality associated with physical processes versus depredation and to distinguishing between two possible pig depredation scenarios. Methods: We documented laying and mortality patterns on Pennefarther Beach (CYP) over a 49-day period in 2007. We partitioned mortality into components attributable to beach erosion, inundation and depredation and also assessed the relative magnitude of depredation associated with different nest predators. We used these data to test whether the temporal and spatial pattern of pig depredation was random with respect to patterns of nest availability. Key results: The overall level of nest mortality was 40.2%. Depredation was responsible for 93% of nest losses. Pig predation was high, accounting for 89.6% of all mortality. Depredation occurred equally across nests of all three turtle species. Although nests were laid uniformly in both time and space, pig depredation was significantly clustered. Conclusions: Depredation by feral pigs was the principal cause of turtle nest mortality in the present study. The pattern of nest destruction was consistent with the occurrence of pig depredation by single individuals in discrete feeding areas. Implications: Current feral pig management involves aerial shooting. This is effective at removing large numbers of animals over large areas. However, aerial shooting is also expensive. Our results suggest that targeted monitoring and eradication of locally active individuals depredating nests may better manage pig impacts, specifically those on turtle nests. Additional keywords: conservation, flatback, hawksbill, olive ridley, threatening processes.

Section V: General

Alava, J. J., & Barragán-Paladines, M. J. (2017). The Missing Hawksbill Sea Turtles (*Eretmochelys imbricata*) from the Guayaquil Gulf, Ecuador: Novel Occurrence and Conservation Implications.

Journal of Marine Animals and Their Ecology, 9(1), 6 Retrieved from http://www.oers.ca/journal/volume9/issue1/communication.pdf

Sea turtles in Ecuador are threatened by diverse anthropogenic stressors. The Guayaquil Gulf is the largest estuary along the Pacific coast of South America and commercial trade route in Ecuador. This bioregion seems to be an important foraging ground for hawksbill sea turtles (*Eretmochelys imbricata*), as well. Based on field observations and information provided by secondary sources, we report two important sightings of hawksbills, including a juvenile (CCL= 40 cm) and mature female (CCL = 74 cm), observed in the Gulf of Guayaquil in 1999. These findings were the first records of this species in riverine mangroves and estuaries for Ecuador's mainland coast where the Gulf of Guayaquil constitutes a suitable ecosystem for hawksbills, which have managed to adapt as a response to the reduced availability of healthy habitats in their distribution area. The occurrence of hawksbills in the Guayaquil Gulf demonstrates the importance of estuarine habitats as feeding grounds for this threatened species, highlighting the imperative need of protection measures needed to enhance resilience of hawksbills and conservation actions for this special ecoregion.

Azanza-Ricardo, J., Gerhartz-Muro, J. L., Martin-Viana, Y. F., & Moncada-Gavilan, F. (2015). Effectiveness of Monitoring Techniques Employed to Determine Reproductive Success of Marine Turtles in Cuba. *Latin American Journal of Aquatic Research, 43*(3), 548-556 https://doi.org/10.3856/vol43-issue3-fulltext-16

Monitoring of nesting has been used globally to estimate the population size of marine turtles. Nevertheless, monitoring effort varies widely, for instance in Cuba, four different approaches are applied: nighttime systematic monitoring, daytime systematic monitoring, sporadic monitoring with nest verification, and sporadic monitoring with no verification. These variations imply that the amount and accuracy of data gathered and the quality of derived information, differ amongst the approaches. This paper assesses the effectiveness of the different methodologies used for determining the reproduction success of marine turtles in Cuba. Nighttime systematic monitoring is only carried out in one area, while sporadic monitoring with nest verification is the most used approach along the country. The proportion of the nesting season covered with monitoring personnel is low in most of the beaches and for all the three species (*Chelonia mydas*, *Caretta caretta* and *Eretmochelys imbricata*), although the species in the most critical situation is hawksbill. Significant differences were found between systematic and sporadic monitoring, which has important implications for the understanding of the nesting behavior, as the capacity to detect false and true crawls essentially depends on the monitoring frequency, according to our findings. Low detection capacity in sporadic monitoring hampered the development of efficiency assessments in all the nesting beaches. In summary, despite the effort carried out nationwide to monitor nesting populations that has even increased in the last three years, important gaps exists and new monitoring strategies are needed to guarantee the right information for the species is gathered, while adequate cost-benefit balance is achieved.

Barrios-Garrido, H., Sandoval, M. G., Barrientos-Muñoz, K. G., & Rojas-Cañizales, D. (2018). Report of the 24th Retomala: Annual Meeting of Latin American Sea Turtle Specialists (Kobe, Japan - 19 February 2018). *Marine Turtle Newsletter*(155), 25-28 Retrieved from http://www.seaturtle.org/mtn/archives/mtn155/mtn155-8.shtml

Costa Rica-Pacific region. Since 2009, there has been an ongoing in-water monitoring program based on turtle captures with turtle nets, which was initially stimulated by information provided by artisanal fishermen about the presence of hawksbill turtles in Punta Coyote. The presentation compiled data from 2001 to 2015. Since 2014, the Sea Turtle Conservation Curacao (NGO) has been conducting volunteer programs with sea turtles. The goal of this NGO is to protect sea turtles and their habitats, monitoring four sections of the island, both in land and in-water, and doing active stranding response and habitat surveys. [...]six to ten hawksbill nests have been reported. In the eastern part of the country, the presenters have assessed the effect of industrial fishing on hawksbill turtles, as well as threats of bycatch and illegal trade, specifically in 'Los Testigos' Archipelago and Mochima National Park where they captured and tagged juvenile and adults individuals.

Baumbach, D. S., Anger, E. C., Collado, N. A., & Dunbar, S. G. (2019). Identifying Sea Turtle Home Ranges Utilizing Citizen-Science Data from Novel Web-Based and Smartphone Gis Applications. *Chelonian Conservation & Biology, 18*(2), 133-144 https://doi.org/10.2744/CCB-1355.1

Animals are tracked using a wide range of methods. Some researchers track animals by manually recording global positioning system locations while others combine manually recorded locations with sophisticated mapping software. Individuals of the public regularly come in contact with animals and, as citizen-scientists, may represent a relatively constant source of data for researchers through written forms, web maps, or smartphone applications. We collected hawksbill (*Eretmochelys imbricata*) sightings from citizen-scientists using a new geographic information systems web map and smartphone application, and then calculated home ranges of individual turtles to gain insights into hawksbill movements within a marine protected area in Roatán, Honduras. We found that 3 of 4 individual turtles had home ranges of less than 1 km2 within the West Bay and West End zones of the marine protected area, whereas the fourth turtle had a home range of 1.44 km2 that extended from West Bay to Sandy Bay. We also found significantly more prey sponge in the West Bay and West End zones than in the Sandy Bay zone and suggest the small home ranges of hawksbills in our study may be due to the abundance of prey sponges within the Sandy Bay West End Marine Reserve. This study is the first to use citizenscience data collected via web-based and smartphone geographic information systems software to identify sea turtle home ranges. Our results correspond well to prior home range estimations derived using very high frequency radio telemetry. Although we analyzed small-scale home ranges for hawksbill sea turtles using citizen-based data, this method may potentially be applied around the world to any animals with home ranges.

Belskis, L. C., Frey, A., Jensen, M., LeRoux, R., & Stewart, K. R. (2016). *Proceedings of the Thirty-Fourth Annual Symposium on Sea Turtle Biology and Conservation : 2014 International Sea Turtle Symposium, 14 to 17 April, 2014, New Orleans, Louisiana, USA*. https://doi.org/10.7289/V5/TM-SEFSC-701

No abstract

Calmanovici, B., Waayers, D., Reisser, J., Clifton, J., & Proietti, M. (2018). (Is)-S-3 Pattern as a Mark-Recapture Tool to Identify Captured and Free-Swimming Sea Turtles: An Assessment. *Marine Ecology Progress Series, 589*, 263-268 https://doi.org/10.3354/meps12483

Identifying individual sea turtles is essential for understanding population dynamics and, in turn, planning conservation efforts. Traditionally, sea turtle individuals are identified through the application of external flipper tags and/or internal passive integrated transponders (PITs). However, sea turtle identification and consequently population studies are hampered by the loss of external flipper tags and migration of PITs. In this study, we assessed the accuracy and time efficiency of the Interactive Individual Identification System software ((IS)-S-3 Pattern v. 4.02) to photo-identify facial patterns of immature captured and free-swimming green turtles *Chelonia mydas* and hawksbill turtles *Eretmochelys imbricata*. Using a library of 436 photos representing 189 sea turtle individuals, we evaluated the accuracy and time taken for (IS)-S-3 Pattern to match individuals. A high proportion of individuals were successfully identified from photographs taken of captured turtles (97%) and free-swimming turtles (85%). (IS)-S-3 reduced data analysis time by 80% when compared to the visual assessment of photos, and is further optimised when photographs are of increased quality. These results demonstrate that (IS)-S-3 has great potential to contribute to population studies and management plans by facilitating both specialised research and citizen science programmes.

Department of the Environment and Energy. (2017). *Recovery Plan for Marine Turtles in Australia, Commonwealth of Australia 2017.* Government of Australia Retrieved from http://www.environment.gov.au/marine/publications/recovery-plan-marine-turtles-australia-2017

Six of the world's seven species of marine turtles occur in Australian waters and are protected under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). These species are the EPBC Act listed threatened 'endangered' loggerhead (*Caretta caretta*), olive ridley (Lepidochelys olivacea), and leatherback (Dermochelys coriacea) turtles, and 'vulnerable' green (*Chelonia mydas*), flatback (Natator depressus) and hawksbill (*Eretmochelys imbricata*) turtles. Marine turtles are found throughout Australia's marine environment and are most common across northern Australia. Australia has some of the largest marine turtle nesting rookeries in the Indo-Pacific region and is the only country where flatback turtles nest. Anecdotal evidence from European explorers indicates that marine turtles were abundant in Australian waters in the early 1800s[44, 82]. From the mid-1800s turtles became subject to commercial harvest by European settlers for general consumption (meat and eggs), canned turtle soup, meat export, and for the tortoiseshell trade. Although commercial harvest ceased in the mid-1900s, it contributed to an observable decline in nesting numbers. Contemporary threats, including habitat degradation, fisheries bycatch, nest predation and marine debris, have also contributed to the decline in marine turtles in recent decades. Coastal Aboriginal people across northern Australia and Torres Strait Islander communities have cultural, social and spiritual ties to marine turtles and manage land and sea country with marine turtle conservation and ongoing customary use as a high priority. The first Recovery Plan for Marine Turtles in Australia was adopted in July 2003. The Australian Government reviewed the 2003 plan and recommended that it be remade. This new Recovery Plan for Marine Turtles in Australia (the plan) has been developed in conjunction with state and territory governments, Indigenous communities and other stakeholders.

Dunbar, S. G., Ito, H. E., Bahjri, K., Dehom, S., & Salinas, L. (2014). Recognition of Juvenile Hawksbills *Eretmochelys imbricata* through Face Scale Digitization and Automated Searching. *Endangered Species Research, 26*(2), 137-146 https://doi.org/10.3354/esr00637

Advancements in digital photography have facilitated the use of photo-ID to track individual animals, making this technique of great value for conservation biology. However, the time required to manually match new photographs to those stored in a database is proportional to the size of the database. Therefore, there is need for investigating the potential to automate the searching processes through computerized means. We encountered hawksbill turtles *Eretmochelys imbricata* (n = 2) that were members of an ongoing study but had lost flipper tags and shell etchings. To identify individuals, we first manually searched photographs of turtles previously captured and released. Manual visual matching of the 2 turtles encountered was successful for 100% of tested photographs. To investigate automated recognition of turtles in a database, we used the spot recognition program, I super(3)S, to digitize scutes on the dorsal and lateral surfaces of the head and to compare spot patterns through the automated system. I super(3)S successfully identified the 2 return turtles as the same turtles identified by the manual visual matching method. To assess the ability of I super(3)S to identify turtles both present in and absent from the database, we blind-tested a series of photographs of turtle heads and faces using both manual visual methods and I super(3)S. With I super(3)S, 84.6% of the computerized photos were successfully matched with photos in the database, with scores produced ranging from 0.069 to 0.435. This study showed the potential for using a photo-database for long-term identification of individual turtles, but that the usefulness of a photodatabase depends on the quality of the photos and the flexibility of the computer program used.

El Kafrawy, S. B., Said, R. E. M., Saber, S. A., Soliman, M. A., & Al Attar, N. M. (2018). Using Remote Sensing and Geographic Information System to Assess the Status of the Nesting Habitat of Hawksbill Turtles (*Eretmochelys imbricata*): At Big Giftun Island, Red Sea, Egypt. *The Egyptian Journal of Remote Sensing and Space Science* https://doi.org/10.1016/j.ejrs.2018.07.005

Remote sensing has become a worldwide tool for natural resource managers as well as government agencies, industry and conservation organizations. Furthermore, it is a valuable technique in detecting and mapping different types of cosmopolitan hazards. Activities and development along the Egyptian Red Sea coast have grown in fast and remarkable manner. Tourism is one of the leading sources of income to Egypt's economy; tourism activities can affect marine and coastal living and nonliving components of local ecosystems. Sea turtles are among the most threatened and endangered animals due to human encroachments that affect nesting grounds and fishing activities that affect animals at foraging grounds and during migrations. The hawksbill *Eretmochelys imbricata* is a critically endangered species that nests in Giftun Island in the Red Sea off Egypt. Remote sensing and satellite imagery provided observations that show that Giftun Island is suffering from anthropogenic and physical threats; the results explain a decline in nests of *Eretmochelys imbricata*.

Evans, K., Bax, N. J., & Smith, D. C. (2018). Enhancing the Robustness of a National Assessment of the Marine Environment. *Marine Policy, 98*, 133-145 https://doi.org/10.1016/j.marpol.2018.08.011

The Australian government produces an independent report on the state of the Australian environment every five years. Based on 123 assessments of key pressures, key components of the marine environment, and the effectiveness of management responses to those pressures, the 2016 assessment identified that the overall state of the Australian marine environment can be regarded as good. However, the historical impacts of a number of pressures (e.g. commercial and recreational fishing) and ongoing pressures caused by activities currently inadequately managed (e.g. climate change and marine debris) have, and are continuing to, deteriorate its state. As a result, the outlook for the marine

environment can be regarded as mixed. Addressing the challenges facing the marine environment will require a coordinated, collaborative and dedicated effort across jurisdictions and sectors. A number of improvements to the assessment framework were implemented for the 2016 report, the most substantial being the development of clear and repeatable processes for information synthesis and assessment. This improved transparency and supported the robustness of conclusions made. Improved communication of uncertainties associated with assessments, and comparability with assessments in previous reports has furthered the quality of the report and laid the foundation for improvements going forward. Processes that will continue to improve assessments include identifying key indicators that can be reliably and effectively monitored, improving data provision processes, enhancing assessment frameworks and reporting processes to ensure that approaches are integrated and support the delivery of tangible and practical risk mitigation and adaptation pathways.

Fretey, J., Frétey, T., Dupré, A., Dupré, J., André, A. A., & Meunier, A. (2013). Is the Hawksbill Turtle, *Eretmochelys imbricata*, a Regular Nester on Rodrigues Island (Indian Ocean)? *Marine Turtle Newsletter*(138), 22-24 Retrieved from http://www.seaturtle.org/mtn/archives/mtn138/mtn138-8.shtml

Fretey et al features the hawksbill turtle which is considered a solitary nester, with nesting observed in the whole of the Western Indian Ocean, particularly on the islands. The hawksbill turtle was observed in Rodrigues on the beach of Jeantac at the end of January 2013. On Rodrigues Island, the presence of marine turtles had been noted since Pingre.

Kelly, I. K., LeFors, J., & Tosatto, M. D. (2014). *Environmental Assessment, Marine Turtle Management and Conservation Program (Mtmcp)*. Retrieved from https://repository.library.noaa.gov/view/noaa/4949

This Environmental Assessment (EA) was prepared in accordance with National Environmental Policy Act of 1969 (42 U.S.C. '4321, et seq.), as implemented by the Council of Environmental Quality regulations (40 C.F.R. '1500-1508); and NOAA Administrative Order Series (NAO) 216-6, Environmental Review Procedures for Implementing the National Environmental Policy Act, of May 20, 1999. Executive Order (EO) 12114 furthers the purpose of NEPA with respect to the environment outside the United States, its territories and possessions; accordingly, this EA also analyzes potential impacts of the proposed action to foreign territorial seas in accordance with the EO as implemented by Department Administrative Order 216-12. The green, hawksbill, loggerhead, leatherback, and olive ridley sea turtles are all listed as threatened or endangered under section 4(c) of the Endangered Species Act of 1972 (16 U.S.C. '1531, et seq.). Under the proposed action, the Marine Turtle Management and Conservation Program (MTMCP) proposes to continue and expand funding of projects for monitoring, conservation, and management activities in the U.S. Insular Areas of the Pacific Islands Region (PIR) and internationally as relevant (i.e., of populations with documented linkages to the PIR). These projects would be funded to collect biological and ecological data on marine turtle populations, reduce or mitigate anthropogenic and environmental impacts (including projects working to reduce fishery interactions), support community-based educational outreach, and/or collaborate with marine turtle researchers and managers to build capacity for the protection, conservation, and management of Pacific sea turtles and their habitats. The potential impacts on the human environment of the proposed action, and a range of reasonable alternatives, are discussed and analyzed in this EA.

Liles, M. J., Peterson, M. J., Lincoln, Y. S., Seminoff, J. A., Gaos, A. R., & Peterson, T. R. (2015). Connecting International Priorities with Human Wellbeing in Low-Income Regions: Lessons from Hawksbill Turtle Conservation in El Salvador. *Local Environment, 20*(11), 1383-1404 https://doi.org/10.1080/13549839.2014.905516

Hawksbill turtles (*Eretmochelys imbricata*) are highly endangered in the eastern Pacific Ocean, yet their eggs continue to be an important subsistence resource for impoverished coastal residents in El Salvador. In this study, we use naturalistic inquiry to explain the realities experienced by coastal residents who share habitat with hawksbills in El Salvador, and then suggest implications of the disparities between these realities and international priorities for hawksbill conservation and community development in El Salvador and other low-income regions. To provide a context for understanding hawksbill conservation and its implications for similar challenges related to conservation and wellbeing, we first summarise the conservation context, including the emergence of sea turtle conservation in El Salvador. We then describe our naturalistic approach, including the ethnographic methodology for this study. Finally, we detail the analysis of interviews conducted with tortugueros (i.e. local sea turtle egg collectors), to help explain how hawksbills fit into local realities. Our results demonstrate that, from the perspective of tortugueros, (1) the primary importance of hawksbills is the economic value attached to egg sales, but there exists a deeper connection to local culture; (2) egg purchase by hatcheries is a socially just conservation strategy that benefits both hawksbill and human wellbeing; and (3) opportunities for local residents to participate in decision-making regarding sea turtle conservation are limited, and should be increased. We argue that harmonising international conservation priorities with local community development realities is one path towards simultaneously contributing to long-term sea turtle recovery and human wellbeing in low-income regions.

Liles, M. J., Peterson, M. J., Seminoff, J. A., Altamirano, E., Henríquez, A. V., Gaos, A. R., . . . Peterson, T. R. (2015). One Size Does Not Fit All: Importance of Adjusting Conservation Practices for Endangered Hawksbill Turtles to Address Local Nesting Habitat Needs in the Eastern Pacific Ocean. *Biological Conservation, 184*, 405-413 https://doi.org/10.1016/j.biocon.2015.02.017

Conservation biologists frequently use data from the same or related species collected in diverse geographic locations to guide interventions in situations where its applicability is uncertain. There are dangers inherent to this approach. The nesting habitats of critically endangered hawksbill sea turtles (*Eretmochelys imbricata*) cover a broad geographic global range. Based on data collected in the Caribbean and Indo-Pacific, conservationists assume hawksbills prefer open-coast beaches near coral reefs for nesting, and that individual hawksbills are highly consistent in nest placement, suggesting genetic factors partially account for variation in nest-site choice. We characterized nest-site preferences of hawksbills in El Salvador and Nicaragua, where >80% of nesting activity occurs for this species in the eastern Pacific, and ~90% of hawksbill clutches are relocated to hatcheries for protection. We found hawksbills preferred nest sites with abundant vegetation on dynamic beaches within mangrove estuaries. Nests in El Salvador were located closer to the ocean and to the woody vegetation border than nests in Nicaragua, suggesting female hawksbills exhibit local adaptations to differences in nesting habitat. Individual hawksbills consistently placed nests under high percentages of overstory vegetation, but were not consistent in nest placement related to woody vegetation borders. We suggest conservation biologists use caution when generalizing about endangered species that invest in specific life-history strategies (e.g., nesting) over broad ranges based on data collected in distant locations when addressing conservation issues.

Long, S. L., & Azmi, N. A. (2017). Using Photographic Identification to Monitor Sea Turtle Populations at Perhentian Islands Marine Park in Malaysia. *Herpetological Conservation and Biology, 12*(2), 350-366 Retrieved from http://www.herpconbio.org/Volume_12/Issue_2/Long_Azmi_2017.pdf

Perhentian Islands Marine Park is home to foraging and nesting Green Turtles (*Chelonia mydas*) and Hawksbill Turtles (*Eretmochelys imbricata*) but little information is available other than nesting trends and hatching success. We used photographic identification (photo-ID) methods to identify individuals and to determine their sex ratios, habitat use, and site fidelity. We collected 1,826 sightings between 2009 and 2015 from conservation projects (998 in-water sightings, 184 nesting sightings) and members of the public (639 in-water sightings, five nesting sightings), and used NaturePatternMatch (NPM) software and manual visual matching to identify individuals. We identified 120 (minimum) to 131 (maximum) individual Green Turtles, including a maximum of 17 males, 58 females and 56 turtles of unknown sex from both in-water and nesting beach sightings. We identified 20 (minimum) to 23 (maximum) individual Hawksbills of unknown sex from in-water sightings. Green Turtles were sighted most frequently at seagrass beds and Hawksbills only among coral reefs. We resighted 47 Greens and eight Hawksbills between one and 144 times (mean = 23.1 times). Nesting Greens also showed strong site fidelity, although the nesting home range for some individuals included different beaches on adjacent islands within approximately 30 km. We identified boat-related injuries in eight turtles and mortalities of two turtles. Our study suggests that photographs from conservation projects and members of the public were appropriate for photo-ID to provide information on the turtle populations in the Perhentian Islands Marine Park.

Lopez, G. G., Sallies, E. D., Lara, P. H., Tognin, F., Marcovaldi, M. A., & Serafini, T. Z. (2015). Coastal Development at Sea Turtles Nesting Ground: Efforts to Establish a Tool for Supporting Conservation and Coastal Management in Northeastern Brazil. *Ocean & Coastal Management, 116*, 270-276 https://doi.org/10.1016/j.ocecoaman.2015.07.027

While tropical and subtropical coastal areas are considered prime areas for a wide range of tourism projects, they also host important sea turtle nesting grounds. Preserving these nesting areas is critical to ensure reproductive success and maintain viable sea turtle populations. The northern coast of the State of Bahia, in northeastern Brazil, is an important sea turtle nesting ground. Sea turtle conservation activities in Brazil began in 1980, focusing initially on reducing harvesting of nesting females and egg collection. Recently, new threats resulting from unplanned coastal development have emerged. In this paper, a geospatial tool, as an initiative of the Brazilian National Sea Turtle Conservation Program (TAMAR) to identify key areas for sea turtle nesting along the coast northern coast of Bahia, is presented. A Sensitivity Map was created, using a detailed GIS map graded by colors representing relevance levels of the coast for sea turtle nesting. From this map, recommendations of management practices that correspond to each sensitivity category can be made. This methodology allows for the identification of critical sea turtle habitats and the subsequent implementation of mitigation measures at nesting beaches, as well support coastal management policies.

Mangel, J. C., Rees, A., Pajuelo, M., Córdova, F., & Acuña, N. (2019). *Proceedings of the Thirty-Sixth Annual Symposium on Sea Turtle Biology and Conservation*. Miami, FL https://doi.org/https://doi.org/10.25923/ng2d-c375

The 36th Annual Symposium on Sea Turtle Biology and Conservation was held in the City of Lima, Peru from February 29 to March 4, 2016. This year the Symposium's theme was Crossroads, highlighting the need for multi-disciplinary, multi-taxa, multi-national, and multi-gender efforts in advancing marine conservation worldwide. This meeting aimed to break down barriers and boundaries between people and countries in order to achieve marine conservation through its most global flagship, the sea turtle.

Mazaris, A. D., Schofield, G., Gkazinou, C., Almpanidou, V., & Hays, G. C. (2017). Global Sea Turtle Conservation Successes. *Science Advances, 3*(9), e1600730 https://doi.org/10.1126/sciadv.1600730

We document a tendency for published estimates of population size in sea turtles to be increasing rather than decreasing across the globe. To examine the population status of the seven species of sea turtle globally, we obtained 299 time series of annual nesting abundance with a total of 4417 annual estimates. The time series ranged in length from 6 to 47 years (mean, 16.2 years). When levels of abundance were summed within regional management units (RMUs) for each species, there were upward trends in 12 RMUs versus downward trends in 5 RMUs. This prevalence of more upward than downward trends was also evident in the individual time series, where we found 95 significant increases in abundance and 35 significant decreases. Adding to this encouraging news for sea turtle conservation, we show that even small sea turtle populations have the capacity to recover, that is, Allee effects appear unimportant. Positive trends in abundance are likely linked to the effective protection of eggs and nesting females, as well as reduced bycatch. However, conservation concerns remain, such as the decline in leatherback turtles in the Eastern and Western Pacific. Furthermore, we also show that, often, time series are too short to identify trends in abundance. Our findings highlight the importance of continued conservation and monitoring efforts that underpin this global conservation success story.

National Fish and Wildlife Foundation. (2019). *Sea Turtle Business Plan.* Retrieved from https://www.nfwf.org/sites/default/files/seaturtles/Documents/sea-turtle-business-plan.pdf

The purpose of a National Fish and Wildlife Foundation (NFWF) business plan is to provide a concise blueprint of the strategies and resources required to achieve the desired conservation outcomes. The strategies discussed in this plan do not represent solely the foundation's view of the actions necessary to achieve the identified conservation goals, but instead reflect the view of the many federal, state, academic, and organizational experts that were consulted during plan development. This plan is not meant to duplicate ongoing efforts, but rather to invest in areas where gaps might exist so as to support the efforts of the larger conservation community.

Nivière, M., Chambault, P., Pérez, T., Etienne, D., Bonola, M., Martin, J., . . . Chevallier, D. (2018). Identification of Marine Key Areas across the Caribbean to Ensure the Conservation of the Critically Endangered Hawksbill Turtle. *Biological Conservation, 223*, 170-180 https://doi.org/10.1016/j.biocon.2018.05.002

Acquisition of data on animal movement when developing management strategies is a common challenge in species conservation, especially when dealing with a critically endangered species as the hawksbill turtle *Eretmochelys imbricata*. To reach the objective of the 2008 national action plan for Martinique Island (French West Indies), the present paper examines horizontal and vertical movements

in juveniles (n = 3) and adults life stages (11 females and 2 males) of 16 hawksbill turtles. Our results reveal the strong site fidelity of individuals to their foraging grounds (mean male foraging home range: 89.3 ± 20.2 km2, mean female foraging home range: 336 ± 284.7 km2, mean juvenile foraging home range: 157.3 ± 71.2 km2) and to the females' inter-nesting areas (mean home range: 284.2 ± 523.7 km2). A spatial foraging overlap occurred between juveniles and males as they shared 41% of their 95% kernel foraging habitat. The turtles performed mainly long and shallow dives within the first 20 m deep around Martinique Island, occupying shallow waters close to shore. The migratory routes of the adult females revealed regional connectivity between the Caribbean islands, crossing 31 exclusive economic zones and international waters, and featuring distinct foraging grounds. This finding reinforces the significance of a cooperative network at the Caribbean scale to ensure the efficient conservation of this critically endangered species.

Olendo, M. I., Okemwa, G. M., Munga, C. N., Mulupi, L. K., Mwasi, L. D., Mohamed, H. B., . . . Ong'anda, H. O. (2019). The Value of Long-Term, Community-Based Monitoring of Marine Turtle Nesting: A Study in the Lamu Archipelago, Kenya. *Oryx, 53*(1), 71-80 https://doi.org/10.1017/S0030605317000771

Monitoring of nesting beaches is often the only feasible and low-cost approach for assessing sea turtle populations. We investigated spatio-temporal patterns of sea turtle nesting activity monitored over 17 successive years in the Lamu archipelago, Kenya. Community-based patrols were conducted on 26 stretches of beach clustered in five major locations. A total of 2,021 nests were recorded: 1,971 (97.5%) green turtle *Chelonia mydas* nests, 31 (1.5%) hawksbill *Eretmochelys imbricata* nests, 8 (0.4%) olive ridley Lepidochelys olivacea nests and 11 (0.5%) unidentified nests. Nesting occurred year-round, increasing during March–July, when 74% of nests were recorded. A stable trend in mean annual nesting densities was observed in all locations. Mean clutch sizes were 117.7 ± SE 1 eggs (range 20–189) for green turtles, 103 ± SE 6 eggs (range 37–150) for hawksbill turtles, and 103 ± SE 6 eggs (range 80–133) for olive ridley turtles. Curved carapace length for green turtles was 65–125 cm, and mean annual incubation duration was 55.5 ± SE 0.05 days. The mean incubation duration for green turtle nests differed significantly between months and seasons but not locations. The hatching success (pooled data) was 81.3% (n = 1,841) and was higher for in situ nests (81.0 ± SE 1.5%) compared to relocated nests (77.8 ± SE 1.4%). The results highlight the important contribution of community-based monitoring in Kenya to sustaining the sea turtle populations of the Western Indian Ocean region.

Revuelta, O., Hawkes, L., Leon, Y. M., Godley, B. J., Raga, J. A., & Tomas, J. (2015). Evaluating the Importance of Marine Protected Areas for the Conservation of Hawksbill Turtles *Eretmochelys imbricata* Nesting in the Dominican Republic. *Endangered Species Research, 27*(2), 169-180 https://doi.org/10.3354/esr00660

Understanding spatial and temporal habitat-use patterns to protect both foraging and breeding grounds of species of concern is crucial for successful conservation. Saona Island in Del Este National Park (DENP), south-eastern Dominican Republic (DR), hosts the only major hawksbill (*Eretmochelys imbricata*) nesting area in the DR (100 nests yr(-1), SD = 8.4, range = 93-111), with the population having been critically reduced through hunting. We satellite tracked 9 female hawksbill turtles, and present analyses of their core-use areas with respect to Marine Protected Areas (MPAs) in both their internesting and foraging areas. Kernel utilization distributions indicated that during the internesting period all turtles remained close to their nesting beaches in small home ranges in the territorial waters of the DR, mostly

over the continental shelf (< 200 m depth). Common core-use areas were located inside the DENP, and 82.7% of all locations were within the DENP. In foraging areas, only 23% of locations were inside MPAs, either in waters of the DR or in waters of the Bahamas, Nicaragua and Honduras. Our results highlight that the protected areas of the DR are vital for hawksbill conservation, and the enforcement of existing legislation governing protected areas in the country is crucial. The present study also corroborates that the waters off Nicaragua and Honduras are exceptionally important foraging areas for hawksbills in the Caribbean, showing the turtle's vulnerability in these waters.

Revuelta, O., León, Y. M., Aznar, F. J., Raga, J. A., & Tomás, J. (2013). Running against Time: Conservation of the Remaining Hawksbill Turtle (*Eretmochelys imbricata*) Nesting Population in the Dominican Republic. *Marine Biological Association of the United Kingdom. Journal of the Marine Biological Association of the United Kingdom, 93*(4), 1133-1140 https://doi.org/10.1017/S0025315412001518

Saona Island hosts the last hawksbill turtle (*Eretmochelys imbricata*) nesting population in the Dominican Republic, which has experienced a severe decline in the last decades, mostly due to illegal egg take. Here we present the results of an artificial incubation programme started in 2007 to protect the clutches from human predation. A preliminary survey in 2006 showed that about 60% of clutches laid were taken by humans. Over the study period (2007-2010) we recorded 400 clutches, of which 38.2% were predated by humans, 40.7% were artificially incubated and 21% were incubated in situ. Overall, the artificial incubation programme allowed the release of 12,340 hatchlings. No differences were found in hatching and emergence success between clutches incubated in situ and clutches artificially incubated. However, incubation temperatures and incubation durations recorded suggest a male-biased hatchling sex-ratio in artificially incubated clutches. Although artificial incubation may mitigate the effect of egg take, our results indicate that other measures, such as clutch relocation to protected sections of the beach should be taken. Beach patrolling and education are currently implemented so that artificial incubation will be eventually phased out in favour of in situ incubation.

Ribeiro, A. B. N., Barreto, L., Ribeiro, L. E. D., & Azevedo, R. R. (2014). Conservation Aspects of Sea Turtles in Maranhao Island, Sao Luis, Brazil. *Bioscience Journal, 30*(3), 874-878 Retrieved from http://www.seer.ufu.br/index.php/biosciencejournal/article/view/14004

In order to obtain information about the species of sea turtles that occur on the island of Maranhao, Sao Luis, surveys were started through observations of catching and stranding of these animals in partnership with fishing communities, from June 2006 to October 2007. There are five species of sea turtles that inhabit the coastal area of Brazil and all of them were observed in Maranhao Island, Sao Luis, such as: loggerhead turtle (*Caretta caretta*), hawksbill turtles (*Eretmochelys imbricata*), leatherback turtle (Dermochelys coriacea), olive turtle (Lepidochelys olivacea) and green turtle (*Chelonia mydas*). It was observed puppies newly hatched of E. imbricata (indicating reproductive activity). All adult and juvenile specimens found dead or alive were observed with some injury due fishing artifacts such as fishing gill, fishing nets, long lines or knife blows on the head or on the hull. These animals are at risk of extinction due to the consumption by fishing communities, caused by catch and the lack of information of the fishermen how to manage the returning of the animals to the sea. For this reason, conservation efforts for these animals should focus not only on reproductive activity, but in raising awareness of illegal fishing and consumption by the fishing communities along the coastal zone. In this aspect, the importance of this work was to delineate the main impacts on these animals to improve the protection

at the beaches and the fishing activities on the Island. The results of this research may lead to the intensification of efforts to conserve these species in the coastal zone of all the island of Maranhao, including also the municipalities of Sao Jose de Ribamar, Paco do Lumiar and Raposa to insert them at the national conservation program of endangered species.

Robson, N. A., Hetzel, Y., Whiting, S., Wijeratne, S., Pattiaratchi, C. B., Withers, P., & Thums, M. (2017). Use of Particle Tracking to Determine Optimal Release Dates and Locations for Rehabilitated Neonate Sea Turtles. *Frontiers in Marine Science* https://doi.org/10.3389/fmars.2017.00173

Sea turtles found stranded on beaches are often rehabilitated before being released back into the wild. The location and date of release is largely selected on an informal basis, which may not maximise the chance of survival. As oceanic conditions have a large influence on the movements of neonate sea turtles, this study aimed to identify the best locations and months to release rehabilitated sea turtles that would assist in their transport by ocean currents to the habitat and thermal conditions required for their survival. A particle tracking model, forced by ocean surface velocity fields were used to simulate the dispersal pathways of millions of passively drifting particles released from different locations in Western Australia. The particles represented rehabilitated, neonate turtles requiring oceanic habitats (green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and loggerheads (*Caretta caretta*)) and flatback turtles (Natator depressus) which require neritic habitats. The results clearly identified regions and months where ocean currents were more favourable for transport to suitable habitats. Tantabiddi, near Exmouth on the north-west coast, was consistently the best location for release for the oceanic species, with dominant offshore-directed currents and a very narrow continental shelf reducing the time taken for particles to be transported into deep water. In contrast, release locations with more enclosed geography, wide continental shelves, and/or proximity to cooler ocean temperatures were less successful. Our results produced a decision support system for the release of neonate marine turtles in Western Australia and our particle tracking approach has global transferability.

Schut, K., Nava, M., & Rivera-Milán, F. F. (2019). *Research and Monitoring of Bonaire's Sea Turtles: 2018 Technical Report.* Sea Turtle Conservation Bonaire Retrieved from http://www.bonaireturtles.org/wp/wp-content/uploads/2019/04/STCB-Technical-Report-2018_FINAL.pdf

Sea Turtle Conservation Bonaire (STCB) has been protecting sea turtles on Bonaire since 1991, so this year represents the 27th Anniversary of our organization. In 2002, we standardized our research and monitoring efforts, following the appointment of a Scientific Officer. Annually we monitor our nesting beaches around Bonaire, conduct intensive netcapture and transect-count surveys, and we regularly track sub-adult and post-breeding migrations using satellite telemetry. These techniques provide us with a better understanding of Bonaire sea turtles' breeding success, abundance, health, growth rates, migratory paths and distant feeding grounds, residency duration, habitat quality, and threats. Following the analysis of our in-water transect counts, net captures, and nesting data by Scientific Advisor Dr. Frank Rivera-Milán, we implemented new methodologies in 2018 to allow estimation of sea turtle abundance. Some of the results are shared in this report.

SWOT Report: The State of the World's Sea Turtles. (2019)*, 14*. Retrieved from https://www.seaturtlestatus.org/swot-report-vol-14

No abstract

Velez-Zuazo, X., Mangel, J. C., Seminoff, J. A., Wallace, B. P., & Alfaro-Shigueto, J. (2017). Filling the Gaps in Sea Turtle Research and Conservation in the Region Where It Began: Latin America. *Latin American Journal of Aquatic Research, 45*(3), 501-505 https://doi.org/10.3856/vol45-issue3-fulltext-1

The studies cover diverse subjects including the nesting ecology for the most endangered populations of sea turtles in the world -the Eastern Pacific hawksbill turtle (*Eretmochelys imbricata*) and leatherback turtle (Dermochelys coriacea); the origins and connectivity of nesting and foraging populations of hawksbills and green turtles (*Chelonia mydas*); the detection of a new foraging ground for hawksbills in the Eastern Pacific; and the pervasive occurrence of incidental capture as well as illegal retention of sea turtles. Here, Dr. Carr started a pivotal long-term study to investigate basic aspects of the biology and ecology of the nesting population of green sea turtles (*Chelonia mydas*) (Carr & Ogren, 1960), thus setting the stage for future efforts in Latin America. All five sea turtle species present in Latin America are listed, either at the species or population-level in a threatened category by the IUCN Red list (www. iucnredlist.org, Table 1). Many nesting populations of leatherback turtles in the Caribbean have experienced significant increases after years of conservation efforts and are considered as Least Concern by the Red List (Tiwari et al., 2013), while EP green turtles and olive ridleys are also increasing in abundance following historic depletions (Plotkin et al., 2012; Delgado-Trejo & Alvarado-Figueroa, 2012). Separate populations of loggerhead turtles traverse the Pacific Ocean during their life history, tracking oceanic gyres between nesting and foraging grounds in the North and South Pacific Oceans (Bowen et al., 1995; Boyle et al., 2009). [...]despite the tremendous discoveries made since the first studies began many decades...

Walcott, J., & Horrocks, J. A. (2014). Design of a Protected Area for Inter-Nesting Hawksbills in Barbados: An Evidence-Based Approach. *Bulletin of Marine Science, 90*(4), 969-987 https://doi.org/10.5343/bms.2014.1033

To aid in the designation of a marine protected area for hawksbill sea turtles, *Eretmochelys imbricata* (Linnaeus, 1766), nesting at one of the largest rookeries in the Wider Caribbean Region (Needham's Point, Barbados), we elucidated key inter-nesting behaviors (i.e., the approximately 2-wk period of time spent at sea between nesting events) from published spatial, diving, and habitat utilization data, and the areas of overlap and potential conflict with anthropogenic uses of the coastal zone. Historically, much of the focus of conservation efforts for this species has been on protecting breeding females and their eggs from harvest, and more recently protection of nesting beaches. However, protecting the habitats in which these animals spend their inter-nesting interval and addressing the indirect anthropogenic mortality they are exposed to while in these nearshore habitats has received less attention. Despite a relatively small percentage of a hawksbill's life-cycle being spent in inter-nesting habitats, the relative value of adult females for population recovery and the vulnerability associated with large aggregations of females adjacent to rookeries makes this mature stage of their life-cycle one of high conservation priority.

Wieting, D. (2013). *Environmental Assesment on the Effects of Issuing Incidental Take Permit No. 16230 to the North Carolina Division of Marine Fisheries for the Incidental Take of Sea Turtles Associated with the Otherwise Lawful Commercial Inshore Gillnet Fishery in North Carolina Inshore State Waters*. Retrieved from https://repository.library.noaa.gov/view/noaa/4746

The National Marine Fisheries Service (NMFS) proposes to issue an incidental take permit (ITP) to the North Carolina Division of Marine Fisheries (NCDMF), under Section 10(a)(1)(B) of the Endangered Species Act (ESA) (16 U.S.C. 1531 et seq.), and the regulations governing the incidental taking of endangered and threatened species (50 CFR 222.307). The ITP would authorize the incidental capture, with some mortality, of five species of endangered and threatened sea turtles, including green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), Kemp's ridley (Lepidochelys kempii), leatherback (Dermochelys coriacea) and loggerhead (*Caretta caretta*) sea turtles, in the North Carolina inshore gillnet fishery and would be valid for ten years. Since 2000, NMFS has issued four separate incidental take permits to NCDMF for the incidental take of sea turtles in inshore gillnet fisheries occurring in Pamlico Sound. Since 2006, incidental take of sea turtles has been documented in areas outside Pamlico Sound, which are not covered under an existing ITP. In 2010, the Duke Environmental Law and Policy Clinic filed suit against NCDMF and the North Carolina Marine Fisheries Commission (NCMFC) on behalf of the Karen Beasley Sea Turtle Rescue and Rehabilitation Center (Beasley Center) for the illegal taking of sea turtles in state regulated inshore gillnet fisheries. As a result of the lawsuit and resulting settlement agreement, NCDMF has amended their commercial fishing regulations for their inshore gillnet fishery to minimize the incidental capture of sea turtles. NCDMF has also submitted a completed application to NMFS for an ESA Section 10(a)(1)(B) ITP, including a conservation plan, for the operation of the state-wide inshore gillnet fishery with measures intended to further monitor, minimize, and mitigate the impacts of incidental take in the fishery to the maximum extent practicable.

Wildermann, N. E., Gredzens, C., Avens, L., Barrios-Garrido, H. A., Bell, I., Blumenthal, J., . . . Fuentes, M. (2018). Informing Research Priorities for Immature Sea Turtles through Expert Elicitation. *Endangered Species Research, 37*, 55-76 https://doi.org/10.3354/esr00916

Although sea turtles have received substantial focus worldwide, research on the immature life stages is still relatively limited. The latter is of particular importance, given that a large proportion of sea turtle populations comprises immature individuals. We set out to identify knowledge gaps and identify the main barriers hindering research in this field. We analyzed the perceptions of sea turtle experts through an online survey which gathered their opinions on the current state of affairs on immature sea turtle research, including species and regions in need of further study, priority research questions, and barriers that have interfered with the advancement of research. Our gap analysis indicates that studies on immature leatherback Dermochelys coriacea and hawksbill *Eretmochelys imbricata* turtles are lacking, as are studies on all species based in the Indian, South Pacific, and South Atlantic Oceans. Experts also perceived that studies in population ecology, namely on survivorship and demography, and habitat use/behavior, are needed to advance the state of knowledge on immature sea turtles. Our survey findings indicate the need for more interdisciplinary research, collaborative efforts (e.g. data-sharing, joint field activities), and improved communication among researchers, funding bodies, stakeholders, and decision-makers.

Williams, J. L., Pierce, S. J., Fuentes, M. M. P. B., & Hamann, M. (2015). Effectiveness of Recreational Divers for Monitoring Sea Turtle Populations. *Endangered Species Research, 26*(3), 209-219 https://doi.org/10.3354/esr00647

Five sea turtle species, all globally threatened, are found in southern Mozambican waters. Illegal hunting of foraging turtles, nest raiding and modification of coastal habitat are assumed to affect local sea turtle populations, but a lack of capacity and resource constraints hamper monitoring and compliance activities. Enlisting the recreational SCUBA diving community to report sea turtle sightings is a potential solution for population monitoring. The effectiveness of recreational divers as monitors was tested through the review of 2 approaches: the use of a routine dive logbook with sightings, and data from a dedicated survey. These approaches provided 37 consecutive months of data between 2008 and 2011 from dive sites in Inhambane Province, Mozambique. A total of 317 sightings of loggerhead *Caretta caretta*, green *Chelonia mydas*, hawksbill *Eretmochelys imbricata* and unidentified turtle species were reported from 918 dives. While the dedicated survey collected more detailed behavioural data (e.g. response to divers and feeding behaviour), independent logbook records provided a more robust data set for analysis of sighting trends. Useful data on sea turtle species composition, size and distribution were obtained from both approaches, although there were concerns with regard to species identification and size estimates. With refined methodology, particularly the incorporation of photographic verification of species identification, reports from divers can provide cost-effective and useful data for monitoring foraging turtle populations.