



NOAA Technical Memorandum NMFS-SEFSC-701

doi:10.7289/V5/TM-SEFSC-701

PROCEEDINGS OF THE THIRTY-FOURTH ANNUAL SYMPOSIUM ON SEA TURTLE BIOLOGY AND CONSERVATION



2014 INTERNATIONAL SEA TURTLE SYMPOSIUM

✿ NEW ORLEANS, LOUISIANA, USA ✿

14 to 17 April, 2014
New Orleans, Louisiana USA

Compiled by:

Lisa Belskis, Amy Frey, Michael Jensen, Robin LeRoux, and Kelly Stewart

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, Florida 33149

December 2016

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December 2016

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For bibliographic purposes, this document should be cited as follows:

Belskis, L., Frey, A., Jenson, M., LeRoux, R., and Stewart, K. compilers. 2016. Proceedings of the Thirty-Fourth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NOAA NMFS-SEFSC-701: 262p. doi:10.7289/V5/TM-SEFSC-701

Technical Editor:
Lisa Belskis

A PDF version is available at <http://www.sefsc.noaa.gov/species/turtles/techmemos.htm>

Copies may be obtained by writing

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TABLE OF CONTENTS

Page #	
	PRESIDENT’S REPORT.....iv
	COMMITTEES, ORGANIZERS AND BOARD OF DIRECTORS.....vi
	SPONSORS AND CONTRIBUTORS.....viii
	STUDENT AWARDS.....ix
	ISTS AWARDS 2014.....xi
	SPECIAL FEATURES.....xi
	WORKSHOPS.....xi
	ABSTRACTS
	Opening Remarks and Keynotes.....1
	Anatomy, Physiology and Health.....4
	Collaborative Fisheries Research and Mitigating Marine Turtle Bycatch: Special Session.....40
	Conservation, Management and Policy.....43
	Education, Outreach and Advocacy.....77
	Fisheries and Threats.....91
	Genetics and Population Biology.....117
	In-Water Biology.....144
	Nesting Biology.....189
	Research Highlights from Southeast U.S.A.....221
	Sea Turtle Biology and Conservation in the Gulf of Mexico: Special Session.....230
	Social, Economic and Cultural Studies.....241
	Video Presentations.....250
	Author Index.....253

Abstract titles marked with an * at the end of the title denote an Oral Presentation.



2014 INTERNATIONAL
SEA TURTLE SYMPOSIUM
✦ NEW ORLEANS, LOUISIANA, USA ✦

PRESIDENT'S REPORT

34rd Annual Symposium on Sea Turtle Biology and Conservation

10-17 April 2014, New Orleans, Louisiana, USA

Roldán A. Valverde, President, ISTS

A total of 785 people from 73 countries registered for the Symposium. The venue for the symposium was the Marriott Hotel on Canal Street, New Orleans. A total of 176 oral papers and 273 posters were originally submitted to organizers. These original submissions included the highest number of oral presentations on in-water biology science ever submitted to a symposium, with a total of 35, or approximately 20% of all oral presentations originally submitted. Due to normal attrition associated with every symposium, in the end the symposium included a total of 158 oral presentations in general sessions and a total of 235 posters. Of the oral presentations, 32 (20%) corresponded to in-water biology research, more than any other category presented in this symposium.

Travel grants: A total of 119 registrants received a travel grant to the New Orleans symposium (12 from Africa, 13 from US/Canada, 5 from English Caribbean, 4 from South Asia, 8 from Asia Pacific, 16 from South America, 6 from Europe, 23 from Mexico-Central America, 32 others). This level of travel grant awards represents about 15% of the total registered participants. Travel grants took the form of room grants, which was highly advantageous for the awardees and for the ISTSociety. Room awards contributed a total of about 561 room nights, which made a significant contribution to our hotel's room block. Because rooms were awarded to a group and not to individuals the organizing committee was able to serve more people in a more effective way. Also, this strategy saved our Treasurer the time and effort to write checks and keep track of the awards, and gave the ISTSociety better control over how the grants are assigned and used, thus increasing efficiency and effectiveness of the awards.

Pre-symposium Meetings Workshops: A total of eight Special Interest and Regional meetings were held prior to the main symposium. These were the Terrapin, Tortoise & Freshwater Meeting, the RETOMALA, the Africa Regional, the Mediterranean Regional, the East Asia Regional, Indian Ocean South East Asia Regional, the Pacific Islands Region-Oceania, Eastern Pacific Hawksbill Initiative and the Marine Turtle Specialist Group. These meetings were successful and contributed to bring attendees early to the symposium. A total of five workshops were offered before the symposium. These were the Sea Turtle Rehabilitation and Health Workshop (with a total of 237 registered participants), the Educators Outreach Workshop (with 18 local, national and international participants), the Digital Marketing Workshop (with 83 participants), the GIS Workshop with 197 participants, and the Temperature-dependent Sex Determination Workshop (with 151 participants).

Key Note Speakers: Three Key Note speakers delivered three 30 minutes addresses to symposium participants. Jack Frazier's presentation gave the audience a comprehensive overview of the topic Sea Turtles and Cultures, which nicely served to frame the theme of the symposium. Duncan MacKenzie immediately

followed Jack's presentation, speaking about the pros and cons of using sea turtles as animal models to conduct physiological studies. Lastly, David Owens delivered an enthusiastic, informative and entertaining speech about the history of sea turtle research and the historical involvement of women in this research. All three speeches were excellent and very well received by the audience.

Symposium Sessions: Two special sessions were held during the symposium: Biology and Conservation of the Sea Turtles of the Gulf of Mexico and Collaborative Fisheries Research. The first session focused on work conducted in the Gulf of Mexico and was held the first day of the symposium. This session included papers from the entire Gulf (Mexican and US waters), and offered an emphasis on in-water work. The second special session on collaborative fisheries focused on work being done by scientists in collaboration with fishermen to collect fisheries-specific information and promote effective conservation and management practices among fishermen.

Business Meeting: Very important issues were addressed during the plenary business meeting conducted the last day of the New Orleans symposium. One of the most important issues was the approval of the overhauled Constitution and Bylaws of the Society. Other issues discussed were the travel committee report, the Treasurer's report and the Resolutions submitted, among others.

Social Events: Welcome Social, Live and Silent Auctions, Farewell party, Student Awards were some of the social events held during the symposium. Among those events, a Speed Chatting with Experts event was held the night of the first day of the meeting. Of all these vents, the Welcome Social held the night before the first day of the symposium was arguably the most popular. This included a surprise Mardi Gras-style parade with a second line Jazz band guiding symposium attendees over the streets of New Orleans.

Resolutions: A very important component of the every symposium is the issuing of Resolutions, documents that allow the IST Society at large to pronounce itself with regard to issues pertaining to sea turtle conservation around the world. Two very important resolutions were passed during the New Orleans symposium: The first resolution was relayed to the Australian Minister of the Environment, Hon Greg Hunt regarding the protection of sea turtle populations in the Great Barrier Reef region. The second resolution was sent to the President of Mexico Enrique Peña Nieto and pertained to the protection of loggerheads in Baja California, Mexico. Receipt of letters was acknowledged and press notices regarding these letters appeared in Australian and Mexican newspapers.

Finances: Society's finances were a major concern going into the New Orleans symposium. Indeed, during the plenary business meeting we learnt that the Society's finances were in worse shape than originally thought. Fortunately, thoughtful planning by the Society's Board and effective execution by the organizing committee resulted in a very successful symposium, both scientifically and financially. After paying for all our obligations incurred prior and during the symposium, our revenues were sufficient to overcome past debts and leave us in a solvent situation. Hopefully, the model developed for the New Orleans symposium will be adopted for future symposia.

The financial success achieved in New Orleans was due to a series of measures taken. For instance, historical but expensive items, such as simultaneous translation and exceedingly high travel grant levels were significantly reduced or eliminated. Also, the New Orleans symposium was held as a joint meeting with the Southeast Regional Sea Turtle Network, which eliminated any competition for resources. Additionally, important sponsorship was secured from major donors, such as Shell and the National Federation of Wildlife and Fisheries, as well as the Marine Turtle Conservation Act of the USFWS, and the National Atmospheric Aeronautic Administration. Also importantly, organizers were able to secure sponsorship from the Virginia Institute of Marine Science to cover all meeting expenses for one entire day of the Symposium (CFR session), which significantly reduced our costs. Significantly, the organizing committee was able to partner with Southeastern Louisiana University, which allowed us to receive tax-exempt status in Louisiana, among other measures. Finally, significant assistance from The Zenith Group, our contracted meeting provider, made it possible for us to realize significant savings on hotel expenses.

EXECUTIVE COMMITTEE

President	Roldán Valverde
Secretary	Manjula Tiwari
Treasurer	Terry Meyer
President-Elect	Yakup Kaska
Past President	Ray Carthy

ORGANIZING COMMITTEE

Activity Coordinator	Emma Harrison
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Event Coordinator	Kate Walsh Donna Broadbent
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Student Judge Committee Chairs	Matthew Godfrey Andrea Phillott
Volunteer Co-Chairs	Kimberly Smelker Sara Webb

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Program Co-Chairs	Kelly Stewart Michael Jensen
Poster Co-Chairs	Jane Provanca Barbara Schroeder
Video Night Chair	Katherine Comer Santos
New Orleans Local Coordinators	Lisa Rodriguez Stephanie Wolfe Erin Thomas
Proceedings Compilers	Lisa Belskis Amy Frey Michael Jensen Robin LeRoux
Program Coordinators	Kelly Stewart Robin LeRoux Katy Garland

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Regional Chair - Africa	Angela Formia
Regional Chair – Caribbean (English speaking)	Karen Eckert
Regional Chair - Europe	Aliki Panagopoulou
Regional Chair – Mexico and Central America, Spanish-speaking Caribbean	Emma Harrison
Regional Chair – Middle East	ALan Rees
Regional Chair – South America	Alejandro Fallabrino
Regional Chair – South Asia	Andrea Phillott
Regional Chair –Southeast Asia/Pacific	Maggie Muurmans
Regional Chair – USA and Canada	Kelly Stewart

MEETING AND WORKSHOP ORGANIZERS

Africa	Manjula Tiwari Jacques Fretey Angela Formia
Caribbean (WIDECAST) Freshwater Turtle and Tortoise IUCN Marine Turtle Specialist Group (MTSG)	Karen Eckert Chuck Shaffer Roderic B. Mast Nicolas J. Pilcher
Indian Ocean & Southeast Asia (IOSEA)	Lalith Ekanayake Nadia Swidan
Latin America Meeting (RETOMALA)	Juan Manuel Rodrigues Ninive Espinosa Rocio Alvarez
Mediterranean East Asia Meeting Education Workshop	Paolo Casale Asuka Ishiazaki Frances Kinney Karen Burns Lisa Landry
Sea Turtle Medicine Workshop Digital Marketing Workshop GIS Workshop TSD Workshop	Daniela Freggi Miguel da Silva Andrew DiMatteo Marc Girondot

BOARD OF DIRECTORS AND THEIR END OF TERM

Jack Frazier	2014
Mark Hamann	2014
Cynthia Lagueux	2015
Roldan Valverde	2015
Paolo Casale	2016
Aliki Panagopoulou	2016
George Balasz	2017
Alejandro Fallabrino	2017
Pam Plotkin	2018
Emma Harrison	2018
Jeff Seminoff (past president 2011)	2014
Ana Baragan (past president 2012)	2015
Ray Carthy (past president 2013)	2016

SPONSORS AND CONTRIBUTORS

The International Sea Turtle Society gratefully acknowledges the generous financial support from the following organizations and individuals:



2014 INTERNATIONAL
SEA TURTLE SYMPOSIUM
NEW ORLEANS, LOUISIANA, USA

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Marydele Donnelly Kiki Jenkins
ProFaunaBaja - ASUPMATOMA Usagi Family
Mission: Clean Beaches

STUDENT AWARDS

There were 54 oral presentations and 92 poster presentations entered by students in the Archie Carr Prize Competition. The Program Chairs worked closely with the Student Award Chairs to minimize conflicting student presentation times, thereby ensuring all student presentations were seen by the judges. The Symposium President graciously provided space and lunch for the judges during their final meeting.

Judges of the presentations in New Orleans were:

Larisa Avens, Ana Barragan, Cathi Campbell, Wendy Dow Piniak, Mariana Fuentes, Marc Girondot, Caroline Good, Emma Harrison, Jen Keller, Cynthia Lagueux, Ann Marie Lauritsen, Kate Mansfield, Zoë Meletis, Dave Owens, Erin Seney and Brian Shamblin.

The winners of the student awards included two undergrad presenters (noted in the table below). Students receiving awards were from universities in the USA, Australia and Spain.

Award amounts: Winners = US \$300 each, Runners-up = US \$150 each. Grand total for all student awards = US \$2100.

Student Awards for Poster Presentations at ISTS34, New Orleans, USA:

Category	Format	Prize	Student	Institution	Title
Biology	Poster	Winner	Eric Parks (<u>undergrad</u>)	Savannah State University, USA	Analysis of trace element composition of loggerhead sea turtle bone via laser ablation
Biology	Poster	Runner up	Celine Mollet Saint Benoit (<u>undergrad</u>)	University of Central Florida, USA	No news is good news. Juvenile marine turtles unaffected by HABs in Indian River Lagoon, Florida
Biology	Poster	Runner up	Cristian Ramirez-Gallego	University of Puerto Rico, USA	Genetic diversity of leatherback turtles from Puerto Rico
Conservation	Poster	Winner	Meghan Gahm	University of Rhode Island, USA	Reducing sea turtle mortality in the Mid-Atlantic and Southern New England summer flounder trawl fishery
Conservation	Poster	Runner up	Kimberly Riskas	James Cook University, Australia	Patterns of marine turtle bycatch reported in commercial fisheries logbooks, Australia

Student Awards for Oral Presentations at ISTS34, New Orleans, USA:

Category	Form at	Prize	Student	Institution	Title
Biology	Oral	Winner	Cali Turner Tomaszewicz	University of California, San Diego, USA	Habitat use of North Pacific loggerhead turtles and duration spent in a high-bycatch area near Baja California using skeletochronology and stable isotope analysis
Biology	Oral	Runner up	Melanie Lopez-Castro	University of Florida, USA	Evaluation of scute thickness to infer life history records in the carapace of green and loggerhead turtles
Biology	Oral	Runner up	Nathan Robinson	Perdue University, USA	Revealing the migratory behavior of nesting leatherback and loggerhead turtles from South Africa using satellite telemetry and stable isotope analysis
Conservation	Oral	Winner	Jose Luis Crespo-Picazo	Complutense University of Madrid, Spain	Systemic gas embolism in dead and live loggerhead sea turtles due to bycatch
Conservation	Oral	Runner up	Aliki Panagopoulou	Drexel University, USA	Untangling fishermen-turtle relationships: perceptions of sea turtle interactions with small-scale fisheries in Crete, Greece

ISTS AWARDS 2014

Members: Sally Murphy (Chair), Dean Bagley, Stephen G. Dunbar, Kimberly Maison, Jim Spotila

Life Time Achievement Award

Anne Meylan

Frank Paladino

Jim Richardson

President's Award

Jennifer Homcy

Rod Mast

SPECIAL FEATURES

SPEED CHATTING WITH THE EXPERTS

Chairs Emma Harrison, Zoë Meletis

Panel: Jack Frazier- "Hall of Fame" (anything turtle related!)

David Godfrey- NGO funding

Robert Hardy- Tracking technology

Michael Jenson- Genetics

T. Todd Jones- Physiological ecology

Brad Nahill- Volunteering and ecotourism

Nancy Mettee- Veterinary medicine, first aid in the field and sea turtle rehabilitation

Anne & Peter Meylan- In-water research

Pamela Plotkin- Conservation science

Erin Seney- Independent consulting and marine policy

Roldán Valverde- Arribadas and sea turtles of the Gulf of Mexico

FILM NIGHT

Chair- Katherine Comer Santos

See Video Presentations beginning on page 250.

DEEP WISDOM FROM EPIC FAILURES

Chair: Wallace J. Nichols

Panel: Ana Barragan, Alejandro Fallabrino, Rod Mast, Dave Owens, Nick Pilcher, Pam Plotkin, Jeffrey Seminoff, Bryan Wallace

WORKSHOPS

DIGITAL MARKETING

Organizer: Miguel da Silva

GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Organizer: Andrew DiMatteo

SEA TURTLE REHABILITATION & HEALTH

Organizers: Daniela Freggi & Terry Norton

TEMPERATURE-DEPENDENT SEX DETERMINATION (TSD)

Organizer: Marc Girondot

IN-WATER WORKSHOP WITH ROBERT HARDY

Speaker- Robert Hardy

EDUCATION OUTREACH

Organizers: Frances Kinney, Karen Burns, & Lisa Landry

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Opening Remarks and Keynotes

THE STATUS AND THREATS OF SEA TURTLE POPULATIONS IN THE GULF OF MEXICO*

Roldán A. Valverde

Southeastern Louisiana University, Hammond, LA, USA

Five sea turtle species are known to inhabit the Gulf of Mexico. Historical exploitation of these populations was significant after the discovery of the New World and this exploitation contributed to the decimation of these populations. Data on commercial landings of sea turtles in the Florida west coast showed a large level of harvest between 1880 and 1897, reported in the hundreds of metric tons annually. On the western Gulf, a large but ephemeral sea turtle fishery directed mainly to green turtles operated in Texas for only a few years, harvesting approximately 250 metric tons annually; this unsustainable fishery collapsed before 1900. Between 1880 and 1973 the Louisiana sea turtle operation harvested less than 10 metric tons annually, indicating that sea turtle populations in the north central and western Gulf were not robust enough to support a directed fishery for long. Sea turtle landings in Florida and the rest of the Gulf declined significantly through the early and mid 1900s. As a result, sea turtle imports increased significantly through this period to supply to US markets. However, sea turtle imports placed significant strain on the sea turtle populations of the Caribbean and elsewhere, causing a significant drop in imports up to 1975, when the international trade was halted by the enactment of the Endangered Species Act and the Convention on International Trade of Endangered Species. Hereafter the main threats to sea turtle populations in the Gulf of Mexico became incidental catch in long line and shrimping fisheries, along with pollution and habitat destruction. This caused sea turtle strandings to increase appreciably since the mid 1980s to date in the Gulf. A major oil spill, the Deepwater Horizon explosion, coincided with a significant reduction in the number of nesting events of the Kemp's ridley sea turtle in the western Gulf since 2010. It is unknown what the long term effect of that oil spill will be on the Kemp's ridley. Current status of sea turtle populations show that these are very low in the Gulf of Mexico judging by the low nesting observed throughout their range. In-water data show that sea turtles are more abundant on the eastern Gulf, around the Florida Peninsula. No data on in-water abundance is available for the southern Gulf. The low abundance of sea turtle populations in the Gulf renders them highly vulnerable to natural and anthropogenic threats; this is particularly true for the Kemp's ridley. The data-deficiency of the Gulf makes it very difficult to establish the status of sea turtle populations, and precludes the establishment of population trends and future assessments of the populations following major disturbances in the Gulf. The development of in-water index sites along the entire Gulf represents a critical need to ascertain current population trends and the impact of future anthropogenic and natural phenomena on the sea turtle populations of the Gulf of Mexico.

CULTURES OF TURTLES; TURTLES OF CULTURE*

Jack Frazier

Department of Vertebrate Zoology–Amphibians & Reptiles, National Museum of Natural History, Smithsonian Institution, Washington, DC, USA

Diverse roles are played by marine turtles in various societies, a fact well known by “members of the global sea turtle community.” These vary from tangible, consumable items like basic sources of meat, eggs, oil, leather, and tortoiseshell, to intangible, highly complex matters such as foci of intellectual, emotional, and spiritual inspiration. For example, the cosmological vision of a massive turtle supporting the world, which occurs in diverse societies from Asia to America, is commonly cited. In fact, there is an astounding diversity and pervasiveness of cultural roles played by marine turtles in diverse societies around the world; and not all of them are viewed in a positive light. While this provides for curious stories and general amusement, in a realm where “hard science” is held as the utmost of

achievements, such cultural information is routinely regarded as peripheral, inconsequential, or irrelevant to the greater objective of understanding and conserving turtles. In societies that put an enormous premium on technology and “progress,” a relatively lower value for cultural information is particularly accentuated. In contrast, many activities that are wrapped in the cloak of “science,” and especially technology, are sanitized, sanctified, and bestowed enhanced acceptability, attractiveness, and significance. The devaluing of cultural aspects contradicts fundamental veracities that form the foundations of human-turtle interactions, and are the derivations of the complex ways in which different people and societies interact with marine turtles. This encompasses the full range of human-turtle interactions, from direct predation for food and commodities, to veneration of objects of emotional and spiritual importance, to selection of subjects for scholarly investigation. It is essential to understand that the cultures of turtles are extremely diverse; and what one person or society may assume is a basic given, other people or societies may not perceive, appreciate, or accept. This is illustrated by the diversity and complexity of responses of different societies to identical turtles employed as various flagship species: to one group a turtle can be the highest symbol of Nature, all things sacred and requiring veneration and protection; to another group the same turtle can be a powerful symbol of cultural identity and traditions, requiring capture and butchery. In diverse respects, cultural considerations are akin to gravity: invisible, omnipresent, impossible to remove, and often very difficult to explain except in the most general of terms. Indeed, the scientific endeavor itself – no matter how “hard” the science – is embedded within a complex cultural context, no matter how much some practitioners try to deny this. The presentation will elaborate on the turtles of culture.

GETTING PAST N=1. CHANGING CULTURES OF SEA TURTLE SCIENCE MAKE AN UNLIKELY CANDIDATE A MODEL SPECIES FOR COMPARATIVE ENDOCRINOLOGY*

Duncan S. MacKenzie

Texas A&M University, Dept. of Biology and Graduate Program in Marine Biology

As threatened or endangered species broadly distributed in remote locations and poorly suited for laboratory study, sea turtles would seem to be inappropriate subjects for endocrinology, which traditionally has required invasive and precisely controlled studies in captivity to elucidate hormone function. Indeed, many early studies of sea turtle hormones were limited by small sample sizes. However, a review of sea turtle endocrine studies over the past fifty years reveals that in spite of these constraints they have made numerous important contributions to comparative endocrinology, particularly in the areas of pituitary hormone function, stress physiology, and reproductive endocrinology. Although sea turtle endocrinology arose out of the study of captive animals, it provides excellent examples of how comparative endocrine research initiated to understand basic aspects of animal function can yield practical applications to conservation of wild species. Several examples will be given in this presentation, including characterization of gonadotropin function during multiple nesting, evidence for vasotocin secretion during oviposition, and the use of androgens to establish sex ratios or determine nesting frequency. As the culture of sea turtle science has evolved away from studies of captive animals to focus on understanding animal function in the wild, so too has comparative endocrinology. Sea turtle endocrine studies are thus poised to make unique and potentially transforming contributions to the developing fields of eco-endocrinology and evo-endocrinology, among the grandest of challenges in the future of comparative endocrinology.

SEA TURTLE PEOPLE CULTURES: CAN WE BE WEIRD, PASSIONATE AND FUNCTIONAL?*

David Wm. Owens

College of Charleston, Grice marine Lab., Charleston, South Carolina

This informal talk is based on some random and not very scientific observations of the People who study and do conservation on the magnificent organisms we call sea turtles. Human societies are often defined by their cultures. More than other scientific groups I have known, Sea turtle People have a culture of passion, adventure, collaboration and caring for both the turtles and the people who live with the turtles. In my dichotomous key of sea turtle people there appear to be two major taxa. The first group is small and defined by a primary focus on the turtles. We call these “Turtle-Turtle People” with such figures as Dr. Colin Limpus, Dr. Peter Pritchard and Mrs. Sally Hopkins Murphy and Dr. Jack Frazier leading this very small and select cohort. The other branch of my key are the “People-Turtle People” which includes most of the rest of us. Like the first group we are passionate, but not very focused and largely influenced by the other people who love sea turtles - and there are now thousands of us. Because true sea turtle people are durable and persistent, they usually keep coming back to the fold and thus the men become somewhat blustery and fine folk we affectionately call “Silverbacks” from our relatives the gorillas. The ladies on the other hand are especially wise and wonderful collaborators and match makers. We call them the Madams of the sea turtle world. All sea turtle people will become either Silverbacks or Madams long before you would guess this could happen. As an old guy, my favorite Silverbacks were Archie Carr, John Hendrickson, Fred Berry and Larry Ogren. My favorite Madams are Thelma Richardson, Sally Hopkins Murphy and Barbara Schroeder. In the early 1980s these three ladies formed the heart and soul of what we now know as the International Sea Turtle Society (ISTS). Interestingly, or rather should I say “uninterestingly”, prior to this early 80s era there were almost no Madams in the sea turtle world. For example, the leaders of the IUCN Marine Turtle Survival Group were all males for the first 20 years. It was all Silverbacks top to bottom. Thanks to the inspired leadership of Dr. Carr, Dr. James Richardson and Dr. Llewellyn Ehrhart, this all changed radically in the late 70s and early 80s as many outstanding larval Madams soon joined the ranks and have now assumed their rightful roles as world leaders of sea turtle conservation and research. Numerically, ladies outnumber men in the sea turtle world today and one does not have to be very astute to realize that most of the student awards at the ISTS meetings now deservingly go to the larval madams. Finally, we must be very proud that the small and loosely organized Sea Turtle Workshop from the Southeast US of the 1980s has now evolved into the important international organization representing the worldwide distributions of our focal species. These are all Good Things that we should all be proud of in the ISTS. Good things for sea turtle science and good things for all of marine conservation.

Anatomy, Physiology, and Health

GOT PLASMA? VALIDATION OF A TESTOSTERONE ELISA FOR SEX DETERMINATION AND REPRODUCTIVE ASSESSMENT OF THREE SEA TURTLE SPECIES*

Camryn D. Allen¹, Jeffrey Schwenter², Dave Wm. Owens², Anne Meylan³, Peter Meylan⁴, Michelle N. Robbins¹, Nicholas M. Kellar¹, Tomo Eguchi¹, Hendrik Nollens⁵, and Jeffrey A. Seminoff¹

¹ Southwest Fisheries Science Center, NMFS, NOAA, 8901 La Jolla Shores Dr., La Jolla, CA 92037

² College of Charleston, 205 Fort Johnson Rd, Charleston, SC 29412

³ Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 100 8th Avenue S.E., St. Petersburg, FL 33701

⁴ Natural Sciences, Eckerd College, 4200 54th Avenue South, St. Petersburg, FL 33711

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A variety of immunoassay techniques [e.g., radioimmunoassay (RIA) and enzyme-linked immunosorbent assay (ELISA)] are available to quantify testosterone concentration in sea turtle plasma samples for sex determination and reproductive assessments. While RIAs have been the traditional standard because they produce extremely sensitive and specific hormone results, the use of ELISAs is growing because they are as sensitive and do not require the use of radioactive substances. However, the use of ELISAs for measurement of hormone concentration in many species has not been validated and this is particularly important for commercially available ELISA kits which are generally used to determine testosterone concentration in humans. In this study we validated the use of an ELISA hormone assay to determine testosterone concentration in green, olive ridley and leatherback sea turtle plasma. Firstly, we demonstrated parallelism ($t = -1.11$, $p = 0.83$) between the serial dilutions of pooled plasma samples ($n = 6$) and known standard concentrations and confirmed that the testosterone assay measured the same antigen in the standard controls and plasma extracts. Secondly, we determined the precision of the assay by running samples multiple times within the same assay (intra-assay variation) and running those same samples over multiple assays (inter-assay variation). The average intra- and inter-assay variation was 7.6% and 2.3%, respectively. More importantly, we confirmed that testosterone results obtained from the ELISA were similar to the RIA technique by running duplicate samples of adult and juvenile green turtles of known sex (via laparoscopy) that were previously analyzed using the RIA technique. Ultimately, the results of this study confirm the importance of hormone assay validation and once validated the ELISA hormone assay system can be used to determine sex and reproductive condition in several sea turtle species.

WHAT TAIL MEASURES EXPLAIN ABOUT SEXUAL DIMORPHISM BETWEEN MALES AND FEMALES OF JUVENILES OF *CHELONIA MYDAS* IN THE SOUTHERN COAST OF BRAZIL?

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Male and female juvenile green turtles do not exhibit apparent sexual dimorphism, however adults have secondary characteristics which differentiate them. Adult males have a prominent tail compared to the females, which is a morphological characteristic and its analysis in juveniles may collaborate with the differentiation between the sexes, besides increasing knowledge of the regional populations. In addition, this information subsidize the analysis about juveniles development, which is essential for conservation efforts in foraging areas. Paraná coast is an important feeding area for green turtles in the region of Southwestern Atlantic Ocean (SAO), where seagrass meadows are found. Between the years of 2012 and 2013, 70 specimens of juvenile stranded dead green turtles were collected. Among these, 24 had been sex identified by histological analysis of the gonads and the others were in an advanced degree of

decomposition. All specimens had a curved carapace length (CCL) measured in centimeters and the tails were removed from the pelvic girdle. All tails were analyzed to assess the number and/or size of vertebrae, and these data were compared between males and females. The tails were macerated and individually arranged with support of a wire so that all vertebrae remain in the original position. The number of vertebrae was counted and the length of the vertebral body measured with the support of a digital caliper with a precision of 0.01 mm. The sum of the length of the vertebral bodies (LVB) of each tail was calculated for comparisons between the sexes. The average CCL was 39.5 ± 4.7 cm (30.5 - 51.0 cm, $n = 70$), the average number of vertebrae 20.8 ± 1.2 (16 - 23) and the sum of the length of the vertebral bodies average was 6.4 ± 1.5 cm (3 - 6.7 cm). The 18 females analyzed did not differ for CCL (mean = 40.2 ± 5.2 cm, 32.8 - 50.0) ($p = 0.5$) and LVB ($p = 0.2$) of $7.1 \text{ cm} \pm 1.2$ (5.4 - 9.7 cm) when compared to the six males analyzed with CCL average of 38.6 ± 4.5 cm (34.2 - 44.2 cm) and LVB 6.5 ± 1.5 cm (4.6 - 8.7 cm). The number of vertebrae did not differ ($p = 0.6$), males had on average 21.3 ± 0.5 (21 - 22) vertebrae and females 20.9 ± 1.6 (17 - 23). Individuals with 21 and 22 vertebrae were analyzed separately and when males and females were compared, no significant difference was found regarding the CCL ($p = 0.7$ and $p = 0.5$) and LVB ($p = 0.9$ and $p = 0.07$), for 21 and 22 vertebrae respectively. Thus, the analysis of tails, as the number of vertebrae and the length showed no relationship between sexes. However, it was observed that the number of vertebrae ranged between individuals, with 44.3% of specimens sampled with 21 vertebrae, the most representative. Populations of green turtles in feeding areas in SAO are composed mainly by mixed stocks. The variation in the number of caudal vertebrae can be considered an intrapopulation difference and directs a genetic evaluation of specimens to evaluate whether this is a characteristic of distinct genetic stocks.

AGE AT MATURATION AND ADULT STAGE DURATION FOR LOGGERHEAD SEA TURTLES IN THE WESTERN NORTH ATLANTIC*

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Although many sea turtle assessment efforts have emphasized the importance of age at maturation data for understanding population dynamics, obtaining this information is challenging due to the delayed maturity and highly migratory behavior characteristic of sea turtle species. To address this research need for loggerhead sea turtles, we conducted skeletochronological analyses of humerus bones collected from 304 loggerheads (17.6 - 108.2 cm straightline carapace length (SCL); mean = 61.1 ± 19.1 cm SD) stranded dead around the Azores Islands or along the US Atlantic coast. The sample comprised 101 females, 65 males, and 138 turtles of unknown sex. The relationship between skeletal growth mark (GM) number and GM diameter for younger turtles was modeled using a non-parametric smoothing spline, allowing us to predict the number of GMs potentially lost to core bone reconstruction in older individuals and estimate total age. The relationship between humerus diameter and SCL was characterized as allometric and analysis of humeri from 12 tagged turtles provided validation for converting GM diameters to SCL estimates, as well as support for annual GM deposition and assignment of a calendar year to every GM. These validations allowed somatic growth rate back-calculation by taking the difference between SCL estimates generated from all successive GM pairs, which yielded a total of 2,949 annual growth increments corresponding with calendar years 1975 to 2010. GM spacing in humeri of a sub-set of larger turtles became significantly compressed toward the bone's outer edge, consistent with a decrease in somatic growth and the phenomenon 'rapprochement', thought to signify attainment of reproductive maturity. As a result, SCL at maturation for these turtles was assigned by converting the diameter of the GM marking the onset of rapprochement to a SCL estimate, yielding estimates of 75.0 to 101.3 cm SCL for females (mean = 90.5 ± 5.8 SD) and 80.6 to 103.8 cm SCL for males (mean = 95.8 ± 6.5). Sex-specific longevity after reaching maturity was estimated by counting the number of GMs deposited following onset of rapprochement, with females exhibiting 4 to 46 post-rapprochement GMs (mean = 18.5 ± 12.5 SD) and males 4 to 42 (mean = 19 ± 8.8 SD). Total age estimates for loggerheads >80 cm SCL ranged from 18 to 77 yr for females (mean = 46.2 ± 18.8 SD) and 21 to 70 yr for males (mean = 43.7 ± 15.2 SD). Generalized Additive Mixed Models (GAMMs)

were used to characterize the influence of potential covariates on growth rates and effects of SCL, age, and calendar year were significant. Whereas no sex-specific differences in growth were found for turtles <80 cm SCL, male loggerheads >80 cm SCL exhibited significantly faster growth than females. Sex-specific size-at-age was modeled using two approaches (1) fitting GAMMs to back-calculated SCL and age estimate data and (2) bootstrapping individual, randomly-selected growth increments (one increment per turtle for each re-sampling) and fitting Fabens' modified von Bertalanffy growth curve 1,000 times. Age estimated at minimum and mean SCLs observed at maturation and also inferred during the current study ranged from 22-38 yr for females and 25-42.5 yr for males.

AN EVOLVING REHABILITATION PROGRAM FOR SEA TURTLE HATCHLINGS

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Sea turtle rescue, rehabilitation, and release play a valuable role in the conservation and preservation of the species. While many facilities offer rehabilitation for juvenile, subadult, and adult turtles, only a few offer care for hatchlings. Mote Marine Laboratory's Hatchling Hospital provides rehabilitation for hatchlings that strand anywhere between Pinellas County and Manasota County, on the west coast of Florida. On average, the hospital sees 1200 hatchlings each year. Hatchlings can come into the hospital for a number of reasons, including disorientation, predation (fire ant, crab, and bird injuries are commonly seen), lethargy, excavations, and depredations (usually by a raccoon or armadillo). All hatchlings are weighed, measured, and assessed for injuries on intake. Hatchlings which need short-term care are kept quiet and in a dark container throughout the day, and then taken to the beach on which they hatched for release at sunset. Short-term care can include treating minor injuries, allowing them to rest, or even assisting them in rounds of physical therapy. Hatchlings have approximately three days energy from yolk reserves, so any hatchlings that need longer than a few days care have to be admitted to the hospital tank where they can begin to eat. Each hatchling is evaluated individually, to see if long-term care is necessary. The most common reason for hatchlings to require long-term care is depredation injuries. In 2013, Mote had a record year, treating a total of 1587 hatchlings. Over 600 of these hatchlings were from depredated nests, 99 of which were admitted to the hospital. Typically with depredations, the predators dig up a nest before hatching, rupturing the eggs and leaving hatchlings with missing or compromised yolk sacs. This type of injury can often take several weeks to heal. These hatchlings are put on a course of antibiotics, have their injuries cleaned daily, and are monitored closely. They are fed a variety of tiny pieces of shrimp, krill, and fish and then transitioned to a nutritionally complete pellet diet when they are eating well. Each hatchling admitted is given a letter and number (which is painted on their carapace with nail polish) to track their progress. In order for a hatchling to be medically cleared, it must be able to feed and dive, and all injuries need to be healed. Hatchlings go through a 'swim frenzy' when they enter the water so those that have been admitted to the tank must be released offshore by boat into the weedline. Mote Marine Laboratory's Hatchling Hospital has advanced and expanded over the years to be able to provide care for a growing number of patients each season. Support from local turtle watch groups, private donations, and Mote Aquarium allow the hospital to continue to evolve each year, increasing our knowledge and quality of care for sea turtle hatchlings. We continue to develop our treatment plans and protocols, and have successfully released about 84% of our patients back into the wild.

CONGENITAL MALFORMATIONS IN SEA TURTLES: FIRST REPORT OF *SCHISTOSOMUS REFLEXUS* SYNDROME*

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Schistosomus Reflexus (SR) is a rare and fatal congenital malformation syndrome occurring during embryonic development. SR causes severe and often lethal malformations in the thoracic and abdominal tunics, spine, limbs, and digestive and urogenital systems. SR is observed mainly in mammals, mostly in ruminants, but also in canines and felines. There is only one report of SR for reptiles in the lizard *Pogona vitticeps*, but none has been reported for sea turtles, making this the first report of its kind in sea turtles. The present study identifies and describes congenital malformations in the olive ridley (*Lepidochelys olivacea*) based on external anatomy observations. We examined 209 olive ridley nests of Turtle Camp "El Verde Camacho", Sinaloa, México, during the 2012 nesting season recording presence, number, and type of malformations in embryos and hatchlings. We recorded for each nest: number of eggs, live and dead hatchlings, and eggs with or without embryonic development. All malformations were recorded, but when several malformations were present in an organism, each one was recorded separately and photographed. The incidence of malformations was estimated with the prevalence index: the proportion of organisms and nests in which there was at least one malformation. Results showed 140/209 nests with at least one malformed organism, 67%, and 400/16,709 (2%) organisms showed some type of malformation. We observed SR in 120, 30%, of malformed embryos; this was relevant since SR is a rare condition that has not been reported for sea turtles. Malformed organisms showed a marked lordosis, frequently diagnosed as other vertebral column malformations such as scoliosis, kyphosis, and vertebral and rib alterations (number, shape, and fusion). The shell was underdeveloped: bones and scutes agenesis, subnumerary and deformed scutes, cervical vertebrae were also affected resulting in a shortened neck. Anura was also diagnosed, but in some cases we could observe a caudal dysostosis or the complete tail. Flippers displayed malformations: partial albinism, arthrogryposis, and dysmelias: amelia, phocomelia, syndactily, among others. Craniofacial malformations observed: encephalocele, anophthalmia, arhinia, and agnathia, among others. We also registered adrenal-kidney-gonad complex hypoplasia. Until now SR was only attributed to mammals. Compared to previous studies in mammals, SR prevalence was very high. The etiology is unknown but it may be due to genetic factors, mutations, chromosomal anomalies, infectious agents, or environmental factors, or the combination of several of these factors. The high prevalence of SR in this species suggests a primary genetic etiology, although environmental factors may be involved. However, more studies are needed to understand SR etiology in sea turtles.

OCCURRENCE OF ECTOPARASITES OF THE GENUS *OZOBRANCHUS* ON JUVENILE *CHELONIA MYDAS*, IN CERRO VERDE, URUGUAY

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Different diseases affecting sea turtles directly influence at their survival. Recently, a neoplastic disease called fibropapillomatosis has become important. Another of the most common diseases of sea turtles is infestation by parasites. These marine reptiles are affected by a variety of endoparasites; however, they are only parasitized by a few ectoparasites species, for example, some species belonging to the genus *Ozobranchus*. However, little is known about that parasite-host relationship. The aims of this research are to: (1) identify which species of marine leeches are parasitic on juveniles of *Chelonia mydas* at the Coastal-Marine Protected Area of Cerro Verde and La Coronilla

Islands, Uruguay; (2) determine species relative abundance; (3) analyze possible interspecific interactions between the leech species; and (4) analyze the relationship between the occurrence of these ectoparasites and tumors on *C. mydas*. Marine leeches were collected from captured and stranded turtles during warm months (January-April), between 2007 and 2009, within research and conservation activities carried out by Karumbé NGO. Turtles were weighed, curved carapace length (CCL) was measured as well as presence/absence of tumors. Leeches were identified using Sawyer's (1975) key, and data analyses were performed using the free software R. From a total of 662 individuals of juvenile *C. mydas* that were examined, 111 (16.8%) were parasitized by leeches identified as *Ozobranchus branchiatus* (relative abundance 0.38, n = 2,453) and *O. margoi* (relative abundance 0.62, n = 4,042). A negative correlation was found for these species co-occurrence [Spearman coefficient = -0.3852791 (p < 0.01)]. However turtles parasitized with intensities above 50 parasites of *O. margoi* had none, or very few, individuals of *O. branchiatus* (Fisher exact test, p < 0.01); while high intensities of individuals of *O. branchiatus* were not significantly associated with the absence of individuals of *O. margoi* (Fisher exact test, p = 1). At low intensities of parasites of both species, they could co-occur on the same host. Despite the fact that no significant relationship was found between the occurrence of tumors and the occurrence of parasites of genus *Ozobranchus* (p > 0.05) a strong relationship between the size of the turtles (CCL) and the presence of tumors was found, being more frequent in larger animals (p < 0,01). Given the various threats faced by populations of *Chelonia mydas*, considered as "endangered" species and priority species for conservation by the National System of Protected Areas of Uruguay, long-term monitoring of *Ozobranchus margoi* and *O. branchiatus*, it's a very interesting tool to consider in the design of future management plan to be implemented in the Coastal-Marine Protected Area of Cerro Verde and La Coronilla Islands, Uruguay.

PREVALENCE OF PARASITISM OF THE SPECIES *OZOBRANCHUS BRANCHIATUS* AND *O. MARGOI* IN JUVENILE GREEN TURTLE POPULATION IN CERRO VERDE, URUGUAY

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The aim of this work was to determine the association of the prevalence of parasites with attributes of the host, like the body mass index and morphometry; and environmental variables, like site and season of capture. This work was carried out in the foraging and developmental ground "Coastal Marine Protected Area of Cerro Verde and La Coronilla Islands", Uruguay. Marine leeches were collected from captured and stranded turtles during warm months (January-April), between 2007 and 2009, within research and conservation activities carried out by Karumbé NGO. For all sampled turtles were collect data such as weight, curved carapace length (CCLn-t) and width (CCW), presence of tumors and epibionts. Leeches were stored separately and their identifications were made using Sawyer's (1975) key. In order to describe the nature of the relationship between *Ozobranchus* spp. and *Chelonia mydas*, parasite abundance, mean intensity, and prevalence of infection were calculated. To determine if exist an association between prevalence infection, host's attributes and environmental variables a multivariate analyses (logistic regression model) was performed. Dependent response variables were the prevalence of each species of leeches recorded, and the summatory of them; while the independent variables considered were the presence of the other leech species on the same host, CCL, CCW, Body Mass Index (BMI), weight, season (year), month and site. The Akaike Information Criterion (AIC) was used to select the model, the presence of interaction between pairs of each term was assessed; and variables that were not important to explain the variability in the response were removed from the model. Analyzing the prevalence of total parasites on *C. mydas*, it could be observed that the probability to be infected with leeches increases when the BMI of turtles increases (p < 0.05). In turn, the probability of infestation with leeches for *C. mydas* in Cerro Verde increases between January and April in each season (p < 0.05). The prevalence of infection by *O. margoi* shown that in presence of the other parasite (*O. branchiatus*) it is more probably the presence of *O. margoi*, and respect to the weight of turtles it could be observed that heavier animals were more susceptible to infection by this species of leech (p < 0.05). Also, the prevalence of infection by *O. margoi* tends to decrease towards the end of each season (January to April). In terms of prevalence of *O. branchiatus*, in the presence of *O. margoi* it is more likely to find this species, and as well as with *O. margoi*, hosts with higher BMI has a higher prevalence of infection with *O. branchiatus*. Also,

the probability to be infected with *O. branchiatus* increases since January to April. Therefore, leeches of genus *Ozobranchus* could be not a problem to the Cerro Verde's sea turtle population, in Uruguay, and probably the parasite load could be constant within this population. What is more, this population could have a dynamic host-parasite stable, with certain parasitism patterns, within each season and for each species of parasite.

OLIVE RIDLEY SEA TURTLE EMBRYO MORTALITY AS A FUNCTION OF THE NEST MICROBIAL COMMUNITY AT OSTIONAL, COSTA RICA*

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The olive ridley sea turtle population at Ostional, Costa Rica exhibits mass nesting events (arribadas) estimated at up to 500,000 nesting females over a period of only seven days. Despite the large population of nesting females, concern remains that the low hatching success (8%) at this beach is not enough to sustain the population long-term. Several studies have suggested that embryo mortality is associated with the high microbial load resulting from the decomposition of eggs broken by subsequent nesting turtles due to the high nest densities characteristic of arribada events. Thus, a legalized community-based egg harvest program is aimed at reducing the number of nests destroyed while providing the funds to support local infrastructure and family income. However, no previous research has directly quantified microbial abundance and the associated direct and/or indirect effects on hatching success in situ. This study aims to determine the impact of microbial abundance on hatching success by applying experimental treatments to reduce the microbial load of the sand into which nests are relocated. Temperature, oxygen, and organic matter content were monitored throughout the incubation period. The microbial abundance of nest sand was quantified using qPCR molecular analysis. Experimental treatments that successfully increase hatching success could be applied as a management technique to improve hatching success in hatcheries and at beaches experiencing issues with microbial infestations. This study will help identify a relationship between hatching success and the microbial community of the sand and increase our understanding of the potential impacts of anthropogenic organic loading on nesting beach sand quality.

CONCENTRATION OF HEAVY METALS IN SCUTE SAMPLES FROM NESTING FEMALE OLIVE RIDLEY TURTLES, *LEPIDOCHELYS OLIVACEA*, AND EASTERN PACIFIC GREEN TURTLES, *CHELONIA MYDAS AGASSIZII*, IN COSTA RICA*

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Sea turtle populations are declining worldwide due to a number of anthropogenic factors: fishery by-catch, habitat destruction, illegal egg harvesting, and marine pollution. Marine pollution is the result of industrial processes or waste disposal that produce by-products that are either discharged into the atmosphere or directly into oceans. Sea turtles undertake extensive migrations; therefore, they can readily serve as biomonitors for the overall health of the aquatic ecosystem, especially for the evaluation of heavy metals that biomagnify across trophic levels. Heavy metals are known to have endocrine-disrupting properties, and at high concentrations, can be lethal. The objective of this study was to provide baseline toxicological information on heavy metal concentrations in nesting female sea turtles, specifically, the olive ridley (*Lepidochelys olivacea*), a pelagic omnivore, and Eastern Pacific green (*Chelonia mydas agassizii*), a neritic herbivore, that migrate to Playa Grande and Playa Cabuyal in Guanacaste, Costa Rica. Tissue samples were collected along the posterior marginal scutes located on the carapace and analyzed for the following

metals: Cd, Co, Cr, Mn, Ni, and Pb. Concentrations were analyzed using inductively-coupled plasma mass spectrometry (ICPMS) at the level of parts per billion (ppb). Scute tissue was sampled as it has been shown to yield higher metal concentrations than blood and provides a more accurate estimation of long-term metal accumulation. Other studies have demonstrated that metals have a high affinity for keratin, which is the tissue that makes up the outer layer of a turtle's scute. For this reason, sea turtle scutes serve as an accurate storehouse of exposure to marine metal exposure. Since green turtles are herbivorous and remain in neritic, nearshore environments and olive ridley turtles are open-ocean pelagic omnivores these results should provide a good comparison of possible differences in exposure and accumulation in two distinct habitats and lifestyles. A total of 34 scute samples were collected from olive ridley (n = 17) and Eastern Pacific green (n = 17) nesting females. Olive ridleys were sampled from Playa Grande, while Eastern Pacific green samples were collected from Playa Cabuyal. Concentrations (mean \pm SE) for olive ridleys and Eastern Pacific greens are reported in ppb, respectively: Cd – 26.9 \pm 1.5; 30.9 \pm 1.6, Co – 26.7 \pm 8.0; 69.8 \pm 6.8, Cr – 106.0 \pm 6.6; 123.5 \pm 6.9, Mn – 524.2 \pm 52.0; 485.8 \pm 68.7, Ni – 216.8 \pm 75.8; 123.7 \pm 20.2, Pb – 90.5 \pm 25.1; 94.8 \pm 25.1. Cd and Co were significantly different (p < 0.05) between the two species with Eastern Pacific green turtles having higher concentrations. Relative size comparison using curved carapace length, a rough estimate of turtle age, was not correlated with metal concentration within the sea turtles sampled (p > 0.05). The reported concentrations found in these two marine turtle species are lower than other studies that used scute tissue samples as indicators of heavy metal pollution. However, study site locations were associated with major industrialized areas whereas this study was along the somewhat undeveloped Central American Pacific coast where there may be differing concentrations of pollution, explaining these differences. Furthermore, the results of this study suggest that Eastern Pacific green turtles, a neritic herbivore, may be at a higher risk of contamination by specific metals than a pelagic omnivore like the olive ridley. Sea grasses and red algae, the main staple of the Eastern Pacific green's diet, have unique uptake pathways where some metals are utilized in the plant's metabolic processes, while others accumulate as free ions. Accompanied with their inshore, neritic habitat utilization, the Eastern Pacific green turtle's risk of runoff and land-based contamination will increase if it happens to reside in a heavily polluted area. Determining a baseline for the amount of heavy metal contamination in ocean habitats using long-lived species like sea turtles from both pelagic and neritic environments is important for understanding anthropogenic influences on aquatic ecosystems. Sea turtle species spend the majority of their lives in the ocean, only coming ashore for brief periods during nesting events. During their lifetimes, they traverse waters with varying levels of pollution that can provide us with important insight into the health of the environment they inhabit.

BREVETOXIN METABOLISM AND PHYSIOLOGY – A FRESHWATER MODEL OF MORBIDITY IN ENDANGERED SEA TURTLES*

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The dinoflagellate *Karenia brevis* is a key organism in harmful algal blooms (HABS, Red tide) that occur off the coast of Florida. *K. brevis* produces a suite of neurotoxins which are collectively referred to as brevetoxins (PbTx). PbTx-3 is one of the brevetoxin congeners and is known to bind voltage-gated sodium channels (VGSC), which affect cellular permeability, resulting in a cascade of events leading to cell death. Brevetoxin exposure affects marine life by interrupting neurological functions, decreasing immune function, and inducing inflammation. HABS are increasing in frequency and distribution and are not only of immediate concern to species that inhabit areas where these blooms occur, but may have long term effects due to biomagnification and bioaccumulation. In 2005, at least 109 loggerhead sea turtles in Florida were affected by red tides with over 70 impacted during a 2006 bloom. However, brevetoxicosis is difficult to treat in sea turtles as the physiological impacts have not been investigated and the magnitude and duration of brevetoxin exposure, as well as the specific toxin congeners involved are generally unknown. Experimental

exposures are necessary to determine the fate of PbTx in turtle tissues, and to design appropriate treatments, but are not performed in sea turtles due to their endangered and threatened status. We are using freshwater turtles (*Trachemys scripta*) as a model for brevetoxin exposure. Turtles were exposed to intratracheal instillation (0.05 ug/ul; 3.12 ug/kg PbTx-3) or oral dosing (33.48 ug/kg) over periods ranging from 2 to 5 weeks. The heart, lungs, kidneys, brain, fat, intestine, liver and spleen were frozen for ELISA assay to investigate uptake, tissue distribution and routes of excretion; tissues were also preserved for histology and blood samples were collected for immune function studies. To determine the effects of PbTx on turtle neurons, primary neuron cell cultures were exposed to PbTx-3 in the presence and absence of the VGSC antagonist, tetrodotoxin (TTX) to examine cell viability and calcium influx. PbTx-3 was widely distributed in tissues and fluids of *T. scripta* within 24h following intratracheal exposures. High concentrations of PbTx-3 were found in the feces and bile but lower in urine and plasma. While PbTx exposure had evident clinical effects and impacted immune function, however, these short term exposures did not result in obvious tissue pathology. Turtle neurons are surprisingly resistant to PbTx-3; while cell viability decreased in a dose dependent manner across PbTx concentrations of 100 - 1000nM, the LC50 was significantly higher than is seen in mammalian neurons. PbTx-3 exposure resulted in significant Ca²⁺ influx, which can trigger a cascade of excitotoxic events eventually leading to cell death. TTX prevents Ca²⁺ influx when PbTx-3 + TTX are both added to the medium suggesting that the mechanism of PbTx action is through its binding to VGSC. Understanding distribution, clearance, and effects of PbTx in these model turtles will allow us to design treatment strategies for threatened and endangered sea turtles.

MORPHOLOGICAL CHARACTERIZATION OF JUVENILE GREEN TURTLES (*CHELONIA MYDAS*) IN PARANÁ, SOUTHERN COAST OF BRAZIL

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Chelonia mydas has global distribution and makes use of several different areas for reproduction and feeding. Little information is available regarding growth and migration patterns, especially during the juvenile development phase. Therefore, this study aims to analyze the size variation of skull morphological structure and identify patterns of seasonal and gender variation of the green turtle found in intertidal zone in the Paraná State. From 2004 to 2012, 260 dead, stranded juvenile green turtles were collected. The carapace, skull, humerus and claw of all individuals were measured using traditional morphometric techniques. The allometric coefficient was determined by regression analysis. It suggested that the growth was distinct and might be related to morphological function. Even though females are structurally bigger than males, no separation by gender was found in the multivariate analysis, indicating that during the juvenile phase green turtles do not present sexual dimorphism. Temporal variation was detected among seasons, with the highest range of size variation in the spring season. This is related to the occurrence of all green turtle size classes in Paraná coast, which coincides with the bloom of the seagrass *Halodule wrightii*, which is the main diet item of green turtles in this region. This may be an indication that green turtles are arriving from regions where there is less availability of food resources. The results of this study provide important information for understanding biological growth and migration of green turtles. Besides, morphometric studies associated with age estimations, analysis of mixed stocks and diet composition increase the knowledge about migration patterns and habitat use by the species, which are important parameters regarding the natural history and evolution of sea turtles.

LEAD AND CADMIUM IN BLOOD, LIVER AND KIDNEY OF OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*) FROM “LA ESCOBILLA” BEACH (OAXACA, MEXICO)*

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Pb and Cd are the two most studied heavy metals in environmental biomonitoring due to their high toxicity potential. Successive studies can show if the bioavailability of these metals varies with time, and thus evaluate the toxicological risk to which marine turtles are subjected. In the present study we have analyzed blood, liver and kidney samples from olive ridley sea turtle (*Lepidochelys olivacea*) from "La Escobilla" beach, in the state of Oaxaca (Mexico), which is considered one of the most important in the world for its "arribadas". Concentration of Pb in blood samples was 0.02 ± 0.01 µg/g wet weight (n = 41), one of the lowest reported in literature and ten times less than that found on the same beach seven years ago by other authors. This could indicate a decrease in this metal bioavailability to the turtle population from “La Escobilla”, which could be due to the gradual disuse of leaded gasoline in Latin America, the lower industrialization of this area in which these turtles inhabit, or a possible tendency to organic regulation of this element in the turtles’ organism. Cd in blood concentration was 0.166 ± 0.098 µg/g ww, n = 41; in liver and kidney 87.87 ± 36.64 y 150.87 ± 110.99 µg/g ww (n = 13) respectively, leading the hypothesis that the levels of this element are the result of chronic exposure, probable kidney accumulation of Cd through digestion. Finally, it should be noted that Cd concentration in kidney samples was one of the highest concentrations reported in all species of sea turtles worldwide. This work has been possible thanks to the support of Consejo Nacional de Ciencia y Tecnología (CONACyT), Universidad Autónoma "Benito Juárez" de Oaxaca through the Laboratorio de Investigación en Reproducción Animal (LIRA) and Centro Mexicano de la Tortuga. Thanks to Luz Ramírez and ALL the students who participate in our fieldwork. Thanks also to Erika Peralta y Tere Luna in "La Escobilla" to make our fieldwork much easier. Also we are grateful to the International Sea Turtle Symposium and ALL the donors who make our attending possible to the ISTS 2014. THANK YOU!

A LONG-TERM ASSESSMENT OF GREEN TURTLE FIBROPAPILLOMATOSIS RATES IN THE DEGRADED INDIAN RIVER LAGOON

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Florida’s Indian River Lagoon (IRL) serves as an important developmental habitat for many species, including manatees, dolphins, and pelicans. Recently, the IRL has been subjected to a great deal of public attention due to the degraded condition of its environment and the rising mortality rates of inhabiting species. This public attention has extended to the effects of habitat degradation on juvenile green turtles (*Chelonia mydas*) in the IRL. In order to understand these effects, we will use the long-term data set collected by the University of Central Florida Marine Turtle Research Group since 1983. In particular, we are interested in understanding how the prevalence of fibropapillomatosis (FP) has changed over time, as previous studies have shown that as more degraded habitats have a higher prevalence of FP. We also will examine how prevalence of FP varies among different size classes, hypothesizing that larger turtles that have spent more time in the lagoon will have higher rates of FP. Not much is currently known about whether juvenile green turtles maintain year-round residency in the IRL or whether they move out to the pelagic environment during certain times of the year. Therefore, we will also incorporate an examination of seasonal variation in FP rates. In conducting this study, we hope to increase our understanding of FP, its effects on

green turtles, and its association with environmental degradation. This is necessary knowledge for evaluating the consequences of human actions over a large spatial scale on an endangered species and its habitat.

THIRSTY TURTLES: HYDRATION AND BEHAVIOR OF LEATHERBACK (*DERMOCHELYS CORIACEA*) HATCHLINGS

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Leatherback (*Dermochelys coriacea*) hatchlings are difficult to raise in captivity because of their pelagic life style and not much is known about their behavior, physiology, or dietary needs in captivity. The laboratory at Florida Atlantic University has been raising Leatherback hatchlings for 20 years as part of a series of behavioral studies and a long-term hatchling sex-ratio assessment. Past studies of captive mortalities identified renal anomalies that were consistent with dehydration in some animals. This observation led us to supplement captive leatherbacks with freshwater as a part of our daily husbandry protocol. The turtles are maintained in sea water tanks that receive partial sea water changes twice daily. The neonate turtles were provided with a freshwater shower once per day to mimic rainfall and provide a freshwater source. Delivering water as a gentle shower can produce a lens of freshwater at the surface. The duration of the shower spanned 10 s to 60 s, depending on the reaction of the turtle. During freshwater showers, any changes in behavior were recorded, as well as whether or not the animal drank water, as indicated by mouth movements. Since initiating the freshwater showers renal disease associated with dehydration or renal congestion has not been noted. Although leatherbacks are a pelagic species, like all animals that live in seawater, adequate freshwater or elimination of excess salts is a necessity. Supplemental hydration appears to contribute to good health of leatherback neonates in captivity. Through continued observation of leatherback hatchling behavior in the freshwater shower, we are able to monitor behavior and characterize normal behavioral responses.

CAN MORPHOMETRICS BE USED TO SEX JUVENILE GREEN SEA TURTLES?

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Knowledge of the sex of study subjects as well as sex ratios of populations is crucial to the overall understanding of population ecology in many organisms. Sea turtles are sexually monomorphic animals for the majority of their life stages, making it difficult to gather information about the sex of sea turtles noninvasively while studying them. Currently many of the accurate sexing techniques for sea turtles involve invasive methods. Because of the conservation status of most species of sea turtles, these invasive and potentially damaging methods are not ideal or practical for many field and lab studies; thus, alternative methods are necessary to aid researchers in accurately identifying sea turtle sex. One possibility is the morphometric analysis of external characteristics of sea turtle morphology to identify subtle, sex-specific differences. The goal of the current study was to identify morphometric parameters and analytical approaches that could be used to sex juvenile green sea turtles, *Chelonia mydas*. Using the external measurements of a sub-set of 434 green turtles cold stunned in Florida in 2010, a multiple logistic regression was performed. No significant differences were found among the external measurements between the sexes, as the ranges of measurements for the two groups exhibited too much overlap. This initial assessment was followed by a discriminant function analysis of carapacial landmarks for another sub-set of the cold stunned turtles collected from photographs.

The results of the morphometric analysis indicate that carapace shapes are also not sexually dimorphic in juvenile green sea turtles, and cannot be used to predict sex. These initial results demonstrate that morphometric analyses may not be a practical and accurate method of sexing juvenile green turtles, and suggest that research in other noninvasive methods are necessary. Currently, a follow up study is being completed to determine whether the use of morphometric analysis of landmarks on the plastron will produce accurate predictions of juvenile green sea turtle sex.

THE USE OF ULTRASOUND INVESTIGATION TO IDENTIFY LINES ALONG SEA TURTLE INTESTINAL TRACT AND EVALUATION OF THE CORRELATED DAMAGES

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Accidental hook and line ingestion can cause serious damage to the digestive tract of sea turtles, representing one of the most frequent problems to be faced during their care and rehabilitation. Radiographic examination easily identify hooks, but lines can not be detected as they are radiolucent, limiting the ability of diagnosing their presence, as to evaluate their extent into the digestive canal. Even if the presence of a line is evident because it protrudes from the mouth or the cloaca, it is not possible to detect any injury caused to the intestinal walls, which is evident only during surgery. In this study two juvenile loggerhead sea turtles (*Caretta caretta*), with a line coming out from the cloaca, underwent ultrasound examination. X-rays had shown a hook lodged into the wall of the cervical esophagus. The ultrasound scans were performed through the cervicobrachial, axillary and prefemoral right and left acoustic windows. The transducer was oriented parallel to the plastron with cranial marker to obtain longitudinal scans, for transverse scans the transducer was rotated 90° anticlockwise with dorsal marker. More diagnostic significant images and movies were obtained by ultrasound scans through the right acoustic prefemoral window. In both cases, it was evident the presence of an abundant amount of particulate fluid in the coelomic cavity. In one turtle it was possible to explore a long tract of the small intestine that showed irregular and tortuous course, with a plicate pattern and a linear intraluminal shadow highly reflective, with a distinct posterior acoustic shadow, compatible with a packaging intestinal loop. The stratigraphy of the intestine showed normal conditions, but the luminal contents of the loop were not detectable for their stretch around the mesentery. In the other case there was a reflective linearity in the coelomic cavity, with a weak posterior acoustic shadow. Moreover, a clear dissection of the intestinal wall, small tears and alteration of the intestinal tract stratigraphy were detectable. In both cases, the exposure of the intestine during surgery revealed the extension of the intestinal walls alterations and the severity of injuries, reflecting what was detected by ultrasound examination and confirming the authors' opinion. Ultrasound examination may provide a valuable support in assessing the extension and severity of digestive tract lesions, caused by the tension of ingested lines. This valuable diagnostic ability has a real important prognostic value, allowing a better adequate planning of surgery.

IDENTIFICATION OF FIBROPAPILLOMA-ASSOCIATED HERPESVIRUS IN GREEN TURTLE, *CHELONIA MYDAS*, ON THE SOUTH OF BRAZIL

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Fibropapillomatosis is a debilitating neoplastic disease of the skin and internal organs that affects all sea turtle species, especially juvenile green turtles, *Chelonia mydas*. The etiology and pathogenesis is partly understood and it has been associated with papillomavirus and mainly herpesvirus found in tumors. This study investigated the presence of papillomavirus and herpesvirus in skin fibropapillomas of green turtles found along the Paraná coast, southern Brazil. The intertidal zone was monitored from 2009 to 2012 for sea turtle carcasses. Each turtle's age class was estimated externally based on their midline curved carapace length (CCL). In total, 22 fibropapillomas samples were collected from six juvenile green turtles (37 – 62 cm CCL; mean \pm SD of 51.7 ± 11.3 cm). The number of sampled fibropapillomas varied from one to seven from each animal (mean \pm SD of 3.7 ± 3.01). DNA from all samples was extracted using a Qiagen DNeasy tissue kit, according to the manufacturer's specifications. Two consensus primers set were used to amplify the papillomavirus (PV) DNA, FAP59/FAP64 that target a fragment of 480 bp of PVs L1 ORF, and AR-E1F2/E1R9 that target a fragment of E1 ORF. For herpesvirus DNA identification, a nested-PCR was performed using specific *Chelonia mydas* HV primers set at GTHV1/GTHV2 (165bp) and GTHPR1/GTHPR2 (110 bp). The primers AR-E1F2/AR-E1R9 allowed the amplification of approximately 580 bp in one sample, which was negative for herpesvirus identification. However, the low quality of the sequencing product failed to identify the PV type. The degenerate primers FAP59/FAP64 did not amplify the PV DNA in all samples. In the nested-PCR, the amplicons of the expected length were obtained in 21 DNA samples. Five positive nested-PCR samples were sequenced to confirm the presence of herpesvirus associated with fibropapilloma of the green turtle. The nucleotide sequence showed 100% identity with *Chelonia* Herpesvirus 5 (ChHV-5) (GenBank accession number AF299108.1). The present study represents the first DNA characterization of ChHV-5 in green turtles on the Paraná coast; an important foraging area for this species. The same variant was detected in fibropapilloma of a stranded green turtle further south (Rio Grande do Sul). This sample was allocated in the phylogeographic group of variants found in Porto Rico (Central America) and the Gulf of Guinea (Africa). It has been suspected that the virus gene flow occurs during animal migrations by strong equatorial currents to the Brazilian coast. However, analyses of green turtle mitochondrial DNA sequences from southern and southeastern Brazil demonstrated low haplotypes frequencies from the Gulf of Guinea, and besides this, the records of the disease from the African coast are recent. These results suggest that there could be another source of infection between animals on Brazilian coast. The results support the herpesvirus association with fibropapillomatosis in green turtles and that the ChHV-5 variant is possibly widespread in southern Brazil. However, other studies are required to understand the dissemination of the viral strain between regional management units of green turtle on the Brazilian coast and the role of PV infection in fibropapilloma pathogenesis.

MECHANISTIC NICHE MODELING OF LEATHERBACK SEA TURTLES USING COMPUTATIONAL FLUID DYNAMICS

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To aid sea turtle conservation, academic literature and government publications state the need to predict future potential sea turtle nesting sites given different global warming scenarios. To accomplish this goal, managers will need to have a clear picture of how sea turtles respond to many combinations of climatic conditions across turtle migratory ranges and between terrestrial nesting sites and adjacent waters. Because global warming will create climatic combinations sea turtles do not currently encounter, assessing the sea turtle response is difficult and a mechanistic model may be the best approach. Our lab has successfully mechanistically niche mapped many terrestrial animals but not yet an aquatic species. As sea turtles are a marine species, the animal-fluid interactions make constructing a highly accurate mechanistic model complicated. The animal-fluid interaction not only affects the turtle's energy use (through thrust and drag) but also the heat transfer with its environment. To solve these issues we combine modern 3D design programs, computational fluid dynamic (CFD) software and in-house programs to construct a realistic, swimming leatherback sea turtle CFD simulation. These simulations allow us to analyze not only the animal-fluid interaction but also the turtle's internal heat transfer. We validate these models with data from the literature and with our own nesting leatherback thermal images. This simulation provides inputs for a mechanistic niche model, Niche Mapper™, which can predict where leatherbacks can thermally persist both in water and on land. Thus with the niche model output, we can predict future potential nesting sites under different global warming scenarios.

ACOUSTIC COMMUNICATION IN SEA TURTLES

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Until recently studies of turtle communication involved only visual and olfactory signals. Sound communication among turtles was recently documented, however almost nothing is known about how or where these sounds they use are produced, or the functions of these sounds. This information gap stems from the fact that turtles were thought to be deaf mutes, and the sounds they produced were simply percussion sounds made during robust courtship activities. However, in the last few years novel studies have demonstrated that turtles possess a considerable auditory capability below 1000 Hz, nearly 50 species have been documented using sound for information exchange both in and out of the water. Sound communication, contrary to conventional wisdom, is widely used among both freshwater and marine turtles. We studied the sounds recorded of hatchling *Chelonia mydas* in Ascension Island, South Atlantic Ocean, *Dermochelys coriacea* and *Lepidochelys olivacea* from Oaxaca, Mexico as well as adult *Lepidochelys olivacea* before and during an arribada. Analysis of 25 h of recordings under natural conditions shows that these three species use sound in and out of the water to communicate. The mean peak frequency of the vocalizations of hatchling *D. coriacea* was 993.71 Hz (187.5 - 2437.5; sd = 440.6), *C. mydas* 1389.2 Hz (562.5 - 2718.8; sd = 519.76) and *L. olivacea* 1023.7 Hz (187.5 - 2062.5; sd = 518). A peak frequency of adult *L. olivacea* was 5791.1 Hz (281.2 - 10593.8; sd = 3205.6). It appears that sea turtles are using sound in their social activities similar to freshwater and terrestrial turtles. Future bioacoustic studies of turtles from all habitats need to be conducted in order to understand the importance of sound communication in the survivorship and conservation of this group of formerly antisocial animals.

TREATMENT OF SEVERE HEAD INJURY IN SEA TURTLES BY “MIX 557”, A NEW HERBAL PRODUCT WITH ANTISEPTIC AND HEALING PROPERTIES

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Often rescue centres receive sea turtle showing traumatic injuries of the skull, due to impact with boats, trawling nets, or suffering from a disease and having been hit against rocks by waves. More unfortunately, in some cases this kind of injury is caused intentionally by fishermen, using harpoons or tools. The repair of skull fractures is a real deal in sea turtles because of the morphological structure and the anatomical features of the cranial bones, making difficult the surgical reduction of the fracture. In this study we describe the treatment of 5 sub-adult loggerhead sea turtles (*Caretta caretta*) with severe skull fractures of parietal, frontal and postorbital bones, characterized by loss of matter and deep lesions; in a case there was the exposition of the meninges. After X-ray evaluations, the injured area was treated every one to two days with applications of “MIX 557” (EP 48211/BE 2008), a combination of plant extracts of Neem and St John’s wort in plant oil, extensively tested for its capacity to properly regulate the complex events of the wound healing process. After each treatment the part has been covered with strips of sterile gauze impregnated with Vaseline™ oil in order to isolate the lesion and allow the turtle in the water. During the treatment period, as the granulation tissue was progressing, the bone fragments in necrosis or not integrated in the repair process were removed. In all cases, after a treatment period between 70 days to 4 months, there was an excellent repair of the lesion, with satisfactory replacement of bone lost by keratinized granulation tissue, which had adequately compensated the loss of matter. In two cases the evolution of the repair process has been documented by CT and 3D reconstruction. In one case, despite the restoration of the tissue, a severe neurological deficit persisted, correlated to the severe brain trauma. At the end of the healing process, the remaining 4 turtles have been released in the wild.

MAGNETOCEPTION IN MARINE TURTLES: SEARCHING BEYOND BEHAVIOR*

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Marine turtles perceive the intensity and inclination of the Earth’s magnetic field. The neural basis of this ability remains unknown. We have launched a long-term, multidisciplinary effort aimed at unveiling the neurobiology of

magnetoception in marine turtles using *Chelonia agassizii* as our study model. Here, we report that turtle hatchlings exposed to changing environmental magnetic fields, display increased cFos immunoreactivity in visual structures (retina, optic tectum and visual thalamic nuclei), olfactory areas (piriform cortex), multisensory integrative regions (dorsal ventricular ridge), sensory-motor integrative areas (pallium) and areas involved in spatial navigation (medial cortex) of the brain. Golgi impregnation and immunocytochemical labeling suggest that multipolar projection neurons and interneurons, the latter positive to glutamic acid decarboxylase 65/67, calretinin, tyrosine hydroxylase, serotonin and substance P, occupy territories that overlap with those having cFos positive nuclei following magnetic stimulation. Since visual structures responded to changing magnetic environmental stimuli we pursued the identification of magnetite in the eyes. In doing so, we first revealed the existence of magnetic susceptibility artifacts in the eyes, nose and pharynx after imaging turtle heads with high resolution nuclear magnetic resonance. We then extracted, isolated and identified single domain (25 - 50 nm), hexa-octahedral magnetite crystals (interplanar distances = 111) from the eye by combining High Resolution Electron Microscopy (HRTEM) and Energy Dispersive Spectrometry (EDS) followed by Fast Fourier Transform (FFT) analysis. Finally, we turned to investigate whether *C. agassizii* genome contains genes that could be involved in magnetite synthesis. We have cloned partial sequences that seem homologues of mamK, mamB, mamN and mamO; these genes are involved in the process of magnetite synthesis in the bacteria *Magnetospirillum magneticum* AMB-1. Magnetite, nonetheless, might not be the only way turtles may have to transduce magnetic information in the eyes. We also provided evidence that suggests the presence of cryptochrome 1a in the retina through immunocytochemistry; this pigment has been suggested to transduce magnetic information in birds. Lastly, we provided preliminary evidence that objectively supports that turtles indeed perceive changes of the environmental magnetic field intensity through the eyes. Indeed, magnetic stimulation of the eyes evoked electrocortical responses and led to a resetting of the electro-myographic activity during fictitious swimming. Financial Support: UMSNH CIC-8.37 to ALFF and EMH; CONACYT 82879 to GGO and ALFF; 94312 to GGO; 180762 to EMH; PAPITT IN203912 to GGO and ALFF; PROMEP PTC336 to EMH.

ANTIBIOTIC RESISTANT ENTEROBACTER IN AN URBAN POPULATION OF BLACK SOFTSHELL TURTLE (*NILSSONIA NIGRICANS*)

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The Shrine of Bayazid Bostami in Chittagong, Bangladesh, is home to a captive population of the black softshell turtle (*Nilssonina nigricans*), locally known as the Bostami turtle. The turtles are thought to have existed as a closed population for the last century, and possibly longer, in a closed artificial pond currently 95 m long and 61 m wide, with a depth of 2.5 - 5.0 m depending on the season and rainfall. Pilgrims to the site believe the resident turtles to be descendants of ancient deities and make religious offerings, in addition to drinking and bathing in water from the pond. We isolated 4 species of *Enterobacter*, including *Enterobacter cloacae*, *Eserichia coli* and *Serratia plymuthica*, from pondwater inhabited by the turtles; all are known human and turtle microflora. Isolates were resistant to penicillin and ampicillin, a known natural trait of *Enterobacter*, but not chloramphenicol, ciprofloxacin, erythromycin, gentamicin and tetracycline. We were unable to acquire cloacal swabs from turtles to conclusively determine the origin of the *Enterobacter*, but the lack of acquired resistance to antibiotics widely and prolifically used in Bangladesh suggests the bacteria were shed by turtles, and not humans, into the pondwater. With improved sampling methods, we suggest the urban population of black softshell turtles in Chittagong could be used to monitor the emergence of antibiotic resistance traits at the human-wildlife interface.

AGE-RELATED VARIATION IN PATTERN AND COLORATION OF GREEN TURTLES (*CHELONIA MYDAS*) FORAGING AT PALMYRA ATOLL

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The foraging population of green turtles (*Chelonia mydas*) at Palmyra Atoll National Wildlife Refuge in the Central Pacific Ocean has been studied for six consecutive field seasons, with data collected on the size, sex, weight, and age of the turtles, as well as samples for genetic and stable isotope analysis. Each measured turtle has also been photographed from multiple angles, with emphasis on the carapace, top and sides of the head, and any morphological anomalies or scars. In this study, we analyzed hundreds of photographs of these turtles to characterize coloration patterns on the carapaces and heads. We found that most of the turtles could be described as having one of two broadly defined carapace patterns: light-colored lines radiating outwards from a corner of each scute or a uniformly dark carapace with random light mottling. Analysis of the coloration of the heads indicated a similar dichotomy, with most turtles showing either a reddish head with black around the edges of the scales or a dark green to black head with random light mottling. These head patterns matched almost universally with the light burst or mottled carapace patterns, respectively. There was a strong correlation between size of the turtle and pattern, with smaller turtles showing the burst pattern with a reddish head and larger turtles having dark, mottled carapaces and heads. As size is correlated with age in green turtles, our findings showed a clear difference between adult and juvenile color morphology among the green turtles foraging at Palmyra Atoll. However, contrary to previous observations of other populations, there was no difference between the patterns of males and females. Also contrary to previous descriptions of reported subspecies in the Pacific basin, coloration and patterning did not correspond to geographic origin, as turtles genetically identified as originating from the eastern Pacific Ocean were more similar in color to western Pacific turtles of the same age class than to other eastern Pacific turtles of a different age class. A subset of turtles did not fall clearly into one of the two pattern groupings, but rather showed an apparent blending of the two characteristic carapace and head patterns. Almost all of these turtles belonged to the mid-size range of green turtles foraging at Palmyra, suggesting they are either large juveniles or sub-adults. This intermediate pattern would fit with the markings of these turtles changing over their lifetimes, from a light burst pattern to a dark, mottled pattern later in life. Besides increasing our general knowledge of turtle morphology, distinguishing between the two pattern groups could be useful in determining age class of Pacific green turtles observed at a distance or from photographs when size measurements were not possible, leading to more detailed field surveys. However, it is currently unknown if this correlation between pattern and age applies to all green turtle populations. Each distinct population may warrant preliminary analyses using our methods to establish a possible link and assess its usefulness as a tool for population surveys.

NEW PROXY FOR SEX RATIO IN FIELD NESTS TAKING INTO ACCOUNT FLUCTUATION OF TEMPERATURE*

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Since its discovery in the 70's, temperature dependent sex determination remains an evolutionary mystery. Part of the difficulty in solving this evolutionary puzzle comes from the difficulty of predicting sex ratio, which is the driven force, in natural conditions. Indeed the only current 100% certain method to establish sex ratio of a nest is to dissect embryos or juveniles, which is of course not possible at a large scale from an ethical point of view. Dozens of proxies have been used until now but none of them are fully adequate: - some of them use proxies relevant of temperatures experienced by embryos during all development (for example, the incubation duration) whereas only temperature

during the thermosensitive period (TSP) of development is important, - other proxies use the middle third of incubation to estimate the TSP, whereas TSP is really at the middle third of development (it is different from incubation when temperature fluctuates). I propose to use the constant temperature equivalent (CTE) within the thermosensitive period (TSP) of development as a new proxy for sex ratio. The development of this new proxy has been made possible using a recently published model of embryo growth, which permits for the first time to define precisely the position of the TSP (In press).

CLONING AND EXPRESSION OF AROMATASE IN EMBRYONIC BRAIN AND GONADS OF A SPECIES DISPLAYING TEMPERATURE-DEPENDENT SEX DETERMINATION: THE OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*)*

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Several species of fish and reptiles display temperature-dependent sex determination, in which the differentiation of the gonads into ovaries or testes depends on the incubation temperature of the eggs during a critical period of embryonic development known as the thermosensitive period. Aromatase is a key enzyme responsible for the transformation of androgens into estrogens, and presents several isoforms expressed in different tissues. Here we report the isolation and expression of gonad and brain aromatase isoforms, plus a splice variant from olive ridley (*Lepidochelys olivacea*) embryos incubated at male- and female-promoting temperatures, at the undifferentiated period (stage 24) and the differentiated period (stage 27). Since the three aromatase sequences obtained for *L. olivacea* contained an almost identical open reading frame, we suggest they are encoded by the same gene, driven by tissue-specific regulatory mechanisms, including alternative splicing events. The splice variant obtained in this study was isolated from gonads, but it was also expressed (at lower levels) in the brain. Aromatase expression levels in gonads were low before sexual differentiation, nevertheless, after the thermosensitive period, expression levels increased in female gonads, suggesting aromatase participates in ovarian sex differentiation rather than sex determination. The splice variant was expressed (almost exclusively) in the differentiated female gonad, although at lower levels, and its biological importance needs to be further investigated. Aromatase is also expressed in the brain, showing higher expression levels in anterior brain areas at both temperatures. Both incubation temperature and developmental stage are critical factors affecting aromatase expression, and brain aromatase may participate in the imprinting of sexual trends related to reproduction and sexual behavior at the onset of sex differentiation.

BLOOD CHEMISTRY OF NESTING FLATBACK SEA TURTLES (*NATATOR DEPRESSUS*): BASELINE RESULTS PRIOR TO OFFSHORE OIL AND GAS DEVELOPMENT

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Flatback Sea Turtles, *Natator depressus*, forage for molluscs and other invertebrates over the continental shelf of northern Australia. At least four discrete meta-populations use separated nesting sites on mainland and coastal islands. Satellite trackings suggest the meta-populations mix on the feeding grounds. The more southern populations nest during the austral summer, November to February, while the northern populations nest either in the winter months, June to August, or throughout the year. Few reports address the physiology of Flatback Sea Turtle blood and none address biochemistry. In the 2013 breeding season, blood samples were collected from the lateral cervical sinus of ten female Flatback Sea Turtles after nesting on Bare Sand Island, Northern Territory. The blood was divided into Lithium

Heparin and EDTA blood tubes, chilled and transported to Berrimah Veterinary Laboratories (BVL) in Darwin, 50 km away. The analyses started within 24 hours of collection with the Packed Cell Volume determined from the EDTA tubes. Plasma from the heparinized samples was analysed for proteins, enzymes, electrolytes and other compounds. The analyses with their results as means and standard deviations are given below: - Packed Cell Volume (0.31 ± 0.04), - Glucose (3.78 ± 0.62 mmol/L), - Total Bilirubin (17.40 ± 8.11 μ mol/L), - Liver and cardiac enzymes; Alanine Aminotransferase (31.80 ± 5.88 units/L), Aspartate Aminotransferase (124.3 ± 18.12 units/L), Alkaline Phosphatase (90.00 ± 56.76 units/L), Gamma Glutamyl Transferase (4.3 ± 1.16 units/L) and Creatine Phosphokinase (511.90 ± 504.13 units/L), - Proteins; Total Protein (44.60 ± 9.89 g/L), Albumin (18.60 ± 4.72 g/L), Globulin (25.90 ± 5.63 g/L), Albumin/Globulin ratio (0.75 ± 0.07), - Kidney function compounds; Creatinine (28.10 ± 9.55 μ mol/L), Urea (1.30 ± 0.73 mmol/L) and Uric Acid (75.18 ± 15.82 μ mol/L), - Electrolytes; Sodium (144.90 ± 2.51 mmol/L), Potassium (4.91 ± 0.33 mmol/L), Chloride (105.40 ± 2.72 mmol/L), Calcium (5.19 ± 2.56 mmol/L), Phosphorus (3.90 ± 1.37 mmol/L) and Magnesium (2.70 ± 0.21 mmol/L). These concentrations differ, in part, from published values for adult Green Sea Turtles *Chelonia mydas*. This study addresses a select subset of adult Flatback Sea Turtles that have common parameters such as time of day, season, genetics, reproductive and body condition. Although the sample size is small, the results form part of the base line survey of nesting Flatback Sea Turtles that forage widely across the northern Australian continental shelf. Trawl, net and trap fisheries have been the major industries of the seas of northern Australia for more than 50 years. Within the last decade many oil and gas prospecting and production leases and licences have been issued as Australia strives to supply the World's demand for cleaner energy. Bare Sand Island has been a reference beach for trends in the annual nesting population of Flatback Sea Turtles. The blood chemistry of the nesting population now acts as a sentinel to habitat degradation and pollution.

LOGGERHEAD FIBROPAPILLOMATOSIS IN FLORIDA BAY, USA: FREQUENCY OF OCCURRENCE, TUMOR GROWTH, AND TUMOR REGRESSION

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Fibropapillomatosis (FP) is a neoplastic disease that has been documented in all hard-shell sea turtle species. It occurs frequently in green turtle populations from many areas of the world, but appears to be relatively uncommon in loggerheads. During 1990 – 2012, we had 1355 loggerhead captures (989 loggerheads – some were captured multiple times) at Florida Bay, USA, which is approximately 20 km south of the southern tip of the Florida peninsula. Each turtle was examined for external tumors consistent with FP as part of field data collection. For loggerheads with FP, each tumor was measured and drawn on turtle diagrams. Tumors were categorized by size (< 1 cm, 1 - 4 cm, 4 - 10 cm, > 10 cm) and turtles were assigned an overall tumor severity score based on the number and size of tumors. The standard straight carapace lengths of loggerheads with and without FP were 75.5 cm (n = 133, standard deviation: ± 6.8 cm) and 76.7 cm (n = 1222, standard deviation: ± 10.5 cm), respectively. Tumors were found mainly on the skin of axillary areas (base of front flippers, around neck) and inguinal areas (base of rear flippers, around tail). The annual prevalence of FP remained relatively constant (9.7 %, standard deviation: ± 4.7 %) over the study period. Almost all (98%) loggerheads with FP had mild to moderate overall tumor severity scores. The total recapture rate of loggerheads at this site was 25% – recapture periods ranged 1 – 16 years and recapture occasions ranged 1 – 7 times per turtle. Review of photographs and turtle diagrams demonstrated regression, progression, and no status change of tumors.

The results of 235 recaptured loggerheads showed from no-FP to FP (9%), from FP to no-FP (4%), from no-FP to FP to no-FP (1%), FP to FP (3%), and no-FP to no-FP (82%).

COMPARISON OF HOOK REMOVAL PROCEDURES EMPLOYED IN IMMATURE SEA TURTLES INCIDENTALLY CAPTURED AT FISHING PIERS IN MISSISSIPPI*

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Since 2010, over 500 incidental captures of sea turtles by recreational fishermen have been reported from local fishing piers in Mississippi. Whereas the species involved include Kemp's ridley, green, and loggerhead sea turtles, the vast majority of the captures have been immature Kemp's ridleys, with an average straight carapace length (Notch-Notch) of 30.75 ± 4.23 cm. The Mississippi Sound has been identified as an important developmental habitat for Kemp's ridley sea turtles, but this region and its inhabitants have endured a series of recent environmental catastrophes, most notably the Deepwater Horizon oil spill. Therefore, the restoration and recovery of Kemp's ridley sea turtles in addition to other sea turtle species depend on successful care and rehabilitation of these incidentally captured turtles. The majority of captured turtles were transported to the IMMS veterinary hospital, where they were given a full veterinary exam, including radiographs and blood work analyses. In 2012, the primary method to remove internal hooks was to back the hook out and suture any injuries; however, many of the turtles had longer rehabilitation periods due to iatrogenic esophageal lacerations. In 2013, a less evasive stab-incision method, in which a small external incision is created so the hook barb can be easily pushed through and cut, was the primary hook removal procedure. This method does not require sutures, and turtles in 2013, on average, required a shorter rehabilitation stay. In 2012, the average stay was 46 ± 42 days whereas turtles in 2013 required an average rehabilitation stay of 12 ± 9 days. The shorter rehabilitation period did not necessitate certain post-procedure medical care, such as antibiotics, calcium supplements, and iron supplements. The major hook type observed in captured turtles was J-hooks (70%), with circle hooks (17%), kahle hooks (10%), and jig hooks (3%) also documented. Other studies have concluded that circle hooks decrease overall sea turtle by-catch as well as hook ingestion. However, these studies focused on other species and older life history stages than the turtles that were commonly treated and reported in this study. Ingested circle hooks presented more difficult hook removals, thus, advocating for the use of circle hooks in this coastal recreational fishery may not be a suitable mitigation strategy.

SEA TURTLE RESEARCH, RESCUE AND REHABILITATION CENTRE (DEKAMER), DALYAN, MUGLA-TURKEY; EVOLUTION OF THE FIRST SIX YEARS

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The first sea turtle rescue center (DEKAMER) in Turkey was established in 2008 and its activities during the first six years are shown in these results. A total of 100 injured turtles were admitted to the centre during the first four years (2008 - 2013): 78 *Caretta caretta*, 19 *Chelonia mydas* and 3 fresh water turtles *Trionyx triunguis*. A total of 51 were treated, recovered and released back to the sea as healthy individuals. Unfortunately, 38 died. There are currently 11 sea turtles still under treatment and rehabilitation. The spatial and temporal patterns of the injured animals is presented. The main causes of injuries and deaths were found to be related to fishery and boat activities, such as fishing line and

hook ingestion (8%), fishing line entanglement (21%), propeller cuts and speed boat crashes (17%), buoyancy problems (16%) and other physiological and undetermined problems (38%). The treatment period varied between 2 weeks to the 2.5 years depending upon the type of injury, and size and depth of wounds being treated.

UPDATE ON THE BIOLOGICAL AND ENVIRONMENTAL MONITORING AND ARCHIVAL OF SEA TURTLE TISSUES (BEMAST) PROJECT: SAMPLE ARCHIVE AND CONTAMINANT ANALYSIS*

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The National Institute of Standards and Technology (NIST) expanded its analytical measurement capabilities and specimen banking resources into the U.S. Pacific Islands region in 2010. As part of this Program, NIST established the BEMAST Project in 2011 to archive tissues from sea turtles primarily for health and contaminant assessments. The rationale for the BEMAST project, its stringent protocols, and sample collections are described in a recent NIST Internal Report. The collection now includes 695 samples from 235 individual sea turtles and 27 sea turtle nests. These samples came from live captures, necropsies, and egg excavations. Samples from five species have been collected and locations encompass the Hawaiian Islands, Palmyra Atoll, and pelagic waters of the tropical Pacific Ocean. Tissues, including blood, scute, muscle, liver, fat, fibropapilloma (FP) lesions, bile, follicles, ingested plastics, eggs, and mouth algae, are stored at - 150° C at the NIST Marine Environmental Specimen Bank (Marine ESB) at the Hollings Marine Laboratory in Charleston, South Carolina. Analysis of subsamples has begun, including contaminant measurements, as well as metabolomics and lipidomics. Proteomics are expected soon. This presentation will report the organic contaminant results. Subsamples of plasma from green sea turtles from Hawaii (n = 54) and Palmyra Atoll (n = 5) have been analyzed for 164 persistent organic pollutants (POPs) and halogenated phenols. A smaller sample size (n = 12) of Hawaiian and Palmyra green turtle plasma has been analyzed for 12 perfluorinated contaminants (PFCs). These samples include green turtles from four groupings: 1) from sites free from FP, including Kiholo Bay, Hawaii, and Palmyra Atoll; 2) a site with low FP (Kailua Bay, Hawaii); 3) a site with moderate FP (Kapoho Bay, Hawaii); and 4) highly tumored Hawaiian stranded turtles. None of the compounds increase in concentration through these groupings, suggesting that they do not contribute to the onset of FP. The concentrations are low compared to green turtles from other regions and to other sea turtle species. These differences and the implications of these results will be discussed. Collections continue for all species with expansion into additional Pacific Islands. Organic contaminant analysis will focus future efforts on populations of more critical concern (leatherbacks) and species expected to accumulate higher levels (hawksbills).

THE EFFECT OF INCUBATION TEMPERATURE ON HATCHLING FEATURES IN LOGGERHEAD TURTLE

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Many studies have reported that incubation temperature influences hatchling attributes of reptiles including turtles. The range of these effects is diverse and can include determining the hatchling's sex, body shape, coloring, size, amount of yolk converted to tissue during embryonic development, locomotor performance and behavior. Variation in these traits could have consequences on hatchling fitness, and although studies documenting this type of phenotypic variation are numerous, only a relative few have attempted to relate such variation to hatchling fitness in a quantitative way. Direct measurements of fitness in hatchling turtles are difficult due to their relatively long life cycles (20 years for most species). Laboratory studies can help clarify these kinds of effects on offspring, to improve hatchling conservation strategies in nesting beaches through better management of nests. Studies in green turtle (*Chelonia mydas*) found that incubation temperature influence sex, size, and amount of yolk material converted to hatchling tissue as well as swimming performance during the 24 h frenzy swimming period that occurs within 48 h of hatching. These results clearly indicate that incubation temperature can have an important influence on hatchling fitness by influencing post-hatch mortality. In 2006, a project was started to expand the breeding habitat of loggerhead turtle (*Caretta caretta*) in the eastern Atlantic, through the reintroduction of the species in the Canary Islands. From 2006 to 2010, about 4000 loggerhead eggs were brought from Cape Verde to Canary Islands beaches and laboratories. Loggerhead turtle eggs were collected immediately after ovoposition in Cape Verde beaches, transported in less than 24 hours to Canary Islands, and incubated in the laboratory at several different temperatures. At hatching, biometric and fitness attributes was measured in all neonates. This study analyzes the influence of different incubation temperatures on the size and fitness of loggerhead hatchlings, comparing variable/constant temperatures and low/high temperatures, and their influence on the features of the sex-determined hatchlings.

FUNGAL SPECIES: A POTENTIAL EMERGING THREAT ON LEATHERBACK NESTING POPULATIONS

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Hatching success of sea turtle species appears to be affected by the presence of pathogenic fungal species, such as two specific phylogenetic species of the *F. solani* complex (FSSC), *i.e.*, *Fusarium falciforme* and *Fusarium keratoplasticum*. However, the presence and symptoms produced by these fungi in eggs of leatherback turtle have never been reported. In this study, we have analyzed eggs of leatherback sea turtle species in Pacuare beach located on the Caribbean coast of Costa Rica. The main aims of this research were to identify the presence of these potential pathogenic fungi and to develop a methodology of visual identification in order to assess the level of infections in eggs. In order to analyze fungal diversity in leatherback eggs, fungal isolations were made from eggshells. Eggshell samples (n = 56) were collected after hatching of nests and subsequent excavations from relocated clutches situated in a controlled hatchery. Isolations were made by placing eggshell pieces on sterile Petri dishes with peptone glucose agar (PGA) supplemented with ampicillin addition (100 mgL⁻¹). From the resulting axenic cultures DNA extraction, amplification, purification and sequencing of internal transcribed spacer (ITS) regions were performed. Molecular characterization and phylogenetic analyses were completed and the results highlighted the presence of diverse number of potential pathogenic fungi, including *F. falciforme* and *F. keratoplasticum*. Because of the impact of fungal emerging infectious diseases, sea turtle conservation management should consider the effect, prevention and control

of these potential harming diseases. Conservation programs based on disease-prevention are becoming of increasing interest, especially in ‘hot-spot areas’ of biodiversity. Overall, our results are of key importance in leatherback conservation, as well as in other sea turtle species, because it may allow us to identify the presence of these pathogens, to track possible impacts and consequently, to propose conservation strategies to mitigate its effects.

WIDECAST ONLINE VETERINARY GUIDE

Nancy Mettee¹, Sandy Fournies², and Karen Eckert¹

¹ WIDECAST

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Online Sea Turtle Veterinary Guide www.WIDECAST.ORG The Veterinary Guide is intended to be a starting point for practicing veterinarians with little or no experience in reptile medicine, and an ongoing reference for those with greater experience. It is designed as a “work in progress” with additions, changes, and more information added as needed. It complements WIDECAST's earlier Marine Turtle Trauma Response Procedures: A Field Guide PDF and Marine Turtle Trauma Response Procedures: A Husbandry Manual PDF, further encouraging standardized approaches with regard to sea turtle rescue, care and release. Florida Fish and Wildlife Conservation Commission's Holding Marine Turtles in Captivity PDF and United States Fish and Wildlife Service's Standard Permit Conditions for Care and Maintenance of Captive Sea Turtles PDF are also helpful. In veterinary medicine there are a number of ways to approach the treatment of a patient. The recommendations herein are based on experiences and may be helpful in helping to avoid some of the more common pitfalls. However, resources will vary and each veterinarian must be free to exercise their clinical judgment and to make decisions based on circumstances and what is available to them. Sea turtles are protected as endangered species by the SPAW Protocol and are protected - in most cases year-around - by the national laws of nations throughout the Western Atlantic region. You may need specialized training and a state and/or federal permit to handle, transport, retain, or treat a sea turtle. This is certainly true in the US. Specialized actions, including euthanasia, may also need a permit (again, this is definitely true in the US). Contact the U.S. Fish & Wildlife Service and your state agency (e.g., Florida Fish and Wildlife Conservation Commission Marine Turtle Permit) or your WIDECAST Country Coordinator for details.

BODY CONDITION REFERENCE RANGES FOR GREEN TURTLES (*CHELONIA MYDAS*) IN SOUTHEASTERN FLORIDA

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Green turtles (*Chelonia mydas*) can be found in the coastal waters of southeastern Florida, where they encounter numerous anthropogenic and natural threats. Each year hundreds of sick or injured green turtles in the state are taken to rehabilitation facilities where their injuries are treated. We examined body condition, one health parameter used during sea turtle health assessments that lacks reference values. Body condition is considered a broad measure of general health. It is typically quantified by a condition index (CI), a ratio of the turtle's mass to length, or by visually assessing physical characteristics such as plastron shape and amount of muscle mass on the head and neck. We found that CI varied significantly by size class, season, presence or absence of fibropapillomatosis, and capture location. However, these differences were too small to have a meaningful effect when establishing reference values. We also found that field biologists and veterinary staff assessed body condition similarly when using the visual assessment technique. This allowed us to establish body condition reference intervals for the population of wild green sea turtles and associate visual assessment condition categories with CI values. The overall goal of this study was to provide a standardized method for assessing body condition of green sea turtles in southeastern Florida waters.

AN OVERVIEW OF THE HEMATOLOGIC EVALUATION OF ANEMIC SEA TURTLES IN REHABILITATIVE CARE AT THE GEORGIA SEA TURTLE CENTER*

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Defined as decreased erythrocyte (red blood cell, RBC) mass in the peripheral blood, anemia is one of the most common disorders of the hematopoietic system in both human and veterinary medicine. Anemia can occur after blood loss, increased RBC destruction, decreased RBC production, or a combination thereof. In stranded sea turtles, anemia is often suspected to be multi-factorial in nature. Clinicians and technical staff are able to identify and assess anemia by use of clinical history, physical examination findings and laboratory evaluation. Between January 2010 and December 2013 (4 years), two-hundred and twenty-two (222) sea turtles (*Caretta caretta* [n = 74], *Chelonia mydas* [n = 122], and *Lepidochelys kempii* [n = 36]) with various conditions (i.e. trauma, debilitation, fisheries interaction, cold-stunning) were admitted to the Georgia Sea Turtle Center (GSTC, Jekyll Island, Georgia, USA) for hospitalization. A packed cell volume (PCV) less than 25% is used to identify anemia in immature and mature sea turtles. The majority of admitted sea turtles (61.3%; n = 136) initially presented with or developed anemia during rehabilitation at the GSTC. The anemia was further classified as mild (19 - 24% PCV) in 42.6%, moderate (13 - 18% PCV) in 23.5%, severe (6 - 12% PCV) in 22.1% or critical (< 5% PCV) in 11.8% of the patients. The objectives of this study were to investigate the onset, severity and frequency of anemia in sea turtle patients, to evaluate treatment success, regenerative responses and potential causes in anemic patients and to compare the results among species, age/size class and admission causes. Since red blood cells of reptiles are nucleated and thus can only be analyzed by manual methods, the laboratory assessment of anemia is limited and can be challenging compared to mammalian patients. In-house hematologic analysis includes PCV, white blood cell (WBC) count, WBC estimate, WBC differential and morphologic evaluation of RBC, WBC and thrombocytes upon blood film evaluation. Microscopic evaluation of RBC morphology for evidence of a regenerative response to the anemia is most useful in the characterization of anemia in reptilian patients and it provides guidance to the clinician in choosing appropriate therapeutic approaches and elected medical intervention. As one of the leading facilities in the world for sea turtle care, the GSTC has established many medical treatment regimes for anemic sea turtles including optimal nutritional support, fluid therapy, iron supplementation, erythropoietin administration and blood transfusions. The results of this study provide a platform for future research on the topic of anemia in sea turtles and reptiles in general.

DEBILITATED SEA TURTLE CLINICAL MANAGEMENT*

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The Georgia Sea Turtle Center (GSTC) integrates rehabilitation of injured sea turtles and other wildlife; veterinary, ecological, and conservation research; and professional student training and interactive education for the public. The GSTC has treated 380 sea turtles over the last 6.5 years. Of those, 198 were loggerheads (*Caretta caretta*), 118 greens (*Chelonia mydas*) and 61 Kemps ridleys (*Lepidochelys kempi*). Approximately 65 percent have been released back to the wild. Common presenting problems include boat strike injuries and other forms of trauma, cold stunning, fish hook and line related injuries, flotation abnormalities, and debilitation. Debilitation in sea turtles is a common presenting problem at rehabilitation centers worldwide. This discussion will focus on the clinical management of debilitation in loggerhead sea turtles. The cause of debilitation in sea turtles is multifactorial and the primary etiology may be masked by secondary and opportunistic diseases. In 2003, a large number of debilitated loggerhead sea turtles stranded along the Southeastern US. Standardized diagnostic and necropsy protocols were established and utilized in

2004 and 2005 to establish a common etiology among these cases. The final results indicated that this condition was likely end stage disease for loggerhead sea turtles and likely has numerous causes. The large mortality event in 2003 may have stemmed from a single cause but that was not definitely determined. When a loggerhead sea turtle presents in a debilitated state, the most helpful initial diagnostics include a thorough physical examination, a complete blood count and plasma chemistry profile and radiographs. Physical examination often reveals heavy epibiota (e.g. leeches, small barnacles, etc.) on the skin and shell, ulcers and other deep wounds on the skin and shell secondary to the poor nutritional state of the turtle, severe emaciation, and fluid in the coelomic cavity. Care should be taken when handling these turtles because there have been several cases of heart lacerations secondary to sharp plastron bone penetration (Norton, unpublished). Blood work typically reveals a severe non-regenerative anemia secondary to bone marrow suppression, hypoproteinemia and hypoalbuminemia, hypoglycemia or hyperglycemia, and low blood urea nitrogen. Low plasma iron is relatively common. Radiographic findings often reveal colonic impactions from chitinous exoskeleton and shell parts secondary to ileus. Spirorchid trematode egg embolism with secondary granuloma formation in multiple tissues is a common finding on histopathology. An ulcerative colitis has been documented in most cases which is secondary to trematode egg embolism to the capillaries of the colon and other parts of the GI tract. Many of these turtles do respond to therapy despite the severity of their condition. Successful treatments have included crystalline and colloidal fluid therapy intravenously, transfusions, synthetic erythropoietin (Procrit), motility modifying drugs (Cisapride and Metaclopramide), mineral oil or GoLytely, and oral nutritional support with a highly absorbable elemental diet, deboned and debeaked prey items, iron supplementation, specific vitamin and mineral supplementation, antimicrobial therapy, endoscopy guided saline ememas and cortisone suppositories, and treatment of Spirorchid trematodes and other parasites. Treatment will vary depending on the severity of debilitation and secondary complications.

SEASONAL INVESTIGATIONS ON THE PATTERN OF SPERMATOGENESIS IN THE AFRICAN SIDENECK TURTLE (*PELUSIOS CASTANEUS*)*

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In order to describe the pattern of spermatogenesis in the African sideneck turtle, a twelve-month study involving gross anatomy of reproductive organs, sperm morphology, gonadal and extragonadal sperm reserves, histology and ultrastructure of the testis and epididymis of the turtle were carried out. In each month, 6 adult male *P. castaneus* picked at various river drainages in Ibadan, Nigeria, were used for the study. The average body weight of the turtles was 723 ± 23.36 g, while the curved carapace and plastron lengths of the turtles were 24.4 ± 1.47 cm and 15.7 ± 1.23 cm, respectively. The testis and epididymis were attached to the peritoneal wall in all the turtles examined being located posterior to the lungs and ventrolaterally related to the kidneys on both sides of the median plane of the turtle. The testis was yellow, smooth and ovoid in shape while the epididymis was relatively sigmoid in shape and creamy in colour. The mean gonadal sperm reserves of the *P. castaneus* was $48.50 \pm 2.13 \times 10^6$ /ml; accounting for 27.5% of the total sperm reserves while that of the extragonadal was $127.61 \pm 12.28 \times 10^6$ /ml being 72.5% of the total sperm reserves with a significant difference ($P < 0.05$). Spermatozoa of the *P. castaneus* are filiform in shape and approximately $80.6 \mu\text{m}$ in length with the head measuring $18.2 \mu\text{m}$ in length and $3.4 \mu\text{m}$ in diameter. The mid-piece and tail lengths were $8.9 \mu\text{m}$ and $53.7 \mu\text{m}$, respectively. The testis is ensheathed by a capsule organised into two layers, the outer tunica vaginalis and the inner tunica albuginea. The highly convoluted seminiferous tubules of the testicular tissue had basement membranes lined with germ cells arranged in successive layer representing different stages of cell division. The epididymis had spermatozoa within its lumen with about 5 to 8 ductuli efferentes found within its lamina propria. The epithelia of the epididymis and ductuli efferentes were lined by pseudostratified ciliated columnar cells. The outcome of the histology and ultrastructure of the testis and epididymis, gonadosomatic index, epididymal mass index, seminiferous tubule diameter and epididymal ductal diameter all suggest the postnuptial pattern of spermatogenesis. Sperm production in the *P. castaneus* starts in May (onset of raining season) and peaks in September. It is thereafter released into the epididymis and the degree of sperm packing of the epididymis increases from October, reaching its peak in January (dry season). Spermatozoa were found in the epididymis of the turtles all through the

year. The study shows that the postnuptial pattern of turtle spermatogenesis is not unique to turtles in the temperate regions of the world alone and that the spermatogenic cycle of the *P. castaneus* is similar to those of other chelonians with minor variations. This report, the first of its kind for a pelomedusid turtle, therefore serves as baseline information for the family in comparative studies of the spermatogenic cycle of turtles and in the ultrastructural investigations of the spermatozoa of sea and freshwater turtles.

INVESTIGATING CHELONID FIBROPAPILLOMA-ASSOCIATED HERPESVIRUS IN SYMPTOMATIC AND ASYMPTOMATIC INFECTED GREEN SEA TURTLES*

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Chelonid fibropapilloma-associated herpesvirus (CFPHV) is the most important infectious disease of marine turtles. This virus has been consistently associated with fibropapillomatosis (FP), which affects all hard-shelled sea turtle species but has reached epizootic proportions in green sea turtles (*Chelonia mydas*). CFPHV has also been identified in normal turtles, likely representing early or subclinical infection. In this study, we develop and apply molecular techniques to better understand the virus-host pathosystem of CFPHV, and investigate how the virus is shed in symptomatic and asymptomatic infected green turtles. Our research objective is to identify cryptic sources of potentially transmissible viral particles in specific sample and cell types involved in symptomatic and asymptomatic CFPHV infection. This is a comparative study of juvenile, wild-caught green sea turtles in rehabilitation facilities throughout eastern Florida and Georgia, USA. Turtles are retrospectively assigned to one of 3 study groups based on identification of CFPHV presence/absence in samples using polymerase chain reaction (PCR) and serological screening: symptomatically infected, asymptotically infected, and uninfected. Quantitative PCR (qPCR) assays for CFPHV DNA polymerase were developed and optimized in order to explore in more depth the properties of the infecting virus, the cell type(s) infected, the extent of virus replication, and viral loads in various biological samples. Biological samples tested for quantities of CFPHV DNA include skin, mucosal epithelium, blood, feces, and urine. Additionally, laser capture microdissection and qPCR are combined to assay microscopically differentiated cells from skin, gastrointestinal, renal and pulmonary epithelium, oral and cloacal mucosal epithelium, blood, and oviduct samples. Finally, we apply qPCR to seagrass and seawater samples since, if present, persistent CFPHV virions in the environment can be critical to sustaining viral transmission cycles, particularly in green sea turtle populations with shifting densities. We expect to identify CFPHV particles in specific biological and environmental samples, suggesting previously unidentified routes of viral transmission. Finding CFPHV DNA on the skin of non-tumored turtles would indicate subclinical carriers; CFPHV in mucosal epithelium could indicate cloacal or orocutaneous shedding; and CFPHV in body excretions would indicate persistent infection. Intermittent shedding by asymptotically infected turtles could explain spontaneous infections in established turtle colonies, and suggest additional mechanisms for CFPHV transmission under natural conditions. Understanding characteristics of subclinical infection would allow for better identification of biological factors leading to viral transmission, and help to optimize detection and control strategies for FP in natural and captive settings.

ANALYSIS OF TRACE ELEMENT COMPOSITION OF LOGGERHEAD SEA TURTLE BONE VIA LASER ABLATION

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Intrinsic biogeochemical markers (e.g. stable isotopes, trace elements, lipids, chemical pollutants) are commonly used as tracers of life history for many long-lived marine organisms. Trace element assays in particular can be used to identify migration and foraging patterns among different taxa. The utility of these assays in aquatic systems arises because consumers accumulate trace elements in their tissues in relation to those present in their diet and occupied habitats. The purpose of this study was to determine if trace element composition could be used to examine foraging ecology and habitat use of loggerhead sea turtles by comparing bone tissue elemental ratios obtained through laser ablation-inductively coupled plasma mass spectrometry (LA-ICPMS) to paired stable isotope ratios ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) and skeletochronological data. LA-ICPMS is widely used to measure trace element ratios in fish otoliths and bones; however, this is the first application to the study of sea turtle bones. Two mm thick humerus bone cross-sections were collected from 12 loggerhead sea turtles for use in this study. LA-ICPMS was performed along two transects perpendicular to annual growth layers in each bone to quantify ratios of 20 elements (B, Ba, Be, Ca, Cd, Cr, Cu, Fe, Hg, Kr, Li, Mg, Mn, Pb, Rb, Se, Sn, Sr, V, Zn). Of the elements measured magnesium was present in the greatest ratios ($\text{Mg}/\text{Ca} = 39.81 \pm 5.37 \text{ mg/g}$), followed by strontium ($\text{Sr}/\text{Ca} = 10.70 \pm 0.91 \text{ mg/g}$), barium ($\text{Ba}/\text{Ca} = 0.88 \pm 0.42 \text{ mg/g}$), and zinc ($\text{Zn}/\text{Ca} = 0.61 \pm 0.17 \text{ mg/g}$). Bioapatite is the major component of bone (~70%) and can easily absorb and retain magnesium, which may explain why magnesium was found in greater ratios than any other element measured. The next most abundant elements included: chromium (1.85 ± 0.23), manganese (0.60 ± 0.70), copper ($0.17 \pm 0.078 \text{ mg/g}$), boron ($0.18 \pm 0.047 \text{ mg/g}$), tin ($0.015 \pm 0.0023 \text{ mg/g}$), and lead ($0.012 \pm 0.0064 \text{ mg/g}$). Preliminary analyses show a negative relationship between elemental ratios (Sr/Ca , Ba/Ca , Zn/Ca) and stable isotope ratios ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$), indicating that as stable isotope ratios become more enriched with increases in trophic position of prey and migration to nearshore habitats there may be a subsequent depletion in elemental ratios of strontium, barium, and zinc. Ongoing analyses will work towards characterizing the strength of this relationship to further investigate that application of LA-ICPMS to the study of sea turtle foraging ecology and habitat associations.

BREVETOXIN EXPOSURE, OXIDATIVE STRESS AND PLASMA PROTEIN ELECTROPHORETIC PROFILES IN KEMP'S RIDLEY SEA TURTLES (*LEPIDOCHELYS KEMPII*) IN SOUTHWEST FLORIDA

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Because of their vulnerable population status, assessing exposure levels and impacts of toxins on the health status of Gulf of Mexico marine turtle populations is critical. From 2011 – 2013, two large blooms of the red tide dinoflagellate, *Karenia brevis*, occurred along the west coast of Florida USA (from October 2011 – January 2012 and October 2012 – April 2013). Other than recovery of stranded individuals, it is unknown how harmful algal blooms affected the Kemp's ridley sea turtles (*Lepidochelys kempii*) inhabiting the affected coastal waters. It is essential to gather information regarding brevetoxin exposure in these turtles to determine if it poses a threat to marine turtle health and

survival. From April 2012 – May 2013, we collected blood from 13 immature Kemp's ridley turtles captured in the Pine Island Sound region of the Charlotte Harbor estuary. Nine turtles were sampled immediately after or during the red tide events (intra-bloom group) while four turtles were sampled between the events (inter-bloom group). Plasma was analyzed for total brevetoxins (PbTx-3 backbone), superoxide dismutase activity, total protein and protein electrophoretic profiles (albumin, alpha-, beta- and gamma-globulins). Brevetoxin concentrations ranged from 7.0 – 33.8 ng eq/ml. Plasma brevetoxin concentrations in the nine turtles sampled during or immediately after the red tide events were significantly higher (by 59%, $P = 0.04$) than turtles sampled between events. No significant correlations were observed between brevetoxin concentrations and plasma proteins or superoxide dismutase activity, most likely due to the small sample size; however alpha-globulins tended to increase with increasing brevetoxin concentrations in the intra-bloom group. Smaller (mass and carapace length) intra-bloom turtles had higher plasma brevetoxin concentrations than larger intra-bloom turtles, possibly due to a growth dilution effect with increasing size. Lastly, turtles with higher PbTx-3 concentrations had increased plasma superoxide dismutase activity, indicating that brevetoxin exposure may be related to oxidative stress. The research presented here improves the current understanding of potential impacts of environmental brevetoxin exposure on marine turtle health and survival.

EXPLORING HEAD SIZE VARIATION IN ADULT FEMALE LOGGERHEAD TURTLES

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Variation in trophic morphology among individuals within a population suggests intra-population variation in diet and resource use. In these situations, individuals are more specialized and occupy a narrow portion within the ecological niche of a more generalist population. Among loggerhead sea turtles (*Caretta caretta*), adult individuals appear to exhibit variation in head size, a trait that is known to be an important predictor of feeding performance in turtles. To better understand head size variation in adult female loggerheads, we sought to answer the following questions: (1) Is variation in head size mostly explained by body size? (2) Is variation in head size related to foraging area? (3) Is head size related to differences in trophic level? To answer these questions, we measured head size (length, width and depth) and body size (curved carapace length) of nesting female loggerheads on Wassaw Island, Georgia, USA. For (1), we quantified the amount of variation in head size that is explained by body size using linear regressions. For (2), we compared relative head size among turtles from different foraging areas identified through stable isotope analysis ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) of skin. For (3), we compared relative head size with nitrogen isotope values ($\delta^{15}\text{N}$) using linear regressions. Our initial results suggest that (A) head size variation is only partially explained by body size, (B) head size variation may be related to foraging area, and (C) head size variation is not related to trophic position. These results represent a first step towards understanding how patterns of individual variation in trophic morphology are distributed in a sea turtle population and further our understanding of the ecological roles sea turtles play in different habitats and in different life stages.

DEVELOPMENTAL ANALYSIS OF ROD AND CONE PHOTORECEPTORS IN THE RETINA OF THE GREEN SEA TURTLE (*CHELONIA MYDAS*)

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The objectives of the project provide a comprehensive comparative analysis of retinal structure over the course of development (the first of its kind) in the green sea turtle (*Chelonia mydas*). A two prong approach was implemented to ensure proper characterization of the retina, specifically the photoreceptors. In order to characterize the retina, immunohistochemical techniques were conducted (L eye) to localize opsin proteins along with other morphology only able to be seen through light microscopy techniques (R eye). *C. mydas* tissue were obtained through The Cayman Turtle Farm, a captive breeding organization located on Grand Cayman Island. The eye tissue collected from the turtle farm were freshly dead *C. mydas* with varying causes of death by euthanasia and/or sacrificing at the farm. The eyes were immediately enucleated (all during daylight) and the anterior segment (cornea, iris, and lens) of the eye was cut out to ensure proper infiltration of fixative. A small “v” was cut through the sclera for later orientation. There was a total sample size of 12 among three developmental stages of sea turtles: four hatchlings, three juveniles, and five adults. The hatchlings had a MCL of 5.3 cm, MCW of 4.1 cm, and were all less than one month of age. The juveniles had a MCL of 17.8 cm, MCW of 14.3 cm, and an approximate age of 0.8 years. The adults had an MCL of 80 cm, MCW of 57 cm, and an approximate age of four years. Experiments included localizing cone-opsin and rhodopsin proteins via immunohistochemically staining cross sections of the retina with anti-opsin antisera with a fluorophore tagged secondary antibody. The antibodies used were tested numerous times in different species of turtles, including local sea turtle samples with positive cone immunoreactivity (CIR) and positive rod immunoreactivity (RIR). Positive CIR as well as positive RIR was concluded from the Cayman Island (CI) tissues samples (non-specific labeling was not present). Controls included (1) omission of secondary antisera and (2) pre-absorption of primary antisera. High-resolution image acquisition was performed with a Nikon CISI laser scanning confocal microscope on site with quantitative analysis using NIS-Elements AR 3.16. Characterization of the retinal tunic was further analyzed via light microscopy to confirm immunoreactivity and add to our understanding of their visual processes. The hatchlings were confirmed to have a visual streak (high concentration of cone photoreceptors in a specific region) in the central region of the eye. In addition, throughout the retina the rods appear to be more ubiquitous while the cones tend to bundle together. In addition, at least for the hatchlings and juveniles there is a significantly more cone photoreceptors in the dorsal region compared to the ventral region ($p < 0.05$). A statistical significance has not been found between any of the developmental stages (statistics of all subsamples have not been completed). However, it appears that intraretinal variability is ever present in the sea turtle eye and immunohistochemical techniques can be successfully used to study and characterize the retina of the sea turtle throughout development in many different ways.

EFFECTS OF FLUCTUATING INCUBATION TEMPERATURES ON THE SEX OF A TURTLE EXHIBITING TEMPERATURE-DEPENDENT SEX DETERMINATION

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Traditionally, constant temperatures have been used when examining the relationship between incubation temperature and sex in turtles exhibiting temperature-dependent sex determination (TSD). While this method is appropriate for predicting the sex of species with relatively deep nests (i.e. sea turtles), it does not accurately represent the natural fluctuations in temperatures seen in turtles with relatively shallow nests (e.g. emydid turtles). It has been suggested that fluctuating temperatures during incubation can result in observed sex ratios that stray from predicted sex ratios under the constant mean temperature model due to changes in developmental rate as temperature changes. The current

study examines how incubation temperatures varying $\pm 6^{\circ}\text{C}$ from a mean of 28.2°C affects the sex and incubation duration of species exhibiting TSD using the red eared slider (*Trachemys scripta*) as a model. The fluctuating temperature group with a mean temperature of 28.2°C was compared to a control group incubated at a constant 28.2°C . *T. scripta* exhibits a male:female pattern of TSD, where males are produced at relatively cool incubation temperatures and females produced at relatively warm incubation temperatures. Results indicate that individuals incubated under the fluctuating temperature regime have a significantly longer incubation duration compared to those incubated at a constant 28.2°C . Eggs incubated under the constant temperature regime resulted in a heavily male biased sex ratio as predicted by the mean constant temperature model. Interestingly, the eggs incubated under the fluctuating temperature regime predicted to have the same sex ratio produced 100% female hatchlings. With the exception of carapace width, there were no significant differences found in hatchling mass or carapace length among the two groups. Collectively, the results indicate that fluctuating temperatures have a complex effect on hatchling phenotype that may not be completely explained by differing developmental rates alone.

CAN DEAD STRANDED SEA TURTLES YIELD VIABLE SAMPLES FOR STABLE ISOTOPE ANALYSIS?

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Stable isotope food web studies traditionally rely on samples collected from live animals to provide insight into diet and foraging behavior. Although bone samples can provide a wealth of foraging information, utilizing soft tissue samples enables simpler and more cost effective measures to analyze stable isotopes. One major hurdle in sea turtle research programs is that live animals are rare and difficult to sample, often resulting in small sample sizes for statistical analyses. Dead stranded sea turtles present an opportunity to obtain a wide variety of tissue samples for isotopic analysis, potentially resulting in greatly increased sample sizes. Using frozen flippers from fresh dead stranded sea turtles, we tested two hypotheses to assess the feasibility and reliability of utilizing dead muscle and skin tissue. The first hypothesis stated that $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values would not show significant variability in muscle samples from eight different muscles in the right front flipper: distal and proximal bicep, distal and proximal extensor, distal and proximal tricep, flexor and subscapularis (at the flipper insertion), analyzing each location in triplicate. The results indicated an overall effect of sample location ($F_{7,16} = 14.32$; $p = 0.0003$). The $\delta^{15}\text{N}$ values did not vary significantly ($F_{7,16} = 2.74$; $p = 0.0543$) between muscle groups, but $\delta^{13}\text{C}$ values reflected significant differences ($F_{7,16} = 3.51$; $p = 0.0178$). The differences in $\delta^{13}\text{C}$ were between the proximal extensor and three other muscles (proximal biceps, proximal triceps, and subscapularis; $p < 0.05$). No other locations revealed values that were significantly different. These results suggest that samples should be taken in the same location to ensure consistency, and, if an alternate location is required, the proximal extensor region should be avoided. The second hypothesis stated that $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values in samples taken from skin and skeletal muscle tissue would not show significant variability as the tissues decomposed. Flippers from eight different fresh dead loggerhead and Kemp's ridley sea turtles were sampled over a 21-day period while they decayed in either air ($n = 4$) or salt water ($n = 4$). We found no overall effect of number of days from the first sample ($F_{10,116} = 0.53$; $p = 0.8635$), but there was a significant effect for tissue type ($F_{2,57} = 39.01$; $p < 0.0001$). Skin was different than muscle tissue for both $\delta^{13}\text{C}$ ($F_{1,58} = 59.98$; $p < 0.0001$) and $\delta^{15}\text{N}$ ($F_{1,58} = 6.98$; $p = 0.0106$). The disparity between tissues was expected because stable isotope ratios in skin and muscle have different turnover times and the two tissues likely reflect isotope ratios from different locations with different prey species. There was considerable variation, however, between individuals. We were able to explain individual variation by using a repeated measures approach. These results suggest that we can include samples from both fresh and moderately decomposed animals. Although not significant, there was higher variability in all values after seven days of decomposition following initial sampling, suggesting that severely decomposed animals should be excluded from the analysis. These results suggest that stable isotope samples from stranded turtles provide viable samples and may greatly increase the number of samples that can be included in studies to increase or be compared with studies on live turtles.

ANEMIA AND CONCURRENT GASTROINTESTINAL DISORDERS IN GREEN SEA TURTLES: A STORY OF SUCCESS AND LOSSES*

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Gastrointestinal (GI) disorders are frequently observed in green sea turtles admitted to rehabilitation facilities. Among the most common causes are infectious etiologies, motility disorders, trauma, foreign body and other obstructive processes that often lead to gas accumulation and buoyancy disorders. In addition to physical examination and diagnostic imaging of these patients, initial diagnostically useful laboratory tests include complete blood counts and plasma biochemistry. The objectives of this study were to summarize clinical, laboratory and pathologic findings in green sea turtles with diagnosis or clinical suspicion of GI disorders and concurrent anemia and to present medical treatment options and clinical decision factors that can be helpful to optimize medical care for such patients. Medical records of green sea turtles admitted to the Georgia Sea Turtle Center, Jekyll Island, GA (GSTC) from January 2010 to February 2013 were reviewed retrospectively. Inclusion criteria were clinical diagnosis or suspicion of GI disorder, packed cell volume of 25% or less and rehabilitation for longer than 5 days. Of forty-seven sea turtles with anemia at admission, six were included in the study. Three animals were successfully released and three died. Survivor turtles were diagnosed/suspected with gastrointestinal diseases such as impaction, cloacitis and/or distention of GI tract. The three survivors had mild to moderate anemia at admission and one developed moderate anemia during rehabilitation. The time from the presence of anemia to evidence of regeneration ranged from 12 to 48 days. Additional blood work results of all three survivors included monocytosis, heterophilia and elevated creatine kinase enzyme concentrations. Nonsurvivor turtles with clinical diagnosis/suspicion of GI disorders had impaction, ileus, stricture, abscesses and/or intestinal ulcerations upon gross and histopathologic examination. Consistent laboratory findings in turtles that died were mild to severe nonregenerative anemia without development of regeneration in any of the turtles. Other laboratory findings were monocytosis, hypocalcemia and hyperphosphatemia in two turtles that died. Sea turtle patients with GI disorders often present a challenge to the clinician with regard to diagnosis and medical care. The concurrent condition of anemia in these patients complicates treatment and the rehabilitation process, since the pathogenesis of anemia in these patients is often complex and poorly understood. First intention treatment is symptomatic and includes fluid supplementation, appropriate antibiotics, gastroprokinetics and/or laxatives, oral or injectable iron supplementation, and blood transfusions and/or bone marrow stimulants in the most severe cases. Treatment regimes for these clinically challenging cases will be discussed.

LONG-TERM MONITORING OF BLOOD PARAMETERS OF INJURED SEA TURTLES UNDER REHABILITATION

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Two species of sea turtles (*Caretta caretta* and *Chelonia mydas*) are using Turkey's Mediterranean coastline for nesting and foraging. Dozens of sea turtles are being injured or killed in consequence of fishery interactions, speed boat accidents, ghost nets etc. along the coastline of Turkey. Annually around 20 injured turtles are being admitted by DEKAMER (Sea Turtle Research, Rescue and Rehabilitation Centre, Turkey). Most turtles need long term

rehabilitation after receiving treatment at the centre. To assess baseline health parameters of turtles, we have been recording healthy and injured turtles' biochemical blood parameters since 2009. Sixty-two of a total 96 admitted injured turtles kept under rehabilitation more than 60 days. Therefore, we started to record monthly monitoring of 16 biochemical blood parameters in injured turtles since 2012. Twenty-one loggerhead turtles have been monitored in the last 14 months. We also captured 41 healthy loggerhead turtles from wild to compare the results of injured turtles. 10 of 16 monitored parameters showed significant differences between healthy and injured turtles. These results are the first long term monitoring of blood biochemical parameters of injured loggerhead turtles and comparison of these results with healthy individuals will be very useful as a complementary diagnostic tool in rehabilitation of turtles.

ECOSYSTEM HEALTH AND ENVIRONMENTAL INFLUENCES ON INNATE IMMUNE FUNCTION IN THE LOGGERHEAD (*CARETTA CARETTA*) AND GREEN (*CHELONIA MYDAS*) SEA TURTLE*

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Sea turtles are remarkable, long-lived reptiles that have occupied the marine realm for millions of years, migrating thousands of miles to nearshore habitats that pose numerous anthropogenic threats. Of increasing concern is how anthropogenic impacts and global climate change may affect the emergence of infectious disease within Florida's coastal wildlife populations. Our understanding of disease processes in sea turtles, however, is hampered by our lack of basic knowledge of their immune function. While adaptive immune responses have been previously investigated to some extent, there has been virtually no work on the far older, native system of innate immunity. By elucidating the basics of innate immune function in sea turtles, we will gain a better understanding of their physiology in degraded near shore habitats as well as predict responses to ever increasing global temperatures. As non-specific immune defenses evolved relatively early, it is likely that the sea turtle as a "living fossil" relies heavily on this modality in addition to mounting an adaptive response. The objective of this research was to quantify phagocytosis by the innate immune cells in the loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtle. We isolated peripheral blood mononuclear cells (PBMCs) from polymorphonuclear granular leukocytes (PMNs) and utilized both flow cytometry and fluorescent microscopy to quantify phagocytosis of FITC labeled latex beads and fluorochrome conjugated *Staphylococcus aureus* to demonstrate that sea turtle monocytes and heterophils engage in phagocytosis. We examined the innate immune response at a variety of temperatures in both healthy turtles and those from habitats where disease is prevalent. Results showed that the innate immune system is likely to play an important role in the overall immune response of sea turtles, as suggested by both the high proportion of heterophils in the circulating WBC population, and the finding that their rates of phagocytosis exceed those of the monocyte/lymphocyte enriched cell layer at all temperatures and in both degraded and pristine habitats. Despite the fact that very cold or warm temperatures generally have negative impacts on reptile physiological processes, sea turtle white blood cells continue to function across a wide range of temperatures and are capable of phagocytosis across a temperature range of 7° to 37°C. However, animals that resided in a polluted habitat (the environmentally degraded Indian River Lagoon) mounted a far less robust immune response than those from the more pristine Trident Basin, which exhibited five-fold higher heterophil phagocytic activity ($p < 0.05$). With the innate response likely to be such a critical part of the overall immune system, its suppression in degraded habitats as has been previously shown for the adaptive immune response may in part explain the prevalence of GTFP in young green sea turtles. By interpreting how aspects of their habitat influence the immune function of sea turtles, we will be better equipped to develop recovery plans for these endangered and threatened species, as well as manage their diseases in captivity with the hope of releasing them back into the wild after rehabilitation.

BLOOD BIOCHEMISTRY AND POST-RELEASE MOVEMENTS OF LOGGERHEAD TURTLES (*CARETTA CARETTA*) CAPTURED ON LONGLINE FISHING GEAR*

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The southwestern Mediterranean has been identified as one of the world's hot spots of sea turtle bycatch, with estimates of over 20,000 loggerhead turtles (*Caretta caretta*) per year. Longline gear targeting swordfish and albacore tuna are set shallow (<30 m) and have catch rates of ~ 2 and 4 turtles per thousand hooks, respectively. While immediate survivorship is known to be high, the potential for delayed mortality and modified behavior due to the stress of capture remains high. The objectives of this study were to analyze blood biochemistry and to monitor the post-release movements of loggerhead turtles captured on longline gear to evaluate the potential for post-release stress, as evidenced by blood biochemistry as well as movement patterns. Subadult loggerhead turtles were captured on shallow-set longlines (n=11) and by hand as they basked at surface (control, n=17) during the months of July and August between 2008 to 2012. Biochemical parameters indicative of stress, such as levels of corticosterone and glucose, were higher in longline caught turtles vs. controls. In general, levels of ions and enzymes indicative of metabolic disruption and cellular and tissue damage were relatively similar in blood samples from both turtle groups. Blood chemistry profiles indicated higher levels of red blood cells and hematocrit (PCV) in control vs. longline-caught turtles, whereas levels of white blood cells were similar between groups. We discuss implications of the various biochemical and physiological findings on turtles' long and short-term health effects. Turtles from both groups were tracked via satellite telemetry, specifically SPOT and SPLASH Wildlife Computer tags. Much to our surprise, duration of tracking was considerably longer for longline-caught and released turtles compared to controls. Overall, tag duration was shorter than expected and varied by year. We will discuss potential explanations to account for these findings and how they relate to overall impacts of fisheries interactions on the physiology and behavior of loggerhead turtles in the Mediterranean Sea.

PHOTOGRAPHIC EVIDENCE OF REGRESSION OF FIBROPAPILLOMAS IN GREEN TURTLES, *CHELONIA MYDAS*, CAUGHT IN NITERÓI, SOUTHEAST BRAZIL

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Fibropapillomatosis (FP) is a disease characterized by cutaneous or visceral tumors affecting marine turtles, mostly *Chelonia mydas*. The growth of tumors, depending on location, can affect locomotion, feeding, respiration, vision and health of the turtles. The etiology of FP is not yet completely known, but is associated with several factors (i.e. bacterial infections, chemical contaminants, parasites), not only a herpesvirus, such as primary initiating agent. Tumor masses may regress and may remain stable or increase in size and quantity. Regression can occur as a direct effect on the replication of the infectious agent, or as an indirect consequence of the natural response of the immune system of sea turtles. Environmental factors may also play an important role in the regression of tumors. However, there are few studies about this in the world, probably because the observations from the regressions derived from a continuous and long term capture-recapture of specimens with tumors. The main objective of this study was to verify the incidence of regression of fibropapillomas in green turtles captured incidentally and intentionally in trawl beach nets in the coastal region of Itaipu, Rio de Janeiro, Brazil, between July 2008 and August 2013. At each capture, were photographed the carapace, plastron and head of the turtles to the photographic identification of individuals and to verify, by comparison of photos of capture and recapture, the presence of regression. Were considered partial (i.e.

decrease in size) and total (i.e. disappearance) regressions of fibropapillomas. Each turtle also had its length curved carapace (LCC - cm), straight curved carapace (SCC - cm) and weight (kg) recorded and examined for the presence of tumors. Two hundred thirty-three green turtles were captured during the study period. The LCC ranged from 28 to 81.5 cm (48.1 ± 13.4 , $M \pm SD$). Ninety green turtles had visible fibropapillomas and these, fifty-three (58.9%) were recaptured. The prevalence of FP in the study area and study period was 38.6%. Fifty-seven green turtles (63.3%) had visible fibropapillomas at first capture and thirty-three (36.7%) began to show signs of tumors only in recapture. Seven turtles (13.2%) showed clear signs of regression of at least one tumor. The photographic catalog combined with record of localization, quantify and size of tumors has been shown to be a valuable tool in the detection of the cases of regression. Records of regression in juvenile and sub-adults turtles in this study demonstrate that regression can occur in both stages of development, although it is still unknown in which developmental stage the disease was contracted. Furthermore, may suggest that FP not represent an impediment to the recovery and development of the green turtle to adulthood. However, studies of continuous capture-recapture at all stages of maturity are important for monitoring the disease cycle and determine if the regression is permanent, if turtles with FP may survive and if it's possible to determine survival rate.

USING AN IMMUNOHISTOCHEMICAL APPROACH TO IDENTIFY THE SEX OF MARINE TURTLES

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Marine turtles are animals that exhibit temperature dependent sex determination (TSD). During critical periods of embryonic development, the nest's thermal environment determines whether an embryo will develop as a male or a female. Sea turtle nests that incubate at warmer temperatures tend to produce female-biased sex ratios. In light of the rapid increase of global temperature, a number of studies highlight the need for clear assessment of the effects of climate change on sea turtle sex ratios. However, because the mechanisms that trigger male vs. female development are understood only in part, identifying and predicting the hatchling sex ratios at rookeries or of nests remain very coarse estimates. To verify hatchling sex, we rely mainly upon laparoscopic procedures; even those can be quite challenging, particularly in some species. Recent research using immunohistochemical techniques identified that the gonads of female red ear sliders (*Trachemys scripta*) embryos over-expressed a cold-induced RNA binding protein, when compared to developing testes. We developed a variation of this technique and successfully identified the sexes of loggerhead sea turtles (*Caretta caretta*) hatchlings, a species that can also be identified using standard histological methods. We are further testing the technique for use with a much more challenging species, the leatherback turtle (*Dermochelys coriacea*). Morphology of hatchlings gonads remains challenging to interpret in leatherback turtles, particularly when dead-in-nest hatchlings and embryos are the source of sex ratios. Our purpose is to introduce and discuss the efficacy of this immunohistochemical approach. The development of this new technique for identifying the sex of hatchling sea turtles has the potential to greatly enhance our ability to identify and investigate the effects of global climate change in sea turtle populations.

SEA TURTLE CONDITION: A COMPARISON BETWEEN WILD CAUGHT AND STRANDED *CARETTA CARETTA* IN VIRGINIA

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For this study we compared body condition, epibiont load and blood values between wild and stranded *Caretta caretta*. The study included wild caught (n = 17) and stranded (n = 25) juvenile/sub-adult turtles in Virginia from 2006 to 2013

in May-July. We obtained wild turtles through incidental fishery and dip net capture. We divided the stranded animals into two categories: acute, which included fresh trauma from vessel strikes, entanglement and hook ingestion (n = 8) and other, which included healing trauma, chronic entanglement, pneumonia, anemia, and buoyancy problems (n = 17). Using Fulton's condition factor with SCL-NN as the body size variable, we compared body condition of the three groups. Although the relationship was not significant (F = 0.364; df = 2; p = 0.697), wild turtles had higher body condition values than either stranded group. We classified epibiont load into three categories based on the percentage of carapace covered by epibiota. Epibiota load categories were: 1) Mild 0 - 24%; 2) Moderate 25 - 50%; and 3) Heavy > 50% coverage. Using a contingency table analysis, there was no significant relationship (chi-square value = 6.364; df = 4; p = 0.174) between epibiota load and turtle category. However, 56% of the others had a heavy epibiont load, while only 18% of the wild had a heavy epibiont load. We believe epibiota load is not only affected by the condition of the animal, but also by environmental factors such as water body and temperature. A more robust epibiota analysis may take into account number of species and size of barnacles along with carapace coverage. Each animal within the study had a Reptilian Profile I conducted by IDEXX Laboratories, Inc. We compared albumin, total protein, glucose, white blood cell count (WBC), globulin, and hematocrit among the groups. None of these values showed significant differences. Among the blood variables, there was greater dispersion in the stranded group data, especially the others. Stranded turtles, in both groups, had higher mean glucose, total protein and albumin values than wild turtles. The mean hematocrit values were similar for wild and acute, but lower for other. The mean for WBC was higher in other than in the wild or acute groups. Differences in blood values may be associated with various disease processes and do not necessarily correlate with any one factor, but may be a result of malnutrition, stress, or environmental factors, etc. This preliminary analysis was limited by a small sample size. We attempted to separate stranded turtles into two groups, one with recent injures who were perhaps otherwise normal (acute) and one with longer-term illness or trauma (other). There was no way to determine whether turtles with acute injuries were suffering from other conditions before being injured. Interestingly, the blood values for wild, presumed normal turtles were not within published normal limits for albumin and WBC and were low for glucose. A larger data set for both wild and stranded turtles will allow us to better understand normal values for wild turtles and thus compare wild and stranded turtles.

INVESTIGATION OF ALTERNATE TECHNIQUES FOR STABLE ISOTOPE ANALYSIS OF SEA TURTLE BONE COLLAGEN

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Stable isotope analysis (SIA) of skeletal structures is increasingly used to reconstruct historical marine animal foraging ecology and life history. Nitrogen isotope values ($\delta^{15}\text{N}$) are used to examine trophic relationships as there is a predictable 3 - 5% increase in $\delta^{15}\text{N}$ values with increasing trophic levels. Carbon isotope values ($\delta^{13}\text{C}$) from animal tissues can be used to reconstruct animal movement patterns due to spatial variation across productivity gradients and geographic regions. In order to accurately reconstruct sea turtle diet and habitat use through SIA of bone tissue, potential differences in the isotope values of the two main components of bone (70% bioapatite and 30% collagen by weight) must be addressed. The $\delta^{13}\text{C}$ values from bone collagen reflect diet-based carbon, whereas the carbon source in inorganic apatite can vary and is therefore typically removed via acidification prior to SIA. Ongoing research involves extracting samples from the individual growth layer rings of sea turtle humerus bones, which yields very small amounts of bone dust (~1.5 mg), far less than is required for traditional SIA collagen preparation. The primary objective of our study was to test alternative methods of collagen extraction from small amounts of sea turtle bone. We measured differences in the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values in bulk bone and isolated collagen to determine the most accurate method for measurement of bone $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values. We measured this in two sea turtle species representing three distinct populations across two ocean basins (North Pacific loggerhead (n = 20), East Pacific green

(n = 20), and Northwest Atlantic loggerhead (n = 20)). SIA was performed on paired bulk bone and bone collagen samples that had been acid-treated (0.25M HCl) to remove inorganic carbon (total n = 60). We tested a second method that involved sampling individual annual growth layers of 10 partially decalcified bone sections that were previously processed for skeletochronology from the same Pacific-based sea turtles. Annual growth layer ring samples were compared to paired untreated samples (bone dust) from corresponding annual growth layers (n = 68). Successful collagen isolation was confirmed by %C and %N, which varies predictably between bone and collagen (%C/%N of bone: 15/5; collagen 45/15). Preliminary analyses show an effect of acid treatment on $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$, indicating that there is a difference in stable isotope signatures between bulk bone dust and bone collagen. Ongoing analyses will work toward clarifying the significance of these differences and determining the best preparation method for measuring $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ of sea turtle bone. This is the first study to examine variation in stable isotope values between acid treated and bulk bone samples from sea turtles.

TIME THROUGH TORTOISESHELL: A RECORD OF AGE, DIET, AND HABITAT IN HAWKSBILL SCUTES

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Some of the most basic questions of sea turtle life history are also the most elusive. Life span, age at maturity, population spatial structure, and growth rates can all be challenging variables to estimate, yet are critical pieces of information for risk assessments and conservation planning. Here, we examine the ecological record in the keratinized hard tissues of the hawksbill carapace. Scutes have previously been established to contain a reliable dietary record, and hawksbills have the largest keratin deposits of any hardshell sea turtle species, suggesting that a near-complete life history record may be present. We sectioned, polished, and imaged posterior marginal scutes from 65 individual hawksbills representing all life stages, several Pacific Ocean populations, and spanning the past six decades. We counted the number of apparent growth lines in each sample, micro-sampled along growth lines, and analyzed the stable isotope and radioisotope profiles of the sub-samples. We used the results from these analyses to develop age estimates for each turtle, and fit a Von Bertalanffy Growth Function (VBGF) to the data. This provides several results of interest. To begin, hawksbills display on average 15 growth lines per year (range 6 - 26). For Hawaii turtles, the VBGF yields an intrinsic growth rate (k) of 0.25 and a first breeding age of 12 - 18 years. But perhaps more significantly, isotopic changes through time indicate the foraging ecology of Hawaii hawksbills has significantly shifted from 1950 - present. This suggests that long-term ecosystem changes may be a significant factor in the critically low population levels today.

LETHAL AND SUBLETHAL CYTOTOXICITY TESTING IN LOGGERHEAD SEA TURTLE (*CARETTA CARETTA*) PRIMARY SKIN CELL CULTURES EXPOSED TO PCB77 AND PCB126*

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Sea turtles are exposed to multiple contaminants in the marine environment and have the potential to build up high concentrations of these toxicants over their long lifespan. Currently, very little is known about the long term effects

of these contaminants. Due to restrictions inherent to research on endangered species it can be challenging to evaluate these effects. To accommodate for these limitations our lab has characterized *C. caretta* primary skin fibroblast cell cultures and is currently optimizing their use in toxicological assays. Cell culture provides an excellent model system for evaluating the effects of toxicants at the cellular level. The work described here involves the use of these *C. caretta* skin fibroblasts to examine sea turtle cell response to two common marine contaminants and known Cytochrome P450 1A (CYP1A) inducers: polychlorinated biphenyl (PCB) 77 (0.01 μ M, 0.1 μ M, 1.0 μ M, 10 μ M), and PCB 126 at four time points: 24 hr, 48 hr, 72 hr, and 96 hr. Cell health and toxicity assays included 1) cell death assays using tetrazolium dye reduction (MTT) and lactate dehydrogenase (LDH) leakage from cells, and 2) enzymatic activity and expression levels of the CYP1A biomarker using alkyloxyresorufin-O-dealkylase (AROD) and real-time quantitative PCR (qPCR). MTT and LDH assays were carried out using one 96-well plate, which allowed for direct comparison of results from each assay. Similarly, qPCR and AROD analyses were carried out using cells from the same culture flask, allowing a direct comparison of gene expression and enzymatic activity for each dose. Preliminary MTT and LDH data showed no significant cell death following exposure to PCBs. Preliminary q-PCR and AROD results showed significant CYP1A5 gene induction and changes in CYP1A5 enzymatic activity following exposure to PCB77 for 72 hours. Cytotoxicity evaluations act as a precursor to whole animal studies and give important information about the mechanism of toxicants at the cellular level, demonstrating quantitative contaminant-tissue interactions provides relevance to contaminant concentrations measured in the tissues of these endangered species.

SOUND LOCALIZATION ABILITIES OF TWO LOGGERHEAD TURTLES (*CARETTA CARETTA*)*

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At present, there have been few studies examining the hearing of sea turtles and literature on their sound localization abilities is non-existent. On average, 25% of patients admitted to Mote's Sea Turtle Rehabilitation Hospital have sustained a human induced injury and 72% of these cases are boat related. Across Florida, recorded propeller injuries have shown an increasing trend. Recent studies on sea turtle hearing have demonstrated that sea turtles can detect low frequency sounds ranging from 0.05 – 1.131 kHz, with best sensitivity between 0.1 – 0.4 kHz. Recreational boat engine noise generally produces frequencies between 0.01 – 2 kHz, which suggests that sea turtles have the potential to hear boat traffic. Understanding if sea turtles can localize sound in a laboratory setting may provide insight into their ability to avoid collisions with watercraft in the wild and aid conservation efforts. A two alternative, forced choice paradigm was adopted for this study and tested with two resident loggerhead turtles (*Caretta caretta*) at Mote Marine Laboratory and Aquarium in Sarasota, FL. The behavior was trained using operant conditioning and positive reinforcement techniques, primarily food rewards. Two speakers (Clark Synthesis, Aquasonic AQ39) were positioned at 90° and 270° to the turtle's head (the turtle oriented towards 0°) at a distance of 1 m from the subject and 0.5 m deep (mid-water level). The turtles were trained to touch the corresponding response paddle to indicate from which speaker the sound was presented. Correct responses received a food reward; incorrect responses received no reinforcement and a short time-out before the next trial. Stimuli were generated by Tucker-Davis Technologies hardware (RP2, PA5) programmed using custom MATLAB software. Balancing filters for the stimuli and calibrations were conducted using an HTI-96-MIN hydrophone. The initial stimuli tested were broadband signals with sound levels at ~130 dB (+/- 3 dB), with frequency ranging between 0.1 – 0.4 kHz, the best hearing sensitivity for loggerhead turtles. This level was chosen because it is about 20 dB above thresholds for sound detection as found by behavioral audiograms conducted with these 2 subjects. The level was varied randomly by 3 dB to remove level artifacts that could be associated with speaker location. The two sea turtles were able to localize a 4 sec broadband stimulus at or above a criterion level of 75% correct. Subjects demonstrated better performance levels when presented with a longer duration of sound stimulus. This may suggest that sea turtles require time to orient their head to detect sound direction or may be using alternative cues to process sound location. This research was conducted under FWC Permit MTP-13-126.

THE CYTOTOXIC AND GENOTOXIC EFFECTS OF HEXAVALENT CHROMIUM IN SEA TURTLE CELLS

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Sea turtles are a charismatic and ancient ocean species and can serve as key indicators for ocean ecosystems such as coral reefs and sea grass beds as well as coastal beaches. Genotoxicity studies in the species are largely 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 have demonstrated it to be a global marine pollutant and concern. Thus, we evaluated the cytotoxicity and genotoxicity of soluble and particulate Cr(VI) in hawksbill sea turtle cells. Cr(VI) was both cytotoxic and genotoxic to sea turtle cells. Concentrations of 0.1, 0.5, 1, and 5 uM ug/cm² lead chromate induced relative cell survival levels of 111, 81, 59, and 9 percent, respectively. Additionally, concentrations of 0, 0.1, 0.5, 1, and 5 ug/cm² lead chromate induced damage in 5, 10, 14, 30 and 40 percent of cells and 5, 12, 16, 35, and 62 chromosome aberrations in 100 metaphases, respectively. For soluble chromium, concentrations of 0.25, 0.5, 1.0, 2.5, and 5 uM sodium chromate induced relative cell survival levels of 97, 66, 46, 24 and 4 percent, respectively. Genotoxic studies of sodium chromate are pending. These data suggest that Cr(VI) is a concern for sea turtles. This research was supported by NIEHS grant ES016893 (JPW).

Collaborative Fisheries Research and Mitigating Marine Turtle Bycatch: Special Session

This Special Session was made possible by the support of Virginia Sea Grant, WWF International, and the Virginia Institute of Marine Science.

OPENING DISCUSSION: MARINE TURTLE BYCATCH REDUCTION & CONSERVATION*

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On April 16th 2014 the International Sea Turtle Symposium (ISTS) in Louisiana held a special session on how turtle conservationists and fishers can work more collaboratively to find joint solutions to bycatch issues.

Bycatch or the accidental capture of marine turtles is one of the most significant threats to these animals today. Every year hundreds of thousands of turtles die through bycatch in fishing gear worldwide. Today scientists and conservationists have learned that the best way to find solutions that reduce bycatch and maintain the livelihoods of fishers is by working jointly. At the New Orleans ISTS we held a session on how to achieve this through the Collaborative Fisheries Research (CFR) method. The venue was ideal since Louisiana was experiencing an emerging turtle bycatch concern in the inshore shrimp trawl industry. “TED use has helped curb sea turtle fisheries-related mortality in the US and many countries”, said Roldán Valverde, President of the International Sea Turtle Society.

“This CFR session was an important step toward developing fisheries research questions that will be implemented internationally and in our own bayous. The inshore waters of Louisiana, and other areas where the TED issue is not yet resolved, will certainly benefit from the development of bycatch mitigation strategies, especially if existing barriers between industry and scientists can be broken down by using the CFR method”. While Turtle Excluder Devices (TED) that prevent the capture and drowning of marine turtles in trawls have been around for over 30 years, certain shrimp fishers embrace TEDs and others have questioned the use of this gear. How can scientists work with the fishing industry to consider the adoption of TEDs to reduce marine turtle bycatch while maintaining their catches? This was one of the questions explored during the special CFR session sponsorship of Virginia Sea Grant and WWF. “CFR provides a wonderful opportunity and proven method for marine conservationists and the fishing industry to jointly explore solutions to challenging bycatch problems,” said Dr. Troy Hartley, Director of Virginia Sea Grant and a session co-organizer, “Globally-recognized leaders in CFR participated in this session, and as a result, the session helped build capacity and inspired new conservationist—fishermen partnerships both locally in Louisiana and abroad.” Presenters discussed research on the CFR method and provided examples of conservation measures that have been developed in partnership with the fishing industry—innovations that have benefited turtles but also sea birds, marine mammals and people. The session actively engaged attendees and their experiences with the fishing industry, improved CFR skills and capacity, enhanced professional CFR mentoring networks, and fostered new CFR projects worldwide. “We strongly believe that by working together, conservationists and fishers will find solutions that benefit both species and people,” said Aimée Leslie, Global Cetacean and Marine Turtle Program Manager for WWF International. “Our International Smart Gear Competition is a great example of cross-sector collaboration that is achieving results. We worked with participants in and outside of this special session to build bridges that will lead to the sustainable fisheries we need to protect our marine life for future generations.”

For further information on CFR or this special session, contact organizer: Tony Nalovic, Collaborative Fisheries Research Fellow, Virginia Institute of Marine Science manalovic@vims.edu, bigsharkchum@yahoo.com

PANAL DISCUSSION- CAN CULTURAL BARRIERS BE BROKEN THROUGH THE COLLABORATIVE FISHERIES RESEARCH APPROACH: TOWARDS TED USE IN LOUISIANA AND ABROAD?*

Howell Bonne¹, Ricky Brown¹, David Chauvin¹, Patrick Riley¹, Gary Graham², Jack Forrester³

¹ *Captains /Shrimpers from Georgia, Mississippi, Louisiana and Texas*

² *Gulf & South Atlantic Fisheries Foundation, Texas Sea Grant*

³ *NOAA Pascagoula, International TED program*

PAN-ATLANTIC ANALYSIS OF THE OVERLAP OF A HIGHLY MIGRATORY SPECIES, THE LEATHERBACK TURTLE, WITH PELAGIC LONGLINE FISHERIES*

S. Fossette, M. J. Witt, P. Miller, M. A. Nalovic, D. Albareda, A. P. Almeida, A. C. Broderick, D. Chacón-Chaverri, M. S. Coyne, A. Domingo, S. Eckert, D. Evans, A. Fallabrino, S. Ferraroli, A. Formia, B. Giffoni, G. C. Hays, G. Hughes, L. Kelle, A. Leslie, M. López-Mendilaharsu, P. Luschi, L. Prosdocimi, S. Rodrigues-Heredia, A. Turny, S. Verhage, and B. J. Godley

Presenter: Michel A. Nalovic, *Collaborative Research in Fisheries Science Fellow, Virginia Sea Grant, Virginia Institute of Marine Science*

**COLLABORATIVE RESEARCH AND LITIGATION TO MITIGATE BYCATCH IN HAWAII PELAGIC
LONGLINE FISHERIES***

Svein Fougner, *Hawaii Longline Association*

**REDUCING SEA TURTLE MORTALITY IN THE NEW ENGLAND AND MID-ATLANTIC SUMMER
FLOUNDER TRAWL FISHERY***

M. Gahm, J. DeAlteris, C. Parkins, H. Milliken, and E. Matzen

Presenter: Meghan Gahm, *University of Rhode Island*

**INCIDENTAL CAPTURE OF SEA TURTLES IN INDUSTRIAL BOTTOM TRAWL FISHERY IN THE
SOUTHEAST OF BRAZIL***

Suzana M Guimarães and Cassiano Monteiro-Neto, *Universidade Federal Fluminense, Niterói, Rio de Janeiro, Brazil*

**KEYNOTE- COLLABORATING WITH INDUSTRIAL AND ARTISANAL FISHERS TO REDUCE
BYCATCH: 30 YEARS OF EDUCATION***

Martin Hall, *Head of Tuna-Dolphin Program, Inter-American Tropical Tuna Commission*

**INTRODUCTION TO COLLABORATIVE RESEARCH AND ITS ACCOMPLISHMENTS IN
FISHERIES***

Troy Hartley, *Director, Virginia Sea Grant, Virginia Institute of Marine Science*

**THE U.S. TED EXPERIENCE, LESSONS LEARNED AND APPLICATION TO NEW CHALLENGES IN
THE SKIMMER FISHERY AND INTERNATIONAL TRAWL FISHERIES***

John Mitchell, *Harvesting Systems Branch, NOAA Southeast Fisheries Science Center*

THE TED PROGRAM IN GABON*

M. A. Nalovic, M. Tiwari, J. Bibang, J. Forrester, J. Mitchell, A. Formia, R. Parnell, C. Nyama-Mouketou

Presenter: Manjula Tiwari, *NOAA Southwest Fisheries Science Center, Marine Turtle Ecology and Assessment Program*

INSPIRING INNOVATION BY CAPITALIZING CREATIVITY*

Michael Osmond, *Senior Program Officer, SmartGear Competition, WWF*

MARKET BASED APPROACHES TO AUGMENTING THE SUSTAINABILITY OF SMALL-SCALE FISHERIES*

Hoyt Peckham, *Center for Ocean Solutions, Stanford University*

Conservation, Management and Policy

SEA TURTLES NESTING BEACHES IN LAGOS; SIGNIFICANCE FOR CONSERVATION AND COASTAL DEVELOPMENTS

Oyeronke M. Adegbile, J. A. Obienu, F. C. Olakolu, H. O. Omogoriola, and S. N. Awosanya

Nigerian Institute for Oceanography and Marine Research Victoria Island, Lagos Nigeria

Five sea turtles species are found in Nigeria and West African waters; All five species nest in several beaches along Nigeria's coastline. Turtle Exclusion Devices are used in Nigeria's industrial shrimp trawl fisheries. Threats to nesting female sea turtles are direct takes, collection of their eggs for consumption and sales. Other threats include rapid coastal development, coastal flooding due to low-lying nature, beach litter, pollution and by-catch during their movement to nesting site. The rapid rate of coastal developments in coastal areas like Lagos is of high interest to the conservationist due to the fact that some of these areas play host to nesting female turtles on a seasonal basis. There is presently no coordinated conservation program in place for nesting females and their eggs as regulations are non-existent and awareness of conservation status is really low among the public. This present study reports on some nesting beaches in Ibeju-Lekki Local Community Development Area, Lagos where preliminary nesting season surveys have been conducted. Species confirmed nesting include the olive ridley, leatherback and green turtles. The nesting season in this area is between July and March. The result of this survey presents a background for conservation action and awareness creation for coastal schools, communities and general public living in this area while providing baseline information to developers both private and government when planning coastal developments in future.

SHARING DEVELOPED BEACHES WITH 19 MILLION RESIDENTS, 70 MILLION TOURISTS AND SEA TURTLES: FLORIDA'S BEACH HABITAT CONSERVATION PLAN*

Gary Appelson

Sea Turtle Conservancy

The survival and recovery of sea turtles in the U.S. depends greatly on the degree to which government agencies and citizens in this state protect sea turtles and their important nesting habitats. Sea turtles in Florida, where 90% of U.S. nesting occurs, share their nesting beaches with 19 million Florida residents and many tens of millions of annual visitors. Balancing these often competing needs is complicated. Activities such as beachfront construction for homes, condominiums, businesses and seawalls, beach cleaning and raking, dune crossover construction, artificial lighting, sand fencing and beach nourishment all have the potential to harm sea turtles or their nesting habitat thereby causing “take” of federally-protected species as defined under the U.S. Endangered Species Act (ESA). For decades, Sea Turtle Conservancy (STC) has closely monitored beachfront activities permitted by Florida’s Department of Environmental Protection (DEP), the state agency responsible for permitting of most activities that take place on the coast, and we have determined that permitted activities sometimes can and do result in illegal (unauthorized) take of sea turtles. In response, STC has recommended to numerous levels of government in Florida that the state apply for an Incidental Take Permit (ITP) from the U.S. Fish and Wildlife Service that would acknowledge and authorize a limited amount of take and bring the state into compliance with the ESA. The ITP will require the state to implement a long-term Habitat Conservation Plan (HCP) that outlines comprehensive terms and conditions to ensure the State’s permitted beach activities minimize potential impacts to sea turtles and define how the State will mitigate for any impacts that cannot be avoided. In late 2008, the Florida DEP applied for an ITP for its coastal construction regulatory program; the Coastal Construction Control Line Program, which regulates activities on and adjacent to the state’s sandy beaches. The corresponding HCP is in its 5th year of development and is expected to be completed in 2016. The presenting author, STC Policy Coordinator Gary Appelson, serves on the 9-member Steering Committee guiding the development of the HCP. This presentation will focus on Florida’s HCP, the most comprehensive state effort to reform beach management policies to protect sea turtles in the United States. It will review the need for the ITP, summarize current state permitted activities that cause the potential take of sea turtles such as construction of sea walls on nesting beaches, outline and summarize reports and data essential to the Plan’s development, and what the outcome may look like.

MARINE CONSERVATION IN COSTA RICA'S SOUTHERN NICOYA PENINSULA, A HOLISTIC APPROACH INVOLVING COASTAL COMMUNITIES, SEA TURTLES AND SUSTAINABLE FISHERIES*

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PLANS (Playas de Anidación Nicoya Sur) is a marine conservation project that stretches over 30 km, and which includes sea turtle conservation projects at 5 different nesting beaches (Corozalito, Bejuco, San Miguel, Costa de Oro, Caletas), as well as a sustainable artisanal fisheries project with the fishermen of Bejuco and Coyote. The project initiated in 1997 with the protection of nesting olive ridley (*Lepidochelys olivacea*) sea turtles in the coastal community of San Miguel. The project was later extended to include Caletas (2002), Costa de Oro (2009), Corozalito (2010) and Bejuco (2011). Due to the importance of the area for nesting olive ridley sea turtles, two National Wildlife Refuges were established in 2006 in Caletas and 2009 in Camaronal, both including Marine Protected Areas where destructive

fisheries practices such as shrimp trawling, gillnetting and compressor diving are outlawed, and only hook and line and bottom longlines are allowed. In 2007, a process was initiated to obtain a sustainable fisheries certification under Marine Stewardship Council (MSC) principles. A precertification obtained in 2011, the first in Central America, highlighted the need to create a new MPA in the area to protect not only snapper stocks from the ill effect of shrimp trawling, but also the resident foraging aggregation of critically endangered hawksbill turtles (*Eretmochelys imbricata*). This principally juvenile population appears to use specifically the non-protected area between Caletas and Camaronal National Wildlife Refuges, being still affected by irresponsible fishery methods but in turn adding weight to the need of a connected protected marine area. If successful, by 2014, the PLANS project will successfully protect 5 sea turtle nesting beaches that are used by at least three species (*Lepidochelys olivacea*, *Chelonia mydas*, *Dermochelys coriacea*) as well as over 45,000 hectares of marine area for the sustainable use of coastal communities in harmony with critical endangered marine species.

SHARING 10 YEARS OF SEA TURTLE CONSERVATION IN GUINEA-BISSAU: ENGAGING LOCAL COMMUNITIES, A CHALLENGE IN A CULTURAL DIVERSITY CONTEXT RELATING HUMANS TO SEA TURTLES IN SO MANY DIFFERENT WAYS

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Five of the seven species of sea turtles occurring worldwide have been confirmed to occur in the Bijagós archipelago, Guinea-Bissau, namely green (*Chelonia mydas*), olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*) and loggerhead turtle (*Caretta caretta*). The green turtle nesting population is of particular interest. Around 30,000 nests per year were estimated on the João Vieira and Poilão Marine National Park, making this the most important nesting area for green turtles in the whole of Africa, and ranking amongst the most important worldwide. Although the islet of Poilão is the most important rookery for green turtles, several hundreds or even thousands of nests are laid in other Bijagós beaches, outside this park. At the Orango National Park are the sites with greater diversity. Although in smaller numbers, green, olive ridley, leatherback, hawksbill, and possibly loggerhead turtles nest there. For the past 10 years, IBAP, the governmental Institute of Biodiversity and Protected Areas of Guinea-Bissau, has the mission to manage protected areas and biodiversity strategic resources, valuing the scientific and traditional knowledge. Of the five existing protected areas in Guinea-Bissau, two are especially important for sea turtles, the João Vieira and Poilão Marine National Park and the Orango National Park, with important nesting beaches as well as shallow marine areas with foraging and mating grounds. Till now IBAP has met considerable success in its mission to protect sea turtles, one of the main biodiversity values of Guinea-Bissau and one of its priorities, which has been contributing significantly to the long-term monitoring of the population of green turtles nesting at Poilão Island, for the establishment of a monitoring and surveillance plan at the Orango National Park, and for providing scientific tools for a better management and conservation of the main nesting beaches, while building capacity of local communities, rangers and national technicians. Monitoring activities are dependent on a strong complementary commitment toward raising awareness and integration of local communities in conservation, a particular challenge in Guinea-Bissau, due to its great diversity of ethnic groups, which in their rules, customs and beliefs, are related to sea turtles in so many different ways. Although sea turtles are not commercialized, are still highly poached and used for traditional purposes. For example for the Bijagós ethnic group sea turtles are very important in traditional ceremonies, for medicinal purposes and egg shells are used in the fertilization of agricultural soils. But for the Felupes and the Balantas ethnic groups, sea turtles are considered sacred animals. Converting turtle poachers and fishermen into turtle patrollers and monitors is one of IBAP's main strategies and challenges. IBAP staff and the turtle team members have become very active in directly enforcing turtle protection. Although poaching is still a reality, community participation and levels of awareness have increased considerably in the past 10 years, thanks to the engagement of the community members.

**DETERIORATION OF SEA TURTLE NESTING HABITAT ON ST. CATHERINES ISLAND, GA;
PLANNING FOR THE FUTURE WITHIN THE MODERN MARINE TRANSGRESSION – A
GEOLOGICAL AND BIOLOGICAL PERSPECTIVE**

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Fluctuation of sea level, a normal geologic process throughout the 110 million year history of sea turtles, has recently entered a phase with sea level persistently and continuously rising against the continents in a process termed “transgression.” The Modern Transgression has been documented on St. Catherines Island (SCI), Georgia (USA) by a Rapid Habitat Analysis over the interval 1999-2013, by twenty-five years of shoreline monitoring and by photogrammetry and analysis of aerial photography and sequential maps using GIS methods and application of the USGS DSAS Model (v 4.2). These direct surface methods have been substantiated by stratigraphic studies of the evolution of SCI by vibracoring, ground-penetrating radar, and by 14C dating. All lines of evidence converge to support an ongoing, significant rise in sea level since the Late Pleistocene with an accelerating rate as global climates warm. The position of SCI near the head of the Georgia Bight concentrates the energy of coastal systems and the distance to an appreciable source of river discharge and sediment supply combine in making St. Catherines the most erosional of the Golden Isles, a “Sentinel Island” for predicting the future of Georgia barrier islands and those throughout the world. Effects of The Modern Transgression include rapid landward retreat of the shoreline as it adjusts to changing sea level, increasing erosion along nearly all beaches, with consequent deterioration of “acceptable” backbeach nesting habitat from 25.00% in 1999 to 11.94% in 2013. Additional impacts on the ~20 km of backbeach habitat include reduction of dune fields, fragmentation of the beaches by incision of small inlets, and inundation of low-lying habitats along the Atlantic shoreface by washover fans, washin fans, and the inundation of maritime forest producing jumbles of tree “boneyards.” Offshore shoals and inshore estuarine systems change rapidly and erosion exposes relict marsh mud on the beachfront. Vibracoring and ground penetrating radar (GPR) studies reveal ancient marsh complexes buried beneath the beaches, and these muddy marsh sediments act as aquicludes that perch water tables during rain events and storm events, drowning low-lying nests. Nesting sea turtles in Georgia normally encounter conditions of nesting in a habitat characterized by a 2.5 m spring tidal reach, powerful storms, and dynamic beach systems. Sea turtles attempting nesting during the Modern Transgression face a diverse gauntlet of threats, including a burgeoning coastal human population, with consequent shrinking nesting habitat, intense commercial and recreational fishing, increased marine cargo transportation, increasing numbers of recreational boats, and ubiquitous pollution. The short-term solution to these problems and to a shrinking shoreline habitat has been relocation of up to 80% of deposited nests, most of which would otherwise be lost to erosion and inundation. This conservation strategy is effective in enhancing hatchling production into the population, but must be practiced with caution to avoid over manipulation of threatened and endangered sea turtles. Critical habitat designation for the Atlantic Coast presents an opportunity to preserve additional nesting habitat and possibly create some offshore protection for the Northwest Atlantic loghead subpopulation and other migrating species.

SAVING GEORGIA'S SEA TURTLES ONE NEST AT A TIME: LOGGERHEAD SEA TURTLE NEST RELOCATIONS INTO NURTURIES: ST. CATHERINES ISLAND, GA

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The focus of conservation efforts during recovery of the Northern Loggerhead Sub-Population of sea turtles in the Western North Atlantic is limited to two main aspects of their life cycle; 1) the protection of loggerhead nests on the beaches during nesting and the 2) protection of late juvenile and adult sea turtles from drowning in intensive coastal fisheries, including in trawls, on long lines, and in gill nets. Each national, state and local sea turtle program attempts to support their respective sea turtle recovery plans to the best of their ability and resources. However, recognizing that each program is different, each program is expected to attempt to support common goals of the management plans, but not expected to be cookie-cutter copies of one another. The mission of the St. Catherines island Sea Turtle Conservation Program includes “Conservation, Research, and Education” to further the conservation, protection, and stewardship of sea turtle nests deposited along approximately 20 km of dynamic nesting habitat on St. Catherines Island (SCI) beaches. The challenges of conservation of sea turtle nests in the dynamic environment of SCI beaches within The Modern Transgression caused by rising sea levels by rapid dynamic changes of coastal geomorphology of our changing and eroding barrier island system; challenges confronting sea turtles many times in the past, but never at the time when human populations were adding new and significant stressors into the nesting system. Following the lead of the USF&W Service, facilitated by the Georgia Department of Natural Resources, the St. Catherines Island Sea Turtle program (SCISTP) has developed a program of aggressive relocation of nests into natural nesting habitats currently utilized by nesting sea turtles. These natural sea turtle nesting areas are termed “nurturies,” because they act to nurture the “at risk” and “doomed” nests of sea turtles utilizing this challenging nesting habitat. A “nurtury” is a natural nesting area currently utilized by nesting sea turtles into which “at risk” or “doomed” nests may be relocated, enhancing their likelihood of hatching in a natural environment. Rates of erosion on 88% of St. Catherines’ beaches average approximately 3.0 m per year, resulting in the necessity to relocate between 60 and 80% of loggerhead sea turtle nests into three major nurturies. Data indicate this powerful conservation management tool enhances hatching of nests and the rate of hatching in a minimally invasive manner, especially during years with extreme weather conditions. The goal of sea turtle conservation in The Modern Transgression should be to balance production of hatchlings in sufficient numbers to maintain and restore the current population to historical levels while minimizing negative effects of manipulation of nests by their relocation; as measured against scientific data. Until nesting goals stipulated in the Management Plan for the Northern Sub-Population of Loggerhead Sea Turtles are reached, it seems reasonable to assure maximum hatches of loggerhead sea turtles by minimally invasive means, including the relocation of at risk or doomed nests into natural nurturies.

OPERATING A FULLY FUNCTIONAL SEA TURTLE LAB WITH PUBLIC OUTREACH: WHAT ARE THE COSTS?

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Running a sea turtle lab is costly, but when public outreach is added in, the costs become more complex. The diverse costs are repeatedly not accounted for because monetary value is often hard to assign. A model is needed to understand and plan for proper spending and maintenance. The Florida Atlantic University Marine Biology Lab at Gumbo Limbo

Environmental Complex in Boca Raton, Florida, provides a unique structure to analyze and develop a business model. Priorities at this facility are at least trifold including animal husbandry in support of research and teaching, staff support, and public outreach. The animal husbandry priorities include, but are not limited to, feeding, cleaning, and proper maintenance of three species' of endangered sea turtles in the laboratory. Staff support encompasses lab technicians, volunteers, undergraduate and graduate students who are all involved in daily laboratory activities. Through our public outreach, we are able to educate members of the public about issues related to sea turtle monitoring and conservation. By studying the monetary outline of the yearly costs associated with maintaining this facility, we developed a model to establish the best practices to maximize available funding. The interdisciplinary nature of this facility possesses a variety of challenges in monitoring the expenses. With this analysis, we provide a fiscal guideline for other multiplex sea turtle facilities and research labs from around the world.

RENATURA: AN INNOVATIVE PARTNERSHIP TO FIGHT AGAINST SEA TURTLE BY-CATCH IN THE REPUBLIC OF CONGO

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Renatura is a NGO protecting and studying sea turtles in the Republic of Congo since 2000. In 2012, Renatura launched an innovating program to tackle the issue of sea turtle by-catches. The fishing practice accompaniment program in Congo (PA2PC). This program is an original answer associating the public and private sectors as well as the civil society. It includes two main directions of actions: - Concerning the artisanal fishing, the PA2PC reinforce an activity developed earlier from 2005 onward: the release of sea turtle incidentally caught in traditional fishing gears. In turn for the release of a turtle the Renatura provide fishermen with wire bobbins to repair the fishing gears damaged by the release. This activity allows for the release of more than 2000 sea turtles every year. - As regard the industrial fisheries, the PA2PC is supporting the fishing ministry. Joint surveillance patrols are organized by the Ministry and Renatura ever weeks. The ministry provides the patrol vessel and the technical and administrative staff. Renatura in close partnership with the private Partner, Total E&P Congo, is responsible for supplying the fuel and maintaining the vessel. In addition, at least one Renatura observer is on board on every patrol. This joint work allow for the control of tens of fishing vessels in the coastal waters of Congo, which it had not passed in over many years. Several cases of infringements have been observed and sanctioned mainly at the beginning of the project. It is now rare to observe illegal fishing boat from the beach during daytime near shore in the artisanal fishing zone. Nevertheless this work has to be done over and over again since illegal fishing trawlers rapidly and easily change their habits to get around the national fishing regulation. In addition, this kind of private public partnership is not an easy task and it even brings news issues.

STATE OF THE ISLA CANAS ARRIBADA BEACH IN PANAMA

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Panama hosts one of only 11 recognized arribada sites in the world at Isla Cañas on the Azuero peninsula. Based on our observations and interviews, the sea turtle program on the Island is in a state of crisis. Historical observations of 5,000-12,000 nesting turtles per arribada (a 3-day mass nesting event) from August through December on Isla Cañas have been published, although to date no systematic monitoring program has been implemented. Our goal was to conduct the first strip transect in time (STIT) censuses of this population from July 2 to Sept 27, 2013. Peace Corps Volunteers, local members of the Ecotourism group, The Science Exchange interns, and National Environmental Authority (ANAM) government staff were trained by biologists on STIT methods. However, the arribadas expected to start in July did not occur in 2013. Islanders and ANAM officials we interviewed reported that this is the first year that no arribada occurred since 1980. Meanwhile, nearby Marinera Beach reports four arribadas in 2013 with an estimated 45,000 turtles for the year. We also report on the observed poaching. Despite being decreed a Wildlife Refuge in 1995, adopting a community-based management plan for sea turtles in 1999, and a national moratorium on egg harvest since 2008, we observed nearly 100% poaching of solitary nests during the study period. This is higher than the estimated 90% poaching in the early 1990's when a legal harvest program existed. Our turtle teams patrolled most of the 14 km beach nightly or every other night, and observed a steady high density of poachers on the beach. Poachers allowed tourists and our team to watch the nesting process, but afterwards every nest was taken for consumption. On rare occasions if a poacher was not present, the nest was relocated on the beach by the turtle team. ANAM authorities started monitoring the beach in August, but did not stop poachers. In August and September ANAM reportedly translocated 68 nests to an unfenced hatchery, burying nests ~40 cm apart and ~10 cm deep (denser and shallower than recommended). On Sept. 24th we checked 21 marked nests but only five had eggs, indicating that perhaps these nests were also poached or never translocated. Currently, ANAM keeps no records for the hatchery. The only data provided to us by ANAM were collected from 2003 to 2005 and suggest lower hatching success from the hatchery than those left in situ. We observed locals and tourists eating turtle eggs, a traditional dish, and taking them off the Island to sell. The going rate is US\$1 per dozen eggs, up from \$0.50 in 1995. Locals we interviewed suggested that the moratorium on sea turtle egg harvest and the presence of ANAM authorities and police on the beach are not deterrents to the illegal harvest. Our observations support these views. The program lacks technical training in hatchery management and monitoring methods, enforcement of anti-poaching laws, and there is an urgent need for an educational outreach campaign. We encourage government agencies and non-profits to support the small but enthusiastic turtle conservation group (Isla Cañas Tours) that is working hard to save this globally-important arribada population.

**CURRENT SITUATION OF THE BLACK SEA TURTLE POPULATION IN MICHOACÁN:
CHALLENGES AND PERSPECTIVES**

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The population of black turtle (*Chelonia agassizi* or *Chelonia mydas*) is one of the most conspicuous in the Eastern Pacific. In Mexico it was abundant in the decade of the sixties but its population declined by the strong pressure of capturing breeding adults in Michoacán and Mexico Northwest and the looting of their Broods in the coastline of Michoacán, mainly on the beaches of Colola and Maruáta. Black or green turtle of the orient Pacific is currently in the category of endangered species by the IUCN and the Norma Oficial Mexicana. Since 1982 when actions were performed to restore the population of black turtle on the coast of Michoacán, the indigenous communities of Colola and Maruáta together with the Universidad Michoacán de San Nicolás de Hidalgo have led conservation actions jointly for the recovery of population of black turtles in these locations that represent major nesting sites in Mexico. While the population of black turtle in Colola and Maruáta declined to having less than 300 females nesting at the end of the 80s, from 2001 the population of nesting females has exhibited a slight increase at least at the beach of Colola, which remains to date. Nesting in 2010 and 2011 have exceeded ten thousand nests between August and February. The substantial increase in the number of nesting females in Colola is mainly due to the constant effort of conservation in the area reaching 30 consecutive years in 2012. On the other hand, the efforts for the preservation of black turtle on the Baja California peninsula have helped this recovery. While Colola in the number of black females has increased in the last decade, considering the historical range of black turtle in Michoacán's 79 km of coastline from the mouth of the Río Nexpa Al Faro de Bucerías, its population has decreased by 42% in 30 years. The beaches of Cachan, passage of Noria, la Llorona, Chocola and motin del oro, suffered looting of nests that reach 100% of the nests which continue to decline year after year due to the discontinuity of conservation activities. This situation puts at risk the recovery of black in Michoacán where nesting is lost in most of its range and focusing most of their reproductive effort in a single beach in this case Colola.

COMPARISON OF SEMI-NATURAL WITH HATCHERY NESTS AT PUNTA RATON, HONDURAS

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Punta Ratón is the main nesting beach for *Lepidochelys olivacea* in Honduras. The local community consumes the eggs during most of the year, but the 25 day "veda" enforced by the Central Government requires that eggs collected at this time be translocated to a hatchery and the neonates released after hatching. Outside of the "veda" period, when egg harvesters at Punta Raton see female turtles emerging from the surf, they will often collect them from the intertidal area, carry them on their shoulders, and deposit them in artificial body pits on the upper part of the beach. Surprisingly, many females will lay eggs after this process. The goal of our study was to compare thermal regimes and performance of hatchlings from these semi-natural nests with nests within the hatchery. We compared 4 nests from each location deposited on the same or consecutive nights. We deployed thermo-data loggers in each nest at the time of laying or burying, programmed to take temperature samples every 60 minutes during the incubation period. After emergence, we calculated hatching success and randomly selected 15 hatchlings from each nest. We measured and weighed them, assessed running speed and swimming style. Running trials consisted of three measures of the time required to walk a 1 m PVC gutter with a light at the end. The gutter was located on the beach, following the natural inclination, and

all trials were performed at night. For swimming trials, hatchlings were video recorded for 10 minutes while swimming in an aquarium 52L x 32H x 27W cm, attached with a harness so they could not reach the walls. The number of power strokes per minute and the time swimming dog-paddle style were calculated. Hatching success was significantly higher for beach nests than for hatchery nests (86.2 % vs 24.1 %). The incubation temperatures at the hatchery were significantly higher than on the beach, reaching 37.5 C° for several days during the last third of the incubation period. We found hatchlings from the beach nests to be significantly larger both in weight ($t(82.8) = 4.4$, $p < 0.001$) and SCL ($t(116) = 6.1$, $p < 0.001$). Average weight was 16.0 ± 0.1 g for the beach and 15.0 ± 0.2 g for the hatchery. SCL was 39.8 ± 0.2 mm for the beach and 38.2 ± 0.2 mm for the hatchery. Hatchlings from the beach swam using a higher number of power strokes per minute than hatchlings from the hatchery (38.9 ± 5.5 vs 25.7 ± 3.1 , $t(36.6) = 2.095$, $p = 0.043$) and spent more time dog-paddling per minute (19.2 ± 1.6 s vs 14.3 ± 1.1 s, $t(39.6) = 2.4$, $p = 0.02$). All reported measures are average \pm SE. To improve number and quality of hatchlings released from the conservation project at Punta Raton, we recommend rather than translocating eggs to a hatchery, that sections of the beach be established and protected in which turtles are moved to lay eggs. At these locations nests can then be kept in situ.

SUSTAINED EXPONENTIAL GROWTH IN FLORIDA GREEN TURTLE NEST PRODUCTION AT THE ARCHIE CARR NWR: HISTORIC AND CURRENT PERSPECTIVES OF A CONSERATION SUCCESS STORY

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The only estimate we have of annual nest production (an index to adult female population size) by the green turtle on Florida's east coast, prior to the 1990's, was that of Carr and Carr (1978): 30-40 nests. The Florida green turtle became subject to the U.S. Endangered Species Act in 1978. Four years later (1982) our research group began systematic, season-long surveys of marine turtle nesting on a 21 km stretch of beach near Melbourne Beach, in southern Brevard County, Florida. During the first three years (1982-1984) we documented fewer than 50 green turtle nests per season. The daily surveys showed that, with an average of 9,300 loggerhead nests per season in the 1980s, this beach was one of the most densely nested *Caretta* beaches on the rim of the Atlantic Ocean. Although miniscule by comparison, green turtle nest production on this beach proved to be greater than that seen anywhere else in the continental U.S. For these reasons the U.S. Congress authorized the formation of the Archie Carr National Wildlife Refuge in south Brevard County, in 1989; dedicated to the protection of marine turtle nesting habitat. The refuge was established administratively in 1990. At about the same time green turtle nest numbers began to grow, gradually and in small increments during the early and mid-1990s. While adhering to the characteristic green turtle pattern of biennial highs and lows, the total moved above 2,000 by the year 2000, then doubled again to 4,000+ by 2010. Nest production reached 5,500 in 2011 and then, in adherence to the biennial pattern, fell to 3,023 in 2012. In the most recent season (2013), green turtle nest production continued to grow exponentially and more than doubled the previous record, with 11,839. Chaloupka *et al* (2007) showed that major green turtle rookeries in Australia, Japan, Hawaii and Costa Rica grew at a rate of 3.8% to 6.8% in the past 25 years. At 13.9%, the Carr Refuge rookery has grown 2-4 times as rapidly as the other rookeries, even though that analysis did not include the two recent, extraordinarily productive seasons (2011: 5,505 nests; 2013: 11,839 nests). The trend at ACNWR consistently mirrors that statewide and in 2013 nest production on the refuge constituted 40% of the 26,873 green turtle nests reported to the Florida Index Nesting Beach Program. The recovery of the Florida green turtle rookery, especially at the Carr Refuge, is one of the great success stories in American wildlife conservation, exemplifies the efficacy of the Endangered Species Act, and confirms the wisdom of the Archie Carr NWR concept.

EXPLOITATION OR CONSERVATION? PLAN TO LICENSE SEA TURTLE HATCHERIES IN SRI LANKA COMES UNDER FIRE

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A decision taken by the Wildlife Resources Conservation Ministry to issue licenses to all the turtle hatcheries presently in operation has raised concerns among environmentalists who say this would encourage further exploitation of turtles. The first ex-situ sea turtle conservation programme or the turtle hatchery was initiated in 1956 at Yala National Park by the Department of Wildlife Conservation (DWC). Commercial sea turtle hatcheries began in Sri Lanka since 1970's and still functioning well. The number of hatcheries has changed during this period as some hatcheries closed and new ones began. Although their prime motive is profit, relying on tourists for their viability, unlike in the past, all the current hatcheries operate throughout the year, not only during tourist season. Since 1972 the establishment and operation of turtle hatcheries in Sri Lanka is illegal according to the law. But, the Director General of the DWC can authorize the establishment of a hatchery for the purpose of protection, preservation and scientific studies. Little or nothing is known about the long-term success of these programs, as hatchery operations rarely track hatchlings once they leave the beach and thus have no measure of overall success. While the contribution of turtle hatcheries towards conservation of sea turtles is highly debated, the DWC holds the view that management techniques in operation at a majority of the hatcheries are not conducive to the conservation of sea turtles. However, up until now environmentalist have not protested about the illegal functioning of turtle hatcheries. But, when the ministry decided to legalize these hatcheries by issuing licenses some environmentalists are now protesting. According to our experience on long term in-situ conservation programmes, it is high cost and difficult to continue for the long term. But, if the hatcheries maintained in a scientific manner following the guidelines in the Marine Turtle Conservation Strategy and Action Plan for Sri Lanka, many hatchlings (at least 90%) could be released as soon as they emerge from the nests. This would be a good contribution for the conservation of these creatures rather than closing the hatcheries. At the moment the hatchery owners do not follow the Action Plan and there is no mechanism to regulate the hatcheries. Hence, it is better to legalize these hatcheries rather than continuing illegal hatcheries with low contribution for the conservation. So conservationist should clearly think about this without pointless shouting. It is planning to discuss the progress of the hatchery licensee programme from this abstract.

SEA TURTLES AND THE DECOMMISSIONING OF OFFSHORE OIL AND GAS STRUCTURES IN THE GULF OF MEXICO (GOM)*

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Bureau of Safety and Environmental Enforcement

The Bureau of Safety and Environmental Enforcement (BSEE) is responsible for ensuring that all oil and gas facilities and structures are removed from the Outer Continental Shelf when they are no longer active. This can include structures on expired leases, those that are no longer useful for oil and gas operations, and those damaged by hurricanes. Currently there are approximately 2,600 platforms in federal waters in the GOM, and over 600 additional platforms that are eligible for decommissioning. Explosive severance is currently used during approximately half of the decommissioning operations in the GOM annually to cut the structures' bottom-founded components from the seabed and allow for their removal. Sea turtles are frequently found associated with these structures. One recent study documented loggerhead sea turtles nearby to oil and gas structures more than one-third of the time. The use of explosives during severance operations, and their potential impacts to sea turtles, is of concern to both BSEE and the National Marine Fisheries Service (NMFS). Mitigations are required for explosive severance in the GOM in order to protect sea turtles (and marine mammals) from potential impacts from explosives. These mitigations include limits on charge size and placement, detonation staggering, required visual observers, surface and aerial observations, and

pre/post detonation surveys. NMFS's Platform Removal Observer Program (PROP) provides observers for all BSEE permitted removal operations that propose explosives. PROP monitoring data were collected from decommissioning operations in 2011 (N=188) and 2012 (N=130). Explosive severance was used for 174 (2011) and 121 (2012) of these removals. While decommissioning activities occur year-round in the GOM, most decommissioning activity takes place during the summer months (July-September). During 2011-2012, the majority of structures decommissioned were in offshore western and central Louisiana (68% in 2011; 82% in 2012) in water depths of less than 31 meters (100 feet). Sea turtles were observed at the offshore structures roughly 1/3 of the time. PROP observers documented all five species of sea turtles found in the GOM: Kemp's Ridley, Green, Loggerhead, Leatherback and Hawksbill. An estimated 182 individual sea turtles were sighted in 2011 and 293 individuals in 2012. Impacts to four turtles by explosives were recorded. The presence of marine turtles at offshore structures requires an increased level of monitoring and mitigation. These mitigations effectively reduce the probability that sea turtles will be injured during decommissioning operations while enabling oil and gas operators to remove structures safely.

RAISING THE HATCHING SUCCESS OF LEATHERBACK NESTS AT THE OLIVE RIDLEY MASS-NESTING BEACH IN OSTIONAL, GUANACASTE, COSTA RICA*

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Playa Ostional, Costa Rica is a unique sea turtle nesting beach, where Eastern Pacific leatherbacks (*Dermochelys coriacea*) share a beach with another species of sea turtles, the olive ridley turtle (*Lepidochelys olivacea*), which exhibits both, solitary nesting and synchronized mass nesting, called arribadas. The latter is a rare behavior which has been observed in fewer than a dozen nesting beaches worldwide. Leatherbacks in Ostional use the same areas of the beach where major arribadas occur. Information and management strategies for the critically endangered leatherback sea turtle nesting on an arribada-beach such as Ostional are unique. Specific management challenges in Ostional are the presence of huge amounts of decaying organic matter (olive ridley nests) and high sand temperatures as a result of different factors including decomposition, assumed high levels of microbe load, soil-like consistency of sand, and possible reduced nest ventilation due to high density of nests (5/m²). Moreover, leatherback nesting takes place in the dry season, which further contributes to high temperatures and reduced humidity. Natural nests of leatherbacks have 0% hatching success. Mean incubation temperature in natural nests monitored during the years 2004-2009 averaged 35.2°C. First management strategies focused on lowering incubation temperature and raising humidity levels within the hatchery. Hatcheries were built completely caged and different types and colors of shading, as well as numbers of layers were tested. Treatment always included the sifting of the sand to remove large organic matter. This treatment lowered mean incubation temperatures inside of hatchery to 30.9°C and the hatching success rose and averaged 25.98% during the years 2004-2009. In the 2010/11 season the hatchery was moved about two meters closer to the high tideline to enhance tidal ventilation, with no further effect. The results during the years 2004-2009 were encouraging but left room for improvement. Temperatures were now sufficiently low to allow incubation, but hatching success was still low compared to other nesting beaches. A new focus was placed on the load of microbes that cannot be removed by sifting. A new treatment was tried in the 2011/12 season, where half of the sand inside the hatchery was replaced with sand taken from the first 15-20cm of the surface, close to the low tideline. The hypothesis was that this sand should be naturally disinfected by the NaCl of sea water. The hatchery was built as in previous years, completely caged and shaded. Hatching success rose in the half containing replaced-sand to an average of 61.48% in comparison to 32.9% in the half containing untreated sand. In the following season all the sand of the hatchery was replaced with sand taken from the low tideline and hatching success averaged 52.55%. Mean incubation temperatures remained the same as in previous years. Preliminary analyses for microbe load and humidity levels suggested a significant decrease in microbe levels for the treated sand, but extensive analyses are still needed to identify the important variables responsible for the increase in hatching success.

SEA TURTLE RESEARCH IN FRENCH POLYNESIA: FROM NESTING SITES TO IN WATER INVENTORY , THE EXAMPLE OF TE MANA O TE MOANA FOUNDATION

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French Polynesia is a vast geographical area, known for the beauty of its landscapes, the warmth of its people and its biodiversity. Coral reefs are home to a rich and colorful wildlife and large species such as whales and sharks. Among these iconic species, sea turtles, which are symbols of Polynesian culture, are threatened. Since 2004, the NGO Te mana o te moana works in the field and lead programs of research, conservation and education. A specially developed sea turtle clinic has received and taken care of over 300 injured turtles from all Polynesian archipelagos. Species collected involve green, hawksbill, but also limited numbers of olive ridley and loggerhead turtles. Since 2007 an in-depth program on green sea turtle nesting has been developed on Tetiaroa atoll with very intriguing numbers. Temperatures in nests are also monitored now. Satellite tracking of nesting females has shown clear migration to the west, towards Fiji while follow up project is done on rare loggerhead individual. A new technique for in-water inventory has been developed by our team and used around six islands: the "manta tow". This technique provides good data for outer slope coral reef population estimation and its results will be shared. In addition extensive education programs and community involvement is continuously taking place to increase awareness that includes tradition and cultural knowledge around sea turtle in this vast Polynesian country.

SEA TURTLES AND GIS MAPS AS A BASIS FOR ADVOCACY TO CREATE A MARINE PROTECTED AREA AT 'POINTE-INDIENNE', LOANGO BAY, IN THE REPUBLIC OF CONGO (CONGO-BRAZZAVILLE, CENTRAL AFRICA)

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Renatura is a non-profit organization protecting sea turtles in the Republic of Congo (Congo-Brazzaville) since 2001. Two species of sea turtles: the olive Ridley turtle and the leatherback turtle are nesting on a regular basis on the Congo's beaches. Besides the nest monitoring, Renatura has developed from 2005 an original program designed to release the sea turtles incidentally caught in artisanal fishing gears. Sea turtle by-catches are concentrated in the South of the Loango Bay, at the Pointe Indienne, a rocky sea ground stretching seaward and located north of the town of Pointe Noire. The Pointe-Indienne is an area combining a high biodiversity with intense artisanal fishing activities. Every year, the by-catch/release program leads to the release of more than 2000 sea turtles. Juvenile green turtles represent the major part of the by-catches. The 'Pointe-indienne' is located 20 km north of Pointe Noire, the biggest town and the main commercial and industrial harbor of the Congo. The town is currently developing very fast and industrial and urban projects are numerous, including mineral port facilities just south to the 'Pointe-Indienne'. This development is menacing the area of interest on the short term. That is why Renatura is undertaking an intense advocacy work to obtain the classification of the 'Pointe-Indienne' as a protected area. Data collected in the Framework of the release program are used to advocate for the creation of a marine protected area at the 'Pointe Indienne'/Loango Bay. Mark Capture recapture modeling permitted to assess the sea turtle abundance. It demonstrated that 2000 to 3000 juvenile turtles are resident all along the year at the 'Pointe-Indienne'. According to GPS tracking, green turtle population is concentrated on a rocky sea-ground of only few square kilometers. A population of hawksbill turtles is also observed, rather small but still important at the East Atlantic level given the status and trend of this species along the Atlantic coasts of Africa. The artisanal fishing products have also been assessed on the basis of artisanal fisheries' catches surveys. It shows a large diversity of fish and crustaceans species, including endangered sharks and rays. In addition, the rocky sea-ground hosts some rare species of gorgona and corals. Thanks to the data

collected, we are building tools and communication materials such as GIS maps summarizing the fishing effort, by-catch level, sea turtle abundances and other threats such as erosion, coastal development, mining port projects. This map includes data about pelagic species, intensity of human activities, and identification of the areas of conflict. This tools and materials are used to convince stakeholders, as well as local and national authorities. Renatura is thus lobbying for the creation of a community managed marine protected area. The advocacy work relies on the objective data collected year after year, the 'Pointe-Indienne' being a major growing and feeding site for green turtle at the sub-regional level (Central Africa).

SATELLITE TRACKING OF SYMPATRIC MARINE MEGAFUNA CAN INFORM THE BIOLOGICAL BASIS FOR SPECIES CO-MANAGEMENT

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Systematic conservation planning is increasingly used to identify priority areas for protection in marine systems. However, ecosystem-based approaches are typically used which frequently utilize density estimates, surrogates for animal presence, and modeling to identify areas for protection which make many assumptions, are often subjective, and do not take into account daily or seasonal movements of animals. In addition, sympatric and inter-related species are often managed separately. The aim of our study was to provide an evidence-based method to inform the biological basis for co-management of two sympatric species, green sea turtles (*Chelonia mydas*) and dugongs (*Dugong dugon*). This approach can then be used in systematic conservation planning to objectively delineate areas for protection of these sympatric animals. Fast-acquisition satellite telemetry was used to track ten green sea turtles and eleven dugongs at two geographically distinct foraging locations in Queensland, Australia (Shoalwater Bay and Torres Strait). The inter- and intra-species spatial relationships within and between geographic locations were determined and the efficacy of existing protection areas at two locations in northeast Australia was evaluated. Home-range analysis and bathymetric modeling were used to determine the spatial use of each individual and these were compared with existing protection areas using GIS. Results showed green turtle and dugong home-ranges significantly overlapped in both locations with the majority of green sea turtles having much smaller ranges than dugongs. However, both species used different core areas and significant differences existed between regions in species' depth zone use and home-range size, especially for dugongs. Both species used existing protection areas in Shoalwater Bay, but only a single tracked dugong used existing protection areas in Torres Strait. These results show that fast-acquisition satellite telemetry can provide evidence-based information to delineate relationships between green sea turtles and dugongs in regions where they co-occur, which can be used to augment existing management plans and protection areas and also increase the efficacy of systematic conservation planning. Results also showed coexisting dugongs and green sea turtles use similar habitats, making complimentary species co-management possible, but differences exist between geographic locations. Additionally, delineating animal movements can enhance effective conservation planning by providing information on individual animals to complement more broadly based survey information. This methodology could be applied on a broader scale to include other sympatric and inter-related species.

CONSERVATION STATUS OF THE SEA TURTLES IN SÃO TOMÉ AND PRÍNCIPE - ONE STEP CLOSER TO THE EDGE OF EXTINCTION

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The Program "Tatô" (local name given to the Olive Ridley sea turtle) is based in São Tomé and Príncipe, an archipelago located in the Eastern Atlantic in the Gulf of Guinea, a breeding place for four of the eight known species

of marine turtles in the world. This program was launched in 2008 and in partnership with the international NGO ATM, its main goal is to seek a good understanding of the sea turtle populations at these islands and assess their conservation status. This paper presents the first results of this program, at a critical time, when in São Tomé turtle meat (all species, all age classes) is openly sold in the capital's markets and consumption on both islands is still common practice. From 2008 to 2012, in the four main sites that have been monitored on the island of São Tomé, 93 turtles were tagged, more than 400 nests were observed, 372 of which were relocated by the rangers in the different incubation centers. The relatively low number reflects the reality of the island; during this same period, at least 450 nesting turtles were harvested, mainly on the north around the community of Micoló (54%). In 2013 the situation was getting worse, with mortality reaching nearly 100% in most nesting beaches, and uncontrolled at sea. To the beach data we will add results of market surveys carried out during the 2013/2014 season, picture of the real impact of this legal hunt. We discuss these results in light of the social, economic and political reality of this small country, while some possible solutions to this potential unsustainable use are presented.

EFFECT OF INCUBATION METHOD AND TEMPERATURE ON OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*) HATCHLING FITNESS IN SOUTHERN NAYARIT AND NORTHERN JALISCO, MEXICO

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The relocation of nests is a common practice in sea turtle conservation projects worldwide. In Mexico intensive protection of nesting beaches has reduced poaching and destruction of nests on protected beaches resulting in increased recruitment of hatchlings into the sea. Traditionally 3 methods of incubation have been used in Mexican conservation programs: in situ or natural incubation where nests are undisturbed and left where the female turtle laid them; beach hatcheries, where nests are relocated to a protected area of the beach and Styrofoam boxes where nests are incubated within boxes which are then placed in an incubation room. The use of each incubation method was decided by those in charge of conservation projects in response to local conditions. However, changing the location and incubation method of a nest can cause result in modified incubation temperatures, affecting the sex ratio produced naturally in addition to having an impact on the health of the hatchlings produced. During the olive ridley (*Lepidochelys olivacea*) nesting season 2012 and 2013 (July – December) we monitored incubation temperature every hour in nests incubating in Styrofoam boxes (El Naranjo, Nayarit) and beach nursery (Mayto and El Salado, and Careyeros Jalisco, Nayarit). On hatching 10 neonates were selected at random to partake in fitness tests. Each was weighed (g) and measured (SCL and SCW). Fitness tests included righting ability and the time to run 3 meters. Our results highlight important differences between incubation methods and the use of each on temperature and hatchling fitness.

COMMUNITY-LED SEA TURTLE CONSERVATION IN COSTA RICA - LESSONS LEARNED FROM EIGHT YEARS OF ECOTOURISM DEVELOPMENT IN DRAKE BAY, OSA PENINSULA

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The non-profit Corcovado Foundation is committed to the conservation and sustainable development of the Osa Peninsula, which is considered Costa Rica's last wilderness frontier and one of the most biodiverse places on earth. It is also the only remaining region along the Pacific coast where 'eco-tourism' is still the predominant tourism model, yet it currently stands on the precipice of an inevitable expansion of the industry over the next decade which has the potential to either gravely threaten or positively guarantee the integrity of the local natural heritage. In 2006 the Corcovado Foundation began working with the community in Drake Bay to protect the sea turtles nesting on their beach from poaching. The program aimed to create jobs, provide training and environmental education, and develop the infrastructure for a locally-managed conservation and ecotourism program in the future. By pursuing a policy of transparency, respect and engagement from the outset, the program succeeded in reversing the destructive trend of poaching, saving 90% of the nests laid on the beaches and releasing over 65,000 hatchlings into the Pacific Ocean. But, more importantly, the program succeeded in changing the attitude of an initially skeptical community toward the unsustainable extraction of their natural resources. Eight years on, the fledgling local conservationist association, ACOTPRO, is preparing to assume responsibility for the sea turtle project in 2014. Mission accomplished, it would seem. But the road to this accomplishment was far from smooth, and the future of the association is far from certain. Many unanticipated social and logistical obstacles threatened the survival of the initiative, related to the distribution of income, the proliferation of negative perceptions, misunderstandings, miscommunication, conflicting interests and visions of the associates, and the existence of deeply-rooted political and familial prejudices. Whilst the model of community-led ecotourism development has been proven successful in Drake Bay, the dissemination of the lessons learned from this endeavor will undoubtedly be of great value to those wishing to empowering similar poor communities around the world.

TURTLES DIG THE DARK! COASTAL COMMUNITY BELIEFS ABOUT LIGHT-GLOW REDUCTION

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Artificial lighting is recognised as a significant threat to the breeding success of marine turtles. Yet, artificial light at night is an integral aspect of modern human society and globally light-use is increasing with population growth. As a result managers face a substantial challenge: how can society's need for artificial lighting be balanced against effective marine turtle conservation measures? Determining public perceptions and beliefs about light mitigation measures for turtle conservation is an essential first step towards developing effective and appropriate light pollution management strategies. The Woongarra coast of Queensland is an important nesting area for loggerhead turtles, and has been the site of an active light-glow reduction campaign since 2008. We investigate community engagement with light-glow reduction after four years of campaign exposure, and evaluate the potential for using persuasive communication techniques, based on community beliefs elicited using the Theory of Planned Behaviour (Ajzen, 1991), to increase engagement. Despite high levels of cognitive and affective engagement, behavioural engagement with light-glow reduction in this community is limited. Based on significant differences in beliefs held by campaign compliers and non-compliers, we provide several recommendations that may be used to develop future campaign materials with increased persuasion potential, as a means of improving behavioural engagement with light-reduction

recommendations. As the significance of artificial light as a pollutant gains attention around the world, our study will be of interest to anyone needing to manage public use of light at night.

POPULATION MONITORING OF LOGGERHEAD TURTLES FOR DALYAN BEACH IN 2013, TURKEY: IT WAS REACHED THE HIGHEST NUMBER OF NESTS DURING THE PAST 25 YEARS

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Dalyan beach is one of the most important and best protected nesting sites of Loggerhead turtles (*Caretta caretta*) in Turkey. The minimum nest number occurred in 1994 nesting season with 86 nests and the maximum number of nests was observed in 2013 nesting season with 522 nests. We recorded a total of 1339 emergences in 2013, of which 522 (38.98%) was resulted nests respectively. The nest density was calculated as 116 nests per kilometer. 25024 hatchling emerged (74.48%) from 36306 eggs and 24589 hatchlings reached to sea in 2013 nesting season. The regular monitoring of the beach started nearly 25 years ago and we know that the sexual maturity age is somewhere between 20-25 years. As a result of continuous protection efforts, the last 6 years (2008-2013 breeding seasons) the average nests per year was calculated to be 238 nests. One of the possible explanations of these increases in nest numbers is the continuous conservation activities run by the Turkish authorities and universities over the last 25 years. Dalyan beach is closed to visitors at night and there are limitations to the beach usage for the public during the day. Dalyan beach demonstrates a very good example of coexistence of turtles and tourists and suggested for other nesting beaches to be applied.

USE OF SURROGATES FOR ESTIMATING TAKE UNDER THE ENDANGERED SPECIES ACT: IMPLICATIONS FOR SEA TURTLES

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Managing and mitigating the effects of human activities on threatened and endangered species is essential to their recovery and survival. The Endangered Species Act requires formal consultation between federal agencies before undertaking activities that may affect a listed species. These consultations are designed to ensure that the proposed action is not likely to jeopardize the species' continued existence, and results in a Biological Opinion that outlines the effects of the action, baseline environmental information, and potential mitigation measures. Each Biological Opinion includes an Incidental Take Statement (ITS) that authorizes the amount of allowable, anticipated take and serves to 'trigger' reinitiation of formal consultation should actual take exceed the anticipated amount. Court decisions and legislative history prescribe that this amount should be expressed as a specific number, but that a surrogate may be used if it is not possible to derive numeric estimates. However, the standard for when a surrogate can be used remains a contentious subject. In 2013, the National Marine Fisheries Service and the U.S. Fish and Wildlife Service issued a proposed regulation that would create overly broad standards for when it is permissible to use surrogate information as a proxy for direct take. This proposed regulation would allow the Services to avoid providing numeric take estimates if it is deemed too difficult or costly to do so, rather than because it is scientifically not possible. Additionally, it would enable the use of surrogates that are "coextensive" with the scope of an action, which could lead to an unlimited number of takes as long as they result from the action in question. This proposed regulation would apply to all

threatened and endangered species, without additional provisions or understanding about the impacts of these changes to specific animal groups such as sea turtles. In this study, we show how both elements of the proposed regulation potentially undermine existing protections and conservation measures dedicated to the recovery and survival of sea turtle populations in the U.S. For example, most lethal take of sea turtles occurs from interactions with commercial fisheries. Even when allowable take is outlined within ITSs, reinitiation is slow to occur and there are only a few circumstances where the authorized number serves as a strict limit. The use of surrogate information to determine take would allow further flexibility to estimate take based on proxies such as fishing effort without including coinciding direct observations from observer data. This approach would not be conducive to managing cumulative impacts, as there would be no numerical take estimates to aggregate across authorized projects. Additionally, we demonstrate how unlimited takes could occur when using surrogate data coextensive with the scope of the action. We use these and other examples to show that the use of surrogate information places sea turtles at risk in light of climatic changes and rising anthropogenic activities in the marine environment, which undermines the purpose and intent of the Endangered Species Act.

PROTECTING MARINE ECOSYSTEMS THROUGH DESIGNATION OF LOGGERHEAD SEA TURTLES' IN-WATER CRITICAL HABITAT UNDER THE U.S. ENDANGERED SPECIES ACT*

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A combination of scientific discovery about loggerhead sea turtle habitat and threats has increased demand for management measures to preempt and mitigate harm to sea turtles. Recent scientific techniques – tracking sea turtle movements, mapping nesting populations' genes, and collecting environmental data remotely from tagged turtles – have improved the understanding of the physical, biological and ecological ocean characteristics essential to loggerhead sea turtle conservation. The results underscore the importance of loggerhead sea turtles' marine habitat for conservation and recovery. At the same time as detailed knowledge of in-water sea turtle habitat has developed, awareness has grown about emerging threats to marine habitat such as marine debris and other pollution from land and ship-based sources. We will briefly summarize current in-water protections for loggerhead sea turtles under U.S. law and highlight upcoming changes likely to result from designation of critical habitat under the Endangered Species Act. To protect and recover endangered loggerhead sea turtle populations in the Northwest Atlantic Ocean, federal law requires the U.S. Fish and Wildlife Service and National Marine Fisheries Service to designate critical habitat on nesting beaches and in waters of the Southeast United States, respectively. The Endangered Species Act defines critical habitat as specific geographic areas essential for conservation and that may require special management and protection. Critical habitat thus protects not only listed species, but also the ecosystems upon which they depend. In 2013, the National Marine Fisheries Service proposed to designate in-water critical habitat which it intends to finalize in July 2014. The National Marine Fisheries Service's proposal includes nearshore reproductive habitat (814.3 mi²), migratory habitat (9,191 mi²), breeding habitat (4,498 mi²), and overwintering habitat (6,541 mi²). In addition, the proposal solicited comments on whether to identify foraging habitat or two large areas of *Sargassum* habitat that encompass U.S. waters south of 40° N. lat. in the Atlantic Ocean and Gulf of Mexico from the 10-m depth contour to the outer boundary of the Exclusive Economic Zone (520,839 mi²). The additional and increasingly complex information on loggerhead distribution, life history and genetics requires renewed efforts to protect loggerhead sea turtles in their marine habitat. Much of the proposed marine critical habitat under the Endangered Species Act overlaps with existing protections such as essential fish habitat identified under the Magnuson-Stevens Fishery Conservation and Management Act and measures designed to reduce fishing's impact on loggerhead sea turtles. Identification of critical habitat provides an overarching framework by which to prioritize and address threats to loggerheads' marine habitat from federally permitted activities and coordinate the various protections already in place.

GREEN TURTLE OF OGASAWARA, JAPAN -SEASON 1 THE BEGINNING

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The Ogasawara Islands, 1,000 km south from Tokyo in the main island of Japan are some of the most significant rookeries of green turtles (*Chelonia mydas*) in the world. The islands are also known for a long history of turtle harvest. When whalers from the western countries and Hawaiian local people came to settle for establishing a whaling base in 1830, harvest of green turtles began. In 1876, the islands were included in the territory of Japanese government. The Japanese Ministry of Agriculture and Commerce encouraged the harvesting of turtles for economic growth and it is estimated that approximately 3,000 turtles were caught in the following few years, which lead to a drastic decline in the turtle population. The harvesting of turtles was legally conducted under the control of the governor of the Tokyo Metropolitan. The ‘Tokyo fisheries adjustment regulation’ was created by the Fisheries Agency in 1994 and the number of turtles harvested is currently restricted to 135 turtles. The turtles were mostly consumed within the islands and turtles have been a part of an important traditional culture among the islanders. On the other hand, harvest of turtles’ eggs has been prohibited since the islands have belonged to Japanese territory for the purpose of maintaining sustainable use of the turtle stock. Moreover, the Japanese Ministry of Agriculture and Commerce commenced ‘Hatching and Releasing Project’ in 1910 as the world’s first trial to recover the nearly depleted stock that had resulted from the overharvesting. As the Ogasawara’s method, eggs were not transferred from the natural beaches for the project but breeding turtles were caught in mating seasons and temporarily kept in captivity for breeding. Then the eggs were collected for incubation and subsequent hatchlings were released from the beaches into the wild. Although the project paused for 32 years from 1941 to 1972 after the World War II, a total of 309,714 hatchlings were released by 2008. The project which was continued for almost a hundred years was closed in 2009 because any remarkable results weren’t obtained and the project was considered to be ineffective to accomplish the initial purpose. Although there has been critical human exploitation of green turtles in the late 1800’s and harvesting of turtles is still conducted nowadays, the nest abundance in Chichijima group has increased with the annual growth rate of 6.8% for 25 years from 1978 to 2003. Furthermore, the number of the nests in Chichijima group was recorded 1,982 in 2013, which is the greatest number since the full-scale monitoring had started in 1975. It is necessary to understand the cultural and historical background of the rookery to implement effective management and develop appropriate monitoring methods. Nevertheless, long-term nesting data is essential to estimate the stock status and trend, which is also crucial to apply adequate protection.

IT IS A TUMOR! A REVIEW OF FLORIDA’S EFFORTS TO REHABILITATE MARINE TURTLES EXHIBITING FIBROPAPILLOMATOSIS TUMORS

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As the lead agency for protection of marine turtles in Florida, the Florida Fish & Wildlife Conservation Commission (FWC) must review and issue permits approving all activities involving marine turtles. This includes oversight of permitted individuals and their affiliated facilities conducting rehabilitation of sick and injured marine turtles. Rehabilitation activities, conducted under the guidance provided in FWC’s Marine Turtle Conservation Guidelines (Guidelines), are performed with the goal of returning individuals to the wild population yet also provide an effective and invaluable opportunity to educate the public on the threats to marine turtles and their recovery. From 1987 to June 2013, FWC-permitted organizations provided treatment to 900 marine turtles displaying external tumors associated with fibropapillomatosis (FP) upon admittance (98.8%) or developed while in residence (1.2%). Green turtles were

the most common species to exhibit FP tumors; loggerhead turtles and hybrids comprised the remainder. Prior to 2010, the maximum length of stay was 6427 days prior to final disposition, in part due to a mandatory one-year holding period during which a turtle did not experience any FP tumor growth. Once FWC eliminated the mandatory holding period, the maximum length of stay at a facility decreased to 563 days. Overall, 27% of turtles with FP tumors admitted into a FWC-permitted rehabilitation facility were successfully rehabilitated and released. Turtles that died or were euthanized represented 68% of the total. Turtles remaining in a facility, either undergoing treatment or designated non-releasable, accounted for 5% of the total. When sufficient data was available, severity of FP tumors was assigned using a common 0 to 3 scoring system established by Work and Balazs (1999) where “0” is indicative of no external tumors and “3” represents either a large number of tumors or the presence of very large tumors. Of the 613 cases that were assigned a tumor score (TS) turtles with TS 2 or 3 comprised 83.7% of the total, while turtles with TS 1 accounted for only 16.3%. Of the scored turtles with a final rehabilitation outcome during the reporting period, turtles with TS 1 exhibited the highest rate of successful rehabilitation and release (38.9%) while turtles with TS 3 demonstrated the lowest rate of successful outcome (16.9%). While the annual number of stranded turtles requiring treatment and displaying FP tumors has increased over time, the number of facilities conducting rehabilitation of turtles with FP tumors has remained fairly consistent, increasing from two (2) to four (4). This represents only a small fraction of the overall capacity of the fifteen (15) FWC-permitted rehabilitation facilities in 2013, despite the increasing need. Resource managers should review the available data to evaluate the success of current strategies for rehabilitating turtles exhibiting FP tumors and implement appropriate changes to the Guidelines with input from veterinary professionals. Any plans to enhance rehabilitation capacity in Florida should place the highest priority on enhancing capacity for treatment of sick and injured turtles exhibiting FP tumors in areas lacking a nearby FP facility.

PROPOSED TERRESTRIAL CRITICAL HABITAT FOR THE NORTHWEST ATLANTIC LOGGERHEAD SEA TURTLE POPULATION*

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The Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) jointly issued a final rule on September 22, 2011, changing the loggerhead sea turtle’s listing under the U.S. Endangered Species Act (ESA) from a single, globally-threatened listing to nine Distinct Population Segments (DPS) listed as threatened or endangered. Two of these DPSs occur within the United States – the North Pacific Ocean DPS and the Northwest Atlantic Ocean DPS. The USFWS coordinated the selection process for loggerhead terrestrial critical habitat. Because critical habitat can only be designated in areas under U.S. jurisdiction and because loggerhead nesting in the United States occurs only within the Northwest Atlantic Ocean DPS, the USFWS only proposed to designate critical habitat for this one DPS. The best available scientific information was used to identify the physical and biological features essential to the conservation of the loggerhead, as well as the primary constituent elements that support these features, for its nesting habitat. These included unimpeded nearshore access to the beach, a beach elevation without frequent inundation by high tides, sand that allows for nest construction and facilitates egg development, and sufficient darkness for successful nesting and hatchling sea finding. The USFWS applied a methodology for conserving imperiled species known as the “three Rs”: representation, resiliency, and redundancy. Representation means conserving not just a species but its associated habitats. Resiliency means ensuring that the habitat is adequate for a species and its representative components. Redundancy ensures an adequate number of sites and individuals. Thus, the strategy used by the USFWS was based on conserving the: (1) Beaches that have the highest nesting densities; (2) beaches that have a good geographic spatial distribution to ensure genetic diversity; (3) beaches that collectively provide a good representation of total nesting; and (4) beaches adjacent to the high density nesting beaches that can serve as expansion areas and to accommodate nesting females whose primary nesting beach has been lost. This process used to select the beaches for potential designation of terrestrial critical habitat was developed in coordination with State agency technical advisors. Ninety sites were identified in six southeastern States for consideration as terrestrial critical habitat designation (North Carolina-8, South Carolina-22, Georgia-8, Florida-47, Alabama-3, and Mississippi-2).

Approximately 756 miles of sandy beach is considered for designation. Critical habitat designations allow the USFWS to prioritize its recovery efforts. It emphasizes the value of the habitat on which loggerheads depend. Once critical habitat is designated, Federal agencies are to ensure that they do not fund, authorize, or carry out actions that will adversely modify critical habitat. This is in addition to the requirement under section 7 of the ESA that Federal agencies ensure their actions do not jeopardize the continued existence of listed species.

EMPOWERING COMMUNITIES ENHANCES LONG-TERM SEA TURTLE MONITORING IN FIJI*

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Empowering traditional fishermen promotes long term protection of sea turtle population. Sea turtles in Fiji are referred to as delicacy and importantly a cultural totem to many of the coastal provinces. Twenty-five local fishermen of the identified ten hawksbill and green nesting sites along the Great Sea Reef are now turtle monitors. Recent satellite telemetry results illustrated the Great Sea Reef as an important feeding grounds for hawksbill, green and loggerhead turtles. These fishermen were once turtle hunters with immense traditional knowledge in sea turtle habitat, sea turtle recipe and hunting skills. Establishing turtle monitoring programme along the two provinces of Bua and Macuata have enhances initiative in the long-term protection of sea turtles. The 25 turtle monitors in place are now spearheading sea turtle conservation and protection along the Great Sea Reef. Interests from associated communities had increased, leading to the extension of the turtle network to two new sites of Galoa and Tavewa. Baseline information unveiled an increase in tagging, protection of nesting and feeding sites, decrease in illegal harvesting of sea turtles, submission of detailed information of nesting beaches and even advocacy on sea turtles protection, its biology, ecology and existing turtle moratorium at village, districts and provincial level. The granted mandate as fish warden enabled turtle monitors to better its role by means of enforcing existing legislations. The existing turtle monitoring programme is creating vast sea turtle conservation awareness throughout Fiji. Maintaining support from regional organizations, government, non-government organizations and institutions is a continuing challenge in this early stage of establishing community based turtle monitors.

LOGGERHEAD CRITICAL HABITAT: FACTS AND FICTIONS ABOUT ITS POTENTIAL LEGAL AND BIOLOGICAL IMPACT*

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In 2013, the U.S. Fish and Wildlife Service and National Marine Fisheries Service proposed to designate critical habitat for the Northwest Atlantic Distinct Population Segment of loggerhead sea turtles on nesting beaches and in waters of the Southeast United States. Critical habitat is required for all species listed under the Endangered Species Act and is intended to provide a layer of protection for habitat that is essential for the conservation of the species. In addition to protecting species, critical habitat ensures protection of the ecosystems upon which those species depend. Despite decades of familiarity with sea turtle protections and strong support from local communities for sea turtle conservation generally, there has been strong opposition to the critical habitat proposals by some sectors. Opposition has taken the form of letters from congressmen, state officials, and local governments, as well as local resolutions, media campaigns, and notices of intent to sue the federal government. Here, we examine what critical habitat designation would mean for sea turtles and local communities and address some of the myths and fears that appear to fuel the opposition. Critical habitat is an important conservation tool that will complement existing efforts to recover

the loggerhead sea turtle by identifying the areas most important for the species so that people can better plan coastal activities and mitigate impacts to that habitat. Because critical habitat requires only that federal governments ensure their actions – rather than those of local communities or individuals – are not likely to adversely modify or destroy critical habitat, it will have no impact on local communities unless federal permits are required. Moreover, even where federal permits are required, decades of existing sea turtle protections may already provide protection to the habitat itself such that no additional regulatory burden would ensue. The critical habitat designation will require federal agencies to look and see whether sea turtle habitat – essential for nesting, migration, foraging, breeding, and other essential life functions – might be affected. For example, dredging and sand replacement projects on significantly eroded beaches will have to ensure that the type of materials they are using and the timing of their actions will not destroy nesting beach critical habitat. Critical habitat designation will also allow agencies to plan ahead and perhaps choose locations for activities that are less important for sea turtle conservation. Critical habitat will likely have little effect on the everyday lives of people in coastal communities, but still benefit sea turtles. Species with critical habitat are twice as likely to have an improving population trend, and less than half as likely to be declining as species without critical habitat. Protecting habitat will not limit public access to beaches. In fact, it will protect continued public access to beaches and make the experience more enjoyable by keeping beaches clean and healthy for generations to come.

INCORPORATING MARINE DEBRIS REMOVAL INTO SEA TURTLE MONITORING: AN INTEGRATED CONSERVATION APPROACH

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Collection and analysis of robust data is a critical component of any conservation initiative. Citizen science has emerged as a vital component of natural resources conservation and nowhere has this been more exemplary than in the realms of marine debris research and sea turtle conservation. Within the marine debris realm, citizen scientists have been collecting data for twenty-eight years as part of the International Coastal Cleanup (Cleanup). Likewise, sea turtle volunteers perform an array of data collection services that directly aid sea turtle conservation, including beach patrols to check for signs of nesting activity, marking new nests, relocating nests that are in danger of washing away during storms, and calculating hatch success rate. Volunteers who engage in these activities monitor the same strand of beach or coastline that is subject to accumulations of debris and plastic pollution. In the current political climate, many states and countries lack sufficient resources to adequately monitor sea turtle nesting activity. With all 7 species of sea turtles listed on the International Union for Conservation of Nature (IUCN), minimizing the threat of marine debris to sea turtle survival is imperative. Plastic pollution and other forms of debris on the beach and in marine environments are ubiquitous and significant perils that impede conservation directives both domestically and abroad. Removing the threat of debris from coastal and pelagic environments poses major challenges. However, eliminating debris hazards from sea turtles' terrestrial environments is uncomplicated and feasible, and opportunities to do so should be maximized. Ocean Conservancy partnered with the Wrightsville Beach Sea Turtle Patrol and Wrightsville Beach--Keep It Clean in 2013, to expand existing sea turtle monitoring efforts to include the removal and cataloguing of debris. Data collected during this pilot project allowed us to build on current Cleanup data analysis to establish new, scientifically robust techniques for analyzing and interpreting data with respect to sea turtle conservation. The simplicity of integrating marine debris protocols into existing sea turtle monitoring programs warrants expansion to the hundreds of sea turtle conservation projects taking place around the world, and we are working to replicate these protocols into existing sea turtle patrols in the southeastern United States and abroad. Conservation benefits associated with concurrent turtle-debris monitoring efforts include an enhanced understanding of the potential ways trash affects nesting sea turtles and hatchlings, as well as increased awareness among beachgoers of the threats plastics and other forms of debris pose to sea turtles. These collaborations yield new ways to augment sea turtle protection and mitigate harmful conditions for turtle populations in the municipalities and communities where collaborative monitoring takes place.

THE FLORIDA BEACHES HABITAT CONSERVATION PLAN: A COLLABORATIVE EFFORT

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Beaches are home to a wide variety of wildlife, including many species that are protected by the U.S. Endangered Species Act (ESA). In Florida, this includes five species of nesting sea turtles; loggerhead, green, leatherback, hawksbill, and Kemp's ridley. Beaches are also utilized by a large and growing population of seasonal and year-round residents, who place an increasing burden on coastal resources. Construction and other activities that may impact the beach-dune system typically require a Coastal Construction Control Line (CCCL) permit. The Florida Department of Environmental Protection (FDEP) endeavors to condition these permits to avoid harm to listed marine turtle species, but unintentional (incidental) impacts to these and other listed species may still occur. For this reason, FDEP is preparing a Habitat Conservation Plan (HCP) in order to apply for an Incidental Take Permit (ITP) that will ensure full compliance with the ESA. The Florida Fish and Wildlife Conservation Commission (FWC) has been tasked with coordinating the development of this HCP. The purpose of the habitat conservation planning process associated with a permit is to ensure the impacts to protected species resulting from authorized activities are minimized and mitigated to the maximum extent practicable. The Florida Beaches HCP (FBHCP) integrates development and land use activities with conservation by providing a framework for the preservation and management of the states critically important but spatially limited natural resources. Its development is being funded by a Habitat Conservation Planning Assistance Grant from the U.S. Fish and Wildlife Service (USFWS), as provided under Section 6 of the ESA. A Work Group, consisting of staff from the FWC, FDEP, USFWS and several FDEP contractors (Coastal Technology Corporation, Ecological Associates Inc., Florida Natural Areas Inventory, Geodesign Technologies), is compiling requisite data for inclusion in the FBHCP. The Work Group is also assembling, reviewing, and summarizing background information on substantive policy issues affecting FBHCP development and implementation. Key policy issues, along with Work Group recommendations, are presented to a Steering Committee for consideration. The Steering Committee was appointed by the Secretary of FDEP and consists of representatives from FWC, FDEP, Florida Fish and Wildlife Research Institute (FWRI), Florida Association of Counties and Florida League of Cities, Lee County Tourism Development Council, Audubon Society and Sea Turtle Conservancy, and Humiston and Moore Engineers. The Steering Committee discusses and debates key policy matters, and makes recommendations to the FDEP Secretary, who will make the final decision on all policies and programs proposed for inclusion in the FBHCP. Although this composition was intended to represent a broad range of stakeholder groups, additional stakeholder input is sought as the FBHCP development nears completion. This statewide beaches HCP is the first of its kind and covers approximately 825 miles of sandy beaches in Florida. Stakeholder involvement and broad support for the plan is not only desirable, but essential to the overall success of the FBHCP as the future of some of Florida's rarest natural resources rests in the balance.

HATCHERY PRODUCTIVITY ANALYSIS TO IMPROVE NEST MANAGEMENT TECHNIQUES IN ERVATO BEACH, BOA VISTA ISLAND (CAPE VERDE)

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One of the most important actions to protect and preserve endangered species is to ensure and increase annual recruitment into the population. In sea turtles, this action takes place through the protection of nesting beaches and the creation of controlled incubation areas (hatcheries) with optimal conditions to nest development. The hatchery is an important conservation tool to improve the productivity of nesting beaches that have a low hatchling success by natural

or artificial causes: high rates of predation, significant tidal ranges, densely vegetated, presence of clays, poaching, human alteration of nesting beaches, etc. Boa Vista island host the 75% of nests disposed by loggerhead females in the Cape Verde archipelago, and the higher density beaches are located in the Reserva Natura das Tartarugas (RNT), in southeastern Boa Vista. However, much of these beaches do not meet the optimal conditions for egg incubation, mainly due to high levels of predation and flooding. Since 1998, Cabo Verde Natura 2000 NGO conducts the conservation and protection activities in the most important nesting beaches of the RNT. In 2005 began to carry out hatchery activities every season. This study analyzes the results obtained in the CV Natura 2000 hatchery in the last two seasons, 2012 and 2013. A total of 723 nests were relocated to hatchery (387 nests in 2012 and 336 in 2013) where 655 were monitored and surveyed until their exhumation in the 70th day. All these nests were relocated from three low productivity beaches: Ervatão, Benguinho and Ponta Cosme beaches. The number of eggs, incubation time, emergence success, hatchling success, number and stage of unhatched eggs, and the hatchling anomalies are analyzed in relation with: the relocation time, their localization in the hatchery (far or close to the sea), and the moment of relocation along the season. Different nests of the same female are also compared and studied. Broadly, results place the most adequate areas of the hatchery; set the relocation time ranges; and show the productivity variations along the season. This data will allow improved the nest management techniques to increase the hatchery productivity for the next seasons and overcome the more than 40.000 hatchlings released in 2012 and 2013.

**NOTES ON THE BIOLOGY AND ECOLOGY OF *CARETTA CARETTA*, *CHELONIA MYDAS*,
DERMOCHELYS CORIACEA AND *ERETMOCHELYS IMBRICATA*, IN THE COLOMBIAN CARIBBEAN**

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Caribbean plain extends along the northern coast of Colombia, in the northwest from the border with Panama to the peninsula of La Guajira including the Archipelago of San Andres and Providencia. This area is only interrupted by the mountain Sierra Nevada de Santa Marta which is close to the National Natural Park Tayrona (PNNT). Ceballos-Fonseca (2004) found 181 nesting beaches of sea turtles. On these beaches there are records feeding and reproductive activity and by-catch, of four of the six species of turtles living in the Colombian Caribbean. A fifth species the olive ridley, *L. olivacea*, has only been sporadically viewed in Colombia. Each of these 5 sub-regions has its predominant turtle species. Since the sixties, seventies and eighties it has been observed that the reproductive processes of these species are closely related to specific nesting areas and a reproductive cycles which can be annual, biannual or triannual, and are dependent on the summer (Dry season). All sea turtle species that exist in the Caribbean, are present in colonies and populations in the Colombian Caribbean, demonstrating the importance of the Colombian coast as a transition zone between the feeding and reproductive processes. Playona beach in the Gulf of Urabá is the most important nesting area of *Dermochelys coriacea*; also called leatherback in Colombia, with a colony of 200-250 females. The most recent research and protection in this important area were ended in the late nineties. Kaufmann (1973) recorded nesting of *Caretta caretta* or "Gogo" and leatherback in the Department of Magdalena, centered on the beaches of Buritaca, Don Diego and Quintana (northern Tayrona). The latest monitoring of sea turtle species was performed in 2005 and 2007 in the (PNNT) by the Group of Sea Turtle Conservation of University de Bogotá Jorge Tadeo Lozano (GCTM-UBJTL) confirming the presence of these species. The species *Chelonia mydas* or the green turtle and *Eretmochelys imbricata* or "Carey" have a wide range and are found in all 5 sub-regions, but in very low numbers. Even with the available outdated research it is clear that knowledge of nesting ground location, turtle species, seasons and climate are essential for effective conservation. Further research is therefore necessary to determine the main nesting grounds and the numbers of breeding females per species, and also the migratory routes to establish targeted conservation projects. This knowledge gives us the initial tools to develop effective long term protection programs that integrate local communities and private and public institutions, due to establishing the conservation of sea turtles and their habitat.

STATUS, CONSERVATION, AND DISJUNCT SEASONAL PATTERNS OF NESTING TURTLES IN THE OUTER ISLANDS OF THE REPUBLIC OF SEYCHELLES*

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Sea turtles were legally exploited by people in Seychelles throughout its human history (since at least 1770) until 1994 when national legislation was passed prohibiting all killing of sea turtles and their eggs, and sale and possession of turtle parts. With 115 islands spread across an EEZ of 1.4 million km², enforcement of protective legislation is a challenge. But, programs to monitor nesting turtles have been established on as many islands as possible in Seychelles (currently at >20 sites) and effectively provide the following benefits: a) collection of scientific data to assess population status, nesting seasonality, breeding periodicity, long- and short-distance migrations of adult animals, as well as other aspects of their biology; b) involvement of the local community in sea turtle conservation activities, which creates awareness of and support for conservation; and c) they serve as de facto anti-poaching campaigns by providing a watchful presence on the nesting beaches. Historically, most of these programs were located in the inner islands of Seychelles, within 100 km of the human population centers. In the remote outer islands (i.e. those >200-1200 km from the main island, Mahé) only Aldabra Atoll, a UNESCO World Heritage Site, had a long term turtle program and protected status as a nature reserve. The Aldabra turtle monitoring program has operated intermittently since 1968, and consistently since 1981. But, in 2004 a long-term turtle monitoring program was initiated at D'Arros Island / St. Joseph atoll in the Amirantes group of islands (270 km from Mahé). It is currently managed by the Save Our Seas Foundation (SOSF). Since 2004, additional turtle programs have been implemented by the Island Conservation Society (ICS) at other sites in the remote Amirantes Islands Group – including Desroches Island and Alphonse Island / St. Francois atoll. ICS will establish at least three more such programs in 2014. All these monitoring programmes have generated reliable assessments of turtle population size and trends. They also reveal interesting and unexpected disjunct patterns of nesting seasonality for green turtle rookeries separated by as little as 2 km (with significantly different patterns of seasonality consistent over multiple years). In addition, these programs have virtually eliminated poaching; and increases in nesting activity are already evident at D'Arros / St. Joseph. Now that the threat from Somali pirates is abating in Seychelles, new initiatives are underway to promote conservation throughout the outer islands. These include the implementation of various management regimes for the islands, with novel funding mechanisms to ensure long term sustainability of conservation programs conducted in partnership with tourism development, and a proposed network of outer island protected areas to ensure long term protection of critical habitats.

SEA TURTLE NESTING AND CONSERVATION AT TURNEFFE ATOLL, BELIZE

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Turneffe Atoll is located approximately 40 kilometers east of Belize City and is part of the Mesoamerican Reef. The archipelago spans 15 by 50 kilometers and consists of a shallow reef and low-lying beaches fringed by an extensive mangrove system. Green, hawksbill and loggerhead sea turtles are frequently observed in the shallow waters of the atoll and nesting occurs sporadically throughout the numerous Turneffe cayes. The majority of these cayes are uninhabited, aside from a few scattered resorts and primitive fish camps that are occupied seasonally. Fishermen build these camps by clearing vegetation from the shoreline that indirectly, creates sea turtle nesting habitat. However, they also introduce lights, humans and often dogs that deter nesting. Since 2007 we have surveyed the numerous cayes

looking for nests, but because of their remoteness, tide cycles and beach trash, this task is very difficult to accomplish. In the 2013 summer we collaborated with the University of Belize and did a thorough and extensive survey of every beach at Turneffe that could support sea turtle nesting. We documented three loggerhead nests on the eastern side of the atoll, and we found eighteen possible hawksbill and/or loggerhead nesting sites on northern and southern cayes. Based on our data we believe that loggerhead and hawksbill nesting is more common at Turneffe, but because of its remoteness accurate documentation is very difficult. We are proposing to start a sea turtle conservation program and recruit the help of local fishermen to report nesting. These volunteers would be trained by the Belizean Sea Turtle Network members and they would be tasked to survey, report and protect any sea turtle nesting near their camp location. Along with an increase in Turneffe nesting data accuracy, this program also has the propensity to foster an attitude for sea turtle conservation that is not very common among local fishermen. Sea turtle harvesting is unofficially known to occur and this proposed conservation program, especially if it incorporates an end of season participant recognition, will reverse this attitude.

LONG TERM MANAGEMENT OF MARINE TURTLES BY THE LOCAL COMMUNITY IN ITSAMIA MOHÉLI MARINE PARK (COMOROS UNION)

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Pressure of human activities is the main cause of reduction of marine turtle population all around the world. And because these migratory species have a large repartition area, their conservation cannot only be built on sanctuaries. Thus it is important to find a model where local communities and sea turtle can share the same territory. Since 1998, the Association for the Itsamia Socio-Economic Development "ADSEI" at Mohéli Marine Park set up a monitoring and control of sea turtle's nesting beaches, with the scientific support of Kélonia, the observatory of Marine turtles of Reunion Island. Since the beginning of these programs, the poaching reduced significantly, and the number of nesting females increase. More than 3000 females per year nest on the 5 five beaches monitored by ADSEI. Itsamia is the inhabited nesting site the most important in the western Indian Ocean, where a turtle and men lived together in perfect harmony. Today, sea turtles are a source of income for the whole village, because the development of ecotourism activities. Itsamia is also an open-air laboratory: Turtles are present yearlong on the beaches and sea grass beds. So Itsamia, has received several scientific programs and contribute to increase knowledge on marine turtles, as well as capacity building in the field of protection of natural resources.

SITUATIONAL ANALYSIS OF SEA TURTLE CONSERVATION EFFORTS IN GUATEMALA

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The Guatemalan National Sea Turtle Strategy (ENTM, its acronym in Spanish) was elaborated by the government's National Council of Protected Areas (CONAP) in 2002 in order to standardize and strengthen sea turtle conservation activities in the country. Much has changed since 2002. The Interamerican Sea Turtle Convention has come into force, and Guatemala became a signatory in 2003. Under this Convention, Guatemala must justify its exemption allowing the collection and consumption of sea turtle eggs. The touristic frontier has advanced, and hotels and travel agencies are increasingly sponsoring sea turtle conservation activities. Mining, oil exploration, industrial fisheries and infrastructure projects are increasingly threatening sea turtle populations and nesting habitat. With the support of the MAREA project (MAREA/Chemonics/USAID), CONAP, the Guatemalan government's FONACON fund, and the Marine Turtle Conservation Fund (MTCF/USF&WS), the Wildlife Rescue and Conservation Association (ARCAS)

and other conservation organizations in Guatemala undertook an analysis of the present state of sea turtle conservation efforts in the country. The objectives of this evaluation were to: 1. Analyze the effectiveness of sea turtle conservation actions in Guatemala within the framework of the ENTM and with particular attention paid to current mechanisms for the donation and sale of eggs. 2. Evaluate the effectiveness of the current management and conservation system in Guatemala, especially in terms of socio-economic and ecological sustainability in the short and long terms. The Situational Analysis was based on an interview survey to all of the sea turtle hatcheries on the Caribbean and Pacific coasts (20-30 hatcheries operating depending on the year), markets and border crossings, including interviews with important stakeholders such as hatchery managers, egg collectors, egg buyers, teachers, CONAP employees and enforcement officers. The results of this analysis were compiled into a report in February, 2011 and submitted to CONAP so that they may serve as an important input to updating the ENTM in order to help Guatemalan sea turtle conservationists meet the challenges of the future. In 2012 and 2013, ARCAS has continued its efforts to strengthen sea turtle conservation efforts in Guatemala by conducting crawl count surveys along the Pacific coast of Guatemala and revising the national sea turtle strategy, and will continue to work with CONAP and the IAC to determine the long-term sustainability of the current egg collection system.

BUILDING CAPACITY AND SUPPORTING THE EFFORTS OF GOVERNMENT AUTHORITIES IN THE SURVEILLANCE AND PROTECTION OF SEA TURTLES OF THE BASTIMENTOS ISLAND NATIONAL MARINE PARK, BOCAS DEL TORO, PANAMA

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Important feeding, breeding and interesting habitats and/or migratory routes for the green turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), and leatherback (*Dermochelys coriacea*) occur within the Bastimentos Island National Marine Park in the island archipelago of Bocas del Toro, Panama. Although the three beaches within the protected area receive consistent monitoring and protection, reducing the illegal take of nests and turtles, the accidental and intentional capture of juvenile and adult sea turtles in near-shore waters has been identified as a significant threat. The level of take at sea is further exacerbated by the fact that key authorities in the region suffer from a lack of resources and adequate training for field staff. The increased nesting in this marine protected area, a product of more than 20 years of continuous monitoring and protection efforts, along with community outreach and education programs, is being hindered by the impact of the harvest of turtles at sea and on beaches adjacent to the park. With the goal of safeguarding sea turtles in the region the Sea Turtle Conservancy (STC), in cooperation with the Wildlife Conservation Society (WCS), are working towards improving the capacity of local entities in charge of enforcing environmental legislation through training workshops for park staff and other wildlife authorities; training of indigenous community members as beach monitors; surveys of stakeholder groups to assess awareness about the park; and marking of marine boundaries of the park. Furthermore, the initiative focuses on increased protection to guarantee the effective application of legislation while building local support for government authorities and creating awareness about the importance of the region for sea turtles in general.

SEA TURTLE HATCHERY PRACTICES IN THE INDIAN OCEAN

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While in situ incubation of sea turtle nests is recognised as the most desirable scenario for most nesting beaches, natural and human threats, including poaching, predation, habitat loss and beach erosion can create conditions that require eggs to be transported to a hatchery for incubation. We have constructed a questionnaire to determine the egg collection area, egg collection and transportation methods, nest density, hatchling productivity, and housing, feeding and release regimes for hatchlings and captive turtles at hatcheries in the Indian Ocean. Our survey of hatchery practices will identify those that may negatively impact upon hatch success and hatchling survival, including more than a 2hr delay between oviposition and transport of eggs, incubating eggs in shallow nests, mounding sand on nests, shading hatcheries without monitoring nest temperature, and holding emerged hatchlings for extended periods before release to the sea. We suggest a greater understanding of events that occur during egg incubation, embryonic development and hatchling emergence is needed to ensure hatcheries make a positive contribution to sea turtle conservation.

COMMUNITY VOICE METHOD - A CONTEMPORARY APPROACH TO ENGAGING STAKEHOLDERS IN THE DEVELOPMENT OF MARINE TURTLE MANAGEMENT*

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The political ecology of endangered species conservation policy traditionally favours ‘experts’, who have more influence over international agreements and national legislation formulation, than the stakeholders dependent on the use of these species and their habitats. Consequently, the implementation of species conservation policies can lead to confusion, conflict, distrust and ultimately non-compliance amongst local stakeholder groups if they have not been included in the decision-making process. The Turks and Caicos Islands (TCI) Turtle Project is a collaborative, multidisciplinary initiative that has used biological and social research to inform the development of a contemporary management policy for the islands’ traditional marine turtle fishery. In 2010, the project employed the ‘Community Voice Method (CVM)’, a novel research methodology that seeks to overcome barriers to meaningful stakeholder engagement in resource management, decision-making and policy development. Thirty-three detailed interviews were conducted with community members representing a broad demographic in South Caicos, the ‘fishing capital’ of the TCI. All interviews were filmed and responses were analysed. A documentary film, with a narrative entirely led by this analysis, was the primary research output from these interviews. The film was then screened in formal and informal settings to public audiences throughout the TCI (n=22) and followed by semi-structured discussions that captured the views of over 270 participants’ on the development of a turtle fishery management plan. These discussions were recorded, analysed and combined with the results of the biological research to formulate specific management recommendations, which were subjected to further consultation with TCI turtle fishers (n=75) in 2011. The final recommendations were approved by the TCI government in 2013. CVM thus provided an engaging opportunity for hundreds of stakeholders to participate in shaping local turtle fishery policy development. In assessing the challenges

and benefits of the CVM approach this paper suggests the possibility of this adaptable methodology being applied in a variety of contexts.

**ADVANCES IN RESEARCH AND CONSERVATION STRATEGIES OF SEA TURTLES IN COLOMBIA:
A HOLISTIC REVIEW**

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Five of the seven species of sea turtle inhabit or navigate through Colombian waters in the Pacific and Caribbean Coasts: green turtle (*Chelonia mydas*), loggerhead (*Caretta caretta*), olive ridley (*Lepidochelys olivacea*), hawksbill (*Eretmochelys imbricata*) and leatherback (*Dermochelys coriacea*). Due to their current state of global vulnerability, all sea turtles found in Colombia are subject to conservation and protection, covered by several national laws and international conventions and agreements. In the country for the past 45 years, there have been several efforts for protection, conservation and research of sea turtles; however, the information collected during that time is scattered, anecdotal, with both limited diffusion and availability. The main goal of this study is to review the state of knowledge and conservation of sea turtles in Colombia. It takes a holistic approach to the process of sea turtle conservation in the country regarding research, strategic plans, and government's stance against international treaties that promote the preservation of these species. Maps are developed which locate areas where research and monitoring programs have occurred, specifying the type of study conducted. Also, there are presented the main conservation measures that have been established in Colombia since 1979, as well as an analysis of the main results of those strategies and the lessons learned from each one. Finally, it's analyze the Colombian government's position against international conservation policies, such as The Convention on Biological Diversity (CBD), Convention on International Trade in Endangered Species (CITES), Inter-American Commission for the Protection of Sea Turtles (CIT), The International Tropical Tuna Commission (CIAT) and the Permanent Commission of the South Pacific (CPPS). All information presented in this study is part of official reports, consultancy and scientific papers, aimed not only to organize disseminate information from Colombia, but also emphasize the gaps in information and steps to take to ensure the articulation of national conservation efforts in an international framework.

18 YEARS OF MANAGEMENT FOR THE GREEN TURTLE (*CHELONIA MYDAS*) AND LOGGERHEAD TURTLE (*CARETTA CARETTA*) ON SAN JUAN BEACH, BIOSPHERE RESERVE OF SIAN KA'AN, QUINTANA ROO, MEXICO

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The marine turtle conservation program in Riviera Maya, Tulum, is conducted in the central coast of Quintana Roo, Mexico, between Playa del Carmen and the Sian Ka'an Biosphere Reserve. Currently, 13 nesting beaches are protected, covering 36 km of coast. These beaches represent the most important sites for nesting populations of the loggerhead (*Caretta caretta*) and green turtle (*Chelonia mydas*), at national level. The breeding season for both species in this area is from April to November. The reserve is comprised of 528,000 hectares and approximately 120,000 are marine. This report summarizes the data obtained from 1996 to 2013 on San Juan beach, located within the reserve.

The beach is 5.5 km long and from the total nests recorded throughout the program, 5.09% of green turtle nests and 3.84% of loggerhead nests were situated in San Juan. The majority of the nests on the beach were left in situ, however, in 2013 a partnership between Global Vision International, Amigos de Sian Ka'an and Flora, Fauna y Cultura of Mexico was established. This partnership began conducting daily nocturnal patrols and the relocating of nests if necessary. In the survey, a total of 981 nests and 60,259 hatchlings were recorded for the loggerhead and 4,069 nests and 182,381 hatchlings for the green turtle. The highest number of loggerhead nests was recorded in 2013 with a total of 86 and the lowest in 2005 with only 20. In comparison, the highest number of green turtle nests was recorded in 2013 totaling 653, but only 7 nests were recorded in 1999. The year 1999 was atypical for the green turtle, showing the lowest levels of nesting, not only for San Juan Beach, but for the whole program. For the loggerhead the average curved carapace length of the gravid females was 97.2 cm (sd = 6.29, range 83 - 110), the average curved carapace width was 89.06 cm (sd = 5.45, range 78.4 - 100). For the green turtle the average curved carapace length of the gravid females was 104.7 cm (sd = 5.92, range 86.3 - 121), the average curved carapace width was 93.83 cm (sd = 5.19, range 81.3 - 110). Five categories were established for the nest status: predated, destroyed, flooded, unanalyzed, poached and protected. Predation and poaching were relatively low for both species throughout the 18 years of the survey and did not exceed 5% for the majority of the years. In general, the protected category had the highest percentage of nests on San Juan. In 2006 the total percentage of protected loggerhead nests reached 94.12%. In contrast, 65% and 77.78% of the nests were flooded in 2005 and 2007 respectively. For the green turtle, the year with highest percentage of protected nests was 1997 with 96.88%, whilst 70.89% of nests were flooded in 2004. In conclusion, different physical characteristics of the study area, such as geographic and climatic factors which coincide with the turtle breeding season, should be taken into account. These characteristics will be described in greater detail in the final presentation.

RED INTEGRAL DE TORTUGAS MARINAS (RITMA) / INTEGRATED NETWORK FOR MARINE TURTLES: FROM COSTA RICA TO THE EASTERN PACIFIC

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Four species of sea turtles nest along the Costa Rican Pacific coast: the olive ridley, Eastern Pacific green, leatherback and hawksbill turtle. Recent studies confirm the presence of resident hawksbill turtles foraging in coastal habitats of the Northern Pacific and several sightings suggest the presence of many more potential feeding areas for this critically endangered species. New and apparently highly important nesting beaches for Eastern Pacific green and hawksbill turtles are being discovered. Satellite tracks as well as mark-recapture data obtained from nesting hawksbill and green turtles prove constant movements between Nicaragua and Costa Rica. Considering this scattered information, there is a necessity to complete the puzzle of these turtles' population dynamics, their ecological importance, natal origins and most accurate conservation strategies. RITMA was born in August 2013, within the framework of the project "Support to Thematic Investigation Networks at the University of Costa Rica" that aims to unite academic institutions with NGOs and other scientific organizations. In this sense, RITMA proposes to provide a platform of exchange between Costa Rica and other regional countries for the integrated investigation of sea turtles in the Eastern Tropical Pacific (ETP), concentrating the combination of methods to study the connection of habitats used by different species throughout their life cycles. To start with, this network promotes the investigation of the hawksbill (*Eretmochelys*

imbricata) and Eastern Pacific green turtle (*Chelonia mydas*), two particularly threatened species in the region, whose knowledge in terms of diet/nutrition, habitat distribution and genetic characterization of their populations is very limited. RITMA thus focuses on four main principles: 1) Diet, 2) nesting beaches, 3) genetic characterization and 4) promotion/dissemination of scientific knowledge. Due to the diverse objectives that this regional network aims to target, different groups converge in RITMA, including public academic research centers (Research Centre in Marine Sciences and Limnology - CIMAR and Research Centre of Cell and Molecular Biology - CIBCM) and students of the University of Costa Rica, as well as independent researchers and non-governmental organizations (Sea Turtle Restoration Program - PRETOMA, Institute of Tropical Field Studies (ITFS), Paso Pacífico - Nicaragua). The successful interaction between these groups seeks to increase academic productivity through a greater linkage between the academic and the public and private sectors, both within and outside of Costa Rica. Through RITMA we expect 1) to run a platform to share and organize scientific information, 2) provide scientific knowledge to policy makers, 3) to identify informational gaps and research priorities for sea turtles in Costa Rica and the ETP, 4) to contribute to the understanding of population dynamics in the ETP and 5) to promote conservation strategies not only domestically but internationally, based on population and biological corridor concepts. RITMA is an effort created in Costa Rica, but aims to spread throughout the entire Eastern Pacific to promote the holistic investigation and management of sea turtle populations.

ADVANCES IN THE VOLUNTEERING MONITORING PROGRAM OF SEA TURTLES IN AZUERO PENINSULA IN THE PACIFIC COAST OF PANAMA

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During the 2009 to 2010 sea turtle conservation projects were initiated with support from Conservation International (CI) and participation of Autoridad de Los Recursos Acuáticos de Panamá (Aquatic Resources Authority of Panama in english), The International Maritime University of Panama (IMUP) and the Smithsonian Tropical Research Institute (STRI). In early 2011-2013 the non-governmental organization Agua y Tierra (FUNDAT) (Water and Earth Foundation in english) created two programs: the Conservation of Marine Turtles of the Azuero Peninsula and the Volunteer Program, with the aim of supporting research, protection and conservation of sea turtles, incorporating volunteer work and community involvement, to help with reducing the threats to these species and their nesting habitats in the Panamanian Pacific. This follows up on previous actions of organizing and strengthening volunteer participation in raising awareness in conservation and sustainable management of these charismatic species and to provide professional knowledge to new scientific research, conservation and protection of endangered species, such as sea turtles, in communities. Currently volunteers have participated in conservation projects in Cambutal and Mata Oscura. 40 volunteers have participated, including students, professionals and community members, who have supported nesting beach monitoring, hatchery construction and environmental education and outreach. It seeks support from companies such as sponsors to strengthen this program.

ROLE OF THE LOCAL COMMUNITY IN MARINE TURTLE CONSERVATION

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The proximity of México to the United States and Canada makes it an exceptional tourist destination. Many tourists flock here for the beautiful coastline, which have provoked expansion and creation of new tourist destinations. As well, many foreigners have chosen to relocate or construct second homes in these same tourist centers. This increased demand creates an unregulated rush of coastal development projects and beach activities, such as ATV beach tours which threaten marine turtle nesting beaches and coastal biodiversity. In the southern Pacific region of the Baja California Peninsula *Lepidochelys olivacea* is the primary nester in the region, followed by *Chelonia mydas (agassizii)* and *Dermodochelys coriacea*. As climate change provokes changes in nesting behavior further north, this region will be vital for conservation, especially for *D. coriacea*. Despite international and federal laws protecting marine turtles, nesting conservation efforts are clashing with the increase of coastal tourism development, creating a loss of coastal habitat. These anthropological threats, combined with natural threats from inundation and beach erosion from tropical storms, pose grave challenges to in-situ monitoring. Thus, relocation to a protective corral is necessary and has proven successful in terms of the increase of nests protected annually by ASUPMATOMA (The Association for the Protection of Marine Turtles and the Environment). However, as with any wildlife conservation project, the goal is always to employ in-situ practices. As a way to increase in-situ monitoring, ProFaunaBaja a local research group in coordination with ASUPMATOMA, began a pilot research project in 2012 to digitally mark nests with GPS units before relocation to a protective hatchery. In 2013, the project was successfully implemented as full project thanks to funding from Rufford Small Grants Conservation Fund in 2013. The objective is to identify areas that can be targeted to increase in-situ nest monitoring practices at within the ASUPMATOMA nest monitoring area for 2014. There are ways to implement marine turtle conservation through the coordination of local residents, students, and tourists. By combining research efforts with environmental education and awareness, the local community can be an integral conservation tool for not only marine turtle populations, but also maintaining coastal biodiversity and coastal stability. Local tourism companies can be participants in marine turtle conservation by promoting economic opportunities for conservation tourism. For example, in 2013, Todos Santos Eco Adventures started bringing tourism and student volunteer groups to camp to patrol overnight with local biologists. This poster (1) reviews the efficacy of conservation tourism efforts at ASUPMATOMA camps (2) presents results of environmental education with local students from primary to university, and (3) identifies future in-situ monitoring coordination with local community participants through ProFaunaBaja.

DARKER BEACHES, BRIGHTER FUTURES: REDUCING LIGHT POLLUTION ON SEA TURTLE NESTING BEACHES AROUND THE GLOBE

Karen Shudes

Sea Turtle Conservancy

Each year in Florida tens of thousands of sea turtle hatchlings are disoriented by poorly managed beachfront lights. To address this problem, Sea Turtle Conservancy (STC) applied for and received grant funding to implement a program that increased sea turtle hatchling survivorship on Florida's high-density nesting beaches by correcting problematic lights on private properties with histories of causing sea turtle disorientations. The latest technologies in "sea turtle friendly" lighting were used to effectively reduce and manage exterior lighting at over 75 multi-family properties and businesses, which effectively darkened over 10 miles of prime sea turtle nesting habitat. Monitoring of nesting at project sites following lighting retrofits showed significant decreases in sea turtle disorientations, resulting

in the safe emergence of thousands of hatchlings each year that otherwise would have been disoriented by lights. STC staff, skilled in sea turtle lighting criteria, will focus in on the details of designing cost-effective lighting plans for coastal properties. Emphasis will be placed on how this project could be replicated in other coastal communities where poorly managed artificial lighting degrades nesting habitat. The most common lighting problems seen on nesting beaches around the globe and possible “sea turtle friendly” alternatives will be explained. The latest technologies in “sea turtle friendly” lighting and the financial benefits associated with using energy-efficient LEDs will be discussed in detail. By following simple turtle-friendly lighting concepts to eliminate light pollution, coastal communities around the world can effectively reduce disorientations and save thousands of newborn sea turtles each year.

PROTORMAR-UAS: 37 YEARS OF RESEARCH AND CONSERVATION OF SEA TURTLES

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Human activities related with marine turtles in nesting beaches cause mortalities, in all stages of their development (nesting females, eggs, hatchlings). They are vulnerable to diverse potentially lethal interactions, these include direct predation and modification of the habitat. Due to this the objective of this presentation is to provide a retrospective of data and experiences obtained over 37 years for the olive ridley turtle (*Lepidochelys olivacea*) population in Playa Ceuta Sinaloa Mexico. The PROTORMAR-UAS (Programa de Tortugas Marinas of Universidad Autónoma de Sinaloa), began in 1976 and scientists as well students have collected nesting data on female olive ridley turtles and occasionally other species. Female turtles lay their eggs along 37 km beach at Sanctuary Playa Ceuta. The Project has accumulated continuous annual data on nest size, nesting frequency, as well as focusing on environmental education. Monitoring data is helping piece together the life history patterns of the olive ridley turtle population and informing policy decisions in Sinaloa and regionally to protect sea turtle populations from poaching, incidental catch in fishing nets and egg collection by coastal communities. The Project has also engaged local fishing communities to transition from poaching turtles and eggs to embracing alternative livelihoods and in the year 2006 a turtle museum was built.

AN INVITATION TO GOVERNOR BOBBY JINDAL TO REVERSE LOUISIANA'S ANTI-TED LAW

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Louisiana law currently prohibits its state Department of Wildlife and Fisheries game wardens from enforcing federal Turtle Excluder Device (TED) regulations established for the conservation of endangered sea turtles. The 1987 Louisiana Fisheries Code claimed that TED regulations were “unjustified, inequitable, and unworkable” and will not be enforced by the state because “there is little information to conclude that shrimping is a significant causal factor in sea turtle mortality.” The statute was intended to remain in place only until “TEDs have been thoroughly and scientifically tested.” After 30 years of research and testing in shrimp fisheries, TEDs have been proven to be 97 percent effective without reducing shrimp catch. Shrimp fleets in all other coastal states use them and benefit from Joint Enforcement Agreements to enforce TEDs laws. This poster will provide a timeline of actions taken by scientists, conservationists, politicians, regulators, and sea turtle advocates to convince Louisiana to update its TEDs laws. It

will also review Louisiana's actions to undermine or prevent TEDs enforcement in its shrimp fleet. The timeline includes Governor Bobby Jindal's veto of state legislation to reverse the 1987 anti-TEDs law that led to the recent red listing of Louisiana shrimp by the highly regarded Seafood Watch as non-sustainable and to be avoided. Thousands of sea turtle biologists, conservationists, regulators, and other members of the international sea turtle community are meeting April 10 to 17, 2013 in New Orleans for the 34th Annual Symposium on Sea Turtle Biology and Conservation. Now is the time for Governor Jindal and the state of Louisiana revisit and revise the antiquated anti-TEDs regulation to align Louisiana with modern fishing and environmental practices. We invite Governor Jindal to join us and learn why his action is critical to the long-term survival of sea turtles and the Louisiana shrimp fishery.

THREATS TO CONSERVATION EFFORTS IN KYPARISSIA BAY, GREECE - ONE OF THE LAST PRISTINE NESTING BEACHES FOR LOGGERHEAD SEA TURTLES IN THE MEDITERRANEAN

Theresa M. Stewart, Panagiota Theodorou, and Dimitrios Dimopoulos

ARCHELON, the Sea Turtle Protection Society of Greece, Solomou 57, GR-10432 Athens, Greece

Sea turtle conservation has been undertaken by ARCHELON in Kyparissia Bay, western Peloponnese, Greece, since 1983. Nest numbers on this, the second most important loggerhead nesting beach in the Mediterranean, have been increasing within the 9.5km core area, since 2006. In 2013 conservation efforts were met with mounting opposition by local stakeholders and residents. This shift in local opinion was due to the fact that ARCHELON challenged recent plans for construction of up to fifty private houses over 2.7km of sand dunes located directly behind the nesting beach from Elaia to Agiannakis. The risk of permanently damaging sand dune systems and the nesting beach was communicated to the European Union by NGOs. The EU has requested the Greek government implement appropriate measures to safeguard this unique loggerhead rookery. In response to this, the government has issued a suspension of building permits in the Natura 2000 site, which includes a zone behind the beach, from Elaia to Kalo Nero, approximately 7km), as well as a Ministerial Decision for beach management measures. This decision which included the cessation of the operation of three beach bars on the nesting beach and a call for cooperation with ARCHELON for the management of beach furniture on the nesting beach, triggered reaction from both the land developer and local groups with vested interests in the area. As a result, ARCHELON volunteers from the 2013 Kyparissia Bay project experienced negative pressures, from the land development company employees, certain local hotel and bar owners, and the Mayor of Trifylia under whose jurisdiction the entire nesting area falls. ARCHELON was prohibited from presenting talks in hotels within the core area and the permit to assemble an information kiosk in the village of Kalo Nero was not renewed by the Mayor. Employees of the land developer requested to observe ARCHELON's morning monitoring surveys, to confirm or deny rumours that ARCHELON is falsely reporting increased nest numbers to justify the introduction of strict protection measures. Authorisation was granted by ARCHELON, subject to strict guidelines. The observers signed an agreement to respect the volunteers and to allow them to work undisturbed; however, this was not always adhered to. Volunteers were followed daily, from 25th May until 30th September. The observers were frequently intimidating and occasionally aggressive. Volunteers also experienced direct aggression from certain hotel and bar owners when nests were identified in front of their establishments. The owners were observed removing nest protection during installation. ARCHELON volunteers observed people erasing sea turtle tracks at night, using lights to scare female turtles from the beach and taking flash photos of volunteers working with nesting turtles. In addition, an increase in nest vandalism was also identified. Intimidation tactics and vandalism of nest protection continued until the end of the project in 2013, including damages to an ARCHELON vehicle and equipment. It is unknown how this situation will continue in 2014, as ARCHELON is lobbying the EU and the Greek government for a Marine Protected Area, similar to the National Marine Park of Zakynthos.

DECONSTRUCTING MARINE TURTLE CONSERVATION: A GLOBAL PERSPECTIVE ON THE FUNDAMENTALS OF A SUCCESSFUL PROGRAM*

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Conservation projects worldwide face many challenges in establishing sustainable programs. Diminishing sources of funding, lack of community support and education, poverty, inadequate law enforcement, corruption, and structural instability are some of the elements that impede conservation efforts. In this presentation, we draw from our combined experiences of sea turtle projects around the world and from our collaborations with diverse groups, cultures and governments to share insights about what is needed to achieve long-term stability and success in the face of challenges en route. While substantial funding is essential to maximize conservation efforts, this is more challenging to sustain. Smaller or more modest levels of financial support can be more effective than a boom and bust approach that breaks continuity in the project's long-term plans and disrupts trust-building with local communities. Funding alone however, regardless of amount, is not sufficient to ensure a successful project. Despite many years of funding and conservation presence, some projects have not achieved success or stability because of weaknesses in the infrastructure, philosophical approaches, and inter or intra organizational conflict. Furthermore, in many communities adjacent to nesting beaches, conservation is sometimes misinterpreted and perceived as a luxury benefitting the self-interests of outsiders who seem to put turtles above local community needs and interests. Therefore, concrete benefits that communities can attribute to the project's presence, education and outreach that develop greater appreciation for the intrinsic and extrinsic value of resources, and strong local and national governance and ownership supported by an adaptive management strategy are just some of the many essential factors for successful conservation. Ultimately, for a project to be successful, stable and self-sustaining, it must be financially, structurally, philosophically, and socially healthy. These multi-faceted aspects are discussed in the context of the projects with which we are directly involved.

EXPANDING SEA TURTLE CONSERVATION IN SOUTHWESTERN NICARAGUA

Kim Williams-Guillen, Liza Gonzalez, and Salvador Sanchez

Paso Pacífico, Managua, Nicaragua

Since 2008, Paso Pacífico has led a program protecting sea turtle nesting beaches along southern Nicaragua's Pacific coast, primarily in the buffer zone of La Flor Wildlife Refuge. In late 2011 Paso Pacífico carried out an assessment of minor nesting beaches across southwestern Nicaragua to identify additional beaches of importance for the more threatened sea turtle species. Since that time, Paso Pacífico has begun partnerships with hotel owners at two of these priority beaches in order to improve protection and gather descriptive data regarding sea turtle populations nesting on these beaches. The two key beaches have been Playa Hermosa in San Juan del Sur municipality and Playa Escondida in the Tola municipality. In addition to these two new beaches, Paso Pacífico has increased its protective efforts to ensure 24-hour monitoring year round by employing additional rangers. The results have been a strengthening of our ability to collect genetic material, affix satellite transmitters, and tag turtles for the benefit scientific research in the region. Paso Pacífico has joined forces with the Red para el Estudio Integral de las Tortugas Marinas del Pacífico Este Tropical (RITMO) through the University of Costa Rica. Through these efforts we have been able to protect nests for these four species: *Chelonia mydas*, *Eretmochelys imbricata*, *Dermochelys coriacea*, and *Lepidochelys olivacea*. Here we present our multi-year nesting data from our principle nesting beaches, a priority site for green turtles, and we summarize our results from beaches protected in partnership with hotels. The results highlight the value of public/private partnerships and the need to expand sea turtle protection across these relatively underdeveloped beaches throughout Nicaragua where sea turtles may still find quality nesting habitat.

Education, Outreach and Advocacy

IMPLEMENTATION OF FESTIVALS AS A SOCIAL PARTICIPATION STRATEGY FOR THE CONSERVATION OF SEA TURTLES

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This work shows the implementation of an environmental education strategy for strengthening the educational process, as well as cultural and social practices which are harmonious with endangered species and their environment. It is directed to children, youth, mothers, fathers, teachers and fishermen of fishing communities in the Municipality of Guasave, Sinaloa, México. We employed a methodology primarily focused in awareness and community involvement. Emphasis was placed on the practice of dynamic and interactive activities such as talks, museum, handicrafts exhibition, food fairs, bulletin board contests, drawing, creative writing and a candidate for queen of the festival. These activities promote the active participation of the people and make possible the developing of a responsible culture of marine turtle conservation. The strategy also strengthened the principles and values in terms of improving the human-nature relationships to achieve sustainable development and conserve species as charismatic and endangered as sea turtles. Three festivals were held for the conservation of sea turtles, one per year in 2010, 2011 and 2012, with a participation of 800, 1,000 and 1,500 people respectively, as well as 7, 8 and 11 fishing communities, including neighboring municipalities. The results demonstrate the great interest that has been awakened in the society at this subject and how festivals strategy offers the possibility of opening a direct communication channel to sensitize society about the conservation of sea turtles.

ESTABLISHING REGIONAL MULTI-SECTOR PARTNERSHIPS TO FACILITATE MARINE TURTLE CONSERVATION RESEARCH AND AWARENESS IN THE ARABIAN/PERSIAN GULF*

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In 2010, Emirates Wildlife Society in association with WWF (EWS-WWF) launched the Marine Turtle Conservation Project, in collaboration with the Marine Research Foundation, aiming to identify important foraging habitats for hawksbills in the region. With the use of satellite telemetry technology, 75 hawksbill turtles nesting in four countries (UAE, Qatar, Oman and Iran) were monitored remotely. The output of this research is expected to provide critical information for policy making and spatial planning identifying important areas for turtles in need of protection. One of the main priorities for this project was to promote collaboration and data sharing among key stakeholders, as well as the scientific community working with turtles in the region, as well as filling regional data gaps. To achieve this, EWS-WWF established partnerships with a number of government organisations, NGOs and scientists. These regional and cross-sector partnerships were managed and, to the fullest extent possible, strengthened, throughout the duration of the project owing to continuous collaborative fieldwork efforts, open communication, as well as regular information sharing throughout the duration of the research. A regional workshop involving current project partners, to be held in early 2014, is expected to provide a platform for current project partners and key stakeholders to review, validate and endorse research findings on important areas for hawksbill turtles, assess different conservation strategies, and suggest key recommendations. In addition, EWS-WWF established partnerships with the private sector using a unique fundraising model that offered a number of organisations the opportunity to contribute financially to the project by sponsoring one or multiple turtles for a year, or throughout the duration of the project. The financial contribution from each sponsored turtle covered expenses equivalent to the cost of the transmitters, satellite telemetry fees, fieldwork equipment, fieldwork logistics, as well as public communication related costs. This allowed for EWS-WWF to secure considerable funds from multiple donors for the large scale effort involving fieldwork in four countries over three consecutive years. With such financial backing, EWS-WWF seized the opportunity to combine scientific research with environmental awareness around marine turtle conservation, resulting in a successful public campaign, leading to increased interest not only from the project partners but also the wider community in the UAE and the region. Overall the project had a remarkable outreach impact with a dedicated website, thousands of followers on social media, numerous articles in local newspapers, over 25 project sponsors (and their hundreds of thousands-strong employee base), presentations and guest lectures and partner linkages with over 9 government, academic and NGO institutions throughout the region. Please note that additional input from co-authors and project partners will also be included in the presentation.

SPREADING ROOTS OF SEA TURTLE CONSERVATION ON THE OSA PENINSULA, COSTA RICA

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The Committee for the Conservation of the Sea Turtles of Corcovado (COTORCO) is an Osa Peninsula-based group of people with a shared interest in the protection of endangered sea turtles in Costa Rica. Our mission is to find the necessary resources to protect sea turtles on the Osa Peninsula while raising awareness, educating, and encouraging the participation of communities and institutions in the process. Our geographic focus of sea turtle conservation is on, but not limited to, Carate and Rio Oro beaches. This 8km stretch of pristine beach provides a richly biodiverse area as a vital nesting habitat for four species of sea turtle: olive ridley (*Lepidochelys olivacea*), Pacific green or black (*Chelonia mydas agassizii*), leatherback (*Dermochelys coriacea*), and hawksbill (*Eretmochelys imbricata*). COTORCO was formed in 2011 due to the findings of a study that showed Carate and Rio Oro beaches to be the most problematic in terms of human poaching on the Osa Peninsula. We combine grassroots education, organization, hands-on conservation, and research with an aim to reduce threats to turtles along our coastal beaches before they disappear altogether. Our project has four parts: biological monitoring, nest protection, community stakeholder meetings, and training workshops. Locally, we hold a community focus to enable the education of children and adults, to keep awareness raised, and to increase opportunities for locals. We hold open meetings that allow community members to assist in making decisions about the future of the project. Community members are hired as hatchery and patrol managers, giving them three months of work during a time of year when other work opportunities are limited.

Proceedings of the 34th Annual Symposium on Sea Turtle Biology and Conservation

Regionally, we work in collaboration with other conservation organizations, including Osa Conservation. Federal governmental support is received from MINAE-SINAC-ACOSA, police, and coast guards through seasonal personnel assistance for beach patrols and enforcement of Costa Rica's anti-poaching laws. International partnerships with the Georgia Sea Turtle Center, Frontier, and Planet Conservation provide various types of support, including data collection, community education, and scientific expertise. In the future we plan to keep our project growing in terms of community participation and awareness, while also increasing the hatch success of sea turtles on the Osa Peninsula. Additional community education and involvement opportunities will be provided through activities at the school, workshops, training, and volunteer and job positions. We are in the process of making a plan for governmental agencies to have a permanent presence on Carate and Rio Oro beaches. Along with the growth of our project, we will continue to conduct professional scientific research with community involvement to maintain and increase sea turtle conservation efforts. ***K. Mascovich and E. Mitchell contributed equally to this work

RESPONSIBLE PIER INITIATIVE

Tommy Cutt and Tom Longo

Loggerhead Marineline Center, Juno Beach, FL USA

The Responsible Pier Initiative is a first of its kind program in Florida and is designed as a collaborative tool to work directly with fishermen and fishing piers to promote a healthy pier environment for sea turtles and other marine life. The purpose of these efforts is to provide first-responders on fishing piers with the necessary resources to respond effectively to traumatic sea turtle injuries and strandings. The Responsible Pier Initiative is comprised of the following three components: 1. Workshops for sea turtle stranding first-responders which provide action steps to follow in the event a sea turtle is accidentally hooked, becomes entangled, or strands on or around a fishing pier. 2. Educational signage is installed on fishing piers and provide information for fishermen and pier goers regarding the appropriate steps to follow in the event a sea turtle is accidentally hooked, becomes entangled, or strands on or around a fishing pier. 3. Underwater cleaning beneath fishing piers and surrounding areas on a regular basis to remove potential threats to sea turtles, such as debris and monofilament line. We've found that often times fishermen fear prosecution when they accidentally hook a sea turtle. The Responsible Pier Initiative is an opportunity for us to open the lines of communication with the local/state-wide fishing community and work together to establish responsible pier environments. This initiative is a true compliment to LMC's mission of promoting conservation of Florida's coastal ecosystems with a special focus on threatened and endangered sea turtles. The program was launched as a pilot program at the Juno Beach Fishing Pier in 2012 and we are already seeing positive results. Since the program inception, over 1,300 lbs. of debris has been removed from beneath the Juno Beach Fishing Pier and sea turtles are being rescued based on our established protocol. In addition to the Juno Beach Fishing Pier, the Responsible Pier Initiative is currently underway at the Lake Worth Fishing Pier and the Dania Beach Fishing Pier. Additionally, there are currently 10 other piers across the state of Florida who have already committed to participating in the program. The program has been endorsed by the following organizations: • Florida Fish and Wildlife Conservation Commission • Palm Beach County Parks and Recreation • Palm Beach County Environmental Resource Management • City of Lake Worth • City of Dania Beach • SCUBAPRO • Jupiter Dive Center • Loggerhead Marina • Marine Industries Association of Palm Beach County, Inc. • West Palm Beach Fishing Club • Southeast Florida Coral Reef Initiative • Loggerhead Marina Loggerhead Marineline Center (LMC), a non-profit organization, is committed to the conservation of Florida's coastal ecosystems through public education, research and rehabilitation with a focus on threatened and endangered sea turtles. The center features an on-site veterinary hospital, learning exhibits and aquariums. Situated on one of the world's most important sea turtle nesting beaches, LMC is open daily and hosts over 220,000 visitors each year.

SEA TURTLES OF THE AMAZON: FIRST STEPS TOWARDS A CONSERVATION NETWORK

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Located in the Brazilian Amazon, Para State presents a unique environment, recognized for high biodiversity. The Northern region represents 20% of Brazilian marine and estuarine fisheries and 93% of these are classified as artisanal. Fisheries-dependent communities are impacted by any reduction of fish stocks, stemming from advances in fishing technology driven by competition, a lack of effective management and a host of anthropogenic impacts, leading to a decrease in the economic power of coastal fishing communities. Aside from direct overexploitation, bycatch presents a considerable environmental and economic consequence of large and small-scale fisheries, and the primary cause of the decline of several marine megafaunal species, including endangered sea turtles. Several reports have shown that nesting females are highly impacted by interactions with fisheries as they approach shore. Sea turtle assessments have been conducted in Brazil for the past three decades, however sea turtle status in Para remains unknown. Reports by local fishermen and two studies have confirmed occurrence of five sea turtle species (*Caretta caretta*, *Lepidochelys olivacea*, *Chelonia mydas*, *Dermochelys coriacea* and *Eretmochelys imbricata*). In order to collect and share information about sea turtles and fill data gaps in Northern Brazil, the first sea turtle observation network of Para State was established in 2013. The network provides links among governmental agencies, research institutes, researchers, fishermen and other stakeholders. Social media was an important starting point, with the main goal to provide awareness about sea turtles in the region and to create a network allowing people to post pictures and information about sea turtle encounters. Folders and identification keys were produced and distributed among local fisheries communities. As results, in the period from March to August, we received seven calls reporting sea turtle nesting activity at three different locations (Protected Area Algodual/Maiandeuá, Protected Area Marajó and Extractivist Reserve of Soure), and 20 calls of stranding turtles (in APA Algodual/Maiandeuá, where four turtles were poached, one was caught dead, and the remaining were released). Data was also recovered that was not immediately reported. For the future, the Sea turtles of the Amazon Project (PROTAMAM) will focus on anthropogenic threats such as direct capture, bycatch, and poaching on the major nesting beaches in Marajo Island; monitoring of the nesting beaches; training of local individuals to be part of a community based conservation project; and implementation of environmental education actions within the communities of the area. These objectives will be reached through participatory strategies and formal research.

EFFECT OF SEA TURTLE REHABILITATION CENTERS IN QUEENSLAND, AUSTRALIA, ON PEOPLE'S PERCEPTIONS OF CONSERVATION

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Sea turtles are found worldwide, with all 7 species considered species of conservation concern. The public has seen sea turtle rehabilitation centers as an important tool for conserving sea turtle populations. However, educating the public regarding threats to sea turtles and how they can minimize these threats by making a change in their own lives may be more beneficial than rehabilitation alone, in terms of the ability to restore turtle numbers. In order to determine the educational role of rehabilitation centers, 245 surveys were distributed at several Australian-based rehabilitation centers. The survey was in 2 parts. The first part collected information about visitor's knowledge of threats, their willingness to pay for conservation, and socioeconomic information. The second part determined what threats visitors had learned about, whether visitors would make a change to help support sea turtle conservation, and whether they would be willing to pay more for conservation following their visit. Overall, results showed that all visitors to the sea turtle rehabilitation centers were willing to make a change in their lives to help protect sea turtles. Additionally, the

majority of visitors were willing to donate annually to sea turtle conservation. The extra revenue raised could be used for conservation purposes and further research to address the threats sea turtles face. Combining the opportunity for visitors to observe sea turtles up close and learn about threats and how they can be minimized at rehabilitation centers will assist in increasing population sizes and protecting them into the future.

CHANGE IN CHACOCENTE: A SMALL WISCONSIN SISTER CITY ORGANIZATION PROMOTES SEA TURTLE CONSERVATION

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Loss of biodiversity may be linked to poverty and the struggle of local communities to satisfy their needs through an unsuitable use of their natural capital. This has been the case for the sea turtles and the tropical dry forest in one of the most important protected areas in Nicaragua, the Rio Escalante-Chacocente Wildlife Refuge, in the Santa Teresa municipality. The Richland Center-Santa Teresa Sister City Project (SCP) began in 1987 as a friendship gesture towards Nicaragua during the Contra War. In 1997, Santa Teresa mayor José Martínez requested urgent help for Chacocente--its sea turtles and the municipality's five poorest communities, all within the reserve. As part of a government program, families received a quota of turtle eggs to sell. This program was neither improving the lives of local villagers nor reducing widespread poaching and trafficking of sea turtles' eggs. From 1999 to 2002 a Wisconsin volunteer organized the Chacocente communities and began our ongoing programs to ameliorate village poverty and improve sea turtle conservation. Since then, SCP has provided sustained support to Chacocente's communities with a \$20-30,000 annual budget. Our efforts include: 1. Sea turtle conservation support: • bringing Mayor Martínez to the 1999 ISTS to stop highway construction along the arribada beach • funding a patrol boat • turtle-egg trafficking exposé • 2002 leatherback hatchery, later along with Fauna and Flora International • sea turtle coloring book for Chacocente schoolchildren • initiating a successful campaign to change Nicaraguan laws to ban egg-taking (2005) • funding for Chacocente guards' equipment • environmental education workshops in Chacocente schools, turtle beach field-trip • arribada beach clean-ups 2. Food security initiatives • ecological agriculture training program • help purchasing implements and grain storage silos • forest and fruit tree reforestation • initiating successful beekeeping 3. Health • funding 65 wells, 90 rope pumps, 130 latrines, and 190 clay household drinking water filters • construction of 3 small clinics • training community health promoters • providing basic medicines 4. Education • building two schools • school supplies for five primary schools • school gardens and lunch programs • secondary scholarship program Difficulties faced: • running programs from a distance -- finding a committed and honest Nicaraguan coordinator • overcoming destructive survival customs based on poverty and isolation • Increasing family cash income possibilities Our current coordinator, in charge of all the projects, is Alma Susana Chávez, a Santa Teresa biologist. Our 15-year continuous presence has created a trusting relationship with Chacocente's villagers. At community meetings people comment that SCP is the one organization they can count on to keep promises and to give them the support to better their lives. Our work has helped decrease the pressure of Chacocente's human residents on its natural resources. Olive ridley nest numbers have increased, from a low of 27,000 in 2003, to 71,770 nests in 2012-13. Our experience shows how an initiative committed to long-term engagement, taking into account the human dimension of conservation problems, can be a key to achieving biodiversity conservation goals.

RALLY PARLAMA AND OTHER ENVIRONMENTAL EDUCATION MECHANISMS TO CREATE SUPPORT FOR SEA TURTLE CONSERVATION EFFORTS ON THE PACIFIC COAST OF GUATEMALA

Lucia Garcia and Colum Muccio

ARCAS

ARCAS is a Guatemalan nonprofit NGO founded in 1989 committed to preserving wildlife and its habitat. In a country with such high levels of poverty and inequality, environmental education is crucial in attacking the root causes of wildlife trafficking and other environmental threats, and ARCAS typically dedicates half of its annual budget to carrying out educational activities ranging from presentations in local schools to educational reforestations to environmental festivals. At its sea turtle and mangrove conservation program in the Hawaii area of the Pacific coast of Guatemala, it operates two of the most productive hatcheries of the country, rescuing and incubating 40,000 – 50,000 endangered olive ridley and leatherback sea turtle eggs per year. One of the most important aspects of the Hawaii program is environmental education, and ARCAS staff and volunteers carry out activities such as beach clean ups, festivals and hatchling releases. One of the most effective and popular educational activities carried out in Hawaii is Rally Parlama, whereby local children are encouraged to donate sea turtle eggs to a hatchery, and those that donate the most eggs are rewarded with a trip to a popular touristic destination. (Parlama is the local name for the olive ridley sea turtle) Rally Parlama trips have included visits to a theme park, the national zoo, and the Mayan ruins of Tikal. The majority of the residents of the Hawaii area live below the poverty line, and visits to such popular sites would normally be out of the question for them. The Rally has been very successful in changing local peoples' attitudes towards the sea turtle, working through the children to reach their parents, the majority of whom are egg collectors. Visits to such stunning sites by such marginalized people creates a lasting impression and deep support for ARCAS's conservation efforts. To broaden support for its conservation activities in the area, ARCAS will be working with the 6 communities within the proposed Hawaii Protected Area (a 4,000-hectare natural reserve pending formal declaration by the Guatemalan government), to develop a sea turtle environmental education route. The route will be created by local children and will have the objective of creating support for ARCAS's conservation activities in the area while attracting ecotourists.

COMMUNITY AND SCIENCE: AN INTEGRATION IN PROGRESS DURING THE *DERMOCHELYS CORIACEA*'S 2013 NESTING SEASON AT THE METROPOLITAN NORTH COAST OF PUERTO RICO

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The 2013 leatherback turtle nesting season finished with a total of 17 nests in an area that covers Ocean Park, Condado and Isla Verde beaches. These are distinguished by their proximity to the urban area, and for being a vulnerable nesting site of *Dermochelys coriacea* on the island. The high incidence of visitors represented an opportunity to educate about light pollution, solid waste and the importance of the conservation of marine life. The first nesting female came on March 15 and the last one came on July 25th. The first hatchling was reported on May 18th and the last one on July the 27th. The mother's carapace was measured, tagged and identified morphologically. As the females departed, their nests were marked using Global Positioning System and protected with a fence to minimize the impacts on the site, such as dogs and humans. A total of 16 nests hatched and 15 were assisted to reach the ocean. One nest was relocated during the tropical storm, Chantal. Educational outreach activities were fulfilled thanks to the integration and action

of members of the community, visitors, students, government agencies and non-governmental organizations. The main focus was on cigarette butt and solid waste possible impacts on this ecosystem. Since these beaches lack management, law enforcement and *Dermochelys coriacea* is in the brink of extinction, visitors and community members acted as active protectors of the turtle even though some visitors obstructed the nesting and hatching processes. Education and further investigation is needed to prevent impacts of human activities to the species.

INTEGRATING EDUCATION & SEA TURTLE CONSERVATION

Katie Higgins

Georgia Sea Turtle Center, Jekyll Island, GA 31527

Education is an integral part of the Georgia Sea Turtle's (GSTC) overall objectives, comprising one of three supporting pillars of our mission: rehabilitation, research and education. From our public viewing window into the Rehabilitation hospital treatment room to our guided tours of the nesting beach with first-hand contact with our Research team, each of the essential tasks performed at the GSTC includes an educational component. Evaluation of the effectiveness of these myriad of programs is integral to understanding our mission's impact on the conservation of sea turtles and environmental stewardship as a whole. The aim of this poster is to give an outline of the types of programs we are conducting at the GSTC and our initial attempts at evaluating their effectiveness measured through the impact we have achieved on the local community and those that visit Jekyll Island as a vacation destination. From public programs, to community involvement, to more traditional educational settings, we offer a full spectrum of programming to a range of audiences. The impact of these programs on the conservation-mindedness of those we encounter is of utmost interest in our mission to conserve marine turtles and their habitats, although other criteria such as customer satisfaction and curriculum appropriateness are also important milestones of program success. Program evaluations have been conducted principally via participant survey (public programs, teachers), pre and post testing (school outreach), direct observation (use of exhibits within visitors' center) and direct public feedback via social media and visitor comments.

INTERNATIONAL FISHER LEARNING EXCHANGES FOR CONSERVATION: EXAMINING LESSONS LEARNED (FLEXCELL)*

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Over the past decade, fisher learning exchanges, in which representatives from different fisher communities are brought together to share knowledge, have emerged as a key tool for improving fisheries management globally. Fisher exchanges have been used worldwide to develop sustainability and management solutions, empower fisher leaders, create communities of practice, and build social capital. Notably, international fisheries learning exchanges have been used repeatedly to address turtle bycatch. For example, TED University sponsored by the United States National Marine Fisheries Service brought gear experts from around Latin America to the United States to learn about TED construction. Similarly, a program organized by the Marine Research Foundation brought Malaysian gear experts to the United States for the same purpose. The on-going trilateral exchanges between Japanese, Mexican, and Hawaiian fishers to develop solutions to turtle bycatch in longlines is another example. Clearly, government agencies and NGOs are increasingly investing in exchanges as a tool to promote better fisheries management, but until now there have been no comparative studies of how exchanges work. As exchanges become widely applied, it is strategic to develop a framework of best practices for the design and production of exchanges. Thus, in May 2013, we organized the workshop Fisher Learning Exchanges for Conservation: An Examination of Lessons Learned (FLEXCELL) at the National Socio-Environmental Synthesis Center (SESYNC). The object of the workshop was to bring together fishers,

NGO practitioners, government managers, and academics in order to share their lessons learned for how to best produce fisher learning exchanges, focusing on what has worked best and what can be done to optimize future exchanges. The participants were twenty of the world's most experienced organizers of exchanges and key fisher ambassadors who came from as far as Guam, Madagascar, and Malaysia and represented groups including the Nature Conservancy, U.S. Government, and Grupo Tortuguero. Lessons learned covered how best to develop exchange objectives and how best to design the exchange to encourage a transformative experience with measurable lasting results. Lessons learned also included suggestions for exchange activities and tips for managing exchange logistics. The outputs of the workshop include: 1) A learning exchange network formed among participants that extends to their partners worldwide, 2) An outline and production plan to publish a guidebook of lessons learned for fisher exchange organizers, and 3) A research plan for a future comparative case studies of learning exchanges. The overall results of the workshop were formalizing the community of learning exchange practitioners, the development of a shared understanding of learning exchanges, and the creation of a shared vision for the future of learning exchange research and practice.

USING A CREATIVE MULTI-MEDIA COMMUNICATIONS & FUNDING CAMPAIGN TO RAISE AWARENESS OF MARINE TURTLE CONSERVATION IN THE MIDDLE EAST

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Emirates Wildlife Society in association with WWF (EWS-WWF) launched in 2010 the Marine Turtle Conservation Project, a comprehensive research and awareness programme, in an effort to provide concrete links between critical nesting and foraging habitats in the Arabian/Persian Gulf and raise the collective awareness about marine turtles and their plight in the region. Focusing on the critically endangered hawksbill turtle (*Eretmochelys imbricata*) the project used satellite tracking technology to monitor post-nesting females and identify key migratory routes and foraging grounds in the region. By collaborating with various organisations in the region (Iran, Oman, Qatar, and the UAE) this project encompassed a regional approach with regards to conservation of hawksbill turtles in the Arabian/Persian Gulf. The project findings are expected to contribute to a regional baseline on hawksbill turtle biology and conservation needs upon which conservation policy and management decisions can be made at a local, national and regional level. To raise awareness of the project and its aims, a comprehensive communications campaign targeting both corporate partners and the public was implemented. Using a combination of traditional media (print) and new media (social media & e-newsletters) as well as corporate partners' communications tools, a wide ranging and all inclusive effort was made to engage with individuals to highlight the importance of the project and how they can feel involved and contribute. Our keystone campaign, "The Great Gulf Turtle Race" (adapted from a previously successful campaign by Conservation International), turned complicated scientific migration tracking data into easily digestible and dynamic information for the public and sponsors. Using this four-week campaign, for two years of the project; drew together opportunities for sponsors to contribute financially, be recognised for their contribution and engage with their employees and the wider public. With weekly updates and a live, interactive website, individuals could go online, vote for their favourite turtle and see what distance they had travelled since the start of the race; with a winner being declared at the end of the race for most popular and for furthest distance travelled. It was an opportunity some sponsors really embraced, with one managing to gain over 60,000 votes for their turtle to be crowned the most popular. The success of the suite of engagement tools was proven with improved numbers of followers and likes on social media, including an increased Facebook following of 25%, as well as measurable media coverage, such as unique website hits reaching 120,000 over the period of four weeks during "The Great Gulf Turtle Race" campaign. This multi-media approach has shown to be effective in significantly increasing awareness of the project. As a result, when looking forward with future projects, a similar multi-faceted communications programme should be also implemented; targeted both towards the general public and corporate partners and sponsors.

DEFENDING ENVIRONMENTAL ADVOCATES: SOMETIMES SHINING A BRIGHT (FIGURATIVE) SPOT LIGHT IS GOOD FOR SEA TURTLES*

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Jairo Mora Sandoval was a sea turtle monitor in Costa Rica. On May 30, 2013, during an evening patrol on Moín Beach, near Limón on the Caribbean coast, masked men kidnapped him and four foreign volunteers. The volunteers escaped, but police found Jairo dead on the beach. Moín Beach's dark sand, lack of artificial light, and remote location make it an ideal beach for nesting sea turtles -- and criminals. Police finally arrested suspects in connection with Jairo's murder, but the beach where Jairo was murdered remains vulnerable to dangerous poachers and narcotraffickers, and the political climate in which environmental advocates work remains at best indifferent, and at worst, hostile. Using the sea turtle habitat on the Caribbean coast of Costa Rica and the tragic murder of Jairo as a case study, we find that areas that lack adequate protection for conservation resources may leave environmental advocates vulnerable to crime. We conclude that nations have a responsibility to protect environmental resources and advocates that seek to conserve them. The largest nesting colony of green sea turtles in the western hemisphere can be found on Costa Rica's Caribbean coast. Leatherbacks are also widely distributed throughout the region. Threats to nesting habitat include beach erosion, coastal development, sand mining, agricultural runoff, and beachfront illumination. Marine threats include seagrass and coral reef degradation, impacts from fisheries, pollution, predators, disease, and parasites. Compounding these threats are the killing of sea turtles and harvesting of their eggs by humans. Jairo had been previously threatened at gunpoint for his work on the beach, and similar threats and attacks have occurred in Moín against other volunteers. Unfortunately, Jairo's death was just one of the recent events that marks over twenty years of abuses and intimidation directed towards environmental advocates. In Costa Rica alone, there were the suspicious deaths of María del Mar Cordero, Óscar Fallas and Jaime Bustamante, leaders of the Costa Rican Ecologists Association, and the homicide of Kimberly Blackwell in the Osa Peninsula in 2011. Other forms of intimidation, such as the destruction of property have been reported recently. A 2012 report to the United Nation's Human Rights Council and the Commission on Human Rights found that environmental advocates often endure serious attacks, such as murder and attempted murder. Threats and intimidation are also perpetrated against environmental advocates, including being the subject of campaigns to discredit their work. Stronger protections for environmental resources could result in better safety for environmental advocates. While sea turtles in Costa Rica enjoy protection under a general prohibition against poaching, Moín Beach does not have any additional special protection. Better protection of an area could increase police presence and public awareness. A brighter (figurative) spotlight on natural resource issues, including violence against environmental advocates, will better protect those resources and those who seek to defend them.

BILLION BABY TURTLES: A FUNDRAISING INITIATIVE TO SUPPORT NESTING BEACH CONSERVATION PROJECTS

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Billion Baby Turtles is a new marketing and fundraising initiative of SEE Turtles. The basic premise is that every dollar donated helps save at least one sea turtle hatchling at a community-based turtle nesting beach conservation project. Our goal is to diversify the sources of funding for turtle conservation projects in developing countries. We are raising funds through a variety of sources, including sea turtle conservation tours, individual donations, corporate

sponsorships, and school fundraisers. Funds donated to field projects are designated for personnel costs involved in patrolling nesting beaches, as well as equipment and supplies for hatcheries where applicable. In addition, we are earmarking roughly 10% of funds to provide scholarships for students living near turtle nesting beaches to visit and learn about sea turtles. To date, the initiative has helped to save more than 100,000 hatchlings at 11 nesting beaches managed by 9 local organizations in 7 countries. Grants to date are focused on Latin America and the Caribbean and have ranged from US \$1,000 to \$10,000 with an average of just under \$4,000 per grant. For the student scholarships, we have provided 5 grants that have brought just over 900 students to 5 turtle nesting beaches in 4 countries. To date, two-thirds of funds have come from grants from corporate sponsors and foundations, roughly 15% each from tours and individuals, and 3% from school fundraisers.

ROCK, PAPER, TURTLES: BUILDING CAPACITY FOR SEA TURTLE EDUCATION WITH TEACHERS IN RURAL SCHOOLS*

Celene Nahill¹ and Brad Nahill²

SEE Turtles, Beaverton Oregon USA

Education is an important part of any field-based sea turtle conservation program. However, most educational activities run by small community-based organizations are limited by human resources, funding, and training in current educational techniques. These limitations often result in educational programs taking a back seat to nesting beach conservation and research efforts where project staff organizes a small number of visits to local schools for presentations or short visits to nesting beaches for schools in close proximity. This limited outreach can prevent buy-in and participation by members of local communities, affecting the long-term outlook for localized turtle populations. In addition, rural coastal schools in developing countries are typically primary schools and in many communities, students drop out after primary school. We decided to focus on these younger grades for this program to reach more students at the schools near the turtle sites. To help small field-based projects effectively expand educational programs, SEE Turtles has launched an effort to build local capacity for teachers to teach about sea turtles at schools near conservation programs. Our strategy is to provide training and resources for teachers so that sea turtle education can become a regular part of the subject matter covered by local schools. To this end, SEE Turtles developed two workshops for teachers in Jiquilisco Bay, El Salvador, home to nearly half of all known nesting for the critically endangered Eastern Pacific hawksbill (*Eretmochelys imbricata*). During two workshops over 3 days, SEE Turtles staff, in partnership with local organizations, gave turtle educational presentations to 25 teachers and youth leaders from 15 schools, advised participants on current didactic educational techniques, as well as sharing simple games and activities that can be used to translate complicated concepts. Following the workshops, we also provided 5 lessons in Spanish for grades kindergarten to sixth grade, which are being shared with the teachers. Based upon feedback that we are requesting from the teachers, these lessons will be revised and then disseminated to schools in rural coastal areas across El Salvador and other countries in Central America. Based on surveys conducted during the workshops, the participants substantially increased their knowledge about sea turtles and the threats they face and most plan to incorporate the activities they learned into their daily teaching.

HOW YOU CAN HELP SEA TURTLES: A REVIEW OF SUGGESTIONS PROVIDED FOR THE GENERAL PUBLIC

Amber L. Pitt

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Conservation is often largely dependent on the support, choices, and behavioral modifications of private citizens. After becoming aware of conservation needs, members of the general populace often rely on suggestions provided by conservation organizations to learn how they, as private citizens, can help. I conducted internet searches using Google,

Bing, and Yahoo and the search terms “how you can help sea turtles”. As approximately 97% of internet search traffic targets the first three pages of results, I compiled the suggestions from the websites listed on the first three pages of search results to evaluate the type and number of suggestions. Suggestions were categorized according to location dependency, type of commitment (e.g., time, financial), relevance to major threats, and number of times the suggested action was offered. I found 42 unique websites that offered suggestions for how people could help sea turtles. The five most common suggestions were to donate or provide financial support through purchases to an organization (n=20), avoid nesting, hatching, or swimming turtles (n=14), reduce lighting near and on nesting beaches (n=14), avoid littering (n=13), and volunteer (n=12). Few suggestions were offered for people that were not in the vicinity of nesting sea turtles. “How you can help sea turtles” lists could be improved by including actions for people that are not in the vicinity of turtles. Additionally, more actions should be included that target major threats to sea turtles in their marine environment.

DO ACTIONS SPEAK LOUDER THAN WORDS? A LITERATURE BASED MARINE TURTLE EDUCATION OUTREACH PROGRAM ON BIKO ISLAND, EQUATORIAL GUINEA

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Four different species of turtles nest on the Southern beaches of Bioko Island, Equatorial Guinea, located in the Gulf of Guinea. Protecting these endangered species in places where resources are limited, small educational class excursions are valuable to furthering conservation efforts in local communities. Involving local youth can have a positive impact on these efforts. In October of 2012, we developed an educational program in collaboration with Universidad Nacional de Guinea Ecuatorial (UNGE) and Bioko Biodiversity Protection Program (BBPP) to teach elementary school children (ages 6 – 12) about sea turtle nesting ecology and conservation. This program was developed using *Moon Over Bioko; The Sea Turtles of Bioko Island*, a children’s book that is specifically written for sea turtle conservation on Bioko Island. The book is translated into Spanish (the local language on Bioko) and is scientifically accurate. Our lesson includes a lecture, a short video about the biology and nesting ecology of sea turtles and a discussion about Bioko specific threats to sea turtles. An interactive question and answer session related to the material covered follows along with a hands-on activity using life-sized replicas of the four sea turtles that nest on Bioko Island. It is our hope that by using Bioko specific materials, it will create a connection and foster an appreciation for biodiversity conservation on Bioko Island. Acknowledgements: The authors gratefully acknowledge and thank the following for their support: HESS corporation, ExxonMobil, MEGI (Mobil Equatorial Guinea Inc.), Universidad Nacional de Guinea Ecuatorial (UNGE), Jose Manuel Esara Echube (UNGE), Faustino Anda Esono Asangono (UNGE), Dr. Gail Hearn, David Montgomery, Drexel University, Philadelphia, PA, Peter Muir, Bizucate, and Holly Smith, ILEX.

ENGAGING YOUTH IN LOCAL COMMUNITIES IN SEA TURTLE CONSERVATION, NICARAGUA*

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Community participation and trust are at the core of Paso Pacifico’s sea turtle conservation program. We present the results of our community and youth outreach programs during the past two years. First, Paso Pacifico developed a Junior Ranger program, by which Paso Pacifico sea turtle rangers mentor local children and help teach environmental education lessons, including a unit focused on marine turtles. Upon graduating, these Jr. Rangers assist rangers during beach cleanups and help to spread environmental messages in their communities through awareness campaigns and

the production of theater performances focused on sea turtles. There are currently over one hundred and twenty-five Junior Rangers who aspire to serve their community just as the sea turtle rangers. Additionally, through support from SEEturtles.org, Paso Pacifico guided one hundred high school students from the city of San Juan del Sur to visit the La Flor Wildlife Refuge, where a range of sea turtles nest. Some of these same students have formed volunteer brigades that come to help protect the La Flor ‘arribada’ beach during large nesting events. Finally, community outreach has taken place in other forms, with film events, and community theater. When the turtle conservation program was launched through funding from the SWAT Conservation Grant program, Paso Pacifico conducted a survey to assess community views on sea turtles. In 2008 Paso Pacifico conducted a survey that aimed to consider community perspectives and values within its sea turtle conservation program. We repeated this survey in 2012 and also provided a comparison of attitudes and perspectives over this four-year period. The results indicate that there has been an increase in positive attitudes toward sea turtles and a greater interest and involvement in sea turtle conservation efforts.

SEA TURTLES & TRASH: COMBATING A GLOBAL PROBLEM THROUGH LOCAL COLLABORATION

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Ocean trash is one of the most persistent and pervasive issues facing the coastal and marine ecosystems. As a result, sea turtles are uniquely impacted and demonstrate significant susceptibility to ocean trash, specifically plastics, through both ingestion and entanglement. Over the past year, Ocean Conservancy has partnered with Wrightsville Beach Sea Turtle Project and Keep It Clean Wrightsville for a pilot initiative to increase the understanding of the potential land-based interactions of sea turtles and marine debris by incorporating a marine debris cataloging and collection protocol as part of an existing sea turtle monitoring effort. Volunteers utilize a customized Ocean Trash Data Form during morning sea turtle nest patrol. As volunteers walk designated transects, they collect marine debris present along the beach and catalog each item using the data form. By incorporating this marine debris data collection protocol throughout the six monitoring zones of Wrightsville Beach, Ocean Conservancy is able to better understand the potential interaction sea turtles—nesting females and hatchlings—have with marine debris while on land. By overlaying local sea turtle nesting data, including false crawls, nest locations, and hatchling counts, with proximate trash data collected, we are able to identify potential areas for increased sea turtle protection and mitigate harmful conditions that persist in local nesting grounds. To further our understanding, Wrightsville volunteers are the first to implement a newly redesigned data form. This new data form allows for greater specificity in reporting of material size and type, with special emphasis placed on plastics. By recording debris with greater specificity, Ocean Conservancy can work with local partners to combat the debris items that are most impactful and abundant in sea turtle nesting grounds. Additionally, Wrightsville Beach is one of the most highly visited beaches in North Carolina. As a result, Wrightsville Beach Sea Turtle Project volunteers interact with visitors frequently while monitoring the beach, utilizing this time to educate beach visitors about the plight of sea turtles and the actions many are taking to help protect these species. This season, sea turtle volunteers served not only as valuable sea turtle educators, but also as ocean health environmental ambassadors. Armed with Ocean Trash Data Forms and general marine debris information, volunteers were able to bridge the gap between debris present along the beach as well as in sea turtle nesting grounds and actions taken by people who live miles from the coast. This is a crucial segue for local sea turtle conservation organizations as many beach visitors do not live in an area that enables them to become hands-on volunteers. However, their knowledge and behavior at home—related to consumption, trash disposal and litter clean ups—can have immediate and lasting impacts on sea turtles globally. Ultimately we believe the simplicity of this standard debris monitoring protocol, the need for greater understanding of the terrestrial relationship between sea turtles and debris, and the outreach and advocacy benefits of these new analyses warrant expansion to sea turtle conservation groups globally.

IT'S THE LAW: IMPROVING ENFORCEMENT OF WILDLIFE LAWS THROUGH OUTREACH TO LAW ENFORCEMENT PERSONNEL IN INDONESIA*

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The Republic of Indonesia has strong national laws that provide full protection to sea turtles, their eggs, and other endangered wildlife. Unfortunately, however, these laws are poorly known and rarely enforced on the ground and in the waters where sea turtles occur, and poaching is widespread throughout the country. The Alliance for Tompotika Conservation/Aliansi Konservasi Tompotika ("ALTO"), a small non-profit international partnership, has been working with local communities to conserve sea turtles in the Tompotika region of Indonesia's island of Sulawesi since 2008. Significant strides have been made through encouraging residents' voluntary participation in conservation efforts, but these efforts can reach full fruition only with active and consistent enforcement of existing laws. Starting in 2012, ALTO began developing a program of outreach specifically targeted toward educating police and local government personnel about wildlife law, and encouraging them to enforce it. In a series of workshops and meetings, ALTO worked with government agency partner BKSDA (Balai Konservasi Sumber Daya Alam) to facilitate personnel from nine government agencies and jurisdictions in coming together to examine the barriers to wildlife law enforcement and to brainstorm ways to overcome them. Through this process, the group developed standard protocols for dealing with different types of violations, then returned to their respective jurisdictions to apply them. ALTO also significantly boosted its outreach efforts to the general public. Only one complete sea turtle nesting season has passed since this program began, but in that season (Feb-Sept 2013) a marked reduction in poaching was observed, and 83% more live hatchlings reached the ocean via ALTO's nest protection program than in the previous best year (2011). To date, participants in the law enforcement outreach program have been enthusiastic about their experience with the program, not least because it has provided them with a peer group and forum in which to discuss law enforcement matters, which can have positive implications beyond laws pertaining only to wildlife. These early results clearly show promise in the efficacy of targeting law enforcement personnel for strengthening sea turtle conservation efforts in Indonesia; ALTO plans to further develop this law enforcement program in future seasons. ALTO wishes to thank the International Conservation Fund of Canada, Pt. Defiance Zoo and Aquarium, and the ISTS travel grant committee for their support.

FROM ABANDONED “GHOST FISHING NETS” TO QUALITY SOCKS AND SPORTSWEAR, THE HEALTHY SEAS INITIATIVE

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Approximately 640,000 tons of abandoned, drifting fishing nets are currently wandering our seas and oceans. These synthetic nets can persist in the marine environment for hundreds of years, indiscriminately capturing and killing marine animals, smothering habitats and acting as hazards to navigation. Sea turtle entanglement, leading to injury and/or death due to “ghost” nets is particularly high, especially in Australia. The localized nature of lost and abandoned nets creates ecological problems for ecosystems and marine species, but it also allows focused recovery action. Recovered nets are usually dumped in landfills or incinerated. The Healthy Seas Initiative is a joint venture of Environmental Non Governmental Organisations (ENGOS) and businesses whose objective is to remove waste, such as abandoned fishing nets, from the seas. The Initiative’s founders are the ECNC Land &Sea Group, Aquafil Nylon 6 producers (Italy) with Econyl Regeneration System Project and Star Sock (Netherlands), a wholesale business for

socks that focus on both environmental and economic sustainability. Salvaged nets will be transformed into high-quality nylon yarn with which new products can be created. The Initiative aims to identify procedures that will act both to discourage the abandonment of redundant nets at sea and to facilitate their responsible handling by recovering and recycling them into new products. Between June and September 2013 diving actions took place in the Netherlands (North Sea, Atlantic) and Croatia (Mediterranean Sea). Nets were recovered from the seabed or from shipwrecks, either by a specialized marine salvage company in co-operation with divers or directly by divers working alone. Collection points were located at a harbour, inside containers, by arrangement with the local municipalities. Finally, the nets were cleaned and delivered to a plant in Ljubljana (Slovenia) to be prepared and delivered to the Econyl Regeneration System, ready for recycling.

PLASTIC POLLUTION AT TANZANIA'S LARGEST GREEN TURTLE ROOKERY: TURNING TRASH INTO TREASURE*

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Mafia Island is Tanzania's most important sea turtle nesting site. More than 250 green turtle nests are laid there each year and the critically endangered hawksbill turtle is also known to nest on the tiny islands around Mafia. However, nesting beaches are on the east coast of the island and are continually covered in large amounts of plastic debris that washes in on equatorial currents from as far away as Indonesia and the Philippines. Plastic bottles, flip-flops and discarded fishing nets are the most common types of debris. The amount of marine debris on nesting beaches poses a considerable threat to female turtles and emerging hatchlings and also threatens the long term sustainability of a developing sea turtle ecotourism initiative. Sea Sense is working on a creative solution to the marine debris issue in Mafia Island in an enterprise that is providing new skills to local people, reducing threats to marine turtles and generating a sustainable source of funds for marine turtle conservation in Tanzania. Sea Sense has formed a partnership with Ocean Sole Foundation, a Kenyan based organisation that has been driving local level recycling activities for the past 15 years. 20 local men and women in Mafia Island have been trained in the art of flip-flop recycling and are now creating jewellery from discarded flip-flops collected from nesting beaches. The 'Beach Life Bracelets' are on sale at a number of outlets across Tanzania and Zanzibar and the flip-flop artisans are earning much needed income from the project. A proportion of the funds generated by the sale of the 'Beach Life Bracelets' are being used to support ongoing efforts by Sea Sense to conserve and protect sea turtles in Tanzania. To elicit community support for the flip-flop recycling project, Sea Sense has implemented a diverse range of community based education and outreach activities that promote improved waste management practices. Community events have been held on World Environment Day and World Sea Turtle Day together with beach clean-ups and marine debris education programmes in local schools. A recycling hub has been constructed at a secondary school and students are actively recycling plastic bottles, flip-flops and plastic bags. Sea Sense has also been lobbying members of Mafia District Council for the development of localised waste management strategies that encourage recycling and reusing. The project is an example of a regional partnership that has the potential to make a long lasting change to the way local communities view plastic waste.

Fisheries and Threats

IMPACT OF ARTISANAL FISHERIES ON SEA TURTLES IN THE PROPOSED KRIBI-CAMPO MARINE PARK, CAMEROON (WEST AFRICA)

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Southern Cameroon is host to several species of sea turtles in both nesting and foraging habitats. Survival of these populations is threatened by a number of anthropogenic activities, including intentional and incidental capture for human consumption. Fishing is the main socio-economic activity for the local people around the proposed Kribi-Campo Marine Park in Cameroon. The main fishing ports in this area are Kribi, Grand-Batanga and Ebodje (150-200 fishermen), Londji (50-100 fishermen) and Campo (1-50 fishermen). An estimated 648 active fishermen were recorded during the time of our surveys, of which 260 were interviewed. The main fishing boat we recorded is the “Monoxyle type” but fishermen also use boats with planks “Cameroonian type” with an engine boat; gillnets form 67,7% of the fishing gear used. Our survey results revealed that turtles accidentally captured in fishing nets are (leatherback, *Dermochelys coriacea* 26.95%; olive ridley, *Lepidochelys olivacea* 25.46%; hawksbill, *Eretmochelys imbricata* 25.09%; and green turtle, *Chelonia mydas* 22.49%). Our results will contribute to better inform authorities and conservationists with respect to the best management strategies for these endangered species. The proposed marine park in the area will hopefully address sea turtle mortality in artisanal fisheries in the region.

STRANDINGS INDICATE THAT REPRODUCTIVELY ACTIVE GREEN TURTLES, LEATHERBACKS, AND LOGGERHEADS IN FLORIDA ARE PARTICULARLY VULNERABLE TO VESSEL STRIKES

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The most common injuries of known cause noted for dead, sick, or injured (i.e., stranded) sea turtles in Florida are those associated with vessel-strikes (i.e., propeller or skeg gashes). From 1980–2010, these vessel-strike injuries were documented in 4,848 stranded sea turtles. For stranded green turtles, leatherbacks, and loggerheads, the percentage occurrence of these wounds was greatest in adult-sized animals. Almost all of the stranded adult-sized green turtles with vessel-strike injuries were found in Palm Beach County or Broward County. This is north of the likely adult green turtle foraging areas (in Miami-Dade and Monroe Counties) and in the southern portion of the primary green turtle nesting beaches in Florida. About 90% of the stranded adult green turtles with vessel-strike injuries were found during the green turtle breeding and nesting season in Florida (May– October). The highest concentration of stranded leatherbacks with vessel-strike injuries was in Martin County and Palm Beach County. These two counties account

for about 75% of leatherback nesting in Florida. Most of the stranded leatherbacks with vessel-strike injuries were found during the leatherback nesting season in Florida (February-July). Stranded adult-sized loggerheads with vessel-strike injuries were almost all found in the southern half of Peninsular Florida, an area that accounts for the vast majority of loggerhead nesting in Florida. Almost 80% of the stranded adult-sized loggerheads with vessel-strike injuries were found during the loggerhead breeding and nesting season in Florida (March–August). Reproductively active sea turtles in Florida may be particularly vulnerable to vessel-strikes because they move into or through nearshore areas when and where boating activity is likely the greatest. Adult green turtles and loggerheads in Florida have been documented using relatively narrow nearshore migratory corridors when moving between foraging areas and nesting beaches. The adult females in particular gather in large numbers in the nearshore waters adjacent to nesting beaches and remain there for many months. Reproductively active sea turtles may also behave in ways that make vessel-strikes more likely. Dive data indicate that migrating sea turtles spend an unusually large amount of time at or near the surface.

HIGH SEASONAL STRANDINGS OF JUVENILE KEMP'S RIDLEY TURTLES IN THE NORTHERN GULF OF MEXICO

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High seasonal strandings have been documented by the Sea Turtle Stranding and Salvage Network (STSSN) during the March–June time frame in northern Gulf of Mexico. Juvenile Kemp's ridleys are most commonly found stranded in this area, with occasional juvenile green and loggerhead turtles found as well. "Preliminary necropsy information from stranded turtles in Louisiana, Mississippi, and Alabama shows a large proportion of turtles to be in good nutritional condition, with no traumatic injuries and with gut contents being predominantly fish" (Brian Stacy, pers. comm.). Sea turtle feeding on fish at this scale is suggestive of opportunistic foraging upon dead fish from bycatch. Little is known about the distribution and movements of juvenile Kemp's ridley (*Lepidochelys kempii*) turtles in the Mississippi Sound and surrounding areas of the northern Gulf of Mexico. It has been hypothesized that the coastal areas of the northern GOM are foraging habitats used by juvenile Kemp's ridley turtles. As juvenile ridley turtles reach 20-25cm SCL they appear in neritic zones feeding benthically. The turtles may forage throughout much of the year coastally but in winter are thought to move offshore in response to dropping water temperatures. Turtles return to nearshore areas to feed as the waters warm in the early spring. We hypothesize that turtles are congregating to feed on discarded fisheries bycatch and subsequently being subject to capture and forced submergence by fishing activity in the area. Intensive fishing activity occurs in the northern Gulf of Mexico from commercial trawl fisheries (otter and skimmer trawls) that target shrimp and select fish species and from the recreational hook and line fishery. These fisheries are known to catch marine turtles but the levels of impact in the Mississippi Sound area are currently unknown. Future work should investigate the movements, distribution, and habitat utilization of juvenile Kemp's ridley turtles in the nearshore waters of the northern Gulf of Mexico. Satellite telemetry will potentially provide temporal and spatial information on their movement patterns and habitat usage. Analyzing isotopic composition from sea turtle skin and blood samples as well as from local potential prey, and comparing these results to gut contents collected through lavage and fecal samples should provide a more complete picture of sea turtle trophic ecology.

PRELIMINARY DATA ON OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*) STRANDINGS IN NORTHEASTERN BRAZIL

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The coasts of the state of Sergipe and the northern state of Bahia, are considered the main nesting grounds for olive ridleys (*Lepidochelys olivacea*) along the Brazilian coast. However, the region is also considered an important fishing area, where a sizeable coastal trawling and gillnet fleet operates, leading to high rates of sea turtle bycatch. This occurs mainly because the area has an extensive mud bank, which is the shrimp habitat during its benthic phase that shrinks during summer. Such situation, associated with lack of enforcement, induce fishers to operate closer to the coast, in areas that overlap with important sea turtle habitats. This study aims to present an analysis of olive ridley strandings (n=2,220) over a 12-year period (2001-2012) along the coasts of Sergipe and northern Bahia, in order to investigate sea turtle interaction with fisheries. Almost 91% (n=2,013) of the turtles were sub adults or adults (curved carapace length greater than 60 cm, which is the minimum size at reproduction) with size composition reflecting the demographic structure of the nesting population of northeastern Brazil. The majority of turtles were dead (n=2,140; 96.4%), while only 80 individuals (3.6%) were alive. Additionally, strandings were far more frequent during summer (42% from December to March). Because of the high rates of mortality among adults, in 2004, a Normative Rule was established extending the shrimp seasonal closure from 50 to 90 days, divided into two periods, the first in the austral fall (01 April to 15 May) and the second in the summer (01 December to 15 January). According to literature, fisheries interaction is by far the main cause of strandings in Brazil. In this research, 33.5% of the stranded turtles (n=744) had evidence of fisheries interaction. Of these animals with signs of fisheries interaction, almost 33.3% (n=738) were in good body condition, based upon the subcutaneous and visceral adipose tissue and musculature. This condition suggests that the turtles had been feeding recently and had a sudden death, probably as a result of getting caught in fishing gear. Additionally, 324 out of 491 female olive ridleys (sex confirmed at necropsy or during a rapid carcass analysis) were classified as reproductively active, based on the presence of eggs in their oviducts. As we know, nesting turtles are generally in good health, since they are capable of reproducing, thus, we can also assume that these animals had died as a result of drowning. However, stranded turtles, whether dead or alive, rarely exhibit external signs of capture in fisheries and the lack of external injuries may, therefore, underestimate the actual bycatch levels. Furthermore, probability of strandings may vary widely in space and time, and usually it is not considered a representative sample of total mortality at sea, as scavengers, predators and currents prevent carcasses from reaching the shore. Despite continuous threats to their survival, the Brazilian olive ridley stock continues to recover following protection since the early 1980s. In addition, effective measures to reduce sea turtle bycatch along the Brazilian coast are currently under way.

MODELING INTERACTIONS BETWEEN TWO MAJOR SOUTHEASTERN U.S. SEA TURTLE NEST PREDATORS AND THEIR EFFECTS ON NEST DEPREDATION RATES

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Sea turtles face many anthropogenic (e.g., incidental fisheries by-catch, vessel strikes, oil pollution) and natural (e.g., predation, tidal inundation, disease) threats throughout all of their life stages which contribute to population decline. In order to mitigate these losses for the Northwest Atlantic loggerhead (*Caretta caretta*) population, a recovery plan

with objectives including minimization of nest depredation was developed. In the last decade, there has been a series of studies investigating intraguild predation (the consumption of your fellow guild member) between two major nest predators, North American raccoons (*Procyon lotor*) and Atlantic ghost crabs (*Ocypode quadrata*). Studies have also highlighted that ghost crab predation assists raccoons in finding nests, thereby facilitating secondary nest depredation (i.e., facilitative predation). However, the combined effects of these two intraguild interactions and their consequences on nest depredation rates have not been examined explicitly. Here we develop a population model involving these two nest predators with opposing intraguild interactions. Our main objectives are to (1) characterize the dynamic interactions between intraguild predators and their effects on sea turtle nests through the use of a differential equation model and (2) determine the role that facilitative predation has in influencing nest densities. We will use sensitivity and stability analysis to examine the relationships among species-specific attack rates, facilitative predation, and three-species population dynamics. Results from stability analysis will give us insight into regions of co-existence (where all three species persist). We expect that sensitivity analysis will show the importance of facilitative predation in influencing variability in species densities. A past study revealed that complete raccoon removal from an east central Florida nesting beach led to increased nest depredation rates, perhaps due to an increase in ghost crab population size. Implications of this model include identification of species densities which would minimize nest depredation rates. Our results will demonstrate how facilitative predation is likely to function in a three-species system through a range of different scenarios. We anticipate our analysis to be a useful tool for managers of threatened and endangered sea turtle populations. This model is a starting point to test the effectiveness of different conservation management strategies that could subsequently be applied practically. For example, if facilitative predation due to ghost crabs has a large negative effect on nests, then an increased focus on factors that influence ghost crab density should be examined. Improved understanding of facilitation processes is directly related to the development of effective tools for conservation management and simulating community responses to different drivers.

THE SEA TURTLE FISHERY IN TOBAGO, WEST INDIES*

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At the time of this study (2007), local regulations allowed for the legal harvest of sea turtles in Trinidad and Tobago within a five-month season annually. The level of exploitation has not been adequately monitored, but an uncontrolled harvest reportedly continued year-round due to inadequate enforcement. The objectives of this study were (1) to review existing information on the sea turtle fishery in Tobago, much of which has been qualitative, and (2) to conduct a survey of fishers to obtain quantitative data on the extent to which sea turtles are target species, the catch rates of the different species and the role that sea turtles play in the socio-economy of fishers. Past levels of sea turtle harvest and socio-economic information on the fishery in Tobago were obtained through a review of published literature and unpublished technical reports produced by Government agencies with responsibility for sea turtles and their management. To obtain data on the current level of harvest, a questionnaire was administered to fishers at 25 landing sites around the coast of Tobago in 2007. Approximately 10% of interviewed fishers distributed widely around the island reported targeting sea turtles. Effort varied widely from targeting turtles daily and year round, to opportunistic capture. Consequently, annual catch by each fisher varied widely. The data allows an estimate of the total annual sea turtle catch in Tobago. The results are discussed in relation to the economic incentive for turtle harvest. Acknowledgements: Funds to support field research for this study were provided by the Government of the Republic of Trinidad and Tobago Research Development Fund and the US National Fish and Wildlife Foundation. Travel grants to participate in this meeting were provided by the Campus Research and Publication Fund, The University of the West Indies, St. Augustine, the International Sea Turtle Society, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation, U.S. National Marine Fisheries Service, Sea Grant-Texas, Shell, International Seafood Sustainability Foundation, Wildlife Computers, Environmental Business Specialists LCC, Sea Turtle Conservancy, Florida TURTLE license plate program, SIRTRACK, CLS America, Ecological Associates Inc., Desert Star Systems LLC, Loggerhead Marinelifelife Center. Janet Hochella, Kiki Jenkins, Sea Turtle Project-Bangladesh, Marinelifelife Alliance, Matthew Nash, Mission: Clean Beaches, Sandy Sly, ProFaunaBaja – ASUPMATOMA, Usagi Family and Debbie Sobel.

SYSTEMIC GAS EMBOLISM IN DEAD AND LIVE LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) DUE TO BY-CATCH*

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We describe “gas systemic embolism” linked to by-catch as a likely new clinical and pathological entity, resembling decompression sickness (DCS), in marine turtles. Evidence of acute and chronic tissue damage in stranded cetaceans that results from the formation in vivo of gas bubbles was reported in 2003, challenging the view that these mammals do not suffer DCS like human divers. DCS was suggested following observations of lesions (i.e. abnormal tissue) coincident with intravascular and major organ gas emboli found in beaked whales mass stranded in spatial and temporal association with military exercises deploying sonar. Osteonecrosis-type surface lesions in skeletal materials have been interpreted as the result of chronic diving injury in sperm whales. Even though, evidence of DCS have been demonstrated in stranded cetaceans using forensic methods this disease had not been clinically diagnosed in any marine animals. Dead sea turtles as a consequence of by-catch is a worldwide common problem exacerbated depending on multiple factors (i.e. fisheries pressure, fishing gear type, population density) where death was supposed to be caused by drowning. Sea turtles are along the longest and deepest diving of the air-breathing vertebrates (marine animals). There are references of osteonecrosis-type surface lesions in marine turtles in Cretaceous age while very rarely observed in specimens younger than Miocene age. It has been hypothesized that at present, the minimal susceptibility to the underlying “DCS” is the result of evolution of physiologic and/or behavioural mechanisms for compensation. To the best of the authors knowledge, no reference of turtles suffering of acute gas embolism, has been previously reported either in live or dead individuals. Here we report an “in vivo” and “postmortem” diagnosis of systemic gas embolism in 27 loggerhead sea turtles (*Caretta caretta*) which were recovered dead or still alive from by-catch trawlers and gillnets at different depths from Valencian coast region (eastern Mediterranean Spanish coast) since 2010 until present. Diagnosis in live animals was made based on different clinical diagnostic techniques as well as systematic and detailed necropsy and histopathology on dead turtles. Additional gas analysis was also performed on dead turtles. Based on these observations, a final diagnosis of “acute gas embolism” consistent with “DCS” was confirmed in several specimens after being trapped in fishing gears. This finding has direct implications for sea turtle conservation through appropriate diagnosis, treatment and subsequent release of live surfaced bycatch compared with the present direct release indications. This also reveals that the impact of fisheries worldwide could be much higher than previously estimated. Many of the turtles recovered alive from net gears could subsequently die because of DCS. It could be essential to review regional sea turtle bycatch interventional protocols worldwide to ensure health status of direct release animals, and to assess the real health impact of interactions between sea turtles and the different kinds of fishing gears included those who are equipped with systems to mitigate sea turtle by-catch (i.e. turtle exclusion device). The importance of these new findings regarding rehabilitation and releasing of by-catch turtles will be also discussed. We thank the Symposium Travel Fund and specially donors for assistance.

THE INS AND OUTS OF THE U.S. FAILURE TO REQUIRE TEDS IN SHRIMP SKIMMER TRAWLS

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When the world's first turtle excluder device (TED) regulations were promulgated in 1987 for the U.S. shrimp fleet, skimmer trawls were excepted because regulators believed that sea turtles were not being drowned in these nets. At that time, skimmers were not used widely and fishermen assured the National Marine Fisheries Service (NMFS) that they had to empty their nets frequently to fish efficiently, thereby preventing captured turtles from being held underwater for any length of time. Unlike otter trawls which are towed, skimmer trawls are mounted near the front of the vessel and pushed through the water. Skimmers catch less bycatch (non-target species) than other trawls and have become very popular in recent years, in part because their design allows them to fish in very shallow water. Today thousands of skimmer boats ply the inshore waters of Louisiana, North Carolina, Mississippi, and Alabama. Through research and observation, skimmer trawls have been implicated in the capture and drowning of significant numbers of sea turtles, including strandings in the Gulf of Mexico which coincide with the Spring opening of skimmer shrimp fishing. Longer tow times and increasing fleet size as well as extensive fishing in sea turtle developmental areas contribute to the estimated mortality of thousands of turtles each year. Requiring TEDs in skimmer trawls would go a long way toward addressing this problem. Five years ago NMFS committed to phasing in comprehensive TED regulations in all trawl fisheries and amending the rules for shrimp skimmer trawls, starting in mid-2009, but after proposing to require TEDs in skimmers it failed to follow through with this needed regulation. This presentation will review the most important aspects of this situation – TED research and testing, political wrangling, government failure, and legal action.

HOW EXPOSED TO HUMAN DISTURBANCE ARE TURTLE NESTING AREAS IN THE USA?*

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The existence of viable nesting areas is crucial for the persistence of marine turtle populations. These areas are necessary for reproduction and thus recruitment into the population. Yet many nesting areas are highly impacted by coastal development. Aside from direct loss of nesting habitat, other factors associated with development, including artificial lighting, beach compaction, noise, and pollution, jeopardize the quality of nesting areas, alter the behaviour of both adult and hatchlings, and influence the reproductive success and output of marine turtles and the ability of offspring to reach the ocean. Knowledge of the extent to which nesting areas are exposed to coastal development is essential to guide management initiatives and to identify areas which require further protection. To inform management of marine turtles in the USA, we assessed the extent that nesting areas used by loggerhead, leatherback and green turtles are exposed to coastal development and therefore human disturbance. Night-time lights (2012) and housing and population density (2010) were used as proxies for coastal development. Species and nesting areas that face the greatest and least exposure to coastal development were identified. To further inform the potential for strategic management at nesting areas we also assessed the proportion of nesting areas in different tenure categories: private (private, private conservation lands) and public (federal, state, local, regional agency, joint ownership). Our assessment, using a radius of 5km, indicates that the majority (> 80%) of nesting areas in the USA are exposed to coastal development. Alarmingly, more than 90% of leatherback and green turtle nesting areas are exposed to

development, with an average 8617 ± 13226 and 9396 ± 13847 houses within 5km of each nesting area for each species respectively. Loggerhead nesting areas are the least (83%) exposed to coastal development. This might be a reflection of a higher proportion (3% compared to 0.3%) of loggerhead nesting areas being privately owned and set aside for conservation. Similarly, more than 90% of nesting areas are potentially exposed to light pollution (within 1km radius), with leatherback turtles having the highest proportion (97%) of exposed nesting area. The high proportion of nesting areas exposed to development highlights both the need for mitigating management in exposed areas and protection of those areas without any exposure to development. Within the USA, these areas represent habitats of extreme importance to marine turtle populations, especially in light of climate change. As climate change progresses marine turtles will be more dependent on optimal nesting areas, to buffer impacts from sea level rise and increases in temperature, since some nesting habits will be impacted by climatic processes and no longer suitable.

REDUCING SEA TURTLE MORTALITY IN THE MID-ATLANTIC AND SOUTHERN NEW ENGLAND SUMMER FLOUNDER TRAWL FISHERY

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In summer and autumn 2013, a 160-foot headrope topless trawl equipped with two restrictor lines was tested in the field to evaluate its performance in reducing the incidental bycatch of sea turtles in the southern New England and Mid-Atlantic summer flounder trawl fishery. The test results, based on 132 paired tows conducted using the commercial twin trawl vessel F/V Karen Elizabeth, indicated that the topless trawl reduced sea turtle bycatch by about 50% with a 23% loss in summer flounder catch compared to a traditional trawl. These findings suggest that the use of a topless trawl as configured in our study would significantly reduce sea turtle mortality in the USA summer flounder trawl fishery.

DEVELOPMENT OF A KEMP'S RIDLEY SEA TURTLE STOCK ASSESSMENT MODEL

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We convened a workshop to develop a stock assessment for the Kemp's ridley sea turtle (*Lepidochelys kempii*). The primary objectives were to examine Kemp's ridley population status, trends and temporal-spatial distribution in the Gulf of Mexico; estimate fishing mortality from shrimp trawls, and estimate total mortality. Shrimp trawl mortality was identified in 1990 as the greatest threat to sea turtles at sea, and widespread utilization of Turtle Excluder Devices (TEDs) began in 1990 or shortly thereafter. The assessment also considered other factors that may have had significant influence on the population. The Kemp's ridley demographic model developed by the Turtle Expert Working Group in 1998 and 2000 was modified for use as our base model. The TEWG model uses indices of the annual reproductive population (nests) and hatchling recruitment to predict nests based on a series of assumptions regarding age and maturity, remigration interval, sex ratios, nests per female, juvenile mortality and a "TED-effect" multiplier after 1990. This multiplier was necessary to fit the data observed after 1990. To this model, we added the effects of shrimp effort directly, modified by habitat weightings. Additional data included in the model were incremental growth of tagged

turtles and the length frequency of stranded turtles. We also added a 2010 nest reduction multiplier that was necessary to fit the data for 2010 and beyond. Lastly, we used an empirical-basis for estimating natural mortality, based upon a Lorenzen mortality curve and growth estimates. From 1966 through 2009 the number of nests increased exponentially. In 2010, the number of nests plummeted to 12,377, a 35% reduction from 2009. Prior to 2010, the average rate of increase had been ~ 19%. In 2011 and 2012, preliminary estimates of nests observed were 19,368 and 20,197, respectively. Prior to the use of TEDs, shrimp trawls were estimated to kill 2,051 (76%) of the total annual mortality of 2,715 Kemp's ridleys. The population increased exponentially through 2009 when 3,679 shrimp trawl deaths were estimated to be included in the total mortality of 15,291 Kemp's ridleys. Shrimp trawl mortality was thus about 24% of the total mortality in 2009, suggesting a decrease in shrimp trawl mortality on the order of 68% as compared to 1989. The use of TEDs and shrimp fishing effort reductions since 2003 appear to be the primary factors associated with this reduction. In 2010, total annual mortality was estimated to be on the order of 65,505 Kemp's ridleys including 1,884 (4%) individuals killed in shrimp trawls. In 2012, shrimp trawl mortality was estimated to be on the order of 3,300 turtles (20%) within the total estimate of 16,128 Kemp's ridley deaths. More years of data and corresponding stock assessment will be necessary to explain the 2010 reduction and its effects on the population. We recommend expanded data collection at nesting beaches be a priority, and that the next stock assessment be conducted in 2014 or 2015.

IS THERE ANY RELATIONSHIP BETWEEN THE AVAILABILITY OF DEBRIS AND INGESTION BY *CHELONIA MYDAS* (LINNAEUS, 1758) ALONG THE COAST OF PARANÁ, SOUTHERN BRAZIL?*

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Marine debris is one of the most detrimental anthropogenic environmental pollutants, and is a threat that has only recently been recognized. Usually land-based debris are prevalent in the samples from coastal environments, and a major threat to marine life is pollution by plastics. Green turtle (*Chelonia mydas*) is one charismatic species that is negatively affected by marine debris. It uses the Paraná coast, in the Southwestern Atlantic Ocean for feeding, development, and migration. The ingestion of marine debris by juvenile green turtles causes many injuries and health problems. Despite the presence of several protected areas along the Paraná coast, there are urban areas and ports and in recent years, large numbers of stranded green turtles have had ingested debris. Nevertheless, little is known about the availability of marine debris in the environment. From 2011 to 2013, two methods were used to evaluate debris occurrence (>2 cm) in (i) seagrass meadows and (ii) the intertidal zone of Paraná. The amount of debris in sea grass meadows was evaluated through quadrats and 20 linear transects (200 m² each), with both methods covering areas of 1 km². Debris in the intertidal zone was investigated via two 5000 m line transects (covering 10 km²). As part of the latter work from 2008 to 2013, any stranded dead green turtles were assessed for debris ingestion. All debris recorded were separated according to their color (transparent, white, black or other colors) and their type (simple or rigid plastics, fishery debris and others). Debris found in the digestive tract were also collected and measured, and the occupied area was evaluated. In seagrass meadows, < 5% of the monitored area had debris and among those collected, 87.5% (n=14) were simple plastics and 50% (n=8) white colors. Along monitored beaches, 5692 debris items were found, with 52.1% (n=2969) rigid plastic and 48.7% (n=2771) colored. Among 80 stranded dead green turtles (CCL= 39.69 ± 6.61 cm), 68.8% had ingested debris, with simple (49.7%) and colored plastics (34.3%) the most common. The consumption of simple plastics may be explained by their pliability and therefore easier capture by green turtles. Further, compared to rigid plastics, simple plastics are more buoyant and provide an increased possibility of conglomeration by incrusting species and algae. Irrespective of the type of plastic, the high rate of ingestion supports proper management actions and environmental education to reduce debris in Paraná marine environment and, therefore its threats to the marine wildlife. Acknowledgements: We thank the following organizations for travel grants, International Sea Turtle Society, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation, U.S. National Marine Fisheries Service, Sea Grant-Texas, Shell, International Seafood Sustainability Foundation, Wildlife Computers, Environmental Business Specialists LCC, Sea Turtle Conservancy, Florida TURTLE license plate program, SIRTRACK, CLS America, Ecological Associates Inc., Desert Star Systems LLC, Loggerhead Marinelife Center. Janet Hochella, Kiki Jenkins, Sea Turtle Project-Bangladesh, Marinelife Alliance, Matthew Nash, Mission:

Clean Beaches, Sandy Sly, ProFaunaBaja – ASUPMATOMA, Usagi Family, Debbie Sobel, and the International Sea Turtle Symposium. We thank Fundação Araucária for the logistical support.

HAWKSBILL BYCATCH IN LOBSTER GILLNET FISHERIES OPERATING ALONG THE PACIFIC COAST OF CENTRAL AMERICA*

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Hawksbill (*Eretmochelys imbricata*) turtles are on the brink of extinction in the eastern Pacific Ocean. Via interview surveys carried out in 2011, lobster gillnet fisheries operating out of El Maculis in El Salvador and La Salvia in Nicaragua were identified as incurring high bycatch of the species. These sites are located in close proximity to the primary nesting sites of hawksbills in the eastern Pacific, increasing potential fisheries bycatch interactions. In 2012, we began conducting fisheries research at El Maculis and La Salvia, with the objective of quantifying hawksbill bycatch in local lobster gillnets. Activities have been carried out in close collaboration with local lobster fishers and fishing cooperatives, who were trained to record data. A total of 423 observation trips were carried out between 12 September 2012 and 30 September 2013. Nets ranged from 200 m to 3600 m in length, with an average of 2,227 m per set. Soak times ranged from 1.1 hrs to 30.0 hrs long, with an average of 14.8 hrs. A total of 22 hawksbills have been observed during that time, of which 16 were directly caught in lobster gillnets and six were found adrift at sea. Nineteen (86.3%) of the 22 hawksbills encountered were dead, while three (13.6%) were alive. These catastrophic bycatch rates represent one of the gravest threats to hawksbills in the eastern Pacific. It is crucial that options be found to reduce or eliminate hawksbill bycatch in the lobster gillnet fisheries operating at these two sites. We recently initiated experimental lobster trap trials to test this technique as a sustainable alternative to gillnets. While still preliminary, lobster yield from experimental traps to date has been non-existent at both sites. In contrast, reference gillnets consistently yielded lobster, particularly in La Salvia. While these preliminary results indicate traps may not be a viable alternative to gillnets, it is necessary to evaluate their effectiveness using different bait types as well as during different months of the year (e.g. corresponding to peak lobster catch dates) before discarding this option. The program has been carried out by the Eastern Pacific Hawksbill Initiative (ICAPO) in alliance with Programa Restauracion de Tortugas Marinas (PRETOMA) (Costa Rica), Fauna & Flora International (FFI) (Nicaragua), as well as with the Ministries of the Environment of El Salvador and Nicaragua (MARN and MARENA, respectively). Financial support has been provided by the Disney Worldwide Conservation Fund, National Fish and Wildlife Foundation and USAID Regional Program for the Management of Aquatic Resources and Economic Alternatives.

A RAPID ASSESSMENT OF SEA TURTLE BYCATCH IN A COASTAL GILLNET FISHERY OFF A SEA TURTLE NESTING BEACH IN PALOH, INDONESIA

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Paloh beach, which is located within the District of Sambas in the Province of West Kalimantan, Indonesia, is a major nesting beach for sea turtles in Indonesia. This 63 km length of beach has been known as nesting site for green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) sea turtles. Beach and nest surveys indicate that green sea turtles account for 98% of the nests, while hawksbill turtles account for 2%. Nesting abundance is concentrated in a segment of beach known as Sebusus (89.41%) as compared to the neighboring beach segment called Temajuk

(10.59%). For decades, sea turtle eggs in this region have been exploited, either by the local government who sells them through auction or by local people. In addition, bycatch due to coastal fisheries is most likely a major threat to this population of sea turtles. A drift gillnet fishery operates within 1- 3 km directly offshore of the nesting beach and a region known to be a leatherback sea turtle foraging ground. This fishery targets Pomfrey species (*Pampus* spp) and consists of approximately 35 fishing boats. The fishing vessels have engines ranging from 5-10 GT, lengths from 7-12 m, widths from 1.5-2.5 m, and crews consisting of 2-3 fishermen. Fishing trips last from 2-4 days with a drift gillnet set each night. Gillnets are surface nets set at depths of 2-15 m depth from the surface. Their length ranges from 800-2800 m and are 7.7 m wide. Bycatch in this fishery consists of green, hawksbill, olive ridley (*Lepidochelys olivacea*), leatherback sea turtles (*Dermochelys coriacea*), various shark species (including whale sharks), and dolphins. A rapid assessment of this fishery suggests that each boat catches 1-2 sea turtles every month during the fishing season (March-Oct). To address this issue of bycatch in the coastal fishery, we organized a fisheries bycatch workshop in which various stakeholders such as local fishermen, government officials, NGOs, fishery academics, and other bycatch researchers described the current state of the fishery's bycatch issues, discussed potential solutions, and decided on establishing a systematic observer program. This observer program would be linked to the testing of illuminated nets as a potential partial solution for the incidental capture of sea turtles in this region.

SPATIAL AND SEASONAL CHARACTERISTICS OF LOGGERHEAD RESIDENCE AREAS ON THE WEST FLORIDA SHELF, WITHIN THE GULF OF MEXICO, AND EVIDENCE OF OVERLAP WITH A COMMERCIAL FISHERY*

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We examined a twelve-year dataset of the postnesting residence areas of 81 adult female loggerhead turtles on the West Florida Shelf (WFS) in the northeastern Gulf of Mexico (GOM). These turtles were satellite-tracked one or more times from nesting beaches on Florida's east and west coast. Turtles were tracked within residence areas for an average of 217 days. We identified several seasonally persistent, high-use residence areas within offshore WFS waters, many of which occurred at depths ranging from 35 - 70 m and south of 28° latitude. The majority (60%) of individuals remained within a single, discrete residence area throughout the tracking period. The remaining individuals made brief departures (i.e., lasting days to weeks) away from their residence areas. These departures varied in both seasonality and in direction of travel. Departures from residence areas were correlated with decreasing water temperatures for eight individuals (mean $r = -0.22$, $p < 0.05$). All but one of these latter individuals had residence areas in shallow waters, inshore of the 10m bathymetric contour. Analyses of the dive data and corresponding water depths showed that these turtles made regular dives to depths equivalent to the sea floor throughout the tracking period. Incorporating recent spatial data on the fishing effort for the bottom longline component of the GOM commercial reef fish fishery, we found that there was substantial spatial and seasonal overlap between loggerhead residence areas and this fishing effort on the WFS. Regulations designed to reduce sea turtle bycatch in this fishery were promulgated in 2009, restricting fishing areas during the summer when loggerheads were thought to be most at risk from the fishery. However, we observed no broad-scale seasonal shifts in loggerhead residence areas on the WFS, where overlap with the fishery exists. Information on loggerhead residence areas can inform management actions to reduce significant threats, including fisheries bycatch.

A GLOBAL OVERVIEW OF LEGAL MARINE TURTLE FISHERIES*

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The direct take of nesting and foraging marine turtles for meat, shell and other products has taken place for millennia from the subsistence level to large-scale commercial take. Direct take is thought to have contributed significantly to the global decline in marine turtle populations. Despite increasing levels of protection, the direct take of turtles has continued legally in many regions and countries and is now characterised by culturally significant use by traditional coastal populations, or small-scale fisheries supplying local markets with meat and sometimes shell. There is however a paucity of information on direct take and we set out to assess the current legal direct take of marine turtles globally. A comprehensive literature review was undertaken (>500 reports and papers), and >150 in-country experts contacted to gather information on countries that permit the legal take of marine turtles (as of 1st January 2013). Current annual take for each country and species was estimated, and estimates generated for the 1980s, 1990s and 2000s. Currently 42 countries permit the direct take of turtles and collectively take in excess of 40,000 turtles per year of which the majority (>80%) are green turtles, *Chelonia mydas*. Legal take is focussed in the wider Caribbean and Pacific Islands. Ten countries account for >90% of legal take, with the highest consumers being Papua New Guinea, Australia and Nicaragua. Within the 42 countries included in this study, there has been a significant decrease in take since the 1980s. Our results provide the most comprehensive global synthesis of legal take of turtles in recent years and suggest that legal take has the potential to be a major driver of marine turtle population dynamics, comparable to mortality estimates through recorded bycatch. However, it is likely that illegal take, along with bycatch, are significantly under-recorded and far greater than the total level of directed legal take. A severe lack of quantitative data on direct turtle take still hampers the ability to assess the relative impacts of numerous threats to marine turtles.

TEMPORAL CHANGES IN ARTIFICIAL LIGHT EXPOSURE OF MARINE TURTLE NESTING AREAS*

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Artificial light at night poses a significant threat to marine turtle breeding success across the globe, and light-use continues to increase with human population growth. Prioritising effective management of this issue requires an understanding of marine turtle exposure to changing light levels close to nesting areas, in response to changing temporal and spatial distributions of coastal development. Spatial analysis of multi-temporal, satellite night-light data, in combination with linear mixed model analysis was used to determine broad-scale changes in artificial light exposure at Australian marine turtle nesting areas between 1993 and 2010. At a population management unit (MU) scale, flatback turtles nesting in east Australia experienced the fastest increases in light over time. MUs previously identified as having high exposure to light pollution (located in Western Australia and southern Queensland) did not show a significant change in light exposure over time, 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, nesting areas experiencing significant increases in light predominantly occurred close to heavily industrialised coastal areas, thus emphasising 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 'buffer' areas in the future. This is valuable information which 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. As such, our methods and findings will be of interest to managers of marine turtles around the world.

TRENDS IN BYCATCH REDUCTION RESEARCH: WHEN CAN WE IMPLEMENT WHAT IS ALREADY PROVEN TO BE SUCCESSFUL?*

Amanda J. Keledjian

Oceana

Bycatch is one of the most significant and persistent threats facing sea turtle populations around the world. Substantial research has been dedicated to examining the efficacy of various techniques for reducing bycatch, many of which have been proven successful in a variety of fisheries and regions. However, the results of this research are not always acted upon or applied to fisheries management. Here we compare the proven efficacy of existing bycatch reduction techniques and their current implementation through a global review of published bycatch reduction literature. Through this meta-analysis, we compiled information from more than 100 peer-reviewed publications through a robust, systematic review of existing databases and summary articles from 1980-2013 to identify historical trends in bycatch reduction research, existing regional gaps, and potential future research priorities. This review encompassed 18 different techniques tested for reducing sea turtle bycatch, with the greatest number of publications from the United States East Coast (24%), North Atlantic and North Pacific Oceans (22%), Australia (17%), and the central and eastern Pacific regions (18%). Overall, the majority of studies (70%) resulted in reduced bycatch or increased avoidance behaviors, with the greatest number of studies conducted in the mid-2000s. A significant majority of publications evaluated the efficacy of excluder devices and hook type, comprising more than half of the total papers, followed by bait type and net height. Little research has been conducted for applications to artisanal fisheries or throughout the Indo-Pacific and Central America, where bycatch has been identified as a serious threat. Our analysis revealed the tendency to study a smaller number of select techniques (i.e., TEDs and circle hooks), highlighting the importance of field testing for a broader spectrum of new and innovative solutions in the future. However, even the most effective and well-tested techniques have not been fully implemented in the U.S., much less in fisheries around the world. Here we review the number of fisheries that have not adopted or even tested the appropriateness of proven techniques for reducing bycatch, such as circle hooks or excluder devices. Despite potential biases in the data collection process (English language publications, online accessibility of older papers, etc.), this review highlights how management requirements can often lag research findings, to the detriment of protected wildlife. Using technological fixes is essential for the continued management of fisheries impacts on threatened and endangered species in the future.

EFFECTS OF CLIMATE CHANGE ON LEATHERBACK NESTING HABITAT: EROSION AND DUNE VEGETATION

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Leatherback turtles (*Dermochelys coriacea*) are a critically endangered species mainly due to anthropogenic effects. However, little is known about its response to additional new threats, such as climate change. For example, sea level rise or spreading dune vegetation could negatively affect the quality of the nesting habitat. Thus, we assessed the potential impact of climate change on the nesting habitat and the resulting effects on the behavior of nesting females and hatchling leatherback turtles at the Pacuare Reserve, on the Caribbean coast of Costa Rica. To estimate

topographic changes on the coast and to quantify changes in erosion at a small scale, we took three types of measurements: (i) berm height (ii) distance from fixed posts located in the vegetation to the berm, and (iii) distance from the berm to the sea. We also developed a new methodology to monitor berm changes throughout the season in order to measure the effect of topographic changes on sea turtle nesting habitat. In addition, we analyzed the effect of berm presence, berm height, distance from the berm to the sea and from the nest to the berm, in every turtle encountered. We recorded their nesting activity and the results showed that berm presence significantly increased the number of doomed clutches and altered the behavior of the turtles since they seem to prevent females from laying eggs on the optimal areas, which are less likely to get inundated. Finally, we analyzed the effect of spreading dune vegetation on hatchlings by measuring the rate at which hatchlings moved to the water from open beach locations versus vegetated areas. Thus, we found that dune vegetation seemed to negatively affect hatchling speed which increasing the exposed time to predators. To sum up, presence of high berms and spreading dune vegetation appears to negatively affect nesting females and hatchling of leatherback turtles in Caribbean Costa Rica. These effects may be higher in a present scenario of climate change with expected increase in beach erosion by sea level rise.

RESEARCH & CONSERVATION PRIORITIES TO PREVENT EXTINCTION OF THE WESTERN PACIFIC LEATHERBACK (*DERMOCHELYS CORIACEA*) BOREAL WINTER NESTING GROUP

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The Pacific leatherback (*Dermochelys coriacea*) is critically endangered and may be on the verge of extinction. In the western Pacific there are two nesting seasons, during the boreal summer (June-September) and the boreal winter (November-February) that show different post nesting movements. The boreal summer group moves northward into large marine ecosystems of the temperate North Pacific Ocean or into tropical waters of the South China Sea, while the boreal winter nesters move south ward into tropical and temperate southern hemisphere waters. Recent analysis of long term nesting beach surveys from the major nesting beaches shown alarming declines in the nesting for both nesting seasons. Previous reports suggest that threats include hunting of nesters on the nesting beaches, collection of eggs, loss of nests due to storms possibly related to climate change, and fisheries bycatch particularly in the shallow longline fishery, unfortunately there is very little quantitative information on the actual threats. This presentation will concentrate on potential threats to the boreal winter nesters that move to the southern hemisphere. Data will be presented: from nesting beaches in Vanuatu: sighting and strandings in New Zealand: and bycatch data from the Western and Central Pacific shallow long line fishery in southern hemisphere waters (south of 30 degrees). This data will be used to identify major threats, gaps, future research, and conservation priorities.

POLLUTION SURVEY RESULTS ON NESTING BEACHES IN GUANACASTE, COSTA RICA 2011-2013

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Marine debris in the ocean, as well as on beaches, has been shown to negatively affect sea turtles at varying stages of life. Pollution surveys were conducted in July and August of 2011 and 2013 on the tourist beach of Costa de Oro and the remote Caletas-Arío National Wildlife Refuge in Guanacaste, Costa Rica. We used the National Oceanographic and Atmospheric Administration's (NOAA) protocol for marine debris surveys in order to characterize types, sizes and density of debris. We conducted "standing stock" surveys weekly, sampling micro (.5 - 2.5 cm), macro (2.5 - 30 cm), and large debris (>30 cm) along four random transects in 100-m long zones. To compare methodologies, we also implemented the NOAA "accumulation" survey at the end of the study for which every piece of trash was surveyed and removed from the zones. Although the protocol suggests stratifying 100-m zones by land use, we stratified ours into high, low, and zero turtle nest density zones. To test the success of beach clean-ups versus natural pollution movement, we also added a 100-m zone that was cleaned on an as-needed basis by hotel employees. Over the study period the average density of macro trash at Costa del Oro in 2013 was 0.273 pieces/m². The average density of macro trash at Caletas was 0.266 pieces/m² in 2011 compared to 0.186 pieces/m² in 2013. Macro size pollution (0.5 to 2.5 cm) represented over 90% of the items sampled on both beaches and both years, of which the majority was plastic (>90%). In terms of turtle nest density, on Costa del Oro there were no significant differences in trash between the high, low and zero zones for any size debris category (F=1.32; p=0.33, ANOVA). However, for Caletas, during both years there was a significantly lower average macro trash density in the high nesting zone compared to the low nesting zone (t=4.69; p= 0.002, t-test). The zone on Costa del Oro that was cleaned by hotel employees had less debris, but not significantly less than the non-cleaned zones based on our Student's t-tests. When the two survey methods were compared, there was no significant difference between the extrapolated "standing stock" density estimates versus the "accumulation" density results (t=2.10; p= 0.13, t-test). On Caletas there was not a significant difference in density of macro trash between years at Caletas (t=-1.38; p= 0.21, t-test). Because of the apparent stability over time, and similar results from both NOAA methods, we recommend continuing the surveys quarterly on these beaches, and using the less labor-intensive "standing stock" methods. Although we recognize more extensive and controlled experiments are needed, based on our preliminary results we conclude that as-needed beach clean-ups may not be as effective as we believe, especially with a constant pollution source such as a hotel. Therefore, we encourage the government and non-profits to also focus on source control, for example, by promoting plastic alternatives for consumers.

UPDATE ON SEA TURTLE BYCATCH BY DEEP SET PELAGIC LONGLINES IN URUGUAYAN WATERS

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Deep set (>100m hook depth) pelagic longlines are considered to have substantially lower sea turtle bycatch rate than shallow set longlines. The pelagic longliners operating in Uruguayan waters have been exclusively using shallow longlines during the last 25 years. Between the years 2009-2011, the government of Uruguay granted experimental fishing licenses to a Japanese company to assess the abundance and economic feasibility of targeting big eye tuna

within the country's EEZ, where it has not been targeted for the last 15 years. These boats operated with 100% observer coverage of the National Program of Observers Onboard the Tuna Fleet (PNOFA), managed by the National Direction of Aquatic Resources (DINARA). During the falls and winters of 2009-2011, 1,045 sets were deployed. The observers obtained information of the fishing gear and operative, recorded the whole capture and identified the species of each captured individual, including all sea turtles. Hook depth was measured using TDRs, and averaged 133m ranging between 75 and 210 m (n=92 measurements). Most of the turtles were loggerheads, but leatherback, green and olive ridley turtles were also captured. The turtle's CPUE was found to be similar to that of the traditionally employed shallow set longlines operating in the region. Thus, the idea that pelagic longliners targeting tuna with deep set longlines do catch fewer turtles, needs to be considered with caution. Thanks for the support of the International Sea Turtle Symposium and the International Sea Turtle Society, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation, U.S. National Marine Fisheries Service, Sea Grant-Texas, Shell, International Seafood Sustainability Foundation, Wildlife Computers, Environmental Business Specialists LCC, Sea Turtle Conservancy, Florida TURTLE license plate program, SIRTRACK, CLS America, Ecological Associates Inc., Desert Star Systems LLC, Loggerhead Marinelifelife Center. Janet Hochella, Kiki Jenkins, Sea Turtle Project-Bangladesh, Marinelifelife Alliance, Matthew Nash, Mission: Clean Beaches, Sandy Sly, ProFaunaBaja – ASUPMATOMA, Usagi Family and Debbie Sobel.

NO NEWS IS GOOD NEWS, JUVENILE MARINE TURTLES UNAFFECTED BY HABS IN INDIAN RIVER LAGOON, FLORIDA

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The Environmental Protection Agency (EPA) defines the Indian River Lagoon (IRL) as an estuary of national significance. It consists of a multitude of habitats including mangroves, marshes, maritime wetlands and seagrass beds. This area of concern is threatened by humans. The University of Central Florida Marine Turtle Research Group (UCFMTRG) has been studying the IRL juvenile marine turtle populations for over 30 years. Green turtles (*Chelonia mydas*) and loggerheads (*Caretta caretta*) in the UCFMTRG study area utilize the seagrass beds and other natural elements of the lagoon as an important developmental habitat. A harmful algal bloom (HAB) is an extreme concentration of naturally-occurring algae that causes negative impacts to an ecosystem by creating hypoxic conditions, releasing toxins, and increasing turbidity. HABs are often associated with high concentrations of nitrogen and phosphorus, which are often human induced side effects found in water runoff. These blooms have been attributed to a decline in health of a range of species, and in extreme cases can alter the habitat. Since 2011, the IRL has continually been inflicted by HABs, contributing to deaths in mammals, birds and fish. While the impact on this important estuary has been high, thus far no records have been collected on the influence on sea turtles. To address this lack of data, we used the long-term data set collected by the UCFMTRG to examine whether recent HABs have affected the marine turtles of the IRL. Our research focused on whether recent HABs have influenced the body conditions of juvenile green turtles and loggerheads captured in the Indian River Lagoon. From these data, we compared the body condition score of turtles captured in the three-year periods before and after the onset of the most recent HABs in the IRL. I also compared both total capture and recapture rates in these time periods. If the HABs caused poor conditions for marine turtles to be negatively impacted, then I expect to see this reflected in the overall body condition scores or capture rates. Encouragingly, these analyses showed no difference between the time periods, suggesting that the algal blooms have not had a large impact on these species. Though current data indicates that there has not been a significant impact on marine turtles of the IRL, the future of these endangered species will remain poorly known if we are not continuously monitoring the health of their ecosystems. Anthropogenic effects are continuing to have harmful influences upon the world's ecosystems and these impacts are likely to accumulate. Although one species is not altered by human behavior, it does not necessarily accurately reflect the well-being of other species or that of turtle species under continual stress. Continuous monitoring of the ecosystem and the development and application of effective renewal strategies are necessary to restore the health of the watershed. Therefore, it is crucial that we not only continue to gather information on these impacts, but also that we utilize this data to develop strategies for lessening them.

FIRST DOCUMENTATION OF MULTIPLE SEA TURTLES STRANDINGS IN LAKE BARDAWIL, EGYPT, DURING 2012: DATA AND CONSERVATION IMPLICATIONS

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In October 2012, the media reported the “mass deaths of sea turtles” in Bardawil Lake, Egypt, which is a shallow (max. depth 2.5-3 m) and hypersaline (range 37.38-65.59 mg/l) enclosed waterbody with 3 openings into the Mediterranean Sea. Different sections of the lake were surveyed 7-times in October 2012. On 2-3 November 2012, we resurveyed the lake to collect additional data, in parallel to interviewing key informants. Data were assimilated and analysed in conjunction with a literature review, to determine potential causes and propose actions to reduce sea turtle mortality and improve conservation efforts. Around 80–100 sea turtle carcasses were documented by the surveys. A review of the photographic records identified 87 unique dead turtles, plus 1 live injured green. Seventy-two loggerheads, 8 greens and 1 leatherback were identified. Carcass decomposition states indicated that it was not a single mass stranding event, but occurred over at least 6 months (16 within 1 month of being found; 29 within 6 months; and 42 at least 6 months). However, the cause of death could not be determined, with just 5 turtles exhibiting signs of external damage (head trauma). The turtles belonged to sub-adult and adult size classes (loggerheads 54-83 cm CCL; greens 58-84 cm), indicating that the lake is used as a foraging and/or wintering habitat. Furthermore, turtles from breeding areas in the Eastern Mediterranean (including Cyprus and Syria) have been tracked to this lake. Data published prior to 2000 reported low loggerhead and green nesting activity on the lake’s outer shore, also confirmed by local researchers, with fishermen claiming to have observed mating activity within the lake. The cause of death might be attributed to human or natural factors. While the lake does not appear polluted, there is fisheries interaction, with some claims of fishers using poison. Alternatively, excessive salinity levels or toxic algal blooms might make the lake physiologically intolerable to turtles during summer. However, other flora and fauna would have been impacted, which does not appear to have happened. Of concern, interviews with the local community documented a hostile attitude of fishermen towards sea turtles, due to low awareness, turtles damaging gear, illegal and overfishing activity, and limited involvement of fishermen in lake management, among other issues. Bardawil Lake is a Ramsar site of high ecological value, with approx. 45% receiving national protection since 1985. It is important to establish regular and standardised surveys of sea turtle activity (breeding, foraging/wintering), and to document the frequency and causes of strandings. Development projects in the near future may further affect the lake ecosystem; therefore, it is important to implement bottom-up ecosystem-approach management and regulation, with improved coordination among conservation and fisheries authorities, to ensure the lake is afforded the required protection actions and to maintain the lake’s ecosystem services, on which local communities depend. The full peer-reviewed report may be downloaded at www.medasset.org.

A SEA TURTLE CARCASS DRIFT MODEL FOR COASTAL WATERS*

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Estimating the likely source location of sea turtle mortality during stranding events is problematic because of the lack of parameterization of carcass drift and a paucity of high resolution hydrodynamic models. We approached this problem by combining wind, current, and temperature data from two newly developed hydrodynamic models with sets of drift observations from moribund animals, simulated carcasses, and prior studies of temperature related carcass decomposition rates. Two satellite-tagged moribund Kemp's ridley turtles, initially alive and tagged by the Institute for Marine Mammal Studies for a site fidelity study, stranded in Mississippi coastal waters in 2011 and 2013. Data from these two strandings provided an accurate time sequence of 58 h and 60 h, during which the animals were presumed to be drifting based on observed characteristics that were typical of a floating carcass. Additional confirmation of drift properties were also provided by the deployment of surface drifters designed to simulate the drift characteristics of a sea turtle carcass. Object drift data were then compared to simulations using the output of wind, currents, and accumulated degree-hours (ADH) from either the America SEAS (AMSEAS) or Northern Gulf of Mexico Operational Forecast System (NGOFS) hydrodynamic models to provide an estimate of decomposition and surface drift. ADH, is a standard forensic tool used to measure heat integrated over time and assess decomposition and the post-mortem interval. For turtle carcasses, we use a base temperature of 0 deg C, the temperature at which we assume no decomposition occurs. Overall our results in Mississippi coastal waters suggest the best fit to observed drift tracks are provided by using surface currents plus 3.5% of the apparent wind field and carcasses floating from the bottom to the sea surface at 1,000 ADH, with the onset of severe decomposition (skin and scutes sloughing or missing, Code 3), when ADH exceed 2,500.

SEA TURTLE AS BY-CATCH IN ARTISANAL FISHERIES OF FIVE COASTAL COMMUNITIES IN OGUN STATE, SOUTHWESTERN, NIGERIA

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Five species of sea turtles that have been reported as by-catch in artisanal fisheries in Nigeria. They are Atlantic loggerhead, Atlantic green sea turtle, hawksbill, olive ridley and leatherback. Sea turtle investigations in Ogun coastal areas is still in the early stages and adequate knowledge of sea turtle biology and ecology. This study was carried out in five coastal fishing communities in Ogun State including Okunlape, Akede-bolorunduro, Akede-Nla, Okun igbosere and Okun imosan. Sea turtle bycatch was surveyed at fish landings sites and nesting areas between August 2010 and April 2011. Focused group discussion, interviews and questionnaire were used to investigate the occurrence, abundance, and species of sea turtle at each community. Also, human threats to sea turtles were evaluated. All five sea turtle species reported as bycatch in Nigeria are also harvested as bycatch in all five communities surveyed. From this survey there are indications that sea turtle populations in Ogun state is declining compared to the past years. Further investigations into biology and ecology of sea turtles in Ogun State are necessary in order to ascertain the status and conserve this species.

UNTANGLING FISHERMEN –TURTLE RELATIONSHIPS: PERCEPTIONS OF SEA TURTLE INTERACTIONS WITH SMALL-SCALE FISHERIES IN CRETE, GREECE*

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Interactions with small-scale fisheries and the associated direct and indirect mortality present a major conservation challenge for sea turtles in Greece. Despite the fact that Crete is a site of regional importance for Mediterranean loggerhead turtles, these populations are under threat from tourism-related beach degradation, and impacts associated with incidental capture in fishing gear. In an effort to identify effective management policies to mitigate fisheries' impacts on sea turtles in the area, our research focused on small-scale fishing. We interviewed fishermen about turtles and their perceived impacts on their profession and livelihoods. We conducted interviews in 14 fishing ports around Crete, in June-August 2013, using a questionnaire of 36 questions about four topics (demographics, fishing activity, interactions with turtles and fisheries management issues). We administered one questionnaire per fishing vessel, resulting in a total of 101 participating fishermen. Analysis of responses reveals that 96.0% of fishermen state that their catch has decreased by up to 80% over the last 5-10 years, and 84.2% believe that fish stocks have also decreased more generally. Participants also reported significant reductions both in numbers of species (62.4%) and in the sizes of fish caught (77.2%). To compensate for such decreases, 64.4% of respondents said they had increased the amount of gear used - some had even reduced the size of gear (e.g. smaller sized mesh or hooks). In addition, 33.7% of respondents stated that they had substantially increased their fishing effort. Respondent perceptions of sea turtle populations included 67.3% who viewed sea turtle populations in Crete as having increased in the last 5-10 years—a perception that is not in sync with current data on sea turtle nesting activity on the island. Such data indicate sharp population declines. Investigating the root of this perception on the population of sea turtles is therefore a key part of understanding whether a true increase exists or whether an increase in fishing effort results in increased interactions with turtles and thus the opinion that there are more of them. Increased interactions between fishermen and turtles may have significant conservation implications since the associated mortality rate is very high. If one of the reasons for the rise in the numbers of dead turtles reported in Greece since 2006 is more interactions in the face of declining fish stocks and increased fishing effort, the need for more research into the complex relationships between fishermen and turtles is clear. Small-scale fisheries interactions with turtles is a dynamic and multi-faceted issue, intimately linked to the relationships between fishermen and fish. Acknowledgements: This project was funded by the Betz Chair endowment and the Claudio Elia fellowship program. The authors wish to thank ARCHELON's project team on Crete for their support. Special thanks are due to the Presidents of Fishermen's Associations in all ports visited as well as to all fishermen who took the time to participate in the survey.

TRAWLERS, TRASH, TURTLES AND TIME*

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We will show the use of the R language for automated scripting and data mining for scientific reporting. Many organizations are faced with the time-consuming task of generating updates to monitoring and evaluation efforts. This talk will show how those tasks can be automated to provide mapping, statistical analysis and data driven reporting for both interactive online and print reports. We will use beach trash data from the Georgia Sea Turtle Center marine debris program, fisheries catch data from the coast of India, and turtle nesting data combined with oceanographic data

from NOAA and USGS to show how data from a variety of sources can be compiled, joined, analysed, mapped and integrated into ongoing reports. The mapping will use both the Google Maps API and the GGMAPs interfaces to display mapping data. We will also show how this system can produce mapping products for ArcMap. We will test several hypotheses on the fly--particularly for significant changes in relationships. Is trash increasing over time, are traditional fisher folk fishing down the food chain, are there relationships between nesting success and oceanographic parameters. All code and public datasets will be provided to session attendees. Code and tutorials will also be available in advance of the talk.

GLOBAL PATTERNS OF MARINE TURTLE CONSUMPTION

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Directed harvest of wildlife for food is considered to be a major threat to biodiversity and the consumption of rare wildlife continues to impact many vulnerable populations. Sea turtles have historically been an important food resource for many coastal inhabitants, and have been exploited for their meat, eggs, and shell since at least 5000 BC. Today, despite well-documented national and international protection, consumption of sea turtles for food remains a major threat to many populations worldwide. Here, we assess the global patterns of sea turtle consumption based on a comprehensive literature review. We focus on all seven sea turtle species and their corresponding populations and identify global consumption 'hotspots'. We use Regional Management Units (RMUs) to assess consumption. Our poster will display high-quality maps that will depict the global distribution of sea turtle meat and egg consumption. Results of our study will be used to identify consumption hotspots and inform sea turtle management strategies around the globe. Researchers can also use the data to address existing gaps and conduct further studies. Overall, this work will facilitate prioritization of consumption impacts within and among sea turtle populations and will provide a framework for identifying effective management strategies in light of human-use and ecological objectives.

HIGH-USE AREAS, SEASONAL MOVEMENTS OF LEATHERBACK SEA TURTLE AND FISHERIES INTERACTION IN SOUTHWESTERN ATLANTIC OCEAN

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The leatherback turtle (*Dermochelys coriacea*) is a globally distributed species, which undertake broad oceanic movements while traveling between breeding and foraging areas and is subject to fisheries bycatch throughout its range. Studies in the North Atlantic have suggested that leatherbacks may be particularly at risk along dynamic oceanic fronts where turtles feed on gelatinous plankton and where fisheries also concentrate, although these findings are based on small sample sizes ($n < 20$ individuals). In the past decade, many satellite-tracking studies of leatherback turtles in

the Atlantic Ocean have been published, and each of these studies has given an essential, yet partial, description of habitat use and results have highlighted the importance of the Rio de la Plata Estuary as a key foraging ground for leatherback in the Southwestern Atlantic Ocean (SWA) which should be considered a central focus of attention for conservation efforts. We present the integrative analysis of the spatio-temporal distribution and habitat use of leatherback turtles between reproductive seasons in the Rio de la Plata Estuary. This information is combined with data on the distribution of trawl fishing effort obtained from the data base of Ministry of Agriculture, Livestock and Fisheries of Argentina across the same temporal period. Leatherback turtles were fitted with satellite relayed data loggers (SRDL) in 2005-2013 after being incidentally captured by industrial and artisanal fisheries. Turtles used the exclusive economic zones (EEZs) of Brazil, Uruguay and Argentina in SWA presenting seasonal movements along the coasts. Data suggest that the Rio de la Plata Estuary is an area highly frequented by the leatherback turtle with a high impact which coincides with the development of fisheries. This is a unique opportunity to identify the areas and seasons of highest turtle susceptibility to bycatch and provides much-needed preliminary guidance on the design and implementation of potential bycatch mitigation measures at an oceanic scale. Although turtles and fisheries show highly diverse distributions, we highlight areas of high susceptibility to bycatch that are worthy of further targeted investigation and mitigation. Minimizing bycatch, or the unintended capture of non-target organisms during fisheries operations, is a key component of sustainable fisheries management that maintains marine biodiversity.

PATTERNS OF MARINE TURTLE BYCATCH REPORTED IN COMMERCIAL FISHERIES LOGBOOKS, AUSTRALIA

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The incidental capture (bycatch) of marine turtles in fisheries is widely acknowledged as a serious threat to the survival of turtle populations around the globe. Bycatch rates in commercial fisheries can be difficult to quantify for many reasons, including the typically low levels of coverage by observer programs. In Australian commercial fisheries, bycatch of threatened, endangered and protected (TEP) species such as marine turtles is regulated at both the state/territory and Commonwealth level. All interactions between fishing gear and TEP species are required by law to be recorded in fishers' logbooks and reported to the relevant management agency. For long-lived species such as marine turtles, however, bycatch data must be analysed across multiple fisheries and biologically relevant timescales (>10 years) in order to determine cause and effect between fisheries bycatch and observed population declines. This study collected and analysed >13 years of marine turtle bycatch records from logbooks in Australian state/territory and Commonwealth commercial fisheries. The aim of the study was to determine patterns of marine turtle bycatch, particularly spatial, temporal, species and gear type-specific correlations. All reported interactions between turtles and fisheries were mapped and analysed to determine locations of possible bycatch 'hotspots'. A total of 873 interactions between marine turtles and fishing gear were reported in Commonwealth fisheries (2000-2013). Data from logbooks in Commonwealth-managed fisheries indicates that four fisheries—representing two gear types (pelagic longlines and trawls)—account for >95% of reported turtle interactions.

INTERVIEWS WITH FISHERS SUGGEST EUROPEAN LONGLINING THREATENS SEA TURTLE POPULATIONS IN CAPE VERDEAN WATERS*

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Cape Verde hosts the third-most globally important nesting population of loggerhead turtles, *Caretta caretta*, an endangered species according to the IUCN. No other sea turtles nest significantly on these islands, but young green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles are common in inshore waters. Critically Endangered leatherbacks, (*Dermochelys coriacea*), nesting in the Western Atlantic regularly migrate through the area. Pelagic longlines may represent the single most serious global threat to sea turtles such as loggerheads and leatherbacks. Virtually nothing is known on sea turtle bycatch levels in pelagic longlines in the tropical eastern Atlantic, although this information is likely critical for the conservation of the Cape Verde loggerhead population, as well as for many other Atlantic sea turtle populations. Interviews were obtained from 17 fishermen from 4 Cape Verde islands. The diversity of information on fishermen origins, areas fished and on-board practices, suggests that they covered a wide range of experiences. All fishermen reported that sharks are the main target of the fishery, despite the fact that vessels are licensed to catch tuna, sharks are officially bycatch. All fishermen reported that turtles are regularly captured. Overall, 10 fishermen were willing to present figures and estimated that a mean of 4.2 ± 1.5 SD (range 2-7) turtles were caught per longline set. 35 longliners are licensed to fish in Cape Verdean waters: 26 from Spain and nine from Portugal. Furthermore, there is clear evidence of IUU (illegal, unreported and unregulated) longline fishing in Cape Verdean waters, including vessels from Asia, which might be important given the low levels of surveillance and marine law enforcement. Bycatch is affecting one of the most important loggerhead populations in the world and, according to the present study, the common practice is to kill the turtles that are still alive when they come onboard. There are some limitations of the present study. Nevertheless, there are important lessons to be learnt, with urgent implications for conservation. More data and monitoring are needed to quantitatively estimate bycatch and mortality levels and monitor their evolution in response to changes in fisheries practices and conservation initiatives.

PREDICTING BYCATCH HOTSPOTS FOR ENDANGERED LEATHERBACK TURTLES ON LONGLINES IN THE PACIFIC OCEAN*

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Fisheries bycatch is suspected to be a critical source of mortality for leatherback turtles (*Dermochelys coriacea*) in the Pacific Ocean, where populations have declined precipitously in recent decades. Using tracks from satellite telemetry and state-space models, we describe spatial and temporal use-intensity distributions of leatherbacks from 1992 – 2008, including individuals from nesting populations in the eastern and western Pacific. Turtle distributions were integrated with data on longline fishing effort to estimate the relative intensity of these interactions over space and time. We estimated a total of 31,074 positions for 135 turtles. Areas of predicted interaction between turtles and fisheries included the seas of the Western and Central Tropical and North Pacific, with a region of highest concern adjacent to beaches that harbor the largest remaining nesting population in the entire Pacific. In the Eastern Pacific, predicted bycatch risk was relatively moderate along nesting migration paths but intensified near the Galapagos Islands, while

areas of highest concern occurred broadly in the South Pacific Subtropical Gyre and bordering equatorial currents. The locations of potential interaction hotspots shifted seasonally according to changes in turtle behavior, fishing effort, or both. Our models provide a tool that resource managers can use in regional ocean planning, and to inform fisheries management aimed at reducing leatherback bycatch in longlines.

ENTANGLEMENT OF SEA TURTLES BY FLORIDA TRAP FISHERIES

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The entanglement of marine turtles in fishing gear is considered a substantial threat to the recovery and conservation of these endangered species. Non-degradable polyethylene buoy rope associated with spiny lobster, stone crab, and blue crab traps deployed in Florida represents one source of turtle entanglement in fishing gear. During 2013, the State of Florida issued permits that allowed the commercial fisheries for those three species to deploy as many as 1.9 million traps. In addition to those traps, there are an unknown number of lost and abandoned commercial traps, as well as an unknown number of recreational stone crab and blue crab traps. Data from Florida's Sea Turtle Stranding Network (STSSN) indicate that among fishing gear interactions, the number of marine turtles entangled in the buoy rope of traps is surpassed only by the number entangled in monofilament fishing line. Marine turtles that become entangled in the buoy rope of traps often drown or die from strangulation. Sub-lethal impacts include ligature wounds that can result in loss of a flipper. We summarize observations of trap buoy rope entanglements recorded by the STSSN from 1986 through 2013; we assess the species-specific spatial and temporal distribution of turtle entanglements during this period; and we discuss current management policies and the efficacy of additional management actions designed to minimize the impacts of this fishing gear on marine turtles.

BYCATCH AND DIRECTED HARVEST DRIVE HIGH GREEN TURTLE MORTALITY AT BAJA CALIFORNIA SUR, MEXICO

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Evaluating mortality of rare marine megafauna is crucial for conservation planning, but logistically difficult to undertake at sea. Here, we assess green turtle mortality through surveys of beaches and town dumps for stranded and discarded carcasses at nine index sites along the coast of Baja California Sur, Mexico (BCS). To our knowledge, this is the largest green turtle mortality dataset ever compiled from Latin America. We found a total of 778 carcasses, 93% of which were immature. Mortality rates ranged from 0.05 to 9.20 carcasses per km per year at beaches and 2.84 to 66.75 carcasses per year at dumps. All carcasses found at dumps (N = 339) were attributed to human consumption, whereas cause of death at beaches was largely unknown (62%), followed by bycatch (30%), and consumption (8%).

Proceedings of the 34th Annual Symposium on Sea Turtle Biology and Conservation

Over two thirds of total mortality resulted from consumption (48%) or bycatch (20%), and turtles that died from these causes were significantly larger than those that died from unknown reasons. The majority of carcasses at beaches (69%) and dumps (57%) were found during summer months when small-scale gillnet fisheries operate, including 99% of identified bycatch mortality. Three hotspots accounted for 77% of all mortality, which was disproportionately high (40% of total mortality) at one site where mass-bycatch/stranding events occurred annually. Our results demonstrate that many green turtles are being killed from bycatch and directed harvest at BCS despite over two decades of federal protection; thus, highlighting the need to mitigate these threats at mortality hotspots.

GOING BEYOND TEDS TO SAVE SEA TURTLES FROM SHRIMP TRAWLS

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After three decades of Turtle Excluder Devices, the U.S. shrimp fishery remains responsible for 98 percent of sea turtle bycatch with an estimated 534,756 interactions and 52,534 mortalities every year. Today's excessive bycatch levels are significantly higher than estimated 10 years earlier of 341,150 sea turtle interactions and 8,930 mortalities. Sea turtle bycatch remains unacceptably high because TEDs compliance rates in the otter trawl fleet average 66 percent in the Gulf of Mexico and 40 percent in the South Atlantic. It is also alarming that the state of Louisiana, with the largest shrimp fleet, prohibits enforcement of federal TEDs laws in state waters. As a result of this poor compliance and enforcement, use of TEDs has failed to adequately protect endangered and threatened sea turtles from capture and drowning in shrimp trawls. This presentation will document the need for radical change in the way that the shrimp fishery is managed in order to ensure the long-term survival and recovery of sea turtle populations in the U.S. Technical fishing gear fixes including TEDs can no longer be relied upon as the silver bullet solution to sea turtle bycatch. In addition to requiring TEDs on all shrimp trawls, sea turtle bycatch solutions must include: (1) time and area closures, (2) identification and prevention of hotspots of sea turtle mortality (3) mandatory observer coverage and electronic vessel monitoring, (4) no-fishing marine preserves in key sea turtle habitat, (5) significant reduction of overall fishing effort; and (6) adequate enforcement.

GREAT BARRIER REEF'S MARINE TURTLES AT RISK FROM MASSIVE FOSSIL FUEL PROJECTS IN QUEENSLAND, AUSTRALIA

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More than a dozen massive fossil fuel projects and ports planned in the Great Barrier Reef World Heritage Area will destroy and degrade critical nesting, feeding or migration habitat for globally significant populations of marine turtles in Queensland, Australia. The six species in the region are all considered at risk of extinction due to human activity. Allowing oil, gas, and coal companies to industrialize essential marine turtle habitat in the Great Barrier Reef World Heritage Area will only push these vulnerable marine animals ever closer to the brink. Direct and indirect impacts to marine turtles and habitat from Liquefied Natural Gas (LNG) and coal facilities and ports are generated by construction and operations from dredging, pile driving, drilling, seismic blasting, lighting and flaring, vessel strikes, toxic

discharges, trash including plastics, air pollution, water pollution, oil spills, fuel spills and noise. Spikes in strandings totaling more than 3,000 sea turtles over two years occurred as new industrial projects got underway. Ship strikes alone killed 45 turtles over two years in Gladstone Harbor since Curtis Island's LNG project began, compared to an average of two per year for the previous 10 years. This poster will highlight the LNG and coal projects underway or proposed along the Queensland Coast and the Great Barrier Reef World Heritage Area. It will make recommendations for policies and actions to prevent harm to marine turtles and the ecosystem. Urgent action is needed to prevent harm to vulnerable marine turtle populations and to ensure that the Great Barrier Reef does not lose its World Heritage Status due to rapid industrialization.

CURRENT STATUS OF TURTLE EXCLUDER DEVICE (TED) COMPLIANCE IN THE NIGERIAN SHRIMP TRAWL INDUSTRY

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USA recognises Nigeria as one of the 13 countries world-wide, that have regulatory programs governing the incidental capture of sea turtles in commercial shrimp trawling based on Section 609 of Public Law 101-162. Therefore, a 2-man team of USA Scientists/Experts was permitted by the USA Congress to carry out a thorough inspection of TEDs in shrimp trawl nets in Nigeria as a pre-condition for recertification of Nigeria for shrimp exports mainly to EU and USA markets. The inspection took place between 12th and 19th August 2013, after a pre-inspection workshop under the auspices of Federal Department of Fisheries (FDF) in collaboration with Nigerian Institute for Oceanography and Marine Research (NIOMR). 50 trawlers out of a total of 122 shrimp trawlers registered by FDF in 2013, were scheduled for inspection. However, one trawler was hijacked on her way to the port and a total of 196 TEDs were inspected from 49 vessels from 5 shrimping companies including Atlantic Shrimpers, ORC, Barnaly, Sea Gold/Sea Bless and Karflex. TED specifications included cod end extension, grid type, size and bar spacing, grid angle, size of escape opening and knot orientation of the flap cover as well as floatation. The inspection exercise also involved the construction/refinement of TEDs with single and double covers respectively as well as video presentation on the production of aluminium flat bar grid to replace the pipe grid currently adopted by the Industry. Digital angle meters were introduced during the workshop. The result of the inspection as compiled by the US delegates rated the compliance level of the Nigerian shrimping industry at 63.3% which has been adjudged to be one of the highest in the world and second only to Mexico. Efforts are being made to train more Inspectors and conduct workshops/outreach sessions to update the knowledge of the captains, trawler fishermen and the management staff accordingly.

IDENTIFYING VESSEL-STRIKE PRONE AREAS OF SARASOTA'S INSHORE COASTLINE: A SPATIAL AND TEMPORAL ANALYSIS*

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Mote Marine Laboratory's Stranding Investigations Program (SIP) has been responding to live, injured, and dead sea turtles in all of Sarasota county and part of Manatee county, Florida since 2003. Increasing pressures of coastal development in a large "snowbird" and tourist area have placed sea turtles at a higher risk of negative interactions with humans. The approximate 400 miles of Southwest Florida coastline, including exposed beaches, estuaries, and associated inland rivers that the SIP responds to, largely overlaps with areas of high vessel traffic, leading to conditions that are particularly auspicious towards vessel strikes for sea turtles. The purpose of this study was to examine the distribution sea turtle strandings exhibiting signs of human-interaction to determine if there is an area where sea turtles are more prone to succumbing to anthropogenic factors. Temporal and spatial data on local human activities and

shoreline development were processed in ArcGIS v10.1 and Spatial Ecology LLC's Geospatial Modeling Environment v0.7.2. Over 700 turtles from five species of turtles have been recovered by the SIP from the response area. Of these, over 28% of recovered sea turtles showed indications of fisheries interaction, debris ingestion, mutilation, or vessel strikes. Vessel strikes alone accounted for approximately 67% of all human-interaction related sea turtle strandings. Areas with the highest density for human-interaction stranded sea turtles included passes between the keys and navigation channels within the ICW. We hope to more fully understand the areas of concern for sea turtles to provide for improved conservation and management efforts. Education and outreach outlining areas of concern and safe boating practices appropriate for turtles will be more effective with better insight on where vessel strikes are prone to happen.

EFFECT OF BEACH POLLUTION ON HAWKSBILL HATCHLINGS OFFSHORE MIGRATION IN CARIBBEAN HONDURAS

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Initial migration of turtle hatchlings from nest to water is a critical time period of their life cycle. The speed with which this task is completed has a noticeable effect on their overall survival rate. To observe this initial migration, we constructed four treatment sites with varying densities of pollution on Pumpkin Hill Beach along the northeastern coast of Utila, Honduras. We manipulated the pollution in each treatment site to represent different densities, thereby establishing a control corridor, a high density level corridor (HD), a medium density level corridor (MD), and a low density level corridor (LD). These corridors were $8 \text{ m} \pm 1.3$ long and 1 m wide, and separated from one another by bamboo logs. We then observed the run time of *Eretmochelys imbricata* hatchlings by releasing the hatchlings and measuring their crawl time through these corridors. Two hatchlings were released simultaneously with timing beginning when the hatchlings were released, and ending when the hatchlings reached the end of the corridor at the water's edge. We found that the run time was longest at higher pollution densities. The mean ranking of crawl times was: HD ($854 \pm 28.2 \text{ s}$) > MD ($536 \pm 13.9 \text{ s}$) > LD ($396 \pm 4.88 \text{ s}$) > Control ($336 \pm 12.46 \text{ s}$). These results suggest that an increase in plastic pollution may increase time from nest to water, which may ultimately result in an increased exposure to predation.

GREEN TURTLE PREDATION BY JAGUAR IN THE GUANACASTE CONSERVATION AREA, COSTA RICA

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Adult sea turtles are large vertebrates with relatively few predators. However, at a few places in their distribution range, predators may be large and abundant enough to cause an impact on a given nesting sea turtle population. Although some sea turtle populations are large enough to escape the effect of large predators by nesting in

overwhelming numbers, such as is the case of arribada olive ridleys, some sea turtle populations may be too small and nest too sparsely to cause this “swamping” effect. Green sea turtle populations in the Caribbean coast of Costa Rica are very abundant and support relatively few large terrestrial predators, such as jaguars and crocodiles. However, on the Costa Rican Pacific coast green turtles are present in small nesting populations. Over the last 10 years an increase in the number of olive ridley and green turtle predation by jaguars has been reported at Nancite and Naranjo beaches, indicating that the jaguar populations are recovering, which is particularly true within the Guanacaste Conservation Area (ACG). Recently, a relatively large green turtle population was discovered west of these beaches in the vicinity of the Murcielago Archipelago, in San Jose Island off the Santa Elena peninsula, ACG. Here a peak in green turtle nesting numbers was detected between the months of December through April. It was unclear whether the adjacent mainland beaches supported a jaguar population and if they represented a problem to the newly discovered nesting population. Consequently, we organized an expedition to Colorada beach on the mainland across from the Murcielago Archipelago on June 2013. During our visit we counted just over 70 sea turtles likely killed by jaguar within the last two months. This number is impressive, especially when compared to reports of just over 80 green turtles killed in Tortuguero National Park over the lapse of a season. Only four of five of the turtles were olive ridleys; the rest were green turtles. This suggests either a preference for green turtles or a small nesting ridley population. No other species was recognizable among the casualties during the expedition. Interestingly, four green turtles had been tagged during the previous months at the main nesting beach on San Jose Island, which indicates a relatively loose site tenacity for nesting green turtles in the region. Given that this green turtle population is not as large as its counterpart in Tortuguero, it is possible that the level of jaguar predation sustained by these turtles may play a role in regulating the abundance of this green turtle population. We recommend the continued monitoring of the predation levels along with the abundance of this green turtle population to inform potential protection strategies to ensure the long term survival of both jaguar and sea turtles in this part of the GCA.

GETTING HOOKED: A STUDY TO BETTER UNDERSTAND SEA TURTLE LONGLINE BYCATCH*

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Loggerhead and leatherback sea turtles are often caught as longline bycatch in fisheries worldwide. These species of sea turtle differ greatly in life history, morphology, and the ways they are hooked. Leatherbacks tend to be “foul hooked,” externally in the shoulder or flippers, while loggerheads tend to be hooked in the mouth or they swallow the bait so that hooking is internal (esophagus or stomach). The numbers of loggerheads and leatherbacks caught decreased after changes in gear, bait and time of sets. However the proportion of leatherback mouth hookings increased while foul hooking decreased. We described and compared prey approach and attack behavior of both species in the presence and absence of visual targets. Waterborne squid and jellyfish odors were used to elicit feeding behavior in the two species. Visual targets were necessary to elicit biting. Loggerheads approach their prey with the mouth wide open, have exceptionally good aim and usually bite their intended target. This accuracy is consistent with the mouth and internal hooking. Leatherbacks frequently overshoot, miss their intended target then have to re-approach the target multiple times before making contact. Leatherback feeding behavior is disrupted easily if the body or flippers are touched during prey approach. This re-approach behavior may make leatherbacks more prone snagging on lines rigged with J-hooks. The shift by some fisheries to circle hooks, which are less prone to snagging, give the leatherbacks multiple chances to attack the bait and ingest it without getting hooked externally.

MICRO- AND MESO-PLASTICS INGESTION AS A MAJOR SOURCE OF MORTALITY FOR NEONATE SEA TURTLES*

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We studied marine debris ingestion in 380 post-hatchling (neonate) sea turtles that washed ashore dead onto Florida's central Atlantic coast following tropical cyclones. The sample included 284 loggerheads, 95 green turtles, and one hawksbill. All turtles were between 4.09 and 12.56 cm standard straight carapace length (SCL). The strandings occurred between 1994 and 2008. Based upon the small size of sampled turtles and the season during which they were found, none was greater than five months old. All turtles met criteria for post-hatchlings: > 2 SD of mean hatchling size, residual gut yolk < 1 cm greatest diameter, or growth of external hydroids and algae. To sample ingested items, we removed the gut and fixed it in 90 % isopropanol. Plastics or tar ingestion were recorded as yes or no. Tar was verified by rapid solubility in dichloromethane. In a subsample of 92 loggerheads and 88 green turtles, dry weights of total gut contents and of synthetic material (plastics, latex, tar) were measured. In a subgroup of these turtles, ingested plastics were characterized by particle size (length), color, and other characteristics. Of the 380 posthatchlings, 78.7% had ingested plastics and 45.3% had ingested tar. The proportion that had ingested plastics or tar was 89.7%. In the subsample of 92 loggerheads, mean proportion (by dry weight) of plastics in total gut contents was 28.3% (SD=17.8%). In the subsample of 88 green turtles, this mean proportion was 24.4% (SD=19.7%). In both loggerheads and green turtles, there was a significant relationship between turtle size (SCL) and total plastic load at $p < 0.005$. However, there was no relationship between turtle size and proportion of plastics to total gut contents in either species. We conclude that turtles begin ingesting plastics immediately upon first feeding, although larger post-hatchlings are able to ingest more. Colors of ingested plastics ranged widely. Plastic particles included micro plastics (< 5 mm) and larger plastics (meso plastics) with sizes up to 25% of the turtle SCL. The vast majority of particles were flat, angular shards. The evidence points to plastics ingestion as being a major source of mortality in neonate sea turtles.

Genetics and Population Biology

IMPROVED RESOLUTION OF MEXICAN ATLANTIC GREEN TURTLE STOCKS BY USE OF MITOCHONDRIAL DNA SHORT TANDEM REPEAT ANALYSES

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Analyses of the 5' end of the control region sequences from the mitochondrial DNA (mtDNA) have become the method of choice for the identification of sea turtle stocks. In recent years, much needed improvements in the resolution capacity of the techniques have been achieved by increasing the length of the sequence analyzed (e.g. from

360-480 to 740-760bp) permitting, in some species and regions, the capacity to distinguish populations previously believed genetically identical. Using 740 bp 5' mtDNA sequences our laboratory has previously resolved a total of 17 distinct haplotypes in green turtle populations from the Atlantic coast of Mexico with which a total of 4 independent management units (MU) have been identified in the Gulf of Mexico, and at least one more in Quintana Roo state. However, in spite of statistical support for the mtDNA-based MU designations, misgivings remained for population groupings with shared widely-distributed and highly dominant haplotypes such as CM-A1.1 and CM-A3.1. The former was found in more than 70% of the samples in the western range (Tamaulipas and Veracruz), whereas the latter was present in 48-86% of the samples in the eastern range of the Gulf of Mexico rookeries (Cayo Arcas, Alacranes, Campeche, Yucatán). For example, El Cuyo (Yucatan) and Isla Aguada (Campeche) rookeries, more than 550km apart, share CM-A3.1 at frequencies greater than 65% and hence, statistically form part of the same MU. With the aim of verifying the genetic relatedness of samples with dominant and widely-shared mtDNA haplotypes among Atlantic Mexican green turtle rookeries and searching for increased resolution, we have begun genotyping the three loci of short tandem repeats (STR) occurring at the 3' end of the mtDNA on previously characterized samples. Our initial results have revealed informative increases in the genetic variability within unique mtDNA haplotype classes. For example, within the single CM-A3.1 haplotypes class from Isla Aguada and El Cuyo we have found four different STR sequence classes in the former and two in the latter, none of which are shared. In contrast, the CM-A3.1 haplotype samples from Cozumel (Quintana Roo) revealed five STR sequence classes, one of which is shared with El Cuyo, previously considered a different MU. We present a revision of the stock composition of the Mexican green turtle rookeries combining sequence information from both the 5' end singular sequences of the mtDNA control region and the new STR analyses, providing new insight into the levels of connectivity in the region as well as into the evolutionary relationships of these regionally significant populations.

CO-EVOLUTION OF MARINE TURTLES AND FIBROPAPILLOMA-ASSOCIATED TURTLE HERPESVIRUS*

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Fibropapillomatosis (FP) is a neoplastic disease in sea turtles associated with the Chelonid alphaherpesvirus 5 (CFPHV5). FP has global distribution and it has been reported to infect at least five of the seven sea turtle species. Tumours from confirmed cases of FP and non-tumour tissue samples from healthy animals from five different species of sea turtles worldwide were PCR tested and thereafter sequenced for turtle mitochondrial and herpes virus DNA. Posterior probability/bootstrap support (maximum likelihood) chronogram trees were generated. Moreover, quantitative real time PCR method was used to estimate relative amount concentrations of viral and endogenous turtle DNA for tumour and non-tumour samples. Ct values showed that all FP tumour samples showed significant higher concentration of viral DNA, while non-tumour samples from the same infected animals were much lower. All non-tumour samples from the non-infected turtles showed lower concentration of viral DNA. This represents strong evidence that sea turtles without sickness signs or tumour presence can also be potential virus carriers. Furthermore, DNA samples of different species of land and fresh water turtles were also tested for herpes virus, none of them were positive. Thus, CFPHV5 appears to be unique to sea turtles, as it has been shown that this lineage of HV diverged before the separation of avian and mammalian alphaherpesviruses [1], our preliminary results may suggest a much slower evolutionary rate contradicting the previous studies supporting a more recent co-speciation.

INFLUENCE OF BEACH MORPHOLOGY IN NESTING AND HATCHING SUCCESS: NHÔ MARTIN BEACH, EASTERN BOAVISTA (CAPE VERDE)

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Cape Verde hosts one of the largest loggerhead populations in the world, after Oman and Florida (EE.UU) colonies. Furthermore, it is the only breeding colony in the eastern Atlantic. Within Cape Verde, the Marine Turtle Natural Reserve (RNT, Reserva Natural das Tartarugas), southeast of Boa Vista Island, hosts the higher nest densities. The RNT beaches are investigated, protected and preserved since 1998 by CV Natura 2000 NGO. In 2009, the NGO expanded its operation area preserving 10km of eastern Boa Vista beaches, located in the North Marine Park (PMN, Parque Marinho do Norte). The most important beach, in number of nests, of this 10km is Nho Martin beach. Nho Martin beach, located between 15°58'N - 22°40'W and 16°13'N - 22°58'W, is a 500m white sandy beach, morphologically very irregular due to steep slopes and the presence of five river's mouths distributed along the beach. The number of nest counted on this beach varies from 250 to 1.100 nests per season, varying similar to high fluctuations between seasons observed in all Cape Verde beaches. This study analyzes the effect of morphological and natural factors in nesting and hatching success along this beach to achieve the adequate strategies to ameliorate the conservation efforts in the area.

UTILA'S HEAD-STARTED SEA TURTLES RETURN

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The Bay Islands Conservation Association (BICA) founded The Utila Sea Turtle Conservation Project in 1992, with the primary objective to protect and monitor important sea turtle nesting sites in Utila, Bay Islands, Honduras. During the first year of the project a head-starting program was initiated to increase sea turtle populations in the wild. Between 1992 and 2002 a total of 155 sea turtles from 3 year classes (1993, 1994, 2001/2002) were reared in captivity for 10-11 months, tagged and released. The total comprised of 125 hawksbills (*Eretmochelys imbricata*) and 30 loggerheads (*Caretta caretta*). Tag recoveries are summarized by year class, date recovered, and distribution. A total of 17 (11%) tag recoveries have been reported to date, with 12 (71%) of these reports coming from Honduras. Tag recovery data has also come from Belize, Nicaragua, and Mexico. All tag recoveries are from hawksbills, and none from loggerheads. This report highlights two tag recoveries recorded during BICA's 2013 nesting beach monitoring program. Two female hawksbills from the year class 2001/2002 were observed on the nesting beach from where they were released. Neither female was observed nesting, but this documents the first female returns from The Utila Sea Turtle Conservation Project's head-starting program.

THE ORIGIN OF THE HAWKSBILL TURTLES (*ERETMOCHELYS IMBRICATA*) FORAGING ON THE REEFS OF TOBAGO, WEST INDIES

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This is the first study of its kind carried out in Tobago to estimate the relative contributions of regional hawksbill rookeries to the Tobago foraging aggregation using mitochondrial DNA (mtDNA) haplotype frequencies as genetic markers. Tissue samples were collected as part of an in-water sea turtle tagging and monitoring programme conducted on the reefs of Tobago. DNA was isolated from skin samples using phenol:chloroform extraction and approximately 740 bp of the mtDNA control region was amplified by polymerase chain reaction (PCR) using primers LTEi9 and H950. Sequences were aligned and matched against published Atlantic hawksbill mtDNA control region sequences and unpublished new and longer sequences. Haplotype (h) and nucleotide diversities (p) for the Tobago mixed stock were estimated using Arlequin 3.01. Sequences were truncated to the 384-bp reading frame to enable comparison with all published results. The R Package was used to compute Bayesian many-to-many mixed stock analysis (MSA), incorporating published haplotype frequencies from regional rookeries and foraging aggregations in addition to Tobago. Relative rookery size (number of nesting females per year) was incorporated as a constraint. Haplotype diversity was high as expected for a mixed stock and the preliminary MSA results indicate that numerous regional sources contribute to the Tobago foraging aggregation. The lessons learnt have direct application to the management and conservation of sea turtles locally and regionally. Acknowledgements: Funds to support field research for this study were provided by the Government of the Republic of Trinidad and Tobago Research Development Fund and the US National Fish and Wildlife Foundation. Travel grants to participate in this meeting were provided by the Campus Research and Publication Fund, The University of the West Indies, St. Augustine, the International Sea Turtle Society, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation, U.S. National Marine Fisheries Service, Sea Grant-Texas, Shell, International Seafood Sustainability Foundation, Wildlife Computers, Environmental Business Specialists LCC, Sea Turtle Conservancy, Florida TURTLE license plate program, SIRTRACK, CLS America, Ecological Associates Inc., Desert Star Systems LLC, Loggerhead Marinelifelife Center. Janet Hochella, Kiki Jenkins, Sea Turtle Project-Bangladesh, Marinelifelife Alliance, Matthew Nash, Mission: Clean Beaches, Sandy Sly, ProFaunaBaja – ASUPMATOMA, Usagi Family and Debbie Sobel.

SPATIAL-TEMPORAL ANALYSES OF EASTERN PACIFIC GREEN TURTLES (*CHELONIA MYDAS/CHELONIA AGASSIZII*) FORAGING AS MIXED STOCK IN GORGONA NNP, COLOMBIAN PACIFIC OCEAN*

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Gorgona Island represents a characteristic foraging ground for the green and black turtles (*Chelonia mydas/agassizii*) that connects rookeries in the Eastern Tropical Pacific Ocean (ETPO). We analysed mitochondrial DNA Control Region sequences of 176 individuals from a seven-year sampling period (2005 - 2011) at Gorgona foraging ground (FG). Control Region sequences (940bp) revealed the presence of twenty-three haplotypes, with high haplotype (h) and low nucleotide (π) diversities of $h = 0.7869$ and $\pi = 0.6576\%$ respectively. At spatial level, we identified two Stock Management Units (SMU) in the Eastern Pacific. We determined that orphan Gorgona FG haplotypes came from three different phylogeographic clades. At temporal level, we found substantial variations in genetic diversity. There were evident changes in the frequency of haplotypes, unique annual, and seasonal haplotypes. There were

temporal variations in the contribution by differential recruitment from various pacific rookeries, where Gorgona FG comprised mostly of animals from the Galapagos rookery (59-93%). Seasonal variations of connectivity in the suitable habitat were found for the species. The suitable habitat models allowed us to define that Sea Surface Temperature (SST), nitrates, dissolved oxygen and salinity have a crucial role in the Pacific distribution of the green and black turtles. We highlighted Gorgona FG as part of the Eastern Pacific SMU with connectivity based on genetic and suitable habitat analyses. Temporal genetic variation could be useful for the conservation and management strategies of the green and black turtles recruited from distant rookeries. It is necessary to implement more sampling efforts at spatial and temporal levels, as well as compliment this information with satellite telemetric analyses and nuclear genetic marker analyses. Effectively reinforcing trans-national conservation programs and to protect the ETPO corridor in international waters throughout the eastern Pacific managed by non-governmental organizations.

GENETIC APPROACHES: NEW TOOLS FOR THE OLD UNANSWERED QUESTIONS*

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Persistent gaps in knowledge on some basic life history information for sea turtles continue to impede progress toward building accurate population models, including age at first reproduction, survivorship, dispersal and migration at different life history stages, mating systems, and sex ratios of the breeding population. Expanded arrays of multiple nuclear markers (SNPs and microsatellites) being developed for sea turtles and new high throughput laboratory technologies provide a basis for cost-effective genetic “tags” for use in Capture-Mark-Recapture (CMR) studies. These genetic approaches can be used in conjunction with traditional tagging studies and satellite telemetry to improve stock assessments by incorporating missing life history and demographic parameters to allow estimation of vital rates of populations. I will review the results of current studies to demonstrate how genetic approaches, such as kinship analysis, can be incorporated into population assessments when direct census of adult animals is not feasible, including 1) numbers of green turtle nesters and nesting ecology in the remote areas of the Main Hawaiian Islands determined from analysis of salvaged nest contents; 2) numbers of Kemp’s ridleys nesting in Texas, and 3) numbers of breeding males and estimates of breeding sex ratios for leatherbacks in St. Croix . Finally, I will discuss the feasibility of mass-tagging of hatchlings using DNA sampling and genetic markers as a CMR tool and discuss challenges and opportunities for application of these approaches in the future.

AGE ESTIMATION OF *CARETTA CARETTA* AND *CHELONIA MYDAS* IN SOUTHERN BRAZIL

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The coast of Rio Grande do Sul, southern Brazil is an important foraging area for green and loggerhead sea turtles. Stranding/bycatch of both species is frequent in the area, however, studies on their demographic parameters are still fragmented. This coast between Lagoa do Peixe (31°20'S, 51°05'W) and Arroio Chuí (33°45'S, 53°22'W) was surveyed once a week, between October 2011 and October 2012, in order to collect humeri from dead turtles washed ashore. Carcasses were mostly of individuals that have already recruited to the neritic environment. Skeletochronology was applied to the humeri in order to estimate their age. The number of lines of arrested growth (LAGs) present in turtles that have retained the first line of growth located in the center of the humerus (annulus) was assumed to represent their age. However, in large individuals, the annulus could not be retained, as well the older LAGs (denoted 'lost LAGs'). In those cases, the lost LAGs were calculated using a correction factor which derives from a relationship between the number of growth layers (x) and the corresponding growth layer diameters (y). For turtles that retained an annulus, the pairs (x,y) were measured, and the power function model $y = ax^b$ was fitted to the data. To estimate model parameters, the hierarchical error structure was assumed. For turtles without an annulus, the resorption core diameters were measured (y_{core}), and the corresponding number of lost lines inferred by reverse prediction (x_{core}). Therefore, the number of growth layers observed in the outermost region of the bone section (x_{obs}) plus the predicted number of resorbed growth layers represented in the resorption core of the humerus is the turtle's estimated age ($x = x_{core} + x_{obs}$). For 23 loggerhead turtles (*Caretta caretta*), ranging from 46 - 59.9 cm (51.76 ± 5.04 cm), the equation LAG diameter (mm) = 2.18 * (LAG number) 0.35 was used. For this sample age varied between 6 and 13 years, which suggests that some of these animals are juveniles in transition from the oceanic to the neritic stage. For the green turtle, the equation LAG diameter (mm) = 2.0 * (LAG number) 0.3 was obtained through use of the correction factor. The 18 green turtles (*Chelonia mydas*) were also juveniles, and the age (3 to 14 years) and size, ranging from 45.2 - 60.5 cm (56.32 ± 3.39 cm) were similar to those of loggerheads. Growth patterns for these age classes were obtained through the Schnute growth model. The Schnute's growth model allows for the generation of growth curves to fit to a set of data related to one age window of life cycle of the sea turtles. The model indicates that for the same time window, greens grow slower than loggerheads turtles. It also suggests that loggerheads grow relatively fast up to about 10-11 ys of age when the growth rates drop markedly.

SHOULD I STAY OR SHOULD I GO NOW? MOLECULAR TECHNIQUES COMBINED WITH TRACKING TECHNOLOGIES PROVIDE INSIGHT INTO COMPLEX MOVEMENT PATTERNS OF EAST PACIFIC GREEN TURTLES FORAGING AT REMOTE COCOS ISLAND, COSTA RICA*

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The Cocos Island National Park is a remote island in the Tropical Eastern Pacific, located at ca. 550 km from continental Costa Rica, 850 km from the Galapagos Islands and more than 1000 km from any other major East Pacific Green Turtle nesting site. Since green turtles do not nest at Cocos Island, knowledge of their origins and migratory patterns is crucial for informing conservation strategies that aim at protecting critical habitats and maintaining population connectivity between regional sites. However, vast costs and difficult logistics challenge continuous monitoring and thus the methods used should be highly effective. Since 2009, this foraging aggregation has been monitored during 2 to 4, 7-day expeditions per year, in which green turtles are captured via SCUBA. In 14 expeditions, more than 100 green turtles have been captured. Demographic statistics show a subadult dominance with a curved carapace length (CCL) mean of 73.6 cm (SD = 6.8 cm, range = 45 – 87, n = 112). Of the 56 presumed adults (CCL ≥ 75 cm), 14 were probable females and 42 were males based on secondary (i.e. morphological) sexual characteristics. With the goal to obtain information about local movements around the Cocos Island and broader migratory tracks on a regional scale, a total of 17 satellite transmitters and 36 acoustic transmitters were deployed and, of these, 11 turtles were equipped with both devices. Five satellite transmitters ceased transmissions shortly after release. Tissue samples (n = > 87) were taken from all turtles with the aim of revealing natal origins by analyzing maternally inherited

mitochondrial DNA (mtDNA) and migratory status (e.g., resident versus recruits) by comparing stable isotope ratios ($\delta^{13}\text{C}$ vs. $\delta^{15}\text{N}$). Preliminary results show that size classes are correlated with types of movement behaviors- whereas most juveniles are resident in Cocos Island, adults tend to migrate towards Central- and South America. No adult turtle was tracked moving towards the Galapagos Islands, the natal origin of most of the Cocos turtles and where we would expect adult turtles direct their reproductive migration once nesting season begins. A benefit of combining satellite and acoustic tags was exemplified by three turtles that were tracked over distances of 150 to more than 1000 kilometers (21-31km/day travel speed), before the satellite devices stopped transmitting. A few months later, they were “recaptured” by acoustic receivers after returning to Cocos. Combining stable isotope and genetic data suggests, that green turtles from a high variety of natal origins use Cocos Island as a final development, adult residency and migratory stopover site. These findings highlight the value of combining technologies to estimate long-term movement profiles in a regional context at remote and difficult to access foraging sites which provide a sound scientific basis for regional conservation strategies.

HIDDEN IN NO-MANS-LAND NEWLY DISCOVERED NESTING AND FORAGING SITES FOR EASTERN PACIFIC GREEN (*CHELONIA MYDAS*) AND HAWKSBILL TURTLES (*ERETMOCHELYS IMBRICATA*) IN THE BORDER LAND OF COSTA RICA AND NICARAGUA AND THEIR BI-NATIONAL CONNECTIVITY

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The Santa Elena peninsula and its adjacent bays describe Costa Ricas’ most Northern Pacific coastline that directly connects with Nicaragua to form an even, unique and almost untouched habitat from tourism and major human development. Because of its difficult and expensive access, only few studies have been carried out about the areas’ marine realm. In April 2012, we had the opportunity to explore Matapalito Bay, which under park rangers and local guides has already been well known for hosting easy to observe sea turtles. Using tangle nets with a mesh size of approximately 18 inches and 160 meters of length, we captured a total of 17 hawksbill, 12 green and 2 olive ridley turtles in a medium soak time of 5 hours per day (n=12 days). Similar sources of information stated a frequent presence of nesting sea turtles at San José Island, which is part of the Bat Islands in the Southeast of the peninsula, where we initiated continuous monitoring by November 2012. Since then, we tagged more than 400 Eastern Pacific Green Turtles on the beaches of San José Island and Coloradas, the latter being a solitary beach on the peninsula, which was monitored during approximately 30 nights. At both beaches, green turtles appear to nest all year round and on two occasions, turtles originally tagged at other beaches to the South of the peninsula, were recaptured. On the contrary, one turtle tagged at San José Island was recaptured at Brasilon Beach, Nicaragua. This cross-bordering connection of nesting beaches is also confirmed by satellite tracked females that nest on Brasilon Beach and directed apparent inter- and post-nesting movements to the Bat Islands and Coloradas Beach. These discoveries are highly informative for recent population evaluations of Eastern Pacific green and hawksbill turtles and more importantly, crucial to be included in a bi-national conservation strategy that focuses on connecting foraging habitats and nesting beaches in neighboring countries. Ongoing monitoring of all sites is necessary to estimate more accurate numbers of nesting females, foraging site recruitment rates and frequencies of bi-national interchange, as well as the impact in their populations of recently reported mass stranding.

GENETIC STRUCTURE OF SOUTHERN PART OF NORTH PACIFIC LOGGERHEAD TURTLE POPULATION AND ITS IMPLICATION OF GENE FLOW WITH SOUTH PACIFIC POPULATION*

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North Pacific loggerhead turtles nest on only Japanese beaches, however, there are some nesting groups that have different body size, clutch frequency, remigration frequency, foraging habitat and prey items, and frequency of mitochondrial DNA (mtDNA) haplotypes. On the other hand, previous studies were conducted on mainland Japan and around because of the accessibility to nesting beaches and nesting density. So, this study aims to figure out the genetic structure of nesting group in Ryukyu Archipelago located southwest of Japan and there has been restricted to studies because of numerous inaccessible beaches. Night patrols were conducted during the 2012- 2013 nesting season to measure body size (straight carapace length from notch to tip: SCL) and collected tissue samples from nesting females. In addition, tissue samples for genetic analysis were also collected from embryos and nesting females from 2003 to 2013 without duplication from same nesting females. Approximately 820bp of mtDNA control region was analyzed by using LCM 15382/H950 primers. In the result, SCL of Ryukyu Archipelago nesting group was measured from 55 females and was 85.6 ± 4.7 (SD) cm (range: 76.4-96.4cm). This was significantly bigger than ($p < 0.01$, Welch's t-test) or almost same with nesting groups on and around mainland Japan. The result of bigger SCL distribution in Ryukyu Archipelago inferred that foraging habitat of most of nesting females in Ryukyu Archipelago is neritic ocean such as East China Sea or South China Sea that spread southwestward of Japan to prey on benthic items. One hundred out of 113 tissue samples were successfully analyzed for mtDNA haplotype and frequency of that was significantly different from major nesting sites on and around mainland Japan ($p < 0.001$, exact test). Most characteristic haplotype was CcP 1.1 that includes 350-bp of CcP1. CcP1 is known as the only haplotype of nesting females of South Pacific loggerhead population in Eastern Australia. CcP 1.1 occupied 20.0 % in Ryukyu Archipelago but only 1 sample from mainland of Japan and nearby. Although there was no significant difference among islands in Ryukyu Archipelago, it tends to increase the ratio of CcP 1.1 from north to south: 12.8% in Amami Island (n=47), 25.0% in Okinoerabu Island (n=24), and 27.3% in Okinawa Island and Zamami Island (n=22). It is inferred from these results that not only Ryukyu Archipelago nesting group is independent from groups in mainland Japan on some level but also there has or had been gene flow from eastern Australia nesting sites of South Pacific population to Ryukyu Archipelago of North Pacific population.

GREEN TURTLES (*CHELONIA MYDAS*) NESTING ACROSS THE PACIFIC ISLANDS: A HOTSPOT FOR GENETIC DIVERSITY*

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In recent years there has been a plethora of studies documenting the genetic population structure of green turtles (*Chelonia mydas*) from around the world. Together these studies now cover most of the global distribution of the species benefiting conservation of this threatened species worldwide. However, important gaps still exist in some

areas of the Indo-Pacific and in particular across many of the Pacific Islands that make up Micronesia, Melanesia and Polynesia. This large area is made up of hundreds of scattered islands and atolls most of which are remote and hard to access. In this study we assess the stock structure of green turtles throughout the Pacific Islands including Australia's Great Barrier Reef using mtDNA from 979 turtles sampled across 27 nesting locations. The results presented in this paper establish that: a) there are at least ten independent stocks in the region considered in this study identifying several new genetic stocks; b) that sequencing of longer fragments (770 bp) of the control region does in some cases increase resolution; and c) rookeries within this region are characterized multiple colonization events of ancient and highly diverged lineages suggesting that parts of the western Pacific is a hotspot for maintaining genetic diversity over evolutionary time scales.

USING MICROSATELLITES TO INVESTIGATE THE POPULATION STRUCTURE OF OLIVE RIDLEY TURTLES NESTING SOLITARILY AND IN ARRIBADA ASSEMBLAGES IN COSTA RICA

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Olive ridley sea turtles (*Lepidochelys olivacea*) are known for their arribada nesting behavior, where groups of 100 or more female turtles emerge synchronously to lay their eggs on a single beach. This species also exhibits solitary nesting behavior on arribada nesting beaches as well as beaches which do not host arribadas. On the Pacific coast of Costa Rica, both nesting strategies can be seen; arribadas are known to occur on Playa Ostional and Playa Nancite. Fifty kilometers south and fifty kilometers north, the beaches of Playa Grande and Playa Ventanas, respectively, are within Parque Nacional Marino Las Baulas (PNMB). PNMB beaches are important solitary nesting beaches in the Guanacaste province. Nesting ecology studies have suggested, but not confirmed, that solitary and arribada turtles belong to separate populations. However, initial findings suggest that both populations are genetically identical. In this study, we will use microsatellites to test whether arribada olive ridley sea turtles nesting along the Pacific coast of Costa Rica are genetically distinct from solitary nesters. This research will provide data that will improve our understanding of the genetic diversity of nesting populations and allow the identification of conservation units for effective management plans that would protect that diversity. We thank Earthwatch biologists and volunteers, The Leatherback Trust, park rangers, biologists and volunteers at Parque Nacional Marino Las Baulas, and park rangers, biologists and volunteers at Refugio Nacional de Vida Silvestre Ostional for their assistance in the field. Area de Conservacion de Tempisque (ACT), Ministerio de Ambiente y Energia (MINAE), and the Comisión Nacional para la Gestión de la Biodiversidad de Costa Rica (CONAGEBIO) provided administrative assistance and permits. Other help was provided by Dr. Maria Pilar Santidrian Tomillo, Elizabeth Solano, Nathan Robinson, Carlos Mario Orrego and Melania Munoz. This research was supported by grants from the Jack W. Schrey Distinguished Professorship. Support for a travel grant was made available through generous donations by the following organizations: International Sea Turtle Society, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation, U.S. National Marine Fisheries Service, Sea Grant-Texas, Shell, International Seafood Sustainability Foundation, Wildlife Computers, Environmental Business Specialists LCC, Sea Turtle Conservancy, Florida TURTLE license plate program, SIRTRACK, CLS America, Ecological Associates Inc., Desert Star Systems LLC, Loggerhead Marinelifelife Center. Janet Hochella, Kiki Jenkins, Sea Turtle Project-Bangladesh, Marinelifelife Alliance, Matthew Nash, Mission: Clean Beaches, Sandy Sly, ProFaunaBaja – ASUPMATOMA, Usagi Family and Debbie Sobel. A final thank you to the 2014 International Sea Turtle Symposium.

INVESTIGATING MALE-MEDIATED GENE FLOW AMONG GREEN TURTLE (*CHELONIA MYDAS*) ROOKERIES OF THE NORTHWEST PACIFIC

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There remains a paucity of information regarding the breeding interactions among green sea turtle (*Chelonia mydas*) rookeries in the Northwest Pacific region. The island nesting sites of Taiwan (LanYu, XiaoLiuChiu and WangAn) and Southwestern Japan (Ishigaki and Iriomote) represent important regional rookeries of high conservation value. Although previous studies of mtDNA have suggested limited gene flow among these rookeries, mtDNA analysis only provides information on uniparental (maternal) gene flow. Therefore, the genetic contribution of males mating between nesting populations remains undetected when analyzing mtDNA alone, and bi-parentally inherited nuclear markers must be utilized to elucidate male-mediated gene flow. Prior satellite tracking studies have also revealed a pattern of female post-nesting migrations from Taiwanese rookeries into areas also utilized by turtles from Japanese rookeries. This information, combined with the opportunistic mating behavior exhibited by male green turtles during migration suggests that male-mediated gene flow may occur between these populations. The purpose of this study is to a) determine the presence of male-mediated gene flow between these rookeries, and b) provide further information on the genetic structure of green turtle rookeries of the Northwest Pacific region. Tissue was collected from nesting female turtles at all three aforementioned Taiwanese rookeries and both Japanese rookeries. All samples will be genotyped at eight nuclear microsatellite loci previously developed for green turtles. It is predicted that this analysis will reveal a greater level of gene flow among nesting populations when compared to previous analyses of mtDNA in these populations, indicating male-mediated gene flow.

GENETIC STOCK COMPOSITION OF LOGGERHEAD (*CARETTA CARETTA*) BYCATCH IN SOUTHEAST U.S. WATERS AND THE GULF OF MEXICO USING MTDNA ANALYSIS

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A variety of fisheries operations including longlines, gillnets, and bottom trawls occur in waters off the southeastern U.S. and in the Gulf of Mexico. Several sea turtle species are caught incidentally to the targeted catch, in particular loggerheads (*Caretta caretta*). Understanding the genetic stock composition of bycaught loggerheads is an important indicator for which nesting populations are being impacted by particular fisheries. Mitochondrial (mtDNA) analysis was performed on 293 loggerhead biopsy samples collected by fishery observers in the statistical reporting zones of the Caribbean, Florida East Coast, Gulf of Mexico, Mid Atlantic Bight, North East Coastal, South Atlantic Bight and Sargasso between 2000 and 2013. To assess stock origin, mtDNA haplotypes were compared to 19 genetically distinct nesting stocks identified throughout the Atlantic Ocean and Mediterranean Sea using a “many-to-many” mixed stock analysis. Results suggest that the majority of bycaught loggerhead turtles in pelagic habitats off the southeastern U.S. and the Gulf of Mexico originate from the Northwest Atlantic Distinct Population Segment (DPS), with small contributions from the Mediterranean, South Atlantic and Northeastern DPSs. Our results will help to evaluate fisheries impacts, further our understanding of loggerhead habitat use, and improve management strategies geared towards reducing the incidental capture of loggerheads in these regions.

HOW MANY MALES ARE THERE? AN EXAMINATION OF OPERATIONAL SEX RATIO AND CONNECTIVITY IN SHARED ROOKERIES*

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Mating systems are important role in shaping life history evolution and population dynamics of a species and should be considered when planning conservation efforts. Polyandry, a single female mating with multiple males, may result in the multiple paternity of progeny arrays (clutches) in turtles. Within a population, multiple paternity influences the effective population size and the diversity of genetic variation. Several recent studies together suggested that multiple paternity occurs in most reptile species but within the Testudines there is a high degree of variation. Within marine turtles, assessing multiple paternity is challenging because males rarely return to land and mating is not often observed. By conducting exclusion analyses we can approximate the number of males and critically assess population estimates. Loggerhead and green turtle nesting mothers and up to 20 offspring were sampled (N> 90 nests) to compare large nesting assemblages in southern Florida during the nesting season of 2013. Two East coast sites and one West coast site were selected to compare rookeries. To determine if species sharing the same rookeries have a common pattern, we assessed the frequency of multiple paternity. Here we compare (i) how many males contribute to the nesting assemblages and (ii) whether males are active on multiple beaches. Our study provides the first assessment of effective population size for important southern Florida nesting populations and addresses connectivity of rookeries through male mediated gene flow.

DEFINING STOCK ORIGIN AND CONNECTIVITY OF GREEN TURTLES FORAGING OFF OF SOUTHERN CALIFORNIA, USA, USING MTDNA*

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Establishing an understanding of population structure is essential for the effective conservation of marine turtles. Recent mtDNA surveys of Pacific green turtle nesting populations have identified genetic stocks in the eastern, central and western Pacific. These studies provide a baseline to evaluate the stock composition of green turtles foraging along the coast of southern California, which is considered the northern range for foraging green turtles in the eastern Pacific. The goal of this project is to define the connectivity between two southern California green turtle foraging aggregations (in San Diego Bay and the San Gabriel River) and potential source (nesting) populations. To examine the stock origin and evaluate current life-history hypotheses, 780 bp of the mitochondrial (mtDNA) control region sequences from 119 juvenile and adult green turtles from these sites were compared to potential source populations across the Pacific. Seventeen haplotypes were observed and preliminary analyses indicate that green turtles foraging along southern California originate from eastern Pacific nesting stocks, mainly Mexico. However, one new haplotype and one haplotype found only to date among samples analyzed from the Galapagos foraging assemblage were identified in the San Gabriel River samples (n=18) indicating that the haplotype frequencies between the two foraging sites may be different, thus, illustrating the need to continue genetic sampling at green turtle rookeries. Our findings are relevant to the status and current conservation issues relating to recognition of the east Pacific green turtle populations as a distinct regional management unit and correct classification of foraging populations under the U.S. Endangered Species Act.

GENETIC DIVERSITY, STRUCTURE AND LIKELY ORIGIN OF GREEN TURTLES FORAGING OFF OF PERU

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Juvenile green sea turtles (*Chelonia mydas*) are widely distributed along all the coast off Peru and show aggregation spots in the northern and central coast. Nesting activity, however, is low, suggesting that green turtles are recruiting from nesting grounds in the Pacific basin. Between 2010 and 2012 samples from individuals were collected from three foraging aggregations: El Ñuro (4°13'S; 81°10'W), Sechura (5°34'S; 80°53'W) and Paracas (13°51'S; 76°15'W). The main objective of this study was to investigate the genetic diversity and structure of the different juvenile individuals representing distinct aggregations by utilizing the mtDNA control region as a molecular marker. We then compared our results with previous published genetic studies from nesting populations in the Pacific to investigate the most likely origin of the individuals recruiting to Peruvian foraging grounds. In summary, we analyzed ~750bp mtDNA control region in 110 green turtles and identified twenty-two polymorphic sites that defined a total of 12 haplotypes. The foraging aggregation of Paracas exhibited the highest diversity of haplotypes (HP=11), followed by El Ñuro (HP=9) and Sechura (HP=4). The most common haplotype was the CMP4.6, followed by the CMP4.7 and CMP4.1. The majority of the remaining haplotypes were rare (i.e. single individual). Although the genetic diversity was largely distributed within populations (89.12%) rather than among populations (10.8%) it was enough to generate significant differences between the foraging aggregations of El Ñuro and Paracas (Fst=0.13, p-value=0.0001). After truncating our sequences to ~400bp we observed that the haplotypes detected in our study have been reported for the nesting populations in Michoacan and Revillagigedo (Mexico), Galapagos Island (Ecuador). Our results suggest that the Peruvian juvenile green sea turtle individuals are of mixed origin. Thus, such juvenile aggregations represent a metapopulation that should be considered a critical component of the Eastern Pacific Ocean green sea turtles. Understanding such an ecologically important aspect in the life history of green sea turtles advocates for a larger global range to conservation efforts in order to successfully protect the species.

INTER-ANNUAL VARIABILITY IN THE NUMBER OF NESTS OF THE MOST IMPORTANT NESTING BEACHES OF CAPE VERDE LOGGERHEAD COLONY

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Long-term nest counts data were analysed for some turtle populations demonstrating that long-term conservation efforts can reverse nesting declines and offers hope that adequate management can result in recuperation of endangered sea turtle species. Nesting beach surveys are the most widely implemented monitoring tool to assess the status of sea turtle populations. Monitoring techniques employed on nesting beaches range from highly structured standardized sampling to “snapshots” of nesting activity within a nesting season. In Cape Verde, monitoring and conservation programs of loggerhead population began in 1998, in the Reserva Natural das Tartarugas (RNT), southeastern of Boa

Vista Island. This protected area houses the 80% of nests of the Cape Verde archipelago, transforming it into the Hotspot of this loggerhead colony. The long-term efforts carried out in the area provide an excellent opportunity to evaluate the success of this sea turtle conservation management and policies. Daily nest surveys have been conducted along 3km of the most important beaches of this hotspot since 2001 (Ervatão, Ponta Cosme and Calheta de Pau beaches). In 2005 the NGO responsible of conservation programs in the area (CV Natura 2000) expanded the study area to 10km of RNT beaches (from Ponta do Roque to Joao Barrosa beaches); and in 2009 enlarged 8km further north, monitoring beaches belonging to Parque Marino do Norte (PMN), on the east coast of Boa Vista. In the last 5 years (from 2009 to 2013), important inter-annual variations in the number of nests have been observed in the 18km of monitored beaches, ranging from about 3,000 nests counted in 2011, to nearly 19,000 in 2012. This study analysed these huge fluctuations examining whether there are differences between areas or beaches. We consider different ecological aspects that may be influencing the results of these nest fluctuations.

THE HAWKSBILL (*ERETMOCHELYS IMBRICATA*) NESTING POPULATION IN BOCAS DEL TORO PROVINCE AND THE COMARCA NGÖBE-BUGLÉ, PANAMÁ — A REGIONALLY SIGNIFICANT POPULATION IN THE CARIBBEAN: ABUNDANCE AND TRENDS BASED ON 11 YEARS OF INDEX SURVEYS*

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The Province of Bocas del Toro and the Comarca Ngöbe-Buglé, Panama, are well known as a historically important nesting site for hawksbills. However, intensive, long-term exploitation led to as much as a 98% decline in nesting on some beaches. Increased nesting in the 1990s, designation of several local protected areas, adoption of national and international legislation (e.g., CITES), and evidence of increased nesting in protected areas elsewhere in the Caribbean, all contributed to our decision to establish a monitoring program to measure abundance and trends in hawksbill nesting along the Bocas coast. Since 2003, daily surveys have been carried out at the Zapatilla Cays (4.2 km) in the Bastimentos Island National Marine Park and at Playa Chiriquí (24 km) following the Index Nesting Beach Survey Protocol for Caribbean Hawksbills. Playa Larga (4.3 km), also located in the Bastimentos Island National Marine Park, was added as an index beach in 2006. The essential elements of the Caribbean INBS Protocol are a fixed sampling window that encompasses the peak of the nesting season, fixed boundaries, consistent timing of the surveys (early morning), demarcation of beach zones, nest verification based on visible evidence of the track and nest, and training of surveyors. The Zapatilla Cays and Playa Chiriquí index beaches have now been monitored on a daily basis throughout most of the nesting season for 11 years. A longer-term data set (23 years) is available for a three-week period during the peak of nesting for the small Zapatilla Cay. The data from these datasets reveal increasing trends in nesting at these sites. Nest counts on the three index beaches and on Escudo de Veraguas, Playa Roja, and Playa Bluff (total of 45.2 km) added to the monitoring program over time have reached about 2000 nests/yr in recent years. This total nest count makes this hawksbill rookery one of the largest in the Caribbean. In order to estimate the number of individual female hawksbills nesting annually in the area, we used mark/recapture data from intensive nighttime patrols in the Zapatilla Cays to derive estimates of clutch frequency. Considering historical levels of nesting and recorded numbers of harvested individuals, the current number of nesting females is still small but reflects an encouraging trend indicative of potential recovery. Many threats, including poaching of nesting females and eggs, continue to hinder population recovery. A companion paper presents information on the genetic composition and diversity in this historically important rookery.

HIGH GENETIC DIVERSITY IN AN IMPORTANT RECOVERING SEA TURTLE POPULATION – RESULTS OF A LARGE-SCALE GENETIC STUDY OF HAWKSBILLS ON THE CARIBBEAN COAST OF PANAMÁ*

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Hawkbills that use western Caribbean Panama beaches in Bocas del Toro Province and the Comarca Ngöbe-Buglé have increased in number over the last 20 years making it feasible to undertake a robust assessment of the genetic diversity of nesting females along the coast. Our broad coverage (samples are from 32.5 of the 82.4 km of monitored nesting beaches) and long-term conservation efforts have allowed us to sample more than 320 individual females over 10 nesting seasons from four separate nesting beaches: Playa Chiriquí, and three beaches in the Bastimentos Island National Marine Park (the two Zapatilla Cays and Playa Larga). This extensive sampling has revealed that, in spite of large declines from over-exploitation, this population (or populations) contains, by far, the highest genetic diversity recorded for the species: at least 18 different 720 bp mtDNA haplotypes are confirmed, seven of which are apparently endemic to the region. In this presentation, we describe the level of genetic diversity found in the Bocas rookery and compare it with that from other Atlantic Basin nesting populations; evaluate the degree of genetic differentiation among Bocas nesting beaches for preliminary identification of management units; and examine the impact of inclusion of the Panama genetic data set on published mixed stock analyses. Nest counts indicate that the Panama nesting aggregation is one of the largest in the Caribbean region; a separate paper describes abundance and trends in this population.

SEA TURTLE STRANDINGS IN SOUTHERN BRAZIL: ELEVEN YEARS OF DATA

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The southern Brazil continental shelf and slope are important feeding grounds for loggerhead (*Caretta caretta*), green (*Chelonia mydas*) and leatherback (*Dermochelys coriacea*) sea turtles. Stranding patterns of these species were investigated based on monthly surveys carried out along a 355 km stretch of coast, between Chui (33°44'S; 053°22'W) and Lagoa do Peixe (31°21'S; 051°02'W), in Rio Grande do Sul state, from January 2002 to December 2012. Generalized Linear Models (GLM) were used to describe spatial and temporal stranding patterns of loggerhead and green turtles. Due to differences in sampling effort, the distance run in each trip was used as offset. Five species were

recorded: loggerhead (N = 2534; 52.6%), green (N = 1865; 38.7%), leatherback (N = 318; 6.6%), olive ridley - *Lepidochelys olivacea* (N = 31; 0.6%), hawksbill - *Eretmochelys imbricata* (N = 27; 0.6%). Thirty-nine individuals could not be identified to species. Only 168 turtles (3.5%) were alive. The loggerhead turtle was most abundant species for nine of eleven years sampled. Most loggerhead and leatherback turtles were juveniles (mean Curved Carapace Length – CCL = 72.1 cm, SD = 12.6 cm and 135.4 cm, SD = 14.3 cm, respectively). Nevertheless, the proportion of adult leatherbacks was high (45%). All greens and hawksbills were juveniles (CCL of 39.2 cm, SD = 5.8 cm and 40.7 cm, SD = 9.4 cm respectively), while most olive ridleys were adults (CCL = 64.6 cm, SD = 5.4 cm). For loggerheads the model that best fitted the data included year, month, area and the interaction month*area as explanatory variables. This model explained 68.5% of the variation in the strandings. The mean number of stranded loggerheads increased significantly from 2002 to 2012. For 2003 the estimated coefficient was 0.47 and between 2004 and 2009 estimates ranged from 1.02 in 2007 to 1.92 in 2004. From 2010 to 2012 estimates ranged 2.28 to 2.37. Whether the large increase in number of strandings is related to population growth or changes in the local fisheries dynamics or effort. The strandings were significantly lower from June to September and higher in December and January. Stranding were also higher in the northern part of the study area in May and September. For green turtles the model that best fitted the data, explaining 69.2% of the variation in stranding numbers, included year, month, area and the interaction year*month as variables. The mean strandings were significantly higher from 2005 to 2012 compared to 2002-2004, from October to December and March and to the northern area. The number of loggerheads and leatherbacks strandings in this region is the highest in Brazil and, for loggerhead, this number is seven times higher than that on the adjacent Uruguayan coast. The areas and months of highest strandings coincide with those of highest fishing effort. Although a better understanding about relationship of stranding with local fishing fleets dynamics and oceanography on the patterns of sea turtle beachcast, it is clear that the mortality is high and measures to reduce it are urgently needed.

JUVENILE DISPERSION OF LOGGERHEAD, GREEN AND HAWKSBILL SEA TURTLES IN THE ATLANTIC OCEAN

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Globally threatened sea turtles connect widely separated geographic areas throughout their life cycles, and thus provide key insight into the biology of migratory species, with applications for conservation and management plans. Although there are still gaps in our knowledge, genetic studies have helped reveal the population structure and connectivity of most sea turtle species. Further, combining genetic data with other sciences like oceanography seems to be a key future research direction needed especially to advance understanding of juvenile sea turtle dispersion. Juvenile turtles are known to drift passively with oceanic currents, thus simulations of transports within an ocean circulation model can provide valuable information about trajectories, spatial distribution and duration of drifting period. Here, we review and compare the connectivity between nesting populations and juvenile foraging grounds for loggerhead (*Caretta caretta*), green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) sea turtles in the Atlantic Ocean basin using published mitochondrial DNA sequences and oceanographic studies. Despite several variables that may affect all three species (e.g. ocean currents, swimming capacity, behaviour, population size, and geographic distance), our results show that unique factors in the life cycle of each species singularly impact their juvenile dispersal patterns, and consequently juvenile distribution, across the Atlantic. Such comparative biogeographic analysis of these threatened groups contributes to a broader understanding of their biology essential for conservation and management.

MTDNA AND DISPERSAL MODELING PREDICT CONNECTIVITY OF GREEN TURTLES FORAGING IN FLORIDA NATIONAL PARKS*

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Spatial distribution and structure of populations are fundamentally related to ecology, evolution, and behavior, yet they remain insufficiently understood in many animal species that shift habitats during their life cycles, including sea turtles. Threatened green turtles utilize feeding grounds in Florida (USA) National Parks of unknown connectivity. The Dry Tortugas National Park and the unusual estuarine Everglades habitat are mixed-stage feeding grounds composed of post-pelagic juveniles, subadults, and adults. In this study multi-locus mitochondrial genetic analysis was paired with high-resolution particle dispersal modeling to comprehensively research the distribution and structure of green turtles foraging at these Parks. Physical transport models based on ocean circulation were used to identify the population sources of turtles reaching these feeding grounds as well as putative dispersal routes. In addition, mitochondrial control region (~857 bp) and microsatellite repeat segments were sequenced from turtles collected at Dry Tortugas (n = 86) and Everglades (n = 17) National Parks between 2008 and 2013. Multiple markers were used to enhance genetic coverage and with the objective of splitting previously lumped haplotypes. Genetic differentiation among years, sexes, and stage-classes at the Dry Tortugas were investigated using both repeats and longer control region subhaplotypes. Control region sequences were necessarily truncated to enable regional comparisons among haplotypes, as the repeats and longer control region segments are not yet available. Natal origins were assessed using one-to-many as well as many-to-many mixed stock analyses, and results were compared. In both Parks CMA3.1 was the most common haplotype, and entirely novel repeat sequences were discovered along with new haplotypes and subhaplotypes. The CMA1 haplotype, for example, split into 4 subhaplotypes. At the Dry Tortugas no significant differences were found among temporal periods, however pending further analysis males appear to be distinct from juveniles and females. The feeding grounds were differentiated from most other regional FGs. Genetic analysis indicated the main natal sources included Costa Rica, Florida, and Mexico. The modeling results suggested that turtles could potentially drift to these Parks via surface currents from various sources. Forward tracking experiments revealed greatest contributions from rookeries including Cuba, Mexico and Costa Rica. The Florida Keys were shown to be high-density areas for 0 – 5 year-old turtles, also known as the “lost years” stage, for most of the rookeries “downstream” of the Loop Current. Comparing findings from genetics and modeling highlighted the complex impacts of ocean currents and behavior on natal origins. Understanding the population distribution of these foraging populations advances knowledge of green turtles and contributes to effective conservation planning for this threatened species.

MORPHOLOGICAL DIMORPHISM ON THE GREEN TURTLE, *CHELONIA MYDAS* (LINNAEUS, 1758), FROM THE COASTAL WATERS OF JAPAN WITH TAXONOMIC DISCUSSION OF THE TURTLES ALLIED TO THE BLACK TURTLE, *CHELONIA MYDAS AGASSIZII* (BOCOURT, 1868)

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External morphology of *Chelonia mydas* occurring in the coastal waters of Japan was assessed in detail. Some authors have reported that two color types of *C. mydas* inhabit in the Japanese waters. They are distinguished by the color of plastron - one is ‘yellow type’ if the color of plastron showed pale yellow or white and ‘black type’ if the color of plastron showed dark to light gray. A total of 127 individuals were examined for external measurements and

coloration. These individuals were classified into two groups by plastral coloration; the yellow and black types. We measured 29 morphological characters in cm using calipers from each turtle and performed analysis of covariance for 28 characters using straight carapace length (SCL) as covariate to assess the statistical differences between the two color types. One hundred and nine (109) turtles were the yellow type and eighteen turtles were the black type. The results of analysis of covariance indicates that the two color types differ in ratios of distances from nuchal notch to left and right 11th marginal joints, or distances from nuchal notch to inner left and right 11th marginal joints to SCL. The morphological difference between the yellow and black types indicates that the two distinct morphotypes show the sympatric occurrence in the coastal waters of Japan. Identifying the species of two morphotypes with reference, the yellow type was assumed *C. mydas* sensu stricto and the black type was assumed *C. m. agassizii*. The sympatric occurrences of the two morphotypes of *C. mydas* sensu lato in the Japanese waters and of the two color types in the eastern Pacific showed in the reference indicate that these two groups are distinct from each other genetically and collectively support the validity of the black type as the independent species *Chelonia agassizii*.

GEOGRAPHIC ASSESSMENT OF THE ISOTOPIC NICHE OF LOGGERHEAD TURTLES*

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Understanding intraspecific niche variation is important to understand the evolutionary ecology and conservation biology of populations. Recently, an increasing body of literature has shown how individuals within populations can occupy different niches, such as the loggerhead turtle (*Caretta caretta*) population in the Northwest Atlantic (NWA). While long thought to be generalist carnivores, loggerhead turtles in the NWA appear to be individual specialists. However, little is known about the factors that could be driving these differences in foraging strategies within loggerhead populations. The foraging areas used by NWA loggerheads are found within different biogeographic regions, each of which has distinct biotic and abiotic characteristics to which turtles are exposed. Within a foraging ground, analysis of stable isotopes of carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) allows the identification of isotopic niches defined by two isotopic axes $\delta^{13}\text{C}$ (habitat type) and $\delta^{15}\text{N}$ (trophic level/diet). In this study, we compare the isotopic niches of four loggerhead turtle aggregations found at different biogeographic regions in the NWA and Caribbean to assess how geographic location may affect foraging strategies of turtles. Most turtles were sampled at their foraging grounds ($n = 309$). For the northernmost aggregation, stranded turtles were sampled ($n = 21$). Our sample size will increase as new samples are processed. Juvenile turtles sampled were assumed to be resident to their foraging areas while adults were only included if their foraging areas were confirmed. Geographic differences in both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ were found among aggregations sampled at the different regions due to differences in baseline isotopic signatures. Because both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ were correlated with the latitude of the turtle's foraging ground for turtles sampled in the NWA, we compared isotopic niche metrics among turtles using a fine scale foraging area within each of the four biogeographic regions. Initial results reveal that diversity of diet may be greater in the aggregation sampled in warm waters of the Florida Bay, with the least variation found in turtles assumed to forage in the cool waters around Massachusetts. This is a reflection of the wide range of isotopic values found in Florida Bay turtles, which could also be evidence of isotopic baseline variation at a finer geographic scale. Additionally, we found that individuals in the aggregation sampled in the South Atlantic Bight had more similar trophic ecology and more even distribution of trophic niches than the individuals sampled in either Florida Bay or the Caribbean. Moreover, we found an increase

of $\delta^{15}\text{N}$ with body size for one aggregation in the South Atlantic Bight, while the aggregations in Florida Bay and the Caribbean exhibited a decrease of $\delta^{15}\text{N}$ with body size. This suggests that larger turtles may be either consuming different prey items than smaller turtles or, if baseline isotopic values at a fine geographic scale are present, that larger turtles are preferentially using different areas within the foraging grounds. Future analysis of compound-specific amino acids will help assess whether these isotopic variations found within individuals of the aggregations sampled are due to variation in diet or baseline isotopic differences.

ADULT FEMALE LOGGERHEAD SURVIVAL: WHY ESTIMATES ARE BIASED LOW*

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Accurate estimates of annual survival rates are critical for management and conservation of sea turtles. Despite multiple calls for new studies, there have been few attempts to update estimates of survival of loggerhead turtles nesting in the US and managers continue to rely on results not estimated with the multistate open robust design (MSORD). New, robust estimates are needed to assess loggerhead status and interpret trends. We estimate apparent annual survivorship for female loggerheads nesting on Wassaw Island, GA, using the MSORD statistical modeling approach. The most parsimonious MSORD model fitted to the 1164 capture-mark-recapture histories comprised constant time-since-marking annual survival probability. After controlling for the transient behavior of some females, the annual survival probability of resident females was 0.87 (95% CI 0.85-0.90). The MSORD approach explicitly accounts for temporary emigration and transience and generates higher, more robust estimates. However, this and other survivorship estimates for adult female loggerheads must be biased low. We extrapolated each survivorship value to estimate the expected adult lifespan [adult lifespan = $-\ln(\text{survivorship})^{-1}$] and found discordance with observed data. Observed adult lifespans suggest that annual survivorship is higher than previous estimates (~0.95). Survivorship estimates of adult female loggerheads might be biased low because (1) loggerheads are more transient than other species (permanent emigration confounds survivorship estimates), (2) sampling geographic ranges for survivorship estimates are too narrow or (3) estimates come from sites that are peripheral to “major” nesting areas.

VITAL RATES FOR A RECOVERING POPULATION OF GREEN SEA TURTLES (*CHELONIA MYDAS*) VARY OVER TIME: POTENTIAL TOOLS TO EVALUATE POPULATION RECOVERY AND DENSITY-DEPENDENCE

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Populations undergoing recovery are dynamic, often showing large fluctuations in abundance and/or age structure. Green sea turtles, *Chelonia mydas*, have shown a remarkable 5.7% per year recovery in the Hawaiian Islands since 1973, but with wide annual fluctuations in nester abundance. This makes estimating population size and diagnosing recovery particularly difficult, and the National Research Council has recommended additional demographic research to understand how life history traits vary over time and potential indicators of density dependence. Often in population models, life history traits are included as static values, usually based on historic records from scientific literature. However, life history theory predicts that these can vary due to age structure, population density, and even selection pressures caused by harvest. Temporal change in vital rates for green sea turtles has not been well studied, but

understanding these dynamics will enhance the predictive power of population models that project population size and response to perturbations. We are evaluating changes in life history traits and population parameters in Hawaiian green turtles from a long-term monitoring program at NOAA Pacific Islands Fisheries Science Center, which has been tagging females nesting at French Frigate Shoals, Northwestern Hawaiian Islands, since 1973. Generalized linear models predicted that year was an influential factor for remigration interval and mean straight carapace length (SCL). Remigration interval ranged from 1.99 (0.95 – 4.22 95% CI) to 4.68 (4.40 – 4.97 95% CI) years. Nester SCL ranged from 89.21 (88.97 – 89.46 95% CI) to 91.69 (91.50 – 91.88 95% CI) cm. These values differ from what is available in the literature for this population and show a high amount of interannual variability. Remigration interval and nester SCL tend to increase with increasing nester abundance, but at different rates. Remigration interval, in particular, is showing promise as an indicator of changes in nester abundance. Clutch frequency, survival rate, and neophyte nester SCL are also being examined. In addition, we are exploring including other covariates, such as a climate index, to improve model fits. This is the first investigation of temporal variability in these traits for the Hawaiian population. Our results will contribute to an individual based population model to assess recovery rate and impacts of future management strategies.

GREEN TURTLE (*CHELONIA MYDAS*) IN ALBANIAN WATERS

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Albanian waters are widely visited by sea turtles. For more than 12 years different studies along the Albanian coast have been conducted to study the status of their populations. These studies seem to provide the same information that the loggerhead (*Caretta caretta*) is the species with the largest populations, especially in Drini Bay. However, since the first evidence of green turtles (*Chelonia mydas*) in Albanian waters, this species seems to be present each year, as well. So far, 24 green turtles have been amongst the bycatch in stavnik, a fishing gear used by Albanian fishermen for different kind of fish. All of the green turtles captured were studied to estimate their age group and highlight the reason of their presence in these waters. Most of them were juveniles, but something has changed during 2013, the number of green turtles and their body size seems to have increased. In 2013 the largest individual found in Albanian waters was recorded, an adult green turtle. Monthly and area distribution of green turtles along the Albanian coast was studied. Recaptures of tagged individuals have occurred and we have been studying the possibility of recaptures of individuals which were released without tags due to their small body size.

GENETIC DIVERSITY OF LEATHERBACK TURTLES (*DERMOCHELYS CORIACEA*) FROM PUERTO RICO

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The leatherback turtle (*Dermochelys coriacea*) rookery that exists in mainland Puerto Rico and surrounding islands hosts about 1400 nests per year (according to nests recorded in 2011 - 2013 seasons), and is the largest rookery under U.S. jurisdiction. Here, the nesting activity exhibits a strong temporal variation and varies widely among localities. For example, in 2013, most of the nesting activity was concentrated at two nesting sites; in Dorado (north coast) and Maunabo (southeast coast). At these two sites, 45.3% of total nesting in PR (630 nests) was observed. While Culebra

Island and the Northeastern Ecological Corridor had less than 20% of all nesting activity (235 nests). In the past, however, it was the opposite; most of the nesting activity was concentrated at Culebra Island and in the Northeastern Ecological Corridor. This spatial shift might be the result of regional dynamics, where each individual turtle recognizes numerous adjacent beaches as a wide area for nesting. Evidence for this includes females that were previously seen nesting in Culebra but recaptured along the northeastern coast of mainland Puerto Rico, and the recapture of females nesting in St. Croix (US Virgin Islands) and Culebra, and vice versa. The large geographic range occupied by nesting females suggest that leatherbacks from northeastern Puerto Rico and the Virgin Islands are part of a regional population rather than distinct groups. Can the same be said for the nesting aggregations in the north and west of Puerto Rico? Are these a part of the St. Croix-Culebra nesting complex or are they grouped with other rookeries like the Dominican Republic and Costa Rica? While monitoring of nesting females at the beaches may shed light about this, the low rate of recapture between sites represents a challenge to address this question in the short time. Genetic tools on the other hand, stand as a powerful approach to test hypotheses about genetic structure and differentiation among nesting aggregations. We collected 262 skin samples from nine nesting sites around mainland Puerto Rico (north coast, northwest coast, and southeastern coasts) and adjacent Culebra Island during the 2012 and 2013 nesting season. Approximately 800-bp of the D-loop of the mtDNA will be used as a molecular marker to address our research questions. This study will increase our understanding about sea turtles nesting behavior and dynamics and is relevant for identifying management units and for refining on-going conservation actions. Note: Results will be presented but the abstract deadline is before the completion of data analysis for the two seasons. The abstract will be edited for results during the edit period prior to the symposium.

GENETIC STRUCTURE OF THE RESIDENT *C. MYDAS* POPULATION OF THE GRAND LAGON SUD, NEW CALEDONIA

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Migratory species are known to pose a challenge for conservation strategies. Indeed, it is essential to understand the underlying ecology of a species before trying to protect it. Large seagrass habitats on the coast of the Great Lagoon South (GLS) of New Caledonia are home to resident green turtles (*Chelonia mydas*). This study is the first to sample *C. mydas* foraging turtles in New Caledonia and determine their origins. To assess the stock composition of this feeding ground, 187 turtles were sampled for genetic analysis of mitochondrial (mt) DNA control region haplotypes. The post-pelagic individuals were captured by the rodeo method at five different sites within the GLS between September 2012 and August 2013. The size of the turtles sampled ranged from 48 to 108.4 cm curved carapace length (56.3 ± 17.5). MtDNA haplotypes of ~800 bp will be compared to known haplotypes and measures of genetic diversity will be estimated and compared to other feeding grounds in the Coral Sea. It is hypothesised that a high percentage of the individuals sampled will belong to southern Great Barrier Reef (sGBR) genetic stock because historical tag recoveries. Results will be discussed from conducting mixed stock analyses (MSA) using Bayesian approaches and data on the genetic composition of breeding populations throughout the western Pacific. This will allow for a better understanding of the movements of green turtles in this region of the world.

GENETIC DIVERSITY AND NATAL ORIGINS OF FORAGING GREEN SEA TURTLES (*CHELONIA MYDAS*) FROM THE SOUTHEASTERN BRAZILIAN COAST

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Chelonia mydas, known as the green turtle, is the most abundant species on the Brazilian coast. Juveniles can be found all over the coast, but females nest almost exclusively in the oceanic islands of Fernando de Noronha, Rocas Atoll, and Trindade. Human exploitation and habitat destruction have caused declines in the abundance of sea turtle populations. Green sea turtles are globally endangered. Bycatch is the most important source of human-associated mortality to all five protected species of sea turtles occurring off the Brazilian coast, including the central-north coast of Rio de Janeiro state. This study aimed to characterize the genetic diversity of green sea turtles foraging in the central-north coast of Rio de Janeiro state, southeastern Brazil, using mtDNA variability and to elucidate their natal origins. Tissue samples were collected from 200 carcasses found during beach monitoring, and 61 green turtles incidentally captured by beach trawling fisheries and released alive. Alive animals were tagged on the front flippers with Inconel tags to avoid re-sampling. Curved carapace length (CCL) and width (CCW) were measured. Samples were stored in absolute ethanol and kept at -20°C. Genomic DNA extraction and PCR amplification of mtDNA control region, using LCM15382 and H950 primers, were carried out. The amplified fragments were purified and sequenced at Macrogen. For each PCR amplicon, a 491 bp consensus sequence was produced by BioEdit. Mitochondrial haplotypes were classified following the standardized nomenclature of the Archie Carr Center for Sea Turtle Research (ACCSTR). *C. mydas* individuals were mainly juveniles. CCL ranged from 27.3 to 75 cm with a mean of 38.9 ± 9.7 cm. We identified 16 haplotypes: CM-A8 (52.11%), CM-A5 (34.48%), CM-A24 (2.68%), CM-A10 (2.30%), CM-A9 (1.92%), CM-A6 (1.15%), and all the remaining considered rare for presenting less than 1%: CM-A1, CM-A3, CM-A21, CM-A23, CM-A25, CM-A32, CM-A41, CM-A42, CM-A45 and a new haplotype. The new haplotype differed by a single transition from CM-A8. CM-A8 is commonly found in South Atlantic rookeries (Rocas Atoll, Ascension and Trindade Islands), while CM-A5 is mainly found in the Costa Rica, Surinam and Aves Island rookeries. There were no significant genetic differences between stranded ($h = 0.5980 \pm 0.0238$, $\pi = 0.003026 \pm 0.002032$) and bycatch individuals ($h = 0.6552 \pm 0.0440$, $\pi = 0.002736 \pm 0.001914$) from Rio de Janeiro state, confirmed by pairwise *F*_{ST} and exact *p* values. These indices also indicated there were no genetic differentiation among *C. mydas* from Rio de Janeiro, Espírito Santo and Bahia feeding grounds (FGs). Mixed Stock Analysis (one-to-many and many-to-many) suggested major contributions from Ascension Island, Surinam, Guinea Bissau and Aves Island rookeries to the Rio de Janeiro foraging aggregation, which corroborates previous results obtained for other FGs on the Brazilian coast, specially to Espírito Santo and Bahia. Thus, the protection of foraging green turtles along the extensive Brazilian coast leads to the conservation of rookeries thousands of kilometers away. Distribution and migrations of green turtles surpass national boundaries, revealing the need for international collaboration in sea turtle management.

GENETIC CHARACTERIZATION OF A MIXED FEEDING AGGREGATION OF SUBADULT KEMP'S RIDLEY SEA TURTLES*

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Despite near extinction in the 1980s, Kemp's ridley sea turtles (KRST) have made an impressive comeback, though the species remains critically endangered. To facilitate this recovery, much attention has been given, and rightfully so, to the protection of nesting beaches, primarily Rancho Nuevo, Tamaulipas, Mexico. However, of additional and perhaps equal importance, concomitant protection of subadults is a fundamental and effective conservation strategy. To date, the latter life history stage has received much less attention in KRST. Given the relatively long maturation period in sea turtles, monitoring of subadult feeding aggregations provides a critical early warning of acute impacts to populations that might show up far earlier than in nesting beach surveys. In addition, genetic assessments of feeding assemblages have been used to inform management decisions in other sea turtle species, e.g., to assess the relative contributions of nesting beaches to subadult feeding grounds. Here we analyze mitochondrial DNA and serum testosterone data collected from 150 subadult KRST during ten summers spanning a fourteen-year period (2000, 2001, 2002, 2004, and 2008-2013). Specifically, we assess mtDNA haplotype diversity in a mixed feeding aggregation extending along the southeastern coast of the United States. These data are used to assess the dynamics of KRST contributions to this feeding aggregation. Additionally, we estimate numerous population genetic parameters including the minimum number of breeding females that contribute to the feeding aggregation, any temporal variance, and sex bias in haplotype frequencies. We evaluate these data in light of the known severe population bottleneck and subsequent expanding population and discuss current limitations to their utility in this species.

USE OF OPEN-ACCESS DATABASES TO ASSESS THE INFLUENCE OF GEOGRAPHIC DISTANCE AND ENVIRONMENTAL FACTORS ON THE GENETIC ISOLATION OF THE GLOBALLY ENDANGERED GREEN TURTLE (*CHELONIA MYDAS*)

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The endangered Atlantic green turtle (*Chelonia mydas*) occurs throughout tropical and subtropical waters ranging from Florida to Uruguay in the West and Mauritania to Angola in the East. In the Pacific Ocean, the green turtle is found throughout the tropics and subtropics as well, from Japan to Australasia in the West and the South Pacific Islands across to Colombia, Mexico, and the Hawaiian Islands in the North and East. While most populations are declining in the Atlantic Basin, several populations in the Pacific (e.g. East Pacific, Central Pacific, Southwest Central) are stable, and in some cases increasing. In both basins, coherent conservation plans will be needed to protect all populations. As with most migratory long-lived marine species, green turtle movements and migration patterns are still not entirely understood. This uncertainty challenges assessments of population structure and gene flow throughout their range and limits our ability to designate Regional Management Units (RMUs) or form effective management plans. Indeed, such perspective is needed to address several research questions that were compiled in 2010 by Hamann and colleagues as top priorities for sea turtle conservation and research. Molecular genetic analyses provide a useful tool for defining conservation management units and elucidating life history. In particular, maternally inherited mitochondrial DNA (mtDNA) is useful for defining genetically distinct nesting populations of this philopatric species. Previous studies have examined mtDNA haplotypes and identified strong population structure for both Atlantic and

Pacific green turtles, finding that most rookeries are genetically distinct. Less well understood, however, is the potential influence of environmental factors and geographic distance on patterns of genetic distance and genetic variation. To assess the possible effects of these factors, we downloaded all publically available Atlantic and Pacific green turtle mtDNA control region sequences as well as relevant environmental data from open-access databases (e.g. GenBank and Giovanni, respectively). We confirmed previously identified haplotypes and population genetic structure in both ocean basins. We then used pairwise comparisons of genetic distances to determine patterns of isolation by distance (IBD), and further incorporated environmental variables (e.g. sea surface temperature, chlorophyll, bathymetry, surface currents) to test for patterns of isolation by environmental distance (IBED). Whereas significant patterns of IBED were not found in preliminary analyses, pairwise genetic distances increased with geographical distance, suggesting IBD. This study demonstrates the value of using combined, open-access datasets to form more comprehensive understanding of broad-scale patterns of population genetic structure. Furthermore, our results address questions regarding population connections and boundaries, as well as the parameters that contribute to sea turtle biogeographic patterns in the marine environment, which have been identified by the sea turtle community as priorities for advancing sea turtle research and conservation.

POPULATION STRUCTURE AND SOMATIC GROWTH OF *CHELONIA MYDAS* IN THE COLOMBIAN PACIFIC (GORGONA ISLAND NATIONAL PARK)

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Gorgona National Park is the only known foraging ground for *Chelonia mydas* in the Colombian Pacific. At this tropical island habitat there are two *C. mydas* morphotypes found year-round: the black *C. mydas* which is common throughout the eastern Pacific, and the yellow *C. mydas* which has been documented in the eastern Pacific only in the Galapagos Islands and Gorgona NP. Genetic studies have shown that the black morphotype is composed of individuals from the Galápagos and Michoacán rookeries, whereas the nesting beach origins of the yellow morphotype individuals are in the Western Pacific. Since 2003 these turtles have been monitored, as part of a joint agreement between Gorgona National Park, CIMAD (Centro de Investigación para el Manejo Ambiental y el Desarrollo), and WWF Colombia. Turtles were captured by hand at night while snorkeling near the coast. Straight and curved carapace lengths, straight and curved carapace widths, carapace height, weight, and coloration (yellow or black) were recorded for all captured turtles. A total of 291 sampling trips were conducted from 2003 to 2012; sampling occurred once a month and lasted 4 days on average. Between 2003 and 2012, there were a total of 762 black turtle captures; 740 turtles were tagged, of which 34 were captured twice and four were captured three times. There were a total of 276 yellow turtle captures; 269 turtles were tagged, of which 18 were captured twice, two were captured four times, and two were captured five times. The mean time-at-large between recaptures was 22.92 months for black turtles and 12.89 months for yellow turtles. Straight carapace lengths of black turtles ranged from 36.0 to 79.0cm (mean= 60.1cm, SD= 6.80cm), and those of yellow turtles ranged from 40.2 to 72.5cm (mean= 53.6cm, SD= 6.58cm). The average growth rate of black turtles was 0.34cm/year with a maximum rate of 3.50cm/year (n=35), while the average growth rate of yellow turtles was 0.81cm/yr with a maximum rate of 5.66cm/year (n=20). Individual growth records were fitted to the von Bertalanffy growth function and compared between the two color morphs. The estimated k parameter was 0.037 for black turtles and 0.028 for yellow turtles, indicating slower growth in the latter. The body condition index was calculated for each morph, as BCI=mass/SCL³. This index was significantly different between the two morphs (Kolmogorov-Smirnov test, p<0.001): it was higher for yellow turtles (mean=1.50, SD=0.25) than for black turtles (mean=1.39, SD=0.20). This study represents the first comprehensive report of population parameters for this foraging area and should prove a vital aid to guide future management plans involving *C. mydas* in Gorgona National Park.

SEA TURTLES IN ANTOFAGASTA (CHILE): ¿A PARTICULAR CASE OF LOCAL EXTINCTION?

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Four sea turtle species are present in the coastal marine areas of Chile. *Chelonia mydas* and *Lepidochelys olivacea* have been associated with some bays in the North of Chile, interacting with fishing ports and thermal discharges of power plants in this sector. In the previous decade, groups consisting of ca. 50 individuals were reported to reside in these bays, consume some benthos and undertake interactions with common sea lions, *Otaria flavescens*. Previous oceanographic conditions were suggested as constraints of the presence of turtles in this region related to shallow currents, which lead the retention inside the bays. However, these hypotheses have not been formally tested. Focusing on estimating the abundance of sea turtles in several bays around Antofagasta (~23°S), we have recently initiated marine surveys for sea turtles with the local artisanal fishing fleet. Here, we report on our results from Antofagasta Bay, located adjacent to a large urban area. Several tracks on these bays present no effective captures or sightings of sea turtles, whilst sea lions and other vertebrates are often present. In this area the sea surface temperature is the lowest in June-October, driven by season, upwelling variability, and process of retention of surface waters. According to this, the sea turtle presence is expected to occur at early months of the year, which could explain our results. On the other hand, fishermen in the area agree on describing January-March as typical months with the presence of sea turtles, while other people have recorded several strandings and sightings around Península de Mejillones of *L. olivacea* and *C. mydas* out of this period. Local fishers suggest that negative interactions between sea turtles and sea lions derived on the reduction in sea turtle numbers. Small Grants Rufford Foundation and the Doctorado en Ciencias Aplicadas Mención Sistemas Marinos Costeros of Universidad de Antofagasta support this work, together volunteers who have donated their time and efforts for its development.

GENETIC CAPTURE-RECAPTURE OF UNSEEN TURTLES: CHARACTERIZING REPRODUCTIVE ECOLOGY OF NORTHERN RECOVERY UNIT LOGGERHEAD TURTLES*

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Traditionally, reproductive parameter estimates for marine turtles have been generated through flipper-tagging studies. However, intercepting all nesting females during each nesting attempt on any given study beach is logistically challenging, and some females exhibit low nest site fidelity relative to the scale of tagging effort. Genetic techniques permit the identification of individual females via genotyping of their eggshells. A single egg taken from each clutch is the source of maternal microsatellite DNA. We have amplified the eggshell-derived DNA at 18 markers to generate a unique genetic fingerprint for each individual female, allowing maternal assignment of clutches without interception of the nesting female. This method was successfully validated during the 2006-nesting season in Georgia by comparing data from freshly laid eggs (< 12 hours from oviposition) to data from skin biopsies collected from tagged females. The Georgia Sea Turtle Cooperative began sampling all morning survey beaches on the Georgia coast in 2008. In 2010, the project was expanded to cover approximately 1000 km of coastline in Georgia, South Carolina, North

Carolina, Virginia, and Maryland. These beaches host a genetically distinct subpopulation of the Northwest Atlantic loggerhead turtle nesting aggregation called the Northern Recovery Unit (NRU). To date, we have assigned over 26,000 clutches to approximately 6,300 individual females. This expansive geographic sampling scheme has provided broad-scale data on inter-nesting movements by females intraseasonally as well as nest site fidelity across nesting seasons. Approximately 70% of females deposited clutches within a 20 km expanse of beach. An additional 20% of females used 20 to 100 km to deposit all detected clutches, with the remaining 10% laying clutches up to 700 km apart. Individuals exhibiting low or high nest site fidelity within seasons have generally behaved consistently across seasons, but a small percentage of females that showed high site fidelity within each nesting season have nested on distant beaches in different years. Modeling of annual female population estimates and clutch frequency estimates are underway using a robust open design in program MARK. Ongoing work also includes spatial analysis of nesting sites of turtles assigned as first order relatives (mother-daughter and sister-sister relationships) to better characterize natal site fidelity given that essentially all NRU females share a common mitochondrial DNA haplotype. This research would not be possible without the enthusiastic support of the extensive network of biologists, cooperators, and volunteers that conduct marine turtle research in the participating states. The integration of nesting and genetics databases via an online interface at seaturtle.org provides sample contributors with real-time feedback on turtle identities as samples are processed and facilitates spatial and capture-recapture analyses.

ASSIGNING SEA TURTLES CAUGHT IN FISHERIES TO SOURCE POPULATIONS USING GENETIC FINGERPRINTING*

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As sea turtles are transboundary species, conservation and threat mitigation policies must be enacted at multiple jurisdictional levels. To assess impacts of fishing practices and bycatch on distinct populations of sea turtles to provide information for managers and policy-makers, we are characterizing bycatch turtles from around the world using genetic fingerprinting. We use both mitochondrial DNA (mtDNA) and nuclear DNA (microsatellites). We then compare each individual's genetic signature to those of known source nesting populations to identify the origin for each turtle. Both assignment testing and mixed stock analysis methods are used depending on the genetic marker (nDNA or mtDNA). In this way we are able to define nesting stock source and estimate stock proportions that comprise specific fisheries bycatch. For any fishery, the proportion of individuals being caught from vulnerable nesting populations may then be identified. Here we will present two case studies from our extensive database of over 3,000 global sea turtle samples (greens, leatherbacks and loggerheads), to show the utility of this approach for assessing threats and identifying where mitigation may be needed. Loggerhead and leatherback bycatch in the Northwest Atlantic will be the focus of our analysis. Using 800 turtle samples, we show that bycatch in this region mainly impacts nesting stocks in the Western Atlantic and we highlight vulnerable populations. Project funding was provided by the Lenfest Ocean Program.

PHYLOGENETIC STRUCTURE OF MARINE LEECHES *OZOBRANCHUS* SPP. IN TAIWAN AND COMPARE WITH THOSE IN THE ATLANTIC

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There are two species of marine *Ozobranchus* spp. in the world. One is *Ozobranchus branchiatus*, which has 7 pairs of ventrolateral gills, mainly parasitizes on the wild green turtle (*Chelonia mydas*). The other is *Ozobranchus margoi*, which has 5 pairs of ventrolateral gills, mainly parasitizes on the wild loggerhead turtle (*Caretta caretta*). Previous

studies focused on the cause and effect of sea turtle diseases and new records in the world. McGowin *et al.* (2011) further use DNA barcoding technique to determine the characteristic attributes (CAs) of CO-I sequence (658 bp) in marine *Ozobranchus* spp. and pairwise distance among rookeries in the Atlantic. In this study, we use CO-I sequence and morphological diagnosis to compare the rookery structures of marine *Ozobranchus* spp. in Taiwan and compare with those in the Atlantic to determine the genetic distance between two regions. Since from 2009, the infection rate between *O. branchiatus* and *O. margo* were 20.4% (10/49) and 28.6% (6/21) respectively in Taiwan. Results showed that, *O. branchiatus* had higher pairwise distance (0.0031-0.0140) than *O. margo* (0.000). Maximum Likelihood tree identified two different *O. branchiatus* populations in eastern Taiwan. Study also found a higher pairwise distance (0.0267 - 0.043) in *O. branchiatus*, but only 0.0031 pairwise distance (3 bp different) in *O. margo* between Taiwan and American populations.

MULTIPLE PATERNITY AND THE RELATIONSHIP WITH THE BODY SIZE OF MOTHERS OF LOGGERHEAD TURTLES, AT THE SENRI BEACH, WAKAYAMA PREFECTURE, JAPAN

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In some mating areas researchers can observe female sea turtles mating with multiple males, and these observations are supported by recent genetic research, which found multiple paternity for some sea turtle nesting populations. Clarifying multiple paternity is important for conservation of sea turtles because it leads us to understand more the effective sex ratio and also the impact of global warming. In this study, we examined multiple paternity of the loggerhead population in the North Pacific, which is one of the most threatened turtle populations in the world. We identified nesting females with flipper tags, measured their SCL with calipers, took a few pieces of skin as DNA samples, and marked their nest sites at Minabe Senri Beach, Wakayama, Japan in 2012 and 2013. When hatchlings came out from egg chambers, we collected non-destructive blood samples of them, whose mothers were identified, from the dorsal cervical sinus (within 50 μ l). We conducted DNA analyzes for about 230 hatchlings from 10 clutches in 2012, and 280 from 14 clutches in 2013 with 4 microsatellite loci. As a result, we found 4 clutches, which means 4 mothers, of 10 clutches in 2012 and 8 of 14 clutches were sired by multiple fathers. Each of the 4 clutches in 2012 was sired by 2 different males, and 6 clutches in 2013 were sired by 2 males and 2 clutches were sired by 3 males. And we found that smaller females mated with significantly more males than larger females did. Former research showed that loggerhead turtles nesting at the Minabe Senri Beach come from 2 different foraging areas, pelagic habitat in the east of Japan and neritic habitat in the East China Sea, and it significantly corresponds with body size, meaning larger females come from neritic areas and smaller ones come from pelagic areas. Unlike Zakynthos, Greece, where larger females mate with more males, no mating turtles are observed off the coast of Minabe Senri Beach, suggesting that females mate on their way from their foraging habitats. Our results imply that the 2 size-related foraging groups have different probabilities of encountering males.

FORAGING SITE MATTERS: DIFFERENTIAL REPRODUCTIVE OUTPUT AND TRENDS IN ABUNDANCE OF LOGGERHEADS IN THE NORTHWEST ATLANTIC

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Loggerhead sea turtles that forage in the Northwest Atlantic are known to use three different areas along the coast of the US that differ in abiotic and biotic features. Stable isotope analysis was used to determine the foraging area of adult female loggerheads and investigate two aspects of the nesting biology related to foraging area use for loggerheads nesting at Wassaw Island, Georgia between 2004 and 2011. First, we examined the effects of differential foraging area use on a suite of reproductive output parameters in 183 loggerheads. Second, we examined the proportion of turtles originating from each foraging area over the same time period. Our data indicate that foraging area preference influences the size, fecundity, and breeding periodicity of adult female loggerhead turtles. We also found that the proportion of turtles originating from each foraging area varied significantly among the years examined. The change in the number of nesting females across the years of the study was not a result of equal increases from all foraging areas. This novel approach to assess differential contributions of various foraging aggregations to trends in abundance of a sea turtle nesting populations can be very beneficial for sea turtle biology and conservation if it becomes a regular component of long-term studies. Our approach can provide an improved understanding of the influences on the causes of increasing or decreasing population trends and allow more effective monitoring and geospatial prioritization of threat reduction.

PRELIMINARY RESULTS OF MITOCHONDRIAL DNA SAMPLING FROM HAWKSBILL TURTLES IN A FORAGING GROUND OFF ROATAN, HONDURAS

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Hawksbill turtles, similar to other species of sea turtles, migrate between nesting beaches and foraging grounds throughout their lifetimes. Large nesting colonies have been identified throughout the Caribbean, of which many exhibit unique genetic haplotypes endemic to regional colonies. The same haplotypes can also be found in turtles present in foraging grounds around the Caribbean region. In this study, we present the first genetic analysis of hand-captured turtles sampled from a foraging ground off the coast of Roatán, Honduras. We sampled mitochondrial DNA haplotypes from individual hawksbills ($n = 40$) during a five-year study period. We used primers TCR-5 and TCR-6 to amplify a 384 bp control region, and LCM-15382 and H950 to amplify an 832 bp control region of the DNA. Sequences were aligned and trimmed in Geneious (v. 6.1.5) and statistical analyses were performed using Arlequin (v. 3.5.1.2). We observed 13 different haplotypes in the sampled turtles. Three of these haplotypes have not been previously documented. Potential nesting beaches ranged in distance from Roatán from approximately 200 km in Belize to over 4000 km in Brazil. Many ($n = 11$) of the haplotypes present in Roatán are also present in foraging grounds throughout the Caribbean. The previously undocumented haplotypes may indicate unknown hawksbill rookeries within the region. Our results support previous hypotheses that the harvest of turtles from foraging grounds could negatively impact nesting populations throughout the Caribbean region.

**ANALYSIS OF POPULATION GENETIC STRUCTURE IN THE EMBEDDING TURTLE BARNACLE
*STEPHANOLEPAS MURICATA***

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Sea turtles are known to host diverse communities of epibiota by providing the substratum needed for their attachment. Epibiotic species include invertebrates such as leeches, amphipods, and barnacles; and their relationships with host turtles range from commensalism to parasitism. Previous studies regarding sea turtle epibionts have focused on species composition, distribution patterns and abundance; however, genetic studies are less common. *Stephanolepas muricata* is an embedding barnacle specific to cheloniid sea turtles. Until recently, it was believed to be restricted to the Indo-Pacific. However, the species was discovered in the Atlantic Ocean in 2011 and reports of Atlantic *S. muricata* appear to be increasing. Little is known about the dispersal behavior or potential of *S. muricata* making it difficult to reconstruct the possible pathway by which this barnacle has invaded the Atlantic. Alternatively, *S. muricata* may have a long history in the Atlantic Ocean but has gone unnoticed until recently. Additionally, it is unclear if these barnacles possess restricted affinity for a particular turtle species, or if their reproductive biology permits dispersal among several host species. Understanding transmission and connectivity in these embedding barnacles may prove informative for conservation managers. Previous reports have suggested *S. muricata* to be injurious for marine turtles particularly when aggregated in large numbers. It may also cause secondary infection due to its embedding nature, alongside other negative effects such as increased drag coefficients. Additionally, a comprehensive investigation of these epibionts using phylogenetics has the potential to reveal information about sea turtle movements, population distribution and migratory routes. Here we present a preliminary investigation of trans-Atlantic-Pacific population genetic structure in *S. muricata* using mitochondrial DNA analyses. Initial data suggest at least some population genetic structure of *S. muricata* within the Pacific Ocean basin. Additionally, we evaluate the potential for recent origins of Atlantic populations.

In-Water Biology

**HISTORICAL VS. CONTEMPORARY CLIMATE FORCING ON THE ANNUAL NESTING
VARIABILITY OF LOGGERHEAD SEA TURTLES IN THE NORTHWEST ATLANTIC OCEAN***

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A recent analysis suggested that historical climate forcing on the oceanic habitat of neonate sea turtles explained two-thirds of interannual variability in contemporary loggerhead (*Caretta caretta*) sea turtle nest counts in Florida, where nearly 90% of all nesting by this species in the Northwest Atlantic Ocean occurs. Here, we show that associations between annual nest counts and climate conditions decades prior to nest counts and those conditions one year prior to nest counts were not significantly different. Examination of annual nest count and climate data revealed that statistical artifacts influenced the reported 31-year lag association with nest counts. The projected importance of age 31 neophytes to annual nest counts between 2020 and 2043 was modeled using observed nest counts between 1989 and

2012. Assuming consistent survival rates among cohorts for a 5% population growth trajectory and that one third of the mature female population nests annually, the 41% decline in annual nest counts observed during 1998–2007 was not projected for 2029–2038. This finding suggests that annual nest count trends are more influenced by remigrants than neophytes. Projections under the 5% population growth scenario also suggest that the Peninsular Recovery Unit could attain the demographic recovery criteria of 106,100 annual nests by 2027 if nest counts in 2019 are at least comparable to 2012. Because the first year of life represents only 4% of the time elapsed through age 31, cumulative survival at sea across decades explains most cohort variability, and thus, remigrant population size. Pursuant to the U.S. Endangered Species Act, staggered implementation of protection measures for all loggerhead life stages has taken place since the 1970s. We suggest that the 1998–2007 nesting decline represented a lagged perturbation response to historical anthropogenic impacts, and that subsequent nest count increases since 2008 reflect a potential recovery response.

DRONE TECHNOLOGY USED FOR FORAGING SEA TURTLE SURVEYS

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Aerial surveys appear to be the most appropriate technique to obtain abundance estimates for air-breathing marine species. The South Western Indian Ocean is an important area globally for foraging green turtles, *Chelonia mydas*. However, the effectiveness of sea turtle feeding habitat management and conservation plans is hampered because of limited data on green turtle distribution. A new program using an autonomous mini-drone aircraft (SenseFly, Switzerland) was tested in 2012 to census green turtles in shallow seagrass meadows of Mayotte. Green turtle population size and structure is estimated by counting individuals on georeferenced aerial images. Spatial distribution and temporal change in turtle numbers may be investigated according to environmental conditions and disturbance factors. This new technology improves current manned aerial survey methods by eliminating observer risk, allowing a more accurate detection of the location, quantity and size of individuals on saved pictures. The silent and low flying drone demonstrated its potential to collect standardized data routinely and is expected to be particularly suitable for long-term surveys of foraging green turtle populations. Drone technology considerably facilitates the accessibility to the marine environment and is a step forward in marine science. Such an approach constitutes an original basis for conservation actions developed on marine ecosystems.

ABUNDANCE ESTIMATES FOR SEA TURTLES IN CHESAPEAKE BAY AND OFFSHORE WATERS OF VIRGINIA AND MARYLAND*

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We conducted aerial surveys in 2011 and 2012 in Virginia and Maryland waters including the Chesapeake Bay. Over the two-year period, we flew a total of 22,000 km of track-line from inside the Chesapeake Bay to 50 km offshore. We flew two years of surveys in spring and summer and one year in fall, and used double sets of observers in order

to correct for perception bias. We applied satellite tags on wild loggerheads to calculate surface time for availability bias. The track-lines were divided into five strata, two in the Chesapeake Bay and three in the Atlantic Ocean. The surveys resulted in 3,927 turtle observations: 3,392 loggerheads, 27 Kemps ridleys, 211 greens, 121 leatherbacks and 176 unidentified turtles. Turtles were sighted most frequently in the spring in the ocean. We used the MRDS mark-recapture engine (MRDS) in program Distance (6.1) to estimate abundance corrected for perception bias. The estimate of abundance (not corrected for availability bias) for all turtles and loggerheads only was 61,135 (CV = 0.066) and 49,957 (CV = 0.065), respectively. We estimated surface time for the ocean waters by adding the percent time the tag was at the surface to the percent time the tag was less than 1 meter deep. We only used the surface percent time for the Chesapeake Bay because of turbidity. Estimated surface time combined for April-October, when turtles are present and surveys were conducted, was 24.07% at the surface and 31.57% within 1 m of the surface. When corrected for availability bias, the overall turtle abundance was 193,649 (CV = 0.937), and 158,242 (CV = 0.937) for loggerheads only. The surface time values represented 4,868 six-hour and 889 one-hour summaries from 25 tagged animals. When we calculated time within 1 m of the surface seasonally, the values were 39.30% in spring (May and June; n = 1086), 31.86% in summer (July and August; n = 2621) and 28.80% in fall (September and October; n = 1944). There was a high standard deviation and variance with surface time estimates, which persisted when we calculated surface time for individual turtles. The difference in values supports Mansfield's (2006) suggestion that abundance estimates in temperate waters should be calculated seasonally, with different surface time estimates applied for each season. In the spring, we estimated an overall abundance of 89,649 (CV = 0.783) turtles and 78,453 (CV = 0.783) loggerheads, and in the summer we estimated 67,024 (CV = 0.863) turtles and 50,477 (CV = 0.862) loggerheads only. There were not enough sightings to estimate fall abundance. Many turtles that were offshore in the spring were likely migrating north to summer foraging grounds, which may account for the higher spring estimate, even when corrected for availability bias. In the lower Chesapeake Bay, numbers were reduced, with corrected abundance estimates of 7,184 (CV = 0.989) in spring and 4,274 (CV = 1.247) in summer and corrected density estimates of 2.204 turtles/km² (CV = 0.989) in spring and 1.344 turtles/km² (CV = 1.247) in summer.

PATTERNS AND PATHWAYS: HATCHLING MIGRATION AND MARINE CONSTRUCTION*

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Barrow Island, Western Australia, is a Class A nature reserve and the location of the Chevron-operated Gorgon Project, Australia's largest single resource development. The Island's east coast supports a regionally substantial flatback turtle (*Natator depressus*) rookery of ca. 1800 individuals nesting annually. Available nesting habitat comprises six primary beaches, two north and four south of the marine construction footprint. On completion, a materials offloading facility (MOF) including a solid causeway and associated jetty will extend more than four km perpendicular to shore. Daytime hatchling dispersal (travel speed and bearing), behaviour and survivorship in the near-shore ≤ 2 km environment were assessed during the 2009/10 (pre-marine project construction) and 2011/12 (during marine construction) flatback turtle reproductive seasons. Hatchlings were tracked during daytime hours due to health and safety issues associated with tracking at night in the presence of a busy offshore marine fleet. Hatchlings marked with light plastic tape attached to the carapace were released from beaches (2009/10: n=17, 2011/12: n=32) located on either side of the causeway. Vessel-based observers recorded position and behaviour at 60 second intervals. Hatchling movement: Hatchling travel speed (m.s⁻¹) is a combination of hatchling swimming effort and sea surface currents. Hatchling travel speed increased where time-at-large and depth exceeded 2 hours or 4.8 m respectively; mean travel speed was significantly faster >2 hours-at-large (0.40 ± 0.23 m.s⁻¹) compared to <120 mins-at-large (0.31 ± 0.14 m.s⁻¹). Hatchling activity: Level of activity is defined as the proportion of time spent engaged in various 'behaviours'. At >2 hours-at-large the most frequent behaviour observed was 'swimming at the surface' (61 % of all observations). This dropped to 44 % during 2 – 4 hours-at-large and dropped to 29 % in the period >4 hours-at-large. The reverse trend involved 'resting in weed' observations where this behaviour accounted for only 3 % of all observations during the first two hours, 37 % during two to four hours-at-large and 56 % of all observations >4 hours at large. Predation rate was 18% in 2009/10 in 43% in 2011/12 and in both surveys reached 0 % >2 km from shore. Before the causeway was in place hatchlings released on the southerly beach travelled north-east over the future footprint of the causeway. Following construction, the majority (89%) of hatchlings typically swam parallel to the

structure, successfully circumnavigated its perimeter and resumed a north-easterly track. Future research on dispersal and survivorship will aim to understand the influence of artificial lighting associated with the project under different lunar phases. The Gorgon Project is operated by an Australian subsidiary of Chevron and is a joint venture of the Australian subsidiaries of Chevron (47.3 percent), ExxonMobil (25 percent), Shell (25 percent), Osaka Gas (1.25 percent), Tokyo Gas (1 percent) and Chubu Electric Power (0.417 percent).

TEMPORAL, SPATIAL, AND BODY SIZE EFFECTS ON GROWTH RATES OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) IN THE NORTHWEST ATLANTIC*

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We analyzed carapace length growth data for Northwest Atlantic (NWA) loggerhead sea turtles (*Caretta caretta*) from 10 research programs in response to a call from the US National Research Council for research programs to combine their data to improve sea turtle population assessments. We assessed growth dynamics over wide ranges of time (1978 to 2012), geography (9 to 33°N latitude), and body size (35.4 to 103.3 cm carapace length). Generalized additive models revealed significant temporal and spatial variation in growth rates and a significant decline in growth rates with increasing body size. Growth was more rapid in waters south of the USA (< 24°N) than in USA waters. Growth dynamics in southern waters in the NWA need more study because sample size was small. Within USA waters, the significant spatial effect in growth rates of immature loggerheads did not exhibit a consistent latitudinal trend. Growth rates declined significantly from 1997 through 2007 and then leveled off or increased. For the same interval, Witherington and colleagues showed in a paper published in 2009 that annual nest counts in Florida declined by 43% before rebounding. Whether these simultaneous declines reflect responses in productivity to a common environmental change should be explored to determine if somatic growth rates can help interpret population trends based on annual counts of nests or nesting females. Because of the significant temporal and spatial variation in growth rates, population models of NWA loggerheads should include growth data from extensive temporal and spatial coverage to ensure that the appropriate variation is included in calculation of demographic metrics such as age at sexual maturity.

A BIRD'S EYE VIEW: ASSESSING SEA TURTLE PRESENCE IN FLORIDA'S GULF STREAM AND COASTAL WATERS*

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Assessing the presence or absence of marine turtles in an open system poses both observational and analytical challenges due to the migratory nature of marine turtles and their use of large current systems. Concentrations can shift as turtles shift between oceanic and neritic stages and migrate between breeding and foraging grounds. Surface counts of marine turtles in waters off Florida's east coast were made in and adjacent to the Gulf Stream, a current which runs north along the coastline. This fast-moving body of water provides transport for hatchling turtles leaving Florida's eastern beaches and has the potential to serve as a migratory pathway for seasonal migrants, as well as breeding turtles entering or leaving the area. We conducted standard aerial surveys monthly from 2011-2012 to capture seasonal snapshots of sea turtle presence. Each survey covered the area from a northern boundary near West Palm Beach, Florida (26°43'N) to a southern boundary near Miami, Florida (25°40'N), USA with transects up to 20-50 km offshore. Loggerhead (*Caretta caretta*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and Kemp's ridley (*Lepidochelys kempii*) turtles were observed during the surveys, as well as hard-shelled turtles that were not identified to species. Two hundred and eighteen turtles were observed during the course of this study (2011: n = 79; 2012: n = 139). We summarize our sightings by season: Winter (December-February), Spring (March-May), Summer (June-August), and Fall (September-November) to examine trends in presence of sea turtles. A variety of sizes was observed throughout the year, indicating the presence of several life stages of marine turtles in Florida's waters during all four seasons. When combined into the categories of "nesting" season (Spring-Summer) and "non-nesting" (Fall-Winter), we determined that surface sightings of marine turtles increased by approximately 400% from non-nesting to nesting seasons. While it is understood that marine turtles use the waters off the eastern coast of Florida, here we document the magnitude of the shift in turtle presence each season throughout two years and where the turtles occur most frequently. Application of distance sampling theory to this study also allows us improve our understanding of turtle presence in the area by estimating abundance from the raw observations. Our assessment of marine turtles in the waters off southeast Florida provide valuable metrics describing the in-water biology of these turtles and for the first time, provide a quantitative assessment of annual and inter-annual fluctuations in presence in the major current and along our coast.

ADULT SEX RATIO OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) IN A MAJOR MEDITERRANEAN FORAGING GROUND

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Sea turtles are species with temperature-dependent sex determination (TSD) and female-biased sex ratios have been observed in most populations. Information on sex ratios at different life stages is necessary for developing population dynamics models used for conservation and to shed light on the possible adaptive value of TSD. Adults represent the less abundant class of sea turtle populations and adult sex ratios at foraging grounds are very difficult to obtain. Thanks to the activities developed in the island of Lampedusa, we could analyze the biometric data of 460 loggerhead sea turtles, ranging in size from 60 to 97.5 cm curved carapace length (CCL). These turtles were collected from the Tunisian shelf, one of the most important neritic foraging grounds for sea turtles in the Mediterranean. An elongated tail is the main secondary sexual character of adult males and a clear bimodal distribution was observed in the size class > 75 cm CCL. In this size class, the proportion of females was 51.5% (95% CI: 41.2 - 61.8%; n = 97) and data

suggest a seasonal variability in sex ratios. The results complement previous studies and support balanced or slightly female-biased sex ratios in adult and juvenile loggerhead turtles in the Mediterranean, in contrast with a highly female-biased sex ratios of hatchlings.

INTEGRATING STABLE ISOTOPE ANALYSIS AND HATCHLING PRODUCTIVITY ASSESSMENTS TO INFER RELATIVE IMPORTANCE OF FORAGING AREAS FOR FLORIDA LOGGERHEADS

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Understanding geospatial linkages is critical to the development of appropriate management and conservation strategies for migratory species. Stable isotope analysis is a powerful tool that is performed routinely across taxa to unravel migratory connectivity. Marine turtles are a highly migratory and widely distributed taxon, but are largely studied at breeding areas where they are more accessible. Satellite telemetry and isotopic values of several slow-turnover-rate tissues (i.e., red blood cells, skin, fresh and unhatched non-viable eggs) have been used to identify the various foraging areas used by loggerheads. Florida hosts the largest rookery for this species in the Western Hemisphere, yet few research groups encounter nesting females at night. In contrast, thousands of nests are marked to assess hatchling production through an extensive nesting survey program. We relied on the established Florida permit-holder system and collected non-viable eggs from a subsample of loggerhead (*Caretta caretta*) nests (n = 200) that were marked as a part of the hatchling productivity assessment program conducted by the Florida Fish and Wildlife Research Institute (FWRI) in 2013. Our sampling design was based on the relative importance of the five geographic areas used in the FWRI sampling scheme (Northeast, Central East, Southeast, Southwest and Northwest Florida) and reflected temporal distribution across the entire loggerhead nesting season (May-August). Up to 10 non-viable eggs were collected at time of excavation for stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope analysis from each of the 200 nests examined. We used discriminant function analysis (DFA) to examine how well $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ classify loggerhead foraging grounds. The DFA model was derived from isotopic signatures of over 100 nesting loggerheads that have been equipped with satellite tags in Florida in the last decade and was used to assign the foraging ground used by the 200 untracked loggerheads. By using a non-destructive sampling method (unhatched non-viable eggs) we provide a comprehensive geographic assessment of foraging grounds used by loggerheads nesting in Florida in a given year and shed light on the relative importance of foraging areas at the population level. As resources are limited, there is a need to prioritize where funds should be spent in order to maximize conservation benefits from management activities. Understanding relative importance of foraging grounds will allow us to make more informed management decisions by focusing mitigation and by-catch reduction measures on areas that represent loggerhead hotspots.

MODELING THE RELATIONSHIP BETWEEN POST-NESTING, NORTHWEST PACIFIC GREEN TURTLE MOVEMENT PATTERNS AND ENVIRONMENTAL CONDITIONS

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Effective management for the conservation of marine turtles requires knowledge of how habitat characteristics relate to turtle movements. Satellite tracking data were used to provide information on migration between reproductive beaches and foraging grounds, location residency times, and utilization of these habitats. Basic oceanography conditions such as bathymetry, sea surface temperature (SST), and surface currents have been linked to sea turtle

movement. In addition, dynamic mesoscale processes such as chlorophyll fronts may also influence sea turtle movements. Our main objective in this study is to understand how environmental conditions influence post-nesting green turtle migratory behaviors in the Northwest Pacific using geospatial modeling. We used 35 satellite tracks from Taiwan and Japan taken from 1994 - 2013 and modeled the effects of environmental parameters (e.g., sea surface height, sea surface and below surface temperature, surface and below surface salinity, distance from the coast, ocean current speed and direction, chlorophyll a concentration, magnetic field strength, wind speed, and bathymetry) on green turtle post-nesting movement behavior. Data from this study will be used to develop multiple regression models. The weightings from the multiple regression will be used to parameterize a circuitscape model which will be used to predict the likelihood of possible movement pathways through the seascape. This study may be useful for improving government-led management and conservation practices for marine turtles.

INTERACTIONS OF OCEANOGRAPHIC FACTORS WITH INTER-NESTING HABITAT SELECTION AND BEHAVIOR OF EAST PACIFIC GREEN TURTLES (*CHELONIA MYDAS AGASSIZII*) FROM PLAYA CABUYAL, GUANACASTE, COSTA RICA*

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Green sea turtles (*Chelonia mydas*) are long lived migratory species that are found across the globe in tropical waters. In the Eastern Pacific, green turtles (*Chelonia mydas agassizii*) remain along the coast and do not venture off the continental shelf. The purpose of this research was to use satellite telemetry to quantify inter-nesting behavior and key habitats for a population of East Pacific green turtles that nest at Playa Cabuyal, Guanacaste, Costa Rica; and compare these movements to known movements of neighboring populations and local oceanography/topography. In Playa Cabuyal, the nesting season for East Pacific green turtles begins in August and continues through April. During two nesting seasons: August-April of 2012-2014, we tether-attached MK10 satellite transmitters and epoxied Spot5 satellite transmitters (Wildlife Computers inc.), to the carapace of turtles during the nest covering and camouflaging process, post-oviposition. Cabuyal is located on the Gulf of Papagayo, which is partially protected as the Santa Rosa National Park. Although the turtles do spend some time in the northern waters (which are under protection), a majority of the inter-nest bout was spent in southern waters. Through satellite telemetry we recorded 3 distinct inter-nesting behaviors: 1) Turtles moved directly off the coast and remained in slightly deeper oceanic habitats, 2) turtles migrated south to nearby beaches or to Las Baulas National Marine Park (PNMB), approximately 50 km south, via near shore migrations or 3) turtles remained within the Gulf of Papagayo. Turtles that displayed post-nesting migrations followed previously described migratory corridors, showing that there is mixing of nesting populations at foraging grounds in the Eastern Pacific. Analysis of dive behavior and oceanographic habitats used were completed using Geographic Information Systems (GIS) software. We included conditions such as currents, temperature, productivity, and bathymetry to create a clear map of what habitats the turtles are using and what behaviors they are exhibiting during the 14-16 days between nests. The creation of layered maps allowed for the quantification of interaction points between sea turtle movements and oceanographic and anthropogenic factors providing insights on how complicated systems like the Pacific Ocean affect these turtle populations. This analysis provides baseline data for future studies on sea turtle movements in the Eastern Pacific, shows possible coastal foraging locations on migratory routes, and emphasized that the Gulf of Papagayo is very important to this population, as well as other populations, and extending the protection of the Santa Rosa National Park is vital to their continued protection. We would like to thank The Leatherback Trust, Indiana University, Purdue University, Community Foundation Sonoma Country, and Seeds of Change for making this research possible.

A COMPARISON OF FORAGING HABITS OF JUVENILE GREEN SEA TURTLES IN SOUTH FLORIDA AND THE CARIBBEAN

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Sea turtles are an important part of our coastal marine ecosystem. Due to constantly changing environmental conditions, available forage resources for sea turtles are of varying quality. We used oral lavage techniques to examine the foraging ecology of juvenile *Chelonia mydas* in 3 separate feeding grounds between 2008-2012: Dry Tortugas National Park (DRTO, N = 11); Everglades National Park (ENP, N = 5); and Buck Island Reef National Monument (BIRNM, N = 18). Foraging grounds in DRTO and BIRNM are dominated by seagrass habitat. In contrast, ENP foraging sites contain a predominance of marine algae. Sampling sites in DRTO and BIRNM tend to have a narrow range of salinity fluctuations, whereas the ENP site has a wide range of salinity fluctuations. Examination of lavage samples revealed that juvenile green turtles in DRTO consumed solely seagrass (*Syringodium* sp., 35%), and juvenile green turtles in ENP consumed solely marine algae (*Halodule* sp., 60%). In contrast, juvenile green turtles in BIRNM had a more diverse diet, as they consumed both algae and sea grass (*Syringodium* sp., 25% and *Rhodophyta* sp., 22%). These results contribute to our understanding of juvenile green turtle ecology and serve as a baseline for future studies or inventories of green turtles and their forage resources in south Florida and the Caribbean.

LONG-TERM ANALYSIS OF FEEDING ECOLOGY OF LOGGERHEAD TURTLES (*CARETTA CARETTA*) IN THE VALENCIAN COMMUNITY (SPAIN)

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We made a preliminary long-term comparison (17 years) in the diet of loggerhead sea turtles (*Caretta caretta*) from the western Mediterranean using samples of turtles stranded in the Valencian Community coast (East Spain) during three periods: Sample 1: period 1995-2000, mean CCL \pm SD: 56.8 \pm 10.4 cm, n = 28; Sample 2: 2001-2006, 60.9 \pm 11.1 cm, n = 29; Sample 3: 2012-2013, 45.9 \pm 12.1 cm, n = 27. The study was based on patterns of occurrence of the six prey groups: Fishes; Cephalopods; Pelagic tunicates; Decapod crustaceans; Benthic gastropods and bivalves, and other benthic invertebrates. Previous studies considered that groups 'Fishes' and 'Cephalopods' are basically consumed as fisheries discards or baits. An Analysis of Similarities (ANOSIM) was carried out to analyze potential differences in prey assemblages between samples. When differences were significant, a Species Contribution Analysis (SIMPER) was also used to identify the individual prey groups that contributed the most to the dissimilarity among samples. Frequency of occurrence (%) of each prey was as follows: Sample 1: Fishes: 39.3%, Cephalopods: 25.0%, Pelagic tunicates: 89.3%, Decapod crustaceans: 3.6%, Benthic gastropods and bivalves: 17.9%, other benthic invertebrates: 35.8%; Sample 2: Fishes: 48.3%, Cephalopods: 44.8%, Pelagic tunicates: 75.9%, Decapod crustaceans: 37.9%, Benthic gastropods and bivalves: 58.6%, other benthic invertebrates: 48.3%; Sample 3: Fishes: 29.6%, Cephalopods: 29.6%, Pelagic tunicates: 63.0%, Decapod crustaceans: 25.9%, Benthic gastropods and bivalves: 44.4%, other benthic invertebrates: 51.9%. Pelagic tunicates exhibited the highest frequency of occurrence in all samples. Significant differences were found among prey assemblages in the samples (ANOSIM, R = 0.059; p < 0.01); a post hoc comparison revealed that only Sample 1 differed significantly (p < 0.03) from Samples 2 and 3. The prey group that contributed the most to dissimilarity between Samples 1 and 2 was 'Benthic gastropods and bivalves' (20.9% of total dissimilarity) and between Samples 1 and 3 was 'other benthic invertebrates' (19.9%). This was confirmed by Chi-square tests (benthic gastropods and bivalves: Sample 1 vs. samples 2, $\chi^2 = 11.57$, p < 0.05; other benthic invertebrates: sample 1 vs. Sample 3, $\chi^2 = 4.11$, p < 0.05). No differences were found in prey groups of potential anthropogenic origin (Chi-square tests, Fishes: $\chi^2 = 2.04$, p > 0.05; Cephalopods: $\chi^2 = 2.77$, p > 0.05). Our results

suggest that, in the Valencian Community waters, juvenile loggerheads feed in neritic zones both in the water column (pelagic tunicates) and at the bottom (gastropods, bivalves and other invertebrates). However, exploitation of benthic resources has apparently increased in turtles sampled in recent years. Interestingly, this higher consumption of benthic prey is observed even in the smallest turtles (Sample 3), suggesting that the transition from pelagic to neritic stages is protracted and flexible. Conservation implications in relation to food availability and potential impact and current situation of local fisheries are discussed.

EPIBIONT FAUNA OF LOGGERHEAD TURTLES (*CARETTA CARETTA*) IN THE SPANISH MEDITERRANEAN: A GEOGRAPHICAL COMPARISON

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A total of 104 loggerhead sea turtles (mean CCL \pm SD: 57.11 \pm 10.46 cm) stranded on the Valencian Community coasts (East Spain) during 1995-2006 was examined for epibiont fauna. Epibionts were detected by the naked eye in 47 turtles, and 57 turtles were also washed over a 0.2 mm light sieve to detect small epibiont species. A total of 39 species were identified: (1) A group of 12 specialist species including barnacles (*Chelonibia testudinaria*, *C. caretta*, *Platylepas hexastylus*, *Stomatolepas elegans*, *Stephanolepas muricata*), the isopods *Caprella andreae* and *Hyale grimaldii*, the copepod *Balaenophilus manatorum*, the amphipod *Podocerus chelonophilus*, the tanaid *Hexapleomera robusta*, the decapod *Planes minutus* and the hirudinean *Ozobranchus margoii*; (2) A group of 27 generalist species including 9 barnacles, 5 bivalves, 4 amphipods, 4 sedentary polychaetes, 1 gastropod, 1 tanaid, 1 copepod, 1 hydrozoan and 1 bryozoan. Four species are new records for loggerhead turtles: *Lepas pectinata* (Cirripedia), *Bittium* sp. (Gastropoda), *Idotea metallica* (Isopoda), and *Jassa* sp. (Amphipoda), and 3 are new records for Mediterranean loggerheads: *Lepas anserifera* (Cirripedia), and *Hiatella arctica* and *Musculus* sp. (Bivalvia). An Analysis of Similarities (ANOSIM) indicated significant differences in epizoit assemblages between 'washed'avs. emblages be'turtles ($R = 0.175$; $p < 0.01$). A further Species Contribution Analysis (SIMPER) suggested that *Balenophilus manatorum* was the only small species that significantly contributed to the dissimilarity. This result stresses the need for a thorough examination of turtles to avoid missing small epibiont species. Hierarchical clustering and Similarity Profile Analysis (SIMPROF) based on the occurrence of 184 epibiont species from different studies was used to explore potential geographical patterns among epibiont assemblages from loggerhead turtles. A total of 8 samples was used: 3 from the northwestern Atlantic, 2 from the eastern Mediterranean, 2 from the central Mediterranean and 1 from the western Mediterranean (present study). Overall, no evidence of significant geographical structure was found. Still, some species appear to be restricted to, or be more prevalent in certain areas. For instance, barnacles of the families Archeobalanidae and Chthamalidae and crabs of the family Panopeidae were recorded in the northwestern Atlantic only, whereas the crab *Planes minutus* was not detected in the eastern Mediterranean. Several neritic taxa (bivalves, gastropods, anthozoans, poriferans, echinoderms, ascidians and annelids) were most frequent in samples of nesting turtles from the eastern Mediterranean and the northwestern Atlantic areas. Accordingly, some of the latter differences could be related to the ontogenetic stage of turtles (thus the habitat they exploit), rather than the specific regions where they are sampled.

INFLUENCE OF TIME OF RELEASE TO AVOID REVERSE TIDAL MOVEMENT DURING HATCHLING OFFSHORE MIGRATION AT PUNTA RATON, HONDURAS

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Punta Ratón is the main nesting beach for olive ridley sea turtles on the Pacific coast of Honduras. This beach is located on the eastern end of the Gulf of Fonseca (GOF), a shallow inlet of the Pacific Ocean 50 km wide (E-W) and 80 km long (N-S). Hatchlings from Punta Ratón must swim more than 30 km toward the Southwest before reaching the open sea. Tides in the GOF are extreme and tidal currents are very strong. In a previous study from 2012 we showed that hatchlings released at Punta Ratón began their offshore migration in the right direction (Southwest) during the outgoing tide, but were pulled back to shore (Northeast) during the following incoming tide, covering very short net distances at the end of the trials. The release of the hatchlings in 2012 followed the protocol of the local hatchery: neonates released directly into the water during mid-outgoing tide (3 hours after high tide). Hatchlings were tracked for 6 - 8 hours. To assess if time of release influenced the final outcome, during October and November 2013 we released 5 hatchlings just after high tide (during the first two hours of outgoing tide) and followed them for 8 - 12 hours, until the next high tide. We attached the hatchlings to a modified Witherington float by 1.5 m of sewing thread and followed them visually with a small fishing skiff, taking GPS positions every 30 minutes. We plotted our data in GIS and calculated total distances, net distances, main direction during outgoing and incoming tide, and distances from the start and end points to the mouth of the GOF. For all calculations we used the low tide time as the midpoint, taking into account the same amount of time for both outgoing and incoming tides. Hatchlings covered an average of 11.3 ± 1.4 km, with mean swimming speed of 1.2 ± 0.1 km/h (mean \pm SE). Although most turtles were pulled back to the East during the incoming tide, net distances were significantly longer than in 2012 (7.3 ± 1.6 km vs. 1.7 ± 0.7 km, $t(9) = -3.5$, $p = 0.007$), and the final position of the hatchlings relative to the start point was significantly closer to the mouth of the GOF (4.5 ± 1.1 km vs. 1.1 ± 0.9 km, $t(9) = -2.6$, $p = 0.029$). If the same pattern of movement is repeated during the following tides, we estimate that the hatchlings would be able to leave the gulf in a few days. Our results suggest that the release of the hatchlings at the beginning of the tidal cycle provides them more time to move away from the shore and escape the influence of the strong tidal current that runs parallel to the coast at Punta Ratón. Therefore, to improve hatchling survival and their potential for leaving the GOF to reach the open ocean, we recommend that hatchling releases take place immediately following high tide, during the first hour of the outgoing tide.

MOVEMENTS OF REPRODUCTIVELY ACTIVE MALE AND FEMALE LOGGERHEADS FROM A SOUTHEASTERN U.S. FORAGING GROUND*

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We studied the movements and diving behavior of reproductively active male and female loggerheads from Florida to identify their possible breeding areas. During early March of 2003, 2004, 2011 and 2013, we captured adult-sized loggerheads on a shallow-water (< 3 m) foraging ground in southwestern Florida Bay (Monroe County). This is an area where we have documented adult loggerheads as long-term residents (up to periods of 17 yrs. to-date). Captured turtles were examined using ultrasonography and laparoscopy to determine reproductive status. Those found preparing to breed were outfitted with a carapace-mounted satellite transmitter. Twenty reproductively active loggerheads were tracked, 13 males and seven females. Six of the females left Florida Bay for their nesting beaches by the middle of April and one departed by early May. All were offshore from their nesting beaches by the end of May. Six nested along the east-central coast of Florida (Martin County through Brevard County, one-way travel distances of approximately 300–450 km) and one nested just northwest of Florida Bay at Cape Sable (Monroe County, one-way travel distance approximately 40 km). Six males remained in Florida Bay (within 15 km of our study site) during the breeding season (March–May). One male traveled northwest to an area about 30 km offshore of the nesting beaches of Collier County (one-way travel distance approximately 175 km). This male spent most of the breeding season offshore of those nesting beaches. The other six males moved south into the Atlantic (oceanside of the Florida Keys at Long Key) and traveled mainly along the seaward edge of the reef tract (along the 30 m isobath). This nearshore area is known to be a migratory corridor for reproductively active females moving from foraging grounds in the Gulf of Mexico (including Florida Bay) to nesting beaches along the east coast of Florida. Of the six male loggerheads that moved into the Atlantic, three traveled northeast to areas from the upper Florida Keys to West Palm Beach (Monroe County through Palm Beach County, one-way travel distances approximately 120–260 km) and three traveled southwest to areas from Long Key to Marathon (Monroe County, one-way travel distances approximately 25–40 km). All the males returned to Florida Bay by the end of May. Dive data indicated that migrating males and females spent an unusually large amount of time at or near the surface and telemetry data indicated that their speed of travel was slowest in areas where males and females overlapped. Adult male loggerheads at our study site appear to make use of a variety of strategies for intercepting reproductively active females prior to nesting. Many remain on the foraging ground and would depend on encountering females before the latter depart for their nesting beaches. Many males move into a nearby migratory corridor where they likely intercept females en route to their nesting beaches and at least some move to areas offshore of nesting beaches and spend the breeding season there.

HABITAT SUITABILITY MODELING OF MARINE TURTLE FORAGING HABITAT IN THE NORTHERN GULF OF MEXICO

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Marine turtles are considered to be especially sensitive to climate change and sea level rise due to the potential negative impacts it would have on nesting success as well as foraging habitat, such as seagrass meadows. *Chelonia mydas* is considered the only herbivorous sea turtle, with seagrasses and marine algae constituting the majority of an adult green turtle's diet. Other marine turtles, such as *Caretta caretta*, consume organisms that live in seagrass beds. As a result, seagrass meadows are profoundly important in the foraging ecology of marine turtles, both directly as a forage item and indirectly as a structural feature that creates habitat for other marine turtle prey species. Declines in marine turtle populations have been associated with the deteriorating condition of seagrass meadows around the world, which underscores the vital relationship between these two organisms. Seagrass beds are habitat for a rich faunal assemblage, including echinoderms, gastropods, bivalves, pelecypods, annelids, and copepods. They also directly provide food to herbivorous grazers, such as certain fish species, sea urchins, marine turtles, waterfowl and manatees, and they also supply a source of prey for other species. Unfortunately, seagrass ecosystems are in global decline from direct and indirect human impacts. The causes of seagrass declines include coastal construction, eutrophication, pollution, overfishing, global climate change and rising sea levels. Seagrass declines are accelerating worldwide and these declines will likely impact marine turtles due to the decrease in food availability and from the loss of habitat for other prey items. My proposed research will focus on creating a series of habitat suitability models for seagrasses as well as marine turtle foraging habitat models and how these models will change with different sea level rise scenarios. The project focuses on Northern Gulf of Mexico but will be sufficiently generic that they could apply to other coastal ecosystems. These models will involve different environmental factors, such as water depth, salinity and turbidity that will impact the distribution of seagrasses and foraging grounds within the study area. These habitat suitability models will then be coupled with hydrodynamic models that will provide predictions of future changes in these environmental variables as a result of sea level rise. Using these outputs, we can predict areas that will become critical foraging habitats for marine turtles as a result of sea level rise. With this foraging habitat model, it is possible to influence future coastal development in a way that conserves critical foraging areas for marine turtles and other marine organisms. The results from the foraging habitat model and the seagrass habitat model will then be integrated with hydrodynamic models as well as marsh and oyster models to create useful conservation planning tools. These tools will enable the visualization of how sea level rise will impact a certain area with respect to the human development as well as different marine habitat types. This information will be important to policy makers and natural resource managers to address future management and policy decisions within the study area.

THERMAL PREFERENCES OF JUVENILE GREEN TURTLES (*CHELONIA MYDAS*) IN FORAGING GROUNDS IN THE BAHAMAS

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Coastal seagrass beds and tidal mangrove creeks in the Bahamas are important foraging grounds for green turtles (*Chelonia mydas*). These coastal habitats are affected by diurnal tidal cycles which influence water temperature and water flow. The thermal characteristics of sea turtle habitats are important to investigate since turtles are poikilotherms and are influenced by changes in temperatures, such as seasonal differences during migrations, determining nesting locations, and global distribution. Internal temperature changes have been shown to impact their digestive abilities, feeding behavior, locomotion, and stress levels. This study investigates the in-water thermal variation across a foraging ground and the thermal preferences of juvenile green turtles utilizing this area on the leeward coast of Eleuthera, The

Bahamas. Starved Creek is located within a semi-enclosed embayment called Rock Sound. This foraging ground is composed of mangroves, rocky shoreline, seagrass beds, and sand flats in depths ranging from 0-4.5 m. Starved Creek is a long, narrow creek (~2.5 km) with extensive red mangroves on either side, and a wide mouth (0.35 km) that connects this important habitat to the Bahamas Banks. Past studies have shown a high density of juvenile green turtles (ranging from 35.5 to 52.5 cm SCL) utilize this creek and surrounding flats for foraging purposes. To determine the thermal regime throughout Starved Creek an array of temperature data loggers (Maxim Integrated Thermochron® Temperature Data Loggers) was distributed across the study site to include a range of habitats and depths. The data loggers were programmed to record every hour, allowing storage of up to 3 months of temperature data. This allowed analysis of temperature variation across the tidal cycle, day and night, and calculation of weekly minimum, maximum, and mean temperatures. Data loggers were also deployed on juvenile green turtles and retrieved following various periods at liberty. Data loggers attached to turtles were programmed to record every ten minutes, producing two weeks' worth of temperature data.

SPATIAL DISTRIBUTION OF ENDANGERED SEA TURTLES, *CHELONIA MYDAS*, *LEPIDOCHELYS OLIVACEA*, AND *ERETMOCHELYS IMBRICATA*, IN THE GOLFO DULCE, SOUTHERN PACIFIC COAST, COSTA RICA

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Endangered sea turtles (*Lepidochelys olivacea*, *Chelonia mydas*, *Eretmochelys imbricata*) nest along the beaches of Punta Banco, at the mouth of the Golfo Dulce, on the southern Pacific coast of Costa Rica. Little is known about the interesting habitats or inwater distribution of these local sea turtle populations. However, anecdotal evidence from incidental capture in local fisheries suggests that sea turtles may exist in higher abundance than previously thought in this area. High abundance of multiple turtle species in a relatively restricted geographic area presents a unique opportunity for spatial management of highly migratory marine fauna. Furthermore, the impending possibility of developing tuna aquaculture in the region necessitates spatially-explicit research to better inform management of these protected species. I performed a visual survey at the mouth of the Golfo Dulce, mapping sea turtle surfacing events and calculating sightings density in two study sites. I found that surface sightings were most common in shallower waters (< 60 m) within 2 km of the coast. Analysis of sea surface temperature, atmospheric conditions and lunar phase did not present significant results, in some cases due to low sample size. However, sea turtle distribution in relation to bathymetry and proximity to the coast, is important information for managers to consider when implementing and enforcing spatially-explicit regulation.

SPATIAL ECOLOGY OF JUVENILE GREEN SEA TURTLES (*CHELONIA MYDAS*) IN CULEBRA, PUERTO RICO

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Following their oceanic phase, immature green sea turtles (*Chelonia mydas*) typically recruit to nearshore foraging grounds and shift to benthic feeding, mostly on sea grasses. These shallow bays are used as developmental habitats, and turtles may spend decades foraging in these areas until reaching sexual maturity. In Puerto Rico, the Culebra Archipelago provides important developmental feeding habitats for immature and subadult green sea turtles. Two bays on Culebra Island, Manglar Bay and Tortuga Bay are regularly used by immature and subadult green sea turtles; however, little is known about how they use these bays and their movements within and out of the bays. Capitalizing on an existing array of remote acoustic receivers established for bonefish in Culebra, our project is using acoustic

telemetry to quantify the habitat use and the broad and fine scale movements of immature and subadult green sea turtles in Culebra, PR. We are tracking turtle movements using an array of 59 fixed receivers (VEMCO VR2W), 34 deployed as nodes and short curtains around Culebra, and 25 deployed as a fine-scale positional system spanning a small reef flat and adjacent lagoon. A total of 30 green sea turtles, measuring from 38.3 to 70.3 cm straight line carapace length, were tagged with acoustic transmitters (Vemco V13 and V16 tags) in March and December 2013, and an additional eight turtles will be tagged in March 2014. Using the data that we downloaded from receivers in early December 2013, we conducted preliminary analyses of the nine turtles tagged in March. Of these nine turtles, one turtle was never detected after release, but detections from the remaining eight turtles were recorded for 67 – 169 days with the last detection on August 30. We had between 623 and 20,984 detections per turtle across 24 receivers. These turtles were regularly detected primarily in seagrass habitat across Manglar Bay during our tracking period, and six turtles were detected in the fine-scale array. Using the frequency of detections at receivers, we used social network analysis to identify associations of turtles within Manglar Bay. Collectively, data from this project will be used to understand how habitat type, temperature, tidal and lunar cycles, and season affect the movements of green sea turtles within Manglar Bay, and adjacent areas. We will determine the proportion of turtles that stay within one bay or move between bays in relation to turtle size. Finally, we will use the data to describe the foraging ecology of immature and subadult green sea turtles in relation to habitat use and availability. Long-term data from this study will provide important insights into site fidelity and habitats used by immature green sea turtles in the Culebra Archipelago.

A LOT OF TURTLES OR ALWAYS THE SAME ONES? LOCAL COMMUNITY PERCEPTION AND POPULATION ECOLOGY

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Population studies have been done globally with objectives of measuring parameters such as: survival, abundance, mortality, recruitment, immigration, emigration, residence, and other factors. These parameters are important for assessing trends in a population and then structuring conservation measures. Due to the ease of sampling, nesting beaches are most widely used for this type of study, but information on foraging areas of juveniles and sub-adults are also important, as these will make up the future stocks of adults. The Itaipu beach, is located in the city of Niterói, state of Rio de Janeiro, Brazil (22° 58'S, 43° 02'W). This beach has a fishing community that has existed for over a century, with activities being passed down for generations. The main fishing gears are beach trawl and gillnet. The region is considered a feeding area for green turtle (*Chelonia mydas*) juvenile and sub-adults. According to local fishermen, the presence of sea turtles has been increasing over the last 10 years, and it is common to hear them say that there are many turtles in Itaipu. Since January 2013 intentional captures has been conducted through beach trawl methods, which we tested in the present study and found that it was not a harmful method of capture for turtles. These captures aim to estimate abundance, survival, residence and mortality of sea turtles that occur in this region. Three tows were conducted daily for eight consecutive days every two months. All captured turtles were marked, measured, photographed and returned to the sea. Until November 2013, we had conducted 24 days of sampling divided equally among the months of January, April, July and October. At the beginning of the study (January) we tagged 25 new individuals, in April, we tagged 23 new individuals and recaptured 18 (n = 21), in July, we tagged 6 new individuals and recaptured 29 (n = 35). Finally, in October we tagged 4 new individuals and recaptured 24 (n = 28). Although this study is still preliminary and we need a longer sampling period to obtain population estimates, we can see is that unlike previous reports, the number of sea turtles that frequent the Itaipu beach is not as high as was reported by fishermen, but that these are the same turtles that are residing here during a given period. This finding was received with surprise by the local community, as they believed that Itaipu really had a lot of turtles. In response to this new finding, there is increased concern for the conservation of these turtles living in the region.

LONG-TERM IMPACT OF THE 2009 MONTARA OIL RELEASE ON THE SEA TURTLES OF THE TIMOR SEA*

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The Timor Sea extends from the northern shores of Australia to Timor. A rich diversity of flora and fauna thrives in marine and terrestrial protected areas in the productive oil and gas fields of the Sahul Shelf. The Montara exploration field sits 200 km north of the Australian mainland near the centre of the Sahul Shelf. On 24 August 2009 a sudden ingress of gas into the well bore of the West Atlas Oil Rig on the Montara field resulted in an uncontrolled flow of hydrocarbons into the Timor Sea. The uncontrolled release and following fire lasted for 74 days before the flow was stemmed. An estimated 30,000 barrels of light crude oil flowed over the surface covering an area of over 11,000 km². The company PTTEP Australasia Pty. Ltd., commissioned impact assessment and monitoring surveys of the region and its biota. In March 2012 and 2013 the long-term impact of the uncontrolled release on the marine turtles and sea snakes of the Timor Sea was undertaken. The surveys drew on pre-impact data collected in the previous 20 years and compared reefs that were potentially impacted with reefs that were clear of the modelled and observed surface slick. Potentially impacted reefs were: Hibernia Reef, 150 km to the north of the West Atlas Rig, Ashmore Reef and Cartier Island, both marine protected areas, at 160 and 100 km distance respectively. The unimpacted reefs were: Seringapatam Reef, Montgomery Reef, Scott Reef and Browse Island, the latter two being Nature Reserves of Western Australia. The surveys consisted of: a) in-water surveys with two observers using manta boards towed by a tender, b) beach surveys on nesting marine turtles and hatching success of recent nests, c) boat surveys of foraging marine turtles on reef flats, and d) assessing changes in blood chemistry of foraging juvenile green sea turtles (*Chelonia mydas*) from Ashmore Reef and Montgomery Reef. The team spent 1280 person hours conducting 200 km of manta board surveys covering 20,000 hectares of reef crests, with boat surveys over 300 km of reef flats and lagoons. Historically there was unequal distribution of marine turtles among the reefs. Ashmore Reef retained the highest density of green turtles with 477 individuals recorded on the 16 unequal sectors of the boat survey. The average number of marine turtles on the reef flat was 17.75 turtles/km or 444 turtles/km². Cartier was next most dense with 371 turtles/km² and Hibernia Reef, which lacks a nesting beach and reef flat at 43 turtles/km². The density of turtles on unimpacted reefs varied from 12 to 182 turtles/km². Seringapatam Reef was the only reef to have a decrease in marine turtle and sea snake numbers in the 12 months between surveys. There was no detectable impact on the number of nesting marine turtles. Results for most of the blood biochemistry parameters of juvenile green turtles were within the reference values from pre-impact surveys and unimpacted sites.

INDIVIDUAL, LONG-TERM TRENDS IN CARBON AND NITROGEN STABLE ISOTOPES FOR JUVENILE LOGGERHEAD SEA TURTLES IN THE ESTUARINE WATERS OF NORTH CAROLINA, USA

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Individual growth rates, life stage durations, and age to maturation are influenced by diet quality and composition and, as a result, management of threatened and endangered sea turtle species benefits from a clear understanding of foraging behavior. Loggerhead sea turtles (*Caretta caretta*) are long-lived and highly migratory, undertaking extensive shifts in habitat and diet throughout their lives. Furthermore anthropogenic activity, such as overfishing of target prey species, has been found to influence loggerhead foraging behavior. Analysis of carbon and nitrogen stable isotopes in animal tissues can offer insight into movement patterns, feeding ecology, and trophic structure of consumers. For loggerhead sea turtles occupying foraging areas in North Carolina's inshore waters, stable isotope studies have

examined diet composition relative to growth rates and migratory patterns. However, little is known regarding potential long-term trends in the foraging behavior of individual loggerhead turtles over time. In the current study, we analyzed stable isotope signatures of 74 plasma samples collected from 31 juvenile loggerhead turtles captured during multiple years from 2001 to 2010, to evaluate trends in nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$). Analysis of samples was restricted to those collected between May and mid-September when the turtles would be expected to be resident in the foraging area. Of the 31 turtles, 7 exhibited an increase over time in $\delta^{15}\text{N}$ consistent with a transition from oceanic to neritic foraging habitat. Initial straightline carapace length (SCL) and $\delta^{15}\text{N}$ for this group (“recruits”) ranged from 54.5 to 66.8 cm (mean = 60.2 ± 4.3 cm SD) and 8.38 to 11.92 (mean = 10.24 ± 1.3), respectively. SCL and $\delta^{15}\text{N}$ for the recruits were significantly lower ($p < 0.02$ and < 0.001 , Student’s t-test) than those observed for the remaining 24 turtles (“residents”), which ranged from 55.3 to 81.8 cm SCL (mean = 66.2 ± 5.9 cm SD) and 10.13 to 15.04 (mean = 13.30 ± 1.18 SD). In contrast, no significant difference in $\delta^{13}\text{C}$ at first sampling was observed between recruits (range = -15.05 to -18.17, mean = -17.16 ± 1.07) and residents (range = -14.36 to -19.20, mean = -16.35 ± 1.25) ($p > 0.05$, Student’s t-test). For the resident group, generalized additive mixed models (GAMMs) that accounted for random, individual effects potentially introduced by longitudinal sampling were initially used to evaluate the effects of potential covariates on $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$. Although no effects of calendar year, year since first sampling, and Julian date on $\delta^{15}\text{N}$ were found ($p > 0.05$ in all cases), the relationships between SCL and both $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ were significant ($p < 0.010$) and linear. As a result, further analysis was conducted using a linear mixed effects modeling approach, which also accounted for random, individual effects. While influence of SCL on $\delta^{15}\text{N}$ was significant ($p = 0.008$, accounting for 79% of the variance in $\delta^{15}\text{N}$), effect of SCL on $\delta^{13}\text{C}$ only approached significance ($p = 0.054$). However, individual effects on both $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ were found to be significant ($p < 0.001$), indicating that foraging patterns vary among juvenile loggerheads inhabiting this area. Results of this study will provide valuable insight into long-term foraging ecology for the species.

DIVING BEHAVIOR IN INTERNESTING EAST CARIBBEAN HAWKSBILL SEA TURTLES*

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The hawksbill sea turtle (*Eretmochelys imbricata*) is a Critically Endangered species that is found throughout the waters of the Caribbean. Many aspects of this species’ life history and behavior remain unknown, preventing the formulation of effective management plans. This lack of information has led the U.S. Fish and Wildlife Service to listing the determination of internesting habitat use as a key priority of the Recovery Plan for Hawksbill Sea Turtles in the U.S. Caribbean. To this extent, we used time-depth recorders (model LAT 1100 by Lotek) to investigate the internesting diving behavior of hawksbills nesting on Sandy Point National Wildlife Refuge, St. Croix, obtaining 7 sets of diving data from 5 different individuals. The average internesting interval was 15.5 days. Analysis of diving behavior indicated that turtles tended to dive more frequently during the first few days after nesting, before becoming less active during the internesting interval. In the middle 10 days of internesting, turtles dove repeatedly to the same depth, presumably to the same location on the ocean floor. Overall, they spent an average of 86.4% of the interesting period underwater with average dive durations of 29 min. This behavior is consistent with previous studies reporting that hawksbills take up residence areas during the internesting interval where they remain sedentary on the seafloor. While this behavior was consistent across all individuals, the average depth at where the turtle remained during this time varied from 3 to 29 m. In the last two days before nesting again, turtles began to dive more frequently, presumably as they swam back to the nesting beach. All turtles performed their deepest dives during this phase, with one individual diving to a maximum depth of 84.4 m and another attaining a depth of 94.4 m. These are among the deepest recorded dives for hawksbill turtles during the internesting interval. In addition to these deep dives, some turtles remained at deep depths, spending over 30 min at depths greater than 50 m. With one exception, all dives greater than 29 m occurred in the two days before or after nesting. This is likely due to the bathymetry off Sandy Point. A few hundred meters offshore, the ocean floor drops off several hundred meters. Since hawksbills tend to inhabit shallow reef habitat, it is likely that the only time they encounter waters deep enough to engage in such deep diving is when they are off Sandy Point. Additionally, these deep waters are not characteristic of typical hawksbill nesting beaches, meaning that the deep diving we documented may be unique to turtles nesting on Sandy Point. In summary these hawksbill turtles

remain relatively stationary during the middle of interesting and remain in a similar point in the water column and probably on the sea floor. Just prior to reneesting they move out offshore and come in contact with deeper waters, making their deepest dives and may be exposed to local fisheries and boat traffic. We would like to thank Claudia Lombard and Mike Evans of the USFWS for logistical support, as well as Jennifer Valiulis, Brian Daley and the staff of Geographic Consulting, LLC. Funding was provided through the Leatherback Trust and Lerner-Gray Fund for Marine Research. Additionally we would like to thank the International Sea Turtle Society, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation, U.S. National Marine Fisheries Service, Sea Grant-Texas, Shell, International Seafood Sustainability Foundation, Wildlife Computers, Environmental Business Specialists LCC, Sea Turtle Conservancy, Florida TURTLE license plate program, SIRTRACK, CLS America, Ecological Associates Inc., Desert Star Systems LLC, Loggerhead Marinelife Center, Janet Hochella, Kiki Jenkins, Sea Turtle Project-Bangladesh, Marinelife Alliance, Matthew Nash, Mission: Clean Beaches, Sandy Sly, ProFaunaBaja – ASUPMATOMA, Usagi Family and Debbie Sobel for travel support which made participation in the International Sea Turtle Symposium possible.

ASSESSING THE RELATIONSHIP OF BODY CONDITION INDEX AND GROWTH RATES OF IMMATURE GREEN TURTLES (*CHELONIA MYDAS*) IN THE BAHAMAS

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Somatic growth rates are variable within and among aggregations of sea turtles. On the north coast of the island of Great Inagua in the southern Bahamas, growth rates of immature green turtles (*Chelonia mydas*) spanning the post-recruitment development phase have been measured for over 30 years in a capture – mark – recapture study. Much of the variation in growth rates of immature green turtles in this aggregation may be accounted for by body size (carapace length), population density, and year of measurement. Body condition index relates an individual's mass and length and is a potential covariate of growth rate that has not been assessed in sea turtles. We calculate body condition index as $BCI = BM / (CL)^3$, where BM is body mass in grams and CL is carapace length in centimeters. In the present study we investigate the relationship of body condition index to carapace length and mass growth rates using long-term growth rate data for immature green turtles in the southern Bahamas to determine the amount of additional variation in somatic growth that can be accounted for by body condition. We also evaluate the extent to which body condition index can be used to estimate relative rates of somatic growth and/or habitat quality.

TETHERED POP-OFF SATELLITE TAGS: A LOW DRAG ALTERNATIVE?

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Animal-borne instruments provide researchers with valuable data to address important questions on wildlife ecology and conservation. However, these devices have known impacts to animal behavior and energetics. Jones *et al.* (2013) recently showed that PTTs disrupt the flow pattern around the host turtle and increase the drag coefficient, leading to increases in power output of the organism or reductions in velocity. These forced changes in energetics and behavior may reduce reproductive-output through increased energy demands or cause phenological mismatches of foraging and nesting events. Herein we study the increased drag from carrying tethered pop-off satellite tags (PSATs) as an

alternative to carapace mounted platform terminal transmitters (PTTs). We used the high speed tow tank in the Department of Mechanical Engineering at the University of British Columbia to measure the drag of commercially available PSATs at known swim speeds of marine turtles (0.3-1.3 m s⁻¹). PSATs increased the drag of an adult leatherback cast (SCL = 148 cm) by 1.5-2.8% and an adult green turtle cast (SCL = 94 cm) by 6.1-11.5%. At speeds greater than 1 m s⁻¹ tethered PSATs ride in the wake of the host turtle where flow disruption from the tag is minimized; however, at speeds less than 1 m s⁻¹ the buoyant force of the tag pulls the tether and tag up above the carapace and out of the turbulent boundary layer around the turtle body. This action places the tag in undisrupted fluid outside of the turtle's boundary layer and wake, thus leading to greater than expected drag costs. On juvenile turtles (leatherback SCL = 35 cm; green turtle SCL = 33 cm) drag from PSATs approached 29.5-34.9% of the turtle body drag alone. Tethered PSATs offer a comparable drag performance to direct attachment of PTTs. Researchers should use PSATs to address appropriate questions (e.g., post-hook mortality) but not as a low drag alternative.

FORAGING PREFERENCES OF HAWKSBILL TURTLES OF THE PACIFIC ISLANDS*

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Once recruiting to neritic habitats hawksbills (> 20 cm CL) have been observed foraging over coral reefs and rocky substrate, seagrass pastures, and in mangrove-fringed bays. The main diet of Caribbean hawksbills after recruitment to neritic habitats is sponges (Porifera) with *Chondrilla nucula* the most abundant. The diet of the hawksbill in the Caribbean and wider Atlantic region has been thoroughly reviewed and Bjorndal (2003) further provides a case study on the impact of hawksbill spongivory in the Caribbean. Few accounts of the hawksbill diet have been given since. Neritic hawksbills (26-83 cm CL) of northern and western Australia (as well as in the Indian Ocean, Cocos Islands) feed in tidal and sub-tidal coral and rocky reef habitats. The diet of Australian neritic hawksbills consists of algae, seagrass, and sponges (Porifera). Western Australian hawksbills have been noted to rely less on spongivory than their Caribbean counterparts. Hawksbills have also been recently noted to feed on hard corals in the Indian Ocean. Here we describe the diet of hawksbill turtles from the main Hawaiian Islands through foraging observations, analysis of fecal samples and stomach contents (from strandings), and the use of stable isotope analysis. We also characterize the prey abundance and energy density (bomb calorimetry) to estimate carrying capacity. The diet of the Hawaiian hawksbill primarily consisted of a protein sponge (*Chondrosia chucalla*) and red algae (*Amansia glomerata*) however the turtles were also observed feeding on unidentified fish roe and invasive algae. The sponge and algae ranged in energy density from 3-12 kJ/g/DM and isotope analysis revealed algae was the primary component of the hawksbills diet. The prey density and energetic analysis reveal that the hawksbill population is below the carrying capacity of the foraging habitat.

RESPONSES OF GREEN (*CHELONIA MYDAS*), LOGGERHEAD (*CARETTA CARETTA*), AND LEATHERBACK TURTLES (*DERMOCHELYS CORIACEA*) TO CHEMICAL ODORS IN WATER AND IN AIR

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The cues used by marine turtles to locate foraging areas in the open ocean are largely unknown though it is clear from field observations that some species (especially the green turtle, *Chelonia mydas*, the loggerhead, *Caretta caretta*, and the leatherback, *Dermochelys coriacea*) somehow locate areas of high productivity. An interesting question centers upon whether they do so by orientation toward chemical cues carried downwind in the air, by chemical cues carried by water currents, or if they are capable of detecting chemical cues both in the water and in air. Previous studies have

shown that loggerheads are capable of detecting airborne odors from synthetic food (turtle pellets) as well as natural airborne odors from a substance (dimethyl sulfide, or DMS) that is found in higher concentrations in highly productive oceanic areas. However, responses were brief in duration (lasting only a minute or two), and a capacity to orient was not investigated. We presented tethered loggerheads and leatherbacks with a laminar flow of air that contained DMS and observed no tendency to orient into the air current. In other experiments, we determined whether loggerheads swimming freely in a tank changed their behavior when exposed to DMS odor vs. seawater (control) “odor” with a neutral visual stimulus (a small plastic ball suspended in the water) present. Turtles showed no change in behavior when exposed to DMS or seawater stimuli. Additional experiments examined if loggerhead and green turtles swimming freely in a tank would respond to the odor of squid presented in air or injected as a homogenate into the water. Turtles were presented with the neutral visual stimulus during these trials as well. During control periods, the turtles were exposed to an air- and waterborne “odor” of seawater. Both species showed significant increases in biting behavior (directed either at the ball, the tank surface, or other turtles) when exposed to squid odor, whether presented in air or in water. We conclude that (i) air currents carrying either DMS or food do not induce marine turtles to orient “upwind,” (ii) turtles can detect and respond to food odors either in air or under water, and (iii) behavioral responses to food (squid homogenate) odors differ from those shown to DMS; only odors from food stimulate the turtles to initiate feeding behavior. None of our results provide support for the hypothesis that turtles locate distant sources of food in the ocean using odor cues.

A NOVEL USE OF AN ANCIENT HAWAIIAN FISHPOND BY GREEN TURTLES (*CHELONIA MYDAS*)

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An ancient brackish-water Hawaiian fishpond connected to Kiholo Bay on the west coast of the island of Hawaii has been found to be prominent foraging and resting habitat for immature green turtles, *Chelonia mydas*. Our study looked at the importance of the fishpond by determining the number of turtles using the fishpond, their behaviors, food sources, diel movements, and persistence of use. The results of our study have strong conservation relevance to land managers currently developing plans to alter certain features of the fishpond to enhance finfish populations. Movement by the turtles between the fishpond and Kiholo Bay via a narrow channel was monitored by video camera and a Radio Frequency Identification (RFID) monitoring station to detect the presence of 32 RFID-tagged turtles. This monitoring showed that 25% of the tagged turtles (n = 8) remained in the fishpond more than 85% of their time and video monitoring showed that a maximum of 74 turtles entered the fishpond in a single 24-hour period. A population of 75-100 turtles was estimated to use the fishpond for foraging, underwater resting and occasional terrestrial basking. Most turtles entered the fishpond from 1300-2400 h and moved out of the fishpond from 0500-1000 h daily. Movements into and out of the fishpond were influenced by tidal currents. Algal forage utilized in the fishpond included *Cladophora laetevirens*, *Pterocladia caloglossoides*, *Schizothrix calcicola* and *Chroococcus* sp. Based on our findings, turtles in the fishpond experience shelter from harsh ocean conditions and are protected from predation by tiger sharks frequenting Kiholo Bay. In addition, algae utilized within the fishpond may be vital to the turtles' nutrition and somatic growth given that published findings indicate that at least one coastal aggregation of green turtles on the same coastline has reached carrying capacity.

STABLE NITROGEN ($\delta^{15}\text{N}$) ISOTOPE ANALYSIS OF GREEN TURTLE (*CHELONIA MYDAS*) AMINO ACIDS: DEVELOPMENT OF A NOVEL INVESTIGATIVE TOOL FOR APPLICATION TO SEA TURTLE ECOLOGY AND CONSERVATION*

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Stable isotope analysis is widely applied to ecological studies and its application to sea turtle research helps inform conservation and management efforts. Since a consumer assimilates the isotopic composition of the environment in which it lives into its tissues, analysis of the isotopic ratios found in its tissues may be used to make inferences into an organism's life history and ecology. For example, stable nitrogen isotope ($\delta^{15}\text{N}$) analysis of a bulk tissue sample can generate insights into the trophic dynamics and critical habitat use of sea turtles. However, the bulk stable isotope method may be influenced by both nutrient cycling dynamics at the base of the food web and the subsequent enrichment that occurs up trophic levels resulting in erroneous data interpretation. This can lead to incorrect estimations of trophic level and other inferences generated therein. Recently a novel technique, $\delta^{15}\text{N}$ analysis of amino acids, has been used to address some of the limitations of the bulk method, namely more accurate estimation of trophic level. $\delta^{15}\text{N}$ analysis of individual amino acids can generate a more accurate estimation of trophic level by identifying amino acids that indicate trophic level ("trophic" amino acids) and amino acids that reflect the isotope composition at the base of the food web ("source" amino acids). However, critical assumptions must be tested and require experimental validation to apply this methodology, e.g., trophic and source amino acid designation, taxa specific trophic discrimination factors, and amino acid $\delta^{15}\text{N}$ incorporation rates. In this study we experimentally validated $\delta^{15}\text{N}$ analysis of amino acids for the East Pacific green turtle by determining I) the appropriate "trophic" and "source" amino acids, II) the trophic discrimination factor for green turtle skin and plasma, and III) the $\delta^{15}\text{N}$ incorporation rates for green turtle skin and plasma. Our results designate the appropriate trophic and source amino acids for both green turtle skin and plasma, determine trophic discrimination factors for both green turtle skin and plasma, and provide experimentally determined amino acid $\delta^{15}\text{N}$ incorporation rates for green turtle skin and plasma. Our study is the first to experimentally validate $\delta^{15}\text{N}$ analysis of amino acids for a sea turtle species and one of the first for a highly migratory marine megafauna. Results from this study satisfy critical assumptions for the correct application of this methodology, making available this tool for use in sea turtle investigations worldwide.

RELATIVE DENSITY OF JUVENILE GREEN SEA TURTLE (*CHEONIA MYDAS*) IN THE MPA CABO POLONIO-BARRA DE VALIZAS, URUGUAY

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The green sea turtle (*Chelonia mydas*) shows a high occurrence in Uruguayan waters, which are considered as key foraging and development areas for this species in the Southwestern Atlantic (SWA). This aggregation is a mixed stock of juveniles recruited from different breeding areas. The green turtle find the algae needed for its diet in the coastal rocky points of Uruguay. These linked spots constitute an important foraging network. The aim of this research was to analyze the green turtle population density in MPA Cabo Polonio-Barra de Valizas to demonstrate this area as

an important developmental habitat in this network. For this purpose Karumbé NGO performed scientific captures of green sea turtles in the MPA in 2005, 2006, 2007 and 2013. The capture periods extended from January to March, coinciding with the peak of green turtle occurrence along the coast of Uruguay. We used the CPUE index (Catch per Unit of Effort) to estimate green turtle abundance. CPUE was calculated by dividing the total number of captured turtles by gillnet soak time (in hours) per gillnet unit (we defined a unit as an area of 75 m²). We captured green turtles in 26 of 55 capture events during the study period, catching 46 green turtles. All turtles were juveniles (mean \pm SD = 38.5 \pm 4.5 cm CCL). We calculate the annual CPUE for each study year. The range for CPUE by year was from a minimum mean CPUE (0.37 \pm 0.81 turtles/hour x gillnet unit) in 2006 to a maximum mean CPUE (1.85 \pm 0.14 turtles/hour x gillnet unit) in 2013. The mean CPUE calculated for the study period in the MPA Cabo Polonio-Barra de Valizas (0.60 \pm 0.81 turtles/ hour x gillnet unit) is similar to mean CPUE observed in the MPA Cerro Verde e Islas de La Coronilla (0.47 \pm 0.91 turtles/ hour x gillnet unit), where Karumbé NGO mainly focuses its research efforts. If we consider this CPUE as abundance index, this means that the MPA Cabo Polonio-Barra de Valizas supports a relative density of green turtles similar to the MPA Cerro Verde e Islas de La Coronilla, which is considered critical habitat for green turtles in the SWA. Thus, we conclude the rocky points and surrounding waters in the MPA Cabo Polonio-Barra de Valizas represent another critical habitat for green turtles in this network, and support a juvenile stock. Moreover conservational policies should be adopted in the MPA Cabo Polonio-Barra de Valizas to preserve and protect this important green turtle stock from potential environmental impacts.

EPIBIONTS OF EASTERN ATLANTIC LOGGERHEADS

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The morphological features of sea turtles make them floating settlement structures for certain marine species that need areas to settle for part or all of their life cycle, thereby creating a mobile ecosystem in the ocean. Studying the presence and characteristics of the epibionts (species that colonize living organism) allows for a deeper understanding of the ecology and behavior of the host. In the Canary Islands (Spanish Archipelago located off the Moroccan coast), Liria Loza *et al.* (in prep.) analyzed the epibiont species living on the carapaces of juvenile loggerhead turtles (*Caretta caretta*) to better understand this ecosystem and obtain more information about the turtles through the specific characteristics of the epibionts that colonize them. A total of 29 epibiont species were found on juvenile loggerheads in Canary Islands waters, but only 14 species colonized more than 3% of the turtles sampled. The frequency and some characteristics related to the distribution and habitat preference of these 14 important species was analyzed, to look into the behavior and habitat preferences of juvenile loggerheads in the area. An interesting interaction was found between the epibiont species and the turtles, with two sea turtle specific species (*P. caretta* and *P. chelonophilus*), one specialized on marine vertebrates (*P. hexastylus*), and some flotsam specialists like *P. minutus*, *L. anatifera*, *C. virgatum*, *C. andreae*, and *F. pinnata* (this last species was found for the first time living on sea turtles) suggesting pelagic behaviors. The presence of the other epibiont species suggests coastal, or perhaps neritic, behaviors.

A PRELIMINARY HOME-RANGE ANALYSIS OF LOGGERHEAD SEA TURTLES RELEASED IN VIRGINIA, USA

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We conducted a home-range analysis on 23 loggerheads tracked by the Virginia Aquarium since 2011. Of the 23, 17 were rehabilitated and six were wild caught. All rehabilitated animals were released in Virginia. Thirteen were released in the Atlantic Ocean, six from ocean-facing beaches located in Virginia Beach, and five from the Chesapeake Bay

beaches. Three wild caught loggerheads were captured using a dip net and released approximately 115 km offshore from Virginia Beach, VA. Two wild caught turtles were recovered from poundnet heads on the Eastern Shore of Virginia and released near their recovery locations. The remaining wild caught loggerhead was captured in a netted swimming enclosure on the York River. We released 12 loggerheads in May-June, five in July-August, five in September-October, and one in November. Location data collection periods ranged from 20 to 299 ($\mu = 115$; standard deviation = 60) days. All transmitters were applied to the second and/or third vertebral scutes using Sita Anchor-Fix™ epoxy. We deployed six Sea Mammal Research Unit and eight Wildlife Computers tags. We applied the Movebank (<http://www.movebank.org>) Douglas filter algorithm to all records and set the parameters to select the records with the best accuracy within 24-hour time frames. Location points collected in the first 48-hours post-release were removed. We estimated each turtle's home-range by creating Utilization Distributions (UD) and 95% probability contours (PC), using Home-Range Tools for ArcGIS® Version 2.0.0004. We used the reference bandwidth from each loggerhead as a smoothing parameter and a fixed normal Gaussian bivariate kernel to calculate for UDs with 250 x 250 m cell size. We summed the intersecting areas of the 95% PCs and used quantile classification to divide the results into three groups. Polygons with the highest numbers of intersects ($n = 15-20$) were identified as areas of intensive use. We assigned geographic zones to each intensive use area based on the state and water body. The area of intensive use was calculated for each zone. The entire home-range (520,607 km²) stretched from New Jersey to Florida, including the Delaware and Chesapeake Bays. We identified 88 intensive use areas equaling 15,848 km², 46% of which were located in the ocean waters off North Carolina, 22% in the ocean waters off Virginia, 21% inside the Chesapeake Bay, and 10% in the North Carolina sounds. Since the turtles were originally found in Virginia, we expected Virginia waters to rank highly as intensive use areas. These results highlight the importance of not only Virginia, but also North Carolina ocean waters for loggerheads that utilize the Chesapeake Bay habitat. While North Carolina ocean waters were used most intensively in this analysis, it is also important to note both the wide geographic area included in the Virginia turtles home-ranges and that the timing of six releases (after September 1) excluded most of the foraging season in Virginia. The methods described here will be used to compare sea turtle movement on different temporal and spatial scales.

EVALUATION OF SCUTE THICKNESS TO INFER LIFE HISTORY RECORDS IN THE CARAPACE OF GREEN AND LOGGERHEAD TURTLES*

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The use of scutes in ecological studies that infer ontogenetic changes of habitat and diet in sea turtles using biological markers is becoming more frequent. Scute material has many advantages, it is an inert tissue so its composition does not change once it is deposited, and it grows continuously with the newest tissue growing below the oldest one. Therefore it passively records habitat and diet changes through time. These changes can be detected through the use of different biochemical markers such as stable isotopes and trace elements. However, the thickness of scutes is not homogeneous throughout the carapace. The thickness in each scute can vary according to the position on the carapace (oldest tissue is lost due to sloughing and abrasion), and can also vary within the same scute due to dissimilarities in retention rates in different areas. Therefore, depending on the size of the turtle and where in the scute a sample is collected, a different version of the life history of the turtle could be obtained and could pose a problem when trying to study the oceanic stages of sea turtles. Our goal was to determine where on the carapace is the thickest scute in green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles and if this area has the longest foraging history record of the turtle based on stable isotopes of carbon and nitrogen. Our results show that regardless of turtle size, the thickest part of the scute is found in the central region of the second lateral scute in green turtles and of the third lateral scute in loggerheads. These thickest areas have the longest record of the history of green turtles and perhaps loggerhead turtles. We were able to observe a clear shift of habitat from the stable isotope values in the central region of the scute of several green turtles that was not observed in the posterior margin. Thus, the central region site should be used to collect scute tissue in order to study the past of sea turtles more accurately.

FIRST SATELLITE TRACKS OF NEONATE SEA TURTLES IN THE SOUTH ATLANTIC*

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NOAA, the University of Central Florida, and TAMAR are working to understand the migratory behavior and dispersal patterns of oceanic stage loggerheads in the South Atlantic Ocean. Fifteen neonate loggerhead sea turtles were satellite tagged using modified small-scale solar-powered satellite tags. Fifteen turtles were lab-reared to 4-8 months old, 10.8-19.2 cm straight carapace length (SCL), and 235-1360 grams. Turtles were released at different times throughout the nesting season to coincide with changes in the current pattern along the coast of Praia do Forte (e.g., southern direction in early/mid-season and northern direction in late season). Oceanographic drifters were released along with the turtles to collect concurrent information on current patterns, and to examine the probability that turtles were passively drifting with the prevailing ocean currents. We examined turtle movements in relation to ocean circulation measured from drifters released alongside turtles, as well as numerical current models. Initially, all turtles followed a general circulation pattern observed with initial drifter trajectories following large-scale current patterns. Young turtles in the South Atlantic appear to be influenced by seasonal changes in current regimes - possibly impacting the connectivity of Brazilian turtles in the western Hemisphere. Our data will be used to compare movements and migratory behavior of neonate loggerhead turtles in the North Atlantic. These preliminary results will be analyzed together with the results of future releases, including data on environmental variables encountered by the turtles and other biological information.

RESPONDING TO A DYNAMIC THERMAL ENVIRONMENT: SPATIAL ECOLOGY OF EAST PACIFIC GREEN TURTLES (*CHELONIA MYDAS*) IN SAN DIEGO BAY, SAN DIEGO, CALIFORNIA, USA*

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The majority of marine turtles are ectothermic and respond to changes in ambient temperature to maintain physiological processes. Marine turtles maintain a body temperature by selecting an appropriate external environment, choosing a thermal niche in which they will perform at maximum physiological and behavioral efficiency. The thermal ecology of turtles has been well described and particular species-specific temperature associations have been found in pelagic and coastal waters. However, our understanding of population-specific thermal tolerances, particularly at coastal foraging or over-wintering areas is limited. For East Pacific green turtles (*Chelonia mydas*; EPGT), 15°C has been proposed as a thermal limit; heart rate and respiration rates have been documented to be lower in water that is below this temperature. San Diego Bay (SDB) serves as an over-wintering and foraging area for a resident population of EPGTs. For many years, the thermal ecology of south SDB was influenced by the fossil fuel-based South Bay Power Plant (SBPP), which discharged warm-water effluent from 1967 until December 2010. EPGTs in SDB were routinely observed in the outfall area of the plant during years of operation. Evidence suggests these turtles may have used the outfall because of the warm-water effluent and exhibited higher growth rates than other populations of green turtles. However, winter water temperatures adjacent to the outfall were often several degrees below the 15°C thermal limit. Because water temperature in SDB was modified by effluent from SBPP, this field site provides a natural experiment by which to evaluate this thermal threshold. From 2009 - 2012, movement and behavior of EPGTs in SDB

were monitored using a combination of acoustic telemetry and time-depth recorders (TDRs). A total of 50 acoustic tags were deployed on 33 unique individuals – as recaptures occurred across seasons: N = 17 turtles in 2009-2010, N = 18 in 2010 - 2011, and N = 15 in 2011-2012. Acoustic telemetry was conducted passively via a Bay-wide array of Sonotronics SUR-1 Submersible Ultrasonic Receivers (SURs) and actively via Sonotronics TH-2 towed omnidirectional hydrophone, DH-4 directional hydrophone, and a USR-08 ultrasonic receiver. To monitor dive behavior as related to water temperature, drogues made of syntactic foam housed a Wildlife Computers TDR-Mk9 archival tag and a Telonics MOD 050 very high frequency (VHF) transmitter. Temperature data were collected via a Bay-wide array of HOBO Water Temperature Pro-V2 Data Loggers and via YSI Multifunction Water Quality Meter. Preliminary data analysis suggest that turtle behavior has changed more in activity level than in spatial distribution, in response to changes in thermal environment. Turtles spent more time resting at cooler water temperatures, while spatial distribution did not change from 2009 to 2012. Water temperature varied widely ranging from as low as 9°C in the winter to as high as 40°C in the effluent area of SBPP during years of operation. Beyond fine-tuning our understanding of thermal thresholds, this study captures how turtles in an enclosed foraging area respond to a thermally dynamic environment. Results of this study may provide insights into how these long-lived marine organisms will respond to long-term changes in ocean temperature.

NEW PERSPECTIVES ON THE OCEANIC NICHE OF NEONATE LOGGERHEAD SEA TURTLES*

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Very little is known about the at-sea behavior of neonate or oceanic stage sea turtles. Young loggerheads are known to associate with epipelagic *Sargassum* for food and shelter; however, the thermal benefits of associating with surface habitats have not been considered. The first satellite tracks of neonate loggerheads in the Atlantic revealed a thermal disconnect between predicted (satellite- and model-derived) sea surface temperatures (SST) and ambient temperatures recorded by the transmitters affixed to the turtles' ecarapaces. Recorded tag temperatures were on average 6 °C higher than predicted SSTs. Tag charge rates and Argos location accuracy codes both suggest that these neonate turtles spent most of their time at the sea surface. We measured the solar reflectivity of satellite tags, turtle shells, *Sargassum* spp. specimens, and seawater to determine whether the observed difference between ambient and predicted temperatures could be explained by differences in solar reflectivity among these different materials. To test the hypothesis and validate the assumptions that *Sargassum* thermal environment is warmer than seawater without *Sargassum*, we measured and compared the thermal profiles of seawater containing *Sargassum*, and seawater without *Sargassum*. Our results show that the average 6°C difference is likely due to either surface-based habitat use or association with *Sargassum* microhabitats. This surface-based habitat selection provides oceanic stage turtles with a thermal refuge that promotes growth and temperature-dependent processes such as feeding, and suggests an evolutionary mechanism that supports the survival of young, heterothermic reptiles in the open ocean.

ABUNDANCE ESTIMATION OF THE OLIVE RIDLEY TURTLE IN THE MEXICAN CENTRAL PACIFIC WATERS DURING 2010*

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Annual nest counts of marine turtles have been used as indicators of population abundance; however, a potential bias could be produced due to females nesting more than once per season and not breeding every year. Abundance estimates from surveys at sea are an alternative and provide insight into temporal fluctuations. In this study we estimated the abundance of olive ridley turtles (*Lepidochelys olivacea*) in the Mexican Central Pacific (MCP; Jalisco, Colima, and Michoacan waters), using distance-sampling techniques. An area of 70,134 km² was covered in three surveys conducted during 2010 from the coast to 185 km offshore. The detectability of the species was estimated from its typical diving profiles, the mean vessel speed, and the Beaufort Sea state at each sighting. The surveyed area was divided into neritic (over the continental platform) and oceanic regions and these were further split into northern (Jalisco) and southern (Colima-Michoacan) portions, which correspond to nesting regions with intermediate and high densities, respectively. Spatial coverage totaled 3,506 km, and 749 sightings were recorded. A weighted average of the three periods (winter, spring and autumn 2010) was 177,617 turtles (CI: 150,762-204,471, CV: 17.2%, 95%). The highest abundance was recorded in winter in the oceanic region of Jalisco (N: 181,150, CI: 117,150-280,110, CV: 21.4%), gradually it decreased in spring (N: 43,496, CI: 21,945-86,213, CV: 31.14) and then, it decreased again in autumn (N: 29,361, CI: 19,951-43,200, CV: 18.45%); and vice versa, the minimum abundance was recorded in the neritic zone in winter (N: 7,386, CI: 3,291-16,354, CI: 32.32%), gradually it increased in spring (N: 12,746, CI: 8,843-18,371, CV: 16.98%) and it increased again in autumn (N: 88,174, CI: 34,170-227,550, CV: 40.48%). These results suggest that the highest abundances in the northern oceanic region (Jalisco) occur during winter and spring, while in the northern continental platform there is an increase during the autumn, which is consistent with the nesting seasonality of the species. Our results indicate that olive ridleys currently are abundant in coastal and oceanic waters of the MCP and their numbers are probably still increasing as a result of the protection programs that began in the 1990s.

POPULATION ECOLOGY AND DEVELOPMENT MODEL FOR GREEN TURTLES IN THE LOCAL AGGREGATION OF CERRO VERDE, ROCHA, URUGUAY*

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Most sea turtle species are globally distributed; but not randomly. Environmental and ecological parameters can influence sea turtle distribution; both globally and locally. Sea Surface Temperature (SST) strongly influences metabolism and activity levels in sea turtles, triggering e.g., different behaviors and somatic growth rates. In Uruguay, Southwestern Atlantic Ocean, the SST averages 15°C year-round; < 10°C in winter to > 26°C in summer. This work presents evidence of the occurrence year-round of green turtles *Chelonia mydas* in the Uruguayan local aggregation of Cerro Verde; furthermore, we propose a development model to this life cycle phase of green turtles at median

latitudes. From 2009 to 2013, intentional captures, sighting, beach surveys, epibiont analyses and monitoring by telemetry (n = 1) were conducted. Green turtles (n = 1120) were captured over 210 sampling days (750 hours in-water); 17% of these were recapture events. We conducted 3200 sighting samplings from a fixed point (10 min/sampling) (mean = 11.63 heads/sampling; s.d. = 15.75). Above 14°C, shallow waters (< 5 m) are important feeding zones; however activity levels and abundance vary seasonally and daily. Below 14°C, reports of green turtles decreased but returned as soon as the temperature rose above the limit. In different areas, green turtles have been observed to become sluggish, cease feeding, or enter dormancy when water temperature is lower than 15°C. In particular, SST observed during winter field trips is considered below this lower limit of the thermal range for green turtles. The reduced number of turtles may be explained by a latitudinal seasonal migration. However, several green turtles (intentionally captured and stranded) showed an ecological succession process in their carapaces; characteristics of rock reefs (mussels, barnacles, algae and polyquates, crabs and fishes). Possibly, the juveniles remained at rest on the seabed due to a reduction in basal metabolic rate, possibly hibernation, making them vulnerable to colonization of benthic organisms, thus developing a microclimate on the turtle's carapace. This was observed during the winter in the region. Moreover, in the warming period (spring) a green turtle concentration could be seen in freshwater channels; 39 were seen in one sampling day; possibly because of the difference between the seawater temperature (21-22°C) and the freshwater temperature (25-26°C). Based on multiple databases, we consider that Cerro Verde is a local aggregation of sea turtles year-round. Because of the variation in SST, different areas are important to the development of sea turtles; feeding zones in the summer and autumn, the seabed in winter and freshwater channels in spring. Possibly part of the stock migrates during the winter and some remain in hibernation. It would be helpful to assess the abundance of juveniles throughout the year and identify the mechanism of survival and home range with the variation in ecological and environmental parameters.

MARINE TURTLE MIGRATIONS FROM THE CUBAN SHELF TO COASTAL WATERS OF NICARAGUA

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The recapture of marine turtles from a specific area indicates the importance of that site for the species. Our work presents the results of tag recoveries from marine turtles originally tagged in Cuba and later recaptured from coastal waters of Caribbean Nicaragua, primarily from the Miskito Cays area. Between 1992 and 2013, 30 green turtles were recaptured in Nicaragua that were originally tagged either nesting on different beaches in the Cuban archipelago, from transit or foraging areas from the northeast region of Cuba, or from an experimental hatchery located in the southwest region. Three loggerheads were recaptured in Nicaragua that were originally tagged on nesting beaches in the Canarreos Archipelago (located south of Isla Juventud and Cayo Largo) in the southwest region. Two juvenile hawksbills were also recaptured in Nicaragua that were originally tagged in developmental areas for this species in the Jardines de la Reina Archipelago, located in the southeast region of Cuba. Analysis of recapture information demonstrates the displacement of immature and adult marine turtles, primarily the green turtle, from the Cuban Archipelago to Caribbean waters of Nicaragua. These migrations indicate the connectivity between the Cuban Archipelago and Caribbean waters of Nicaragua for both immature and adults of at least three marine turtle species and confirms the importance of Nicaragua's waters as a valuable developmental and foraging area for the region's marine turtles.

COMPARISON OF DIGESTIVE TRACT CONTENTS COLLECTED FROM SEA TURTLE CARCASSES STRANDED ON THE COASTS OF KANTO AREA AND OGASAWARA ISLANDS

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Digestive tract contents of sea turtle carcasses from Kanto Area and Ogasawara Islands in 2013 were compared. The Kanto Area and the Ogasawara Islands are two distinct areas in Japan which are approximately 1000 km apart. The coast of Kanto Area, which includes coast of Ibaragi, Chiba, and Kanagawa prefecture, is known as one of the massive stranding sites of sea turtles in Japan. Numerous loggerhead, green, and hawksbill turtle carcasses have been observed. The Sea Turtle Research Collegium has been collecting and analyzing the digestive tract contents of stranded sea turtles since 2003 to clarify the feeding ecology of these turtles as well as attempting to determine the cause of death; this is done in collaboration with the corporation of Everlasting Nature of Asia. The Ogasawara Islands, one of the major green sea turtle rookeries in the Pacific Ocean, is also known to have a tradition of consuming green turtles as cultural cuisine and so these turtles are butchered for meat. The group has been sampling stomach contents from slaughtered green turtles since 2011. This year, a total of 16 specimens (14 loggerheads, 1 green, and 1 black turtle) from the Kanto Area and 7 green turtle specimens from Ogasawara Islands were examined and compared.

DISPERSAL PATTERN OF HAWKSBILL TURTLE (*ERETMOCHELYS IMBRICATA*) HATCHLINGS IN NEARSHORE WATERS OF LIGHTED NESTING BEACHES OF MALACCA, MALAYSIA*

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Increased development of marine turtle nesting beaches with the presence of artificial lights can cause mortality in hatchlings by directing them away from the sea. To date, few studies have been carried out to determine the influence of artificial lights in coastal areas on dispersal pattern of turtle hatchlings. This study is an attempt to determine the impact of artificial lighting from human settlements, tourism infrastructure, street lights and offshore refinery near nesting beaches in Malacca (2°12'N, 102°15'E) on the dispersal pattern of hawksbill hatchlings released at two key nesting beaches. A total of 24 hawksbill hatchlings were used in this experiment, collected between June to September 2013 from hatchery upon emergence and transported to the release site; Kem Terendak (2°16'N, 102°05'E) and Padang Kemunting (2°18'N, 102°04'E). Selected hatchling was tethered using 1.5m polyfilament nylon line to a green luminous glow-stick (approximately 5 - 6% of hatchling's weight). Hatchlings were placed on the beach and allowed to crawl towards the surf. Each hatchling was tracked offshore for approximately 2 hours using kayak and the observer stayed approximately a distance of 1.5m – 3m behind the glow-stick. During the observation, the position of the kayak is tracked using the *TrackLog*, where the position of the kayak is recorded automatically into the GPS (Garmin Oregon 550) every 100m travelled until the completion of experiment. Assumption is made that the position of the kayak is the position of the hatchling. After each experiment, the hatchling was retrieved, the tethered glow-sticks were removed and the hatchlings released back into the water. Concurrently with the experiment, the direction of sea surface current was determined by tracking the direction of drift using a buoyant, equipped with GPS with function of *TrackLog* enabled. Circular Statistics were used to analyze the data by calculating the mean vector of the turtle hatchlings and sea surface current. Rayleigh Z test was then used to determine whether the dispersal is random or non-random. The studies showed that the mean angle orientation (\pm SD) of the turtles was $202.26^\circ \pm 60.85^\circ$, (n = 24) while the mean angle orientation of the sea surface current was $224.13^\circ \pm 78.52^\circ$, (n = 14). Rayleigh test, $Z = 1.521$, n = 24, $p < 0.05$ suggests that the probability of hatchlings dispersal is distributed non-randomly. Throughout the experiment, the hatchlings did not meander or drift back on shore towards artificial light source. In summary, the present study supports the finding that once in the water, the turtle hatchlings use wave direction as cue towards the open sea. However, the results could not determine the impact of lights and gas flares from an offshore refinery located 4 km

south of Kem Terendak beach on hatchling as the observer could not track the hatchlings dispersing with the surface current towards the refinery beyond the boundary of the refinery.

INSIGHTS INTO THE TROPHIC ROLES OF EASTERN PACIFIC OLIVE RIDLEY SEA TURTLES FROM COMPOUND-SPECIFIC ISOTOPE ANALYSIS OF AMINO ACIDS*

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Eastern Pacific (EP) olive ridleys (*Lepidochelys olivacea*) uniquely inhabit and forage in the open ocean. Individuals have the ability to travel tens of kilometers per day. Olive ridleys are thought to be opportunistic, generalist consumers; however intentional movement patterns, possible distinct -- even if dynamic -- foraging regions, niche width, and trophic role(s) in the eastern Pacific Ocean (EPO) are largely unknown. Most, if not all, other sea turtle species consistently use identifiable foraging grounds, including a fellow pelagic consumer, the Pacific leatherback. Stable isotope analysis is an emerging tool used to elucidate foodweb interactions and roles of consumers. Stable isotope values of turtle tissue provide information about an animal's previous location because spatially discrete food webs may be isotopically distinct. Bulk tissue stable isotope analyses alone are not sufficient to tease apart the influences of a region's baseline $\delta^{15}\text{N}$ isotope value(s) versus the consumer's trophic status in a distinct food web(s). However, compound-specific isotopic analyses of amino acids (CSIA-AA) provide the information needed to parse out influences of source nitrogen and trophic position. Therefore, to examine large-scale $\delta^{15}\text{N}$ spatial relationships we performed CSIA-AA on six olive ridley skin (epidermis) samples in four oceanographic sub-regions in the EPO: (1) Gulf of California (GC); (2) North Equatorial Current (NEC); (3) Eastern Pacific Warm Pool (EPWP); and (4) Costa Rica Dome (CRD). CSIA-AA analyses were utilized to determine whether trophic position changed depending on the open ocean region where the individual was sampled. Following Chikaraishi *et al.* 2009, trophic amino acid glutamic acid and source amino acid phenylalanine isotopic values were used to calculate the Trophic Level (TL_{Glu/Phe}) of each individual. Average TL_{Glu/Phe} in the GC, NEC, and the EPWP subregions was 2.65, suggesting that the trophic role of an individual olive ridley sea turtle does not significantly change with foraging location over a large spatial scale in the EPO. Average TL_{Glu/Phe} in the CRD, a highly productive oceanographic region due to a shallow thermocline and persistent upwelling, was ~2.8, suggesting that olive ridleys may be consuming higher-nutrient prey and perhaps able to specialize in that subregion. These results are part of a larger EP olive ridley foraging ecology study that is generating spatial knowledge of olive ridley foraging in the EPO on a seascape scale with the goal of determining if and where discrete, dynamic pelagic foraging areas exist. These results support the use of CSIA-AA as a useful tool to identify drivers of $\delta^{15}\text{N}$ signals in the EPO.

IDENTIFICATION OF IMPORTANT TURTLE AREAS IN THE ARABIAN REGION*

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The Arabian region we describe includes the Persian/Arabian Gulf and the Oman Sea. These habitats support substantial sea turtle populations that are often overlooked, numbering thousands of nesting females per year. The Gulf is a unique environment which undergoes extreme water temperature fluctuations (16°C to 37°C winter to summer), and ambient temperatures (0°C to 50°C). Given these temperature extremes, turtles nest during a short summer period (April-July). Beaches are unvegetated and provide no shade relief for incubating eggs, with sex determination being controlled by the temporal spread in nest deposition. Ambient and sea water temperatures in the Gulf are at or above known tolerance extremes of all species of marine turtle yet sea turtle populations persist. The Sea of Oman connects the Arabian Sea with the Strait of Hormuz, and in turn to the Arabian/Persian Gulf. The Oman Sea is mostly influenced by monsoon winds leading at one point to high surface sea temperatures and salinity, and at another to upwelling events, which cool waters substantially. Nesting populations in the region have, for the most part, been well documented and are periodically monitored by government agencies and NGOs. Virtually unknown however, is the location of foraging grounds and dispersal patterns/behaviour of turtles that use these nesting sites. Conservation of turtles requires protection not only at nesting grounds but also at foraging and developmental grounds. This project was designed to answer the lack of information on foraging areas so that threat analyses could be conducted for those areas, identifying Important Turtle Areas (ITAs) that may become the focus of conservation-related management interventions. The post-nesting movements of 94 hawksbill turtles in the Arabian region were used to identify key foraging grounds, temporal activity patterns and migration bottlenecks. Of these turtles, 75 were tracked from 2010-2013 by an EWS/WWF project in collaboration with numerous regional partners. These partners also contributed the balance of the tags from independent projects of their own to increase sample sizes. This is an incredible dataset that has revealed a wealth of information on turtle habitat use and behaviour in a climate-challenged environment. Going against all preconceived theories, hawksbills tracked from sites across the Gulf proper tended to head west to southwest, using the lower SW corner of the Gulf as important foraging areas. Some turtles also headed northward toward Saudi Arabia and Kuwait. Turtles from Oman primarily migrated to sites along the Omani coast, staying close to shore and inhabiting one of two key foraging areas. One turtle from Oman swam into the Gulf itself and another made it all the way to the Red Sea. Kernel density analysis of filtered datasets has allowed the identification of Important Turtle Areas (ITAs), which are currently being prioritised for conservation action. These are the first datasets on sea turtle in-water habitat use in the Arabian region and will improve the overall understanding of hawksbill habitat and behaviour in a climate-challenged environment, while supporting sea turtle conservation-related policy decision-making at national and regional levels.

**STABLE ISOTOPE ANALYSIS REVEALS MULTIPLE LIFE-HISTORY PATHWAYS FOR JUVENILE
LOGGERHEAD SEA TURTLES IN THE NORTHWEST ATLANTIC***

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Loggerhead sea turtles (*Caretta caretta*) experience pronounced ontogenetic shifts as they recruit from oceanic to neritic habitats and shift from epipelagic to benthic foraging strategies during their life cycle. The prevailing theory has been that this transition occurs as a distinct, one-way shift based largely on body size. However, recent evidence suggests this shift is reversible in both juveniles and adults. Growth rates are affected by prey abundance and quality, factors that vary spatially and temporally among habitats. Thus, facultative ontogenetic shifts between foraging habitats may be reflected in individual growth trajectories and, ultimately, population vital rates. The primary objectives of this study are to combine skeletochronological and stable isotope analyses of juvenile sea turtle humerus bones to examine intra-specific variation in juvenile foraging ecology and habitat associations, and to characterize the relationship between juvenile growth and foraging ecology. Humerus bone sections from 62 juvenile loggerhead sea turtles (51.2 – 88.4 cm straight carapace length [SCL] at stranding) were examined for histological features following Snover and Hohn (2004) and Avens and Goshe (2007). A high-resolution micromilling system was employed to sample individual growth layers for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ to reconstruct diet and habitat use histories. Stable isotope data were paired with back-calculated SCLs to examine relationships between growth rate, foraging strategy, habitat use, and body size. Analyses indicate a strong positive relationship between isotopic signature and body size ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ p-values < 0.0001), indicating that as turtles increase in size they increasingly exhibit benthic foraging strategies and migrations to neritic habitats. Additionally, a logistic regression of foraging strategy (benthic/pelagic) on SCL predicted mean size at recruitment to be 62.0 cm SCL (Odds-ratio = 1.14, p-value < 0.001). Evidence for facultative habitat shifts in response to changes in growth rate has been more elusive; there does not appear to be a clear relationship between growth rate and foraging ecology ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ p-values > 0.05). Reconstructed diet and habitat use histories were used to classify individuals into one of three life-history pathways: fast shifters (shift in one year, abrupt increase in isotope signature, n = 22), slow shifters (prolonged shift of multiple years, gradual increase in isotope signature, n = 10), and non-shifters (no shift, consistent pelagic or benthic isotope signatures, n = 29). The observation of slow shifters suggests that some individuals may alternate between benthic and pelagic foraging strategies and migrate back and forth between oceanic and neritic habitats for several years before fully transitioning to a neritic lifestyle, potentially altering our understanding of loggerhead life history and population dynamics.

**FORAGING ECOLOGY OF JUVENILE GREEN TURTLES IN THE CENTRAL REGION OF THE
INDIAN RIVER LAGOON, FLORIDA, USA**

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Our study site in the central region of the Indian River Lagoon (IRL), 3 km south of Sebastian Inlet, Florida, serves as developmental habitat for a significant number of juvenile green turtles. As part of a study to gain an understanding of the attributes of the lagoon that attract these animals, esophageal lavage was performed on 118 individuals over a two-year period. Red macroalgae comprised 87.3% volume of all lavage samples of which *Gracilaria* sp. (69.2% volume) was the most abundant followed by *Hypnea* sp. (8.4% volume), *Bryothamnion seaforthii* (4.0% volume), and *Acanthopora specifera* (2.4% volume). Seagrasses made up 11.8% volume of the samples of which *Halophila*

decepiens (10.0% volume) was the most abundant species. Green macroalgae, unidentified bryozoans, and unidentified materials were the remaining 0.9% volume. Forage item availability varied seasonally. The red algae were available year-round although species composition varied both seasonally and annually. *H. decepiens* is an annual plant that flourishes during the warmer seasons, when it was 26.3% volume of the lavage samples, but then dies off during the late fall as water temperatures drop. The algae is part of the drift algae found in the deeper areas of the lagoon (~ 2 m) which is also the habitat of *H. decepiens*. A perplexing aspect of the study was the preference for macroalgae over seagrasses, other than *H. decepiens*, despite the expanses of the seagrasses, *Syringodium filiforme* and *Halodule wrightii*, found in the adjacent, shallower areas. Our juvenile green turtle foraging ecology findings are similar to those of K. Holloway-Adkins for Jennings Cove in the southern region of the IRL. They are opposite of those for the Mosquito Lagoon in the northern region of the IRL where a study by M. Mendonca and another by K. Holloway-Adkins determined that juvenile green turtles are foraging primarily on *S. filiforme* and *H. wrightii* with macroalgae as a minor component of their diet despite its abundance in that habitat. Acknowledgements: The U.S. Fish and Wildlife Service provided funding. Hubbs-SeaWorld Research Institute handled the logistics of the project. The University of Central Florida Marine Turtle Research Group captured the green turtles required for the project. We are grateful for all the help provided by the UCF students. A special thanks to Duane DeFreese and John Wang.

EVALUATING THE IMPORTANCE OF MARINE PROTECTED AREAS FOR THE CONSERVATION OF DOMINICAN REPUBLIC HAWKSBILL TURTLES (*ERETMOCHELYS IMBRICATA*)*

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Understanding spatial and temporal habitat-use patterns to protect both foraging and nesting grounds of marine turtles is crucial to successful conservation. The Dominican Republic (DR), in the Eastern Caribbean, hosts regionally significant numbers of nesting hawksbill turtles, and nesting appears to be largely restricted to protected areas. Saona Island in Del Este National Park (DENP), southeastern DR, hosts the last major hawksbill nesting area (100 nests·year⁻¹ ± 8.4 s.d., range: 93-111). We use satellite tracking of 9 post-nesting females (CCL range 81.0 to 94.0 cm) (1) to analyze the movements and behavior of hawksbill females during the internesting period, and (2) to analyze their core-use areas with respect to MPAs both in their internesting and foraging areas. Overall, during the internesting period the common core-use area for all turtles that returned sufficient data was located inside the DENP's boundaries and 82.7 % of all locations were within the DENP's boundaries. Home range analysis revealed that individual internesting areas occupied by the turtles varied between 51.0 and 644.0 km². Kernel utilization distributions indicated that during the internesting period all turtles remained in the territorial waters of the Dominican Republic, mostly over the continental shelf (< 200 m). There was no correlation between size of internesting home range areas and turtle size (Pearson's $t = -1.2$). Mean internesting interval was 15.4 ± 1.1 s.d. days (range: 13 - 17 days), which is in accordance with conspecifics elsewhere. While two turtles remained in the DR after nesting, six migrated to foreign waters to forage (and one transmitter failed). During the foraging period, 78.0 % of locations were outside of MPAs either in the Dominican Republic (n = 2), Bahamas (n = 1) and Nicaragua and Honduras waters (n = 5). Conservation implications of these results and management effectiveness at the MPAs are discussed.

SATELLITE TRACKING REVEALS DEVELOPMENTAL MIGRATIONS AND PLASTICITY IN THE FORAGING BEHAVIOUR OF SUB-ADULT GREEN TURTLES IN THE TURKS AND CAICOS ISLANDS*

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Despite an increase in telemetry studies in recent years, the sub-adult age class remains one of the least studied stages of marine turtle life history. Protection of sub-adult turtles is considered important for facilitating population recovery. A better understanding of the behaviour and movements of individuals during this life stage could, therefore, help inform conservation management, particularly in countries with active turtle fisheries where sub-adults are often targeted. The Turks and Caicos Islands (TCI), a UK overseas territory, regulates a legitimate traditional fishery that lands juvenile, sub-adult and occasional adult green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles. The legislation regulating the turtle fishery is considered inadequate and is currently under review. As part of a broader study to assess management of this fishery, between 2011 and 2013 Argos-linked Global Positioning System (GPS) Fastloc satellite transmitters were attached to the carapaces of 11 sub-adult green turtles captured while foraging in seagrass beds on the Caicos Banks within the 'North, Middle and East Caicos Ramsar site' marine protected area (MPA). Individual curved carapace lengths (CCL) measured between 63.2 and 77.6 cm (mean \pm SD = 70.4 \pm 4.5, N = 11) and tracking durations ranged from 97 to 400 days (mean \pm SD = 263 \pm 87; NB: two turtles still transmitting at 31.01.14). Analysis of the GPS and Argos tracking data revealed that the study animals exhibited a range of foraging strategies. Five turtles consistently foraged within discrete areas within the MPA, while two turtles consistently foraged within discrete areas but exhibited sporadic roaming behaviour away from their preferred areas and beyond the MPA boundaries. Three turtles consistently moved between multiple sites separated by several kilometres and within the MPA, while one turtle also consistently foraged on multiple, separate sites, but exhibited sporadic roaming behaviour beyond the MPA boundaries before returning to the preferred sites. Three of the four largest tracked turtles undertook developmental migrations. The largest study animal (CCL = 77.6cm) travelled northward along the southeast USA coast to North Carolina before heading to waters over 500 km offshore where transmissions ceased. The second largest study animal (CCL = 75.6 cm) travelled south past Hispaniola through the Caribbean Sea arriving in Colombia's coastal waters before traveling along the coasts of Panama and Costa Rica (tracking of this individual was ongoing at 31.01.13). Another animal (CCL = 71.9 cm) migrated west to inshore waters of Holguin province Cuba where transmissions ceased. This research provides valuable insights into the poorly understood sub-adult life stage of the green turtle, including foraging and migration behaviours, and discusses implications with respect to spatial conservation and other management measures. This study suggests that management of the Ramsar site MPA under the TCI protected areas legislation has great potential to protect important foraging sites for aggregations of sub-adult green turtles using the Caicos Banks. However, other conservation measures, such the introduction of additional protective regulations, are required to protect these animals within and beyond the boundaries of the MPA.

REVEALING THE MIGRATORY BEHAVIOUR OF NESTING LEATHERBACK AND LOGGERHEAD TURTLES FROM SOUTH AFRICA USING SATELLITE TELEMTRY AND STABLE ISOTOPE ANALYSIS*

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Satellite telemetry is a powerful tool for investigating the behaviour of marine species, but satellite transmitters have two major shortcomings. Firstly, attachment and retention of telemetry devices can alter an animal's behaviour. Secondly, satellite transmitters are often prohibitively expensive for studies requiring large sample sizes. We evaluated and addressed these issues by comparing the post-nesting movements of leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*) turtles tracked using a variety of different techniques. In the iSimangaliso Wetland Park, South Africa, 18 satellite transmitters were deployed onto nesting leatherback turtles using a 'harness' technique (nine of these tracks have been published previously but the remaining tracks, collected by the Department of Environmental Affairs, South Africa in collaboration with Ezemvelo Wildlife and NMMU, have yet to be published). However, independent experiments demonstrated that harnesses significantly increase an animal's hydrodynamic drag. We therefore decided to investigate whether the movements of leatherback turtles with harnesses differed from those tracked using alternative methods. Between 2011 and 2013 we deployed Mk-10 PAT satellite transmitters onto 16 leatherback turtles using a low-drag 'tether' attachment that were designed so that the transmitter trails in the slipstream of the swimming turtle. During the years when the tethered transmitters were being deployed we also collected skin samples from both leatherback and sympatrically-nesting loggerhead turtles. Skin samples were analysed for $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ using stable isotope analysis – a molecular tool for determining an animal's previous foraging location from a superficial tissue sample. Upon post-nesting, the majority of the harnessed leatherback turtles ($n = 17$) followed the south-flowing Agulhas Current along the east coast of South Africa before heading towards open-water in the South Atlantic or Western Indian Ocean. Only a single individual migrated north, against the Agulhas current, and into the coastal waters of the Mozambique Channel. In contrast, movements of the tethered leatherback turtles ($n = 16$) appeared less guided by the Agulhas Current, with half of the turtles ($n = 8$) migrating northwards against the prevailing currents and into the Mozambique Channel. Combining the results of the tethered transmitters with the stable isotope analysis revealed that leatherback turtles foraging in the coastal waters of the Mozambique Channel had higher values of $\delta^{13}\text{C}$ than their pelagic counterparts. Evidence that leatherback turtles with higher values of $\delta^{13}\text{C}$ were foraging in coastal waters was further demonstrated by the similarity in $\delta^{13}\text{C}$ between coastal leatherback turtles and those of loggerhead turtles also foraging in the Mozambique Channel. Moreover, the stable isotope results corroborate the discovery from the tethered transmitters that the Mozambique Channel is a common, coastal foraging ground for leatherback turtles. We conclude that low-drag transmitter attachment methods, relative to high-drag methods, can provide a more comprehensive and natural representation of a populations movement patterns, especially when individuals are interacting with strong currents.

IDENTIFYING BEHAVIOURAL CHANGES IN MIGRATING LEATHERBACK TURTLES USING A CHANGE-POINT ANALYSIS MODEL

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An animal's movement patterns can provide insights into both its behaviour and the nature of the environments it is passing through. Particularly valuable information may be obtained from the migratory movements of leatherback turtles, *Dermochelys coriacea*, as this species forages exclusively on gelatinous zooplankton prey, a polyphyletic taxa that is commercially and ecologically important. Here, we developed a model based on Change-Point Analysis that enabled us to identify behavioural changes from dive and telemetry data obtained from leatherback turtles nesting in South Africa. We used this information to help identify dynamic prey-landscapes for leatherbacks in the South Atlantic and Western Indian Oceans. Between 2011 and 2013, we deployed 20 Mk-10 PAT tags onto leatherbacks nesting on the beaches of the iSimangaliso Wetland Park near the Mozambique border. These transmitters were programmed to record and relay location and dive data, including dive duration, depth, and frequency. Of the 20 transmitters deployed, 16 transmitters recorded data on post-nesting migrations. Of these 16 turtles, three turtles headed southwest with the prevailing Agulhas Current, before turning westward into the South Atlantic Ocean. Five turtles headed southeast toward the Agulhas Retroflexion. The 8 remaining turtles migrated into the coastal waters of the Mozambique Channel, specifically near the Sofala Banks and the west coast of Madagascar. To determine when an animal switched from transiting to foraging behaviour, we analysed the satellite telemetry data using a novel Change-Point Analysis model (CAM). The CAM identifies 'change-points' – state changes in the mean and/or variance – in a predefined number of behavioural metrics. The metrics used in this study included horizontal movement metrics, such as travel speed and turn angle, and vertical movement metrics, such as median dive duration and % time spent at the surface. The occurrence of a statistically significant 'change-point' in one or more key metrics was interpreted as a change in behaviour. The output of the CAM indicated that turtles migrating toward the Mozambique Channel switch behaviour almost immediately upon reaching the Sofala Banks, suggesting these animals began foraging there. Furthermore, these animals remained at the Sofala Banks for the remainder of the tracking duration, which in one instance extended over 9 months. As such, we conclude that the Sofala Banks is a highly productive year-round, coastal foraging ground for leatherback turtles. In contrast, the turtles that migrated towards either the South Atlantic Ocean or the Agulhas Retroflexion exhibited multiple behavioural shifts over the tracking duration, indicating these open-water animals experience more spatially and temporally patchy foraging conditions. Most modern methods for statistically analysing movement patterns, such as state-space models, only consider horizontal movement patterns. Yet we demonstrate that CAMs can be readily modified to include a wide-range of other behavioural metrics, such as vertical movement patterns (as used in this study) but also including metrics including heart rate, body temperature, accelerometry data, or muscle activity. To this extent, we propose that CAMs are useful tools for analysing behavioural shifts in a wide-range of species from a variety of potential behavioural metrics.

DISTRIBUTION AND ABUNDANCE OF MAIN DIET COMPONENTS OF THE HAWKSBILL TURTLE IN PUNTA COYOTE, COSTA RICA (EASTERN PACIFIC)*

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The rocky outcrops of Punta Coyote, north Pacific Costa Rica (9.760°N, 85.275°W) are home to a resident population of juvenile and sub-adult hawksbill sea turtles (*Eretmochelys imbricata*) that feed mainly on the sponge *Geodia* sp. and the ascidian *Rhopalea birkelandi*, varying the importance of each item seasonally (either dry or rainy). Spatial and temporal availability of these diet components are unknown, and few papers address the dietary preferences and requirements of hawksbill turtles in the Eastern Tropical Pacific (ETP). We quantified the distribution and abundance (ind/m²) of *Geodia* sp. and *R. birkelandi* in Punta Coyote through 6 surveys during both seasons at two depth ranges (2-7.5 m and 8-12 m). For each survey, a 50 x 1 m transect was done parallel to the coastline at each depth range. Counts of individuals of *Geodia* sp. and *R. birkelandi* in each 1x1 m quadrant along 10 consecutive quadrants, were followed by 10 quadrants where no counts were done, resulting in three 10 m² transects per depth. We didn't detect significant differences regarding the depth distribution of the sponge or ascidian. We did detect significant seasonal differences in the distribution of *R. birkelandi* and *Geodia* sp. *R. birkelandi* had a greater density during the dry season (34.82 ± 31.55) than during the rainy season (27.67 ± 11.87) (F = 17.17, p = 0.00045). *Geodia* sp., in contrast, showed a greater density during the rainy season (9.75 ± 7.39) than during the dry season (2.45 ± 3.40) (F = 5.66, p = 0.018). The ascidians were significantly denser than the sponges during both seasons. When the distribution of each diet item is compared to previous analysis held of esophagus contents, we infer that the greater availability of *Geodia* sp. during the rainy season and the inverse greater availability of *R. birkelandi* during the dry season, may jointly contribute to turtles ingesting more sponges during the rainy season and more ascidians during the dry season. Furthermore, to consider if food item selectivity is occurring, potential abundant food sources must also exist for the animal to choose and discriminate from. The greater year-round availability of the ascidians with respect to the sponge but the greater consumption of sponges during the rainy season, suggests that the hawksbill turtles of Punta Coyote could be displaying food item selectivity towards *Geodia* sp., and complements its diet with *R. birkelandi* during the dry season when the sponge is less abundant. More analysis of esophagus lavages is recommended to examine the nutritional quality of the food items and provide greater support to the food item selectivity hypothesis. This study exposes how the rocky outcrops are important habitats in the ETP that host populations of little known benthic organisms, which are the main food items of the hawksbill. According to a previous paper, it is presumed that the hawksbill turtle may be playing an important role in these rocky coastal ecosystems by controlling specific populations of rarely predated benthic species.

BEHAVIOR OF KEMP'S RIDLEY TURTLES DURING SOUTHWEST FLORIDA RED TIDE EVENTS

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The west coast of Florida experiences episodic blooms of the harmful algae *Karenia brevis*, colloquially referred to as "red tide," with corresponding increases in the strandings of marine animals. Little is known on the impacts of red

tide on marine turtles other than the mortality and physiological effects of exposure to the neurotoxins (i.e., brevetoxins) produced by this dinoflagellate. It is difficult to assess the response of marine turtles to red tide conditions as they are cryptic animals, spending most of their time underwater. Satellite telemetry is useful for remotely discerning their activities but there have only been isolated instances of turtles tracked during red tide blooms. We conducted a satellite telemetry study of Kemp's ridley turtles in the Charlotte Harbor National Estuary during the red tide events of 2011-12 and 2012-13. Turtle telemetry data were overlaid on the spatial network of red tide sampling sites using geographic information systems (GIS) software. The spatiotemporal associations of *K. brevis* cell counts and turtle locational data were analyzed to determine the pattern of Kemp's ridley behavior relative to the prevailing red tide conditions. Displacement from the release site was used as a metric for turtle movement. The red tide event of 2011-12 primarily occurred offshore and alongshore the barrier islands over a 4-month period, during which telemetered Kemp's ridleys established relatively small foraging ranges within Pine Island Sound. Accordingly, 71% of the turtle locations during the 2011-12 tracking season were ≤ 5 km from their release sites and 97% were ≤ 10 km from these sites. The red tide event of 2012-13 occurred offshore/alongshore but high counts of *K. brevis* also developed within the inshore waters of the estuary and persisted during a 6-month period. Telemetered turtles responded with greater movements within the estuarine complex and/or moving to offshore waters in what appeared to be "red tide avoidance." Given the greater range of movements during the 2012-13 tracking season, 96% of the turtle locations were > 5 km from their release sites and 76% were > 10 km from these sites. To our knowledge, the current study is one of the first opportunities to compare the behavior of marine turtles during consecutive red tide events.

LENGTH ISN'T ALL THAT COUNTS! HOW JUVENILE MARINE TURTLES OUTGROW GAPE-LIMITED PREDATORS*

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Female marine turtles lay thousands of eggs over a long reproductive life but only a small fraction of their offspring survive to adulthood. Most offspring mortality occurs during the earliest growth stages. During this time hatchlings and juveniles survive in the open ocean by hiding in flotsam until they become too large to be consumed by at least some of their predators, especially those that are gape-limited and so must swallow their prey whole. We observed that laboratory-raised green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles became wider faster than they increased in length. We hypothesized that such a pattern of differential (positive allometric) growth might shorten their exposure time to gape-limited predators by making the turtles more difficult to swallow at a smaller length than if they retained their hatchling proportions (by isometric growth). To test this hypothesis we reared 10 hatchlings from 12 nests of each species and plotted their observed change in shape (ratio of SCW to SCL) with growth over 13 weeks. We compared that shape to an expected shape based upon the retention of the hatchling proportions as the turtles increased in size. All of the turtles grew allometrically. We also measured the gape of a known oceanic predator of small turtles (the dolphinfish, *Coryphaena hippurus*) across its effective predatory size range (50 – 110 cm in fish fork length). We then used this information to compare turtle vulnerability to these predators over time, assuming an allometric vs. an isometric growth pattern. That comparison revealed that allometric growth shortened the time that both turtle species were vulnerable to a natural size distribution of dolphinfish by as much as two weeks, compared to an isometric growth schedule. These results provide support for the hypothesis that allometric growth (in addition to such behavioral adaptations as hiding in weedlines, minimizing movement, or escape diving) may be an important strategy for promoting the survival of young turtles during the time when they are most vulnerable to this class of predator.

PASSIVE ACOUSTIC TRACKING OF JUVENILE HAWKSBILL SEA TURTLES AT BUCK ISLAND REEF NATIONAL MONUMENT: TRENDS IN HABITAT-USE AND MOVEMENTS

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Passive acoustic telemetry has been implemented as an effective tool in tracking the movement patterns of many marine species, and has been beneficial to the development and implementation of MPAs throughout the world. Buck Island Reef National Monument (BIRNM) off the coast of St. Croix, United States Virgin Islands, is one such MPA where we are investigating broad and fine-scale sea turtle movement and habitat use patterns. BIRNM provides important habitat for a number of marine species, but is specifically listed as an index site for federally Endangered hawksbill turtles (*Eretmochelys imbricata*) by The Recovery Plan for hawksbills in the U.S. Caribbean Sea, Atlantic Ocean and Gulf of Mexico. Although previous studies have shown nesting female adult hawksbills to migrate long distances for foraging and nesting, juvenile hawksbill turtles have been shown to have high site fidelity and small home ranges in their developmental habitats. Previous in-water mark-recapture studies at BIRNM documented the distribution and occurrence of hawksbills in relation to habitat features. In 2011 we deployed an array of 43 VR2W Vemco receivers to determine “hotspots” of habitat use within BIRNM boundaries. Thus far, we have outfitted 18 individual juvenile hawksbills (with acoustic tags (either Vemco V16 or V9 69 kHz transmitters). As of the last download of the array in June 2013, 17/18 tags (94.4%) were detected a total of 111,996 times (only 6.2% of the total detections recorded) on 16/43 (37.2%) different receivers in the array. Individual hawksbill tracking durations ranged from 76 to 470 days (mean = 371.7 days, SD = 112.6). Night-time detections (N = 34,983, between 18:00:00 and 06:00:00) accounted for 31.2% (95% C.I. 0.310, 0.315) of total detections whereas daytime detections (N = 77,013, between 06:00:00 and 18:00:00) accounted for 68.8% of total detections (95% C.I. 0.685, 0.689). In addition, receivers in “deep” (> 5 m) locations comprised 52.5% of all juvenile hawksbill detections (N = 58,801; 95% C.I. 0.522, 0.527) whereas those in “shallow” (< 5 m) locations comprised 47.5% of all juvenile hawksbill detections (N = 53,195; 95% C.I. 0.473, 0.477). Preliminary analysis of detection data showed that 81.3% of all juvenile hawksbill detections occurred on 9 receivers located along the south fore-reef, with only 18.8% being detected on 7 receivers located on the north side of BIRNM. Previous mark-recapture results indicated that juvenile hawksbills used areas in the north and east sides of BIRNM, and our data reveals a possible shift in juvenile hawksbill habitat use compared to previous mark-recapture and in-water survey results.

STOP AND GO: GPS TELEMETRY REVEALS SEA TURTLES HALT TO CORRECT DIRECTION*

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Sea turtles are known for their high fidelity to their habitats and exceptional ability to navigate between distant habitats. Accurate navigation occurs not only between habitats in which turtles are familiar with both start and end locations

(e.g., breeding migrations) but from areas unknown to the turtles back to a familiar habitat. For example, some juvenile turtles in the north Atlantic were displaced from feeding habitats but consequently returned to the vicinity of capture. Prevalent hypotheses theorise that sea turtles use geomagnetic and chemical signatures to navigate to home, but the underlying mechanisms remain cryptic, especially for small scale navigation prior to returning home. Here we examine the track they follow on short return journeys to see whether their behaviour while traveling can offer insight into their navigational mechanism. We captured green and loggerhead turtles at their feeding habitats, attached Argos-linked Fastloc GPS transmitters, released them in areas remote to their capture locations (3.7 to 26.9 km), and then tracked their post-release movements. This experiment was conducted on a total of 14 green turtles and 8 loggerhead turtles captured at tropical Torres Strait and subtropical Moreton Bay. No terrestrial objects (e.g., islands, peninsula) were present between release and capture locations. We examined tracks starting at the point of release after displacement, and ending at the first location where a turtle settled down within its foraging habitat. The outer boundary of the foraging habitats was determined using a simple polygon from which a turtle never left after first entry. Point of settlement within the foraging habitats was identified using Resident Time Analysis (RTA). The locations during the post-release phase were then classified into moving and stationary states using RTA for detailed analysis on their movements. In every case, the turtles returned to the vicinity of capture sites; none stayed in or returned to where they were released. During the post-release phase, moving state occurred more frequently during the day than at night. We also found that the turtles tended to make a sharper turn after a stationary state than they did during a moving state. The turtles turned toward their home habitats more often after a stationary state than they did during a moving state. Our results suggest that short distance navigation by green and loggerhead turtles involves stationary state during which the direction of movement is corrected. Thus, we propose that more investigation of these stationary states may offer improved understanding of their sophisticated navigational mechanism. We thank the International Sea Turtle Society, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation, U.S. National Marine Fisheries Service, Sea Grant-Texas, Shell, International Seafood Sustainability Foundation, Wildlife Computers, Environmental Business Specialists LCC, Sea Turtle Conservancy, Florida TURTLE license plate program, SIRTRACK, CLS America, Ecological Associates Inc., Desert Star Systems LLC, Loggerhead Marinelifelife Center, Janet Hochella, Kiki Jenkins, Sea Turtle Project-Bangladesh, Marinelifelife Alliance, Matthew Nash, Mission: Clean Beaches, Sandy Sly, ProFaunaBaja – ASUPMATOMA, Usagi Family, Debbie Sobel and James Cook University for the generous travel grants that allowed TS to attend the symposium.

POST NESTING MOVEMENTS AND FORAGING OF LOGGERHEAD X OLIVE RIDLEY HYBRIDS IN BRAZIL*

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In Brazil, loggerheads and olive ridleys have overlapping temporal and spatial nesting seasons. The major nesting area for olive ridleys is the beaches in Sergipe state, where approximately 5000 nests are laid every year. Loggerheads mainly nest in the neighboring state of Bahia, but also nest in smaller numbers in Sergipe (800 nests/year). The Bahia-Sergipe loggerhead population is genetically homogeneous. Populations of both species have an increasing trend in the number of nests laid annually due to the conservation efforts of TAMAR (Brazilian Sea Turtle Conservation Program) and show initial signs of recovery. On the nesting beaches these populations face the same threats, such as increasing number of residents, tourist exploitation, and animal predation, among other factors. In water, both populations are exposed to the same threats along their nesting areas, but because they travel different paths to their respective foraging areas, different threats may be imposed. Hybridization between loggerheads and olive ridleys was revealed by Reis *et al.* (2010) in the state of Sergipe, where 27% of morphologically identified loggerheads exhibited olive ridley mtDNA sequences. Nuclear DNA analyses of these individuals later indicated they are all first generation

(F1) crosses. In 2006 TAMAR satellite tracked 10 post-nesting loggerhead females in Bahia and 10 post-nesting olive ridley females in Sergipe. The results of the two studies suggested different migratory patterns for each species, with very little overlapping of foraging areas. To learn how loggerhead/olive ridley hybrids behave, we placed satellite transmitters on 8 post-nesting females, identified as putative hybrids based on their morphology. According to studies from our group, genetically identified loggerhead hybrids were all smaller than 95 cm CCL. Therefore, we used that threshold to select putative hybrids. Four females received the transmitters in 2011/2012 nesting season, and 4 females in 2012/2013. Our major goals were to understand the behavior of these hybrids and compare that to studies of non-hybrid turtles we had previously done. To verify the genetic identity of these eight individuals we ran mitochondrial and nuclear analyses. We were able to monitor some animals throughout 328 days. We also determined if the hybrids had a similar diet to non-hybrids foraging in overlapping locations with N and C stable isotope analyses. This study will allow us to compare N and C stable isotope signatures of hundreds of nesting loggerheads, olive ridleys and their hybrids in the beaches of Sergipe to compare their foraging locations and diet.

FEEDING PATTERNS OF JUVENILE GREEN TURTLES (*CHELONIA MYDAS*) FROM AKUMAL, QUINTANA ROO, MEXICO

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Sea turtle feeding grounds, including coral reefs, seagrass meadows, and coastal lagoons are very important marine environments. The Mexican Caribbean represents one of the most diverse marine environments in Mexico and includes foraging areas for juvenile green turtles at Akumal Bay. The purpose of our study was to examine the foraging strategies of green turtles in this life stage. In order to determine juvenile green turtle resource use in Akumal Bay, $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ were analyzed in blood samples (whole blood, WB; red blood cells, RBC; and plasma, PL) of green turtles as well as their potential diet items (three seagrass species). Samples were collected between 2012 and 2013. Nitrogen isotope values in green turtles ranged from 2.6 to 7.8‰, 2.6 to 7.9‰ and 2.8 to 8.0‰ (in WB, RBC and PL, respectively), and carbon isotope values ranged from -11.6 to -5.8‰, -12.2 to -5.9‰ and -10.8 to -5.8 (in WB, RBC and PL, respectively). Nitrogen isotope values in seagrasses varied from 1.6 to 5.9‰, 3.7 to 4.9‰ and 3.7 to 4.1‰ (in *Thalassia testudinum*, *Halodule wrightii* and *Syringodium filiforme*), and carbon isotope values varied from -9.2 to -6.8‰ Nitrogen isotope values in seagr.5‰ (in *T. testudinum*, *H. wrightii* and *S. filiforme*). These results suggest that juvenile green turtles feed mainly on *T. testudinum*, and also that the natural variation of $\delta^{15}\text{N}$ values observed mainly in seagrasses may be related to rain water inputs. According to this, juvenile green turtles from Akumal Bay appear to have an herbivorous feeding strategy, similar to other foraging populations of juvenile green turtles in the Caribbean.

CRITICAL HABITATS OF SEA TURTLES IN FIJI

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Fiji waters are known to be a critical habitat for foraging sea turtle populations in the Pacific region. Recent surveys by the Secretariat of the Pacific Regional Environment Programme on satellite tagging revealed the migration of sea turtles to Fiji waters for feeding. Areas of importance for sea turtle conservation in Fiji were identified through community based sea turtle monitoring and research, traditional knowledge and consultation with partners who have worked in these areas. The collated information was consolidated and mapped out revealing these critical habitats for protection. The great sea reef is one of the critical foraging sites identified given the results of the satellite telemetry

in Fiji. It also highlighted that Fiji's sea turtle populations are residential. More satellite telemetry work needs to be conducted to allow for a stronger justification of the migratory behavior of sea turtles in Fiji. All seven satellite tagged turtles in Fiji did not show any migration out of Fiji. The migration patterns of seven turtles including loggerheads, greens and hawksbills were mainly movements within inshore waters of more than one customary fishing ground. It also showed the ecological connectivity of these marine protected areas and the greater need to enhance community based conservation and engagement in sea turtle monitoring to allow for an informed decision in the protection of sea turtles.

UNDERSTANDING THE EARLY OFFSHORE MOVEMENT PATTERNS OF TURTLE HATCHLINGS AND THE EFFECTS OF ANTHROPOGENIC LIGHT USING ACOUSTIC TELEMTRY*

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Investigation of in-water movement of turtle hatchlings has been hampered by the small size of hatchlings relative to the size of available tracking technologies. We tested the effectiveness of passive acoustic telemetry using new miniature transmitters to track turtle hatchlings in order to measure the influence of artificial light. Passive tracking consisted of an array of 36 acoustic receivers deployed near the benthos in the surf zone at Ningaloo, Western Australia to detect signals from coded acoustic transmitters attached to 40 green turtle hatchlings released into the array. Ten hatchlings were released into the array in each of two treatments, with artificial light present and under ambient conditions over two nights. The receiver array was used to obtain high resolution x-y positions of the turtles moving through the array. Positions can be calculated if a transmission from an animal transmitter is simultaneously detected on at least three time-synchronised receivers. These detections are converted into positions using differences in arrival times of the same signal at different receivers. Once positions were calculated, we calculated the bearing of travel from north (the position of the artificial light source). In the light treatment 80 – 100% of turtles travelled along a northerly bearing whereas in the ambient treatment only 33 – 50% of turtles took a northerly bearing. Whilst these data suggest an influence of artificial light, the data were limited, with only 19 - 30% of animal transmissions resulting in a calculated position. System time synchronization was excellent during both turtle release events, with each synch tag (a transmitter co-located with each receiver that allows the synching of time logged by each receiver in the network) transmission detected by 7-8 different receivers on average. However animal tag transmissions were detected by only 2.8 to 3.2 receivers on average. We suggest this was a result of turtles swimming at or very close to the surface. Given that the transmitter was attached parallel to the longitudinal axis of the turtle, signal strength would be reduced as some of the signal would radiate through the shell and water/air interface. Testing on a dummy turtle using three different transmitter positions relative to the turtle's body (parallel, perpendicular and hanging down from the body on a line) confirmed this. The percentage of animal transmissions resulting in a calculated position during the tests was 31%, 67% and 73% respectively and the average number of receivers hearing the transmissions 2.6, 4.1 and 6, suggesting that a perpendicular transmitter attachment is required for successful positioning of turtle hatchlings using acoustic telemetry. However, this attachment method would likely result in increased drag on the hatchling. We also measured the surfacing rate of turtles with and without dummy transmitters as a proxy of effort, with both groups having similar surfacing rates (7.9 ± 4.4 and 8.2 ± 3.8 seconds respectively). Our results provide an advancement in the understanding of how acoustic telemetry can be used to test hypotheses on the in-water movement of turtle hatchlings.

HABITAT USE OF NORTH PACIFIC LOGGERHEAD TURTLES (*CARETTA CARETTA*) AND DURATION SPENT IN A HIGH-BY-CATCH AREA NEAR BAJA CALIFORNIA PENINSULA USING SKELETOCHRONOLOGY AND STABLE ISOTOPE ANALYSIS*

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North Pacific (NP) loggerhead sea turtles (*Caretta caretta*) are a distinct population segment and are endangered due to decades of population decline. Fishery interactions and bycatch are known sources of mortality for these long-lived, migratory animals, with some of the highest rates of globally-documented mortality. Born in Japan, juveniles migrate across the North Pacific, where significant numbers forage in the Central North Pacific (CNP), and large numbers congregate to forage in the Eastern Pacific near Baja California Peninsula (BCP), Mexico for many years before returning to Japan as adults. It is unknown how long loggerheads inhabit each distinct region (West, Central North, and East Pacific). Our research seeks to determine the time loggerheads spend in distinct areas to better understand exposure to differential threats and prioritize management strategies. Particular focus is given to duration of time spent in the high-bycatch waters of the Eastern Pacific near BCP. To this end, we combine skeletochronology with sequential stable isotope analysis (SIA) of carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) of humerus growth layers. Results from the skeletochronological analysis of 135 juvenile and sub-adult turtles (45 - 90 cm CCL) that dead-stranded on the 45-km stretch of beach at Playa San Ls of, Mexico (BCP) between 2003 and 2011, were combined with previous analysis of 11 juvenile pelagic turtles (14.5 – 46.5 cm CCL) that had been captured during high-seas driftnet fishing in the CNP in 1991 and 1992. These CNP turtles were the focus of a 1995 study by Zug, Balazs, and Wetherall, a 1998 study by Chaloupka, and were also analyzed (skeletochronologically) by Avens, Goshe, and Bickerman in 2011. In addition, 34 of the BCP bones were sequentially sampled for stable isotope analysis of carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$). Naturally occurring stable isotope gradients exist in ocean systems and baseline values may differ among discrete habitats such as the pelagic CNP (depleted $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) and a more coastal, upwelling-dominated area like that near BCP (enriched $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$). Given these isotope gradients, the combination of SIA with skeletochronology provides a multi-year record of location, diet, size, age and annual growth of individual animals, and allows us to reconstruct life history and habitat use patterns. The SIA showed increases of both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ with size and age of turtles, supporting known life history patterns, and previous SI studies of juvenile loggerheads migrating from the CNP to the BCP area. Further, while the age of turtles in the CNP range from 0 - 6 years old (n = 11), the turtles stranded near BCP were estimated at 6 - 24 years old (n = 135). This indicates that NP loggerheads are in the BCP region for upwards of 20 years, which is a significant portion of their juvenile life phase. Given that minimum annual bycatch mortality in this BCP foraging area exceeds 1000 NP loggerheads, the long duration turtles spend in this habitat suggests these turtles have an extremely high probability of interaction with local artisanal fishing gear resulting in the potential for significant impacts on population levels and recovery rates of this endangered population.

FIRST RECORD OF OEGOPSID SQUID IN JUVENILE GREEN TURTLE (*CHELONIA MYDAS*) DIETS IN URUGUAY

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Green turtles are thought to undergo abrupt ontogenetic dietary shifts during their lives, from opportunistic feeding during the oceanic phase to an almost exclusive herbivorous diet once they recruit to coastal habitats. During their oceanic stage cephalopods might constitute a complementary food resource to their normal diets based mostly on pelagic cnidarians, gastropods and crustaceans. The Uruguayan coast includes the second largest estuary in the South Atlantic, the Río de la Plata estuary. The area has been identified as a feeding and resting ground for juvenile green turtles occurring year round, but little is known about the diet of green turtles there. In order to study juvenile green turtle diet along the Uruguayan coast, we collected gut contents from 54 specimens stranded there during the period 2009 - 2013. All the turtles analyzed were juveniles with curved carapace length notch to tip (CCLn-t) < 62.0 cm. A total of 52 cephalopod beaks were found in the stomachs and/or intestines of 17 of the 54 green turtles (FO = 31.5%). Turtles with cephalopod beaks in their guts were significantly smaller than those turtles not having beaks in their stomachs (CCLn-t; $F_{1,45} = 4.567$, $p < 0.05$). Cephalopod beaks were always associated with the presence of floating marine debris (soft and hard plastic, foam, rope, etc.) and other organic floating items (i.e., gelatinous items, *Sargassum* sp., pelagic crustaceans, etc.) in the gut contents. Beaks were assigned to 7 morphospecies of squid (Cephalopoda: Oegopsida) from 5 genera, *Chiroteuthis*, *Histioteuthis*, cf. *Batoteuthis*, cf. *Moroteuthis* and cf. *Mastigoteuthis* (the last three still need to be confirmed). The dominant species in terms of occurrence were *C. veranyi* (FO = 42%) and *H. bonnelli* (FO = 24%), which are oceanic medium-depth to deep-water squids that apparently undergo ontogenetic and diel vertical migrations in the water column in offshore habitats. *H. bonnelli* is widely but unevenly distributed in the southern subtropical areas of the Atlantic, while *C. veranyi* is known to be distributed in the Antarctic, sub-Antarctic and subtropical waters. According to the mantle length estimates, the specimens of *H. bonnelli* found corresponded to immature individuals and *C. veranyi* both to immature and mature individuals. The beaks found were probably accumulated in the turtle's digestive tract during their oceanic stage, remaining in the gut after they reached the coastal zones. This inference is supported by the smaller size of turtles that feed on squids. The squid species found are frequent in the diet of pelagic predators such as tuna, swordfish, blue sharks, petrels, albatrosses and porpoises. However, it is still unclear how non-expert divers such as small juvenile sea turtles predate fast swimming squid species. We hypothesize that turtles could eat squid during their nocturnal migration to the epipelagic zone, although the most likely explanation is a scavenger behavior over dead squid on the sea surface. The present work shows the relevance of the cephalopods in the diet of juvenile green turtles and improves knowledge on the ecology and distribution of Oegopsid squids in the SW Atlantic.

EVIDENCE OF DIETARY SHIFT IN IMMATURE GREEN TURTLES (*CHELONIA MYDAS*) FROM THE TEMPERATE SOUTHWESTERN ATLANTIC

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In Uruguayan coastal waters immature green turtles occur year round and present a narrow size distribution, which suggests that these waters host foraging and developmental neritic grounds for individuals recruiting just after the oceanic phase of their life cycle. In other regions, this habitat transition is accompanied by a dietary shift, with neustonic and pelagic invertebrates replaced by macrophytes as the main food resource. However, the timing and process of this dietary change may vary regionally. Previous esophageal lavage studies showed that green turtles occurring off Uruguay present an herbivorous diet based on macroalgae, but details about the dietary shift were unknown. The present study aims to understand this dietary shift during green turtle ontogeny and to assess their nutritional dependence on the macroalgae community. In order to study juvenile green turtle diet along the Uruguayan coast, we collected gut contents from 54 green turtles stranded between 2009 and 2013. All the turtles analyzed were of immature size, with a mean \pm SD curved carapace length, notch to tip (CCLn-t) = 40.0 \pm 7.0 cm (range: 29.8 – 62.0). The relative importance of each dietary group/species found was recorded as frequency of occurrence (FO). The specimens analyzed had an omnivorous diet, with a high occurrence of both macroalgae (FO = 74.1%) and gelatinous macrozooplankton (FO = 46.3%). Although we found twenty different species of macroalgae, only five taxa occurred in more than 40% of the samples: *Ulva* sp. (82.5%), *Grateloupia* sp. (62.5%), *Condracanthus* sp. (47.5%), *Codium* sp. (40.0%) and *Pterocladia capillacea* (40%). Marine debris occurred in 72.2% of the stomach contents analyzed, thus confirming that green turtles in this area may swallow floating objects opportunistically. To better understand the ontogenetic dietary shift of green turtles, specimens were classified in three size classes: CCL < 35 cm [n = 10], B: 35 cm < CCL < 40 cm [n = 20], C: CCL > 40 cm [n = 17]). Gelatinous macrozooplankton prevailed in turtles < 35 cm CCL (FO = 80%) while macroalgae occurred at a lower frequency (60.0%). Gelatinous macrozooplankton was still frequent in turtles ranging from 35 - 40 cm CCL (FO = 45%), but the frequency of occurrence of macroalgae was 65.0%. Finally, macroalgae was the most frequent food item (FO = 82.3%) in turtles larger than 40 cm CCL, although gelatinous zooplankton was still present (FO = 23.3%). Marine debris were frequent in the three size classes, although the frequency of occurrence decreased with size, from 80% in those turtles < 35 cm CCL to 58.8% in those turtles > 40 cm CCL. This preliminary study shows an important change in the green turtle diet after recruiting to coastal habitats, where they exploit the most abundant food resource in these neritic habitats, the macroalgae benthic community. Nevertheless, gelatinous macrozooplankton still remain as a relevant dietary group after recruitment, thus suggesting that this dietary shift may take place gradually, and that juvenile green turtles occurring in the neritic habitats off Uruguay are best described as omnivores rather than as herbivores.

MOVEMENT PATTERNS OF MARINE TURTLES IN THE WESTERN INDIAN OCEAN REGION AS INFERRED BY INTERNATIONAL FLIPPER TAG RECOVERIES

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Understanding the spatial movements of marine turtles is essential as a means of informing appropriate conservation and management recommendations. Although satellite technology is being increasingly used to improve understanding of spatial movement patterns, simple techniques such as flipper tagging remain effective and are of particular importance in less developed nations like Tanzania where human and financial resources for marine turtle conservation programmes are limited. In response to an increasing number of tag recoveries, a flipper tag recovery database was established in Tanzania in 2004. Each year, 10 - 12 flipper tags are recovered and the database now contains 126 records. Recovered tags have originated from several countries across the Western Indian Ocean region including Comoros (n = 23), Kenya (n = 10), Mayotte (n = 36), Mozambique (n = 2), Seychelles (n = 35) and South Africa (n = 11). Nine tags have also been recovered from turtles originally tagged in Tanzania. Flipper tags have been recovered from green (n = 93), loggerhead (n = 6), hawksbill (n = 1) and unidentified (n = 26) turtles. Gaps in the database are currently being addressed through communications with colleagues in the region. Tags are most commonly recovered by local fishers who receive a small incentive for returning tags to Sea Sense NGO which manages the database. Rufiji and Kilwa Districts in central Tanzania are the most common location for tag recoveries. Bycatch in gillnets is the primary source of tag recovery and it is common for captured turtles to be slaughtered for sale and consumption. Most tag recoveries have come from female green turtles that were originally tagged while nesting in the Seychelles, Comoros and Mayotte, confirming that green turtles in the region undertake open water migrations between Indian Ocean islands and the East Africa continental shelf, a distance of up to 1,000 km. Long distance migrations such as these suggest that the central Tanzanian coast provides important migratory corridors and foraging grounds for green turtles, many of which are from regionally important nesting sites: Seychelles (Aldabra Atoll), Comoros (Itsamia, Moheli), and Mayotte (Grande Saziley). Regional satellite telemetry studies confirm this and have concluded that the central Tanzanian coast is one of only five regional ‘hotspots’ for foraging green turtles. The Secretariat of the Indian Ocean South East Asian (IOSEA) Marine Turtle Memorandum of Understanding has resolved to establish a ‘Network of Sites of Importance for Marine Turtles’ in the IOSEA region. In view of the evidence presented, Tanzania has submitted a formal application for the Rufiji Delta to be considered as a Site of Importance for Marine Turtles in the region.

HOME RANGE AND IN-SITU FORAGING BEHAVIOR OF SUB-ADULT HAWKSBILL TURTLES (*ERETMOCHELYS IMBRICATA*) IN PALM BEACH COUNTY, FLORIDA, USA

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Ongoing mark-recapture studies in SE Florida have shown that sub-adult hawksbill turtles (*E. imbricata*) typically remain in fairly small areas for extended periods of time, but little is known of their patterns of daily activity and habitat use. In this study, we collected data from satellite telemetry and direct in-water observation to test two hypotheses: (1) sub-adult hawksbills repeat non-random, refuge-centered daily movement patterns, and (2) sub-adult hawksbills are highly discriminatory, multi-step feeders that actively seek a narrow range of preferred prey items. Between August of 2010 and October 2013, six (6) wild, previously-identified sub-adult hawksbill turtles were fitted with GPS-linked (Wildlife Computers, Inc. Mk-10 AF) satellite transmitters on the 60 - 90 reefs of Palm Beach

County, Florida, USA. Location, temperature, and depth data were retrieved from Argos through CLS, Inc., decoded and filtered with Wildlife Computers Inc. software, and managed with ArcView 10™ geospatial software. Simultaneously, 141 total minutes (representing 31 subjects) of close-range, in-situ video recordings of foraging hawksbills were opportunistically collected by divers and subsequently scored for behavioral analysis. An ethogram was created that identified five distinct behaviors preceding the focal act of prey ingestion. Transition matrices were created for each video and sequential analyses were performed for each using JWatcher™ behavioral analysis software. Preliminary results support both hypotheses. Though varying quantities of data were gleaned from each transmitter (deployment duration: 102 - 425 days), all six turtles remained within approximately 1.5 km of a nightly place of refuge consistent with a central-place foraging strategy. During feeding bouts, the turtles meticulously examined the benthic substrate seeking only a few (< 5) species of often concealed poriferans. Once targeted, each potential prey item was carefully scrutinized through a non-random, decreasingly-frequent series of behaviors that led to a high rate of rejection (> 85%). It can be concluded from this study that the typical Palm Beach hawksbill turtle is a rather finicky creature of habit that meanders among familiar surroundings for extended periods of time. Turtles foraged on both reef top (low relief) and ledge (high relief) habitats, but places that offer shelter (ledge undercuts/wrecks) appear to be key features influencing habitat utilization patterns, particularly at night. Though not tested experimentally, it was evident from the video footage that both vision and olfaction were important in targeting prey, and that the hawksbills observed were highly fastidious feeders that sought a narrow range of preferred food items. Though elusive, this kind of basic biological information is critical to our understanding and informed management of this, and all, protected species. Where possible, the expanded use of direct observation to supplement in-water sea turtle behavioral studies is strongly encouraged.

ENVIRONMENTAL CHARACTERIZATION OF A SEA TURTLE FORAGING AREA FROM GUASAVE, SINALOA (GULF OF CALIFORNIA), MEXICO

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The coastal marine area of the municipality of Guasave is located in the southern Gulf of California. This is a seasonal coastal upwelling area, with high productivity and where a lot of commercially and protected important species occur. Previous studies have characterized this area as an important foraging zone for different species, including sea turtles, making it appropriate to decree it as a marine protected area. However, it's necessary to undertake a complete justification study to describe the physical, chemical and biological characteristics of the area. Therefore, for this work, Sea Surface Temperature (SST), salinity (SAL), pH and Dissolved Oxygen (DO) were determined *in situ* in a bimonthly monitoring scheme at a 15-station network from February 2012 to April 2013. We collected surface water samples for nutrient quantification: ammonium (NH₄), nitrates (NO₃), nitrites (NO₂), orthophosphate (PO₄) silicates (SiO₄) and chlorophyll a (Cla); surface samples were analyzed using a zooplankton mesh (505 µm) to determine zooplankton biomass (BZ) and permit the identification of major groups of zooplankton. The results of the environmental variables allowed us to distinguish two seasons: a cold season (December to April), characterized by low temperatures (15.8 - 21.1°C) high concentrations of OD (9.78 - 14.26 mg/L), Cla (0051 - 21639 mg.m⁻³), NID = NO₃ + NO₂ + NH₄ (0.36 - 9.99 mM) and BZ (33.15 ml/1000 17456.98 m³) and a warm season (July - October) with high temperature (27.6 - 30.9°C), lower concentrations of OD (5.02 - 7.12 mg/L), Cla (0017 - 5074 mg.m⁻³), NID (0.02-5.44 µM) and BZ (32.89 - 2468.91 ml/1000 m³). The transition months from one season to another were May and November, from cold to warm and warm to cold respectively. Spatially, TSM maximum values were located in the areas closest to the coastline, while the SAL in this area were measured at a minimum in the warm season mainly due to the dilution effect of rainfall. The O.D. concentration had a wide range of variability (2.19 - 14.26 mg/L), the minimum value was recorded during October 2012 and the maximum recorded was in April 2012 at points near the coast. The spatio-temporal analysis showed a higher volume BZ (ml/1000 17456.98 m³) in April at the oceanic stations, with a high abundance of ctenophores; these are exclusively marine and abundant in the seas around the

world, constituting a high proportion of plankton biomass. The highest monthly average of Cla was recorded in February (3.41 mg.m⁻³), which generated a response from the BZ, with an average maximum volume in March of the same year (ml/1000 2076.21 m³) composed mainly of jelly, which is eaten by sea turtles. We conclude that environmental variability in the area promotes foraging conditions for sea turtles.

Nesting Biology

EFFECTS OF INCUBATION TEMPERATURE ON DEVELOPMENT, LOCOMOTION PERFORMANCE AND MORPHOLOGY OF OLIVE RIDLEY HATCHLINGS UNDER LABORATORY CONDITIONS*

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High incubation temperatures (>33°C) in natural nests of olive ridleys in Northwestern Mexico in most seasons would already account for excessive mortalities if no translocation and thermal management was in effect. Additionally, as olive ridley populations increase in abundance, their nesting season is extending into colder months where reduced incubation temperatures (<28°C) may hamper the survival prospects of resulting hatchlings. Aware that these conditions may only worsen under probable future climate warming scenarios, our laboratory began to study the consequences on the morphology and locomotor fitness of olive ridley hatchlings and their relationships with sex, when incubated under temperature regimes encompassing the ranges observed in natural conditions. For the initial phase, we setup a home-made incubation system with six constant temperatures (24, 26, 28, 30, 32, 34°C) controlled by open-source, low cost, Arduino microprocessors and a series of aquaria where the swimming behavior of 24 hatchlings could be video-taped simultaneously. We distributed 90 weighed olive ridley eggs extracted from each of three nests from El Verde beach equally among the temperatures and incubated with Vermiculite and at 100% RH until hatching. No hatching resulted from the 24 and 34°C treatments. All resulting hatchlings were individually marked, weighed, measured and photographed prior to further analyses. As in previous studies, we found a significant maternal origin effect on the morphology and mass of the hatchlings (weight, carapace size) but the temperature effect was greater. Except for 24 and 34°C, hatching rate was 86-98% in all treatments, with the lowest value in 32°C. Instead of a linearly decreasing relationship between hatchling sizes and increasing incubation temperature reported in other similar studies, a bell-shaped response was observed, with increasing sizes from 26-30°C incubations, and a drop to the lowest sizes from the 32°C treatment. Curiously, number of central and costal carapace scutes increased significantly with increasing incubation temperature. Locomotion performance was evaluated by timing hatchling to self-right themselves, crawl 2 meters, and by determining the percentage of time spent swimming during 24hrs. No significant differences were observed among treatments in the self-righting tests with the exception that the hatchlings originating from the smallest eggs performed worse than those from the 26°C incubation. Crawl speed also depicted a bell-shaped curve when compared with incubation temperature, with poorest values from hatchlings incubated at 26°C, best results for hatchlings incubated at 28°C, with decreasing values from 30-32°C incubations. Initial results from the swim tests indicate no significant differences for hatchlings from the 28-32°C incubations, but significantly lower swimming performance from those from 26°C. After the swimming tests, 50% of the hatchlings were euthanized and sexed with standard histological methods. Although male and female hatchling sexes were associated with different morphometric ranges, it was clear that the phenotypes were defined by the incubation temperature instead of the sex, casting doubt over earlier publications proposing morphometric bases for distinguishing sex based on only two incubation temperatures. The importance of these results for conservation practices is discussed.

EFFECTIVENESS OF MONITORING TECHNIQUES EMPLOYED TO DETERMINE REPRODUCTIVE SUCCESS OF MARINE TURTLES IN CUBA*

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Monitoring in nesting areas has been the most useful tool among marine turtle specialists internationally to estimate population sizes. Nevertheless, the data collection can be in different forms, from an “instant photograph” to a highly structured and standardized monitoring program. In Cuba, 100% of important nesting areas of marine turtle are monitored, but the effort varies since three approaches are used: nocturnal systematic monitoring, diurnal systematic monitoring and counting of evident nests. Variation in the monitoring effort implies that the amount and accuracy of the information varies. For this reason the goal of the present work is to evaluate the effectiveness of the monitoring techniques used to determine reproductive success in Cuba. Of the three methods, the counting of evident nest is the most used technique in Cuba while nocturnal systematic monitoring is applied only at Guanahacabibes Peninsula, representing less than 10% of the total effort. On the other hand, the percentage of the reproductive season covered with personnel in the areas is quite low, especially for the hawksbill. Intensity of the monitoring is reflected also in the number of nests and false crawls identified. In both, diurnal systematic monitoring and counting of evident nests, almost all tracks correspond to nests while in nocturnal monitoring normally they represent no more than the 80% of the nests. This is a consequence of making the expeditions too separated in time, and as a result it will overestimate the efficiency of the nesting process per beach. In summary, despite the efforts made at a national level to follow the nesting seasons in the main nesting colonies, it is necessary to increase the number of personnel and the time they spend at the nesting areas to obtain more complete information by species and during all of the reproductive periods.

METABOLIC WARMING IN HAWKSBILL TURTLE NESTS AT MONA ISLAND, PUERTO RICO

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Metabolic activity of development during incubation raises nest temperature above that of the surrounding sand. It is essential to know the metabolic heat generated in order to generate an accurate model of the incubation temperature of nests using beach sand temperatures. During the 2009 - 2013 hawksbill nesting seasons at Mona Island, Puerto Rico, we simultaneously measured nest temperature and adjacent sand ambient temperature in 8-15 nests per season. Calibrated Onset Waterpro temperature dataloggers were placed within hawksbill nests as they were being laid, each paired with an additional datalogger at a ~1m lateral distance from the nest dug into the sand at the same depth. The dataloggers recorded temperatures every hour and were retrieved after hatchling emergence from the nests. Incubation durations, nest size, nest depth, and overhanging vegetation were recorded for each nest. Nest metabolic heating was calculated by subtracting paired measurements of nearby sand temperature from nest temperature. Metabolic nest heating exhibited a typical profile of intense warming just prior to nest emergence. Knowledge of metabolic nest heating profiles is essential when attempting to relate ambient (sand or air) temperatures to conditions inside turtle

nests, for example when trying to estimate sex ratios of emerging hatchlings in relation to pivotal temperatures. Ambient air and sand temperature profiles of Mona Island's nesting beaches are presented and, using the metabolic heating measured in this study, are related to the known pivotal temperature for this breeding population in order to generate estimates of sex ratios in hawksbill hatchlings produced throughout the year.

TEMPERATURE EFFECTS ON THE NEST INCUBATION PROCESS OF THE OLIVE RIDLEY SEA TURTLE (*LEPIDOCHELYS OLIVACEA*): A COMPARATIVE STUDY BASED ON TWO TREATMENT METHODS IN A HATCHERY*

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The use of hatcheries is considered a last-resort management option for the protection of sea turtle nests and should be applied only when the viability of the nests on the beach are compromised. In Costa Rica, the use of hatcheries has become common over the past ten years, especially raised hatcheries or terraces. In most cases, hatcheries are established for specific protection against tidal inundation and human poaching. In Costa Rica, there are not many comparative studies that describe the effects of hatcheries on driving aspects of nest performance, such as incubation period, incubation temperature, hatch success, emergence success, and morphometric characteristics of the hatchlings. On Tortuga Beach, Ojochal de Osa, Costa Rica, a hatchery was established in 2013 with one raised section (6x7 m) 50 centimeters above ground level, and one section at ground level (5x7 m). The majority of Olive Ridley (*Lepidochelys olivacea*) nests on Tortuga Beach were relocated to the local hatchery, and distributed between the raised and ground level (at grade) sections. Daily temperature was monitored using thermocouples and Hobo data loggers, and abiotic factors were recorded using a weather station at the reserve throughout the season. A sample of ten hatchlings per nest was taken to record morphometric data, including straight carapace length and width, and weight. Results from the 2013 nesting season will be presented to compare the methodological protocols of the two temperature devices and effects of the hatchery treatments (raised versus ground-level sections). Additionally, results from analyses of temperature and other environmental factors on nest performance and hatchling morphometrics will be included.

ALL THE EGGS IN ONE BASKET? AN EXAMINATION OF GREEN TURTLE (*CHELONIA MYDAS*) NEST DISPERSAL AS BOTH A RESPONSE AND PREDICTOR

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The green turtle (*Chelonia mydas*) represents a highly migratory, endangered species of marine turtle that exhibits weak migratory connectivity (herein, females from diverse foraging areas frequently utilize the same beach to reproduce). Female fidelity to a generalized nesting beach across breeding seasons has been well documented; however, the degree to which females disperse their nests across this lateral beach landscape over the course of nesting seasons (herein defined as nest dispersal), as well as its associated consequences, has remained poorly described or quantified. Theoretically, greater nest dispersal may be utilized as a bet-hedging strategy, decreasing the probability of isolated perturbations associated with nesting females, predators, and water adversely affecting the majority of nests. In this study, we examined both historical and current data collected from nesting green turtles (n=91) of the Archie Carr National Wildlife Refuge (ACNWR), Melbourne Beach, FL, USA. The green turtle nesting assemblage of the ACNWR has been growing exponentially since monitoring began in 1982 (at approximately 14 percent per annum), and currently constitutes the largest green turtle rookery in the continental United States. As such, this population is of paramount interest, as it may hold clues to the factors associated with the recovery of the species.

Location, animal size, and nest dispersal, as well as their interactions, were evaluated as predictors of hatching success rates. The correlation between animal size and level of nest dispersal was not significant; however, a significant correlation was found between average female size and average hatching success. In 2013, a subset of turtles (n=17) with long-term recapture histories were sampled for stable isotope analysis in order to elucidate aggregations of individuals foraging in distinct habitats. These data were included in additional exploratory analyses to identify potential variation between foraging sites. Stable isotope analysis represents a unique perspective that may aid in assessing variation in nesting behavioral ecology as it relates to variability in environmental conditions at the foraging ground. As capital breeders, quality, quantity, and regularity of forage found at their nonbreeding areas may have a significant impact on female reproductive success. Environmental parameters may act in a combinatorial manner to affect the natural phenomena that is characteristic of the nesting process of these long-lived marine vertebrates.

EVALUATION OF HIGH-RESOLUTION AERIAL IMAGES FOR SEA TURTLE NEST MONITORING

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In 1979, the Florida Fish and Wildlife Conservation Commission established their sea turtle monitoring network to document longitudinally the distribution and abundance of sea turtle nests along the Florida coastline. Though not a significant issue in Florida, monitoring turtle nesting can be problematic in areas that are extensive or not easily accessible to surveyors. In the past, researchers have evaluated airplane-based surveying approaches. A more recent technology, unmanned aerial vehicles (UAVs), represent a lower-cost and perhaps more manageable solution to this challenge. These instruments are becoming widely used to monitor wildlife and recently by NOAA in the Florida Keys to monitor sea turtle activity. We used airplane-derived imagery comparable to that obtained from a UAV with a spatial resolution of ~2.5 cm combined with in situ data. Our research aims to assess the extent to which sea turtle permit holders, who are responsible for seasonal nest monitoring, are remotely able to identify species and determine the turtle crawl behaviors (nesting and non-nesting emergences) based on track images. Specifically, this web-based survey will focus on the interpretation of tracks from loggerheads (*Caretta caretta*) and green turtles (*Chelonia mydas*) from the Archie Carr National Wildlife Refuge on Florida's East coast. A follow-up to this component will involve the evaluation of computer vision/pattern analysis algorithms' ability to identify crawl behaviors automatically based on images of tracks. These data gathered will help determine if UAVs are a viable option for sea turtle monitoring. While this specific project focuses exclusively on sea turtle nests along the Atlantic coast, the implications of a successful study could expand to other remote or inaccessible geographic regions.

SAND CHARACTERISTICS AND RAINFALL EFFECTS ON HATCHING SUCCESS OF LEATHERBACK TURTLE EGGS (*DERMOCHELYS CORIACEA*) DEPOSITED ON THE BEACHES OF OCEAN PARK, CONDADO, AND ISLA VERDE, PUERTO RICO

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In the nest incubation environment, sand characteristics and precipitation influence egg hatching success of species such as sea turtles. The leatherback turtle (*Dermochelys coriacea*), presents the lowest hatching success rank (between 40-60%) among the seven endangered species in the world. The natural dynamics in the sand composition of leatherback nesting beaches in Ocean Park, Condado, and Isla Verde (metropolitan area) have been modified since the early 50's due to strong urban growth and its vocation of recreation and tourism. This could bring negative effects that increase embryonic mortality of the species in this area. Therefore, the alteration in the natural processes of these beaches can contribute to hatching success knowledge of the species in an intervened environment. In addition, the torrential rainfall, occurring mainly in the north of Puerto Rico and during the wettest months of the year (May to September), match with these beaches and with the leatherback nesting season. This phenomenon acts as a significant factor in the decline of the nests temperature and in the hatching success due to nest flooding. Our objective was to determine the relationship of the characteristics of the sand and precipitation on the hatching success of leatherback turtle eggs on the beaches of Ocean Park, Condado and Isla Verde. During the 2013 leatherback nesting season, precipitation data was analyzed from the beaches of Ocean Park, Condado and Isla Verde and six samples of 30 grams of sand were collected. The daily precipitation was taken from the online database of the National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service (NWS). Sand samples were collected after nest hatching and prior to its cleaning to assess the organic content and particle size. In the 17 monitored nests, we found an inverse relationship between precipitation and hatching success. Nests with lower hatching success were related to periods of large amounts of rainfall. The maximum accumulation of rain per nest during the incubation period was 81.5 cm and the minimum was 58.9 cm with a hatching success of 3% and 93 % respectively. Nesting beaches in highly urbanized areas must be monitored since they represent a high threat to the species; hence this investigation may serve to improve the environmental condition of the coastal zone. In this manner, we can contribute to the conservation and recuperation of this species. Note: The results of the effect of sand characteristics (organic content and particle size) on the hatching success of leatherback eggs will be presented but are still being analyzed.

INCUBATION TEMPERATURE EFFECTS FROM METABOLIC HEAT AND THERMAL INERTIA IN HAWKSBILL (*ERETMOCHELYS IMBRICATA*) NESTS ON UTILA, HONDURAS*

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Nest temperatures during the incubation period directly affect the development and sex of sea turtles, and thus are of great interest to researchers. Thermocouple data loggers small enough to be placed inside a nest give us the ability to gather in-depth information regarding the particularities of temperature during incubation. In this study, three DS1922L iButtons were placed in each of four in situ hawksbill nests and measured temperatures every hour over the entire incubation period of approximately 54 days. iButtons were attached to a PVC pipe and spaced evenly at the top, middle, and bottom of the nest. Each nest had a corresponding control pseudo-nest located 1 m away containing a pipe with an identical iButton arrangement. Evidence of metabolic heating was found in all nests, with mean nest temperatures at least 1.0°C higher than corresponding pseudo-nest temperatures. When divided into thirds (n = 12), mean nest temperatures were higher than pseudo-nest temperatures for all cases except two. The middle third of incubation is of particular interest because it coincides with the thermosensitive period during which sexual differentiation occurs, with a pivotal temperature of 29.2°C reported for hawksbills. All four nests had a mean temperature greater than 29.2°C during the middle third of incubation. However, three of the pseudo-nests had temperatures less than 29.2°C, suggesting that metabolic heating is maintaining temperatures above the pivotal temperature during the sex-determining phase of incubation. (The fourth nest and its corresponding pseudo-nest were completely unshaded and both incubated at temperatures above 30°C.) The importance of thermal inertia in the nest was seen when daily weather information was analyzed in relation to the temperature data. Mean daily air temperature did not change significantly over the months of incubation and thus was not a direct cause of nest temperature fluctuations. Large amounts of rainfall (including precipitation from Hurricane Ernesto), however, were found to correspond to drops in nest and pseudo-nest temperature. Nest temperatures fell in response to rainfall, but did not change as rapidly and recovered sooner in nests compared to pseudo-nests because of the thermal inertia of the eggs with respect to the sand. The role that thermal inertia of the nest plays in maintaining consistent temperatures over the incubation period has important implications for developing embryos. Metabolic heat generated within the nest has

the ability to directly affect the sex ratio that a nest ultimately produces. Understanding the interplay of these factors within an incubating nest will become ever more crucial if researchers are to respond appropriately to changing temperatures caused by global climate change.

FIRST ACCOUNT AND DESCRIPTION OF A HAWKSBILL (*ERETMOCHELYS IMBRICATA*) NESTING BEACH IN CARIBBEAN HONDURAS

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Aside from occasional anecdotal reports, information on hawksbill (*Eretmochelys imbricata*) turtle nesting is completely lacking for the country of Honduras. ProTECTOR, in partnership with The Bay Islands Conservation Association (BICA), has established a beach-monitoring program on Pumpkin Hill Beach on the island of Utila off the north coast of Honduras. Data from the first three seasons, 2011-2013, are presented. Pumpkin Hill Beach was monitored nightly between 18:00 and 04:30 hours from May through November. Nesting turtles encountered had standard morphometric data collected, identifying photographs taken, and were tagged with metal Inconel 651-style tags. During or directly following oviposition, eggs were counted. Nests were left unmarked to prevent poaching but were triangulated from nearby objects. GPS coordinates were also recorded at each nest site. Nests were monitored nightly for signs of hatching after approximately 53 days of incubation. Following emergence, nests were excavated and their contents analyzed to determine hatching and emergence success. Additionally, data collected during the 2012 season included the diameters and mass of 10 eggs following oviposition, as well as the mass and straight carapace length and width of emerged hatchlings. These data provide a baseline for hawksbill egg and hatchling size for this beach. Also during the 2012 season, a topographic beach profile was conducted. Pumpkin Hill beach is 475 m long, but data from GPS coordinates indicate turtles nested predominantly in an 80 m section at a higher elevation than the remainder of the beach. Additionally, analysis of vegetation data showed that the nesting section had 47% tree coverage in contrast to 4% tree coverage over the rest of the beach. Since hawksbills nest every 2-3 years, data on returning nesters is still sparse. However, at least one tagged turtle from the 2011 season was recorded as nesting in 2013. Data from future nesting seasons will help fill gaps in our knowledge regarding the nesting status of this critically endangered species in the country of Honduras.

TEMPORARY DISPLACEMENT OF NESTING ACTIVITY OF BLACK TURTLE (*CHELONIA MYDAS AGASSIZII*) IN COLOLA BEACH, MICHOACÁN, MÉXICO: PERIOD 1995-2010

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The black turtle breeding season in the Decade of the eighties in Michoacán traditionally began in September with a peak of nesting in the second half of October and the first half of the month of November, declining nesting in the month of December. In the last decade (2001-2010) we observed an increase in the number of nests due in part by conservation efforts at Colola Beach. During this same time period nesting activities have shifted to January, February, March and April, months that correspond to the period of winter. This phenomenon has important implications for conservation in particular on the issue of the sex ratio of hatchlings produced in Colola where the majority of black turtle nesting occurs in Mexico. The objective of this study was to evaluate the temporary displacement of the nesting activity and the trends in the size of the broods of black turtle (*Chelonia mydas agassizii*) from 1995 to 2010 on the beach of Colola, Mexico. This involved a review of the database of the program of ecological recovery of the black

turtle on the coast of Michoacan. Annual averages of broods, and the total number of nests and eggs in each month in different seasons were obtained. Nesting months were compared for all seasons, and an analysis of variance (ANOVA) for what months the maximum peaks of nesting are presented and in what year a greater number of broods are presented. An increase was found in the nesting activity and the number of nests per season from 2002, which has been maintained until 2010. Also there was an increase of nesting activity in the cold months of the year.

LONG-TERM TRENDS IN SEA TURTLE NESTING ON HUTCHINSON ISLAND, FLORIDA

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Hutchinson Island is a 36-kilometer long barrier island located on the southeast coast of Florida. The island has long been recognized as an important sea turtle rookery. Systematic sea turtle nesting surveys were conducted on the island in odd-numbered years from 1971 through 1979 and then annually from 1981 through 2013. Over the 43 years that sea turtle nesting surveys have been conducted on Hutchinson Island, considerable development has occurred. Development has included construction of single-family homes, resorts, condominiums, restaurants, and a nuclear power plant. In addition, a number of beach and dune restoration projects of various lengths have occurred along the island over the period of study. We will examine long-term trends in nesting by loggerhead, green, and leatherback turtles and relate those trends to changes that have occurred on the island over four decades. Specifically the effects of residential development, power plant construction and operation, and beach/dune restoration projects on spatial and temporal trends in nesting and nesting success will be examined. Changes in the rates of predation on sea turtle nests as well as shifts in the spatial distribution of predation will be presented. Finally, the incidence of nest erosion due to wave action will be summarized and the effects of storms on nest survival will be examined.

NESTING HABITAT PREFERENCES OF GREEN TURTLES (*CHELONIA MYDAS*) AT JOÃO VIEIRA ISLAND, BIJAGÓS ARCHIPELAGO, GUINEA-BISSAU

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The nesting process requires sea turtles to choose among beach habitats that ensure a successful development of eggs. The nesting habitat preferences of green turtles on João Vieira Island were analyzed, as well as the proportion of adult female emergences resulting in a successful nesting event. This study revealed that green turtles do select particular nesting sites and that this is not a process that occurs randomly along the nesting beaches. The differences found in the emergence densities on the different beaches could have resulted not from a preference by green turtles for a particular beach, but from a variation in the availability of a suitable nesting habitat between beaches. A number of habitat features (offshore bathymetry, slope, distance from highest spring tide line to forest, cliff height, vegetation height and sand characteristics i.e. color, grain size, pH and albedo) were assessed to further understand to what extent these might explain the nesting habitat preferences of green turtles. Vegetation height was significantly different on the sites where green turtles emerged when compared with the remainder of the island, suggesting that this habitat feature may influence sea turtles to arrive on the beach independently of the outcome of the nesting attempt. The distribution of emergences resulting in a clutch deposition revealed that green turtles showed a strong preference to nest on supra-littoral herbaceous vegetation areas, exposed to the sun, where green turtles can dig their nests without obstacles. Most of the emergences that occurred on this herbaceous vegetation habitat resulted in a successful nest,

whereas in other habitats such as shrubland and forest the proportion of false crawls was higher. The choice for these herbaceous areas may have major consequences for the reproductive fitness of these females in response to environmental or anthropogenic changes. This is particularly important in the context of current environmental changes and habitat destruction and alteration.

NEST TEMPERATURES IN A LOGGERHEAD-NESTING BEACH IN TURKEY IS MORE DETERMINED BY SEA SURFACE TEMPERATURE THAN AIR TEMPERATURE

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Whereas climate change is now fully recognized as being on the way, its impact on biodiversity is still not fully understood. In order to make predictions of its impact, we need proxies coherent with the studied ecosystem or species. Marine turtles are threatened worldwide (but some populations are recovering) and they are particularly sensitive to temperature for all their life cycles. This is particularly true at the embryo stage when temperature affects growth rate and sex determination. The nest temperature is then of prime importance to understand the persistence of populations in the context of climate change. We analyzed nest temperature from 21 loggerheads (*Caretta caretta*) originated from Dalyan beach in Turkey. The nest temperature is fitted against lagged sea surface temperature, lagged air temperature and age of the nest to take into account metabolism. The very high temporal autocorrelation in daily nest temperature has also been taken into account. Surprisingly, we show that nest temperature is 4 times more dependent on sea surface temperature than on air temperature. We also detected a very significant effect of metabolic heating during development compatible with what was already known for marine turtles' nests. Our new methodology allows for prediction of marine turtles' nest temperature with good precision from a combination of air temperature measured at the level of the beach and sea surface temperature in front of the beach.

HOW ROTTEN CAN IT BE? DETERMINING WHETHER NON-VIABLE, UNHATCHED LOGGERHEAD EGGS PROVIDE THE SAME ISOTOPIC INFORMATION THROUGH TIME*

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Stable isotope analysis has become a valuable technique for assessing migratory connectivity and foraging selection of species such as marine turtles. The use of unhatched, or "rotten" eggs collected at the time that a nest is excavated for hatchling productivity assessment has proven comparable with other tissues (i.e. skin, blood, fresh egg yolk) in identifying the geographic foraging regions used by females during the non-breeding season. Sampling unhatched eggs represents a non-invasive and non-destructive method and it has been proposed as a common currency for stable isotope studies taking place on nesting beaches. However, some isotopic variability among un-hatched, unviable eggs of the same clutch has been reported. Within clutch variability may be a result of natural variation or related to microbial decomposition occurring within the eggs, which may vary over time and thus, hinder the ability to use the isotopic approach for female foraging area assignment. Sea turtle guidelines in Florida, home of the largest loggerhead breeding aggregations in the Western Hemisphere, require nest excavation should be conducted three days after an observed emergence or 70 days after nest deposition if no emergence is detected. Therefore, unhatched eggs may be retrieved anytime between 50 and 70 days after a nest was laid, depending on the circumstances (i.e., emergence observed, incubation length). We investigated whether time of sampling had an effect on stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope values of unhatched eggs in order to develop an appropriate sampling protocol for studies aiming to infer female foraging regions. We sampled 21 loggerhead clutches: three days after emergence (time 1), 70 days after deposition (time 3), and some days in between (time 2). We retrieved multiple unhatched eggs at each

sampling event to account for within clutch variability and limited disturbance to the incubation environment as much as possible. A general linear model was used to investigate the effect of time on the stable isotope signatures of unhatched eggs. A recent study showed that decomposition in a dry environment did not affect loggerhead skin stable isotope values. Similarly, we hypothesize that time since deposition (a proxy for decomposition) will not affect isotopic values. By investigating the effect of time on stable isotope values, we will be able to address this methodological question and refine the protocol for the use of addled eggs as the tissue of choice for studies investigating sea turtle migratory connectivity.

IMPACT OF LIGHT POLLUTION ON *DERMOCHELYS CORIACEA* IN BEACHES OF THE METROPOLITAN AREA IN PUERTO RICO

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The island of Puerto Rico, the smallest of the Greater Antilles, has one of the most modern infrastructures in the Caribbean. Its beaches are renowned worldwide for its white sand and crystal clear water, conditions that involve increased pressure on infrastructure development in the coast of Puerto Rico. The beaches of Condado, Ocean Park (San Juan's metropolitan area) and Isla Verde (Carolina's metropolitan area) are continuous north-central beaches of the island where the leatherback turtle (*Dermochelys coriacea*) nests. These beaches are no exception to this rapid agglomeration of buildings, houses and hotels located on the seashore, showing the lack of urban planning and ignoring the ecological effects on this species. Under these circumstances, the artificial light from these structures disturbs the nesting process and causes disorientation of hatchlings of the leatherback turtles that frequent our coast, as has been shown in numerous studies around the world. Our goal was to identify sources of light pollution and assess their repercussions on the orientation towards the sea of emerging hatchlings. During the nesting season of 2013, the effect of light pollution was evaluated from measuring the level of artificial light in the 17 nests with a photometer, and the events of disorientation at the time of hatching were documented, as well as the assistance to neonates. The presence of artificial light in the nests was registered to be from 0.04 ± 0.01 Lux to 12.02 ± 0.01 Lux. At the time of hatching, less than 469 hatchlings were disoriented and had to be assisted as they headed towards the road, buildings and even sewers, becoming desperately vulnerable and in danger of dying. This research shows that light pollution in the metropolitan coast of Puerto Rico represents a threat to the leatherback turtle, which is why it is necessary to continue the project and generate long-term mitigation strategies to reduce the impact of light pollution in conjunction with community residents and hotels in the metropolitan area.

SHADING AND WATERING AS A TOOL TO MITIGATE THE IMPACTS OF CLIMATE CHANGE IN SEA TURTLE NESTS

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Climate change is projected to impact marine turtles at various levels. Nests and hatchlings may be particularly vulnerable because increasing air temperatures during incubation can affect sex ratios and fitness of hatchlings. In the wake of such environmental changes, mitigation measures may be required to offset the negative impacts of climate

change. To this extent, we analyzed the effect of shading and watering on sand temperatures in a beach hatchery at Playa Grande, Costa Rica. We set up 18 one m² plots and placed thermocouples at 45 cm and 75 cm deep, corresponding to the respective bottom nest depths of olive ridley (*Lepidochelys olivacea*) and leatherback (*Dermochelys coriacea*) turtles, the two species that nest in the area. Nine plots were shaded and nine were exposed to the sun. Within each of these exposure treatments, we applied three watering treatments based on the highest, lowest, and average amount of rainfall registered in October, the rainiest month in North Pacific Costa Rica. We watered plots equally over the course of 31 days. Additionally, we examined gravimetric water content of the sand by collecting sand samples from plots (1) the day before watering began, (2) the day after watering was complete, and (3) one month after completion. At both experimental depths and in both exposed and shaded treatments, the temperatures for the average and high water treatments did not differ from each other, but temperatures in these were significantly lower than those registered in the low water treatments. Thus there was an apparent threshold over which additional water did not seem to affect sand temperature. In control plots (no water added), the presence of shading reduced nest temperatures by 2°C and 3°C at 75 cm and 45 cm respectively. At 45 cm, shading reduced temperatures by 1.7°C in water treatments when compared to the same water treatment in exposed plots. At 75 cm, shading reduced temperatures by 1.5°C for the high, 1.3°C for the average, and 1°C for the low water treatment. Even at the highest water treatment in exposed plots, temperatures at 45 cm were not lower than those in shaded control plots. Shaded control plots at 75 cm were 0.5°C cooler than those exposed plots that received the highest water treatment. Therefore, we conclude that shading seems to be a more efficient mechanism than watering to lower sand temperatures. For all depths and water treatments, temperatures returned to control levels within 10 days of the completion of watering, suggesting that sustained watering may be required to maintain low temperatures under future climate change scenarios. Conversely, gravimetric water content of sand was higher in exposed plots than shaded ones, and shaded plots tended to dry out more quickly than those that were exposed. While further research is required before the implementation of such techniques, these results provide a foundation for understanding how temperature and water content in sea turtle nests will respond to climate mitigation strategies. We would like to thank the International Sea Turtle Society, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation, U.S. National Marine Fisheries Service, Sea Grant-Texas, Shell, International Seafood Sustainability Foundation, Wildlife Computers, Environmental Business Specialists LCC, Sea Turtle Conservancy, Florida TURTLE license plate program, SIRTRACK, CLS America, Ecological Associates Inc., Desert Star Systems LLC, Loggerhead Marinelifelife Center. Janet Hochella, Kiki Jenkins, Sea Turtle Project-Bangladesh, Marinelifelife Alliance, Matthew Nash, Mission: Clean Beaches, Sandy Sly, ProFaunaBaja – ASUPMATOMA, Usagi Family and Debbie Sobel for travel support which facilitated participation in the International Sea Turtle Symposium.

LOGGERHEAD NESTING IN ALABAMA, USA, 2003-2012

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In the United States, six species of sea turtles are federally protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.). Loggerheads (*Caretta caretta*) in the northern Gulf of Mexico Recovery Unit (Franklin County, FL, through TX, including Alabama) are part of the Northwest Atlantic Ocean Distinct Population Segment and are federally listed as a threatened species under the ESA. Monitoring sea turtle nest abundance and trends is an action listed in the Fish and Wildlife Service (Service) and National Marine Fisheries Service's joint recovery plans and has been an important tool used by conservation agencies to track the status of the species of sea turtles. Since 2003, sea turtle nesting surveys have been conducted along the beaches of Alabama following a consistent protocol outlined in the Alabama Sea Turtle Conservation Manual (rev. 2008). Alabama's coastline consists of about 72.5 km (45 mi) of sandy beaches used by nesting sea turtles. From 2003 to 2012, daily

morning nesting surveys were conducted on all 72.5 km of beach from May 1 through August 31 primarily on foot beginning 30 minutes after sunrise and ending by 9:00 am. Nests were detected by observing nesting turtle tracks and sand mounds. Nests were located by digging to the top of the clutch to find its exact location, a wire mesh predator protection screen was placed directly over the clutch and staked in place at all four corners, and were marked with colored flagging tape and signage. Data collected at each nest, as appropriate, included: photos, crawl diagram, date, time, GPS coordinates of nests, distance to the top and bottom of the clutch, and number of eggs. Nests were observed throughout the hatching season, typically through October 31. Any impacts to nests such as vandals, vehicles, predators, or water inundation were noted. Monitoring was conducted by a volunteer group called Share the Beach and Bon Secour National Wildlife Refuge (BSNWR) staff working under Service-issued endangered species recovery permits. For ease of management, the coastline was divided into individual beach segments with an associated team leader assigned to each segment. Comparatively higher nesting occurs on the Fort Morgan peninsula and adjacent Laguna Key beach possibly due to less coastal development and associated lighting in BSNWR. Based on nest monitoring data collected from 2003 to 2012, there were a total of 675 sea turtle nests documented in Alabama, including 654 loggerhead, 10 Kemp's ridley (*Lepidochelys kempii*), 10 unknown sea turtle species, and one green (*Chelonia mydas*). Nest densities, median nest initiation and hatch dates, incubation period and hatching success will be discussed. These data are a valuable contribution towards tracking the status of loggerhead sea turtles and the efficacy of actions in place to achieve delisting and recovery of the species.

EVALUATION OF NESTING HABITAT AND ENVIRONMENTAL PARAMETERS WITH DESCRIPTIVE MODELS OF OLIVE RIDLEY SEA TURTLES (*LEPIDOCHELYS OLIVACEA*) AT OSTIONAL NATIONAL WILDLIFE REFUGE, COSTA RICA*

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Olive ridley sea turtles (*Lepidochelys olivacea*) are recognized for their predator prey saturation tactic in mass aggregate nesting and solitary behavior. The genus (*Lepidochelys* spp.) comprising of (*L. kempii*) and (*L. olivacea*) are unique among the seven species of sea turtles in nesting fashion. The Ostional National Wildlife Refuge (ONWR) in Guanacaste, Costa Rica supports the second largest olive ridley mass nesting population in the world. Nesting may occur on a monthly basis, with variable nesting frequency throughout the dry season. Currently, ONWR is functioning as a multiuse wildlife refuge where the community conducts a legal harvest of ridley eggs for consumption and socioeconomic purposes. The appropriateness of nesting habitat has been in question as to which areas of the beach are most suitable for producing ridley hatchlings. We used a descriptive and predictive analysis approach to evaluate the suitability of nesting habitat throughout Ostional beach for ridley sea turtles. The environmental parameters evaluated include: egg density; beach width; position on beach relative to the high tide line and vegetation; and nesting event. A multinomial logistic regression analysis was used to predict the categorical placement of ridley embryo development. Multiple beach profiles were evaluated for the proportion of eggs that reached each developmental stage in high, mid and low beach areas across beach sections. Based on the Akaike Information Criterion, the probability for embryos to hatch was analyzed for various egg densities at major beach sections and its relative location to the high tide line. The fate of embryos was found to be dependent upon the width of the beach, position relative to the high tide line and nest density. Understanding the incubation potential of the beachscape can lead to creative adaptive management approaches that would support the hatching success of ridleys on Ostional Beach.

**LONG TERM MONITORING OF LOGGERHEAD TURTLES ON FETHIYE BEACH, TURKEY:
POPULATION STILL DECLINE IN DECLINE**

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Decline and loss of sea turtle populations are increasingly becoming an international concern. In this respect conservation efforts are carried out at most of the nesting beaches in the world. Breeding and nesting activities of sea turtles on Fethiye Beach, Turkey take place in Fethiye-Göcek Special Environmental Protection Area. Previous studies showed a negative population trend of the loggerhead turtle population at Fethiye beach, Turkey based on nesting data. We analyzed nesting trends over 21 consecutive years, from 1993 to 2013. A total 2,090 nests were recorded during 21 consecutive years with a mean of 99.52 nests per year. There were also strong annual fluctuations in the number of nests, which ranged from a minimum of 58 nests (in 1994) to a maximum of 158 (in 2004). In 2013, we recorded a total of 258 emergences, of which 104 (40.31%) was resulted in nests. Linear regression analyses showed that there is a statistically significant negative relationship between years and nest numbers at the 99% confidence level ($r^2=0.30$; $p<0.01$). This result leads to the interpretation that the number of nesting turtles is still in decline at Fethiye beach. The main reasons of the decrease can be excessive use of the beach by the people, lights from the backside of the beach, and boat traffic on the shore. Such a potential negative trend at a key Turkish nesting beach indicates a need for more sharp effective conservation programs. The other reason for population decline on these beaches could be in-water mortalities of sea turtles either from fishing activities and/or water sports.

FEMALE-EGG STABLE ISOTOPE DISCRIMINATION FACTORS IN LOGGERHEAD SEA TURTLES

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The carbon and nitrogen stable isotope values ($\delta^{13}C$ and $\delta^{15}N$ values) of animals are assimilated through the diet and reflect the animal's trophic position and foraging location. Because encountering and sampling all sea turtles at a nesting beach can be difficult, we wanted to determine if egg samples provide a good proxy of female isotope values. The main goal of this study was to determine if there is a reliable offset (discrimination factor) between $\delta^{13}C$ and $\delta^{15}N$ values of loggerhead sea turtles and their eggs (both yolk and albumen). Additionally, the effects of ethanol preservation and lipid extraction on the $\delta^{13}C$ and $\delta^{15}N$ values of loggerhead yolk were evaluated to calculate reliable female-egg discrimination factors. Epidermis, albumen, and yolk samples were collected from nesting loggerheads during the 2011 nesting season at Wassaw Island, Georgia, USA and preserved in 70% ethanol or frozen. All egg and epidermis samples ($n = 269$) were processed and analyzed for $\delta^{13}C$ and $\delta^{15}N$ values. Subsamples of the yolks were lipid extracted. We used paired t-tests to compare the $\delta^{15}N$ and $\delta^{13}C$ between the yolks under a combination of different treatments (frozen vs. ethanol preservation and untreated vs. lipid extracted). We found a highly significant correlation between female epidermis $\delta^{15}N$ and $\delta^{13}C$ values and their yolk or albumen isotopic values, which permits the approximation of female epidermis stable isotope values from egg components. Also, we found that lipid extraction significantly affected yolk $\delta^{13}C$ and $\delta^{15}N$ values, while ethanol preservation significantly affected $\delta^{13}C$ values. The changes in isotopic values for both treatments can be accounted for using equations derived from linear regressions

with highly significant correlations. Next, we evaluated the effectiveness of mathematically correcting samples for lipid extraction and ethanol preservation. Our results will allow future studies using stable isotopes to determine female foraging behavior and trophic relationships by assessing egg components.

THE INFLUENCE OF WIND VELOCITY ON HAWKSBILL NESTING SITES ON LONG ISLAND, ANTIGUA, WEST INDIES

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Major wind belts, such as the trade winds and westerlies, are responsible for maintaining oceanic currents across large bodies of water. Numerous species rely upon these currents throughout various stages of their life histories. With marine turtles, such currents may facilitate travel during early, post-hatch developmental stages and improve migratory efficiency during later phases. We hypothesized that winds and currents also may play a role in selection of nesting sites by nesting females. To evaluate this hypothesis, we examined a nesting rookery of critically endangered hawksbill sea turtles on Long Island (Jumby Bay), Antigua, West Indies. Understanding nest site selection has become particularly important on Jumby Bay, as habitat modification and degradation have altered the primary nesting beach and removed large expanses of suitable habitat. During the June through November nesting season, significant numbers of hawksbill females emerge on Jumby Bay's northern (windward) shore to nest. We speculated that on nights in which the prevailing easterlies are strong, hawksbills, which enter Pasture Bay's waters from the east, are more likely to nest in the western reaches of the beach. Primary nesting beaches were patrolled hourly from shortly after sunset to sunrise throughout the nesting season. Upon encountering a crawl, we recorded the time, location, wind direction, and average wind speed over 10 seconds using a portable anemometer. Hourly wind direction and speed were also collected from a nearby airport to provide a parallel data set for comparison. We will use linear regression to assess the relationship between nest location, wind speed and direction. Our results will provide information about the nest site selection process of hawksbills on Long Island and help predict how the distribution of nests along the beach may change with highly dynamic environmental conditions.

GREEN AND HAWKSBILL SEA TURTLE NESTING ON SANDY POINT NATIONAL WILDLIFE REFUGE, ST. CROIX

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The U.S. Caribbean contains numerous beaches that serve as potential nesting grounds for green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) sea turtles. However, in many places nesting tends to be diffuse, making it difficult to quantify the annual number of nesting females. Sandy Point National Wildlife Refuge, St. Croix (USVI) is a 3.2km long beach that is the site of one the longest continuously running monitoring projects for leatherback (*Dermochelys coriacea*) sea turtles, but there is an incomplete data set on its nesting green and hawksbill turtles because they have not been intensively studied. We carried out two separate seasons of intensive nighttime monitoring in 2011 (15 Aug-15 Oct) and 2013 (15 July-24 Sept) to tag and identify all encountered nesting turtles of these two species. Turtles were also tagged opportunistically during leatherback season both years (15 Mar- 15 July). The middle 2.5 km of the refuge was considered the area of highest nesting density, and as such was patrolled nightly. The remaining portion of the beach was patrolled daily as well to record additional nesting activities, nest emergences, and cases of nest predation. No night surveys were undertaken in 2012, but daytime patrols were performed across the

entire refuge daily and tracks were categorized by species and whether a nest was deposited. In 2011, 37 hawksbills and 54 green turtles were identified and in 2013 we identified 25 hawksbills and 104 green turtles. Daytime patrols showed a high amount of activity by green turtles, with 2,735 crawls documented in 2012, which resulted in an estimated 1,150 nests. In 2011, hawksbills laid an estimated 137 nests and deposited an estimated 227 nests in 2012. Data from 2013 is still being collected, but there is an estimated 691 nests laid by green turtles. Though data from previous years on nesting by these species on Sandy Point is limited, our data indicates that nesting by both species, but especially by green turtles, may be increasing on this beach. Although this monitoring encompasses a relatively narrow timeframe, these numbers suggest that Sandy Point may host one of the largest nesting populations for green turtles in the Eastern Caribbean. Furthermore, it is one of the only beaches in the region that hosts large nesting populations of multiple species of turtle (leatherback, green and hawksbill). Future nighttime monitoring efforts should be carried out in order to analyze trends in numbers of all nesting turtles and to confirm the regional significance of this nesting beach for all 3 species in the Eastern Caribbean.

SPATIAL DISTRIBUTION OF LOGGERHEAD TURTLE (*CARETTA CARETTA*) EMERGENCES ALONG A HIGHLY DYNAMIC BEACH IN THE NORTHERN GULF OF MEXICO*

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As coastlines change due to sea level rise and an increasing human presence, understanding how species, such as marine turtles, respond to alterations in habitat is necessary for proper management and conservation. Survey data from a major nesting beach in the northern Gulf of Mexico, where a revetment was installed, was used to assess spatial distribution of loggerhead emergences. Through use of Quadrat analysis and piecewise linear regression with breakpoint, we present evidence to suggest that nest site selection in loggerheads is determined in the nearshore environment, and by characteristics such as wave height, alongshore currents, depth and patterns of erosion and accretion. Areas of relatively dense nesting were found in areas with relatively strong alongshore currents, relatively small waves, a steep offshore slope and the largest historical rates of erosion. Areas of relatively dense nesting also corresponded to areas of low nesting success. Both nesting and non-nesting emergences were clustered immediately adjacent to the revetment and at other eroding sites along the beach. These results suggest that alterations to the nearshore environment from activities such as construction of a jetty, dredging or installation of pilings, may impact sea turtle nest distribution alongshore. We also show that piecewise linear regression with breakpoint is a technique that can be used with geomorphological and oceanographic data to predict locations of nest clumping and may be useful for managers at other nesting beaches.

EVALUATION OF NESTING BEACH TEMPERATURES AND HATCHLING SEX RATIOS OF *ERETMOCHELYS IMBRICATA* IN THE PEARL CAYS, NICARAGUA

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The hawksbill sea turtle is an endangered species that inhabits tropical waters worldwide. Nesting populations are in decline due to a variety of factors including habitat loss, poaching, and fishery by-catch. Since this species possess temperature-dependent sex determination, the incubation temperature of the nest determines the sex ratio of the hatchlings. Incubation temperatures above 29.2°C produce female-biased sex ratios and below 29.2°C produce male-biased sex ratios. It is of importance to the management and protection of this species to assess the sex ratios occurring

on natural nesting beaches within a population, especially considering the potential impacts of global climate change. The goal of this study was to evaluate the nesting beach temperatures and hatchling sex ratios produced from the Pearl Cays, Nicaragua. This poster will report the results from 2007-2011 of an ongoing study. Nesting beach temperatures and nest temperatures were monitored using Hobo data loggers. The nesting beach temperature analysis generally showed temperatures below pivotal temperature. Data loggers then were placed in nests and in sand adjacent to nests in order to evaluate potential metabolic heating. Most of the nests observed showed temperatures above the pivotal temperature and were predicted to produce female-biased hatchling sex ratios. When comparing nest temperatures to adjacent sand temperatures, it seems that the production of metabolic heat starts near the beginning of the middle third of incubation. This corresponds with the temperature-sensitive period of incubation when sex is determined. Additionally, histology of the gonad tissue was utilized as a sexing technique. A subset of nests was selected in which the dead hatchlings were partially dissected and preserved. The gonad/kidney/adrenal tissues were dissected and processed using standard histological techniques and examination of the slides under microscopy to determine sex. The histology results indicate a female-biased hatchling sex ratio at Pearl Cays. The histology results are consistent with the majority of hawksbill nesting beaches worldwide, which report female-biased hatchling sex ratios.

UNDERSTANDING THE SPATIO-TEMPORAL VARIABILITY OF HAWKSBILL HATCHLING SEX RATIO TO ASSESS THE IMPACTS OF GLOBAL WARMING ON MARINE TURTLE POPULATIONS IN BRAZIL AND INFORM CONSERVATION STRATEGIES

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In the context of global warming and predicted skew in marine turtle population's sex ratios it is important to have knowledge of the current and future sex ratio of hatchlings being produced by marine turtle populations. This information is critical to provide a baseline in advance of global warming, to elucidate implications from future extreme female sex biases and to help identify areas that produce a higher proportion of male hatchlings, which will be essential to inform conservation in the context of female sex biases. Information on the sex ratio of hatchlings produced is usually available for one or a few reproductive seasons for a small spatial extent. This makes it difficult to accurately understand the variability of sex ratio within and between seasons and nesting grounds and to accurately describe the sex ratio of hatchlings being produced at a population scale. Generally, there is a lack of wide-scale, long-term information on primary sex ratios as a baseline to infer changes from global warming and to identify nesting areas of high conservation value. To better inform future assessments of impacts of global warming on two subpopulations of hawksbill turtles in Brazil (one that nests primarily in the state of Bahia (BA) and the other in Rio Grande do Norte (RN)) we explored the variability of sex ratio produced between nesting beaches and years. Sex ratio was estimated by using the incubation duration of 5520 *in situ* clutches that successfully hatched from key nesting areas ($n = 5$ in BA and $n = 5$ RN) used by each of the subpopulations for the last 24 and 10 nesting seasons respectively. A significant difference in the incubation durations across nesting beaches in BA and RN was found: BA nests had incubation duration ranging from 45 to 75 days (mean \pm SD: 55 ± 4 days) and RN nests had 49 to 70 days (mean \pm SD: 57 ± 3 days). A strong female bias was observed in all beaches, with 96% (SD = 13%) female sex ratio in BA and 89% (SD = 20%) female sex ratio in RN (range = 0 to 100%). 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 ratios was observed in BA and RN. This spatial-temporal variability in the sex ratio of hatchlings produced across the different nesting areas prompted us to explore the thermal profile of nesting areas used by these two subpopulations. For this, we deployed 60 dataloggers in 2013 along the whole extent of nesting areas and environments used by these subpopulations. Thermal profile will be monitored over three years and will be used to estimate the current sex ratio being produced at each location. This will be coupled with climate models to predict future sex ratio and to help prioritize management in light of global warming.

NESTING SUCCESS OF LOGGERHEAD TURTLES AT MAJOR NESTING BEACHES IN JAPAN

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For a deeper understanding of nesting success as an indicator of wellness of nesting beach environment, the nesting success of loggerhead turtles at 15 major nesting beaches were reviewed and related with beach features such as nesting density (annual number of nests / coast line length), sand particle size, and erosion and structures. More than 100 loggerhead clutches were counted during 7 years from 1993 and 1999. Generally, nesting success differs among beaches rather than years. Using emergence tracks, the stability in nesting success can be extrapolated to determine the number of nests. The maximum nest success of 85% was recorded at two beaches in Miyazaki, Kyushu island. Many of such a long beach with fine sand tends to exhibit higher value in nesting success. On the other hand, the lowest value of 30% was recorded at Maehama of Yakushima Island and Kawajiri Beach in Kagoshima, where seawalls were located between shoreline and vegetation. Beaches with coarse sand such as Inakahama of Yakushima Island and Minabe-Senri Beach, which are known for the high nesting density, also tend to exhibit relatively lower nesting success. At coarse sand beaches annual nesting success increases with precipitation during nesting season significantly. This implies that climate change accompanied by a drop in rainfall would have negative impacts on nesting females in term of their additional energy expenditure at beaches with coarse sand.

TRANSPLANTATION OF 20 NESTS OF *LEPIDOCHELYS OLIVACEA* TO THE COASTLINE OF MUANDA/DRC DURING THE NESTING SEASON 2012-2013

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During sea turtle nesting season, monitoring of the sites makes it possible to record the number of nests deposited by the *Lepidochelys olivacea*. To date, the greatest threat with the survival of these species is the fact that their surfaces of laying narrow following the projection of oceanic water towards the continental ground. Thus, a large portion of nests laid are subjected to the effects of flooding. During the laying season 2012-2013, on an experimental basis, we initiated a new strategy of conservation, in collaboration with our guards of ONG ACODES. We had transplanted 20 nests of the sea turtle of this species to the site of BANANA/Km V. At the end of the season, we were able to release 1,155 hatchlings from 2,236 transplanted eggs, which represent a hatching success rate of 46.9%. While being convinced that this strategy of conservation makes it possible to save several nests containing of the hundreds of eggs, our study also evaluated the rate of success of the artificial incubation (51.6%). We will be able to perform the same experiment during upcoming seasons to know if we will be able to adopt this strategy of conservation definitively in order to contribute to the survival of these reptiles to the coastline of MUANDA/R.D.C.

LEATHERBACKS OF PALM BEACH COUNTY, FLORIDA: A LOOK BACK AT 12 YEARS OF NESTING

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Loggerhead Marinelifelife Center of Juno Beach (LMC) has been conducting one of the longest running sea turtle monitoring programs in the state of Florida. The nesting survey program was started in 1989 and included 9.66 km of beach along Juno and Jupiter beaches in Palm Beach County, Florida. Loggerhead (*Caretta caretta*), green (*Chelonia mydas*) and leatherback (*Dermochelys coriacea*) turtles are the primary species documented nesting along these beaches. This area hosts the highest leatherback nest counts in Florida, accounting for 38.7% of nesting. Although high inter-annual variability has been observed, there was an average of 86 leatherback nests per year from 2001-2005. The average increased to 208 nests per year from 2009-2013. In 2001, the survey program expanded to a nighttime leatherback tagging study to identify individuals and better understand the local population size. Each new turtle encountered on the night survey is marked with two flipper tags and a PIT tag. A total of 503 individual females have been identified and 50% are remigrants to North Palm Beach County. Along the study beach, 126 leatherbacks have been documented nesting in 3 or more different seasons. Using the data collected from the remigrants, LMC is assessing morphometric trends, nest site selection and reproductive success. The continued collection of data on a high density nesting beach like this will prove beneficial to developing appropriate policies and management programs in the future.

PEAK NESTING HABITS OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) ON CUMBERLAND ISLAND, GEORGIA

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A basic understanding of animal nesting ecology is vital to conservation management. This is especially true for sea turtles, since they spend most of their life roaming the open ocean, making it exceedingly difficult to research and manage their populations. We only have ready access to the turtle population when females come ashore to nest. Therefore, much of what we know about sea turtles is from observing the nesting females. The study site consists of an 18-mile stretch of beach on Cumberland Island National Sea Shore, Georgia's largest and southernmost barrier island. Each nesting season, Cumberland Island has historically had the largest number of Loggerhead nests in the state of Georgia. The purpose of the study was to evaluate the nesting habits and success of Loggerhead Sea Turtles (*Caretta caretta*) on Cumberland Island. New nests were located and monitored every morning at dawn from May through October 2011. The objectives of this study were to: determine how many individual females are nesting on Cumberland Island; determine when in the nesting season the Loggerhead Sea Turtles of Cumberland Island have the largest clutch size; determine if there is a relationship between clutch size and nest success; determine if Georgia's shrimp trawling season coincides with the period during which the turtles are laying larger clutches and/or producing the most nests on Cumberland Island; and to determine when in the nesting season loggerheads of Cumberland Island lay the most nests. The average daily clutch size was relatively scattered throughout the nesting season, with a gradual decrease in clutch size as the season progressed. Hatch success had no obvious correlation with clutch size. The 2011 commercial shrimp trawling season occurred during the nesting season when clutch sizes and nest occurrences were lowest, suggesting that the commercial shrimp trawling season was scheduled at a time in the nesting season where fewer turtles would be effected. Loggerheads lay the largest number of nests per day in early June and gradually taper off through August. The data suggests that nest monitoring should be increased at the beginning of the season, as well

as during the week surrounding each full moon/high tide. This should be continued at least through the first few weeks of June in order to make sure the largest clutches and largest numbers of nests are protected. The data suggests a possible increase in neophyte nesting at the beginning of the nesting season, suggested by the more scattered nesting occurrences, and throughout the season they learn when the better times to nest are, suggested by the evening out of nesting occurrences and the increased full moon/high tide nesting occurrences toward the middle and end of the nesting season (to confirm this suggestion further data would need to be collected and a tagging project would be needed). Thank you to the National Park Service, Georgia DNR, the International Sea Turtle Symposium, International Sea Turtle Society, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation, U.S. National Marine Fisheries Service, Sea Grant-Texas, Shell, International Seafood Sustainability Foundation, Wildlife Computers, Environmental Business Specialists LCC, Sea Turtle Conservancy, Florida TURTLE license plate program, SIRTRACK, CLS America, Ecological Associates Inc., Desert Star Systems LLC, Loggerhead Marinelifelife Center. Janet Hochella, Kiki Jenkins, Sea Turtle Project-Bangladesh, Marinelifelife Alliance, Matthew Nash, Mission: Clean Beaches, Sandy Sly, ProFaunaBaja – ASUPMATOMA, Usagi Family and Debbie Sobel for supporting this project and for making my attendance at the 2014 International Sea Turtle Symposium possible.

PHENOLOGY SHIFTS IN LEATHERBACK TURTLES (*DERMOCHELYS CORIACEA*) AS A RESPONSE TO CHANGES IN SEA SURFACE TEMPERATURE

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Modern species of sea turtles have survived past shifts in climate. However, current rates of increase in atmospheric greenhouse gases and associated temperature changes are very rapid and it remains unclear whether sea turtles, limited by their long generation times, will be able to adapt to new conditions. If they do, it may be by changing their nesting; either by moving to new beaches or by shifting their nesting season. The aim of this study is to determine whether the leatherback populations nesting at three beaches (Tortuguero, Costa Rica; Sandy Point, US Virgin Islands; and Playa Grande, Costa Rica) are shifting their nesting seasons in response to changing sea surface temperatures. Correlations were made between sea surface temperatures both at nesting and foraging sites and Julian date by which certain percentages (5%, 10%) of nests have been laid on each beach. The correlation between temperature and net primary production (NPP) was also studied for each site. The temperature at the nesting sites did not have an effect on nesting dates. However, each nesting beach had at least one foraging site at which some temperature was correlated to nesting date. The diversity of relationships between temperatures (that correlated with nesting date) and simultaneous NPP estimates suggest that the effect of temperature on nesting phenology is not driven by NPP, but rather that migratory cues are complex and might differ among foraging grounds. However, the main trend is for increased temperatures to lead to later nesting. Continued monitoring is needed to see if these phenology shifts are maintained and to determine how conditions change at the beach in relation to new nesting dates, what effects this might have on nest success and whether conservation measures such as nest shading or watering should be taken to mitigate these effects.

ENVIRONMENTAL CHARACTERIZATION OF TWO SEA TURTLE NESTING BEACHES IN CAMBUTAL, LOS SANTOS PROVINCE, PANAMA

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Beaches are very dynamic areas which change because of the processes that occur on it. These processes create or destroy the conditions needed for sea turtles to nest. La Cuchilla and La Enjarma beaches were the sites of this study

and they are located in Azuero peninsula in Panama's Pacific coast. Both beaches have their own characteristics and the aim of the study was to determine what characteristics are present in these sites and which affect the nesting process. During sampling (between January and May 2011), beach profile surveys were conducted and include studies of granulometry, organic content and identification of nesting species. La Cuchilla beach seems to be the preferred beach for turtles, despite its proximity of La Enjarma beach that did not have any nesting turtles. Through statistical tests, it was concluded that the sands of the beaches have significant differences. La Enjarma ($p < 0.05$), for example, has the coarse sand. This would affect the nesting process and therefore the beach selection. Among the species that nested on La Cuchilla beach, we found the olive ridley turtle (*Lepidochelys olivacea*) and green turtle (*Chelonia mydas*). The tracks of turtles were found more often than the animal at some stage of nesting. The presence of traces of egg collectors and pets on the beaches were constant during the period covered by this study. At these beaches, it is necessary to support community initiatives in the conservation of turtles, their eggs and habitats to avoid the extinction of these species.

SEA TURTLES SET A NEW SOUTHERNMOST NESTING RECORD AT THE EAST PACIFIC

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There are important sea turtle feeding grounds in Peruvian waters, however nesting activities have been reported along the northern coast, but then have been sporadic and occasional. The species reported were olive ridley and green turtles, with Olive Ridley's being the most reported. The previous southernmost reports were: Negritos, Piura (04°42.25'S; 81°18.62'W) and Playa Tres Cruces, located north of Lobitos, Piura (04°24.22'S; 81°15.41' W) for olive ridley and green turtles respectively. This study describes a new southernmost record of nesting turtles in the East Pacific, a nest with 19 eggs that was observed on August 23rd, 2013 on Puerto Eten beach, Lambayeque, north Peru (06°55'53.1"S; 79°52'01.3"W). The nest was found with exposed damaged eggs at the cliff bottom. The average egg diameter was 46.51±0.63 mm (range 45.86 - 47.27 mm; n = 5). None presented embryo development; at the inside the yolk was curdled, were covered by fungi and some of them were broken, probably because the nest was washed. Despite the fact that no species was determined, this work extends the southern limit of sea turtle nesting by approximately 350 km. This information could be used to implement conservation efforts for sea turtles not only at feeding grounds but also for nest protection in Peru.

POTENTIAL IMPACTS OF CLIMATE CHANGE ON LOGGERHEAD TURTLES IN THE MEDITERRANEAN SEA*

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We identified potential impacts of climate change on nesting and foraging success of loggerheads in the Mediterranean Sea. Within this region, loggerheads primarily nest in Greece. Based on historic data, there was a statistically significant relationship between air (Ta) and sea surface temperature (SST) and the date of first female emergence for the nesting season at Zakynthos Island. As Ta and SST rose, loggerheads began nesting earlier in the year. There was

also a statistically significant relationship between rising ocean temperatures at foraging sites and declines in nests per season at Zakynthos Island and Rethymno, Crete. We used output (Ta, SST, precipitation) from 14 climate model projections developed for the Intergovernmental Panel on Climate Change fifth assessment report and for the World Climate Research Programme's Coupled Model Intercomparison Project phase 5 under the RCP 8.5 greenhouse gas emissions scenario (highest emissions scenario). Model output was statistically downscaled for the region to reduce bias. The Ta and SST are projected to increase by ~4° C while precipitation is projected to decline by ~10 mm yr⁻¹. Using equations from linear trend lines of the relationships between nesting phenology, Ta and SST, we project that nesting at Zakynthos could shift earlier in the year by as much as 74 days. However, as temperatures continue to increase and precipitation declines, these future nesting seasons will most likely remain within the same climate conditions that occurred during past nesting seasons. This will maintain the female biased sex ratio for Greek beaches (>70% female). In recent years, rising ocean temperatures have caused significant increases in sea grass mortality rate and declines in shoot density. Climate models project that ocean temperatures will continue to rise, potentially exacerbating the deterioration of these benthic foraging environments. With the rise in SST at foraging sites, loggerheads will encounter reduced prey abundance and quality as sea grass beds deteriorate. Loggerheads nesting in Greece show fitness differences, smaller carapace and clutch sizes, depending on their foraging sites. These are most likely due to differing prey quantity and/or quality from each region. Reduced prey resources are most likely a result of direct anthropogenic impacts, like industrial runoff and sewage; climate change may intensify these negative effects. As a result, climate change has the potential to seriously threaten the overall survival of the nesting population of sea turtles in Greece.

NEST-SITE SELECTION OF GREEN TURTLES FROM THE THIRD LARGEST ATLANTIC ROOKERY, POILAO, GUINEA-BISSAU*

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For sea turtles, nest-site selection has the potential to affect offspring survival and sex ratio. There is paucity of information on the nesting site preferences of green turtles *Chelonia mydas*, and no study on the repeatability of nest-site choice by individuals of this species is available to date. Studying the individuals' nesting habitat selection is highly relevant to infer if there is potential for behavioural adjustments (individual plasticity) to nesting habitat changes, potentially triggered by environmental shifts, or if selective pressures on heritable nesting site preferences could potentially result in adaptations to new conditions resulting from climate change. In this study we have two main aims: 1) characterize the population's preferential nesting micro habitats and estimate the consequences to clutch survival, fitness and sex ratio, and 2) assess if there is within-individual consistency in nest-site choice among the green turtles nesting at Poilão. From August to November, we followed and tagged nesting females at the Island of Poilão, Guinea-Bissau, which hosts the most important rookery for green turtles in Africa, third in the Atlantic. Here we characterized nesting habitats using distances from the nest to several landscape features (e.g. distance to vegetation line, distance to highest spring tide line), together with other environmental variables (e.g. vegetation type, elevation, sand temperature, shading). At the population level there was high variability on nesting habitat, with 49% of nests placed in areas with at least some vegetation (forest: 23%; forest border: 14%; low-lying vegetation: 12%; open sand: 51%). We found significant differences among females in nest-site choice, and significant repeatability within females on the distances along the beach ($r=0.6$) and to vegetation line ($r=0.4$). A subset of 54 nests were followed throughout the incubation period until emergence, and exhumed, to evaluate nest contents and estimate hatching success. Some areas of low elevation resulted in almost all nests being flooded during spring tides, leading to death of the eggs or reducing emergence rates. We discuss the evolutionary and conservation implications of nest-site selection for this population under predictions of climate change, i.e. sea-level-rise, global warming and precipitation events.

LEATHERBACK TURTLES (*DERMOCHELYS CORIACEA*) IN VANUATU; SUMMARY OF NESTING BEACH DATA 2002-2013

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Leatherback turtles (*Dermochelys coriacea*) were confirmed nesting in Vanuatu in 2002. Since then the Vanua-Tai Resource Monitors, a unique network of local village turtle monitors, have been monitoring nesting beaches, documenting threats and collecting information throughout Vanuatu on leatherback nesting and threats. Two main nesting beaches have been identified on Epi and Ambrym Islands with nesting during the austral summer (November–February). Local monitors and community members have carried out the nesting surveys on these Islands, but the nesting beaches are very long (over 10 kms) and at distance from the villages. As a result coverage has been sporadic in timing and area covered, and some data has been unreliable. In spite of the difficulties, the local monitors have carried out annual nesting beach surveys. The nest counts range from zero to over 40, 13 turtles have been flipper tagged, hatching success has been recorded, and other nesting parameters recorded. Additional scattered nesting has been identified on five other Islands by the Vanua-Tai monitors. This presentation will document the 10 years of nesting on the main nesting beaches, the occasional nesting on other beaches, and include data on hatching rate, threats, conservation measures, and needs for further research.

EFFECT OF NEST DEPTH AND NEST TEMPERATURE ON THE HATCHING SUCCESS OF GREEN TURTLE EGGS RELOCATED IN TURTLE HATCHERIES IN SOUTHWEST COAST OF SRI LANKA

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Temperature of a sea turtle nest during incubation is critical to successful development of hatchlings and for the determination of their sex. Many ecological and physical factors such as rainfall, air temperature, nest depth, sand moisture and gas exchange affect the nest temperature. In hatcheries, the depth of relocated nests can vary as they are buried by the hatchery keeper. Nest depth can influence the nest temperature with deeper nests being constant because they are less affected by solar radiation and air temperature. This study determined the effect of nest depth and nest temperature on the hatching success of green turtle nests relocated in hatcheries in Sri Lanka. Two hatcheries in the southwestern coast of Sri Lanka were selected. Total number of eggs in a clutch and the depth of the nest dug by the hatchery keeper to bury the green turtle eggs were recorded. Temperature data loggers were placed inside the nest to monitor the temperature. At the end of the incubation period number of eggshells, unhatched eggs, and dead eggs were counted to determine the viable and non-viable eggs and then to determine the hatching success. Data was recovered from 18 nests with a total of 2,212 eggs. The hatching success of green turtle nests in hatcheries was 52%. Hatching success of reburied eggs in the hatchery is much lower compared to that of the eggs in the Kosgoda (77%) and Rekawa (82%), the two main Sri Lanka rookeries located in the southwestern and southern coast respectively. Mean temperature of the nests varied during the study period recording 37.5 °C as the highest and 26.0 °C as the lowest. There was no significant relationship between nest temperature and hatching success (Pearson correlation $r=0.016$; $p>0.05$). The nest depth varied from 55 cm to 70 cm mean depth of the nest in the hatcheries was 63.2 cm. There was a strong negative relationship between the nest depth and hatching success (Pearson correlation $r=-0.449$; $p<0.05$). Although the recommended depth for green turtle eggs is 70 cm, deeper nests had a lower hatching success with many dead hatchlings and rotten eggs. Hatcheries purchase eggs that were collected at night from nearby nesting beaches by fishers or villagers. Eggs brought to hatcheries are usually transported in plastic bags or cardboard boxes. Although relocation of eggs should be done within three hours of oviposition and reburied before white spots appear

on the surface of the eggshell, delaying the reburial may have caused high mortality and less hatching success. According to hatchery keepers the usual practice is that the eggs of a clutch are separated and buried in more than one shallower nests to increase the hatching success. These shallower nests have high incubation temperatures, which alter hatchling sex ratios producing more females.

AN EVALUATION OF POTENTIAL DRIVERS OF HAWKSBILL HATCHLING EMERGENCE ON LONG ISLAND, ANTIGUA, W.I.

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Sea turtle hatchlings typically emerge at night, presumably to reduce the risks of predation. Emergence events are thought to be driven by environmental cues, primarily temperature: either a drop in temperature below a critical threshold or the development of a negative thermal gradient in the top-most portion of the sand column functions as a trigger. Although previous studies indicate that hatchlings may prove more responsive to a particular thermal cue (i.e., threshold versus gradient) depending on the species and/or geographic location, the specific mechanisms are not well-studied in the hawksbill sea turtle, *Eretmochelys imbricata*. Here, we evaluate potential drivers of hawksbill hatchling emergence at a rookery on Long Island, Antigua, West Indies (17° N, 61° W). Pasture Bay Beach on Long Island (also known as Jumby Bay) is intensively monitored from June through November annually; all successful nesting events are recorded, nesting females are identified and tagged, and associated biometric, habitat, and weather data are collected. During 2013, we recorded hatchling emergences through direct observation of hatchlings or by noting distinct hatchling tracks during hourly patrols of the entire beach. Additionally, we deployed 24 HOBO Water Temperature Pro v2 data loggers in different habitats and shade cover conditions on the beach surface and at varying depths in the sand. Ambient temperatures were recorded hourly at the high tide line at the midpoint of the beach. We will quantify temporal patterns of hatchling emergence and use multiple regression to examine the relationships between time of hatchling emergences and environmental factors including nest habitat, shade cover, barometric pressure, cloud cover, lunar phase, rainfall, and sand and ambient temperature. Additionally, our study will provide a better understanding of how well ambient temperature reflects changes in sand temperatures and will quantify the temperature profile across Pasture Bay Beach. Our results will inform conservation efforts targeting nest emergences, since light pollution and wayward hatchlings pose management challenges on both Jumby Bay and across mainland Antigua. Our results will also be used to direct more intensive hawksbill emergence studies on Jumby Bay, including thermal cue responsiveness.

NESTING ECOLOGY OF LEATHERBACK TURTLES (*DERMOCHELYS CORIACEA*) AT OCEAN PARK, CONDADO AND ISLA VERDE, PUERTO RICO

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During 2013, Puerto Rico had approximately 1,400 leatherback turtle (*Dermochelys coriacea*) nests. It is the largest leatherback rookery under U.S jurisdiction. The knowledge of the nesting ecology of the species in Puerto Rico is limited by the remoteness, access and population size of the rookeries at every beach. Ocean Park, Condado and Isla Verde beaches are located in metropolitan area and contain a high level of residences and tourism. However, it

provides a good area to understand in detail the nesting ecology of the species, considering that there is easy access to the beaches and low nesting activity, which are located in a sporadic nesting sites. Those factors allow us to monitor all nesting females and their nest productivity. We documented leatherback-nesting season at Ocean Park, Condado, and Isla Verde beaches during 2013 from mid-March to late-August. There were a total of four females and 17 nests. To watch for the safety of the hatchlings and obtain the data, the nests were surrounded with a mesh to protect them from predator such as dogs and a high level of visitors that may not have the knowledge of sea turtle nesting at the particular beach. Also, humans bring a great amount of garbage and contamination that is left on the beaches. Results obtained for nesting females indicated a curved carapace length notch to tip (CCLn-t) of 150.5 ± 13.9 cm (mean \pm SD) and the curved carapace width (CCW) was 113.3 ± 10.8 cm ($n = 4$). The females lay on average 80.2 ± 14.2 yolked eggs per clutch and the average of yolkless eggs per clutch was 25.7 ± 10.8 ($n = 16$). The seasonal reproductive output was 381 ± 41 eggs per female ($n = 2$). Of the 17 nests, ten were in their natural emergence with average incubation of 66 days ($n = 9$). The remaining nests were excavated in order to verify what happened because the incubation period had exceeded 72 days. Of the excavated nests, we found and released 75 neonates alive that could not come on their own to the surface. The hatching success rate was low (35.8 ± 31.2). Threats to this rookery include light pollution, domestic animals, and tourism. Successful conservation actions are beginning to be implemented in collaboration with researchers, authorities and a part of the local residents. However, it is necessary to continue with monitoring and education projects, which have an impact on mitigating threats that are presented, in order to ensure successful leatherback nesting in the area.

NESTING BIOLOGY OF LOGGERHEAD TURTLE IN THE MAJOR NATURAL RESERVE OF CAPE VERDE: SANTA LUZIA

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The shores of Cape Verde host one of the most important nesting populations of loggerhead turtle *Caretta caretta* in the world, and they also have a role as important feeding grounds for hawksbill *Eretmochelys imbricata* and green turtles *Chelonia mydas*. The loggerhead turtle nesting population of Cape Verde is considered the second largest population of this species in the Atlantic and the third worldwide, after the nesting populations in Florida and Oman. All the main scientific studies about the Cape Verde loggerhead population show that 90% of the female turtles breed in the island of Boavista. However, the studies only consider the 9 inhabited islands of the country. Since 2011, Biosfera I has been studying the nesting season of the loggerhead turtle in the marine reserve of the uninhabited islands of Santa Luzia, Branco and Raso, which is the largest nature reserve in the country (total area of 593.9 km²) and one of the last strongholds of Cape Verdean unique wild nature. Through an extensive stratified monitoring program across the island in the seasons 2011-2013, the population of sea turtles in the Reserve of Santa Luzia (unknown until this date) has been extensively studied, the beaches mapped and the threats identified. In the seasons 2011-2013, we demonstrated the main nesting beaches of the island with higher density of nests, particularly in 2012. With the data collected in these 3 seasons of studies we estimated the reproductive success, the time of incubation, the nesting success and the eclosion rate. We also implemented a hatchery in the 2012 and 2013 seasons to compare the reproductive success and eclosion rate in the natural versus hatchery environment. There are many threats to the loggerhead turtle, but in Cape Verde the human predation is one of the factors that most threaten the species despite national sea turtle protection laws. The natural hazards are also varied, but amongst these, the presence of large populations of ghost crabs *Ocypode cursor* is the most significant because they prey on the eggs in the nest, causing massive destruction of the eggs. The characterization of the main nesting beaches has determined which sites have the highest probability of predation by ghost crab. The results have demonstrated the relevance of the island of Santa Luzia, despite its isolation, as an important spot for the conservation of these marine megavertebrates listed as endangered (EN) in the IUCN Red List. Nowadays, the population of loggerhead turtle *Caretta caretta* is in the same degree of importance as the population of Sal and Maio Island.

QUANTIFYING SEA TURTLE NESTING HABITAT: USING BEACH PROFILING AND NEST DISTRIBUTION AS A CONSERVATION TOOL

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In México, relocation of nests to protective corrals is a common methodology for nest monitoring. However, there is a push for more in-situ nest monitoring, especially for *Lepidochelys olivacea*, which is the least endangered species. In the southern Pacific region of the Baja California Peninsula *Lepidochelys olivacea* is the primary nester in the region, followed by *Chelonia mydas (agassizii)* and *Dermochelys coriacea*. As climate change provokes changes in nesting behavior further north especially for *D. coriacea*, this region will be vital for conservation. Biologists from ASUPMATOMA A.C. (The Association for the Protection of Marine Turtles and the Environment) a non-profit group, monitors approximately 21 kilometers of nesting beach in the region. ProFaunaBaja a local research group in coordination with ASUPMATOMA, began a plot research project in 2012 to digitally mark nests with GPS units before relocation to a protective hatchery. In 2013, the project was successfully implemented as a full project thanks to funding from Rufford Small Grants Conservation Fund in 2013. The objective is to increase in-situ nest monitoring practices at the ASUPMATOMA camps. Yet, in most nesting beaches in México, in-situ nest monitoring is not a feasible method of marine turtle nest conservation. For example, while the federal government placed a ban on hunting turtles in 1990, illegal poaching still remains a significant threat, mainly in part to lack of law enforcement and resources. Beach erosion from tropical summer storms, ATV tour companies operating on the beach and dunes, and the onslaught of coastal development projects are also combined threats to nesting beaches. The combination of coastal tourism development and climate change provokes an increase in erosion of nesting beaches at an alarming rate, squeezing out nesting beaches for marine turtles and compromising current conservation efforts. Fortunately most coastal developments are only in the first development phase, or still being reviewed. By combining sound science and environmental education with already published documents and regulations, we can create specific criteria, strategies, and recommendations for the region. For examples, through beach profiles, we are calculating the volume of sand eroded and accreted annually. Through nest distribution studies using GPS and ArcGIS capabilities, we are cataloging nesting hotspots, recognizing areas of high poaching activity, and ranking areas depending on priority conservation concern. This spatial analysis will enable us to more effectively monitor nesting activity and advance in-situ nest monitoring practices in order to reach the goal of in-situ monitoring by the federal government. We can also use this data to make informed management decisions for future coastal developments to safeguard nesting beaches. This poster (1) reviews the region –specific threats with case studies, (2) presents the results of the 2013 beach-dune profile investigations and (3) analyzes 2013 nest distribution data in relation to moving towards increased in-situ nest monitoring practices for 2014.

DO WIDER RENOURISHED BEACHES ENHANCE SKY-GLOW EFFECTS ON SEA TURTLES?*

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Boca Raton is an unusual coastal municipality as nearly one-half of the five miles of beachfront are located within city and county parks with no direct beachfront lighting. However, Boca Raton's location in southeast Florida ensures an overabundance of sky-glow from development from Miami-Dade through Palm Beach Counties. These factors make Boca Raton's beaches an excellent field laboratory for studying the effects of sky-glow on sea turtle nesting behavior and sea turtle hatchling sea-finding (orientation) behavior. Boca Raton's beaches have had seven renourishment projects since 1996. Two of those projects occurred in the northern mile and one-half of Boca Raton

(North Project Area). Two renourishment projects were completed in the mile and one-half stretch north of the Boca Raton Inlet (Central Project Area). In the Central Project Area, more than one-half mile of beach is included in South Beach Park. When beach width was compared to the sea turtle false crawl/nest ratio, a positive correlation was found with the ratio increasing from 1.0 on 50-foot wide beaches to 2.5 on 175 to 200-foot wide beaches. The number of nest disorientations in the area also increased as the beach width increased. The percent of nests disoriented in the area went from less than 2% for a wide beach to just over 10% on a 175-foot wide beach. The dune in the area is relatively low and flat at the dune crest. Except for the loss of two and partial destruction of one Australian pine trees in one specific area, the dune on South Beach Park remained the same height during the study; only the beach width changed in this area from 1997 to present. The North Project Area contains Spanish River Park, which represents one-half mile of the project area. This re-nourishment of this area resulted in significant widening of the beach. Interestingly, there seems to be no correlation of beach width to the false crawl/nest ratio in this area with the false crawl/nest ratio remaining about 1.25 from a 50-foot wide beach to a 200-foot wide beach. This park area had a changing dune height since 2004 due to the loss of predominant Australian pine trees due to hurricane activity and exotic removal projects. When the park predominated in Australian pine trees, the dune height was 3 fold higher than South Beach Park, which may account for these differing results. The nest disorientation rate, however, did show a correlation with beach width. The percentage of disoriented nests increased from less than 5% at 50 feet to 15% at 175 feet of beach width.

SEX RATIO OF *LEPIDOCHELYS OLIVACEA* HATCHLINGS FROM THE MEXICAN PACIFIC*

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It has been observed that temperature is a key parameter for sex determination in many reptiles. In order to estimate the sex ratio of *Lepidochelys olivacea* hatchlings, experimental data of turtle nest temperatures were collected in four rookeries sites along the Mexican Pacific coast: 1) Los Cabos, Baja California Sur, 2) Elota, Sinaloa, 3) Armeria, Colima, and 4) Tecpan de Galeana, Guerrero. Programmable digital sensors were placed in 76 nests, and data from these sensors was analyzed during the 2009-2010 turtle-nesting season (July - December). By using the acquired data sheet of those nesting areas, the sample was extended to 5,358 nests. The main aims of this research were to: 1) Design a new method for determining the temperature thresholds that influence sex ratios in *Lepidochelys olivacea*, based on the assumption that the physiological responses of species of sea turtles in the incubation temperature do not depend on the geographical area, extending the thresholds to 27.1 °C and 32.9 °C, 2) Determine the pivotal temperature, approximately 29.9 °C and 3) The male to female sex ratio was 2:7, 2:5 and 1:2, in BCS, Sinaloa and Nayarit, respectively. It was concluded that even though the proportion of males is high at the end of each season, the overall proportion of males is low. By using nest data from 15 other rookeries in the Mexican Pacific, at ambient temperatures, it was found that Tierra Colorada, Guerrero, had the highest proportion of males (30% from a total of 1,310 nests). The highest numbers of males were present in November. In 2010, Chalacatepec, Jalisco, had the highest number of nests (4,482), 23% of which were males, and a maximum number of males during September.

HIGH TEMPERATURES DURING INCUBATION REDUCE PRODUCTION OF FEMALE HATCHLINGS IN THE LEATHERBACK TURTLE (*DERMOCHELYS CORIACEA*)*

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Temperature during incubation of sea turtle clutches affects developmental rate, embryo mortality, emergence of hatchlings from the nest, sex ratios and, potentially, fitness of hatchlings. In sea turtles, female hatchlings are produced at high temperatures and highly female-biased sex ratios are common on many nesting beaches. Highly female-biased sex ratios have raised concerns because populations might become too female biased under future scenarios of climate change. Because high temperatures also increase egg and hatchling mortality, we hypothesized that these temperatures will likely lower the female hatchling output (production of female hatchlings) coming from the beach. We tested the effect of mortality of embryos and hatchlings produced at high temperatures, on sex ratios in a population of leatherback turtles (*Dermochelys coriacea*) at Playa Grande, Costa Rica over nine nesting seasons, between 2004-2005 and 2012-2013. High temperatures increased embryo and hatchling mortality. Female output increased with increasing temperature until it reached the upper end of the transitional range of temperatures (~30°C in this population) and gradually decreased afterwards. We found a threshold for mean temperatures at ~ 32°C, over which hatchling production was minimal. The effect of temperature on embryo and hatchling mortality lessened female-biased sex ratios from 85% female primary sex ratios to 78% female secondary sex ratios. We recommend that when management actions are needed, these focus in increasing hatchling output, rather than altering naturally female biased primary sex ratios.

IT'S RAINING MALE HATCHLINGS - BUT AT WHAT COST TO HATCHING SUCCESS?

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Incubation temperature of loggerhead turtle nests have been recorded on Keewaydin Island, Collier County, Florida since 2001. Over the course of the study, decreases in incubation temperature were observed in association with rain events, but precipitation amounts were not recorded. Many of the nests impacted by rainfall were predicted to produce male hatchlings based on average incubation temperature during the thermosensitive period. However, these nests had reduced hatching success due to the detrimental effects of storm events (i.e., high tides and erosion). An automated rain gauge was incorporated into the study during the 2010 nesting season, in order to gain a better understanding of the effect of precipitation on incubation temperatures and hatching success. During the past 4 years of the study, there were 316 HOBO temperature data loggers deployed in situ, which recorded hourly temperatures for the duration of the incubation period. The past 4 years have had very different weather scenarios. The 2010 and 2011 sea turtle nesting seasons were uneventful in terms of storms and precipitation. The 2012 nesting season was severely impacted by Tropical Storm Debby and Hurricane Isaac, which washed out many of the nests. The 2013 season was very wet, but lacked tropical storm impacts. These efforts will be continued in the future in order to gain a better understanding of the effects of precipitation on incubation temperatures, hatchling sex ratios, and hatching success under different weather scenarios.

TEMPORAL AND SPATIAL COMPARISON OF SEX RATIO OF HATCHLINGS ON DALYAN BEACH, TURKEY

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Sex ratios for hatchlings were estimated by measuring temperatures of nests on Dalyan beach, Turkey during the 2012-2013 nesting seasons. Analyzing of the nest temperatures during the middle third of the incubation period, the incubation durations were used to analyze the sex ratio estimations different sections of the beach. The mean incubation period of 2012 nesting season 49.5 whereas it was 54.4 in 2013. In general, an increase in incubation temperatures was observed during the seasons. The sex ratios of males were found usually higher in early (May) and late (August) in the season when compared with the middle part of the nesting season, usually June and July. The differences between the incubation duration are attributed to the cooler sand temperatures. The relocation of nests close to the sea, which are usually relocated further inland may also effect sex of hatchlings produced in those nests. The relocation guidelines according to the sand and nest temperatures were applied in relocation of nests. In order to estimate the sex ratio of the hatchlings that were produced on Dalyan beach, temperatures of 83 nests and sand temperatures at nest depths were recorded electronically on the beach. The results of this study indicate between a 65-85% female dominated hatchling sex ratio. The rate of predation, relocation of nests, and temporal distribution of nests within the season were discussed in the view of sea ratio studies.

EVALUATION OF SEX RATIOS OF THE OLIVE RIDLEY SEA TURTLE (*LEPIDOCHELYS OLIVACEA*) IN AN ARRIBADA NESTING BEACH IN MEXICO: THIRD YEAR FOLLOW-UP*

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Climate change is one of the biggest issues facing the world today. During the last decades there have been reports of a temperature increase on a global scale with greater increases in temperature over the land than the sea surface; also, scientists predict a rapid climate change for the next century leading to concern regarding the impact of global warming in many species. Sea turtles present temperature dependent sex determination (TSD), which makes them particularly vulnerable to global warming, since a subtle increase in temperature can cause skewed sex ratios that could affect population dynamics. Therefore it is important to monitor sex ratios in wild populations. La Escobilla is an arribada nesting beach located in the Pacific coast of Mexico with more than 200,000 nests per year. In an attempt to assess the impact of climate change in sex ratios, we have been conducting a study at this nesting beach since 2010. Samples were obtained from overlapping arribadas during three hatching seasons from 2010 to 2013: summer-fall (July-November) and winter (December-March), and processed by histology with hematoxylin-eosin staining for sex identification. Main sexing criteria were based on the thickness of the surface epithelium (cortex in females) and development (in males) or fragmentation (in females) of medullar cords. We estimated sand temperatures from air temperature records from the closest beach of Puerto Ángel located 25 km (15.5 miles) from La Escobilla for every sample period. The percentage of females (68%) found for the overall period (2010-2013) was statistically different from 50%. Individually, for the 2010-2011 season, we found 54% females whereas in the next two seasons, the percentage of females increased to 79% and 80% for 2011-2012 and 2012-2013, respectively. Consistent with sex ratios data, sand temperature estimations showed an increment of 0.9°C from 2010-2011 (29.7°C) to 2011-2012 (30.6°C), and from 2011-2012 (30.6°C) to 2012-2013 (31.5°C). Interestingly, female-biased sex ratios coincided with

the occurrence of climatic events like “El Niño” and “La Niña”. 2010 was a La Niña year, meaning colder temperatures, consistent with a sex ratio closer to 50%, while from August 2011 to date, an El Niño event has been occurring, producing warmer temperatures and therefore, a skewed sex ratio favoring females. This is a three year study, and we plan to continue sampling over several years to collect sufficient data to estimate the real impact of climatic events. So far our results show how subtle (0.9°C) temperature changes affect sex ratios in this species, highlighting the vulnerability of sea turtle populations to the contemporary climate change.

NEST SITE SELECTION AND ITS IMPLICATIONS FOR CONSERVATION FOR THREE SPECIES OF MARINE TURTLES NESTING ON PLAYA NORTE, COSTA RICA*

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All sea turtles today are currently listed as threatened to critically endangered due to interactions with anthropogenic activities during all life stages. Particularly true in the Caribbean; the warm sandy beaches that marine turtles utilize as rookeries are under increasing developmental pressure to satisfy increasing tourism demands and population growth. Various factors such as vegetation, slope/elevation and distances from dunes or water lines have been identified as factors for nest site selection. However, there are both inter- and intra-specific differences both geographically and temporally and it is still relatively unknown why turtles nest where they do. Playa Norte is a small nesting beach located in the Tortuguero Lowlands on the northern Atlantic coast of Costa Rica in the Caribbean Sea. It is used predominantly by Greens (*Chelonia mydas*); however, it also supports considerable numbers of critically endangered Leatherback (*Dermochelys coriacea*) and Hawksbill (*Eretmochelys imbricata*) turtles. As the three species have demonstrated different nest-site selection factors yet are still nesting on the same beach, this study aimed to identify a possible underlying nest site selection factor that all three species utilize. Spatial distribution of percent nesting along Playa Norte was significantly correlated (Spearman Rank, $p=0.0054$) for Greens and Hawksbills whilst Leatherbacks were strongly related to Hawksbills ($p=0.0924$). The use of vegetation by Hawksbills and Greens varied annually whereas Leatherbacks consistently nested in open (exposed) zones. Percent nesting did not change due to removal or change of vegetation. This suggests that vegetation type and location are unimportant factors for nest site selection for Greens and Hawksbills. Contrastingly, for the conservation of Leatherback nesting, it is vital to maintain open areas of beach as Leatherbacks consistently nest in open or exposed areas of beach. This is the first study to use percent nesting as a preliminary indicator for nest site selection for any species of marine turtles. Results of this study are discussed in an evolutionary context as well as providing recommended measures for conservation.

LOGGERHEAD TURTLES SHIFTING TO THE NORTHERN BEACHES FOR NESTING IN TURKEY: CAN IT BE THE EVIDENCE OF GLOBAL WARMING?

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Loggerhead sea turtles are isolated from the Atlantic population, colonized in the Mediterranean and their nesting population seems to be around 2000 females. Nearly half of these populations are nesting on the South Mediterranean beaches of Turkey. Their nests have been recorded on the most north-western beaches of Ekincik and Dalyan. During the last two years a single nest, on Kusadası public beach, in each season were recorded nearly 200 km north of these

present nesting beaches. The first one was recorded on 08.06.2012 and relocated to further open beaches due to closer location of the sea. The relocation of 81 eggs took place 44 hours after being laid. The incubation period was 55 days and hatching continued for 7 days. A total of 74 hatchlings were emerged from this nest. There were 3 dead-in-shell embryo and 4 unfertilized eggs also recorded. The other nest was recorded on 30.06.2013 and protected in situ. The clutch size was 98 eggs. The hatching started on the 57th day of incubation and continued for 8 days. A total of 91 (91%) hatchlings emerged and the nest contained 4 dead-in-shell embryos and three unfertilized eggs. These two nests were protected and watched by local authorities and volunteers on the beaches and attracted almost 20,000 visitors during the entire incubation period. Our genetic analysis of the dead in-shell embryos will show the haplotype of the nests. From the incubation period, by comparing the results with nearby beach of Dalyan, we can assume that nearly equal sex ratios of hatchlings are produced. The results were discussed under the possible shifting behavior of loggerhead turtles as a possible result of global warming.

EMERGENCE OF LEATHERBACK (*DERMOCHELYS CORIACEA*) HATCHLINGS FROM THE NEST AT PLAYA GRANDE, COSTA RICA

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We investigated emergence rate of leatherback turtle hatchlings from in situ clutches over the course of three nesting seasons (October-December) during 2008-9, 2011-12 and 2012-13 at Playa Grande, Parque Nacional Marino Las Baulas, Guanacaste, Costa Rica. We focused on hatchlings, which emerged from their eggshell yet failed to emerge from the nest during the two-day period between the first hatchlings emerging and the nest excavation being performed. We measured the distance from the head of the hatchling to the surface of the sand to determine whether measured variables had an impact on where in the sand column above the nest hatchlings were found at the time of excavation. These variables included: temperature in the week prior to emergence, depth of dry sand above the nest (dry front), hatching success of the individual clutch, number of eggs in the clutch, and total depth of nest. Emergence rate (hatchlings that emerge from a nest related to total number of eggs that hatched) of hatchlings significantly declines as the season progressed in all years of this study. The depth of the dry front significantly increased during the course of all three seasons, and the temperatures in the centre of each clutch also increased through the season; this indicates that the nest environment may become less suitable for emergence as the season advances. This conclusion was supported by results from 2008-9 and 2011-12 seasons where the depth of the dry front had the strongest correlation with emergence rate respectively, and in 2012-13 both dry front depth and temperature were significantly correlated to emergence rate. There was also a significant effect of weeks into the hatching season on the number of dead hatchlings found in the dry front, which also supports this conclusion. Seasonal progression had an impact on the number of hatchlings found in the nests during excavations, and the proportion of these hatchlings that were still alive. The depth of the dry front was significantly correlated to number of hatchlings failing to emerge in all years investigated; this suggests that water content of the sand or sand consistency may be contributing factors to lowering leatherback hatchling emergence rate. By identifying factors responsible for reduced emergence rate we could potentially implement conservation strategies to alter environmental conditions within the nest, therefore increasing hatchling production. We would like to thank all the field biologists and Earthwatch volunteers responsible for collecting the data used in this investigation, the Park rangers at Parque Nacional Marino Las Baulas, the Leatherback Trust, and the Goldring-Gund Marine biology station. Also we would like to thank the International Sea Turtle Society, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation, U.S. National Marine Fisheries Service, Sea Grant-Texas, Shell, International Seafood Sustainability Foundation, Wildlife Computers, Environmental Business Specialists LCC, Sea Turtle Conservancy, Florida TURTLE license plate program, SIRTRACK, CLS America, Ecological Associates Inc., Desert Star Systems LLC, Loggerhead Marinelifelife Center. Janet Hochella, Kiki Jenkins, Sea Turtle Project-Bangladesh, Marinelifelife Alliance, Matthew Nash, Mission: Clean Beaches, Sandy Sly, ProFaunaBaja – ASUPMATOMA, Usagi Family and Debbie Sobel and the International Sea Turtle Symposium for providing the travel grant which enabled participation in this symposium.

**FACTORS AFFECTING LEATHERBACK TURTLE HATCHLING PRODUCTION AT JAMURSB
MEDI AND WERMON BEACHES, BIRD'S HEAD PAPUA BARAT – INDONESIA**

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The Pacific leatherback sea turtle is a “Critically Endangered” species that has experienced a long-term decline over past decades. The largest nesting aggregation of leatherbacks in the Pacific occurs on Bird’s Head peninsula, Papua Barat, Indonesia, and represents the largest producer of hatchlings for the entire Pacific. The adult females as well as hatchlings disperse widely to various areas of the Pacific. The impact of a number of biotic and environmental factors on leatherback nests and hatchling production were quantified at the two primary nesting beaches: Jamursba Medi and Wermon, from 2005 to 2012. The primary threats impacting nests were predation, tidal inundation and erosion, and extreme beach temperatures, all of which significantly affected nest survival, hatching success, and subsequent hatchling production. The minor threats impacting nests were opportunistic poaching, predation by monitor lizards, sand crabs, and root invasions. We estimated an average of 34,364±7,579 hatchlings produced during the boreal summer nesting seasons at Jamursba Medi, and 10,469±6,278 hatchlings produced during the austral summer nesting seasons at Wermon. The results indicated that low levels of nest survival and hatching success represents one of the primary factors causing the decline of western Pacific leatherback at Bird’s Head. As such, the low level of hatchling production will necessitate the development and implementation of effective conservation measures that significantly increase hatchlings production on these beaches. The development of a beach management plan to address these threats is a critical to the recovery of the Pacific leatherbacks. I sincerely thank OneWorldOneOcean Foundation and Biology Department–University of Alabama at Birmingham (UAB) for their generous supports to fund my participation in the Symposium. I also thank the International Sea Turtle Symposium, International Sea Turtle Society, U.S. Fish and Wildlife Service, and U.S. National Marine Fisheries Service for supporting my participation in the Symposium.

FACTORS THAT INFLUENCED NESTING BEACH SELECTION BY GREEN TURTLES (*CHELONIA MYDAS*) IN VAMIZI, MOZAMBIQUE, BETWEEN 2003 AND 2012*

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The identification of the possible clues that drive nest site selection has received considerable attention. Sea turtles are likely to use multiple environmental factors when selecting a nest site. However, the clues that attract nesting females to a specific location of nest placement remain speculative. One method of investigating possible clues used in nest-site selection is to document the spatial pattern of nests in relation to a naturally occurring range of beach conditions. The main goal of this work was to identify the factors influencing nest site selection by green turtles (*Chelonia mydas* L. 1758) in Vamizi, Quirimbas Archipelago, Mozambique, in 2012, 2003-2008 and 2011. The distribution of the nests through the various beach sections was not uniform for any of the years analyzed. Furthermore, there was a change in the distribution pattern of the preferred beaches: Comissete started to be less visited in 2006 and 2007, and Farol and Pangaio started having more nests in 2007 and 2008. This uneven distribution allowed for the identification of three different groups of beaches: Comissete, Soweto+Farol and Pangaio+Munto Nkulo. The change

in nesting pattern might be due to extreme climate events, namely three consecutive positive Indian Ocean Dipole events between 2006 and 2008, but it could also be the result of individual preferences between females that nest in different years. The factor that seemed to have the biggest influence in nest site selection in Vamizi was beach width, since it was selected by the regression analysis every year. The other factors that influenced this selection were tree height (or tree+bush height for the years before 2012), the percentage of weeds, the percentage of dune, rock cover and the proximity to promontories. The results obtained in the present study are in accordance with similar studies on other sea turtle populations. Beach width has been identified as one of the main factors conducting nest site selection. This is, however, one of the few studies which have analyzed and identified proximity to promontories as a factor influencing nest site selection in 2005. The identification of areas of particular biologic and environmental factors associated with high nest densities and success provides clues about the necessities of a species in terms of habitat, which makes the comprehension of the environmental cues used by organisms to select a nest site vital in terms of conservation. From a practical point of view, a better understanding of the variables that affect nest site selection, and, consequently, hatchling survival, can help identify which nesting beaches are priorities. A better understanding of the nesting biology of sea turtles is linked to our capacity to evaluate the effect of various human disturbances on reproductive success, allowing for the improvement of our conservation plans' efficiency.

COMMUNICATION IN HATCHLING *LEPIDOCHELYS OLIVACEA* *

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Communication in animals occurs when one individual uses some type of signal, simple or complex, to modify the behavior of other animals, the relationship established for the transmission and reception of signals. The signals are used with the objective of identifying the quality and quantity of the information exchanged by the individuals, such as identity, position in the group, and behavioral information. It was assumed that the signals most utilized in turtles were information sent via visual or olfactory cues; however today we know that sound is also an important vector of communication in turtles. Nearly 50 species of turtles, including freshwater, marine, and terrestrial utilize sound for communication in different contexts and age classes. We conducted a study to discover if recently hatched *Lepidochelys olivacea* are using acoustic communication. We recorded hatchling *Lepidochelys olivacea* from 1 to 10 days after hatching in the nest and in fiberglass aquaria at Playa Escobilla and the Centro de La Tortuga Mexicana, Oaxaca, México. During 10 h of recordings we found 42 vocalizations, which could be classified into 4 types of sound due to their spectral and aural characteristics as well as variation in pulses, harmonics, and noise. The mean peak frequency of the vocalizations of the hatchlings was 1541.7 Hz (187.5- 2062.5; sd = 518). Only type I and II sounds were recorded in the nest while all sound types were found in the water. We hypothesize that hatchlings begin to vocalize in the egg and nest to synchronize hatching and emergence from the nest, simultaneous emergence facilitates excavation to the surface, and mass emergence is an effective antipredator mechanism. It is also quite likely that the hatchlings continue vocalizing in the sea to maintain cohesive groups while migrating together to the feeding areas. But this hypothesis has yet to be tested in sea turtles, but it is known to occur in the freshwater turtle *Podocnemis expansa*.

LUNAR EFFECTS ON SEA TURTLE NESTING PERIODICITIES IN BROWARD COUNTY, FLORIDA

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It is thought that sea turtles emerge from the ocean in correlation to the lunar cycle. This assumption gives rise to the null hypothesis that there is no relationship between loggerhead sea turtle nesting and moon phase. Eleven consecutive sea turtle seasons (2000-2010) were selected to identify any such correlations between nesting cycles and lunar cycles of Broward County, Florida's loggerhead sea turtles. A 5-point centered moving average was applied to the data and correlated to a moon phase parameter with a maximum at the quarter moons and minimum at the full and new moon phases. The 2000 ($p>0.307$), 2004 ($p>0.133$), and 2006 ($p>0.550$) seasonal results showed no significant relationship between successful nesting and any lunar phase. 2001 ($p<0.012$) and 2003 ($p<0.029$) resulted in a direct relationship of higher nesting near the quarter moons whereas 2002 and 2009 had significant correlations to the full and new moon phases ($p<0.004$ and $p<0.040$, respectively). Conversely, a weak but direct relationship with the quarter moons for the 2008 ($p>0.097$) season was found. Interestingly, 2005 ($p<0.010$ and $p<0.055$), 2007 ($p<0.065$ and $p<0.001$), and 2010 ($p<<0.001$ and $p<<0.001$) demonstrated a shift in direct correlation of the full and new moon phases during the early portion of the season to the quarter moon phases during the latter portion of each season. The splitting of support and rejection for both the null and alternate hypotheses indicate that the lunar cycle is not the predominant determining factor for sea turtle nesting periodicity.

FALSE CRAWLS IN LOGGERHEAD TURTLES (*CARETTA CARETTA*): CAUSATION AND IMPACTS ON NESTING SUCCESS IN BROWARD COUNTY, FLORIDA

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The factors that influence female loggerhead sea turtle (*Caretta caretta*) nest site selection are numerous and complex. Nesting survey data from Broward County, Florida from 2000 through 2010 was used to determine if nest locations were primarily determined before or after the turtles emerge from the sea by examining the impacts of false crawls on the distribution pattern of nests and nesting success rates. Data was examined for loggerhead sea turtle nest counts, false crawls, and nesting success rates in each of 85 beach survey zones covering northern and central Broward County, Florida. If nesting distributions were entirely determined by post-emergence factors, nest counts and nesting success per zone should be directly correlated and nests and false crawls would be inversely related because locations with more negative on-beach factors would have lower nesting, higher false crawls and lower nesting success. These parameters would be reversed in locations where beach conditions were more favorable for nesting. However, if the nest locations were completely determined before emergence, zones with favorable in-water cues would have higher rates of emergence producing higher numbers of nests and false crawls. Nest and false crawls should be directly related and they may not be strongly related to nesting success if post-emergence factors were relatively constant. The results indicated that female loggerhead sea turtles emerged in non-random patterns along the beaches of Broward County, as the distribution of nests along the beach showed highly significant correlations between all the years. There were stronger correlations between nest and false crawl distributions than between nest and nesting success distributions, suggesting that pre-emergence cues have a stronger influence on nest location than post-emergence cues. However, there were weaker correlations of nests and false crawls with nesting success, indicating some type of post-emergence factors also have a role.

Research Highlights from Southeast U.S.A.

NESTING ACTIVITY OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) ON A BARRIER ISLAND IN THE SOUTHEASTERN UNITED STATES: 40 YEARS OF RESEARCH AND CONSERVATION EFFORTS

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Long-term data on nesting sea turtle populations are the only way to directly assess the status of free-ranging populations and provide necessary field data for building population models used to extrapolate species-wide trends for endangered species and IUCN programs. Tagging initiatives and genetic profiling data provide further insight into long-term nesting performance, movements, and survival of individuals. The Jekyll Island Sea Turtle Project (JISTP) has been on-going for over 40 years and is currently operated by the Georgia Sea Turtle Center through the Jekyll Island State Park Authority. Loggerhead sea turtles (*Caretta caretta*) are the primary nesting sea turtle species and the island is more rarely visited by leatherback sea turtles (*Dermochelys coriacea*) and green sea turtles (*Chelonia mydas*). The long-running database on loggerheads has afforded the ability to conduct demographic analyses on nesting behaviors, turtle morphometrics, and reproductive success and output, parameters which contribute essentially to our understanding of how these important biological characteristics vary among populations (within regions and globally). Additionally, adult sea turtle populations experience the greatest terrestrial risks on developed beaches where human infrastructure has displaced and degraded nesting habitat. Specifically, Jekyll Island, a public-access State Park, provides an opportunity to assess these effects of human presence and activity on nesting behaviors and success. This presentation will highlight the following results from a manuscript on the nesting ecology of loggerheads on Jekyll: 1) demographic trends of nesting females; 2) phenology and seasonal nesting patterns among individuals; and 3) individual patterns of nest frequency and remigration intervals. Additionally, we include our findings from an assessment of the influence of human foot traffic and white or red lights on selection of nest site location and rate of false crawls. Lastly, we will share other conservation efforts to increase public awareness and volunteer engagement initiatives along with future research directions.

MARINE TURTLE NESTING AT THE ARCHIE CARR NWR: AN UPDATE, AND THE BEST YEAR ON RECORD FOR FLORIDA GREEN TURTLES

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The UCF Marine Turtle Research Group has been studying the nesting and reproductive success of loggerheads, green turtles and leatherbacks in east central Florida since 1982. On this 21-km beach, loggerhead nest numbers averaged 9,300 during the decade of the 1980s. These were the numbers upon which the concept of the Archie Carr National Wildlife Refuge was based. After its inception in 1990, loggerhead nesting jumped by 52% and continued to climb until 1998, culminating in an all-time high of 17,629 nests. From 1998 until 2004, nesting dropped in what has been described as a “steep and serious decline,” reaching an all-time low of 6,405 in 2007. Since then nesting has increased with some fluctuation, reaching a high of 15,539 nests in 2012. After the great year in 2012, loggerhead nesting dropped by 29.6% in 2013, to 10,933 nests. Florida green turtles laid fewer than 50 nests annually for the first three

years that UCF worked on the Carr Refuge beach. With a few exceptions, green turtles exhibited a biennial pattern of high and low years through about 2005, when low years began to increase as rapidly as high years and the pattern became more obscured. Chaloupka *et al.* (2007) determined that green turtle nesting at the Carr Refuge was increasing at 13.9%; more than twice the rate of that seen at Heron Island, Raine Island, Ogasawara, French Frigate Shoals and Tortuguero. Since that time, green turtle nest production continues to rise exponentially and has set two new records. The 2011 season produced an amazing 5,505 nests. While we were still reveling in that record, Florida green turtles laid an unprecedented 11,839 nests in 2013. Leatherback nesting ranged from zero to one throughout the decade of the 1980s and the first half of the 1990s. In 1996, however, there were 10 nests in the Carr Refuge. Nest numbers dropped to 4 in 1997 but bounced back in 1998, setting up a biennial pattern similar to that of green turtles. Low years remained at about 11 nests while high years continued to increase until 2008, when low years also began to increase. The high years of 2007 and 2011 each produced 52 nests. The 2012 season was expected to be a low year and finished with 37 nests, while the 2013 season was expected to be a high year and culminated in 24 nests. While numbers remain low, leatherback nesting continues to rise exponentially at the Carr Refuge.

CARRY-OVER EFFECTS AND INTERANNUAL DYNAMICS OF FORAGING GROUND CONTRIBUTIONS TO THE LOGGERHEAD BREEDING AGGREGATION IN FLORIDA *

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Migratory individuals spend different periods of their annual cycle in widely separated and ecologically different locations. There is increasing evidence that arrival time to breeding areas, reproductive success and annual breeding population size are linked to non-breeding habitat quality, a phenomenon that is described under the umbrella term of “carry-over effects.” Loggerheads at nesting grounds show large variation in body size and reproductive parameters (e.g., clutch size, remigration interval). Each female from a nesting aggregation typically forages in one of several geographically distinct foraging grounds and appears to show fidelity to both nesting and feeding areas throughout her adult life. As capital breeders (using energy stored at the non-breeding ground for reproduction), sea turtles reproduce every few years but lay several clutches of eggs during a given nesting season, probably after having reached a critical threshold of body condition. These characteristics suggest that carry-over effects may play an important role in the ecology of loggerheads since the resources required for reproduction are acquired months before the nesting season while at the foraging ground. From 2007 to 2012, we collected tissue samples for stable isotope analysis of carbon and nitrogen from 300 untracked loggerheads nesting at the Archie Carr National Wildlife Refuge (Carr NWR), which accounts for approximately 25% of all the loggerhead nests in Florida, aiming to assess whether differences in foraging strategies are associated with female phenotypic variability and if foraging strategies affect female reproductive output. We used discriminant function analysis (DFA) to assign foraging ground locations used by loggerheads during the non-breeding period and determined the relative contribution of the four different foraging grounds (Mid-Atlantic Bight, South Atlantic Bight, Subtropical Northwest Atlantic and Gulf of Mexico) identified by telemetry to the loggerhead population nesting at the Carr NWR over the 6-year period. The DFA model was based on the isotopic signatures of over 100 satellite-tracked nesting loggerheads. Our results indicate that foraging region preference influences female loggerhead size and fecundity and that the proportion of turtles using each foraging area varied significantly among the years examined. Individuals from different non-breeding regions in the Northwest Atlantic Ocean and Gulf of Mexico experience disparate environmental conditions and resource availability. Thus, resources acquired at the foraging ground and associated environmental conditions have implications for estimating overall number of breeding females in the population.

ANALYSIS OF FISHING HOOKS REMOVED FROM IMMATURE SEA TURTLES INCIDENTALLY CAPTURED BY RECREATIONAL FISHERMEN IN THE NORTHERN GULF OF MEXICO*

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Numerous studies have examined the influence of fishing hook type and size on sea turtle by-catch in various commercial fisheries. However, sea turtle by-catch in recreational fisheries is poorly understood. Since 2010, over 500 immature sea turtles, mostly Kemp's ridley sea turtles (*Lepidochelys kempii*), have been incidentally captured by recreational fishermen using hook and line at fishing piers in Mississippi. The majority of these turtles were transported to the Institute for Marine Mammal Studies (IMMS), where they received a full veterinary exam in which fishing hooks were removed if present. The average straight-lined carapace length (Notch-Notch) was 30.75 ± 4.23 cm. Once removed, the hook type was characterized, and the hook length and gape measured. Whether the hook was offset or not and the type of bait were also noted. These data were used to explore the relationship between hook characteristics and both turtle size (i.e., straight-line carapace length) and hooking location (i.e., oral or swallowed). For this analysis, 291 hooks belonging to the three main hook types (J-hook - 69%; circle - 20%; kahle 11%) were included. No significant differences were observed in the means of turtle sizes between the oral and swallowed hooking location groups ($F(1,289) = 1.47, p = 0.22$) or hook types ($F(2,288) = 1.42, p = 0.24$). Classification tree analyses supported these findings as no discernible patterns were evident for predicting hooking location in the incidentally captured turtles. Although the current study was based on observational data and was not a controlled study, it is one of the firsts that has attempted to characterize recreational fishing gear that results in sea turtle by-catch. Previous studies that have focused on various commercial longline fisheries have concluded that circle hooks deter hook ingestion and overall sea turtle by-catch. However, the percentage of circle hooks observed in incidentally captured turtles in Mississippi are comparable to the percentage of recreational fishermen in this area using circle hooks based on the results of a recent survey study (Cook *et al.*, unpublished data). Therefore, circle hooks may not prevent sea turtle by-catch in this coastal recreational fishery.

HOOKED ON KEMP'S – PRELIMINARY RESULTS OF MISSISSIPPI'S ANGLER SURVEY*

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Mississippi has 71 km of general coastline and 578 km of tidal shoreline. Recreational fishing is popular among visitors and coastal county residents. To provide access to fishing and other coastal marine resources, Mississippi has nearly 200 public access points (fishing piers, fishing bridges, boat launches and marinas) in its three coastal counties. Since 2010, there has been a dramatic increase in reported sea turtle incidental captures. According to the Sea Turtle Stranding and Salvage Network (STSSN) at least 514 sea turtles, primarily juvenile Kemp's ridleys, were incidentally caught at 29 different access points by recreational hook and line fishermen (anglers). Due to the high number of interactions, a survey was developed in 2013 by NOAA Fisheries Mississippi Labs and the Institute for Marine Mammal Studies (IMMS) to collect data on angler fishing practices and sea turtle interactions. The survey was conducted as a pilot project from June-September at six different access points that were selected based on prior history of incidental captures and location so that surveys were conducted in all three coastal counties. Participating anglers were asked general questions about fishing practices such as typical fishing times and locations, and type of hook and bait used. They were also asked if they had caught or observed the capture of a sea turtle in the last 12

months and the outcome of the capture. The survey concluded with information about sea turtles in Mississippi waters and fishing practices that can reduce interactions. Cards with the Stranding Hotline number were also distributed and anglers were asked to report any incidental captures because medical attention provides the best chance for survival for the turtles. Preliminary results yielded a high willingness to participate. Interviewers completed 382 surveys and only 14% of anglers declined to participate. Over 60% of anglers used J-hooks and were not targeting a specific fish species. Anglers also used circle (22%) and kahle (6%) hooks. These results are similar to data collected from incidentally caught turtles reported to the STSSN. Over 58% of anglers interviewed were using dead shrimp followed by cut up fish (21%) for bait. This greatly differs from STSSN reported incidental hook and line captured sea turtles where 60% were caught by anglers using cut up fish and only 6% were using dead shrimp. Over a third of anglers reported observing sea turtles in the water while fishing and 28% witnessed others catching sea turtles. Over 17% of participants captured at least one to as many as 20 sea turtles in the last 12 months. The majority of turtles were hooked rather than entangled by the gear. Anglers stated that nearly half of the sea turtles were taken to IMMS for rehabilitation and later release, 41% were released by the angler and 10% broke the line and swam away. Only 60% of anglers reported the capture although many anglers noted that they were unaware they should report it. During and after the survey period we noticed an increase in reported incidental captures possibly due to our outreach efforts.

EXPERIMENTAL ASSESSMENT OF THE EFFECTS OF MOISTURE ON LOGGERHEAD SEX RATIOS*

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Nest sand temperature strongly influences development of sea turtle embryos and sex differentiation; however other environmental factors such as moisture play a role that has received relatively little attention. We studied the relationships among humidity, temperature, and loggerhead (*Caretta caretta*) sex ratios in an experimental study. Standardized containers of eggs in nest sand were incubated in the laboratory under different moisture regimes to test the role of humidity at a constant incubation temperature. A nest temperature was set at 29.4°C, which is the temperature very near and slightly above the pivotal temperature. Moisture was maintained by daily DI water treatments throughout incubation. All hatchlings were collected, raised for several months, then their sex was identified laparoscopically and sex ratios were calculated for each treatment. The experimental treatments tested the effects of (i) very high moisture, (ii) moisture with potential for evaporative cooling, and (iii) moisture added at average rain temperatures also with the potential for evaporative cooling. The nests were expected to produce a moderate female bias if moisture played no role. We found 87-93% males across all experimental treatments. Natural nests sampled on the same beach, in the same sand, and from the same time period produced 100% females. Our results support the interpretation that high moisture conditions can produce shifts in developmental response.

EVALUATING INDIRECT BENEFITS AND DEMOGRAPHIC FACTORS AS DRIVERS OF THE GREEN TURTLE MATING SYSTEM IN FLORIDA*

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Behavioral studies in the green turtle (*Chelonia mydas*) have indicated that promiscuous mating is commonplace. However, why female green turtles would behave in this manner is up for debate. It has been hypothesized that fitness benefits resulting from offspring genetic diversity, hereafter referred to as indirect benefits, offset the costs of multiple mating. Previous studies of indirect benefits have not found an effect of paternity on hatching success, but these studies poorly controlled for environmental variation among nests. Additionally, the interplay of demographic factors such as overall population density, male population density, and operational sex ratio (the ratio of breeding males to breeding

females) are known to have an effect on observed rates of polyandry. Sex ratio is of particular interest in green turtle conservation, due to the likely feminizing effects of a warming climate. Therefore, green turtle mating systems are worthy of study from both an evolutionary and conservation perspective. In this study, we attempted to examine the importance of both indirect benefits and demographic factors as drivers of polyandry in the Archie Carr National Wildlife Refuge aggregation of green turtles. In order to evaluate whether green turtle females receive indirect benefits of multiple mating, we limited environmental variation among nests by selecting nests at a small spatial (1.7 km) and temporal (< 13 days between nests) scale. Through the use of four highly polymorphic microsatellite loci, we found that 24 of 28 (85.7%) ACNWR green turtle females mated with multiple males, the highest rate yet reported for green turtles. Although we were successful in limiting environmental variation, we were unable to make comparisons among nests with one or multiple fathers because of the limited sample size of single father nests. Preliminary analyses indicate an average of 2.21 fathers per nest (range 1 - 4), which may be an indicator that the density of males in the breeding population may be relatively high. By generating genetic data at 4 - 6 more loci, we will obtain a more robust estimate of the number of fathers per nest and further evaluate the benefits of additional mating. High male densities in this population could be the result of high overall population densities, but this is unlikely given the relatively small Florida population size. Our hypothesis is that the breeding population sex ratio is male-biased, at least with respect to other green turtle populations. There are many possible hypotheses that would explain a relative male bias. The most interesting hypothesis is perhaps that Florida beaches have produced more males in the past as a result of relatively cooler incubation temperatures, which through natal homing results in a population that has higher male densities. A more complete understanding of male behavior and how offspring sex ratios translate to the adult population is needed to discriminate between this hypothesis and others. This knowledge is also necessary to make management decisions regarding nest temperature manipulation. This study adds an important piece to this management and conservation puzzle by giving baseline data about the green turtle mating system in Florida.

EFFECTS OF GRANULAR INCLINE ANGLE ON THE LOCOMOTION OF LOGGERHEAD SEA TURTLE HATCHLINGS (*CARETTA CARETTA*) IN THE FIELD*

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Locomotion is crucial to the survival of animals. Many species exhibit a variety of ways to move around in the world, like running, jumping, swimming or crawling. The locomotor strategy used by species depends on the environment they encounter and its complexity. Sea turtles are animals that are adapted to a life in a fluid environment, but emerge regularly onto land for reproductive purposes. They do this by using aquatically adapted limbs for locomotion in both environments. When emerging onto the beach, they encounter sand, a medium that can act as a solid or a fluid when forces are exerted on it, and can cause significant slipping. This can negatively affect locomotor performance of the turtles while laying eggs and returning back to the ocean. Furthermore, natural beach environments often exhibit various degrees of incline angles that affect the physical properties of sand. As incline angle increases less force of the limb is required to make the material yield. Little is known how incline angle affects sea turtle locomotion for adults or hatchlings on the beach environment. We investigated the effects of granular inclines on the locomotor performance of hatchling sea turtles, hypothesizing that as incline angle increased, the animals will adjust limb-ground interactions to prevent slipping, which negatively affects their performance (speed). We captured 25 hatchlings from 5 different nests at our field site on Jekyll Island, GA and tested them on loose and hard packed sand, and on inclines of $\theta = 0^\circ$, $\theta = 10^\circ$ and $\theta = 20^\circ$. Using a fluidized bed trackway, we controlled for granular compaction and incline angle, mimicking a natural beach environment. Two infrared high speed cameras (250 fps) were attached to the trackway to film the detailed mechanics of hatchling locomotion. Results showed that the total distance traveled and velocity decreased as incline angle increased, without granular compaction affecting performance. Maximum angular extent of the flipper at the beginning of stance phase in relation to the body remained the same at $\theta = 0^\circ$ and $\theta = 10^\circ$ ($\alpha = 128.17^\circ \pm 12.12^\circ$; $\alpha = 127.80^\circ \pm 11.40^\circ$; $p > 0.05$), however at $\theta = 20^\circ$, it significantly increased ($\alpha = 143.19^\circ \pm 12.86^\circ$, $p < 0.0001$). The duty factor during stance phase, remained unchanged among compaction levels, at 0.69, which is similar to terrestrial turtles that have a duty factor of 0.75 or higher on level ground. On close packed materials the duty factor decreased at the highest incline angle $\theta = 20^\circ$ to 0.66. Taking

indications of the step interaction effect due to disturbed ground from a bio- inspired sea turtle robot (FBot), the hatchling data was divided into three step distance categories: no interactions between steps, small step interactions, and large step interactions. Results showed that average velocity increased with frequency when turtles utilize adequate step distance to avoid interaction effects for $\theta = 0^\circ$ and $\theta = 10^\circ$. However, little effect was seen at $\theta = 20^\circ$ suggesting that at higher angular inclines slip dominates performance.

A HISTORY OF SEA TURTLE TAGGING, MONITORING, AND CONSERVATION ON JEKYLL ISLAND, GEORGIA, USA

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The natural and political history of Jekyll Island (Georgia, USA) makes it a unique site for studying sea turtle ecology as well as the influence of coastal development. Loggerhead sea turtles (*Caretta caretta*) account for almost all nesting activity on Jekyll Island's beaches, however, the island also serves as a nesting beach for two other sea turtle species, the leatherback (*Dermochelys coriacea*) and green (*Chelonia mydas*). In 1958, Caldwell *et al.* (1962) initiated a multi-year tagging study of loggerhead sea turtles on Jekyll Island, although Jekyll Island has been reported as a rookery for nesting sea turtles since the 1930s. Consistent monitoring of the nesting population of loggerhead sea turtles on Jekyll Island began in 1972. The initial goal of the Jekyll Island Sea Turtle Project (JISTP) was primarily to compare the nesting ecology of loggerheads on Jekyll Island with that of loggerheads on other islands in the area, such as Little Cumberland Island, which started sea turtle monitoring in 1964. Over the past 40 years, the biological research scope, nest management effort, conservation and education foci, and partnerships of the JISTP have evolved. As with many long-term projects, research is initiated with the hope of long-term data collection but a short-term scope in the event that funding becomes unavailable. Long-term projects are the few that are fortunate enough to maintain funding and resources for continued data collection, but sometimes those data are housed in multiple datasets. The phased data collection managed by several entities resulted in multiple datasets on sea turtle nesting activity on Jekyll Island. Previous project managers and participants were interviewed to gather all usable data from Jekyll. All data were entered electronically, proofed, and merged into a single dataset. We present this evolution and history of the JISTP in addition to providing considerations for retroactively constructing a long-term database from multiple datasets. This summary presents the information recently published in Marine Turtle Newsletter (138) that is the first publication produced specifically by Jekyll Island sea turtle biologists on these long-term data. Acknowledgements: Terry Norton; Mark Dodd; Peter Eliazar; Patrol members, interns, & volunteers; GA Sea Turtle Cooperative collaborators. International Sea Turtle Society Travel Award Funded in part by: U.S. Fish and Wildlife Service; National Fish and Wildlife Foundation; U.S. National Marine Fisheries Service; Sea Grant-Texas; Shell; International Seafood Sustainability Foundation; Wildlife Computers; Environmental Business Specialists LCC; Sea Turtle Conservancy; Florida TURTLE license plate program; SIRTRACK; CLS America; Ecological Associates Inc.; Desert Star Systems LLC; Loggerhead Marinelifelife Center, Janet Hochella; Kiki Jenkins; Sea Turtle Project-Bangladesh; Marinelifelife Alliance; Matthew Nash; Mission: Clean Beaches; Sandy Sly; ProFaunaBaja "ASUPMATOMA"; Usagi Family and Debbie Sobel.

COMPARISON OF GROWTH PATTERNS IN THREE SPECIES OF JUVENILE SEA TURTLES*

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Sea turtles are most vulnerable to predators during early growth when they are small and relatively defenseless. Predation risk might be reduced by evolving effective behavioral as well as morphological defenses. Loggerhead (*Caretta caretta*) and green turtle (*Chelonia mydas*) neonates hide in weed lines. They also become wider faster than they increase in length, a pattern of positive allometry that may function to minimize the time during growth when they are vulnerable to gape-limited predators. Virtually nothing is known about how young leatherbacks might reduce their vulnerability to predators. The fact that they are not found in weedlines suggests that hiding in flotsam isn't a behavioral option. However, they might gain some degree of relief from predators because of their larger size as hatchlings. They might also show allometric growth as neonates. Little is known about how young leatherbacks grow. To find out, we reared 30 hatchlings from 10 nests in the laboratory for up to 13 weeks, post-emergence. Once weekly, each turtle's body proportions (straight line carapace length, SCL; straight line carapace width, SCW) were measured to yield an observed pattern of growth. That observed growth pattern was compared to an expected pattern in which the turtles retained their hatchling proportions as they grew larger (isometric growth). We found that all of the leatherbacks showed allometric growth as their SCW increased more rapidly than their SCL. Thus as they grew, leatherbacks (like loggerheads and green turtles) became proportionally wider. There were no statistical differences between loggerheads and green turtles in their proportional shape change over 13 weeks of growth. However, allometric growth in those species was significantly more pronounced than in leatherbacks. An explanation for the similarities (all species show allometric growth) as well as differences (in degree of expression of the shape change) between the species remains unknown. Some possibilities are that allometric growth may be reduced in leatherbacks because hatchlings are larger to begin with, grow very rapidly, and achieve refuge from gape limited predators sooner than in the hard-shelled turtles. Leatherbacks may also possess effective (but presently unknown) behavioral strategies (such as deep diving) that could reduce their encounters with predators. A third possibility is that the array of predators leatherbacks encounter in the open ocean are less likely to consume marine turtles than those that hunt for small turtles near weed lines. Quite possibly, all of these factors may select for "reduced allometry" in leatherbacks. However, the fact that all three species show allometric growth suggests that changing shape may have survival value for young marine turtles, especially during their most vulnerable life stages.

RELOCATION EFFORTS USED ON LOGGERHEAD SEA TURTLE NESTS AFFECTED BY ESCARPMENTS ON SOUTH HUTCHINSON ISLAND, FLORIDA, USA

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Ecological Associates monitors approximately 12 miles of coastline along South Hutchinson Island for sea turtle emergencies. During the 2013 nesting season, a few small storms caused escarpments to form along this section of beach, which adversely affected loggerhead sea turtles and their nests. Nests laid too close to the high tide became exposed in the side of the escarpments. Nests were found during daily morning patrols and by participation from the community. In an effort to protect these nests, they were relocated as they became exposed. The purpose of this project was to determine whether those nests relocated during incubation would produce viable offspring and how it would compare to in-situ nests. Thirteen nests were affected by escarpments, including 6 marked nests. The average number of eggs relocated was 69 ± 45 , with a high of 145 and a low of 8. All 13 nests that were relocated showed some form of hatching, with a mean hatching success of $62.2\% \pm 25.4\%$ and a mean emerging success of 57.5 ± 26.9 . The emerging success seemed to be lower for all relocated nests (for both relocation during nesting and after) compared with in-situ nests. Data for this project is preliminary and contingent upon completion of the project.

MODELING SURVIVAL OF IMMATURE LOGGERHEADS (*CARETTA CARETTA*) AND GREEN TURTLES (*CHELONIA MYDAS*) FROM 10 YEARS OF MARK-RECAPTURE DATA AT THE FLORIDA POWER AND LIGHT ST. LUCIE PLANT*

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Loggerheads (*Caretta caretta*) are listed as Threatened and green turtles (*Chelonia mydas*) are listed as Endangered under the United States Endangered Species Act. While green turtle nest production in Florida has increased markedly in recent years, loggerhead nest production has followed a more tenuous path. Reasons for these differences are unknown. Limited demographic information is available for these species of conservation concern. We used Barker models, which incorporated mark-recapture, live-resight and dead recovery data, implemented in Program MARK. These models were used to estimate apparent survival for immature loggerhead (< 85 cm SCL) and green turtle (< 60 cm SCL) populations foraging in the Atlantic Ocean adjacent to the Florida Power and Light St. Lucie Plant on Hutchinson Island, Florida between 2002 and 2011. Our results indicated annual apparent survival was decreasing (from 0.75 to 0.59) for resident immature loggerheads and was stable (~0.81) for resident immature green turtles over the ten-year study period. We found that permanent emigration models were better supported than no movement models for both species. Size (straight carapace length) was found to be an important covariate for survival and fidelity parameters in the green turtle analysis but not in the loggerhead analysis. Our study is the first to compare survival of two species of immature marine turtles foraging at the same location in the Atlantic. These estimates are also the first available survival estimates for immature marine turtle populations in Florida based on modern mark-recapture techniques, filling a critical knowledge gap. This information is vitally important for managers when evaluating the long-term recovery of these endangered species.

SPATIAL DISTRIBUTION AND INDIVIDUAL NESTING PATTERNS OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) ON BARRIER ISLANDS IN THE SOUTHEASTERN UNITED STATES*

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Due to inevitably increasing rates of human population expansion along coastlines around the world, sea turtle populations will need to be managed in a manner that allows them to achieve nesting and reproductive success in populated areas. In the southeastern United States, barrier islands present an additional challenge for nesting female loggerhead sea turtles (*Caretta caretta*) of a highly dynamic shoreline that experience rapid and variable rates of erosion and accretion. These natural processes are further accelerated by anthropogenic land uses, such as river channelization, sedimentation and chemical influxes, beachfront development, and subsequent bulkheading to secure the safety of hard infrastructure and to attempt to counteract this shoreline mobility. These synergistic inputs result in drastic changes in habitat availability and quality both within and among nesting seasons. Specifically, Jekyll Island is a Georgia state park that has legislative restriction on the amount of development but is reliant solely on tourism dollars and residential and commercial leases. Therefore, Jekyll can serve as a unique model for assessing the balance of land use for viable wildlife populations and economically-progressive tourism that relies on hard infrastructure, beachfront development, and human presence on the beach. Loggerhead sea turtles have been studied on Jekyll for over 40 years lending a long-term database on the spatial distribution of nesting activity and the potential to assess changes in these distributions over time. As such, we assessed nest distribution and relative nest density during a focal

period of research (16 years [1998-2013]) and potential ecological and anthropogenic factors driving spatial patterns in nesting. We further explored the variation in site selection of individual turtles within and among years. Understanding the drivers of loggerhead turtle nesting patterns in this developed, dynamic ecosystem can provide valuable insight and direction for future management and conservation of the species and the ecosystem it inhabits.

REASSESSING THE MISMATCH BETWEEN HATCHLING TEMPERATURE-SEX RATIO RELATIONSHIPS IN LABORATORY AND FIELD STUDIES*

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Sea turtle sex determination is well known from laboratory studies. Briefly, during the period of incubation when embryo sex is environmentally determined, warmer incubation temperatures tend to produce female-biased sex ratios, while cooler incubation temperatures tend to produce male-biased sex ratios. Under laboratory conditions, the sex ratio response curve tends to be sigmoid. Near the curve's inflection point, the sex ratio approaches 1:1 (the pivotal temperature) and small changes in temperatures near to but above or below the inflection point can produce major differences in sex ratio. For more than 10 nesting seasons, we have sampled sex ratios of *Caretta caretta* clutches under natural (field) conditions and incubation temperatures in southern Florida. The temperature-sex ratio response curves are not sigmoidal. Male-producing temperatures (predicted by careful laboratory studies) are rare and male-biasing temperatures do not reliably produce male-biased sex ratios. This difference between the responses of embryos in the field compared to the responses of embryos under controlled conditions of the laboratory suggests that there are environmental variables that in unknown ways modify the response scenario. Consequently, our understanding of how sex ratios are determined under natural conditions is incomplete. In two sets of laboratory experiments, we examined the effects of moisture on hatchling sex ratios when incubation temperature was held constant at just above the pivotal temperature. The results of that first study showed that moisture concentrations shifted sex ratios toward male-bias (see Lolavar and Wyneken, abstract this meeting). In our second study, we tested the temperature-sex ratio response curve by incubating experimental clutches at constant high humidity but at three different temperatures. All incubation temperatures were predicted to produce slight to extreme female-biased sex ratios based on previous laboratory experiments. Our resulting sex ratios were male-biased at 29.4°C (the pivotal temperature approximation) and 30.2 °C, but strongly female-biased at 31°C. These results suggest that (i) the temperature-sex ratio relationship may be shifted to the right in southern Florida *C. caretta*, (ii) the slope of the response curve in the transitional range of temperatures is likely steep, and (iii) that moisture levels can alter the effects of normally female-producing temperatures and result in the production of male hatchlings. Thus, the influences of environmental factors such as humidity, coupled with possible regional differences in the temperature-sex ratio relationship, likely contribute to the mismatch between laboratory-derived sex ratios predictions and observed sex ratio estimates from rookery sites.

Sea Turtle Biology and Conservation in the Gulf of Mexico: Special Session

FEMALE-BIASED SEX RATIO OF JUVENILE KEMP'S RIDLEY SEA TURTLES IN THE NORTHERN GULF OF MEXICO

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Areas of the northern Gulf of Mexico associated with major river systems have historically been noted as important foraging and developmental habitats for Kemp's ridley sea turtles. Recent research conducted in the Mississippi Sound and surrounding waters has supported this conclusion. In the current study, immature Kemp's ridley sea turtles were obtained from hook and line captures by recreational fishermen from a variety of fishing piers along the Mississippi coast. The turtles ranged in size from approximately 20 to 45 cm (straight carapace length), with an average of approximately 31 cm. After capture, all turtles were transported to the Institute for Marine Mammal Studies (IMMS) in Gulfport, MS, examined by an IMMS veterinarian, and rehabilitated until suitable for release. During their intake exam, blood samples were taken from each turtle from the bilateral dorsal sinus for blood work analyses. Circulating testosterone levels were determined for each turtle using a radioimmunoassay. Several hundred turtles were examined in the current study. The predicted sex of each turtle was based on previous studies of juvenile Kemp's ridleys whose sex had been verified through laparoscopy. The results indicate a significant female bias in the immature portion of the Kemp's ridley population in the northern Gulf of Mexico. The female bias is similar to that reported for Kemp's ridley hatchlings produced on the primary nesting beach at Rancho Nuevo, Mexico. The occurrence of a significant female bias in the Kemp's ridley population has implications for the ecology, evolution, and conservation of this Critically Endangered sea turtle.

THE IMPACT OF GLOBAL CLIMATE CHANGE ON SEA TURTLE REPRODUCTION: THE KEMP'S RIDLEY AS A MODEL SYSTEM*

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Various aspects of sea turtle reproduction are sensitive to environmental temperature. In particular, temperature affects sex determination as well as the timing of reproduction. Therefore, sea turtles are a prime candidate for examining the impact of global climate change. The Kemp's ridley may well represent an optimal model for assessing the consequences of long-term changes in environmental temperatures for several reasons. For example, in contrast to most sea turtles it has a restricted distribution (primarily in the Gulf of Mexico) and it has only one primary nesting beach (Rancho Nuevo, Mexico). These factors have the potential to magnify the impact of global climate change on reproduction and sex determination. In previous presentations and publications, we have reported short-term evaluations (e.g. yearly sex ratio evaluations). In contrast, the purpose of the current study is to provide a long-term analysis of hatchling sex ratio production in the Kemp's ridley in relation to global climate change. For the past sixteen years, we have been generating a long-term database for hatchling sex ratios using nest temperatures, egg corral (i.e. hatchery) temperatures, and beach temperatures. We have recently generated high-resolution yearly sex ratio predictions for that entire period. Further, we have examined long-term variation in corral and beach temperatures over the past 16 years. The results indicate that a significant female bias has consistently been produced from the egg

hatcheries used by the Kemp's Ridley Recovery Program, which may be enhancing the recovery of this species. This study indicates that the natural sex ratio produced from the primary nesting beach for the Kemp's ridley would also be female biased, but to a lesser extent. Additionally, long-term changes in sex ratio, corral temperatures, and beach temperatures were evident, suggesting the potential impact of global climate change. The results provide insight on the species-level impact of global climate change on a thermally-sensitive species in the Gulf of Mexico.

DEVELOPMENT AND EVALUATION OF AN ON-SITE PHOTOMICROSCOPY SYSTEM FOR DOCUMENTING THE SEX OF HATCHLING KEMP'S RIDLEY SEA TURTLES AT RANCHO NUEVO, MEXICO

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All sea turtles have temperature-dependent sex determination. This form of sex determination has significant implications for the ecology, evolution, and conservation of sea turtles. Therefore it is advantageous to monitor hatchling sex ratios produced in sea turtle conservation programs. Traditionally, the standard method for sexing a hatchling sea turtle was to dissect the hatchling, remove the gonad, and then process and examine it histologically. While this is the definitive method for evaluating sex, it is also labor intensive. More recently, evaluation of the external morphology of the gonad (as viewed through a microscope) has been reported as more logistically feasible alternative. In the current study, an on-site photomicroscopy system was evaluated as a method of efficiently documenting the sex of Kemp's ridley hatchlings that were found dead in nests at the primary nesting beach at Rancho Nuevo, Mexico. The photomicroscopy system was set up in the turtle camp at Rancho Nuevo, and consisted of a Zeiss DV4 dissection microscope with a video camera that was attached to a computer running Intervideo software for capturing images. Dead hatchlings were obtained from egg corral nests after live hatchlings had emerged. Hatchlings were dissected and the kidney/adrenal/gonad complex area of each turtle was photographed using the microscope. The results included documentation of a variety of gonads that were in various stages of decay, depending on how long the hatchlings had been in the nest after death. Additionally, the results included a comparison of fresh dead hatchlings to dead hatchlings, which had been frozen prior to their evaluation. This system provided high-resolution photographs of individual gonads that can be evaluated in real time or can be evaluated at a later date by multiple individuals. The results suggest that microscopic evaluation of the external morphology of gonads from fresh dead hatchlings can provide an effective method for determining sex. The photomicroscopy system evaluated in the current study provides an efficient method for obtaining morphology derived sex ratio data for validating sex ratios predicted from incubation temperature data.

EVALUATION OF BEACH TEMPERATURES AT TECOLUTLA, VERACRUZ, MEXICO, AN IMPORTANT NESTING BEACH FOR THE KEMP'S RIDLEY SEA TURTLE (*LEPIDOCHELYS KEMPII*) IN THE SOUTHERN PORTION OF ITS NESTING RANGE

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Given that sea turtles display temperature-dependent sex determination, monitoring beach temperatures can provide an indirect method of predicting hatchling sex ratios. Understanding sex ratios has significant conservation and management implications for these endangered and threatened species. A long-term beach temperature monitoring study was initiated in 2013 at an important Kemp's ridley nesting beach located at Tecolutla, Veracruz, Mexico. In 2012, over 800 Kemp's ridleys nested at Tecolutla, which suggests that this beach supports one of the larger nesting aggregations outside of the primary nesting area at Rancho Nuevo. Tecolutla, which lies approximately 400 km south of Rancho Nuevo, is a small fishing village and local tourist destination located at the mouth of the Rio Tecolutla. This river bisects the nesting beach into north and south sections, and more nests are deposited on the north section. Similar to other Kemp's ridley populations, the nesting season occurs from March to July. In the current study, twelve Hobo Pendant data loggers were placed periodically along the approximately 40km length of the nesting beach and buried at mean nest depth for Kemp's ridleys (35 cm). Data loggers were buried on the beach in locations where the majority of Kemp's ridley nesting typically occurs. Daily mean temperatures and average temperatures for the middle third incubation period were analyzed. The temperature that produced a 1:1 sex ratio for a nesting population of Kemp's ridleys at Padre Island National Seashore was found to be 30°C, and the upper limit of the transitional range of temperatures (TRT) was 32.5°C. Based on these temperatures, observed beach temperatures indicated the production of male-biased sex ratios early in the nesting season because temperatures did not go above the 1:1 temperature until late May. After this, female-biased sex ratios were predicted for the duration of the nesting season. The recorded beach temperatures together with the nesting distribution for 2013 suggest an overall female-biased sex ratio was produced at Tecolutla, and this finding is consistent with the overall female-biased sex ratio predicted for this species. Pivotal temperatures and the TRT can vary intraspecifically, so studies are needed to confirm these parameters for this population, which could be reproductively isolated. As stated above, this type of monitoring is critical to the conservation and management of Kemp's ridleys at Tecolutla, especially in light of potential impacts of climate change.

IN-WATER SEA TURTLE RESEARCH AND MONITORING ASSESSMENT AND THE DEVELOPMENT OF AN ONLINE INFORMATION SYSTEM (OSIS)

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In-water sea turtle research exists as a vast amount of efforts that address a variety of biological questions. Individual research efforts are often temporally and spatially discrete, however, they produce valuable information on the abundance, distribution and habitat use of sea turtles. In 2003, Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute with the support of National Fish and Wildlife Foundation initiated an inventory of all in-water sea turtle research efforts conducted within Florida. The primary goal of this project was to make this in-water information available to promote sea turtle conservation and to help identify research priorities. Our initial inventory summarized findings of 42 sea turtle research and monitoring efforts. It allowed for an assessment of knowledge about sea turtle species, life stages, habitat use and temporal occurrence. This provided equally important

compilations of the data that are available and gaps in data that may exist. The in-water inventory has been continuously maintained and expanded and now includes over 60 research and monitoring efforts, which document sea turtles in Florida waters. We are currently establishing an Online Sea Turtle Research and Monitoring Information System (OSIS) to disseminate up-to-date summaries of in-water research and monitoring activities. The primary objective of OSIS is to provide a direct and efficient linkage among sea turtle conservation managers and research information. We hope that OSIS will facilitate communication within the sea turtle conservation community and lead to collaboration and coordinated research prioritization. The geographic scope of this inventory can easily be expanded across broad regions (e.g., the Gulf of Mexico), providing a synoptic assessment of sea turtle research successes and future needs. This inventory also provides the foundation from which a coordinated in-water index-monitoring network could be established. This presentation will review the state of the in-water inventory, present OSIS as a resource for sea turtle managers and researchers, and discuss future objectives for the inventory that are relevant to the sea turtle conservation community.

MARINE CRITICAL HABITATS FOR POST-NESTING SEA TURTLES FROM THE YUCATAN PENINSULA, MEXICO*

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The Yucatan peninsula, Mexico, harbors the largest hawksbill (*Eretmochelys imbricata*) turtle nesting populations, one of the top five most important green (*Chelonia mydas*) turtle nesting populations in the Caribbean, and the only loggerhead (*Caretta caretta*) turtle nesting beaches in Mexico. Since the beginning of sea turtle protection in Mexico, more than 99% of the sea turtle conservation and research efforts had a local and limited geographic approach, focused mainly on individual nesting beaches. During the past decade, a wider sea turtle conservation scope has been initiated, and the knowledge of post-nesting sea turtles' spatial dispersion from the peninsula has been a key factor. Since 2006, 24 turtles (12 hawksbills, 10 greens, 2 loggerheads) were tracked by satellite from 15 different locations around the peninsula. Nine different feeding grounds were identified. Two regional feeding hotspots for hawksbills were identified, harboring 72% of the tracked turtles. The greens clumped at two main hotspots hosting 64% of the tracked turtles. The two loggerheads did not show any hotspot; nevertheless, both reached well-known feeding grounds for this species in the Caribbean and Gulf of Mexico. Regional migratory corridors were also identified at South Gulf of Mexico for green and hawksbill turtles. This wider regional vision for sea turtle conservation linking biological and ecological information for critical habitats (nesting beaches, migratory corridors, and feeding grounds) has provided strategic efforts for sea turtle conservation, strengthening the advances towards a better ecological understanding, aiding to recover sea turtle populations in Mexico.

SEA TURTLE ABUNDANCE IN NEARSHORE LOUISIANA WATERS*

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A barrier to the accurate assessment of impacts from the 2010 Deepwater Horizon oil spill was the lack of baseline information on the distribution and abundance of sea turtles in the impact area. In the summer of 2013, we undertook a broad scale effort to collect fishery-independent information on turtle abundance and distribution in Louisiana state waters (less than three nautical miles offshore) in the eastern portion of the state offshore of Terrebonne, Lafourche,

Jefferson, Plaquemines, St. Bernard, and Orleans Parishes. We established sixteen survey grids distributed throughout the nearshore area, each containing 50 kilometers of transects defined by GPS waypoints. These transect grids were surveyed by experienced observers on an elevated platform on a small boat moving slowly along the transect grids. Turtles observed were identified to species and life stage, and the position and perpendicular distance off the transect line were recorded. The program Distance 6.0 was used to calculate effective swath widths for the transects, allowing for density estimates for each species to be calculated, expressed as sightings per square kilometer. Each grid was surveyed three times, for a total transect length surveyed of approximately 2,400 kilometers. Overall, sea turtle density in Louisiana coastal waters was quite low at 0.1 obs/km². The Kemp's ridleys (*Lepidochelys kempii*) and loggerheads (*Caretta caretta*) were the most abundant species with each being sighted at 0.04 obs/km². Leatherbacks (*Dermochelys coriacea*) were the least abundant and only sighted at 0.02 obs/km². The spatial distribution of turtles was strongly clumped, with 79.2% of observations occurring on three survey grids on the offshore side of the Chandeleur Islands. The relatively greater abundance at the Chandeleur Island grids suggest that this may be a promising area to concentrate further work and may be a good candidate area for the establishment of a long term in-water index site. The spatial distribution of turtles observed in this study corresponded very poorly with the record of the spatial distribution of observed sea turtle strandings, indicating that the frequency of strandings on a shoreline is a poor surrogate for turtle abundance in the adjacent nearshore waters.

FORAGING HABITATS USED BY ADULT FEMALE LOGGERHEAD SEA TURTLES TAGGED IN THE NORTHERN GULF OF MEXICO: IMPLICATIONS FOR CONSERVATION*

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For many marine species, locations of foraging areas are beginning to emerge through combined use of satellite tracking technologies and advanced spatial modeling approaches. We used satellite telemetry and switching state-space modeling (SSM) to identify distinct foraging areas used by 59 loggerhead sea turtles (*Caretta caretta*) in the Northern Gulf of Mexico subpopulation from 2010-2013. We tagged turtles after nesting at three sites, one in Alabama (Gulf Shores; N = 37) and two in Florida (St. Joseph Peninsula; N = 20 and Eglin Air Force Base; N = 2). After migration periods and displacement from nesting beaches, turtles selected foraging sites in 5 geographic regions: western Gulf (WGoM, 2%); northern Gulf (NGoM, 32%); west FL (WFL, 36%); Subtropical Northwest Atlantic (SNWA), including areas in the Florida Keys and along the Florida reef tract (11%); southern Gulf (SGoM) off Mexico (18%); no turtles selected foraging sites outside the Gulf of Mexico. A proportion of foraging sites in the NGOM overlapped with trawling and oil and gas extraction activities. Our results can be used in efforts to designate critical in-water habitat for Northern Gulf loggerheads. Our findings indicate that protection of females in this subpopulation involves both international collaborations and management of threats within distinct foraging habitats.

DATA AND MODELS INDICATE DRAMATIC CHANGES IN KEMP'S RIDLEY GROWTH RATE*

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Following intensive conservation efforts on Mexican beaches and offshore, the Kemp's ridley sea turtle was saved from near extinction. An unprecedented 30-year recovery showed exponential growth from the mid-1980s through 2009, with annual rates of 15-19% per year. Population recovery was fueled by production of large cohorts of hatchlings from protected corrals and augmented by improved survival rates at sea. Models predicted a gradual slowing of the recovery rate as corral capacity was exceeded and density-dependent growth, reproduction rates, or survival kicked in. However, the nest census saw a dramatic reduction in 2010, then return to 2009 levels only; population recovery abruptly ceased. Counts for 2013 are down from 2011 and 2012. Because the nest numbers should

have been carried back to positive growth by juvenile cohorts, either the 2010 impact affected multiple age classes of adults and subadults, or there may be an on-going survival reduction that is preventing the adult population from increasing. In either case, the survival rate change needed to invoke such a strong response is quite large, and reductions in reproductive rate that are required for such a dramatic change are untenable with our current understanding of sea turtle biology. I will discuss a number of hypotheses for the population response, and recommend immediate efforts for research to evaluate changes in vital rates.

DIET OF GREEN SEA TURTLES ALONG THE TEXAS COAST: A 15-YEAR STUDY*

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During the mid-1890s the commercial fishery for sea turtles in the Gulf of Mexico peaked with landings over 1.1 million pounds that ultimately depleted the green turtle stocks in Texas' coastal waters. Recently, the juvenile green turtle assemblage in Texas has begun to recover and exhibit exponential growth, as evident from in-water research and the latest mass cold-stunning events. Prior studies have determined that green turtles in the Gulf of Mexico exhibit a predominately herbivorous diet upon inshore recruitment to seagrass beds. Over the last 40 years, the human population has demonstrated a 75% increase in development adjacent to critical sea turtle foraging habitat along the Texas coast. Consequently, nutrient loading has increased and caused eutrophication of numerous estuaries, which can potentially shift the flora balance from seagrasses to phytoplankton, epiphytes, or benthic macroalgae. The impact of probable changes in Texas' seagrass communities on green turtle foraging ecology has not been evaluated. In this study, the objectives were to identify food items consumed by juvenile green turtles, detect possible food preferences, and assess variations in their diet over an extended period of time. The gastrointestinal tracts of 190 juvenile green turtles (15.4 to 69.6 cm SCL) that stranded on the Texas coast from 1999 through 2013 were collected and examined for diet items. Sample collection was limited to turtles that had recently stranded and had no indication of disease or long-term illness. The relative importance of each diet item was assessed using an index of relative importance (IRI), which incorporates the frequency of occurrence of the target taxon and the mean taxon volume in all individual turtles. Preliminary results illustrate a change in the primary diet item consumed by inshore recruits over the study's time period, as well as regional diet differences, theoretically a result of the shifting health of seagrass beds in Texas.

MONITORING AND PROTECTION OF KEMP'S RIDLEY SEA TURTLES (*LEPIDOCHELYS KEMPII*) AND THEIR NESTS AT TECOLUTLA, VERACRUZ*

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The Kemp's ridley sea turtle (*Lepidochelys kempii*) is unique among sea turtle species in that its main nesting range is limited to a series of isolated beaches centered on Rancho Nuevo, Tamaulipas, Mexico. Once on the brink of extinction, Kemp's ridley nesting has increased due to the conservation efforts of the collaborative bi-national recovery program between Mexico and the United States. However, this increase has stalled since 2010, and the exact cause(s) remains unknown. In addition to Rancho Nuevo, Kemp's ridley nesting in Texas has been well documented over the past several decades, particularly on South Padre Island. While nesting to the north of Tamaulipas has also been well documented and publicized, nesting to the south has received little attention. In his overview of marine turtle populations of the western Gulf of Mexico, Hildebrand (1987) noted the presence of Kemp's ridley nesting in Tecolutla, Veracruz, which is located approximately 400 kilometers south of Rancho Nuevo. Tecolutla is a fishing village and local tourist destination located at the mouth of Rio Tecolutla. This river bisects the nesting beach, with

the north and south sections displaying different characteristics such as beach substrate and erosion rates. Beach monitoring and nest protection has been conducted by Fernando Manzano and Vida Milenaria in Tecolutla since 1974. Monitoring occurs daily during the nesting season from March until October because green and hawksbill sea turtles also nest in the area. Here we present a summary of current nest monitoring and protection activities, historical and current nesting numbers, as well as our expanding research efforts. Over 800 nests were deposited at Tecolutla in 2012, making it the largest nesting aggregation of Kemp's ridleys outside of the Rancho Nuevo area. Tag return data from a very limited number of turtles tagged at Tecolutla, and the lack of encounters with turtles tagged elsewhere, suggest that Tecolutla may be a reproductively isolated nesting population. Studies examining the population and reproductive ecology of this nesting population are currently underway and will contribute to its conservation and management.

MOVEMENTS OF REHABILITATED LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) IN THE NORTHWESTERN GULF OF MEXICO

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Effective management and recovery of threatened and endangered sea turtle species is dependent on filling gaps in our knowledge of species population dynamics, abundance, distributions, foraging dynamics and habitat use patterns. Satellite telemetry is a valuable tool for identifying critical habitat(s) and habitat use patterns essential to assessing potential fisheries and non-fisheries threats to sea turtle survival and revising outdated recovery plans. Radio, sonic and satellite tracking of sea turtles in near- shore waters of the northwestern Gulf of Mexico (GOM) has largely been devoted to movements of the critically-endangered Kemp's ridley and green turtles. Although loggerheads are the second most frequently reported species in Texas stranding records since 1986, few studies have examined this species' movements and habitat use patterns in this region. Thus, the Sea Turtle and Fisheries Ecology Research Lab (STFERL) at Texas A&M University at Galveston collaborated with the Animal Rehabilitation Keep (ARK) at the University of Texas Marine Science Institute (UTMSI) to track rehabilitated loggerhead sea turtles collected in Texas between 2007 and 2008. Sirtrack KiwiSat 202 satellite transmitters were attached to three juvenile/subadults measuring 76.3, 82.7 and 66.0 cm straight-carapace-length (SCL, notch-tip) and each was given a nickname ("Hook", "Lydia Ann", and "Slabby") for purposes of adoption and tracking identification on the seaturtle.org website. Satellite tracks were filtered using ARGOS location accuracy codes (3, 2, 1, A, B), elevation (< 0.5 m), and turtle speed (< 5 km/h) via the Satellite Tracking and Analysis Tool (STAT) administered by the website www.seaturtle.org. All three turtles were released from the beach on Mustang Island, near Port Aransas, TX. Overall, individual loggerhead movements were quite variable and statistically significant differences in track parameters, including depth and distance from shore, were observed between the three tracks. For example, Hook and Slabby remained in closer proximity to shore than Lydia Ann, with the latter spending most of its time in an area south of the Texas – Louisiana border. Hook's movements also spanned the entire Texas coast, whereas, Lydia Ann and Slabby showed more fidelity to certain regions. A mean track duration of 496 days (range: 373–623 days) was observed for all three turtles and these relatively long track durations suggest these rehabilitated turtles were able to successfully re-acclimate to wild conditions and survive for extended periods of time post-release. The longest track duration (623 days), greatest total distance traveled (6,298.4 km) and greatest mean distance from shore (41.5 km) was observed with Lydia Ann, the largest of the three loggerheads (82.7 cm SCL). However, Hook (76.3 cm SCL), utilized the deepest waters on average at -23.2 m (range: 0.5 to -89.8 m) and a mean distance of 21.6 km from shore (range: 0-87 km). Although these tracks give us good preliminary insight into the habitat use patterns of loggerhead sea turtles in the western GOM, more information is needed to identify critical habitats and migration corridors for this species.

INWATER ASSESSMENT OF MARINE TURTLES IN THE BIG BEND REGION OF FLORIDA'S GULF COAST*

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The Big Bend area of Florida's Gulf Coast has received relatively little attention from sea turtle researchers, primarily due to the lack of nesting beaches in the region. In recent years more attention has become focused on developmental habitats, their importance in the life cycle of sea turtles, and the need for research and conservation efforts in these habitats. The Big Bend region is characterized by a very large extent of shallow water seagrass and hardbottom habitat that provides appropriate developmental habitat for loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and Kemp's ridley (*Lepidochelys kempii*) sea turtles. This project utilized vessel based visual transects and captures of marine turtles in the Big Bend Seagrasses and St. Martins Marsh Aquatic Preserves, which encompass 968,000 acres of shallow marine habitat. The project obtained data on species abundance, size frequencies, location, sex ratios, genetic origin, and prevalence of fibropapillomatosis of sea turtles within the preserves. To date, 14 juvenile green turtles and 29 Kemp's ridleys (16 juvenile and 13 subadult) have been captured. Seventy-nine percent of the green turtles had fibropapillomatosis, but no Kemp's ridleys exhibited signs of the disease. While the prevalence and severity of fibropapillomatosis was higher than expected, the turtles were otherwise found to have good or robust body condition. The project directly addresses needs identified in the recovery plans for marine turtles by identifying important habitats and determining sea turtle distribution and abundance in coastal and marine environments. The information gathered from this research will also help produce a comprehensive set of baseline data for sea turtles foraging in the preserves and aid in the conservation decisions made by wildlife managers.

KEMP'S RIDLEY NESTING IN NORTHWEST FLORIDA WITHIN ESCAMBIA COUNTY, GULF ISLANDS NATIONAL SEASHORE

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To date, nineteen Kemp's ridley (*Lepidochelys kempii*) nests have been confirmed in Gulf Islands National Seashore (GUIS) near Pensacola, Florida. Nesting for this species primarily takes place in Rancho Nuevo, Mexico, and to some degree on Padre Island in Texas. Confirmed reports of nesting in Florida are increasing. Confirmation for nests within GUIS has come through either DNA analysis of dead hatchlings/eggs or photos of the adults on the beach, and one nest was confirmed via hatchling photos. Two suspected Kemp's nests could not be verified, as they were both infertile nests or had no development within the eggs to support DNA analysis. The first nest was documented in 1998. The 2008 season witnessed the highest activity with six nests confirmed that year. From nest dates and re-nesting intervals for Kemp's ridley, it is speculated at least 3 females utilized park beaches that year, with a 4th very possible. Nesting has continued into the 2012 season with two more nests from 2 different females. A total of 2,409 eggs have been laid and 1,180 have hatched, for a 49% hatch rate. Nest hatching success has ranged from 0% to 100%. A total of 829 hatchlings have been verified entering the Gulf by staff/volunteers and an additional 119-hatchling tracks have been documented making it to the Gulf.

LONG-TERM REPRODUCTIVE HISTORIES AND SATELLITE TELEMTRY PROVIDE INSIGHT INTO FORAGING SITE SELECTION AMONG LOGGERHEADS NESTING IN THE GULF OF MEXICO*

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Loggerhead life history, spanning from the beach to the open ocean to the continental shelf, exposes the species to numerous natural and anthropogenic threats. Keewaydin Island is located off the southwest coast of Florida in the eastern Gulf of Mexico. Sea turtle nesting on the island has been monitored continuously since 1983. The consistent mark-recapture record over this time provides a unique opportunity to compare adult female migration and foraging selection with reproductive history. Thirty-three platform terminal transmitters (PTTs) were affixed to females encountered on the Keewaydin Island nesting beach over a five-year period: four in 2009, seven in 2010, eight in 2011, six in 2012, and eight in 2013. These satellite tags were affixed to putative neophytes (n=7) as well as documented remigrants (n=26) with observed nesting histories ranging from one to over twenty years. Five individuals were satellite tagged over two reproductive cycles, with one tracked again for a third cycle. We examined reproductive success and remigration intervals for correlations to post-nesting habitat selection. PTTs transmitted from 42 to over 600 days including inter-nesting movements, post-nesting migrations and foraging area selection for all twenty-seven satellite-tagged individuals. Twenty-one of the tracked turtles remained within the eastern Gulf region, while five crossed the Gulf Stream to foraging areas in Bahamian or Cuban waters, and one crossed the Gulf basin to the Yucatan shelf. Results from this project and others build a clearer picture of the habitats that support the species and highlight the need for a combination of domestic management and international collaboration to achieve population recovery.

FINDINGS, CHALLENGES, AND SOLUTIONS: RESTORING THE NIGHT SKY GULF COAST SEA TURTLE RESTORATION PROJECT*

Matt R. Root and W. Scott Kardel

International Dark-Sky Association

The International Dark-Sky Association has entered into a contract with the Florida Department of Environmental Protection and the Florida Fish and Wildlife Conservation Commission to assess the current state of coastal lighting and general sky quality in 27 state, local and federal conservation lands along the Florida Panhandle. In effort to restore these sensitive sea turtle nesting habitats, IDA began conducting extensive lighting surveys of the conservation grounds and adjacent areas. IDA is now working to provide lighting retrofit recommendations in order to mitigate potentially harmful light pollution along the coast with regard to nesting sea turtles. Although a widespread attempt to use turtle friendly lighting near the beach is prevalent throughout the vicinity of these nesting grounds, there are still many areas that need improvement and general misconceptions that need to be addressed. IDA identified many common problems areas and is working on best practice solutions for these applications in order for the retrofit implementation to be carried out practically and effectively. Turtle-friendly light fixtures are designed to keep light where it is needed—pointed downward. And turtle-friendly light sources limit the spectrum of light emitted to minimize the impact on turtles. When used properly, these lights provide proper illumination for human safety without negatively impacting sea turtle nesting or hatchlings' ability to find the ocean. IDA has been working closely with industry leaders to custom design products specifically for these applications; these solutions adhere to the highest standards in terms of light distribution, spectrum, cost-effectiveness, and durability. Not only is the availability of new products essential to the task, properly educating the public on the core elements required for protecting nesting sea turtles is paramount. IDA would like to share its findings, challenges, and solutions at ISTS in hope of broadening support and furthering understanding of this important matter.

MIGRATORY CORRIDORS OF ADULT FEMALE KEMP'S RIDLEY TURTLES IN THE GULF OF MEXICO*

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Kemp's ridley (*Lepidochelys kempii*) is the most endangered sea turtle species in the world and has been the focus of bi-national conservation efforts since 1978. Prior to 2010, the bi-national restoration project documented promising signs of success, and population models projected continued increases in the number of nests at 12-18% per year through 2029 assuming continued high egg survival. However, since 2010, the growth rate in the number of nests both in Mexico and in Texas has declined to near zero although egg survival has remained high. Understanding at-sea habitat-use is vital to both investigating possible causes of this troubling and unexpected population trend and identifying possible locations where protection should be concentrated. Migration corridors are defined for other marine taxa (i.e., seabirds, whales), but not for most sea turtle species. Switching state-space modeling (SSM), when used in combination with satellite-tracking data, can reveal when and where turtles are in 'migration' and 'foraging' behavioral modes. Subsequently, data summaries using SSM output can reveal locations of key foraging sites and migration corridors. In this study, we outfitted 106 Kemp's ridley turtles with satellite transmitters after nesting in Padre Island National Seashore, Texas, USA (N = X); Rancho Nuevo, Tamaulipas, Mexico (N = Y); and Veracruz, Mexico (N = Z) between 1997 and 2013. Rancho Nuevo is the epicenter of nesting for the Kemp's ridley population; Padre Island National Seashore is near the northern extent of the documented historic nesting range, and Veracruz is the southern extent of the historical nesting range. Post-nesting migrations involved coastal movements in Gulf of Mexico waters less than 68 m deep. Most turtles migrated to waters off upper Texas, Louisiana, Mississippi, and Alabama. Some nesters migrated to Florida, including a few Texas nesters that migrated as far the Florida Keys. In the southern Gulf of Mexico, a few nesters migrated to as far as the Yucatan Peninsula. A larger portion of the Mexico nesters migrated to the southern Gulf of Mexico than did the Texas nesters. Using SSM and probabilistic modeling, we defined "hotspots" used during migration, or migratory corridors. The migratory corridors documented were repeatedly used over time; turtles tracked several times used similar migratory corridors, with significant temporal overlap across years. Our results show the importance of the northern Gulf of Mexico waters as migratory corridors for adult female Kemp's ridley turtles, and thus to conservation of the entire population. Results will be useful for managers who may prioritize and recommend at-sea protection measures. The ability to link at-sea habitat use to threats may shed light on likely causes of recent declines in Kemp's ridley nest numbers.

SURFACE-PELAGIC (OCEANIC) JUVENILE SEA TURTLES WITHIN THE GULF OF MEXICO*

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Surface-pelagic juveniles of four sea turtle species are distributed within Gulf of Mexico waters. These are the loggerhead sea turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and Kemp's ridley (*Lepidochelys kempii*). Captures show green turtles to be most common, followed by Kemp's ridleys. Evidence describes reliance of these juvenile turtles on oceanic surface fronts, small-scale convergence zones, and the Sargassum drift community. To describe aspects of this life stage helpful to conservation efforts, we measured

densities of observations from distance line transect methods, diet, behavior, and somatic growth inferred from seasonal size in an assumed single year-class. Captured turtles included both post-hatchlings (39–78 mm straight carapace length, SCL) and juveniles (130–280 mm SCL). Post-hatchlings occur adjacent to nesting beaches and juveniles are more widely distributed. Size and growth of juveniles (8 cm SCL over five months) suggests that green turtles and Kemp's ridleys may complete this life stage in approximately two years. Empirical evidence describes the importance of surface-pelagic gulf waters as developmental habitat for multiple sea turtle species, with pelagic *Sargassum* as a transient hot spot. The oceanographic characteristics of surface-pelagic turtle habitat make these areas focal points for threats to sea turtles including debris ingestion and petroleum.

DETERMINING FORAGING AREA ORIGIN WITH STABLE ISOTOPE ANALYSIS AND SATELLITE TRACKING FOR LOGGERHEADS NESTING IN THE GULF OF MEXICO*

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Stable isotope analysis is increasingly being used to study the diet and foraging area use of female sea turtles away from the nesting beach. While the method has been particularly useful for determining the foraging area used by loggerheads nesting in the Northwest Atlantic, many gaps still exist in our knowledge of sea turtle foraging ecology in the Gulf of Mexico. In this study, we combined stable isotope analysis and satellite tracking of 61 different female loggerheads from four nesting sites on the west coast of Florida representing genetically distinct subpopulations. The purpose of this study was two-fold. First, we examined the geospatial distribution of carbon and nitrogen stable isotope values in turtles of known origin to develop isoscapes for the region. Second, we evaluated whether stable isotope data in combination with prior information about dispersal patterns from each nesting area can be used to accurately determine the foraging area origin and movement of turtles out of the Gulf of Mexico. We compare the assignment accuracy using both discriminant function analysis and continuous likelihood surfaces. The methods developed in this study can be used to effectively direct future research and examine foraging area use in untracked females. An improved understanding of the spatio-temporal distribution of sea turtle foraging populations in the Gulf of Mexico can inform management plans.

Social, Economic and Cultural Studies

VARYING CULTURE AND BELIEFS ABOUT SEA TURTLES WITHIN FISHING TRIBES IN NIGERIA, SOUTHWESTERN NIGERIA

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The Sea turtle is a cultural, emblematic, enigmatic, charismatic species all over the world over and have interacted with man over ages. The Sea turtle is part of the culture of the Nigerian coastal communities comprising of several tribes. The sea turtle is a component of several children's stories and folktales laced with lovely songs all portraying this animal as highly intelligent. This study was undertaken in two coastal states; Lagos and Ondo. Six communities were selected in Lagos state for this study, three on the Western flank; Akodo, Orimedu, Folu and three on the Eastern flank; Aivoji, Yovoyan and Gberefu, and Three communities in Ondo State; Aiyetoro, Abe Oroyo and Ilepete. The result indicates that the sea turtle is seen differently from tribe to tribe, just as the Egun tribe of Lagos state views them as mystical species to be conserved; the Aworis of Lagos and the Ijaws of Ondo state see them as bush-meats provided for their enjoyment by their creator. Just as the Nigeria culture has a rich diversity, culture and beliefs about the Sea turtle in Nigeria is equally diversified, however some of this culture and beliefs can be harnessed for sea turtle conservation in Nigeria.

INTEGRATING TRADITIONAL PERSPECTIVE IN SEA TURTLE CONSERVATION IN GHANA, WEST AFRICA*

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Sea turtles have a significant ecological role in the marine and terrestrial ecosystems, but their ecological functions are currently threatened due to the reduction of populations throughout the globe. Ghana (West Africa) is home to as many as five species of sea turtles: olive ridley, leatherback, green, loggerhead, and hawksbill. Only the olive ridley, leatherback, and green turtles still nest in significant numbers. The primary threats to sea turtles in Ghana include harvesting females, collecting eggs, habitat degradation, and fishery interactions. The Wildlife Division takes a community-based approach that allows community members to become involved with the protection and recovery of these animals. National laws exist to protect both sea turtles and their habitats, but the desire to protect them originates from a taboo that regards sea turtles as mystical totems that should not be harmed or killed. Such reverence is given to turtles in particular non-consuming communities because of folklore about turtles saving ancestors that were lost at sea. Turtles captured in fishing nets from these non-consuming communities are released immediately. The meaning of these beliefs, though stronger and more effective than wildlife laws (Alexander *et al*, 2012), are at risk due to the infiltration of foreign religion (Christianity) and immigration of 'consuming' tribe members into non-consuming communities.

TURTLES, PEOPLE, TEMPLES AND GODS: CULTURAL ADVENTURES AT XIAO LIUQIU ISLAND BUILDING CONNECTIONS FOR CONSERVATION BETWEEN TAIWAN, HONG KONG AND HAWAII*

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Successful sea turtle conservation programs that endure are best built with local communities as their foundation. National legislation and international conventions based on sound research findings clearly have importance. However, strategies for conservation are made robust and equitable when they integrate cultural and traditional components forged at the local level by the very people closest to the turtles and their environment. During 2011-2013, we (GB and KN) made five leisure visits to Xiao Liuqiu, a 6.8 km² island located at 22° 20'N, 120° 22'E, just 15 km off the southwest coast of Taiwan. The island is rich with numerous Tao and Buddhist temples serving as exquisite dwellings for an array of venerable Chinese Gods. Xiao Liuqiu's economy is substantially based on distant-water fishing and, increasingly, on ecotourism involving visitors from nearby Taiwan. The main purpose of our explorations has been to learn about and experience Taiwanese culture through the daily lives of Xiao Liuqiu's 12,000 residents. Paramount to these visits has been the nurturing of friendships with local families, based on a strong mutual interest in the conservation of green turtles (*Chelonia mydas*) occurring prominently year-round in the island's 12 kms of coastal waters. Seasonal nesting at low levels also takes place on several small sand beaches. Numerous turtles can often be seen foraging while snorkeling and from shoreline cliffs, perhaps rivaling such sightings in Hawaii. As guests at Xiao Liuqiu, our principal activity has been to listen and learn from our hosts, and to freely share biological knowledge about sea turtles linked to our own personal experiences with turtles and people in the greater China region, Japan and Hawaii. The key to lasting partnerships for balanced and sustainable conservation action is to build genuine trust and respect, with patience, at the person-to-person level. This presentation explores and photographically illustrates unique aspects of the Xiao Liuqiu culture relevant to current conservation challenges and opportunities. The following web sites provide background and insights into two of our visits: <http://akepa.hpa.edu/~mrice/turtle/liuqiu.pdf>; <http://akepa.hpa.edu/~mrice/st.htm>. China and all of East Asia have vigorous and growing sea turtle conservation programs that deserve praise and partnership to improve the status of regional stocks. We thank Professor I-Jiunn Cheng for kindly introducing us to Xiao Liuqiu during our initial visit in October 2011.

EXAMINING THE IMPACT OF CULTURAL BELIEFS, LOCAL KNOWLEDGE, AND GOVERNMENT PROTECTION ON COMMUNITY-BASED SEA TURTLE CONSERVATION IN GHANA

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Marine turtles play an integral role in the trophic dynamics and ecological processes of the world's oceans. Sea turtle populations have been reduced due to fishery activities and other human interaction. Population models predict that decreasing anthropogenic mortality, such as fisheries by-catch and direct harvest, would have the most immediate impact toward recovering depleted populations. Reducing mortality will require a broad approach that includes formal legislative protection, increased education, and community involvement. In this study, we explore Ghana's artisanal fishery to determine the role of legal protection and traditional knowledge in community-driven sea turtle conservation. A mixed-design questionnaire was administered to fishers from three regions along the coast of Ghana,

West Africa. The selected fishing villages have different exposure to wildlife laws, community education from Ghana Wildlife Division (GWD), and are from different traditional clans. The data revealed differences in how fishers apply traditional knowledge toward protecting sea turtles. Communities with strong traditions release 100% of captured turtles, whereas other communities (including those that had contact with GWD) return an average of 27%. The data revealed that strong traditional beliefs have a more influential role in community-driven sea turtle conservation than the legal protection of the GWD. This study illustrates the important role of culture and traditional knowledge in the protection of wildlife.

THE VALUE OF MARINE TURTLES FOR WAYUU INDIGENOUS' HEALTH

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Marine turtles are connected with a great number of cultures worldwide. These communities are closely related with marine ecosystems and their resources. In fact, many cultures worldwide consider marine turtles as a sign of prosperity and well-being, including the indigenous values; for example, Seri in Mexico; Miskitos in Nicaragua; and Wayuu-Venezuela & Colombia. This last group has been using the marine turtles in many ways, including as a source of health. Considered a divine gift, these reptiles are an important compound into the Indigenous Knowledge (IK) of Wayuu people. Several authors state that in order to design any conservation and management plan it is important to assess the relationship between the IK and the natural resources. In order to understand how and why the Wayuu people use the marine turtles as remedies; we interviewed ten elderly traditional owners (“Mojanes”: healers; and “Brujas”: caretakers witches), from four different communities from the Venezuelan Guajira peninsula. The interviewees are considered by the community leader (“Cacique”) as people with special knowledge of medicinal animal use. We used informal and open questions during interview-questionnaires to approach several topics: the species they use; the body part of the turtle used; the way to prepare the remedies; the indigenous name of the used species; characteristics of potential patient to receive treatments; preparation and use; storage conditions; and traditional uses of the remedies in the communities. The interviewees (100%) affirm that all of them use and recommend using marine turtle products to obtain better health, or to prevent up to 14 different illnesses, using 11 parts of their body (oil, blood, penis, among others). Some specific parts of the marine turtle are used exclusively by woman, men, kids or elders; according to the disease or health problem. Seven different ways of administration were described. We identified species-specific uses to address different illnesses. On another hand, interviewees considered the use of marine turtle products to improve the health conditions or just to put away “the bad spirits” which are the source of the majority of the illnesses; hence, this provides evidence of the connection between spiritual aspects with traditional medicine. We found important Indigenous Environmental Values; the use of the marine turtles as remedies in Wayuu indigenous communities is a spread traditional used value. As ancient wisdom, the Wayuu community has used the marine turtle through generations, and it is an important link between them. The use of marine turtles as medicine is a crucial content of the cultural legacy along Wayuu families. For this reason, is important to consider the Wayuu’s Indigenous Knowledge (IK) to inform future management plans for marine turtles in the Gulf of Venezuela.

WOMEN TRANSFORMED: FROM POACHERS TO CONSERVATIONISTS AND ENTREPRENEURS

Alma Susana Chávez Narvaez

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The Initiative “Tejiendo por la Naturaleza” (Crocheting for Nature) arose as a project promoted by WIDECAS. Fauna and Flora International, eager to find ways to reduce the pressure exerted by human actions on sea turtles in Nicaragua, was interested in supporting this kind of initiative. In our project, used plastic bags are collected, washed

and dried, cut into strips, and used as material to crochet craft products. The project has two fundamental objectives. First, to decrease the quantity of discarded low-density plastic bags found in the natural environment, which reach the ocean as their final destination, causing the incidental death of sea turtles and other species in the marine ecosystem. Second, to become an economic alternative for women in the communities bordering Nicaragua's Rio Escalante-Chacocente Wildlife Refuge, who were engaged in the robbing of and illegal commerce in sea turtle eggs. This group of women tejedoras was formed in 2007 in the communities of El Astillero, Tola, Department of Rivas, and Aguas Calientes-La Pinuela, Santa Teresa, Department of Carazo. These are Refuge buffer zone villages where living conditions are characterized by extreme poverty, and whose economic activities are limited by the Refuge's management plan that restricts activities in a protected area. Since the first workshop given in 2001, where 10 women from the El Astillero community and 10 women from Aguas Calientes and la Pinuela were trained, challenges emerged, some of which were taken as immediate goals of the group. These were: to achieve the making of high quality craft products; that all the products be crocheted from used plastic bags collected in the communities where the women live and surrounding areas; that their products would find a market; that the group would support the Refuge's plan for sea turtle conservation and monitoring; and above all, that this activity could turn into a source of income for their families. At present, after much effort and with the support of many interested organizations, we have achieved a strong, energized women's cooperative. We now have 28 women trained, with high self-esteem; valued by all the members of their families; launching and managing their own business; very well organized; and with a place available to meet and work on their crocheted purses, shopping bags and other craft items. These high quality craft products sell for a good price on the national and international market, becoming an economic alternative that generates an average of \$120 a month for each woman, and retrieves an average of 17,000 discarded plastic bags per year. These are collected in five bag-collection centers in the Departments of Rivas and Carazo, as well as in beach and community clean-ups done four times a year. In conclusion, the Tejedoras are a group of women who have achieved: reducing the spread of plastics in the environment, decreasing the mortality of sea turtles due to plastics, developing socio-economic alternatives for their communities that are financially sustainable, promoting women's participation in micro-enterprise, and producing environmentally ethical products.

WHEN SEA TURTLES MEET BUDDHISTS; PAST AND PRESENT*

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The central spirit of all religions is to highlight the good will and save the soul of human beings. Among them, the philosophy of Buddhism is different from the others. It emphasizes the self-conscious and self-practice. To live in a simple life and views the world from his or her own soul. Therefore, most Buddhists are nature lovers and respect all living beings. They believe the remarkable turn of the soul and any charitable behavior will increase their hidden virtues. This will benefit their "next life" after the soul returns to the world again. About a thousand years ago, a lady called "silent lady (or Mazu later on)" tried to save all the animals from the market by purchasing as much as she could and releasing them back to the wild. This becomes a typical example of charitable behavior for some Buddhists. It then evolves into the religious release ceremony. Among all creatures, the turtle is the most favorable animal, because it is gentle, big (sea turtle) and long-lived (tortoise). However, the involvement of money transactions resulted in the capture of turtles on purpose or holding the animal captive for several months or longer without the proper treatment. With little knowledge on sea turtles, most charitable behavior in the past had abused the animals and the turtles were release under the poor health conditions. We initiated a sea turtle rehabilitation program a few years ago, and release them back to the wild after the proper medical treatments. The philosophy and concept of "release back to the wild" fits perfect to the philosophy of Buddhism. Thus, with the help of a home Buddhist who is well-trained in the wildlife ecology, a cooperative project between my laboratory and a Buddhist society is carried out. We modify the release ceremony by giving a short lecture to the home Buddhists about the pathology history and treatment of sea turtle by an ecologist, and then the Buddhists giving a blessing ritual to the animal, as well as the world, before releasing the sea turtles. The harmony and good will of the new release ceremony provides mutual benefits to both sea turtle conservation and religion.

WHAT'S IT WORTH? QUANTIFYING THE FINANCIAL VALUE OF MARINE TURTLE PROTECTED AREAS

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Historically, marine turtles were harvested and used for food, tools, and decorative objects. Only recently have they begun to fill other economic roles benefiting humans; most importantly, as a focal point of ecotourism. Education-based recreational use of turtles has been shown to generate sizeable amounts of gross income, most often exceeding those produced from traditional uses. Even though marine turtle-based tourism exists in the United States, no data has been published regarding the economic impact of these non-consumptive educational uses. Brevard and Indian River Counties, are located on the east coast of Florida, and are known primarily for their dense loggerhead (*Caretta caretta*) nesting, and the Archie Carr National Wildlife Refuge (ACNWR), the highest density loggerhead-nesting beach in the Western Hemisphere. We examined the economic impacts of the ACNWR on the local economy using two approaches: 1) analyzing the degree to which educational tours (turtle walks) impact the county's economy; and 2) determining whether the establishment of the refuge has impacted property values adjacent to the protected lands over time. Since 2001, there has been a statistically significant increase in the annual number of turtle walks conducted. This expansion has contributed to a significant increase in attendance from 2,162 to 2,764 participants (2001-2012). Thus, the demand for turtle-related educational tourism is increasing on the ACNWR. The economic impact of turtle walks can be used as a conservative estimate of monetary value for sea turtles in the region. During the 2014 nesting season, this impact study will be expanded by the distribution of economic impact surveys to every organization conducting turtle walks. The surveys will break down estimated guest expenditures, within the region, into six categories. These data, once analyzed, will more clearly define the degree to which these tour participants and marine turtles benefit the local economy. It has been shown that the creation of protected lands positively influences property values within and adjacent to the refuge. The ACNWR is a mosaic of land purchases by U.S. Fish and Wildlife, Endangered Lands Program, and the Mellon Foundation. The original capital invested into the ACNWR was 140 million dollars in 1992. Land purchase values pre- and post-refuge creation within, adjacent to, and outside of the refuge were compared. The value of inflation was controlled for during the analyses. Since the date of its establishment, the refuge has seen not only a significant increase in nesting turtle densities because of good management practices, but also the value of these lands has increased. These findings support the argument that the creation of a protected area can create a positive return of investment.

THE ISSF SEA TURTLE CONSERVATION FUND: A VALUE-ADDED MODEL FOR INDUSTRY

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Many sea turtle populations continue to decline despite conservation efforts on their behalf. Since sea turtles have complex life histories they are subject to multiple sources of anthropogenic mortality at every life stage across a broad geographic range. In order to reverse the most serious declines, such as those seen in the Pacific populations of leatherbacks, a holistic approach that addresses all sources of mortality and deals with the trans-boundary nature of these multiple threats is needed. In general, this involves actions on nesting beaches to maximize hatchling production and eliminate adult nester mortality, coupled with reduction of mortality of animals at sea caused by interactions with fisheries in coastal and high seas foraging areas and migratory routes. Conservation action on nesting beaches is a prerequisite for at-sea measures to be effective, and in turn dependent on at-sea measures to ensure survival of animals to complete their life cycles. Traditional approaches to mitigating fishery-related mortality include a suite of technical

change (modification of gear and fishing practices) and time-area closure. While necessary, the challenges and costs, particularly for eliminating threats from wide scale artisanal and industrial fishing are considerable, and often relatively cost-effective actions still needed on nesting beaches are overlooked or curtailed due to lack of resources. In addition to engaging directly in bycatch reduction, fishers and processors can facilitate sea turtle recovery by investing in conservation programs on nesting beaches. For example, investment in conservation of leatherback nesting beaches in Indonesian and the Solomon Islands by the tuna canning industry will enhance recovery efforts toward the leatherback populations that interact with fisheries. The International Seafood Sustainability Foundation (associated with US, European and Asian tuna canning companies) has established a \$100K Annual Fund from taxes to participating companies that can longline-caught albacore. These funds support a dozen or so high priority sea turtle conservation projects worldwide on an ongoing basis. While the amount of funds available for each project is relatively low, the multi-year commitment to these community-based projects is important for continuity and provides value-added benefits for conservation. We describe the projects and outcomes to date for the projects supported since the inception of the fund in 2010, and discuss the potential for expansion of this model to other industry groups as one component of a bycatch mitigation strategy.

SOCIOCULTURAL ASPECTS OF FISHERMEN AND THEIR CONNECTION WITH THE SEA TURTLES IN SINALOA MEXICO

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Since ancient times, sea turtles have been used as a resource for the sustenance of human life. Today this group of animals is threatened by several factors, mainly anthropogenic activities that are causing their decline. For this reason, it is important to know how fishermen view these turtles, since they are the ones that have a greater connection to them. This study was undertaken to determine the perception of the fishermen on sea turtle populations in three protected natural areas of Sinaloa, Mexico, since there is evidence of mortality caused by anthropogenic activities on turtles in these regions; Region Marine Priority Bay of Santa Maria (RMPBSM), the Sanctuary Paya Ceuta (SPC) and the Flora Protection Area and Wildlife Cacaxtla Meseta (APFFMC). From February to September 2012 fishermen from different communities were surveyed, with the aim of obtaining information on the knowledge and use of sea turtle, for the analysis of the surveys we used frequency tables and proportions and also applied an ANOVA one way. The olive ridley and Black turtle were the mostly identified by the respondents, 27.3% of fishermen have been devoted to the capture of these species. In addition, 75% have used for consumption, this group of marine turtles are consumed mainly for pleasure eating especially during Holy Week and the fishing season. The artisanal fishing where most sea turtles fall for bycatch was in Chinchorro with 52% compared to 0.35% harpoon and hook.

SEA TURTLES AND TOURISM: CURRENT STATUS OF TURTLE NIGHT WATCH TOURISM PROGRAMME IN REKAWA TURTLE SANCTUARY IN SOUTHERN SRI LANKA*

Thushan Kapurusinghe and Himali Purnima Kahawita

Turtle Conservation Project (TCP), Sri Lanka

Rekawa is a small fishing village in Southern Sri Lanka. The Green, Leatherback, Olive ridley, Loggerhead and the Hawksbill turtles nest on the Rekawa beach. Until the mid-nineties, there were many environmentally destructive practices practiced by the local community members in Rekawa village. The killing of sea turtles, turtle egg gathering, mining of corals, and cutting mangroves were among the destructive practices. The Turtle Conservation Project (TCP) initiated its pioneering community-based turtle conservation project in Rekawa village in 1996. A ‘turtle night watch’

nature tourism initiative was launched as a self-sustainability exercise. Local villagers were trained as tourists' guides and recruited on the beach to work as the turtle nest protectors. A community-based organisation (CBO) was formed and named as Nature Friends of Rekawa (NFR) consisting the Rekawa turtle nest protectors. In May 2006, Rekawa beach was officially declared a Sea Turtle Sanctuary by the Department of Wildlife Conservation as a direct result of TCP's conservation efforts and campaigns. In late 2012, TCP has terminated the contracts of local community members as "turtle nest protectors" due to lack of funding and encouraged them to continue their work and gain the benefits from turtle night watch tourism with the help of TCP. Currently tourists are charged with 1000 Sri Lankan Rupees per person (128 LKR = 1US \$). Total of 18 local nest protectors patrol the beach 24 hours a day in a shift rotation and involve with the tourism activities at night. A total of 2693 tourists visited the Rekawa Sanctuary between the period of 20th June 2013 and 30th of September 2013. Out of this, 398 visitors were not charged as they did not see a turtle. However, 2295 tourists were charged and generated 2,295,000 (US \$ 17, 930). The money generated is being used to pay the salaries of nest protectors. In addition, 10% of the income is given to the wildlife officers working at the sanctuary. TCP allows the local nest protectors to use its turtle information centre at Rekawa and currently villagers pay the electricity and water bills from their tourism income. The overall programme is currently being monitored by an ex NAVY officer recruited by TCP. The major challenge for this programme is to develop a participatory implementation plan with the involvement of stakeholders such as the community, wildlife department, TCP and Sri Lanka Tourism Development Authority etc. Furthermore, although the programme is financially self-sustainable, the conservation component has to be further improved due to lack of community leadership in Rekawa village. Lack of coordination between the community members and the wildlife officers, some negative attitudes of a few nest protectors disturbs the conservation aspect of the programme and has yet to be addressed.

TOUGH QUESTIONS ABOUT TURTLE TOURISM: CONTEMPLATING RISK, DEPENDENCY, ACCESS AND FAIRNESS, USING RELEVANT LITERATURES, AND EMPIRICAL DATA FROM TORTUGUERO, COSTA RICA*

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In recent years, turtle tourism has grown in popularity among tourists, tourism promoters, and sea turtle conservationists as an economic alternative to direct use or sale of sea turtle products (meat; eggs; shell). It is promoted as a way to foster or encourage sea turtle conservation via its emphasis on revenue generation through indirect (so-called non-consumptive) use of sea turtles, such as turtle tours or hatchery visits, and related concurrent conservation. The local environment, whether manicured or 'relatively pristine', is sold as part of the larger tourist attraction, whether one of mass tourism or alternative tourism. Thus, conservation of the nesting beach, at minimum, fits well with sea turtle tourism marketing and management. Not surprisingly, this has led to increased research on sea turtle tourism. The emphasis in much of this work, however, is on analyzing the balance of costs and benefits of sea turtle tourism, for turtles and/or people (e.g. employment and revenues generated; conservation gains; suggested relationships between tourism, conservation, and education; quality of tourist experiences). The strong ties between much of the literature on sea turtle tourism and the arena of sea turtle conservation in practice (e.g. articles authored by members of the sea turtle conservation community; articles written primarily for this audience) have emphasized certain aspects of sea turtle tourism (e.g. how the presences of tourism can increase conservation, and decrease incentives for illegal turtle takes), while largely neglecting perennial topics in more comprehensive literatures about tourism as: an industry type, a form of 'development', and a livelihood. This paper attempts to bridge some of these gaps. It explores four key topics that are, with some exceptions, underemphasized in academic and professional writings about sea turtle tourism. It discusses tourism theory related to risk, dependency, access, and fairness, and uses empirical data from an ongoing case study of sea turtle tourism in Tortuguero, Costa Rica, to elucidate the need for more explicit explorations of these core elements as they relate to sea turtle tourism. While risk, dependency, access, and fairness are relevant in analyzing many types of tourism, this paper emphasizes potential implications for sea turtles and their conservation if these core considerations remain largely unaddressed.

HISTORICAL PHOTOS OF THREE METHODS OF FISHING OF SEA TURTLES IN THREE STATES OF THE MEXICAN PACIFIC

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For 27 years I have participated as a speaker at the event called "Meeting of the Child by the Sea Turtle Conservation," organized by Acuario Mazatlán. In the event, my lecture deals with historical aspects of the man-turtle and where I talk, among other things, of the fishery developed of these reptiles, prior to 1990, in the states of Sinaloa, Jalisco and Oaxaca. Considering the historical importance of the photographs that I have, the presentation shows the trapping methods used: Sinaloa, was the last fishery in the state, made by the cooperative Teacapan Fishermen in the waters between the island Isabeles and the island Marias, Nayarit state. The fishermen brought their boats to Isla Isabel where they would camp for several days. When sea conditions were favorable they left the island in search of turtles in the water which were directly hooked when they were afloat. In Jalisco, along Chamela Bay, caguameras networks were placed parallel to the coast with which the turtles that were caught were nesting females that arrived to nest on the beaches. Here I observed a large number of specimens captured that were butchered to carcasses and taken to an island where they were sent to the black market, another small part was intended as legal fishing. Oaxaca turtles were caught jumping over them and trapping them before diving, beachfront of Escobilla, whose waters were lavish in turtles as the beach attracted them to carry out their mass spawning.

PROTECTING AND CONSERVING THE HAWKSBILL SEA TURTLES OF GALES POINT BELIZE THROUGH EDUCATION, COMMUNITY INVOLVEMENT, AND PARTNERSHIPS

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The Manatee Bar Beach near Gales Point Belize serves as a major nesting beach for sea turtles. The Manatee Bar Beach has been monitored for nesting activity since 1990. With a lack of resources and no paid researchers, the monitoring process has become largely a voluntary effort. Even as a voluntary effort, the data that has been gathered is extensive. Recently, Hawksbill Hope and Marymount University have partnered with the Gales Point Wildlife Sanctuary Community Management Committee to begin a satellite-tagging project focusing on the hawksbill sea turtle population that is the primary user of the Manatee Bar Beach. Satellite tagging of hawksbill sea turtles in Belize will help with management decisions and also has the ability to provide some revenue to aid the nest monitoring and data collection. Community involvement is also a very important aspect of our project. The Gales Point Community has a number of talented craftspeople. Our plan includes ways to get these craftspeople an income stream and provide turtle necklaces and other items to bring in funds to support the sea turtle nesting surveys. Additionally, the community of Gales Point has several others who are interested in ways they can get involved and help to promote sea turtle protection and conservation. The hope is to use this community involvement and partnership approach as a model to help us expand these research and conservation efforts to other parts of Belize.

CULTURES OF FISHING COMMUNITIES IN COASTAL AREAS OF LAGOS, NIGERIA: IMPLICATIONS ON SEA TURTLE CONSERVATION*

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This paper examines the cultures of fishing communities in the coastal areas of Lagos, Nigeria, associated with sea turtle activities and their implications on the conservation of sea turtle. It started by identifying and developing the Geographical Information Systems (GIS) database of these coastal areas. The coastal areas of study were Magbon Alade, Orimedu, Ilado, Akodo, Folu and Okun-Ibese, where sea turtles are found in Lagos, Nigeria. Other coastal areas have mainly been industrialized for economic reasons, hence the need to conserve the existing sea turtle locations using recent technologies like GIS and Global Positioning Systems (GPS). The spatial locations of the major areas where sea turtles were found were determined using a Garmin® Global Positioning Systems (GPS). ArcGIS software was used in developing cartographic representation of the spatial data of the locations and then linked to the respective attribute data. This was done with the aim of studying the impacts of the beliefs and activities of fishermen and women within these locations on sea turtles and to digitally archive these locations thereby showcasing their Ecotourism potentials with a view to promoting wildlife resources conservation. In order to assess the cultures of the fishing communities especially as they affect sea turtle conservation, the key informant interview method of data collection was used whereby a total of 60 fishermen were interviewed across these coastal areas. Data obtained revealed that 80% of the fishermen believe that encountering sea turtles during fishing activities are associated with ill-luck, as such they kill such turtles in anger. 70% of the fishermen also believe that it is a taboo for their net to catch sea turtles. These fishermen therefore, would kill any trapped sea turtle to appease their god. Moreover, 60% of the respondents believe that sea turtles have medicinal and food values, hence exploit them for medicinal purposes, food, ornaments and leather, among other commercial purposes. A total of 90% of these fishermen were aware of the need to conserve these turtles but were either too tied to their cultures or placed more value on the commerce of turtles than their conservation. The GIS database developed by this study is useful for archiving, analyzing and displaying sea turtle activities in the coastal areas of Lagos State, Nigeria. Such documentation and digital presentation create a database of the areas of Lagos State associated with sea turtle activities and could be useful in planning awareness programmes on sea turtle conservation, which will eventually develop the tourism potentials of these coastal areas. The outcome of this study is expected to be of tremendous benefits to researchers and corporate bodies involved in sea turtle conservation. The creation of the GIS database would also be a tool in the hands of intending tourists and visitors to these areas. Local and State authorities are therefore reminded of the need to enlighten fishermen on the benefits of conservation of sea turtles as well as the enforcement of laws of wildlife conservation.

HISTORICAL COMMERCIAL EXPLOITATION AND THE RECENT RECOVERY OF HAWAIIAN GREEN TURTLES*

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Biodiversity conservation is often limited by short-term records of abundance, geographic distribution, and population dynamics. Historical information can provide a context for assessing current population status and defining recovery, especially for populations recovering from chronic human overexploitation. Here we analyze three decades (1948-1974) of commercial landings from a green turtle fishery in the Hawaiian Islands. Artisanal and commercial overharvesting drove the population to its listing under the U.S. Endangered Species Act in 1978, but the population has since increased and its recovery is being debated. While this turtle fishery was small in scale - with a limited effort, productivity, and revenue - we find dramatic declines in catch per unit effort and a spatial progression that strongly

Proceedings of the 34th Annual Symposium on Sea Turtle Biology and Conservation

suggest rapid local population depletion. Harvests initially targeted coastal areas near commercial markets, but quickly shifted to exploit more remote areas, expanded effort, increasingly relied on more extractive gears, and eventually moved offshore. Additional analyses of economic data, restaurant menus, and expert interviews indicate the fishery was driven by limited, local demand. The seemingly incommensurate scale of the fishery and its impacts indicate the Hawaiian green turtle population was already significantly depleted when commercial fishery began. We describe how historical studies can inform conservation management, including population assessments and ecosystem-based approaches.

Video Presentations

TALKIN' TURTLE IN THE BIG SOUTH

Gabriel Cumming, *Community Voice Consulting*

This video features clips of filmed questionnaire interviews with 33 stakeholders from South Caicos. Participants included active and former turtle fishers, turtle consumers, government officers and minors, who offered their views on life in South Caicos, fishing and fisheries management, as well as the future management of the TCI turtle fishery.

WILD SCIENCE - GREEN SEA TURTLES OF URUGUAY

Daniel Gonzáles Paredes, *Karumbé*

This documentary gives a special role to local fishers and communities and the development of their awareness about sea turtles. Topics include pollution, by catch, and rehabilitation.

FISHER EXCHANGES PROMOTE TURTLE CONSERVATION AND MANAGEMENT

Will Heyman, *LGL Ecological Research Associates, Inc.*

Fisher learning exchanges are used worldwide to improve fisheries management and sea turtle conservation. Topics of the exchanges include using TEDs, hosting sea turtle festivals, and facilitating other capacity building and knowledge sharing surrounding turtle conservation.

SENDING THE GUNGU HOME

Christine Hof, *Species Conservation Project Coordinator, WWF Australia and partners*

This short film showcases the work of indigenous groups such as the Gudjuda Reference Group and the Giringun Aboriginal Corporation, together with the scientists from James Cook University, the Queensland Department of Environment & Heritage Protection, volunteers from the Queens Beach Action Group, and turtle hospitals such as the Reef HQ Aquarium in Townsville. WWF-Australia helps fund turtle research and rehabilitation tanks.

‘SI BOKKO KALASAHAN KU’: TURTLE ICON FOR SEMPORNA

Gavin Jolis, *WWF Malaysia*

presented by **Ooi Ying Cheing “YC”**, *Field Biologist, WWF Malaysia’s Melaka Turtle Team*

The Semporna Priority Conservation Area (PCA) contains nesting beaches and foraging grounds for endangered sea turtles. The area also holds a significant population of Bajau coastal communities that depend on marine resources for livelihood including collecting turtle eggs for consumption. In conjunction with World Sea Turtle Day, which is celebrated annually on the 16 June, Semporna celebrated with gusto with the launch of the Sea Turtle Week.

CULTURARTE

Gustave Lopez, *Projeto Tamar Brazil*

Culturarte is a great festival of culture, art, and sea turtles, held with the community of Pirambu, in Sergipe over the past 22 years. It is one of the main activities of preservation and cultural development supported by Tamar in the State.

PAPA TORTUGA (FATHER TURTLE)

Fernando Manzano, *Vida Milenaria A.C.*

When Fernando was a child, it was common for people in his community to consume sea turtle meat and eggs, and they mixed the blood into sangria for drinking. Fernando was greatly disturbed by these practices and took it upon himself to protect the turtles. But little by little he turned poachers into protectors, and with their help he has made a tremendous impact on the population of Kemp’s ridleys – and on his community, where he has earned the title, Papa Tortuga.

ARCHIE CARR REFUGE AT NIGHT

Raymond Mojica Jr., *Brevard County Environmentally Endangered Lands Program*

A documentary on sea turtles within the Archie Carr National Wildlife Refuge using time-lapsed night vision photography. The video covers two years of data collection documenting natural behavior and positive and negative interactions with humans.

ANCIENT HAWAIIAN FISH POND BECOMES A HONU HAVEN

Marc Rice, *Hawaii Preparatory Academy*

Underwater filming of green turtles utilizing ancient Hawaiian fishpond habitat.

SENYUM PENYU, SENYUM KITA’ (A TURTLE’S SMILE IS OUR SMILE)

Ummi Nadiyah Rosli, *Communications Officer, Peninsular Malaysia Seas Programme, WWF*

presented by **Ooi Ying Cheing “YC”**, *Field Biologist, WWF Malaysia’s Melaka Turtle Team*

In conjunction with World Turtle Day on 23 May 2013 WWF-Malaysia released its turtle song entitled ‘Senyum Penyu, Senyum Kita’ (loosely translated as A Turtle’s Smile is Our Smile). To bring the message of turtle conservation closer to home, the song features traditional musical instruments from each of WWF-Malaysia’s turtle project sites including the Rodat (Terengganu) and Kulintangan.

A SEA TURTLE STORY

Kathy Shultz, *National Film Board of Canada*

A Sea Turtle Story is a moving and exquisite stop-motion animated film that chronicles the life cycle of this critically endangered species. Capturing the beauty of the ecosystems that sea turtles inhabit, the film is ideal for all audiences, and for teaching young and old alike about these fascinating creatures of the sea.

WIKI LOVES SEA TURTLE MONUMENTS

Anna Stamatiou, *MEDASSET*

The presentation aims to bridge our natural and cultural heritage and ultimately help us raise awareness about sea turtles, through collecting images of monuments found around the world. Please take a look at the website <http://seaturtlemonuments.medasset.org> for more information.

THE CALL OF THE ANCIENT MARINER

David Weintraub, *Executive Director, Center for Cultural Preservation*

What is it about sea turtles that has captured man's heart, spirit and folklore (in addition to his stomach) over thousands of years? "Mariner" explores the cultural connection of man and turtles and how the best case for protecting them might better understanding what we lose should this cultural icon vanish from our planet and why we need each other.

Index

- Abdallah, Omari, 90, 187
 Abdel-Moati, Mohamed A., 77, 172
 Abreu-Grobois, F. Alberto, 56, 117, 122, 130, 168, 189
 Aca, Ali Bugra, 22
 Adam, Pierre-André, 66
 Adams, Lotti, 104
 Addison, David S., 214, 222, 238, 240
 Adegbile, Oyeronke M., 43, 107, 241
 Adeogun, Dare A., 107, 241
 Agrazal Melendez, Luis, 49
 Aguilar, Anell, 232, 235
 Aguilar-Claussell, Paula, 77, 188
 Aguirre, Alonso A., 77
 Agyekumhene, Andrews, 241, 242
 Ajulo, Akintunde A., 107, 241
 Akinnigbagbe, Oluwatoyin R., 114
 Aksissou, Mustapha, 91
 Al Abdessalaam, Thabit Zahran, 77, 172
 Al Ansi, Mehsin, 77, 172
 Al Kiyumi, Ali, 77, 172
 Al Suwaidi, Hana Saif, 77, 172
 Al Suweidi, Ali Saqar, 77, 172
 Al Thawadi, Reem, 84
 Albareda, Diego, 41, 109
 Albeldawi, Mohammed, 77, 172
 Albertazzi, Federico, 71, 122
 Alfaro-Núñez, Alonzo, 118
 Alfaro-Shigueto, Joanna, 128
 Alfieri, Amauri, 15
 Allen, Camryn D., 4
 Allen, Carole, 74
 Allman, Phil, 241, 242
 Almeida, Antonio P., 41
 Alonso, Luciana, 7, 8, 186
 Álvarez-León, Ricardo, 65
 Alwi, Andi Faisal, 89
 Amorocho, Diego Fernando, 70, 120, 139
 Anderson, Adren B., 210
 Anderson, Eric T., 13
 Anderson, Sharolyn, 101
 Andersson, Martin, 144
 Andrade, Mariane F., 4
 Andrade-Monteiro, Ravidson J., 119, 128
 Andrewin, Kevin, 248
 Andrews, Allen H., 38
 Andrews, Kimberly M., 221, 226, 228
 Aniebona, F., 114
 Antonopoulou, Marina, 77, 84, 172
 Appelson, Gary, 44
 Arauz, Randall M., 44, 71, 99, 104, 115, 122, 123, 178
 Arbelo, Manolo, 95
 Ardika, I. Nyoman, 89
 Arenas-Alatorre, J., 17
 Arenas-Martínez, Alejandro, 70, 117, 233
 Arendt, Michael D., 133, 138, 144, 147
 Arengo, Felicity, 23
 Argüelo-Gomez, Yeudi, 53
 Ariyoga Gautama, Dwi, 99
 Aromalo, Donald James, 209
 Avens, Larisa, 5, 13, 29, 37, 158, 173, 184
 Avestruz, Amber, 6, 39
 Awosanya, S. N., 43
 Ayissi, Isidore, 91
 Azanza Ricardo, Julia, 169, 190
 Azmaz, Musa, 200
 Aznar, Francisco J., 151, 152
 Badillo, Francisco J., 152
 Bagley, Dean A., 51, 66, 173, 221
 Bailey, Helen, 111
 Bailey, Rhonda A., 91, 112
 Baillet-Hay, Catherine, 54
 Balazs, George H., 23, 134, 162, 242
 Baldwin, Robert, 77, 172
 Ballorain, Katia, 145
 Bañuelos-Valles, Jenny, 188
 Baptistotte, Cecilia, 203
 Barbosa, Castro, 45, 195, 208
 Barbour, Dan, 241, 242
 Bárcenas-Ibarra, Annelisse, 7, 215
 Barco, Susan G., 32, 36, 145, 164
 Barquero-Edge, Phoebe S., 78
 Barraza-Ortega, Marco A., 74
 Barrientos-Muñoz, Karla, 82, 135, 190, 192, 197, 210
 Barrios-Garrido, Hector, 243
 Baskale, Eyup, 22, 33, 200, 215, 216
 Batchoo, Santosh, 176
 Bateman, Brooke L., 96
 Batibasaga, Aisake, 62, 182
 Bauer, Gordon B., 39
 Bayrak, Rahmi, 216
 Beange, Madeleine, 104
 Becker, Paul R., 23
 Beldomenico, Pablo M., 7, 8
 Bell, Catherine D., 146
 Belskis, Lisa, 92
 Berry, Antoine, 48
 Bertelsen, Mads Frost, 118
 Besson, Marc, 54
 Betunde, Domingos, 45
 Bevan, Elizabeth, 230
 Bevilacqua, Maria S., 7, 8
 Bézy, Vanessa S., 9
 Bibang, Jean Noel, 43

- Bickerman, Kalyn, 184
Bignon, Florent, 54
Birdwell, Brett, 49
Bishop, Gale A., 46, 47
Bjorndal, Karen A., 5, 30, 133, 134, 143, 147, 160, 165, 181, 200, 240
Blume, Nicholas, 47
Boettcher, Ruth, 140, 145
Bojesen, Anders Miki, 118
Bolaji, Dunsin A., 114, 241
Bolanos, Allan D., 99
Bolten, Alan B., 5, 30, 133, 134, 143, 147, 160, 165, 181, 200, 240
Boniface, Nigel, 66
Bonka, Amy, 231
Bonne, Howell, 41
Borrat, Virginia, 168
Bossart, Gregory, 10
Bostrom, Brian L., 160
Boura, Liza, 106
Bovery, Caitlin M., 148, 205
Bowen, Gabriel J., 240
Bracarense, Ana Paula F. R. L., 15
Braddock, Kaylee B., 149
Braun McNeill, Joanne, 13, 158
Breheret, Nathalie, 48, 54
Brenes Arias, Oscar, 191
Bresette, Michael J., 147, 228, 233, 237
Briseño-Dueñas, Raquel, 117, 189
Broderick, Annette C., 41, 101, 175, 208
Brooks, Annabelle, 155
Brost, Beth, 21, 154
Brown, Corrie C., 28
Brown, Lucie S., 119
Brown, Ricky, 41
Browne, Darren, 120
Bruno, Ignacio, 109
Bryan, Jacob M., 9
Buckley, Hilary, 104
Burchfield, Patrick, 230, 231, 239
Burgess, Matt, 192
Burney, Curtis M., 220
Burt, Louise, 145
Byrd, Lynne, 6
Caballero, Susana J., 120
Cabanilas-Cabanillas, Francisca G., 74
Caillouet, Jr., Charles W., 97
Camille, Jean-Claude, 66
Campbell, Cathi L., 202
Campbell, Lisa M., 69
Campos-Garcia, J., 17
Canizalez-Roman, Adrian, 188
Cardona, Luis, 185, 186
Carmon, Brittany, 223
Carranza, Alvar, 185, 186
Carron, Alicia, 22
Carter, Sharon, 149
Carthy, Raymond R., 147
Carvalho, Hualton, 55
Casale, Paolo, 148
Castillo, Jairo, 72
Castillo-MacCarthy, Andrey, 53
Castro, Joshua, 93, 192
Catry, Paulo, 45, 111, 195, 208, 211
Cavita, Saúl, 73
Cazabon-Mannette, Michelle, 94, 120
Cedetas, Meliha, 22, 33
Ceriani, Simona A., 12, 149, 191, 196, 222
Cervera, Vicente, 95
Chabot, Ryan M., 191
Chacón López, Rafael, 117
Chacón-Chaverri, Didiher, 41
Chaloupka, Milani, 134
Chateau, Olivier, 136
Chauvin, David, 41
Chávez Narvaez, Alma Susana, 81, 243
Cheing, Ooi Ying, 251
Cheng, I-Jiunn, 126, 141, 149, 244
Cheng, Wan-Hwa, 149
Cherkiss, Michael, 180
Chikhi, Ahmed, 77, 172
Chiquete-Ozono, Yuri, 188
Ciccione, Stephane, 67, 145
Cimen, Gamze, 215
Clark, AnnMarie, 130
Clark, David R., 147, 237
Cluse, Wendy M., 13
Clyde-Brockway, Chelsea, 150
Cocilova, Courtney, 10
Coelho Dias da Silva, Augusto Cesar, 93
Coelho, Valéria F., 11
Coggins, Lew, 5
Cole, Liesl, 115
Coleman, Andrew T., 22, 107, 223, 230, 232, 235
Combs, Brittany L., 232
Contreras-Garcia, I. J., 17
Cook, Melissa, 92, 107, 223
Cope, Kendra, 245
Cordell, Joey, 66
Coronado-García, Areli M., 77
Correa-Cárdenas, Camilo A., 120
Cortés, Jorge, 178
Cortes-Gomez, Adriana, 12
Coyne, Michael S., 41, 140, 175
Cramer, Corinne, 104
Crawford, Lydia, 192
Crespo-Picazo, Jose Luis, 95
Crews, Emily R., 12, 196
Crist, Stacy, 13
Crowder, Andrew, 180
Cuevas, Eduardo, 117, 233
Cuiriz-Rios, Z., 17

- Cumming, Gabriel B., 69, 250
Cutt, Tommy, 79
da Fonseca, Ederson Luiz, 181
da Silva, Isabel M., 218
Damazo, Lindsey Eggers, 193, 194
Daniels, Andre M., 151
Danylchuk, Andy, 156
das Candeias Oliveira, Fábio Lira, 181
Das, Himansu Sekhar, 77, 172
Davis, Shannon, 32
de Alcântara, Brígida K., 15
de Castilhos, Jaqueline Comin, 93, 181, 203
de la Cruz, Jaime, 207
de la Toba, Victor, 184
de Quirós, Yara Bernaldo, 95
DeAlteris, Joseph, 42, 97
del Corral Mancera, Marcela, 117
DeLand, Sarah, 13
Delaunay, Nicolas, 84
Delgado-Trejo, Carlos, 50, 194
deMasy-Pedros, Eva, 128
DePerte, Allison C., 145
D'Eri, Linda R., 36, 145, 164
Desjardin, Nicole A., 195
Di Bello, Antonio, 14, 17
Dias, Beatriz, 80
Díaz-Delgado, Josué, 95
Diaz-Hernandez, Veronica, 20
Díaz-Morales, Dakeishla, 82, 192, 197, 210
Diedrich, Amy, 243
Diéguez-Uribeondo, Javier, 24, 102
Diez, Carlos E., 135, 156, 190
DiGiovanni Jr., Robert A., 145
Dimopoulos, Dimitrios, 75
Dodd, Mark G., 140
Domenech, Francesc, 151, 152
Domiciano, Isabela G., 15
Domingo, Andrés, 41, 104
Domit, Camila, 4, 11, 15, 98
Donnelly, Marydele, 96
Dudley, Peter N., 16
Duhec, Aurélie, 66
Dunbar, Stephen G., 50, 115, 143, 153, 193, 194
Dunch, Victoria, 223
Duran, Noemi, 50, 153
Dusen, Serdar, 58
Duthie, James, 84
Dutton, Peter H., 76, 121, 124, 126, 127, 141, 218, 245
East, Dominic J., 149
Eckert, Karen, 25
Eckert, Scott, 41
Eguchi, Tomoharu, 4, 127, 139, 166
Ehrhart, Llewellyn M., 12, 51, 105, 149, 173, 191, 196, 221, 222, 224, 228
Ekanayake, Lalith, 52, 209
El-Alwany, Magdy A., 106
Elbr, Sevil, 215
Ellis, Stephanie, 248
Enciso-Saracho, Fernando, 74, 246
Epperly, Sheryan P., 126
Epperson, Deborah, 52
Erdogan, Bekir, 58
Ergun, Guner, 200
Ernest, Robert G., 195
Eryigit, Ahmet, 200
Escobedo-Urías, Diana, 188
Estima, Sérgio C., 130
Estrades, Andres, 168
Evans, Daniel R., 41, 222
Fahey, Nancy, 88
Fak, Çiğdem, 22, 33, 215
Fakayode, O. S., 114
Fallabrino, Alejandro, 41, 163, 168
Farman, Richard, 136
Feck, Alexandra, 80
Fernández Alfaro, Carlos, 102
Fernandez, Antonio, 95
Ferrara, Camila Rudge, 16, 219
Ferraroli, Sandra, 41
Ferreira, Maria Betania, 45, 195, 208
Figgener, Christine, 53
Fisher Jr., Louis E., 220
FitzSimmons, Nancy N., 124, 136
Flanagan, Joseph P., 38
Flewellling, Leanne, 10
Foley, Allen M., 21, 91, 100, 112, 133, 147, 154
Fonseca, Luis G., 71, 115, 123
Formia, Angela, 41, 43
Forrester, Jack, 41, 43
Fossaceca, Kathryn, 248
Fossette, Sabrina, 41
Fougner, Svein, 42
Fournies, Sandy, 25
Fox, Trevor, 109
Franchini, Delia, 17
Frazier, Jack, 1
Freggi, Daniela, 14, 17, 148
Fretey, Jacques, 91
Frick, Michael G., 134, 143, 144
Fuentes, Mariana MPB, 55, 96, 110, 203
Fuentes-Farias, A. L., 17
Fuentes-Mascorro, Gisela, 12
Fujisaki, Ikuko, 234, 239, 240
Fukuda, Tomokazu, 40
Furchgott, Jane, 81
Gahm, Meghan, 42, 97
Galbraith, David, 216
Gallaway, Benny J., 97
Galvan, Irma, 232, 235
Gama, Luciana R., 98
Gamage, Ruvani N. N., 18

- Gandra, Tiago B. R., 130
Gaos, Alexander R., 99
García, Lucia, 82
García-Alvarado, Pedro, 233
García-Corrales, Ma. Oralia, 74
García-Gasca, Alejandra, 7, 20, 215
García-Párraga, Daniel, 95
Garvis, Stephanie K., 155
Gary, Meagan, 155
Gaspar, Cécile, 54
Gaspard III, Joseph C., 39
Gaudard, Aliny, 98
Gaughran, Stephen J., 19, 138
Gazey, William J., 97
Gerhartz Abraham, Adrián, 190
Gerhartz Muro, José Luis, 190
Gerlach, Ginny, 113
Giffoni, Bruno, 41
Gilbert, M. Thomas P., 118
Giove, Robin, 100
Giraldo, Alan, 139
Girard, Alexandre, 48, 54
Girondot, Marc, 19, 196, 199
Gleason, Jeffrey S., 198
Godard-Codding, Céline A. J., 38
Godfrey, Matthew H., 13, 140, 203
Godley, Brendan J., 41, 101, 174, 175, 208
Godoy, Dan, 103
Goldberg, Daphne Wrobel, 93
Goldberg, E. Grace, 156
Goldman, Daniel L., 225
Gomez Gamez, Daniel, 239
Gómez-Muñoz, Victor M., 213
Gomez-Picos, Patsy, 20
Gonçalves Filho, Pedro Renato, 168
González Paredes, Daniel, 250
González Camacho, Zuleika B., 74, 246
Gonzalez Diaz Miron, Raul de Jesus, 239
González Paredes, Daniel, 168
Gonzalez, Leia O., 72
Gonzalez, Liza, 71, 76, 87
González-Garza, Blanca I., 233
Gonzalez-Paredes, Daniel, 163
Goodman Hall, April, 13, 158
Gorham, Jonathan C., 233, 237
Goshe, Lisa R., 5, 13, 158, 184
Gottdenker, Nicole L., 28
Goya, Elisa, 207
Grace, Michael, 31
Graciano-Obeso, Adalid, 188
Graham, Gary, 41
Grave-Moreno, Jonathan I., 74
Gredzens, Christian, 55
Griffin, DuBose B., 140
Griffin, Luke, 156
Grimanis, Kostis, 106
Grygotis, Gabrielle, 248
Guandad-González, Jesus Ivan, 74
Guertin, Jeffrey R., 25, 195, 237
Guimarães, Suzana M., 35, 42, 157
Guinea, Michael L., 20, 158
Guissamulo, Almeida, 218
Gusmão, Fernanda D., 12, 196
Guterres, Laís P., 121
Gutiérrez-Berrios, Jorge, 82, 192, 197, 210
Gutierrez-Ospina, G., 17
Guzmán-Hernández, Vicente, 117, 233
Haas, Heather L., 36
Hagemann, Molly E., 38
Hall, Martin, 42
Hamabata, Tomoko, 124
Haman, Katherine, 221
Hamann, Mark, 55, 57, 80, 101, 110, 180, 243
Hamza, Shafeeq, 77, 172
Hancock, Joana, 55
Hardy, Robert, 21, 91, 100, 112, 154, 232, 239
Harfush-Meléndez, Martha, 16, 215
Hargrove, Stacy A., 134
Harms, Craig A., 13
Harrison, Emma, 68
Harrod, Chris, 140
Hart, Catherine E., 56, 77
Hart, Kristen M., 132, 147, 151, 180, 234, 239, 240
Hartley, Troy, 40, 42
Hatchett, Wendy, 22
Hawkes, Lucy A., 174
Haxhiu, Idriz, 135
Hays, Graeme, 41
Hazelkorn, Rebecca, 114
Heidemeyer, Maike, 44, 71, 115, 122, 123
Helmerts, David, 96
Heppell, Selina S., 29, 37, 134, 173, 234
Hernandez, Mauricio H., 231
Hernández-Caraballo, Tania, 82, 192, 197, 210
Hernandez-Cornejo, Rubi, 20
Herren, Richard M., 147
Herrera, Lazaro, 232, 235
Herrera-May, A. L., 17
Herrera-Vega, Ma. de los Ángeles, 117
Heyman, Will, 250
Hidalgo-Tobon, S., 17
Higareda-Magaña, V., 17
Higgins, Benjamin M., 38
Higgins, Katie, 83
Hill, Jacob E., 159, 197, 201
Hillis-Starr, Zandy, 180
Hines, Annie, 49
Hirai, Norio, 142
Hirama, Shigetomo, 21, 117, 154, 232, 239
Hirsch, Sarah, 205
Hof, Christine, 250
Hoffman, Eric, 224

- Hogan, Myers, 232
Hogan, Sophia, 232
Honarvar, Shaya, 87
Hooper, Michael J., 38
Houser, Chris, 202
Howard, Victoria, 223
Howell, Lyndsey N., 235
Huerta-Rodríguez, Patricia, 233
Hughes, George, 41
Humber, Frances K., 101
Hung, Ching-ju, 242
Hupp, Amy L., 26
Indjai, Bucar, 45
Ingram, Dianne K., 198
Isaacs, Jacqueline M., 198
Ishihara, Takashi, 124
Ishii, Minoru, 142
James, Robert, 57
Jang, Jean Wai, 199
Jáuregui-Romero, Guiomar Aminta, 65
Jeanne, Richard, 66
Jenkins, Lekelia D., 83
Jensen, Brenda, 23
Jensen, Michael P., 115, 122, 124, 126
Jiménez-Bordón, Saray, 24, 128
Jobsis, Paul, 180
Johnson, Robert A., 160
Jolis, Gavin, 251
Jones, Rhondda, 101, 180
Jones, T. Todd, 38, 160, 161
Jordaan, Adrian, 80
Jordan, Mark, 125
Jourdan, Vie, 54
Jupiter, Tony, 66
Kahawita, Himali Purnima, 246
Kaletsch, Joey, 22
Kamezaki, Naoki, 124, 132, 142
Kamrowski, Ruth L., 57, 96, 101
Kapurusinghe, Thushan, 246
Kardel, W. Scott, 238
Kaska, Yakup, 22, 33, 58, 196, 215, 216
Katilmis, Yusuf, 200
Kaufman, Temma J., 200
Kaylor, S. Michelle, 26
Kayo, Muneyuki, 124
Keating, Patricia, 34
Kedzuf, Stephanie C., 161
Keith-Lucas, Alastair J., 47
Keledjian, Amanda J., 58, 102
Kelez, Shaleyla, 128
Kellar, Nicholas M., 4
Kelle, Laurent, 41
Keller, Jennifer M., 23
Kerr, Oliver J., 77, 84, 172
Keske, Carrie L., 233, 237
Kiehner, Laura, 232, 235
Kilduff, Catherine, 59
Kilic, Kerem, 201
Kinas, Paul G., 121, 168
King, Cheryl, 161
King, Courtney M., 201
Kittinger, John N., 249
Klaus, Jamie, 223
Koch, Volker, 109, 112
Kondo, Satomi, 60
Koperski, Meghan E., 60
Kotze, Deon, 176
Koval, Julianne, 125
Kowalski, Peter, 126
Krishnankutty, Nimisha, 69
KRSAW Workshop Participants, 97
Kumar, Sonia, 19
Kurle, Carolyn, 37, 184
LaCasella, Erin L., 126, 127
Lagueux, Cynthia J., 133, 169, 202
Lai, Olimpia R., 14, 17
Lamont, Margaret M., 147, 202, 234, 240
Lara Aragón, Cibeles, 212
Lara, Mónica, 73, 212
Lasala, Jacob A., 127
Lauritsen, AnnMarie, 61
Laveti, Merewalesi, 62, 182
Lawrence, Tara, 108
Lawson, Dan, 127
Layton, Jenny E., 202
Leal-Moreno, Renato, 77, 188
Lecoq, Miguel, 195
Lee, Sok Hwan, 162
Lemons, Garrett E., 163
Lenoci, Diana, 14
León, Yolanda M., 174
LeRoux, Robin A., 127
Leslie, Aimee, 40, 41
Lester-Coll, Andres, 128
Leu, J. H., 141
Lewison, Rebecca L., 104, 163, 166
Ley-Quíñonez, César P., 56, 77, 188
Lezama, Cecilia, 163
Liles, Michael J., 99
Lima, Hipólito, 55
Limpus, Colin J., 101, 136, 180
Liria-Loza, Ana, 24, 64, 119, 128, 164
Lôbo-Hajdu, Gisele, 137
Lockhart, Gwen G., 145, 164
Lolavar, Alexandra, 224, 229
Loloum, Bastien, 55
Lombard, Claudia D., 201
Long, Chris, 224
Long, Tonya M., 91, 112
Longo, Tom, 79
López Jurado, Luis Felipe, 131
López Rivas, Marga, 24, 102

- López, Eric, 115, 123
Lopez, Gustave Gilles, 93, 166, 203, 251
Lopez, Jaclyn, 59, 62, 85
López-Barrera, Ellie A., 70
Lopez-Castro, Melania C., 165
López-Jurado, Luis F., 24, 64, 119, 128
López-Mendilaharsu, Milagros, 41, 166, 203
Lovewell, Gretchen N., 114
Loyda-Hernandez, Jorge A., 232
Lundgren, Ian, 180
Luque, Jenny, 119
Luschi, Paolo, 41
Lynott, Margaret C., 36
MacKay, Kenneth T., 103, 209
MacKenzie, Duncan S., 2
MacPherson, Sandra L., 61
Madrak, Sheila V., 166
Maison, Elodie, 151
Mallos, Nicholas J., 63, 88
Mancha-Cisneros, Maria Del Mar, 109
Mancini, Agnese, 112
Mangel, Jeffrey C., 128
Manire, Charles, 205
Manjarrez, E., 17
Mann, David A., 39
Mansfield, Katherine L., 51, 105, 166, 167, 191, 221, 238, 240, 245
Manzano, Fernando, 232, 235, 251
Mapoy, Salom, 90
Marcovaldi, Maria Angela Azevedo Guagni Dei, 93, 166, 203
Margaritoulis, Dimitris, 108, 207
Marsh, Helene, 55
Martí-Bonmatí, Luis, 95
Martín del Campo, Jesús R., 168
Martin, Makenna, 104
Martin, R. Erik, 195
Martínez Bartolomé, Marina, 24
Martínez Ortiz, Hector J., 239
Martínez, Julie, 87
Martínez, Marco A.C., 230, 231
Martínez-Souza, Gustavo, 163, 168, 185
Martínez-Vicente, L., 17
Martín-Viaña, Yanet Forneiro, 190
Mas Gitirana, Humberto, 137
Mascovich, Katie A., 78, 221, 226
Mathew, Jibymol, 69
Matsuzawa, Yoshimasa, 142, 204
Matthews, Melissa, 84
Matthiesson, Louise, 113
Matzen, Eric, 42, 97
Mazouchova, Nicole, 225
Mbungu, Samuel, 204
McCandlish, Maura, 248
McCartha, Michelle, 37
McCorquodale, Donald S., 220
McCracken, Adrienne, 205
McCue, Steven, 176
McFadden, Kate, 23
McGee, Jennifer L., 64
Mchomvu, Boniventure, 90, 187
McLeish, Don, 161
Medi, Rubvani, 169
Medina Cruz, Yosvani, 190
Medina, Yosvani, 169
Medina-Martínez, Fausto, 74
Medina-Suárez, María, 24, 64, 119, 128
Meekan, Mark G., 183
Melendez-Herrera, E., 17
Melero, David, 57
Meletis, Zoë A., 108, 247
Melo, José, 111
Melo, Tommy, 111, 211
Merchant-Larios, Horacio, 20
Mercier, Katie, 192
Mettee, Nancy, 25
Metz, Tasha L., 236
Meyer, Brian K., 46, 47
Meyer, Mike, 176
Meylan, Anne B., 4, 68, 100, 129, 130, 144, 147, 232
Meylan, Peter A., 4, 68, 129, 130, 147
Míguez, Raul, 185
Mihnovets, A. Nicole, 138
Mikkelsen, Jon, 160
Mikos, Veronika, 89
Millán-Aguilar, Olivia, 117
Miller, Jeannie, 108
Miller, Jessica A., 29
Miller, Philip, 41, 104
Milliken, Henry, 42, 97
Milton, Sarah L., 10, 34
Minch, Karrie E., 21, 91, 112, 154
Missamou, Antoine, 48
Mitchell, Emily L., 78, 205
Mitchell, John, 42, 43
Mizuno, Kojiro, 124
Mobaraki, Asghar, 77, 172
Mojica Jr., Raymond, 251
Moktar, Samuel, 48
Molina Barahona, Daniela, 191
Mollet-Saint Benoît, Céline, 105, 149
Moncada Gavilán, Félix, 190
Moncada, Felix G., 169
Monge, Alejandra, 57
Monteiro, Danielle S., 130
Monteiro-Neto, Cassiano, 35, 42, 157
Monzón Argüello, Catalina, 131
Morales-Ramírez, Álvaro, 71
Mora-Sandoval, Jairo, 53
Moreno-Munar, Alvaro Andrés, 65
Morimoto, Yukari, 60

- Morreale, Stephen J., 111, 176, 177, 207
Mortimer, Jeanne A., 16, 66
Moss, Amanda L., 236
Mota, Mario, 66
Mott, Cody R., 25, 237
Moura, Stephane, 98
Moy, Kirsten, 49
Msoili, Anfani, 67
Muccio, Colum, 67, 82
Nada, Mohamed A., 106
Nahill, Brad, 85, 86
Nahill, Celene, 86
Nairn, Campbell J., 140, 143
Nakazawa, Keiji, 170
Nalovic, Michel A., 40, 41, 43
Naranjo, Isabel, 44
Naro-Maciel, Eugenia, 19, 131, 132, 181
Narushima, Koji, 60
Nath, Nirmala W., 20
Navarro Sánchez, Erik Jonathan, 189
Neeman, Noga, 206
Negrete-Philippe, Ana C., 233
Nel, Ronel, 176, 177
Nelson Jr., Steven E., 26, 33
Nero, Redwood W., 107
Nevai, Andrew, 93
Neves-Monteiro, Jandira, 128
Neville, Duncan E., 89
Newman, Rick, 25
Ng, Ka-yan, 242
Nicholas, Mark A, 237
Nichols, Wallace J., 85
Nilsen, Frannie, 23
Nishizawa, Hideaki, 126
Nodarse Andreu, Gonzalo, 169, 190
Nollens, Hendrik, 4
Noor, Noor, 106
Norton, Terry M., 26, 28, 33, 221
Nukui, Kaoru, 170
Nyama-Mouketou, C., 43
O'Connor, Michael P., 206
Obienu, J. A., 43, 241
Ochoa, Cutzi Bedolla, 50, 194
Okamoto, Kei, 132
Oke, Bankole O., 27
Oki, Katsuki, 124
Olakolu, Fisayo C., 43, 107
Olukole, Samuel G., 27
Ommeran, Mossa M., 106
Omogoriola, H. O., 43
Ondich, Breanna L., 191, 221, 226
Ooi, Ying Cheng, 170
Oosthuizen, Herman, 176
Opurum, S. C., 114
Ordoñez, Cristina, 68, 129, 130
Oro, Daniel, 214
Orozco, Aileen, 85
Ortega, Christian D., 168
Ortiz, Concepción, 182
Ortiz, Jaime, 239
Ortiz, Kathryn M., 46, 47
Osmond, Michael, 43
Ostertag, Thomas E., 64
Ostifachuk, Peter, 160
Otterstrom, Sara, 71
Oujo-Álamo, Carolina, 128
Ow Young, Xavier E., 72, 206
Owens, David Wm., 3, 4, 138, 154
Oyeyemi, Matthew O., 27
Page-Karjian, Annie, 28
Pajuelo, Mariela, 5, 133, 143, 200, 240
Paladino, Frank V., 9, 111, 125, 150, 159, 176, 177, 197, 206, 214, 217
Panagopoulou, Aliko, 108, 207
Papa, Riccardo, 128
Pardo, Mario A., 168
Paredes, Evelyn, 207
Parga, MariLuz, 35
Parkins, Christopher, 42, 97
Parks, Eric M., 29
Parnell, Richard, 43
Pastory, Temu, 90, 187
Pate, Jessica, 227
Pate, Michelle, 140
Patel, Samir H., 207
Patrício, Rita, 208
Patrick, Lorna A., 61
Pattiaratchi, Chari B., 183
Payán, Luis Fernando, 139
Peavey, Lindsey E., 171
Peckham, S. Hoyt, 43, 83, 184
Pedersen, Glenn, 119
Pelkey, Neil, 108
Peña, Jaime, 230, 231, 239
Pendoley, Kellie L., 146, 183
Pennathur, Anita, 47
Percival, Franklin, 192
Peres Valdes, Santiago, 49
Perez, Juan Manuel, 67
Pérez-Ríos, Nadia, 117
Perrault, Justin R., 29
Perry, Lisa, 77, 172
Peterson, Casey L., 109
Petit, Matthieu, 54
Petitet, Roberta, 121
Petro, George, 103, 209
Pfaller, Joseph B., 30, 134, 143, 200
Phillips, Katrina F., 238, 240
Phillips, Quentin, 69
Phillips-Farfan, B., 17
Phillott, Andrea D., 18, 69
Piacenza, Susan E. H., 134

- Pierce, Adam, 58
Pilcher, Nicolas J., 77, 84, 172
Pincetich, Chris, 104
Pineda-Lopez, E., 17
Pinos-Crosas, Judit, 64, 119
Piroli, Vilma, 135
Pitchford, Jonathan L., 223
Pitt, Amber L., 86
Plante, Craig J., 9
Plotkin, Pamela T., 40, 97
Pollock, Clayton, 180
Popp, Brian N., 163, 171
Porter, Warren, 16, 167
Possardt, Earl, 76, 230, 231
Powell, Brian, 64
Prescott, Robert L., 133
Pressey, Robert L., 96
Price, James T., 30
Proietti, Maira, 183
Prosdocimi, Laura, 41, 109
Provancha, Jane A., 147
Pugh, Rebecca S., 23
Putman, Nathan, 132, 166
Quattro, Joseph M., 138
Quiñones, Javier, 128, 207
Quiñonez, Ana, 119
Quintana-Ascencio, Pedro, 93
Quirós, Wagner, 71, 115, 123
Quirós-Pereira, Wagner, 53
Rabia, Basem, 106
Raborn, Scott W., 97
Radeloff, Volker, 96
Rader, Heidi, 87
Raga, Juan A., 151, 152, 174
Raith, Andrew M., 20
Rajakaruna, Rupika S., 209
Ramirez, Matthew D., 29, 37, 173
Ramirez, Paquita, 207
Ramirez, Sara D., 210
Ramírez-Gallego, Cristian, 82, 135, 190, 192, 197, 210
Ramirez-Santos, J., 17
Ramos, Julia, 104
Ramos-Silva, Elton J., 119
Rangel Aguilar, Blanca Nallely, 194
Ranger, Susan, 69, 175
Read, Tyffen C., 136
Rebelo, Rui, 195, 218
Redfoot, William E., 12, 51, 173, 221
Reetz, Kelly K., 198
Regalla, Aissa, 45, 208
Reich, Kimberly J., 133, 143
Reis, Estéfane Cardinot, 137
Reisser, Julia W., 183
Restrepo, Victor, 245
Revuelta, Ohiana, 174
Reyes Cajigas, Natalie, 82, 192, 197, 210
Reynolds, Michael O., 198
Rguez-Baron, Juan M., 70, 213
Ribaldo, Gertrudis, 87
Ribeiro Costa, Mariana de Paula, 137
Rice, Marc R., 23, 162, 251
Rice, Nikia, 31, 117
Richards, Paul M., 92, 134
Richardson, Peter B., 69, 175
Riley, Patrick, 41
Rimkus, Mark, 248
Rimkus, Todd, 248
Ríos Olmeda, Daniel, 189
Ríos, Mariana, 163
Ríos, Roman, 74
Riskas, Kimberly A., 110
Robbins, Michelle N., 4
Roberge, Taylor M., 31
Roberts, Mark A., 138, 144, 232, 235
Robertson, Lisa, 64
Robinson II, Abraham, 6
Robinson, Nathan J., 9, 176, 177, 206
Rocha, Patrícia, 111, 211
Rodriguez Heredia, Sergio, 109
Rodríguez Murillo, Jacinto, 49
Rodriguez, A. O., 17
Rodriguez, Jacinto, 72, 206
Rodriguez-Baron, Juan Manuel, 184
Rodriguez-Jimenez, M. G., 17
Rodrigues-Heredia, Sergio, 41
Roe, John H., 111
Rojas-Lleonart, Isaias, 7
Romero, Diego, 12
Romero-Higadara, Cesar E., 246
Romero-Murillo, Patricia, 140
Romero-Urías, Carlos G., 77, 188
Root, Matt R., 238
Rose, Sarah, 32
Rosenthal, Alan, 168
Rosero-Caicedo, Marcela, 70
Rosli, Umami Nadiyah, 251
Rossi, Natalia A., 138
Roth, James D., 222
Rousselet, Estelle, 33
Rousso, Stephanie J., 73, 212
Rubio, Cynthia, 239
Ruiz García, Norma Adanary, 189
Rusenko, Kirt W., 212, 220
Russomagno, Mauro, 168
Saba, Vincent S., 144, 207
Sagarminaga, Ricardo, 35
Sahin, Barbaros, 22, 33
Sakashita, Miyoko, 59
Salmon, Michael, 161, 179, 227
Samaniego V, Edgar, 49
Sampson, Laura, 139

- Sánchez Jiménez, Astrid, 71, 178
Sánchez, Alberto, 182
Sánchez, Astrid, 44
Sánchez, Carla, 73, 212
Sanchez, Salvador, 76, 87, 123
Sanchez, Ynes S., 72
Sánchez-Zazueta, Jorge G., 246
Sandoval, Sarahi, 213
Sanghera, Amdeep, 69, 175
Santiago-Magallanes, Sancy, 70
Santidrian Tomillo, Pilar, 102, 150, 197, 214, 217
Santos, Alexsandro, 203
Santos, Armando JB, 203
Santos, Katherine Comer, 49, 104
Saracho, Fernando E., 248
Sarmiento Ramírez, Melissa, 24
Sarmiento-Devia, Ricardo, 140
Sartain, Autumn R., 234, 239
Sarti Martinez, Laura, 230, 231
Sasso, Christopher R., 133, 222
Sato, Katsufumi, 149
Sawaf, Moaz, 77, 172
Scarola, Joseph C., 227
Schaf, Susan A., 91, 112
Schaffler, Jason, 32
Schembri, Blake, 66
Schilling, Alexandra J., 149
Schmid, Jeffrey R., 29, 147, 178
Schmid, Jill L., 214
Schofield, Gail, 106
Scholl, Joshua, 179
Schroeder, Barbara A., 21, 91, 100, 133, 147, 154, 230, 231
Schutes, Allison M., 63, 88
Schwenter, Jeffrey A., 4, 138, 144
Schwoerer, Monette, 192
Secchi, Eduardo R., 121, 130
Segars, Al, 154
Selangi, Moby, 230
Selby, Thomas H., 180
Seminoff, Jeffrey A., 4, 29, 37, 112, 122, 127, 139, 160, 166, 171, 173, 184
Senko, Jesse, 109, 112
Sezgin, Çisem, 22, 58, 215
Shakya, Anjali, 37
Shamblin, Brian M., 140, 143
Shannon, Delphine, 22, 223
Shaver, Donna J., 235, 239
Shimada, Takahiro, 180
Sho, Celso, 66
Shockey, David I., 109
Shore, Teri, 113
Shrake Perry, Lisa, 84
Shudes, Karen, 73
Shultz, Kathy, 252
Sibaja Garcia, Gabriel, 191
Siciliano, Salvatore, 137
Sifuentes-Romero, Itzel, 20, 215
Silva, Andrine P., 130
Slotkin, Mike, 245
Smelker, Kimberly D., 38
Smith, Alexandra, 40
Snover, Melissa L., 5
Soares, Luciano S., 181
Solangi, Moby, 22, 107
Solarin, Boluwaji B., 107, 114
Solis, S., 17
Solomona, Penina, 62
Sosa-Cornejo, Ingmar, 74, 246
Southwood, Amanda, 35
Souza, Ângela T. S., 4
Sozbilen, Dogan, 22, 33, 58
Spagnoli, Christopher A., 114
Sposato, Patricia L., 34
Spotila, James R., 108, 111, 197, 206, 207, 214
Squires, Dale, 245
Stacy, Brian, 21, 91, 154
Stacy, Nicole L., 26, 33
Stadler, Melanie, 212
Stamatiou, Anna, 252
Stamper, Andrew, 6
Stapleton, Seth P., 201, 210
Steiner, Todd, 74, 113, 122
Steinhaus, Joanie, 74
Sterling, Eleanor J., 19, 23
Sternner, Andrew T., 228
Stevens, April, 216
Stewart, Kelly R., 135, 141
Stewart, Theresa M., 75
Stokes, Lesley, 126
Stringell, Thomas B., 175
Su, Melany, 248
Suganuma, Hiroyuki, 60
Summers, Marcy, 89
Sung, Kyungje, 115
Suprapti, Dwi, 99
Surucu, Bahattin, 216
Sutton, Stephen, 57
Swidan, Nadia, 77
Swiggs, Jennifer, 217
Swimmer, Yonat, 35, 160, 166
Swingle, W. Mark, 145
Tagliolatto, Alícia B., 35, 157
Talavera, Ana L., 182
Tamata, Laitia, 62, 182
Tapilatu, Ricardo F., 218
Tappen, Marshall, 192
Taylor, Ginger, 88
Taylor, Scott, 31
Teas, Wendy, 92
Techera, Bruno Nicolas, 168
Tejedor, Ana, 35

- Teryda, Natalia S., 186
 Tezak, Boris M., 36
 Theodorou, Panagiota, 75
 Thomas, Austen, 221
 Thomas, Marcia D., 36
 Thomas, Rachel S., 26
 Thomas, Shannon, 68
 Thompson, Kathleen R., 83
 Thums, Michele, 183
 Titilayo, Olukole, 249
 Tiwari, Manjula, 43, 76, 91, 218
 Tobin, Renae, 57
 Tomás, Jesús, 151, 152, 174, 185, 186
 Torres Hahn, Anelise, 132
 Tourenq, Christophe, 77, 172
 Trejo-Valdiviezo, I., 17
 Trindade, Joana C., 218
 Trindell, Robbin N., 60
 Tsai, Yao-wen, 242
 Tsaros, Pavlos, 108
 Tschiegg, Karl, 149
 Tseng, Cheng Tsung, 141
 Tsuruta, Yuji, 142
 Tucker, Anton D., 29, 100, 178, 222, 240
 Turner Tomaszewicz, Cali, 37, 184
 Turner, Elizabeth, 85
 Turny, Avanaisa, 41
 Tzeek, Miriam, 70
 Uhlemann, Sarah, 113
 Uribe-Martínez, Abigail, 233
 Urrutia-Fucugauchi, J., 17
 Uzuner, Mehmet, 216
 Valastro, Carmela, 14, 17
 Valdes Castro, Darbelito, 49
 Valiulis, Jennifer, 201
 Valverde, Roldán A., 1, 9, 40, 49, 115, 199
 van Dam, Robert P., 190
 Van Houtan, Kyle S., 38, 161, 249
 Vance, R. Kelly, 46, 47
 Vander Zanden, Hannah B., 30, 143, 182, 200, 240
 Varela Valenzuela, Rosina, 215
 Vasquez, Ozzy S., 72
 Vejar- Rubio, María R., 77
 Velasco, Javier, 205
 Vélez-Rubio, Gabriela M., 163, 168, 185, 186
 Velez-Zuazo, Ximena, 128, 135
 Venizelos, Lily, 89
 Verhage, S., 41
 Vidal, Amanda W., 35, 157
 Viejobueno, Sandra, 44
 Vijayakumar, Aswathy, 18
 Villachica, Wilberth, 123
 Vintinner, Erin C., 19
 Vogt, Richard C., 16, 219
 Von Holle, Betsy, 192
 Wagner, Jeanne, 145
 Wallace, Bryan P., 109, 158
 Waller, Lance, 228
 Walsh, Catherine J., 10, 29
 Wang, Hai-yin, 242
 Wang, John, 160
 Wang, Tien-cheng, 242
 Wantiez, Laurent, 136
 Ware, Betty, 22
 Warraich, Natasha, 116
 Watson, Cheryl, 113
 Weaver, Sierra, 62
 Webb, Sarah J., 38
 Weber, Marilda Inês, 181
 Weege, Steve T., 237
 Wehrtmann, Ingo, 122
 Weintraub, David, 252
 Weishampel, John F., 93, 149, 155, 192, 222
 Welsh, Ryan C., 237
 West, Holly M., 6, 39
 West, Lindsey, 90, 187
 White, K. Nicole, 228
 Whiting, Scott D., 183
 Wibbels, Thane, 31, 202, 218, 230, 231
 Wildermann, Natalie, 243
 Williams, James, 77, 172
 Williams, Kristina L., 30, 134, 143, 200
 Williams-Guillen, Kim, 76, 123
 Wilson, Andrew, 77, 172
 Wingers, Noel L., 143
 Wise Sr., John Pierce, 40
 Wise, Sandra S., 40
 Wishart, Felicity, 113
 Witherington, Blair E., 21, 117, 133, 144, 147, 154, 239
 Witt, Matthew J., 41, 175
 Wood, Karl W., 9
 Wood, Kathleen M., 175
 Wood, Lawrence D., 187
 Work, Thierry M., 23
 Wright, Dean J., 20
 Wright, Laura J., 220
 Wunder, Michael B., 240
 Wyneken, Jeanette, 13, 36, 47, 116, 127, 148, 167, 224, 227, 229
 Xie, Hong, 40
 Yadamec, Thomas J., 198
 Yamashita, Yoshiya, 124
 Yañez, Ingrid L., 99
 Yorby, Jennifer E., 29
 Zaghdoudi-Allan, Nadège A., 144
 Zardus, John D., 144
 Zavala-Norzagaray, Alan A., 56, 77, 188
 Zeng, Jian-wei, 242
 Zhang, Jian, 28
 Zielinski, Michele M., 220